Working Paper: Prospects for Energy Efficiency in the Iron and Steel Industry in Uganda

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Prospects for Energy Efficiency in the Iron and Steel Industry in Uganda

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Abstract

In 2018, the iron and steel industry in Uganda required about 1.12 gigajoules to produce one metric ton of steel, which is relatively low compared to the global benchmark of 16 to 20 gigajoules (GJ) per metric ton of steel produced. This is mainly because the sector relies on the use of metal scraps and imported semi-processed steel as raw materials. However, with new government plans to revive iron ore mining and the production of sponge iron, the energy demand of the sector is projected to surge. This paper assesses the energy-saving and greenhouse gas (GHG) emissions reduction potential of adopting energy-efficient technologies and practices in the iron and steel industry in Uganda. The study findings reveal that in the baseline (business-as-usual) scenario, the annual energy demand for the sector is projected to increase from about 0.5 million GJ in 2018 to 98 million GJ in 2040. However, adopting energy-efficient practices through a systematic energy management approach could result in an annual energy saving of 18 million GJ and a reduction in GHG emissions of about 959,900 metric tons of carbon dioxide equivalent by 2040. Replacing the existing technologies with the best available technologies could reduce annual energy demand by 31.7 million GJ and could reduce GHG emissions by about 1,572,000 metric tons of carbon dioxide equivalent by 2040.

Acknowledgements

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Introduction

Steel, an iron-based metal, is an essential material for society. It is also an important material for sustainable development, being necessary to satisfy people's needs and aspirations. Steel has wide uses and applications, ranging from automobiles, construction materials, and equipment, to healthcare, medical equipment, and the delivery of services (for example, the transmission of energy as electricity and natural gas, food production with tools like tractors and hoes, and supplying supplies water through pumps and pipelines). Global annual steel production increased from 770 million metric tons in 1990 to 1,860 million metric tons in 2020 (Worldsteel Association, 2021). Since 2000 global steel production has grown by 120%, primarily driven by rapid economic development and industrialisation, especially in China. Iron and steel have unique properties, making them indispensable materials. They have no cost-effective substitute. It is hard to build a modern society without steel. The International Energy Agency (IEA) projects the global demand for iron and steel will increase from 4.2 metric tons per capita (metric tons/capita) in 2019 to 6.5 metric tons/capita by 2050. In 2019, Uganda's iron and steel consumption was estimated at 13.1 kg per capita (524,000 metric tons of iron and steel annually); this is projected to increase by 129% (30 kg/capita) by 2025 (NPA, 2020).

It is impossible to imagine sustainable development without iron and steel: for example, the development of cleaner energy systems could not be achieved without them. However, the production of iron and steel is one of the most energy-intensive processes in industry, accounting for 20% of industrial final energy consumption (IEA, 2020). Globally, in 2019, iron and steel were estimated to have consumed 845 Mega tons of oil equivalent of energy. In 2020, on average, every ton of steel produced resulted in 1.851 metric tons of CO2 being emitted into the atmosphere. In 2020, 1,860 million metric tons of steel were produced, and total direct emissions from the iron and steel industry were 2.6 billion metric tons, representing between 7% and 9% of global anthropogenic CO2 emissions (Worldsteel, 2021; IEA, 2020). There is good evidence that investment in energy-efficient technologies and practices in steel and iron production reduces energy intensity and the associated emissions. For example, replacing a conventional electric arc furnace (EAF) with a comet furnace (an EAF powered by direct current (DC)) reduces energy consumption by approximately 100 kilowatt hours (kWh)/ton (Rents and Spengler, 1997). Further, studies show that retrofitting conventional casting to strip (near shape) saves 1 GJ/ metric ton of steel (Sosinsky *et al.*, 2008).

Improving energy efficiency in the iron and steel industry through investment in energy-efficient technologies and practices provides an opportunity for enhancing competitiveness while at the same time reducing environmental impacts. Energy use accounts for 20% to 40% of the cost of steel production (SOACT, 2010). Since 1960 the adoption of energy-efficient technologies and techniques has led to a reduction of about 60% in the energy required to produce a metric ton of crude steel (Worldsteel, 2021). In Uganda, failure to improve energy efficiency and reduce energy costs are believed to have contributed to the closure of a Direct Reduced Iron- Electric Arc Furnace(DRI-) EAF-based iron and steel mill. This paper endeavours to benchmark the best available energy-efficient technologies and practices by comparing the state of technologies in the iron and steel industry in Uganda with global iron and steel manufacturers. It also assesses the energy-saving potential available from adopting the best available energy-efficient technologies and practices in the iron and steel industry. In doing so, the paper attempts to propose a low-carbon pathway for developing the iron and steel industry in Uganda.

