# Reducing CO2 Emissions from Energy-intensive Industries (Iron & Steel, Aluminium and Cement)

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The Abdullah Bin Hamad Al-Attiyah International Foundation for
Energy & Sustainable Development


5148

# INTRODUCTION

## REDUCING CO2 EMISSIONS FROM ENERGY-INTENSIVE INDUSTRIES

*One of the biggest challenges that governments and industry are currently facing is reducing CO2 emitted by heavy industry whilst also meeting the United Nations Sustainable Development Goals (SDGs). The environmental impact of heavy industry, which is integral for inclusive economic growth, needs to be minimised.*

*The transition to more climate friendly sources of electricity generation such, as wind farms and solar panels, also requires significant amounts of steel, cement and rarer metals.*

*Within this context, the Al-Attiyah Foundation, the leading energy and sustainable development think tank, based in Qatar, hosted four international experts to share their opinions about the strategies and technologies required for decarbonising heavy industries.*

## CEO Roundtable Series

**H.E. Abdullah Bin Hamad Al-Attiyah founded the CEO Roundtable Series as a platform for knowledge exchange and support for the global community in the quest towards a sustainable energy future. The quarterly events which have been hosted in Qatar for three-years are a crucial networking and learning opportunity in the calendar of industry CEOs.**

## CEO ROUNDTABLE, 12TH SEPTEMBER 2019, DOHA. SPEAKERS:

**John Drexhage**

*Energy & Extractives Global Practice Consultant – The World Bank.*

**Dr. Patrick Linke**

*Prof. Chemical Engineering Program Texas A&M University Qatar.*

**Liv Rathe**

*Director, Corporate Climate Office, Norsk Hydro.*

**Matthew Bateson**

*Senior Environment and Corporate Affairs Executive Former Head of Environment, Climate Change & Legacy Management - Rio Tinto.*

## MODERATOR

**Sami Ziedan**

*Senior Presenter, Al Jazeera*

# HISTORICAL CONTEXT

Approximately 54% of the global total energy consumption is by heavy industry.[i] The following industries are often categorised as heavy industries: food production; pulp and paper; basic chemical production; refining, iron and steel; and mining and production of non-ferrous metals and non-metallic minerals. The Al-Attiyah Foundation's 3rd CEO Roundtable of 2019 focused on three heavy industry sectors: cement, iron and steel, and non-ferrous metal production.

Reducing CO2 emissions in the electricity and transportation sectors has already received significant attention. However, the issue of heavy industry, which produces 24% of global greenhouse gas emissions, has not been examined in as much detail.[ii] Approximately one half of the amount of heavy industry global greenhouse gas emissions result from the production of iron and steel, cement, chemicals and non-ferrous metals.

| General Sources of Emissions | % of Total Emissions | Million Tonnes CO2 |
|---|---|---|
| Electricity and Heat | 24.9 | 8439 |
| Industry | 14.7 | 4982 |
| Transport | 14.3 | 4846 |
| Other Combustion sources plus emissions | 12.6 | 4270 |
| Agriculture plus land use change | 26.0 | 8811 |
| Industrial Processes | 4.3 | 1457 |
| Waste Processes and emissions | 3.2 | 1084 |

**Source: The Abdullah Bin Hamad Al-Attiyah Foundation – The Phantom Menace: Impact of Methane Leakage on Gas Climate-Friendliness – Research Series Issue 30 – February 2019**

| Industry Sources | % of Total Emissions | Million Tonnes of CO2 |
|---|---|---|
| Iron and Steel | 4.0 | 1356 |
| Aluminium and other non-ferrous | 1.2 | 406 |
| Cement | 5.0 | 1690 |

**Source: The Abdullah Bin Hamad Al-Attiyah Foundation – The Phantom Menace: Impact of Methane Leakage on Gas Climate-Friendliness – Research Series Issue 30 – February 2019**

# NON-FERROUS METALS: ALUMINIUM

- How can aluminium support a low carbon economy?
- What are the technologies required to reduce the CO2 emitted during the production process of aluminium?

