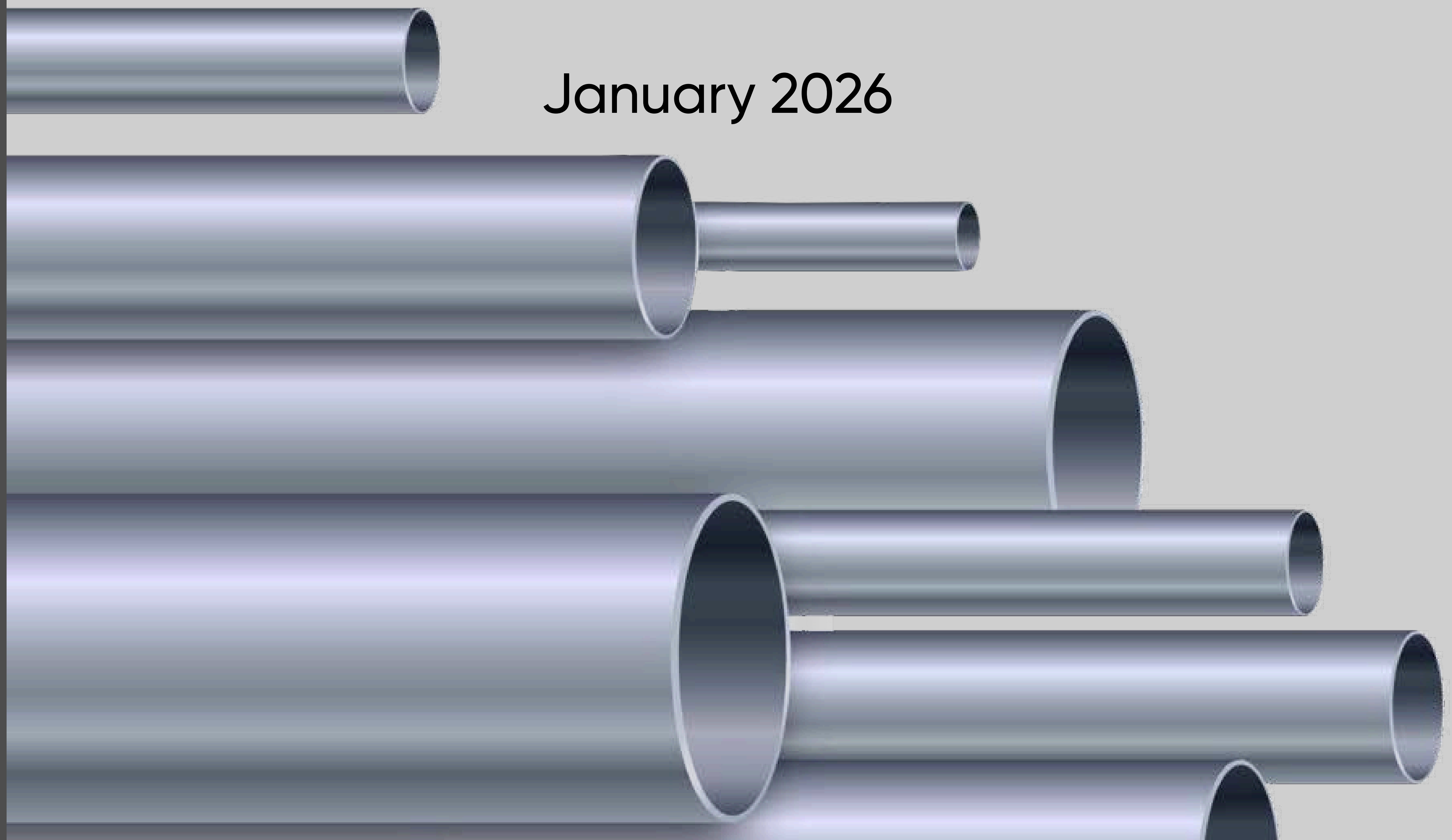
GREEN STEEL TODAY AND TOMORROW



January 2026

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Introduction

December 2025 marks the 10th anniversary of the Paris Climate Agreement, in which 193 countries and the European Union pledged to curb global warming by reducing CO_2 emissions. The practical implementation of the agreement's provisions began in 2020, and now it is possible to assess the work done over 5 years in the leading steel-producing countries.

Steelmaking accounts for 7-9% of global CO_2 emissions. That is why their gradual reduction to zero is an important international task. However, each country solves it at its own discretion, based on its existing potential. Practice shows that there is no single decarbonization strategy that would be equally acceptable to all countries and all steel companies.

Different countries have different structures of steel production and energy generation, different government policies, and plans to develop renewable energy sources. Accordingly, the pace of progress at the national level varies significantly.

However, the challenges faced by steel producers on the path to decarbonization have common features. First of all, it is the reluctance of consumers to pay premiums for environmentally friendly steel. In addition, there is a lack of ready-to-implement, affordable technological solutions that make mass production of green H_2 and CCUS economically feasible.

Finally, there is the limited resource of steel scrap, the need for which increases dramatically when switching from BF-BOF to EAF technology. That is why some companies still do not have long-term specific plans to reduce CO_2 emissions, focusing on implementing the best available technologies today.

Other barriers common to many countries include weak protection of the domestic steel market, which sharply limits the ability of local players to invest in decarbonization projects. High energy prices and limited access to international financing instruments are also high on the list of challenges.

The future of hydrogen steel industry is still unclear. Both in terms of technology and market impact. Against this backdrop, a number of steel mills, primarily in the European Union, have announced the suspension of previously announced green transformation projects. Others are simply cutting costs. The roadmaps of steel producers and the progress of decarbonization projects are not encouraging for either steel companies or other stakeholders. In this regard, the role of government regulation is growing significantly. It is designed to create the necessary conditions for the development of the green steel market.

In this book, we have analyzed and summarized the experience, achievements, paths and challenges of different countries in the green steel transition. We hope that this experience and series of materials will help market participants, researchers, and stakeholders to get a complete and broad picture of the challenges and successes of the green transformation of the steel industry.

Steel on the way to "net zero"

The need to combat climate change on an international scale makes the decarbonization of the steel industry irreversible

The steel industry accounts for 7-9% of the world's greenhouse gas emissions. Therefore, the process of gradual reduction of CO2 emissions from steelmaking has already been launched in most leading producing countries. The pace of progress varies, as it depends on a number of factors. So, what barriers do companies face and what incentives can accelerate the green transition?

Factor 1: Resources

Large coal reserves have made the BF-BOF route the dominant steelmaking method in China, India, Russia, Canada, Australia, Germany, the UK, Vietnam, South Africa, Indonesia, Ukraine, and other countries. Whereas the countries of the Gulf and North Africa, as well as Iran have huge reserves of natural gas.

Therefore, all steelmaking here is based on the NG-DRI-EAF model (natural gas-based DRI production followed by steelmaking in electric arc furnaces).

There are exceptions to the rule. The US, the world's third largest coal producer, produces most of its steel in electric arc furnaces (EAF). And vice versa.

Despite having no coal mining capacity of its own, Brazil has built its steel industry predominantly on the BF-BOF route, using local charcoal.

Finally, there are countries with no metallurgical raw materials of their own. And they have made different choices in their time. Turkey relied on the construction of EAF plants, while Japan and South Korea relied on integrated mills.

Given that the BF-BOF steelmaking route emits an average of 2.2 to 2.4 tons of CO_2 per ton of steel, compared to just 0.4 to 0.7 tons for the EAF process, it's clear which technology has the advantage in decarbonization. Steel products in the Gulf and North African countries, as well as Iran, are already virtually green.

Whereas the rest will have to invest heavily to achieve even that level. And the higher the share of BF-BOF mills in the national steel industry, the more investment is required. But where to invest?

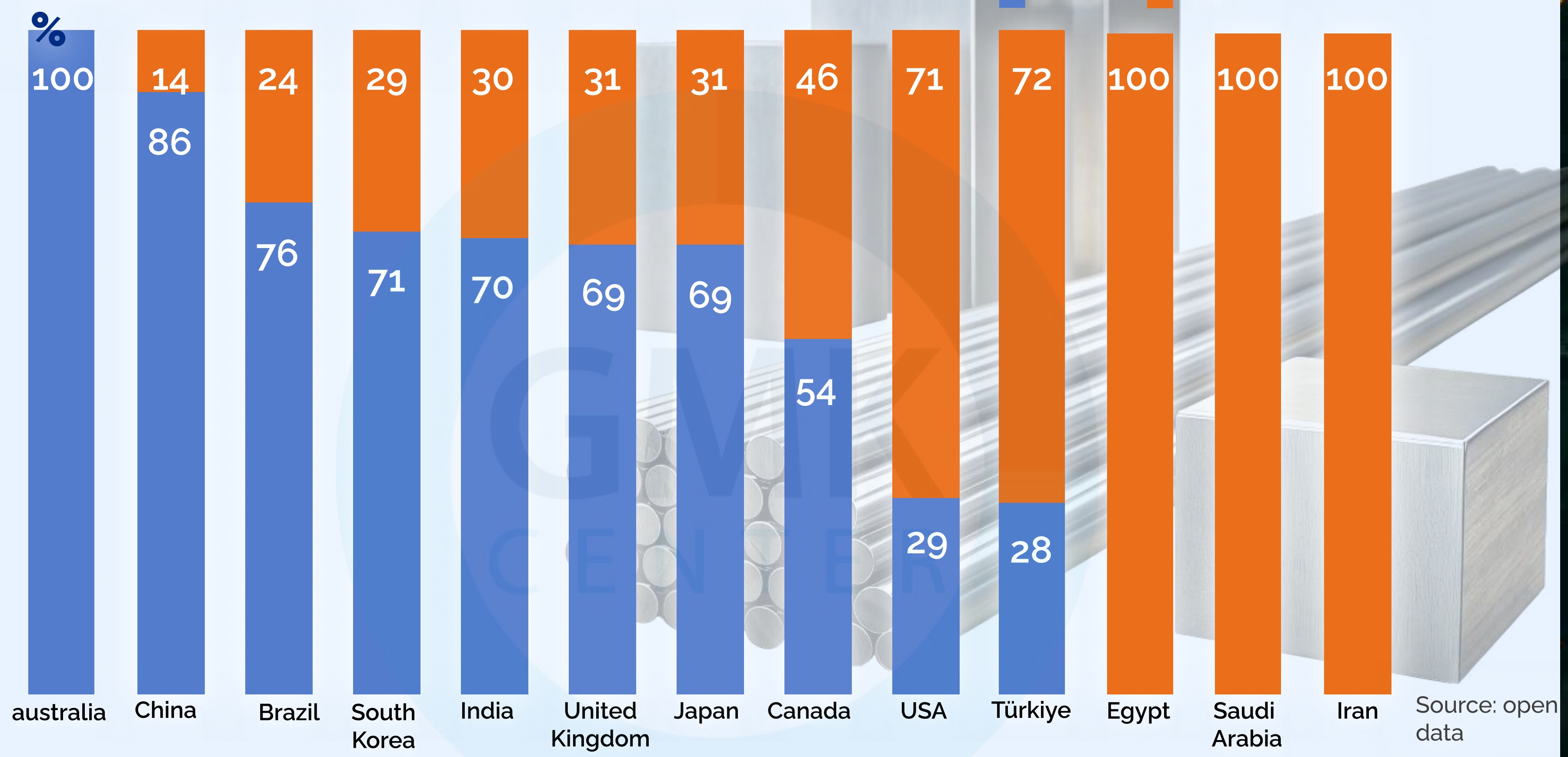
7-9%

of all greenhouse gases in the world come from metallurgy

2,2-2,4

tons of CO2 emissions during the melting of 1 ton of steel along the BF-BOF route

STRUCTURE OF THE STEEL INDUSTRY IN MAJOR PRODUCING COUNTRIES, %



Source: open data

Company strategies

Currently, 2 ways of decarbonization are known. The first one is replacement of BF-BOF capacities by NG-DRI-EAF, with further prospect of transformation into H2-DRI-EAF (DRI production using hydrogen with subsequent steelmaking in electric arc furnaces). This strategy has been chosen by:

- British Tata Steel UK and British Steel for the Port Talbot and Scunthorpe steelworks. The projects cost £1.25 billion and £2 billion;
- ArcelorMittal North America and Algoma Steel of Canada for the Dofasco and Algoma mills. The projects cost $1.8 billion and $880 million;
- British Liberty Steel for Australia's Whyalla Works. The cost of the project is $485 mln;

There are fully completed cases as well.