The iron and steel industry in Uganda

In 2018, the National Planning Authority (NPA) estimated the installed production capacity of iron and steel in Uganda at 1 million metric tons of steel annually. The industry employs about 5,000 people, and has a total investment capital of US$ 1 billion. The investment capital per enterprise in the iron and steel industry is from US$ 50,000 to US$ 40 million (MWT, 2018). Although Uganda has an installed production capacity of 1 million metric tons per year, the reported annual production output is about 501,700 metric tons. This implies that over 48% of installed capacity is not utilised. It is estimated that about 165,000 metric tons are produced from scrap, and that 336,700 metric tons of raw materials for the industry are imported (NPA, 2018). According to the Ministry of Energy and Mineral Development, about 500 million metric tons of iron ore are available in the country, of which only 0.0033% is being utilised per year (Baguma and Atwoki, 2015).

Table 1: Imports of semi-processed iron and steel products in Uganda

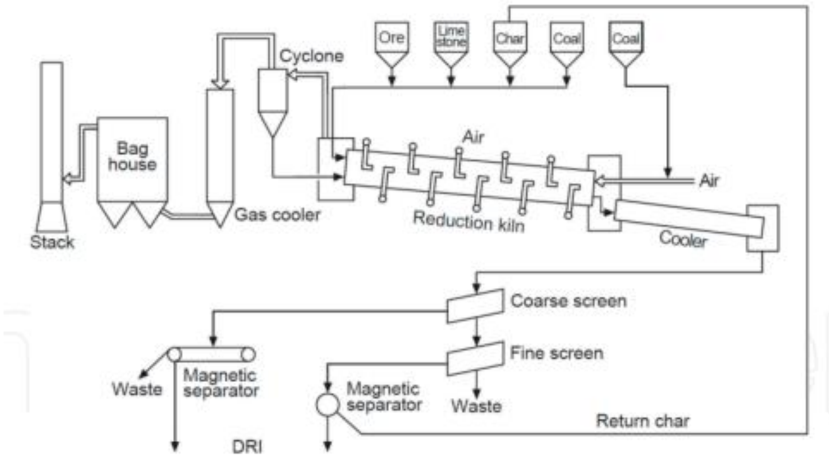
Iron and steel	2012	2013	2014	2015	2016	2017	2018	2019
Imports (US$ thousands)	247,689	258,959	252,230	276,042	207,788	282,004	367,450	356,181

Uganda Bureau of Statistics (UBOS)(2019, 2017)

Iron and steel production involves different process steps, arranged in various combinations depending on the final target products, available raw materials, energy supply, and investment capital. In Uganda, the production routes are categorised as follows.

1. Mini iron mills that use the DRI-EAF route: In the DRI-EAF route, the enterprise applies a coal-based direct reduction rotary kiln to produce directly reduced iron pellets. The iron pellets are melted in an EAF, then cast into billets and subjected to pressure and heat to roll billets into thermal mechanically treated (TMT) bars. In 2010, Uganda, had one enterprise that produced sponge iron based on the DRI-EAF route. Discussion with key stakeholders reveals that the enterprise halted production when it failed to meet its loan obligations in 2017.

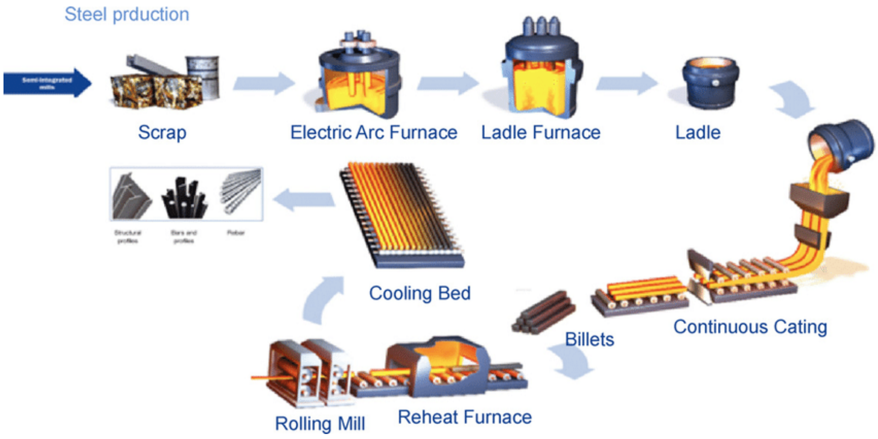
Figure 1: Process flow of DRI-EAF-based rolling mill



2. Scrap-based rolling mills dominate the iron and steel industry in Uganda. They use scrap as the main raw material. The scrap is supplemented with imported iron billets in order to improve the quality of the final steel products. These mills all use EAF to melt scrap and iron billets to produce iron products, including TMT steel bars, mild steel plates, and angle line. Some scrap-based rolling mills import semi-finished products like hot rolled steel plates/coils, which they further process with cold rolling mills into nails and iron sheets of different gauges. The products are finished with colour coating and galvanising to produce customised final products.