Aluminium possesses the unique properties of being strong, lightweight and infinitely recyclable. It is now the second most widely used metal in the world. As countries transition to using more low carbon products, the demand for aluminium continues to grow. This is because the metal is being increasingly used to manufacture lighter cars and more energy efficient-buildings.

**Liv Rathe: Director, Corporate Climate Office, Norske Hydro. Board member of the International Emission Trading Association (IETA)**

> At Norske Hydro, we tackle climate change challenges with a global answer: first, we reduce energy consumption and emissions in the production processes; second, we increase recycling; and third, we develop new products and solutions that reduce energy consumption and emissions in the use-phase

The carbon footprint of primary aluminium production is mainly attributed to the CO2 produced from generating the electricity required to manufacture aluminium. The amount of carbon dioxide produced varies from 4 CO2e/t if the electricity source is CO2 free, to 20t CO2e/t if the electricity is from a coal-fired power plant. The average global carbon footprint of primary aluminium production is 16 t CO2e/t. The reason for this is that 57% of primary aluminium production takes place in China, where coal is primarily used to generate electricity.

The average carbon footprint of primary aluminium production in Europe is 7t CO2e/t, the lowest in the world. This is a result of using low or zero carbon power sources and the implementation of new production technologies.

However, the production of aluminium in Europe is declining and is being replaced by imported metal from China, which has a much higher carbon footprint. Since 2008, primary aluminium production in Europe declined by one-third (approximately one million tonnes). The reason for this is the introduction of climate and energy regulations, which are not implemented in other regions. One example of these measures is the European Union Emission Trading Scheme (EU ETS).

Consequently, whilst every country is being urged to decarbonise their economy, the European countries are having to contend with losing an ever-increasing share of primary aluminium production to manufacturers in other countries with significantly higher production carbon footprints.

If the objectives of the Paris Agreement are to be achieved, the production of aluminium and investment in its manufacturing is required to occur where the carbon footprint of the primary aluminium production is lowest. Additionally, decarbonisation of aluminium production through investment in research and innovation, as well as implementing more climate-friendly solutions, will also need to occur in all aluminium manufacturing countries.

Consumers are becoming more conscious about their environmental footprint and demand is rising for more low-carbon products. In response to this, Norske Hydro, has launched a new low-carbon aluminium product produced with the lowest energy consumption and the lowest emissions in the world. The carbon footprint of Hydro 4.0 is guaranteed to have maximum CO2 content of 4.0 kg per kg aluminium.

## CO2 Contribution by Sector

| | | |
|---|---|---|
| Cement |  | 3 Giga Tonnes / PA |
| Iron & Steel |  | 3 Giga Tonnes / PA |
| Aluminum |  | 0.5 Giga Tonnes / PA |

**1,735**
**MILLION TONNES**

Global demand for STEEL will increase by 1.3% in 2019.

**64,500**
**MILLION TONNES**

Primary global demand for ALUMINUM will increase by 2% in 2019, mostly from construction & automotive industries