- Ukrainian company Interpipe completed construction of an EAF plant with a capacity of 1.32 million tons in 2012, completely abandoning the previous open-hearth steelmaking process. The project cost $700 mln;
- Russia's United Metallurgical Company plans to launch a new Ecolant EAF plant with an annual capacity of 1.8 mln tons of steel this year. The cost of the project is $1.79 bln.

The advantage of this way is that it is based on the best available technologies (BAT). This means that the results of their implementation and payback can be confidently predicted.

Whereas the second currently known decarbonization route, the use of hydrogen in blast furnaces, is still at the stage of searching for optimal solutions.

- The US Cleveland-Cliffs in January 2024 at its Indiana Harbor mill completed trials of H2 injection into blast furnace No. 7, the largest in North America;
- India's Tata Steel in April 2023 conducted a successful hydrogen injection trial in BF at its Jamshedpur mill;
- Turkey's OYAK Mining & Metallurgy in 2024 completed a hydrogen injection trial in BF at its Erdemir mill;
- Japanese Hydrogen Steelmaking consortium of Nippon Steel, JFE Steel and Kobe Steel built small 2 pilot BFs at East Nippon Works in Kimitsu and JFE Steel in Chiba in 2023 for research on H2 utilization in blast furnace production;

The use of hydrogen in blast furnaces has limited potential to reduce CO2 emissions (up to 20%) and may not lead to low-carbon steel production, unlike electric arc furnaces and DRI produced using hydrogen.

According to Hideoki Suzuki, Nippon Steel's Executive Director for Environment, the use of H2 in blast furnaces does not imply complete abandonment of coke. Therefore, the remaining volume of greenhouse emissions is planned to be neutralized using CCUS technology (capture, storage and use of CO2). Now it is far from industrial implementation.
It is all about the cost.

Nippon Steel has managed to achieve a cost of carbon capture at $149/t CO2 and this is the best achievement so far. Obviously, this is too high a cost per 1 ton of finished steel.

Plus dependence on technical solutions in related industries, primarily in terms of carbon transportation and storage. Therefore, it is very difficult to predict progress.

Factor 2: The role of suppliers

ArcelorMittal North America in Canada and Liberty Steel Australia are also planning to build DRI plants with annual capacities of 2.5 million t and 1.8 million t as part of decarbonization. Having such a facility in the future will strengthen the market position of these companies.

But many will have to look for third-party suppliers. First of all, those who now use steel scrap to operate their EAFs. Its availability on the global market will decrease as more and more EAF facilities are built, including to replace existing BF-BOFs.

For instance, in China, no new BF-BOF projects have been approved by the authorities in 2024. According to the Centre forResearch on Energy and Clean Air, permits were issued only for the construction of EAF plants with a total capacity of 7.2 million tons per year.

According to forecasts by the consulting company Wood Mackenzie, the share of EAF in global steel production by 2050 will rise to 48% compared to 29.1% in 2024.

According to various estimates, the operation of these facilities will require about 1 billion tons of scrap per year – while its procurement in 2024 amounted to 460.6 million tons.
Steelmakers cannot expect a twofold increase in scrap procurement.

Moreover, more and more countries are resorting to protectionist measures with regard to steel scrap, regulating scrap export in one way or another. Or even banning it completely.

That's why the importance of DRI, HBI, and CBI is growing – along with the role of countries that can supply these low-carbon iron ore materials to steelmakers lacking the conditions to produce them domestically.

First of all, the Gulf States, North Africa, as well as Iran, Australia, Brazil, Canada and Ukraine could become such suppliers. And they are very interested in such a scenario. Therefore, a number of new projects are being prepared for launch.

- In Mauritania, the state company SNIM together with the consortium CWP Global intends to build a DRI plant with an annual capacity of 2.5 million tons per year;
- Egypt plans to build a DRI plant with a capacity of 2.5 million tons at a cost of €1 billion with a subsequent increase to 4 million tons. The plant will operate in the economic zone of Suez;
- In Algeria, the local company Copresud together with the Italian consortium CEIP Scarl plan to build a DRI plant worth €1 billion;
- In Libya, the Turkish company Tosyali Holding together with the local state-owned company SULB intend to build a DRI plant with an annual capacity of 8.1 million tons. Also in Libya, state-owned LISCO will build a DRI plant with a capacity of 2 million tons;
- Brazil's Vale will build a complex in Saudi Arabia to produce 12 million tons of CBI per year in the Ras-al-Khair industrial zone;
- Bahrain Steel plans to increase DRI output to 24 million tons by 2028, up from 12 million tons in 2019;
- Emirates Steel is to commission a new 2.5 million tons per year DRI plant from 2027.
- Green Steel of Western Australia is building a $1.74 billion DRI plant in Western Australia;

Production of green H2 is an extremely energy-intensive process. Moreover, it requires "green" electricity.

It is obvious that not everyone has such potential for solar energy as the Gulf countries, North Africa, Australia, Iran and Brazil. Or hydropower like Canada.

Therefore, they are the ones that can become suppliers not only of green DRI/HBI/CBI, but also of green H2 for the steel industry in other countries.

On this basis, the decarbonization strategy in China, Japan, South Korea, UK, EU states – envisages significant hydrogen imports by 2050.

It is expected that by then its price will have fallen to $1500/t . This should be a commercially acceptable offer. Currently, the cost of producing "green" H2 in different countries ranges from $5000/t to $12000/t. And the cost of transportation is about the same as the price of the product itself.

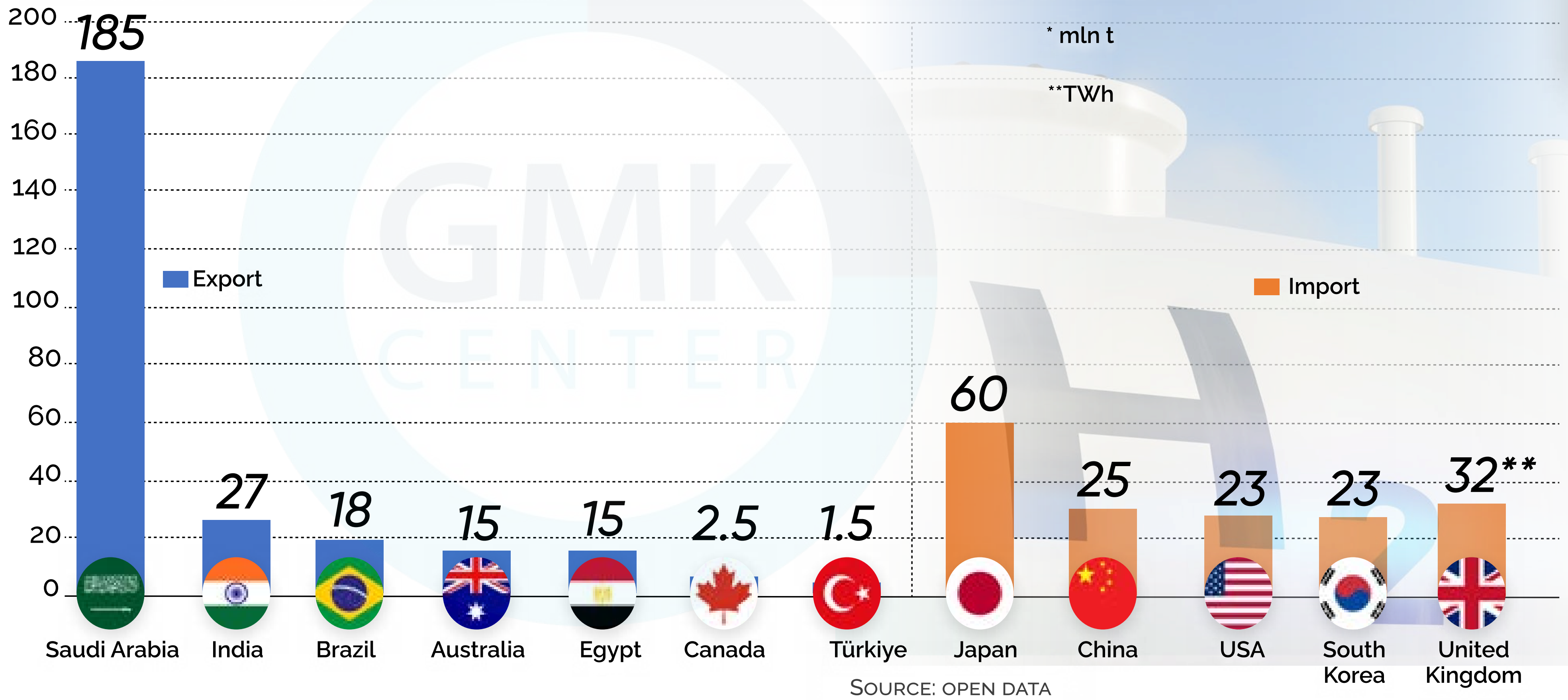
This shows well how far hydrogen decarbonization is now from market realities.

Factor 3: Green government policy

Achieving carbon neutrality of the economy within each individual country is not the problem of CO2 emitters themselves, including metallurgists. It is a national task.

Where the authorities understand this, decarbonization of the steel industry moves much faster.

FORECAST OF H2 EXPORTS AND IMPORTS BY 2050 IN MAJOR STEEL-PRODUCING COUNTRIES*



SOURCE: OPEN DATA

Steel on the way to "net zero"

- In Japan, steel producers can receive a tax deduction of $149 for each ton of “green” steel produced at new facilities. Providing fiscal credits to companies can be a much more effective tool than subsidies and grants from the European Commission for European steelmakers;
- In the UK, steel producers receive equity government funding for green transition projects in the form of interest-free loans from the Sovereign Wealth Fund;
- In Australia, steel green transition projects receive up to 50% of the required investment from the federal Green Iron Investment Fund. In addition, green H2 producers can claim tax credits of $2000/t from 2027;
- In Canada, the authorities promote EAF transition of local companies by means of government funding of projects. The source of funds is revenue from CO2 emission fees paid by companies;

This aspect is extremely important. Because in Ukraine, for example, emitters are also charged a fee for emissions.

It goes to the general fund of the state budget and to the State Energy Efficiency Fund. Where it is spent on current needs.

And without government involvement, such projects are often unaffordable for companies. For example, in Brazil the total cost of decarbonization of the steel industry is estimated at $29.19 billion, in India – $283 billion, etc.

Although there are nuances here as well. Analysis of the situation shows that where there is strong tariff protection of the domestic market, steelmakers are able to move towards carbon neutrality even without significant government involvement. For example, in the USA, Canada and Japan. And sometimes even without it, as in South Korea and Turkey.

And vice versa.

The lack of effective barriers to cheap steel imports is the main challenge to decarbonization in Brazil, Australia, the UK and the EU.

This sharply narrows the opportunities for steel companies to “green” production. And sometimes it simply nullifies them. As local players are forced to compete by reducing the profitability of their sales.

The introduction of CO2 emission trading systems (ETS) is considered an advanced way of carbon pricing. Currently, the emission trading system operates in the UK and the EU.

From 2028, it will become operational in Brazil. In China and South Korea, the carbon market is functioning, but so far it applies only to the energy sector. Full participation by steel companies will start from 2026-2027.

However, emissions trading systems alone do not create incentives for decarbonization, which requires the development and deployment of new technologies.

Alongside the ETS, government funding programs for decarbonization should also be in place to help offset the costs of R&D and large-scale industrial projects aimed at cutting CO_2 emissions.

Theoretically, CBAM, an additional tariff on imports of steel products with a high carbon footprint, could also contribute to decarbonization. In the EU, it will come into effect on January 1, 2026.

The UK has also announced plans to implement such a mechanism after 2027. But not everyone can follow the example of these. For example, the Canadian authorities have unofficially concluded that the CBAM is inexpedient.