3. Finishing mills: Finishing mills mostly import cold and hot rolled steel plates and wire rods, as the major inputs to the production process. The steel plates are subjected to cold rolling to produce the desired thickness, and are then galvanised or coated with zinc, aluminium, and colour to produce iron sheets or metal plates. The wire rods are drawn to the desired diameter and are cut to produce nails, or they are galvanised to produce mesh products.

Figure 2: Process flow diagram for scrap-EAF-based rolling mill



The future of the iron and steel industry in Uganda

Under the Mineral Development Programme (2020-2030), the Government of Uganda plans to increase the per capita consumption of steel from 13.1 kg (2019) to 30 kg (2030); to reduce the value of imported iron and steel from US$ 370 million to US$ 96 million; and to support existing iron factories to increase liquid steel production. The government also plans to work with the private sector to establish sponge iron production (NPA, 2020). Such interventions will further influence the iron and steel industry to shift towards DRI-EAF iron and steel production routes.

Energy-efficient practices in the iron and steel industry in Uganda

Energy efficient practices and technologies observed in the surveyed iron and steel manufacturing companies in Uganda include the following energy-efficient practices: the use of ultra-high-power transformers; automated process controls; the use of engineered refractories; foamy slag practices; the use of adjustable speed drivers to control the speed of combustion air fans; and scrap preheating technologies. Of the 32 energy-efficient best practices and available technologies identified in the industry, only about six of these are currently adopted in the iron and steel industry in Uganda. Inefficiencies in energy use in the iron and steel industry in Uganda include the absence of sub-metering, the use of conventional EAF technologies, ***ad hoc*** implementation of energy-efficient measures, low power factor (ratio of actual power to apparent power), poor process control, lack of heat recovery technologies, and lack of standard energy management systems.

Table 2: Best available energy-efficient technologies and industry adoption status in Uganda

Best available energy-efficient techniques in the iron and steel industry	DRI-EAF	Scrap-EAF		Finishing mills	
		New [1]factory	Old[2] factory	New factory	Old factory
Improved process control (neural network)	No[3]	No	No	Yes[4]	Yes
Adjustable speed drives	Yes	Yes	No	Yes	Yes
Ultra-high-power transformers	Yes	Yes	Yes	N/A	N/A
Bottom stirring/stirring gas injection	No	No	No	N/A	N/A
Foamy slag practice	Yes	Yes	Yes	N/A	N/A
Oxy-fuel burners	No	No	No		

[1] New factory established after 2010
[2] Old factory-established before 2010
[3] No – there was no evidence of the use or application of the corresponding energy-efficient technology or practice.
[4] Yes – the factory is using or applying the corresponding energy-efficient practice or technology.

Post-combustion of the flue gases	No	No		N/A	N/A
DC arc furnace	No	No	No	No	No
Scrap preheating – tunnel furnace	N/A	No	No	N/A	N/A
Scrap preheating, post-combustion – shaft furnace (Fuchs)	N/A	Yes	No	N/A	N/A
Engineered refractories	Yes	Yes	Yes	N/A	N/A[5]
Airtight operation	No	No	No	N/A	N/A
Contiarc furnace	No	No	No	N/A	N/A
Flue gas monitoring and control	No	No	No	No	No
Eccentric bottom tapping on furnace	No	Yes	No	N/A	N/A
Proper reheating temperature	No	No	No	N/A	N/A
Avoiding overload of reheat furnaces	Yes	Yes	Yes	N/A	N/A
Energy-efficient drives in the rolling mill	No	No	Yes	No	No
Process control in hot strip mill	No	No	No	N/A	N/A
Recuperative and regenerative burners	No	Yes	No	N/A	N/A
Flameless burners	No	No	No	N/A	N/A
Insulation of furnaces	Yes	Yes	Yes	Yes	Yes
Walking beam furnace	No	No	No	N/A	N/A
Controlling oxygen levels/speed of air fans	No	Yes	No	N/A	N/A
Heat recovery of the product	No	No	No	No	No
Waste heat recovery (cooling water)	No	No	No	No	No
Energy management policy	No	No	No	No	No
DC twin-shell with scrap preheating	No	No	No	N/A	N/A
Near net shape casting – strip	No	No	No	N/A	N/A
Energy management system	No	No	No	No	No
Natural gas-based DRI	NO	N/A	N/A	N/A	N/A
Preventive maintenance	Yes	Yes	NO	Yes	NO