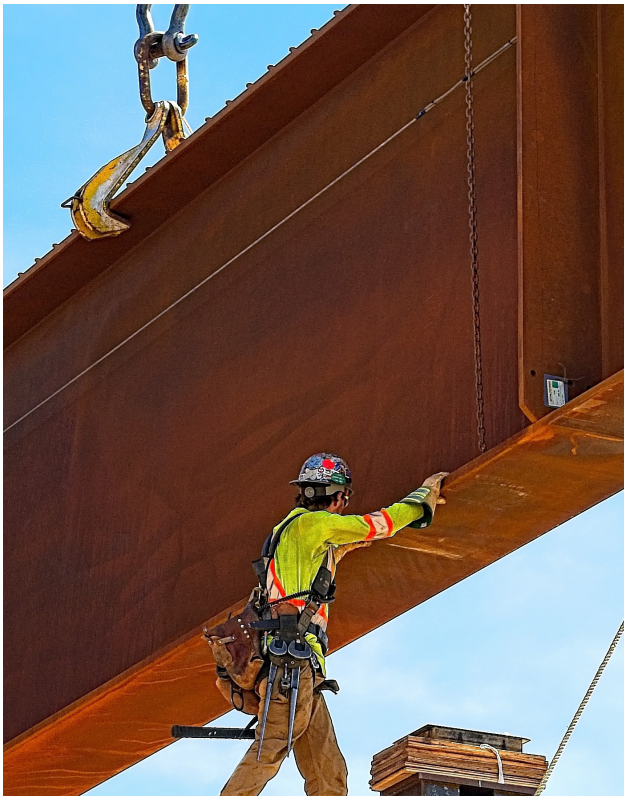
# IRON AND STEEL

The second spokesperson of the CEO Roundtable, Matthew Bateson, Senior Environmental and Corporate Affairs Executive, Former Head of Environment and Climate Change & Legacy Management, Rio Tinto, shared his experience and opinions from the mining and energy sectors in response to climate change.

The iron and steel industry is considered to be vital for a country, particularly for economic development. Thus, industry has often been protected in many countries by tariffs, which have contributed to an overcapacity in global supply. Given this context, it is important to consider carbon neutrality in this sector.

**Matthew Bateson: Senior Environmental and Corporate Affairs Executive, Rio Tinto.Former Head of Environment and Climate Change & Legacy Management**

> In my experience of working in the mining and metals sector, leaders have come to terms with the need to manage their own emissions created by the production of raw and processed materials, but the idea that there is a level of responsibility for the use of their products, is a much harder concept for them to frame and understand." Matthew Bateson, Former Senior Environmental and Corporate Affairs Executive, Rio Tinto.



The steel industry accounts for more than 98% of iron ore consumption. Although iron ore is mined in many countries, the largest iron ore suppliers in the world are Australia, Brazil and China.

When manufacturing steel, a blast furnace is fed with the iron ore, coke and small quantities of fluxes (minerals, such as limestone, which are used to collect impurities). The production of 1 tonne of steel through integrated steelmaking, using a blast furnace (BF) and a basic oxygen furnace (BOF), requires 0.7 tonnes of coal to make the coke needed in the production process. Electric arc furnaces on the other hand, do not use coal as a raw material and on average use only 0.15 tonnes of coal to produce 1 tonne of steel. The BOF is the more widespread process of

steelmaking around the world, accounting for 74% of world steel production, compared to the 25% of steel produced in Electric arc furnaces.[iii]

A new more cost-effective process for steel-making is currently being tested - this could reduce CO2 emissions from the steel sector by 20%. These developments could be coupled with Carbon Capture and Storage (CCS) to reduce CO2 emissions by a total of 80%.

There is also the possibility that advances in material science will result in the development of a market for steel producers to supply high-performance and lightweight steel to downstream consumers who require such steel for reducing the carbon footprint of their products. For other metals such as cobalt, copper and lithium, there is a growing movement amongst customers to demand metals from certified sources.

"Rationalisation, modernisation and increased overall value added at lower sales volumes, could help the cement and steel industries address the current (and possibly structural) overcapacity".[iv]

The companies that operate in the metals and extractives sectors are beginning to take more responsibility for addressing the emissions they create. For example, the Aluminium Stewardship Initiative (ASI) works with stakeholders to develop an independent third-party certification programme for the aluminium value chain. Its aim is "to define globally applicable standards for sustainability performance and to promote measurable and continual improvements in the key environmental, social and governance impacts of aluminium production, use and recycling". This strategy provides a possible framework for addressing the sustainability issues associated with other commodities.[v]

A number of solutions have already been proposed to reduce CO2 emissions in the steel industry. Firstly, new business models that support the growth of a circular economy are being suggested. Secondly, a greater understanding of the role of offsets and natural climate solutions to achieve net zero outcomes is being encouraged. Thirdly, strategies are being devised to shape low-carbon growth solutions for resource-rich countries.

However, developing initiatives to reduce Scope 3 emissions has been most challenging for the steel industry. This has been particularly true for mining companies and those that produce the iron ore or coking coal required for steel production. Scope 3 emissions are all indirect emissions from activities of a company occurring from sources that they do not own or control. These emissions usually account for the greatest share of the carbon footprint of a product since they include emissions associated with the procurement, transportation and the downstream use of a product.

If the objectives of the Paris Agreement are to be achieved, Scope 3 emissions, in particular, need to be reduced and companies can no longer ignore the expectation for them to show accountability for their emissions.