According to the Canadian Ministry of Finance, 76% of exports of local enterprises with high CO2 emissions go to the United States. Washington’s trade response to Canada’s CBAM would be too painful.

And, finally, the priority of greenf steel in public procurement.

So far, it has been legislated only in India and Japan. However, under Japan’s GX Leadership Act, “balanced steel” is defined as low-emission steel produced using the traditional BF-BOF method – without any reference to EAF-based steel.

As a result, incentives are directed toward decarbonizing BF-BOF capacity, while companies that already produce green steel without additional support are discriminated. This is obviously a very serious legislative gap. It is important to pay attention to it where similar initiatives are just being prepared for adoption.

So, decarbonization of the steel industry in many countries is facing big challenges.

These are the need to develop new technologies, to attract investment for this development and implementation, the need to compete with traditional steel products, which are cheaper. Reasonable government policy and market regulation can accelerate their solution.

How the US became a leader in green steel production

The U.S. steel industry went green long before the EU and other countries started talking about switching to greener technologies

American companies made the decision to switch to electric arc furnace steel production with low CO2 emissions long before the world began talking about the need to combat the greenhouse effect in the atmosphere.

As a result, today the steel industry in the US is essentially green. And, very importantly, it relies on its own raw materials.

The move to EAF

The structure of the American steel industry was once no different from that of Europe. In the mid-1970s, there were 45 BF-BOF plants in the country, with an annual production capacity of 1 million tons. Real giants were built, such as Gary Works in Indiana, with a capacity of 7.5 million tons.

The restructuring of the industry began in the early 1980s, when the first electric steel mini-mills with R-EAF scrap-based technology appeared.
Their small production volumes enabled quicker sales of rolled products and allowed for a significant expansion of their product portfolio.

Plus, it was possible to quickly reconfigure the furnace from smelting one type of steel to another. This helped to better meet current market demand and was the main advantage over traditional steel mills. At that time, no one was thinking about reducing the carbon footprint of finished steel products.

By 1992, there were already 65 EAF-based mills in the US with a total capacity of 25 million tons per year. And in 2001, their number exceeded 90, with a total capacity estimated at approximately 92 million tons.

All this required huge investments, around $23 billion, but they paid off many times over.

Another advantage of EAF mills is their independence from imported iron ore. The raw material for EAFs is mainly scrap, and the volume of scrap collection in the US is enormous, 73.3 million tonnes by 2024.

At the same time, the production of DRI, which is also used in EAFs, developed in parallel.

A real breakthrough in this area occurred in the late 1990s. As a result, DRI production grew from 0.51 million tons in 1998 to 1.56 million tons in 2000. In 2022, the figure reached 5.24 million tons.

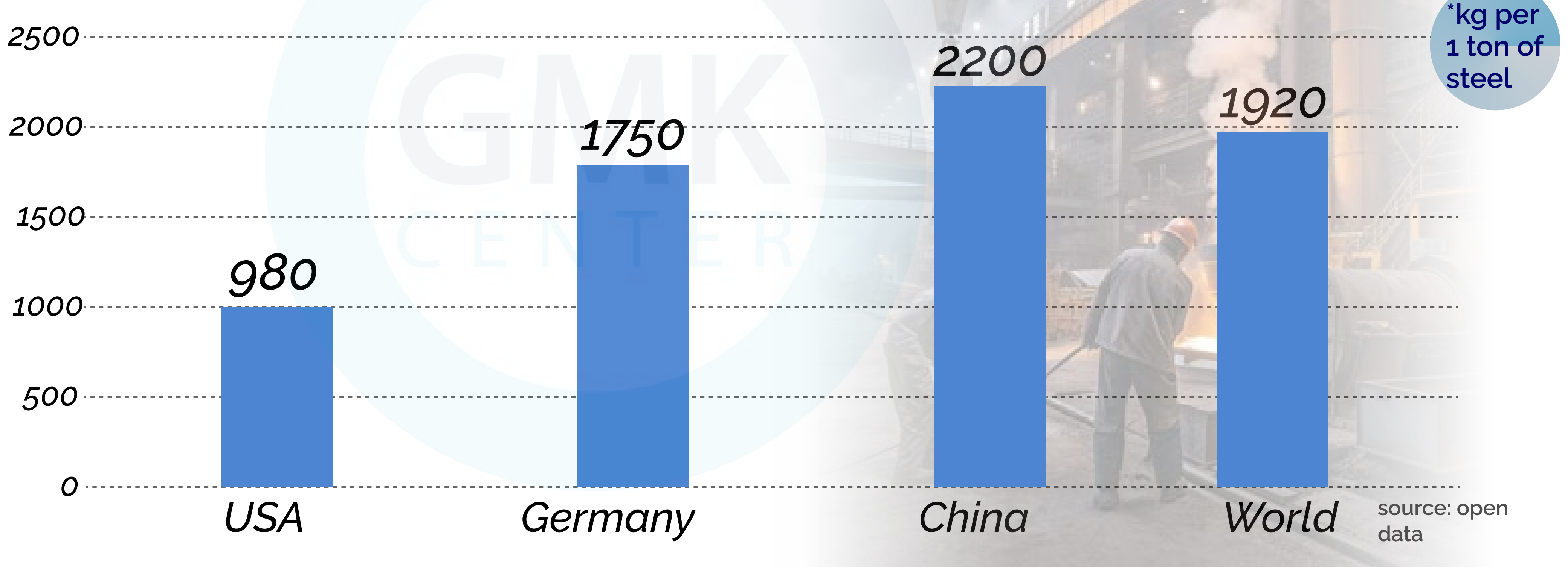
Thus, the American steel industry became green long before the EU and other countries began talking about switching to more environmentally friendly steelmaking technologies.

According to Brandon Farris, vice president of the Steel Manufacturers Association (SMA), US steel producers are now 75-320% more carbon efficient than global markets. And this is indeed the case.

This is an average figure that includes the operation of steel mills using traditional BF-BOF technology. CO2 emissions from R-EAF scrap-based plants are in the range of 0.39-0.8 tons per ton of steel. In other words, they comply with current environmental standards. And the vast majority of plants in the US are of this type.

This explains why green premiums on the price of rolled steel in the US are zero, unlike in the European market.

CARBON INTENSITY OF STEEL PRODUCTION BY COUNTRY*



source: open data

How the US became a leader in green steel production

Incidentally, most American manufacturers, consumers, and experts believe that the difference in the selling price of hot-rolled coils produced in the US and the EU is, in fact, the green premium. But this does not mean that US steelmakers are resting on their laurels.

The American way of decarbonization: investment and innovation

The initiative to bring US steel industry to zero greenhouse gas emissions was actively promoted by the previous administration of US President Joseph Biden.
And all major steelmakers tried to comply with it.

Notably, Nucor has invested $15 million and $35 million, respectively, in research by NuScale and Helion focused on developing small-scale nuclear and fusion reactors.

These projects were initially intended to be built by 2030 to supply electricity to Nucor's facilities in Alabama and Arkansas. It's undoubtedly a highly innovative strategy.

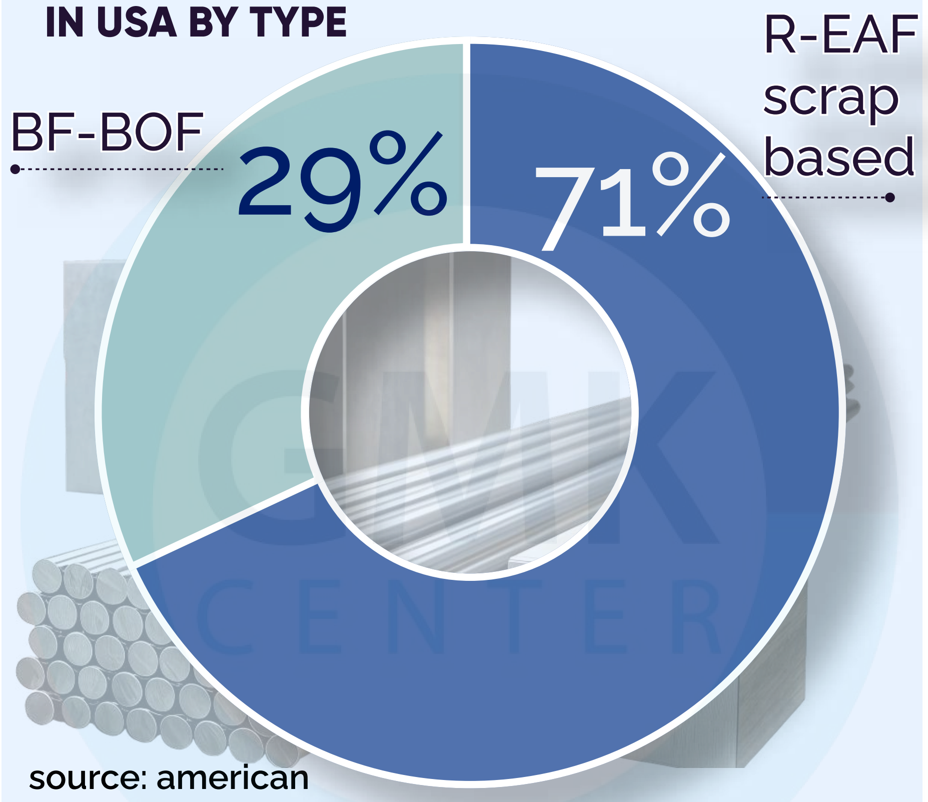
The fact is that green energy has been developing rapidly in the US over the past ten years. In 2024, new solar power plants with a total capacity of 21.4 GW and wind power plants with a capacity of 2.8 GW began operating there. The Federal Energy Regulatory Commission (FERC) predicts that by September 2027, the country will have an additional 93.8 GW of solar power plants and 23.3 GW of wind power plants.

Therefore, Nucor could have chosen not to invest in the development of future reactors, contenting itself with traditional energy from renewable sources.

Nevertheless, the company spared no expense on real innovation. Among other significant projects, the following stand out:

- Carbon capture, transportation, and storage from Nucor's DRI plant in Convent, Louisiana. Under an agreement signed on June 1, 2023, oil and gas corporation ExxonMobil committed to capturing up to 800,000 tons of CO2 per year from the Nucor plant and storing it at its facility in Louisiana. The project was scheduled to begin operations in 2026.
- Construction of an H2 DRI plant in Ohio by Cleveland-Cliffs. The plant will have a capacity of 2.5 million tons per year. In addition to the H2 DRI unit, it will include two EAFs (120 MW each). The new equipment is intended to replace the blast furnaces at the Middletown Works facility.
- Carbon capture, transportation, and storage from US Steel plants in Ohio, Pennsylvania, and West Virginia. A memorandum of understanding with Norwegian oil and gas corporation Equinor was signed in June 2021.
- Capturing and storing CO2 from US Steel's Gary Works steel mill in Indiana. The plan was to capture and mineralize up to 50,000 tons of carbon per year. CarbonFree Chemicals Holdings LLC, which developed the special SkyCycle technology for this purpose, was selected to carry out the work.

DISTRIBUTION OF STEEL PRODUCTION IN USA BY TYPE



source: american iron and steel institute

This is another fundamental difference between the American and European approaches to decarbonization. In addition to H2 DRI-EAF technology, companies in the US have developed another option: capturing greenhouse gases and converting them into a special chemically precipitated calcium carbonate (PCC).

Meanwhile, steel companies in the EU initially focused on creating "enterprises of the future" with H2 DRI-EAF. The problem is that this future turned out to be too distant. Faced with reality (the high cost of producing green hydrogen), European steelmakers are now forced to adjust their plans.

0,39–0,8 т

per 1 t of steel are CO2 emissions from US R-EAF plants scrap based

How the US became a leader in green steel production

In addition, this is a more complex and expensive path that does not give Europeans any competitive advantages.
Meanwhile, decarbonization processes in the US steel industry continue. Analysts attribute their further development primarily to the purchase of US Steel by Japan's largest manufacturer, Nippon Steel.
The Japanese investment plans are based on the transition from BF-BOF to R-EAF scrap-based for US Steel's American enterprises. It is expected that about $7 billion will be allocated for these purposes.

This was one of the main conditions on which the US administration agreed to the deal for the acquisition of US Steel by the Japanese corporation. Thus, an important aspect of the green course in American steel industry is the competent policy of the authorities, regardless of party affiliation.