Table 3: Specific energy intensities in iron and steel industry in Uganda

Iron and steel industry production route	Energy category	Specific energy intensity in GJ/t
DRI-EAF	Fuel	22.17
	Electricity	5.72
Scrap-EAF	Fuel	3.64
	Electricity	2.96
Finishing mills	Fuel	0.112
	Electricity	0.02

Methodology

Data collection methodology: The team collected data from five iron and steel companies/firms and interacted with technical personnel from four companies. Two companies were scrap-EAF-based industries, two companies were finishing mills, and one company was an integrated iron rolling mill. The discussions were guided by a data collection template and questionnaire that aimed to identify current practices and technologies applied in the

[5] N/A – the corresponding energy efficient technology or practice is not applicable in a given factory.

production of iron and steel in Uganda. The data collection template was designed to collect energy consumption and production data from individual companies. The template was discussed with the Ministry of Energy and Mineral Development and representatives from energy auditor associations. The data collection template covered the following:

(i) the installed production capacity of the factory;
(ii) annual energy consumption and production output;
(iii) categories or sources of energy and their percentage contribution to total energy demand;
(iv) types of technologies applied in production;
(v) the scope of production; and
(vi) the status of energy management and implemented energy-saving measures.

Table 4: Categories of iron and steel manufacturing companies assessed and the type of data collected

Category	No. of firms	Type of information	Location
DRI-EAF mills	1	Energy audit report	Eastern Uganda
Scrap-EAF mills	2	Annual energy consumption and production data Technology and production practices	Central Uganda
Finishing and cold rolling mills	2	Low-carbon production reports Annual energy consumption and production data	Central and Eastern Uganda

Challenges encountered during data collection

The description of the iron and steel industry in Uganda: According to UBOS, the iron and steel industry in Uganda includes DRI-EAF mills, scrap-EAF mill and Finishing mill (cold rolling and roofings). This creates further challenges, given that limited studies have been conducted to benchmark energy performance, best practices, and technologies for cold rolling and roofing mills. Therefore, getting reference data to evaluate energy efficiency potential remained a challenge.

Record-keeping at the factory level: In Uganda, data on energy consumption is recorded in monetary values in a reasonable number of iron and steel manufacturers These financial figures include variable charges like peak demand (kilo Volt Amperes) charges, reactive charges, fuel adjustments, inflation, and service fees. It is difficult to convert the monetary values into kilowatt equivalent or energy equivalent. For integrated mills, which produce a range of products, it is challenging to determine specific levels of energy consumption for different production lines, since there is no sub-metering.

Determining specific energy intensities for the baseline, best available practices (BAP), and best available technologies (BAT) scenarios: The specific energy consumption of the iron and steel industry under the baseline scenario was determined using production and energy commutation data collected from the factories. The energy equivalent (gigajoules) was summed to establish the total energy demand and then divided by annual production to establish the baseline energy consumption. For the BAP and BAT scenarios, the specific energy consumption was determined by obtaining the difference in the sum energy-saving potential for BAPs and BATs from the baseline Specific Energy Consumption.

Low Emission Analysis Platform (LEAP) modelling and scenario analysis: Energy demand analysis is based on the first principle of summation of the product of energy intensity and production output, as illustrated in equation 1 below. The principle of total emissions related to final energy demand in the LEAP model is based on Inter-government Panel on Climate Change(IPCC)'s guidelines for national greenhouse gas inventories. The greenhouse (GHG) emissions were calculated by multiplying the fuel consumption by the corresponding default emission factor, as illustrated in equation 2.

$$Final\ Energy\ Demand\ [E_f] = \sum_s \sum_t AL_{f\ s\ t} \times EI_{f\ s\ t} \quad (1)$$

$$Total\ Carbon\ Emission\ [C] = \sum_s \sum_t \sum_f E_f \times EF_{f\ s\ t\ p} \quad (2)$$

Where:
AL = Activity level
EI = Energy intensity
E = Energy consumption
EF = Emission factor
f = Type of fuel
s = Sector t = Technology/equipment p = Pollutant emissions factor

For this analysis, standard pollutant emission factors already pre-defined in the LEAP tool for various environmental externalities (both GHG emissions and Short Lived Climate Pollutants calculations) were used.