# CEMENT

The third sector to be addressed during the CEO Roundtable was the cement industry. Cement is the largest emitter of CO2 amongst the selected heavy industries for the CEO discussion. The 3rd speaker at the session, Dr Patrick Linke, Professor of Chemical Engineering Programme, Texas A&M University, Qatar, addressed this challenge.

Cement is the second most consumed commodity in the world after water. It is vital for infrastructure development and is usually produced regionally because it is expensive to transport. Most cement is created in developing countries where new infrastructure is being built and urbanisation is taking place. Cement is the main ingredient of concrete and its production currently generates approximately 7% of man-made CO2 emissions. "Carbon dioxide is emitted as a by-product of clinker production, an intermediate product in cement manufacture, in which calcium carbonate (CaCO3) is calcinated and converted to lime (CaO), the primary component of cement."[Vi] Approximately 60% of the CO2 emissions from cement production are due to this conversion, whereas 40% come from the heating process – which is mostly generated from fossil fuels. The CEMCAP is the first project funded by the European Union with the objective to implement CO2 capture in the European cement industry on a large scale. The CEMCAP project is testing and analysing four different technologies for separating CO2 from the cement production process. Costs are calculated and compared and also the retrofitability of the investigated technologies into existing cement plants (or cement kilns) are to be evaluated. Successful results could lead to a portfolio of technologies that could create pathways for future climate-friendly cement production with drastically reduced CO2 emissions5.[Vii]

**Dr Patrick Linke, Professor of Chemical Engineering Programme, Texas A&M University**

> Here we have an 'elephant in the room'. Around half the world's cement production is based in China. Consequently, China emits about half of the world's cement emissions!

# DECARBONISATION

- What are the implications of climate change and other related material issues for mining activities?
- What is the growing role of minerals and metals in a low carbon future?

The final speaker during the CEO Roundtable, John Drexhage, has a wealth of experience advising on the implications of climate change and other related material issues for mining activities, and in particular, examining the growing role of minerals and metals in a low carbon future at the World Bank.

**John Drexhage: Energy & Extractives Global Practice Consultant, World Bank**

> A combination of various sources of energy will be necessary to combat the adverse effects of climate change. This will have to be, combined with increased efficiency driven by government regulations, subsidies and taxation. In addition, the quantity of raw materials necessary to produce renewable energy needs to be factored into the equation

Achieving decarbonisation will require the investment of a significant amount of resources. It is not possible for a single source of renewable energy to replace the energy that is currently derived from non-renewable sources.

For example, the preliminary results of a 2017 estimated that 32,850 wind turbines would be required to replace the energy consumed globally every year, which is derived from oil. Also, approximately 1,642,000 turbines would be required over the next 50-years to substitute for the oil-derived energy that is expected to be consumed globally. These figures were calculated on the assumption that the turbines were producing electricity at all times and did not account for the twenty-year lifespan of wind turbines. More accurate values of the number of turbines required would thus be more than three times higher than those initially theorised.

Consequently, this is just a demonstration of how a whole range of sources of energy will be essential in the future, wind turbines alone are not adequate substitutes for the energy requirements of the world.

A combination of various sources of energy will be necessary to combat the adverse effects of climate change. This will have to be, combined with increased efficiency driven by government regulations, subsidies and taxation. In addition, the quantity of raw materials necessary to produce renewable energy needs to be factored into the equation. [ix]

For all industries, there are a number of benefits associated with measuring Scope 3 emissions. For many companies, the majority of their greenhouse gas (GHG) emissions and cost reduction opportunities lie outside of their own operations.

By measuring their Scope 3 emissions, organisations can do the following:

1. Assess where the emission hotspots are in their supply chain.
2. Identify resource and energy risks in their supply chain.
3. Identify which suppliers are leaders and which are laggards in terms of their sustainability performance.
4. Identify energy efficiency and cost reduction opportunities in their supply chain.
5. Engage with suppliers and assist them to implement sustainability initiatives.
6. Improve the energy efficiency of their products.
7. Positively engage with employees to reduce emissions from business travel and employee commuting.