State regulation

The closure of the American steel market by tariffs, including the 50% tariff introduced by Donald Trump on June 4, protected investments in decarbonization made by local companies.

This blocked the flow of cheaper steel produced using the old BF-BOF technology, which had rendered these investments economically meaningless.

It is likely that trade protection will soon be reinforced by implementing a carbon border adjustment mechanism similar to the EU's CBAM, which would apply to the imported steel.

This is what the American Iron and Steel Institute (AISI) is pushing for. And unlike the EU, the US has every reason to roll out CBAM, since Americans are already making eco-friendly steel.

Thus, regulatory measures have allowed the authorities to develop the following scheme for decarbonizing the US steel industry: "tariff protection of the domestic market" – "company investments" – "implementation of green projects." The model works very simply.

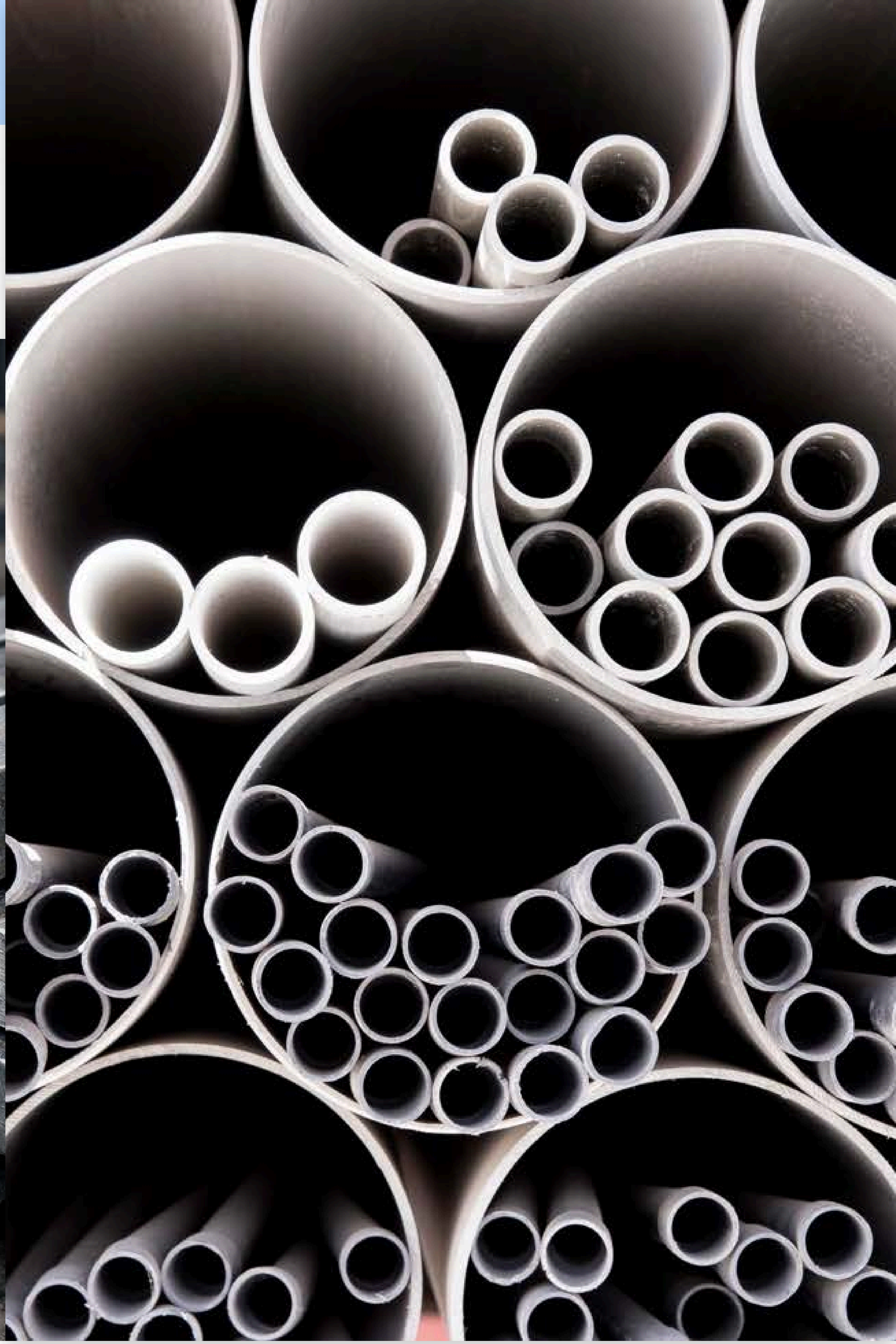
Protective tariffs help steel producers secure higher profit margins, providing them with extra capital to fund green investments. In essence, the end consumer bears the cost of the industry's future transformation.

The situation in the EU is quite different. A complicated and inefficient quota-based system for protecting the steel market has resulted in sustained import pressure and extremely low profit margins for European producers.

This long-standing issue has significantly limited their ability to fund expensive hydrogen-based green transition initiatives.

Therefore, the European Commission and national governments are forced to help fund these projects. However, even with their support, the available resources have fallen short. Hydrogen steel is too expensive with current technologies. And the market is not ready to pay more. Therefore, the implementation of green transition projects in Europe is being delayed. Even despite multi-billion dollar budget subsidies.

This is probably due to a mistake in the choice of decarbonization technology. Meanwhile, European steelmakers simply needed to look at the successful experience of the Americans in this area and create key conditions: market protection and incentives for demand.



China's path to carbon-free steel

China's green transformation policy is characterized by consistency and relies on strong economic potential

Today, China accounts for 55% of global steel production and more than 60% of greenhouse gas emissions in the global steel industry. Therefore, its decarbonization directly depends on China's success.
Today, the production of 1 ton of finished rolled steel in China generates 2.33 tons of CO2 emissions, compared to the global average of 1.92 tons.

So the potential is enormous. And it is gradually being realized as part of Beijing's climate policy. Its effectiveness will largely be determined by this year's outcomes, as China aims to meet a set of ambitious targets within this timeframe.

Green government policy

In 2020 the Chinese government adopted the national "1 + N" plan to achieve zero CO2 emissions by 2060. As part of this strategy, the China's national greenhouse gas emissions trading system (ETS CH) has been in operation in the country since July 2021.

It currently covers approximately 35% of all CO2 emissions in the Chinese economy. This is the share attributable to the energy sector.
As of today, 2,162 power companies, representing 99.5% of all market participants, are involved in ETS CH. From 2022 to 2024, total quota trading volume reached 634 million tons, with a cumulative market value of $6.06 billion. This includes 188 million tons traded in 2024 alone, valued at $2.52 billion.

In March this year, China's Ministry of Ecology and Environment announced that preparations for the expansion of the ETS CH had been completed.

According to ministry representative Liu Shizhe, in 2025-2026, the national greenhouse gas quota market will cover eight more sectors. These include steel industry, which accounts for 17% of all Chinese CO2 emissions.

As with the energy sector previously, emission allowances will initially be allocated to companies free of charge. In the future, the total quota will be reduced, which will lead to an increase in the price of emissions.

Currently, their cost (for energy companies) is $12.5/ton of CO2. In 2022, trading started at $7.4/ton.

The introduction of CO2 emissions system with fees, taking into account their gradual increase in price, will be an important incentive for the decarbonization of the Chinese steel industry.

Among other instruments of state regulation, notable measures are outlined in the Special Action Plan for Energy Conservation and Carbon Emission Reduction in the Steel Industry, approved by China's National Development and Reform Commission (NDRC) in July 2024.

As is well known, the Chinese authorities periodically restrict the utilization of steelmaking capacities for environmental reasons, in particular to combat smog. According to the NDRC's decision, this will not apply to steel enterprises that have achieved Class A emission levels.

Government agencies have been given the right to restrict and even completely ban the export of energy-intensive steel products. Conversely, low-energy steel products are given priority.

Local authorities are also prohibited from issuing permits for the construction of new steel plants that do not meet the requirements for reducing and replacing coal consumption, regional reduction, and complete control of emissions.

In addition, higher electricity tariffs are being introduced for steel companies with Class C and D environmental performance. With these mechanisms, the NDRC plans to achieve the following by the end of 2025:

- a 1% reduction in electricity consumption per ton of pig iron and steel for BF-BOF plants compared to 2023;
- a 2% reduction in electricity consumption per ton of steel for EAF plants;
- a reduction in coal consumption by 20 million tons and CO2 emissions by 53 million tons compared to 2023;

It is worth noting that as early as 2024, the authorities did not approve a single new BF-BOF project.

17%
of all Chinese CO2 emissions come from the steel industry

$2,52 BLN
was the volume of Chinese CO2 quotes trading in 2024

China's path to carbon-free steel

According to the Centre for Research on Energy and Clean Air, permits were only issued for the construction of EAF plants with a total capacity of 7.2 million tons per year.

Thus, the Chinese government is persistently pushing local steel companies toward green changes. First and foremost, this involves the introduction of energy-saving technologies, digitalization, and the rejection of low-grade iron ore in favor of high-grade ore.

These are changes that need to happen right now. In the medium term, they plan to cut carbon emissions by switching to R-EAF scrap-based production.

"The short route"

Electric arc furnace production in China is called "the short route." Currently, it can be called a niche sector of the Chinese steel industry. At the same time, EAF utilization is lower than BF-BOF.

Therefore, the contribution of electric arc steelmaking to Chinese steel production is even smaller than its share of nominal capacity.

Meanwhile, by increasing the share of EAF scrap-based steel production to 56% of total steel production, China could reduce emissions by 39% by 2050 compared to 2020, according to calculations by the E3G climate change think tank.

This is why this area is considered so important. However, in moving along the "short path," the Chinese steel industry faces one very serious obstacle.

Initially, the authorities set a target of achieving a 20% contribution from EAFs to total production by 2025.

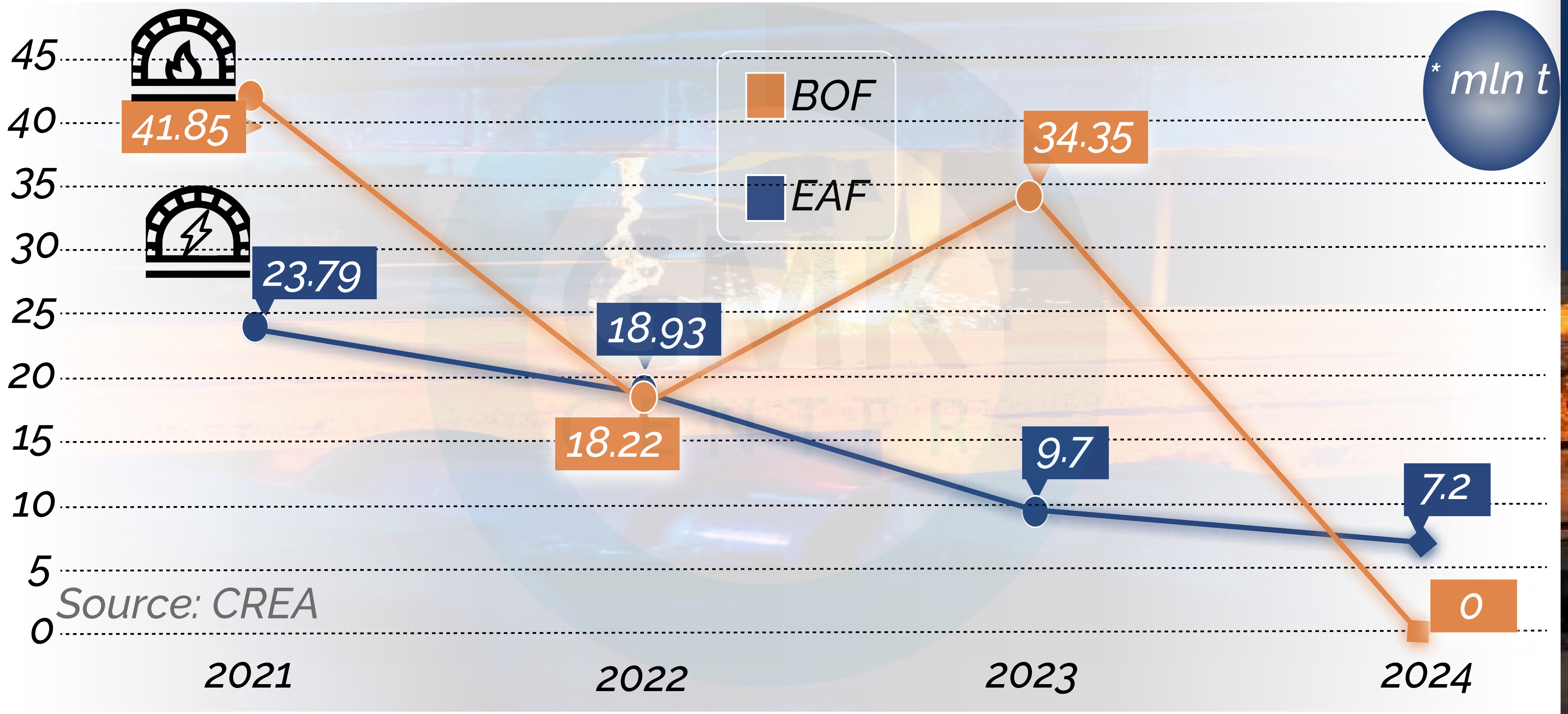
That is, to double the figure compared to 2023. This requires not only working at full capacity at all existing electric steel plants, but also building new ones.