Key modelling assumptions:

The following key assumptions, which are informed by the projections and targets set in Vision 2040 and the National Development Plan III (2021–2050), were considered in determining the production values for the iron and steel industry in Uganda by 2050:

1. The installed annual production capacity of the iron and steel industry in Uganda is 1 million metric tons and it produces 501,700 metric tons, of which 165,000 metric tons are produced from scrap and 336,700 metric tons are produced from semi-processed iron and steel products (NPA, 2018; UBOS, 2019).
2. The national iron and steel demand is projected to increase from 13.1 kg/capita in 2019 to 30 kg/capita in 2025, and will be 76.2kg/capita by the end of 2040 *(NDP III).*
3. The population of Uganda is assumed to grow at a rate of 3.3% per year in the period 2019 to 2050 (World Population Prospects: 2019 revisions) .
4. By the end of 2022, Uganda will have a commissioned 572,000- metric tons annual production capacity for sponge iron (DRI-EAF route); sponge iron production will account for 50% of total iron and steel production by the end of 2040 *(NDP III).*
5. The government plans to reduce iron and steel imports from 700,000 metric tons in 2019 to 125,000 metric tons in 2020. By the end of 2040, iron and steel raw materials will not be imported (NDP III).
6. The Government of Uganda plans to revive iron ore mining and sponge iron production, giving priority to the DRI-EAF production process. Therefore, it is assumed that iron and steel production will shift more towards the DRI-EAF processing route in all scenarios (NDP III).

Scenarios developed: baseline scenario, BAP, and BAT

- **Baseline scenario:** In the baseline scenario, the iron and steel industry is assumed to continue operating at the same level of efficiency and it is assumed that by the end of 2040 the specific energy intensity will stay within the same range.
- **BAP:** This scenario assumes that firms will adopt energy-efficient practices through processing modification/retrofitting, process monitoring, control, and optimisation. Some of the BAP include the following:
  - Scrap preheating to reduce energy consumption in an EAF: this involves modifying the production process with complementary waste heat recovery furnaces to preheat the feed scrap.
  - Converting the furnace operation to high-power or ultra-high-power by installing a new transformer or paralleling existing transformers can save energy of about 10 and 20 kWh/metric ton (Worrell *et al.*, 2010).
  - Process control and optimisation: improved monitoring of process parameters allows manufacturers to model the process parameters and determine the optimum operating parameters.
  - Installing oxy-fuel burners to reduce electricity consumption by substituting electricity with oxygen and hydrocarbon fuels. This can reduce electricity consumption by 0.14 GJ/metric ton crude steel (Centre for Material Production, 1992).

- Cross-cutting energy-efficient practices: (a) Preventive maintenance can reduce energy consumption by 0.14 GJ/metric ton of products (United States Environment Protection Agency, 2012). (b) Using an energy monitoring and management system is estimated to reduce energy by 0.03 GJ/metric ton and carbon emissions by 3.7 kg CO2/t-product. (c) Improving motor use efficiency (e.g. in pumps, rollers, fans, compressors) – to improve the energy efficiency of motors, a systematic approach is required to look for plant-wide energy-efficient opportunities; potential energy savings from motor efficiency improvements are 0.3 Million British Thermal Units per metric ton/metric ton (0.35 GJ/metric ton) (Stubbles, 2000).

- **BAT:** The BAT scenario does not consider emerging technologies, it only considers technologies that are available on a commercial scale. Some of the best commercially available technologies include the following:
  - DRI: The amount of energy consumption of coal-based technologies ranges from 20 to 25 GJ/metric ton for coal-based DRI. Natural gas-based DRI production technologies are considered to be the best available, with energy consumption of 10.4 GJ/metric ton.
  - Steel-making: DC arc furnaces use DC instead of conventional alternating current. Widely used commercially available DC arc furnaces can potentially reduce total energy consumption by approximately 100 kWh/metric ton compared to conventional EAF, whereas Contiarc® furnaces can reduce energy losses by 200 kWh/metric ton compared to other conventional furnaces.
  - Recuperative or regenerative burners: These are gas-to-gas heat exchangers that can recover excess heat in stack or flue gases to preheat combustion air. The use of recuperative or regenerative burners can reduce fuel consumption by 10–20% compared to furnaces without heat recovery.
  - Rolling: The walking beam furnace is reported to be the most energy-efficient reheating furnace commercially available (Worrell *et al.*, 2012). Application of a walking beam furnace can reduce electricity consumption by 25% per metric ton of steel and fuel consumption by 37.5% metric ton of steel reheated, as compared to three pusher-type furnaces.

- **Combined scenario**: Assumes that iron and steel firms will adopt energy-efficient practices and technologies concurrently.

Discussion of results

Energy intensity: In 2015 the energy required to produce sponge iron (DRI) from iron ore in Uganda was 27.89 GJ/t; however, the production of iron and steel from iron ore was put on hold in 2016. In 2018, on average, the specific energy intensity for processing and producing iron and steel in Uganda was 1.196 GJ/t, which is relatively low when compared to the global average of 20.7 GJ/t. This is because the industry currently produces steel by recycling scrap metals and using imported semi-processed iron and steel products, thus avoiding the energy demand required to convert iron ore into steel. In the baseline scenario the energy intensity for the sector remains constant at the current level on assumption that DRI-EAF mills will resume operation with status quo energy efficiency. In the other scenarios the projected energy intensity decreases proportionate to the increased adoption of BAP and/or BAT.