Another change which all industries are experiencing is pressure from external stakeholders. Shareholders are increasingly requiring companies to be proactive about tackling sustainability issues. Also, banks, other potential lenders and equity partners are adopting a similar stance. Furthermore, consumers are requiring suppliers to be more transparent about their efforts to provide sustainable services and products through-out their value chain.

# NEED FOR GOVERNMENT ACTION

The required transition to decarbonisation in energy intensive industries will not take place in the absence of well-designed public policies. Governments will have to do the following:

1. Address the key barriers each sector faces.
2. Provide sovereign loan guarantees to help firms reduce the cost of capital investments.
3. Assist in creating markets for new low-carbon products through public procurement.
4. Ensure an appropriate regulatory framework for stimulating the development of low-carbon processes or business models.

## CONCLUSIONS

There is an urgency to ensure that promising low-carbon process technologies are brought to the commercialisation stage. In addition to being capital intensive, the required investments are also risk intensive, due to their pioneering nature. In the EU, for example, emerging new process technologies will need to be market-ready by 2030 if they are to be deployed across the EU by 2050.

A wide range of approaches will be involved in the decarbonisation of heavy industry, from the changes in material use and improved efficiency, to the use of low-carbon energy, Carbon Capture Utilisation and storage (CCUS) and entirely new processes. Some of these will be expensive and technologically-risky and require government support.

# APPENDIX

[i] This post by The Guardian is licensed under a Creative Commons Attribution-No Derivative Works 2.0 UK: England & Wales License. Based on a work at theguardian.com. Extract from various World Resources Institute;

[ii] BP Statistics Review 2019

[iii] How is Steel Produced. World Coal Association https://www.worldcoal.org/coal/uses-coal/how-steel-produced

[iv] The Institute for European Studies https://www.ies.be/files/The_Final_Frontier_Wyns_Axelson_0.pdf

[v] Aluminium Stewardship Initiative https://aluminium-stewardship.org/asi-launches-certification-program-aluminium-value-chain/

[vi] Marland, G., T.A. Boden, R.C. Griffin, S.F. Huang, P. Kanciruk and T.R. Nelson (1989), ). Estimates of CO2 Emissions from Fossil Fuel Burning and Cement Manufacturing. Data. https://cordis.europa.eu/project/rcn/193788/factsheet/en The CEMAP Project is led by SINTEF Energy Research and is under the EU Horizon 2020 Initiative wwww.sintef.no/cemap

[vii] .www.iea.org/tcep/industry/aluminium/2019

[viii] Pfotenhauer, N. May 12, 2014. Big Wind's Bogus Subsidies. U.S. News & World Report

[ix] https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/Resources/A-corporate. The Greenhouse Gas Protocol Initiative.

# FURTHER BACKGROUND READING

Some interesting reading materials could be found through the following links:

Low Carbon Technologies for Energy-Intensive Industries
https://www.icheme.org/media/7112/postnote.pdf

Industry - Tracking Clean Energy Progress
https://www.iea.org/tcep/industry/

Reducing the carbon footprint of energy-intensive industries
https://emis.vito.be/nl/artikel/reducing-carbon-footprint-energy-intensive-industries

IPCC Fifth Assessment Report – Contribution of Working Group 3 (Chapter 10 - Industry)
https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter10.pdf

Reducing the Concrete Industry's Carbon Footprint
https://www.giatecscientific.com/education/concrete-carbon-footprint/

How Concrete Industry Battles Climate Change
http://www.windermeresun.com/2018/06/04/how-concrete-industry-battles-climate-change/

Making Concrete Change: Innovation in Low-carbon Cement and Concrete
https://reader.chathamhouse.org/making-concrete-change-innovation-low-carbon-cement-and-concrete#

Hydrogen from Renewables Could Make Emissions-Free Steel Possible
https://cleantechnica.com/2018/05/14/hydrogen-from-renewables-could-make-emissions-free-steel-possible/

Inert anode technology for aluminium smelters
https://www.climatetechwiki.org/technology/alu

# OUR MEMBERS

**Currently the Foundation has over fifteen corporate members from Qatar's energy, insurance and banking industries as well as several partnership agreements with business and academia.**

**Our partners collaborate with us on various projects and research within the themes of energy and sustainable development.**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