Currently, EAFs with a total capacity of 48 million tons are being built in China. At the same time, inefficient EAF facilities with a capacity of 21 million tons are to be closed. This means that the real increase will be 27 million tons, which is not enough to produce 200 million tons of electric steel this year.

Therefore, the NDRC has lowered the target for EAFs for 2025 to 15% of total steel production. To achieve this, 143-150 million tons will need to be produced. This corresponds to the existing capacity.

It follows that the pace of development of electric metallurgy in China is lagging behind the previously set parameters.

NEW STEELMAKING FACILITY APPROVALS IN CHINA*



The reason is a shortage of scrap used as raw material for EAF. China's scrap consumption in 2024 amounted to 214 million tons.

However, only 30% of this volume was used in electric steel production. Since a significant part of it goes to BOF together with pig iron.

The authorities see a way out of the situation in increasing scrap procurement to 300 million tons in 2025.

The drivers are state programs of subsidies to consumers for new cars and household appliances. On the one hand, this increases the volume of depreciation scrap.

On the other hand, it increases the load on mechanical engineering plants. Their production waste is the main resource for scrap collection.

39%

of CO2 emissions compared to 2020 can be reduced by Chinese steelmakers by 2050 due to EAF transition

In addition, in June of this year, the China Iron and Steel Association (CISA) proposed that the government add steel scrap to the list of critically important materials. This, in turn, implies a restriction or complete ban on its export.

But even these measures will not provide the resource base for a complete transition to RE-EAF scrap-based production. This is despite the power of Chinese machine building and the possibility of importing scrap. This is because the steel industry in the China is even more powerful. Therefore, its final decarbonization is only possible with hydrogen technologies.

Hydrogen potential

China is the clear leader in the industrial use of H2. In 2024, hydrogen production grew by 3.5% to 36.3 million tons, according to the National Energy Administration (NEA).

However, most of this is so-called “gray” and ‘blue’ hydrogen based on SMR and ATR technologies, which are not environmentally friendly products. The share of green hydrogen in this volume is insignificant.

Nevertheless, some progress has been made. In 2024, 35 new projects for the production of green H2 with a total capacity of 48,000 tons were launched in China. Thus, the potential of the green hydrogen industry reached 125,000 tons per year. This is 50% of the global figure.

For comparison, Europe’s largest operating green H2 production plant, owned by the German concern BASF, has an electrolysis capacity of 54 MW. The capacity of China’s largest plant, Sinopec Xinjiang Kuqa Green, is 260 MW.

In 2020, the NDRC approved the Long-Term Plan for the Development of Hydrogen Energy for 2021-2035. According to the document, by 2025, the production of green H2 in the country should reach 100-200 thousand tons per year. In other words, the industry is developing according to schedule, and the targets are being met. At the same time, hydrogen currently has very limited application in steel industry.

Among the projects already in operation, it is worth noting the HBIS Group plant in the Zhangjiakou area, which produces DRI using H2 as an iron reducing agent.

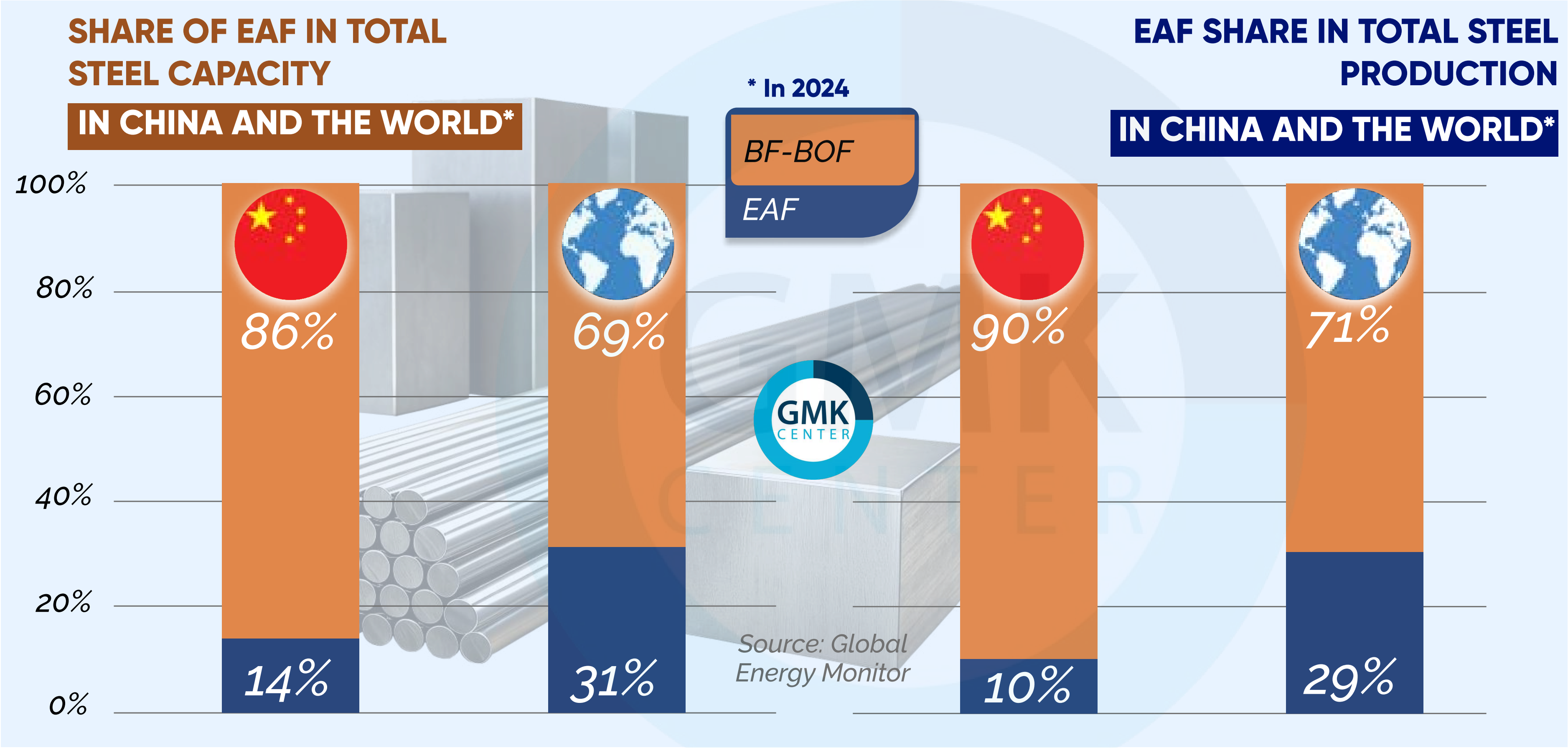
The plant has a capacity of 600,000 tons per year, with plans to expand it to 1.2 million tons.

According to Italian equipment supplier Danieli, this project is the most environmentally friendly DRI production facility in the world, with emissions of 0.25 tons of CO2 per ton of product.

HBIS intends to produce up to 1.5 million tons of automotive sheet using green steel made via EAFs, utilizing hydrogen-based direct reduced iron (H_2 DRI). HBIS also plans to test technology for carbon capture, storage, and utilization (CCUS) at this plant. According to preliminary estimates, it will allow 0.125 tons of CO2 to be captured per 1 ton of DRI produced.

Also noteworthy is the 1 million ton per year H2 DRI plant of Baosteel Zhanjiang Iron & Steel in Guangdong Province.

At the same time, the NEA notes problems with demand for green hydrogen. Therefore, of the more than 600 planned projects for its production by the end of 2024, only 90 have been completed, with another 80 under construction. The reason is that the price of such a product is still too high.



21 MLN TONS

of inefficient electric steelmaking capacity in China to be closed

China's path to carbon-free steel

The cost of producing green H2 in China in 2024 was $3.85/kg, according to the NEA. This is 15.6% less than a year earlier.

The price for end consumers also fell by 13.7% to $6.69/kg. Such a significant markup, almost twice as much, is explained by the high cost of transportation. And this is despite the fact that most H2 plants are located in northeastern China, i.e., where the main steelmaking capacities are concentrated.

In other words, China's problem now is not to reduce the cost of producing green H2 itself. Cheaper delivery solutions are needed. For comparison. According to S&P Global Commodities, H2 price in the US is $5.2/kg, and in the European Union – $6.94/kg.

And under current conditions, the green premium for steel in China exceeds $225/t, according to Global Efficiency Intelligence. This is too much, about 50% of the price of conventional BF-BOF steel.

For example, in shipbuilding, a bulk carrier with a displacement of 40,000 tons needs about 13,200 tons of steel. In the low-carbon version, this means an additional $3 million per ship.

Its average cost is over $30 million, i.e., the markup will be 10%. This is very noticeable for the buyer.

In residential construction, with an average steel consumption of 50 kg/m2, the markup for a standard 2-room apartment with an area of 50 m2 is only $563.

If we take the average current price for such an apartment in Chongqing at $70,000, the markup is less than 1%. Thus, even in the current market situation, there are realistic prospects for the sale of long products manufactured using RE-EAF-scrap based technology.