Projected energy demand for the industry: According to UBOS, in 2018, 446,230.60 metric tons of steel products were produced in Uganda. Thus, the overall energy demand for iron and steel was 533,492,000 GJ/t. Scrap-EAF-based mills consumed 90.1% of the total energy demand and finishing mills consumed 9.9% (52,634,000 GJ/t). Uganda had one DRI-EAF mill whose operation was put on hold in 2017.

To meet the projected demand for iron and steel by the end of 2040, it is projected that DRI-EAF mills will account for 50% of the total iron and steel produced in Uganda while EAF mills and finishing mills will produce 10% and 40%, respectively. This change in the production mix is constant for all modelled scenarios.

The projected energy demand in all four scenarios is given in Figure 3 below.

- In the **baseline scenario**, energy demand in the iron and steel industry is projected to increase from 0.5 million GJ in 2018 to 97.8 million GJ by the end of 2040. This sharp increase is largely because of the projected change in the production mix noted above – specifically, plans to revamp and enhance the production capacity of DRI-EAF mills to produce steel from iron ore (the production of steel from iron ore is more energy-intensive compared to producing steel from scrap). By the end of 2040 DRI-EAF mills are projected to make up 96.5% (94.3 million GJ) of total energy demand in Uganda's iron and steel industry, while energy demand from scrap-EAF will be 3.1% (3 million GJ) and energy demand from finishing mills will be 0.4% (0.4 million GJ).

- In the **BAP scenario** for the iron and steel industry, the total energy demand by the end of 2040 is projected to be 79.9 million GJ. The trends in the BAP scenario can be realised by adopting and implementing energy-efficient practices, which will result in savings of up to 17.9 million GJ as compared to the business-as-usual/baseline scenario. (It is assumed that firms will gradually adopt the best available energy-efficient practices in a uniform sequence year by year and that by the end of 2040 energy intensity will have gradually reduced to 22.67 GJ/t, 5.5GJ/t, and 0.13 GJ/t for DRI-EAF mills, scrap-EAF mills, and finishing mills, respectively).
- In the **BAT scenario**, the projected energy demand is 66.1 million GJ, which is the result of gradually phasing out all old, inefficient technology and replacing it with the best available technologies in the iron and steel industry outlined above. In this scenario, DRI-EAF mills will account for 95.7% of the total energy demand in the iron and steel industry, while scrap-EAF and finishing mills will demand 3.8%% and 0.5% of the total energy demand. (It is assumed that firms will gradually adopt the best available energy-efficient technologies in a uniform sequence year by year and that by the end of 2040 energy intensity will have gradually reduced to 18.68GJ/t, 4.66 GJ/t, and 0.13 GJ/t for DRI-EAF mills, scrap-EAF mills, and finishing mills, respectively).
- In the **combined scenario** the projected energy demand by the end of 2040 is 59.1 million GJ, which is the result of adopting both the best available energy-efficient practices and the best available energy-efficient technologies.

Figure 3: Projected energy demand for baseline, BAP, and BAT scenarios

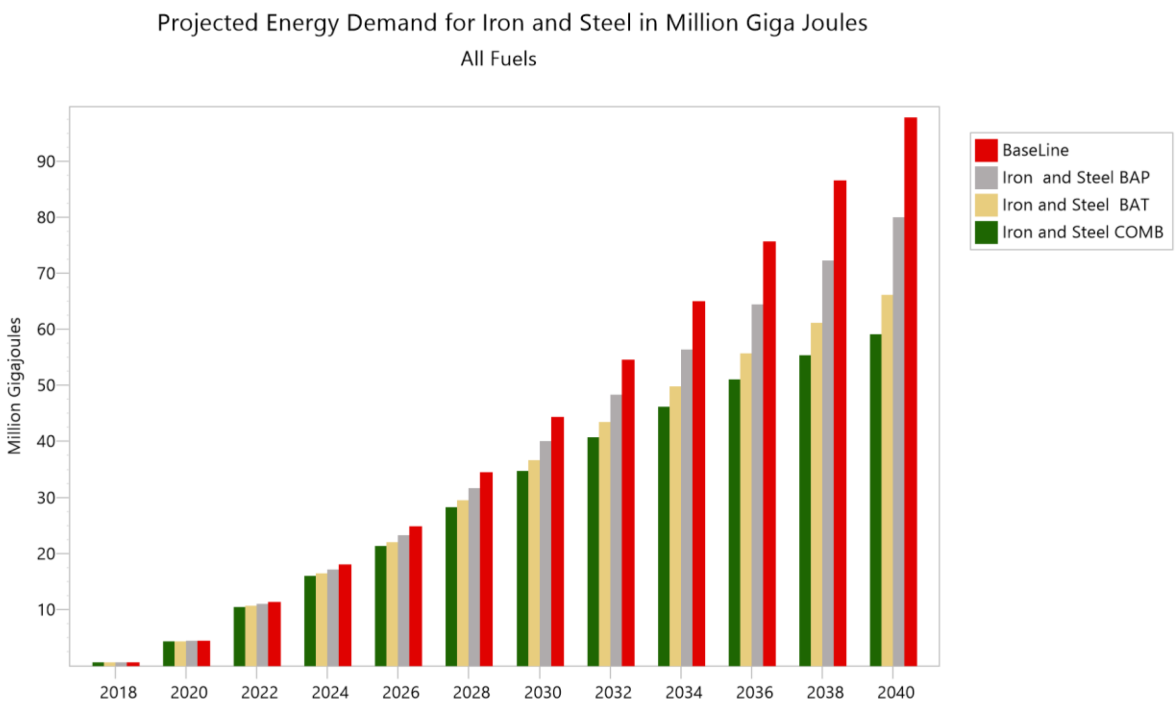


Table 5: Projected production of iron and steel in different production pathways in Uganda in million metric tons

Branch	2018	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
DRI-EAF mills	-	0.13	0.37	0.60	0.83	1.16	1.50	1.85	2.22	2.59	2.98	3.39
Scrap-EAF mills	0.11	0.17	0.23	0.28	0.36	0.46	0.54	0.60	0.65	0.67	0.69	0.68
Finishing mills	0.34	0.46	0.48	0.51	0.71	0.98	1.25	1.53	1.82	2.11	2.41	2.71

Table 6: Projected energy demand of iron and steel production pathways in Uganda for the baseline scenario in million Gigajoules.

Branch	2018	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
DRI-EAF mills	-	3.6	10.2	16.7	23.2	32.3	41.8	51.6	61.8	72.3	83.1	94.3
Scrap-EAF mills	0.5	0.8	1.0	1.3	1.6	2.1	2.4	2.7	2.9	3.0	3.1	3.0
Finishing mills	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4
Total	0.5	4.5	11.3	18.0	24.9	34.5	44.4	54.5	64.9	75.6	86.6	97.8

Table 7: Projected energy demand of iron and steel production pathways in Uganda for the BAP scenario in million Gigajoules.

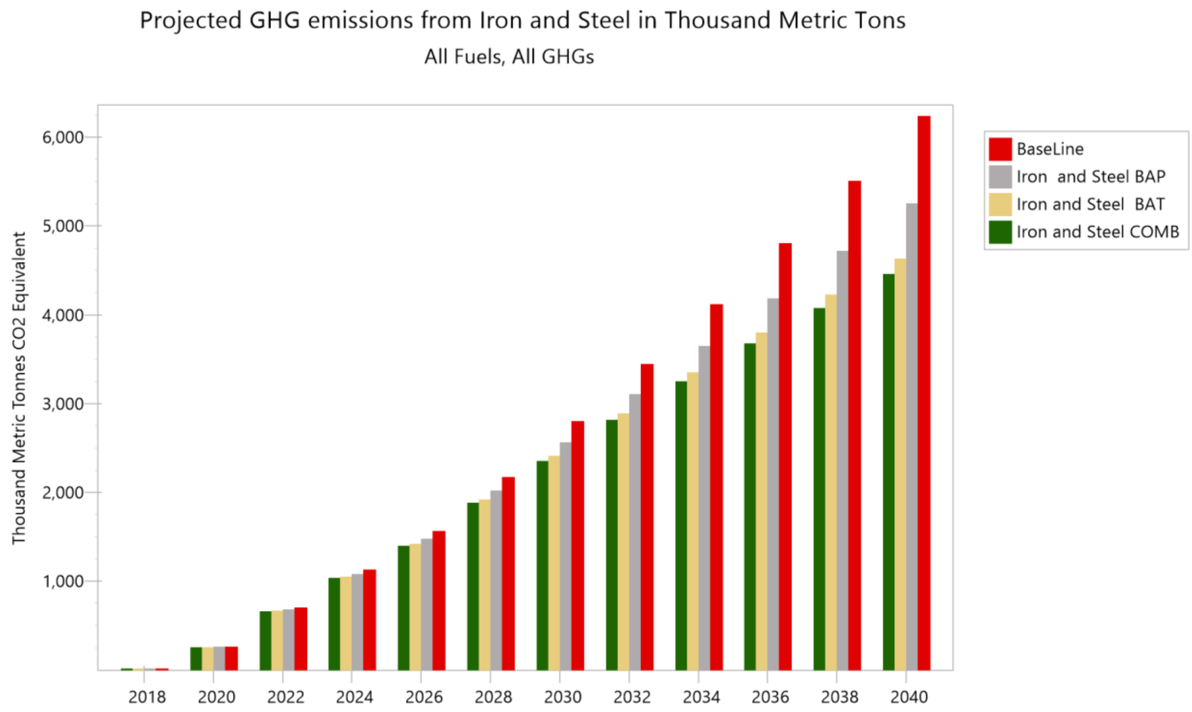
Branch	2018	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
DRI-EAF mills	-	3.5	9.9	15.8	21.6	29.6	37.6	45.5	53.4	61.3	69.1	76.8
Scrap-EAF mills	0.5	0.8	1.0	1.3	1.6	2.1	2.4	2.7	2.9	3.0	3.1	3.0
Finishing mills	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4
Total	0.5	4.4	11.0	17.2	23.3	31.8	40.2	48.4	56.6	64.6	72.5	80.3