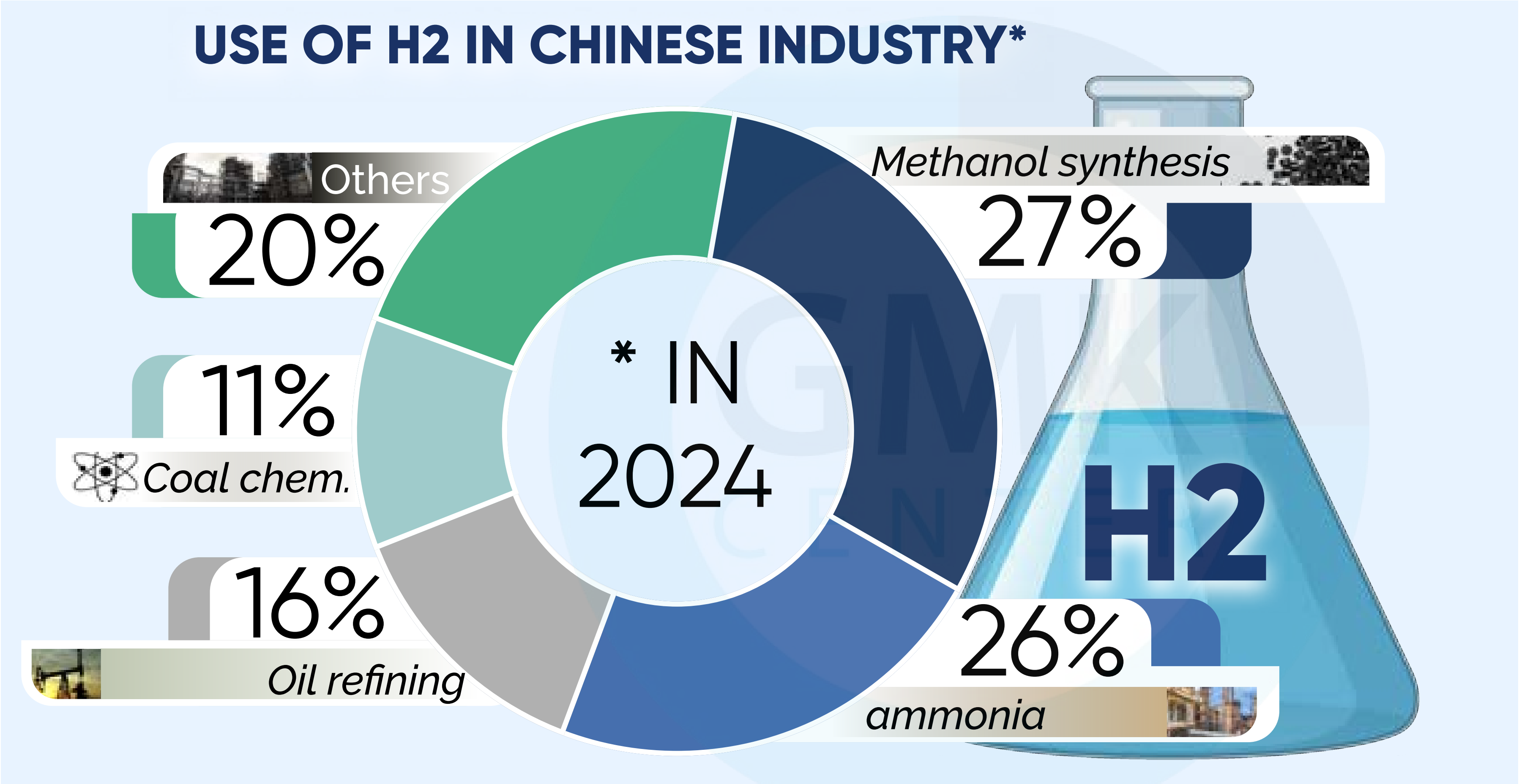
Plus optimization

When assessing the potential for reducing CO2 emissions in the Chinese steel industry, it is worth recalling the statement made by the NDRC in March this year.

At that time, the Commission indicated in a message to the National People's Congress that it would "resolutely promote the restructuring of the steel industry through production cuts."

The scale of the reductions was not specified, but industry sources estimated that it would be around 50 million tons per year.

The timing of the planned restructuring was also not announced – whether it would be by the end of the current five-year plan (i.e., by the end of this year) or the next one, by 2030.



Nonetheless, given that this thesis has been incorporated into an official policy document issued by China's top economic policymaking body, it signals that a reduction in steel production is indeed on the horizon.

This can be achieved by limiting existing production or closing inefficient facilities. Or a combination of these two mechanisms. In any case, these measures will lead to a significant additional reduction in CO2 emissions in the steel industry of the PRC.

The country's government began the transformation by establishing a legal and regulatory framework

Indian steel industry is the most promising in the world today in the context of green transition. In terms of steelmaking growth rates, India leads the top 10 largest steel producing countries by a wide margin.

This is despite modest export volumes and still significant imports of finished steel. Strong domestic demand in the world's fifth largest economy has been keeping the global steel consumption rate from falling for months now.

At the same time, India emits 2.54 tons of CO_2 per 1 ton of steel, compared to the global average of 1.91 tons. So, the potential for their reduction is enormous. And in one very important aspect, Indians are already ahead of the rest.

For the first time in the world their steel has received ecological classification at the state level. This has created a regulatory framework for the forthcoming "green" transition.

Step One: regulation

The Ministry of Steel of India (MSI) on March 21, 2025, published the Green Steel Taxonomy. It will come into force in fiscal year 2026–2027 and establishes three rating categories. To be assigned a rating, the steel produced by an enterprise must meet the following criteria:
5* – emissions must be less than 1.6 t of CO_2 per 1 t of finished steel;
4* – for emissions of 1.6–2.0 t of CO_2;
3* – for emissions of 2.0–2.2 t of CO_2;
When summarizing the categories, Scope 1 and Scope 2 are fully accounted for, Scope 3 is partially accounted for.

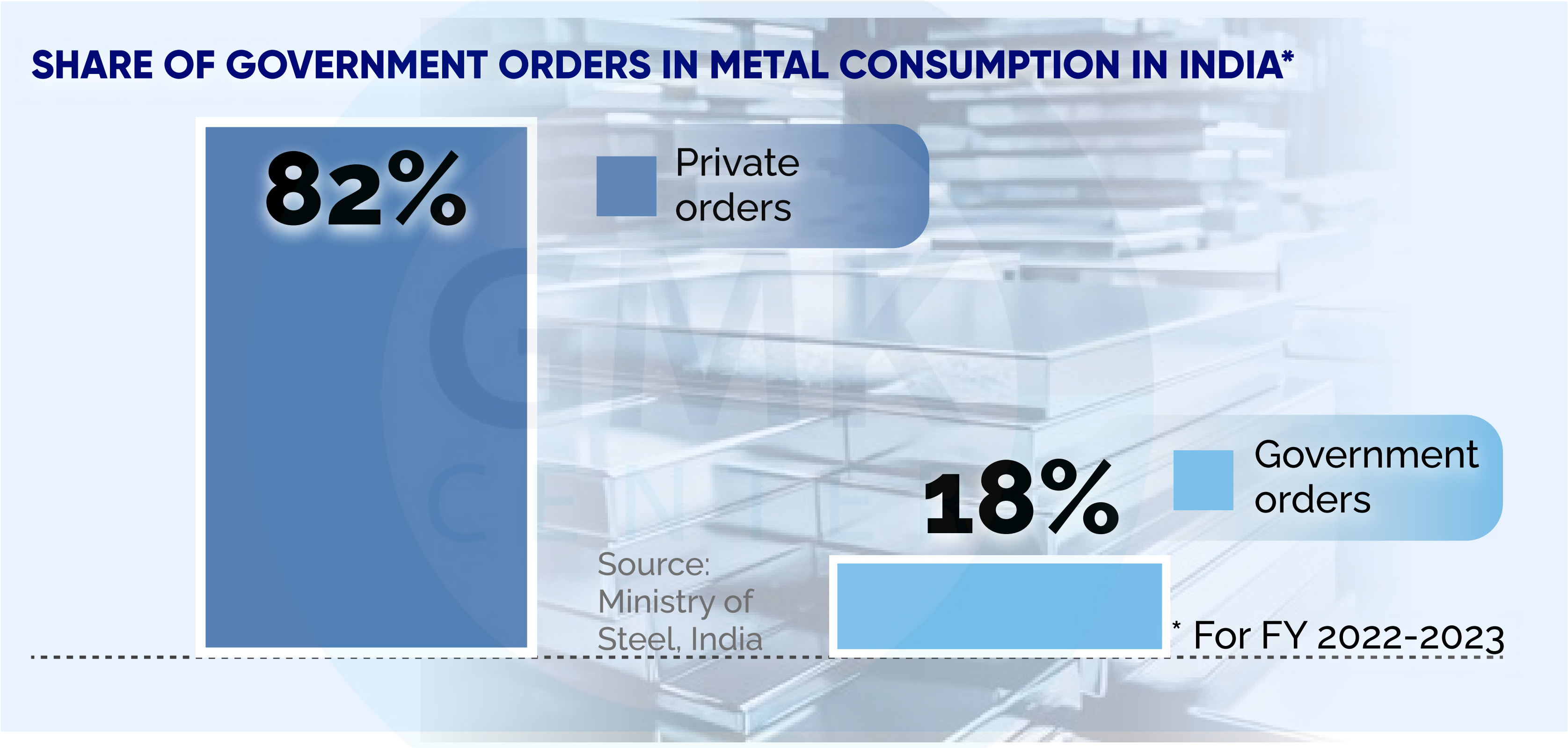
This section includes CO_2 emissions from coke production, sintering and sintering of iron ore, pellet production and transportation of raw materials.

The National Institute of Secondary Steel Technology (NISST) will be responsible for assigning ratings and issuing certificates.

Rating criteria are subject to revision every 3 years. Creation and maintenance of the state register of green steel on the basis of NISST conclusions is entrusted to the Bureau of Energy Efficiency (BEE).

The authorities intend to prioritize such steel under MSI's Green Government Procurement Policy (GPP). This is an important incentive, given the significant role of the government in overall steel consumption.

According to MSI, in the 2022–2023 fiscal year, public procurement of steel products reached 25 million t. By the 2030–2031 fiscal year, it will increase to 67–73 million t.



Step two: optimization

India plans to achieve zero CO_2 emissions in its economy and, consequently, in its steel industry by 2070. But it is realistic.

According to the Ministry of Steel, the cost of the issue for the industry is $283 billion. This is the money needed only for existing steel plants with a total annual capacity of 200 million tons. Without taking into account additional costs for new plants with a capacity of 300 million tons, which are planned to be built by 2047.

But here we are talking about the ultimate goal – completely emission-free production. In fact, Indian steel should become "green" much earlier. And it will cost "only" $13 billion. This is the amount estimated for the introduction of improving technologies.

First of all, in terms of energy efficiency. At present, specific energy consumption of Indian steel mills using BF-BOF technology is 6-6.5 GKal per 1 ton of steel, while for DRI-EAF/IF technology it is 7 GKal, while the world average is 4.5-5 GKal.

$13 BLN
will be spent on implementing BAT in India's metallurgy

The ministry sees ways to reduce this figure in the digitalization of production processes. Plus a shift to renewable energy sources (RES). Currently, the Indian steel industry receives only a small part of its electricity consumption from renewable energy sources.

By FY 2030-2031, the rate should reach 43.33%. This alone will reduce specific CO_2 emissions from the current 2.54 tons to 2.35 tons per 1 ton of steel. It is well known that renewable energy is much more expensive than coal-fired power plants. It is planned to make it more affordable by waiving the fee for electricity transmission.

Among other directions it is possible to note increase of efficiency of materials for Indian steel industry. Currently, it mainly uses low-grade iron ore.

MSI calculates that a 1% increase in Fe content in iron ore increases blast furnace productivity by 2% and reduces coke consumption by 1%. This is achieved through additional beneficiation or pelletizing of iron ore.

How realistic are these plans? ArcelorMittal Nippon Steel India intends to bring its steel products to 70% compliance with green criteria by FY 2026-2027, i.e. in the near future. Already now the company has a CO_2 emission rate of 2.17 tons per 1 ton of steel. By 2030 it should be reduced to 1.8 tons. So it is quite possible.

At the same time, it is obvious that although the 5* category for Indian green steel implies rather high emissions (compared to the USA, the world leader in steel decarbonization), they are not achievable for mills with BF-BOF.

For example, the same ArcelorMittal Nippon Steel India will not be able to get 5* for all products in 2030. Therefore, next steps are needed.

Decarbonization tools

Unlike the US, which has opted for R-EAF scrap based and the EU, which has opted for H2-DRI-EAF, India, in its Roadmap for Greening the Steel Sector, does not define a technology pathway for decarbonization.

It is open to utilizing all possible options. This flexibility is certainly an advantage of New Delhi's strategy.

Today, electric arc furnaces account for 30% of India's steelmaking capacity. At the same time, their utilization is lower than that of BF-BOF mills – 74% and 84% respectively. Among the new plants with a total capacity of 258 million tons per year at the stages from design to implementation, the share of EAF is 13%, or 33.54 million tons.