Table 8: Projected energy demand for different iron and steel production pathways in Uganda for the BAT scenario in million Giga Joules

Branch	2018	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
DRI-EAF mills	-	3.4	9.2	14.3	19.2	25.9	32.3	38.4	44.2	50.0	55.6	61.2
Scrap-EAF mills	0.5	0.8	1.0	1.3	1.6	2.1	2.4	2.7	2.9	3.0	3.1	3.0
Finishing mills	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4
Total	0.5	4.3	10.3	15.6	20.9	28.1	34.9	41.3	47.4	53.3	59.1	64.6

Projected GHG emissions: In the baseline scenario, GHG emissions from the sector are projected to increase from 17,500 metric tons of carbon dioxide equivalent tCO2eq in 2018 to 6,116,900 tCO2eq in 2040. The anticipated increase in the use of fossil fuels (coal) – as required in DRI-EAF mills – will largely account for this massive increase in emissions. However, under the BAP scenario, emissions are expected to be 5,157,000 tCO2eq in 2040. The iron and steel industry can achieve this by adopting energy-efficient practices like energy management systems that are in accordance with ISO 50001. In the BAT scenario, the GHG emissions for the sector are expected to reach a maximum of 4,544,500 tCO2eq in 2040. Achieving such a reduction would require firms to invest in DRI-EAF mills and to choose natural gas-based DRI-EAFs, which are reported to be more efficient than coal-based DRI-EAFs. In the combined scenario, the GHG emissions for the sector are anticipated to be 4,461,600 tCO2eq in 2040. This can be achieved by adopting both energy-efficient practices and BAT.

Figure 4: Projected GHG emissions from iron and steel industry in Uganda for the baseline, BAP, and BAT scenarios



Conclusion and recommendations

The surveyed companies show no evidence of applying a structured operational approach to improving energy performance. In most cases, internal staff are aware of energy improvement measures or such measures are identified in an energy audit report, but the measures are not implemented. This is for several reasons, one being that the top management or other key stakeholders oppose such measures or prefer other investment choices that provide a better return on investment. It is often difficult to justify the application of energy improvement measures because there is no precise system that can provide reasonable data and information in this regard. A systematic approach to energy management is therefore needed in iron and steel manufacturing companies. Systematic energy management, including systematic tracking, analysis, and planning of energy use, is one of the most effective approaches to improving energy efficiency in industry.

Relevant energy data and statistics for iron and steel production sub-processes in Uganda were not available, and modelling was done using the overall energy intensity of the industry. This situation should be improved upon, to allow for bottom-up modelling, so as to provide more precision and a more accurate analysis that can establish the energy, costs, and emissions reduction potential of specific technology or process changes in the iron and steel industry. The data collection process for energy-relevant data needs to be optimised. Firms should be encouraged to install energy sub-meters for energy-intensive sub-processes. It is recommended to establish provisions that require each company to regularly report relevant data, like energy consumption and production volumes.

Given that the Government of Uganda plans to increase the demand for steel from 13 kg/capita to 30 kg/capita by 2025, priority should be given to DRI-EAF mills, which are more energy-efficient than Blast Furnace-Basic Oxygen Furnace (BF-BOF)mills, in its plans to increase the production of steel from iron ore. However, the government needs to encourage investors to install natural gas-based DRI-EAF, which is more energy-efficient than coal-based DRI-EAF.

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The views expressed in this Working Paper do not necessarily reflect the UK government's official policies.