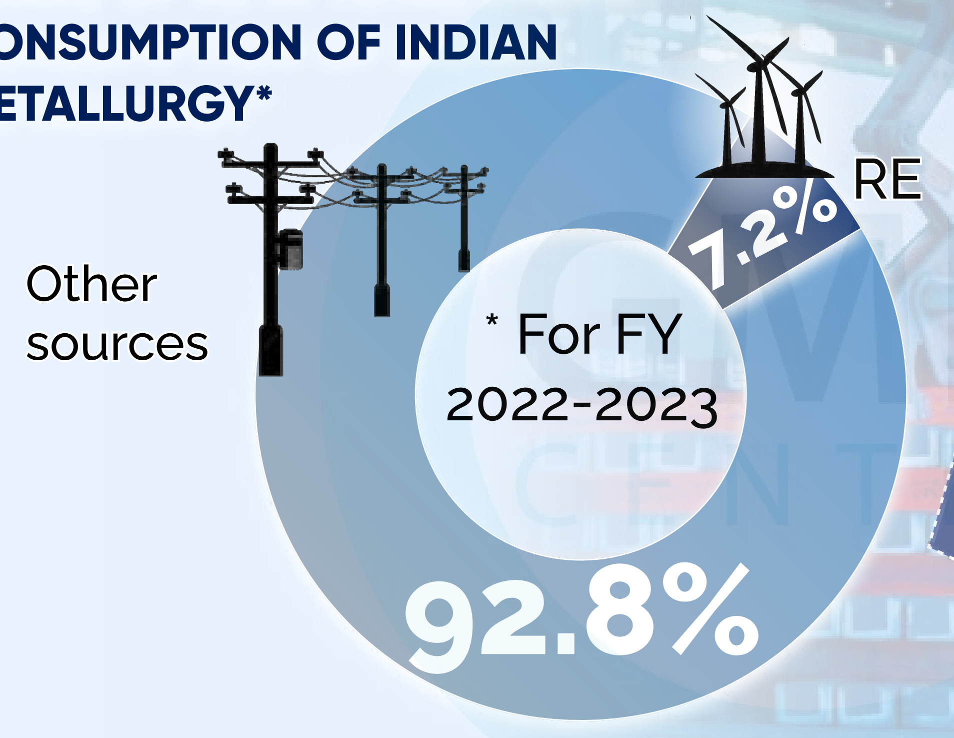
Here we can highlight the construction of Tata Steel's plant in Punjab with a capacity of 750,000 tons of steel per year. And state-owned SAIL's project to build a plant with EAF with a capacity of 1.5 million tons of steel by 2029.

By 2047, the Steel Ministry has declared intentions to increase the share of scrap in steel production from 15% to 50%. This will require additional supplies. It is planned to obtain them at the expense of imports.

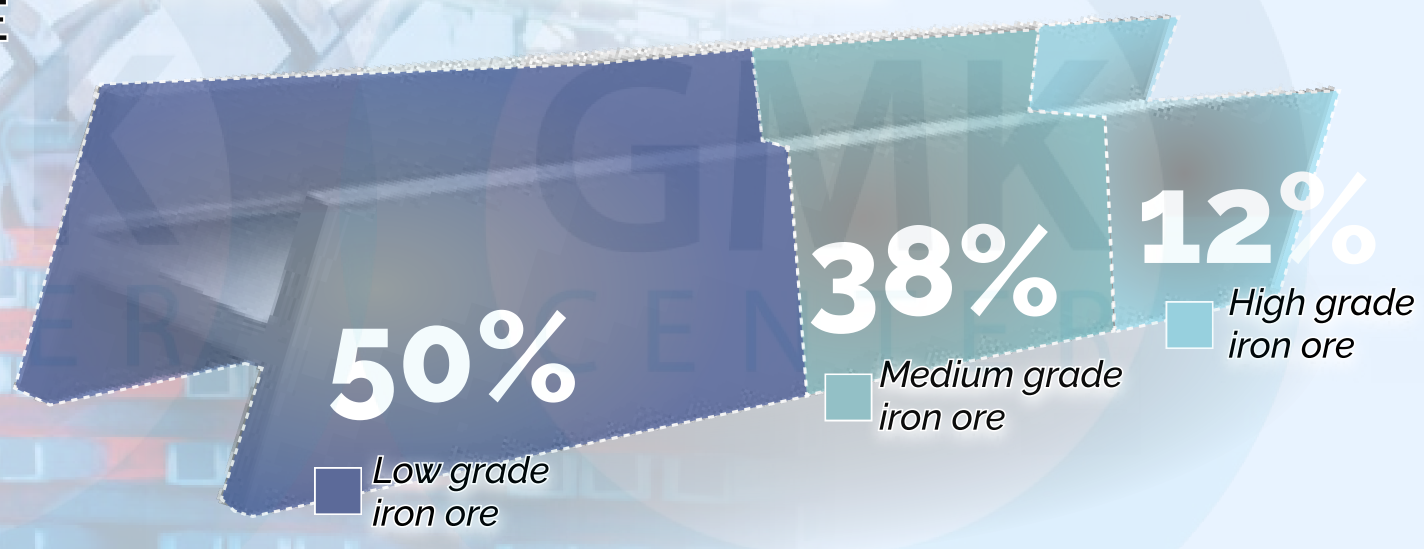
At the same time, India is already one of the world's largest importers of scrap, 9.39 million tons by the end of 2024. Obviously, in the future, the figure may double. Now imports cover about 25% of the demand for this resource. Domestic scrap collection is about 25 million tons.

However, MSI notes the difficulty of securing future production in an environment where more and more countries are restricting or even outright banning scrap exports. India is therefore pursuing a strategy to increase domestic scrap collection.

SHARE OF RE IN TOTAL ENERGY CONSUMPTION OF INDIAN METALLURGY*



STRUCTURE OF CONSUMPTION OF IRON ORE IN METALLURGY OF INDIA



5%
of Indian DRI furnaces run on natural gas

5 MLN TONS
of "green" H_2 India plans to produce by 2030

How India will decarbonize its steel industry

As part of this, major steelmakers such as SAIL and Tata Steel are investing heavily in their own scrap collection.

The authorities also have plans to create a nationwide electronic platform for scrap trading. This should contribute to the "detanization" of the Indian scrap industry.

In addition, a program offering incentives for scrapping to owners of used cars is already in place. And the possibility of restricting the export of steel scrap is being considered. The volumes of which, however, are small: 8,175 containers in 2023-2024 FY.

Another option is CCUS technology to capture, recycle and store CO2. The Indian steel industry has several pilot projects for CO2 capture. But they are unprofitable right now. MSI estimates the current cost of capture at $45-60/t. For steel mills, the acceptable price is less than $20/t. And utilization and storage costs another $300-500/t. In this case, the price of finished steel will rise by 100%. Therefore, technological solutions are being sought to make CCUS more affordable.

It is well known that India is the world leader in DRI production. But only 5% of the kilns are powered by natural gas. The rest are coal-fired.

Therefore, another way to reduce emissions is to gasify this production. This is the path Jindal Steel has taken. The company has built a coal gasification plant at its plant in Odisha. The resulting synthetic gas is used to recover iron in pellets to 99.99%.

Overall, the government aims to achieve an annual coal gasification capacity of 100 million tons by 2030.

To this end, state-owned Coal India Ltd (CIL) has formed joint ventures with Bharat Heavy Electricals Ltd and Gas Authority of India Ltd (GAIL). Government funding of 3.61 billion is being allocated for the respective projects.

And then there is hydrogen. Namely, replacement of coke and coal with H2 in furnaces for iron smelting and DRI production.

This area is still in the pilot stage. Tata Steel in April 2023 conducted a successful trial hydrogen injection in a blast furnace at its Jamshedpur mill.

And in February 2025, i.e. 2 years later, the company announced the development of special steel pipes to transport gaseous H2 at high pressure.

You can see that the work is not progressing too fast. But in fact, there is no point in Tata Steel and other steelmakers forcing technical changes. Because the hydrogen industry itself is slow to develop.

The National Green Hydrogen Mission (NGHM), adopted in January 2023, envisions 5 million tons of the product by 2030. However, it was only in late June this year that the Adani Group Corporation was able to commission the country's first 5 MW electrolyzer plant in Gujarat.

This year, JSW Group is also expected to commercialize an H2 plant with an electrolysis capacity of 25 MW in the state of Karnataka.

Thus, the NGHM target by 2030 will definitely not be achieved.

The reason is that the production cost of H2 is too high. It is now $4.6-6.3/kg, according to the Institute for Energy Economics&Financial Analysis.

This year the government canceled the fee for transmission of electricity, reduced the tariff for distribution of electricity and VAT for producers of green hydrogen. Due to these measures, according to IEEFA estimates, the cost of production is reduced to $3-3.75/kg.

But this is not enough. According to the Steel Ministry, a price in the range of $1/kg would make it commercially viable for Indian steel mills to use H2.

In this case, they will be able to consume about 1.1 million tons per year. Therefore, obviously, the government will have to look for additional mechanisms to reduce the cost of green hydrogen production.

Overall, MS calculations show that decarbonization of Indian steel industry is realistic. With a green premium of 30% to the price of conventional products, with the replacement of 20% of BF-BOF production with emission-free production – green steel will increase the cost of infrastructure projects by only 1.1%, production of cars and household appliances – by 0.5-1%. In such a case, the industry's green transition will be paid for at the expense of end consumers.

Steelmakers face an «unexpected» problem of expensive energy and immature technologies

Leading steel players are revising their previously approved decarbonization strategies, while placing significant requirements on national governments. GMK Center has examined these developments and their potential implications.

Hydrogen on hold

There are currently three ways to reduce CO2 emissions in steel production:
1. Using energy from renewable sources for electric arc furnace melting (R-EAF scrap-based).

2. DRI production using hydrogen to reduce iron up to 99.99%, followed by smelting in EAF

3. Electrolysis of molten iron oxide (MOE).

The latter option is the most complex in terms of technology. The first one has certain limitations: EAF uses scrap metal as a raw material. And the uninterrupted supply of this resource is becoming increasingly problematic.
By establishing hydrogen-based direct reduction from iron ore, it becomes possible to fully phase out blast furnace ironmaking – the core component of the BF-BOF route, which is responsible for the majority of CO_2 emissions in the steel sector.

That is why leading European producers have chosen option 2 as the main one. In particular, in July 2021, ArcelorMittal SA announced the construction of an H2 DRI plant in Gijón, Spain, with an annual capacity of 2.3 million tons. The project cost at that time was €1 billion.

It was expected that the new plant would be operational in 2025 and start supplying products to ArcelorMittal's Sestao electric arc furnace plant.

But… at the end of November last year, the concern officially announced that the project was delayed indefinitely.

The reasons given were the unfavorable market and energy situation, as well as the slow development of green hydrogen infrastructure.

Germany's largest steelmaker, Thyssenkrupp AG, faced similar problems. At the end of March, it suspended (also indefinitely) a tender for the purchase of "green" hydrogen for the 2.5 million tons per year H2 DRI plant in Duisburg. The tender itself was announced in February 2024.

"It is becoming clear that the proposed prices will be significantly higher than expected, and other framework parameters of the hydrogen economy, which is developing more slowly than expected, will change significantly," the concern said in a commentary.

At the end of March, S&P Global estimated the cost of producing "green" hydrogen by alkaline electrolysis in Germany at €9.35/kg. In December last year, it was €14.5/kg, which is much more expensive.

However, given that the Duisburg plant needs 151,000 tons of H2 over 10 years, this is indeed an astronomical amount. Therefore, hydrogen-based steelmaking projects in Europe are currently on hold.

> "We will continue to use hydrogen as soon as it becomes economically feasible and technically possible," – promised. Thyssenkrupp.

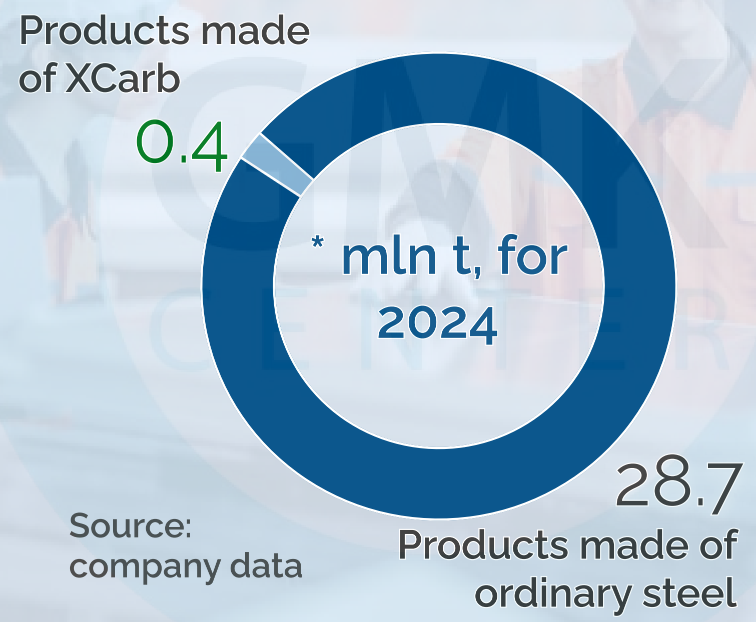
In this regard, scrap-based R-EAF is becoming a priority for decarbonizing the steel industry everywhere. But it is not all that simple.

Consumer reaction

It's not entirely accurate to claim that the high price of green steel is the primary barrier. Cost wouldn't be an issue if buyers were truly willing to pay – but the reality is, they're not, despite earlier commitments.

The automakers General Motors Co, Jaguar Land Rover Corp, Volvo Group AB, Mercedes-Benz Group AG, and Volkswagen AG have all previously stated that they will switch to 100% carbon-free steel in automotive production by 2050. But 2050 is a long way off. In the meantime…
ArcelorMittal Europe sold 400 thousand tons of its carbon-free XCarb steel in 2024, doubling the figure for the previous year. This seems to be a very good result.

The part of green steel in total sales of ArcelorMittal Europe*



Source: company data

€9,35/KG

was the cost of producing "green" H2 in Germany at the end of March 2025

But if you compare it with the total volume of steel sales, it becomes clear why the concern announced in February this year that it would partially suspend its European plan to decarbonize production.

> *«Although customers are interested in low-carbon steel, their willingness to pay a premium is limited. So, in fact, they cannot buy such steel. Because we sell it only at a premium»*, – CFO of ArcelorMittal. Genuino Cristino.

An analysis of the market situation fully confirms this thesis. According to Fastmarkets, in mid-April, price premiums for green steel in the EU were at €200-300 per tonne, depending on the carbon footprint. At the same time, buyers were willing to pay €100-150, which is half as much. Representatives of the plants responded by saying that the maximum discount they could accept was €20-30 per ton.

> Thus, supply and demand are currently far apart. *«According to our estimates, the green premium may exist on the market for a very short time and will not be a decisive factor for investments in the green steel transition»*, – comments CEO of the GMK Center. Stanislav Zinchenko

Key terms and conditions

Thomas Bünger, CEO of ArcelorMittal Germany, says that the main reason for the suspension of decarbonization is the high cost of electricity. According to him, a price of €50-55/MWh would be acceptable for R-EAF scrap-based electric steelmaking, as it was before the energy crisis. The last time electricity in Germany was around this level was a long time ago.

That is why the issue of cheap electricity has become the main one for the decarbonization of the European steel industry. At the end of April, ArcelorMittal Poland CEO Wojciech Koszuta announced the company's readiness to make a large-scale conversion of the plant in Dąbrowa Górnicza from BF-BOF to R-EAF scrap-based.

According to him, this requires guarantees of competitive electricity prices.
It is clear that the market cannot provide such guarantees. Only the government can do this. In this case, the government of Poland.

. It needs to make appropriate regulatory decisions. So far, however, the authorities in Warsaw and other European capitals are in no hurry to meet the demands of the steel industry.

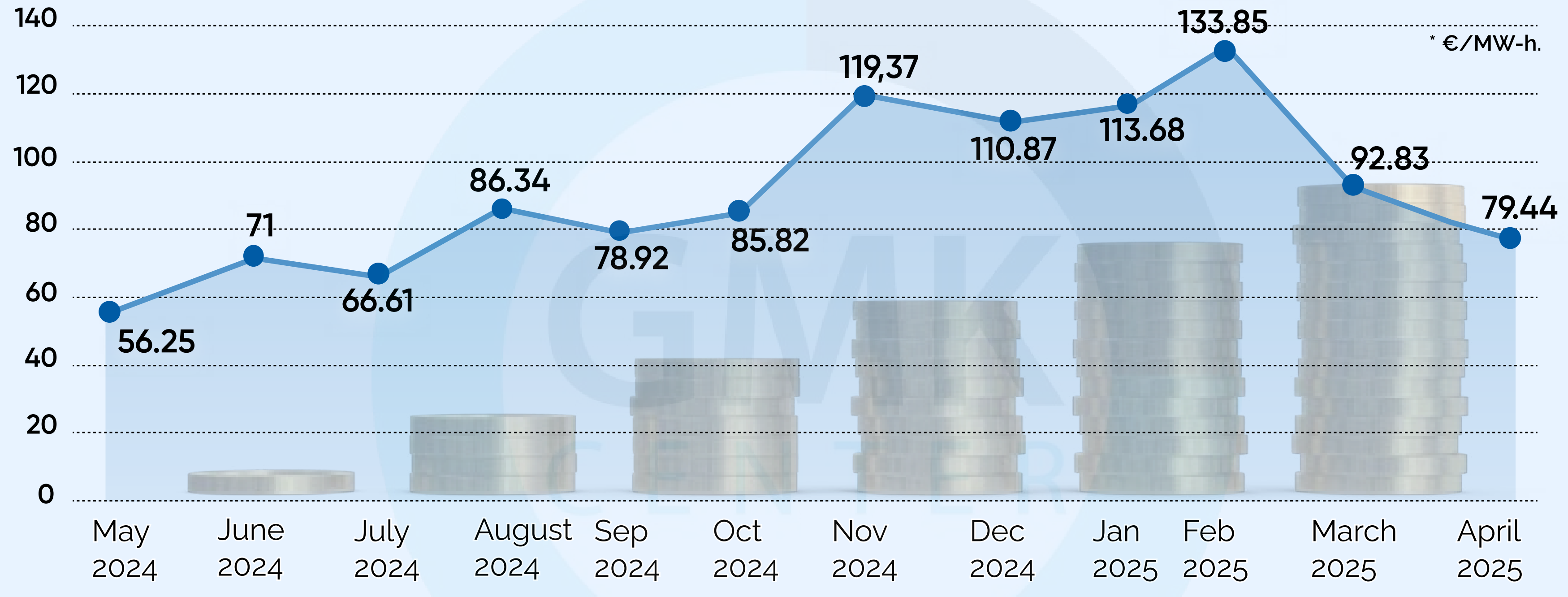
In this regard, the largest Czech manufacturer, Trinecke zelezarne Group AS, postponed previously approved key projects to decarbonize production at the end of April.

For now, for at least 2 years. This refers to the construction of electric arc furnaces and related infrastructure at the plant in Tršinka.
Just a month earlier, in March, the Czech government had pledged its support to the company, even signing a memorandum.

But it seems that commitment never moved beyond words. As a result, the green transition has stalled – not only for Trinecke Zelezarny, but for the European steel sector as a whole.

Obviously, the process will move forward if three conditions are met simultaneously: affordable electricity, economically viable hydrogen production technologies, and public investment. Because companies will not be able to afford such projects on their own.

Electricity prices in Germany*



€200–300/T

were price premiums for "green" steel in the EU in mid-April 2025

Obviously, for a number of reasons, it makes no sense for Ukraine to blindly copy the European decarbonization model.

Each country has its own optimal option, depending on the available resources. The European Union has energy from renewable sources and scrap metal.

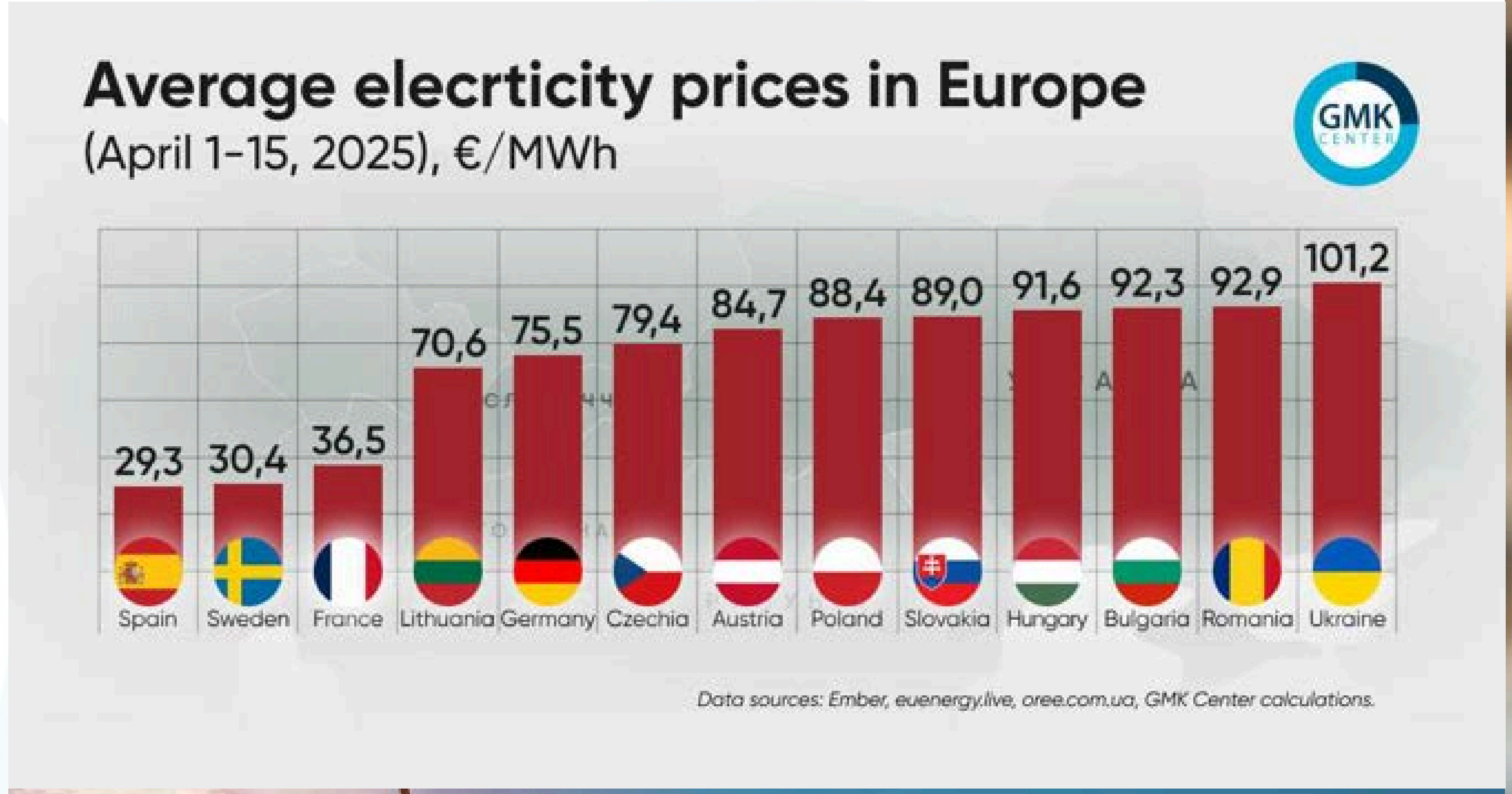
Plus, it has more opportunities to finance hydrogen technologies. Ukraine does not have this – all efforts and money after the war will be directed to rebuilding infrastructure.
Unlike the EU, however, Ukraine has large reserves of high-quality iron ore suitable for beneficiation.

This opens the door to launching DRI production based on natural gas, with the potential to shift toward low-carbon steelmaking through the DRI-EAF route powered by nuclear energy.

The country already operates three nuclear power plants, and there are viable plans to expand their capacity further.

But for this, the industry needs subsidies at the European level. And affordable prices for electricity and natural gas.

“Without affordable and cheap electricity, the steel industry in Europe and Ukraine has no future,” summarizes Stanislav Zinchenko.



A long pause in EU steel industry decarbonization projects

Steel producers are suspending projects and postponing deadlines, citing market conditions and regulatory uncertainty

Major steel companies are postponing their green transformation plans, seeking greater certainty, particularly regarding the bloc's steps to protect the industry and the market.

Status: postponed

In September this year, German steel producer Salzgitter announced its decision to postpone the next stages of its large-scale green project Salcos, which aims to reduce CO2 emissions in steel production through the use of hydrogen, for three years. The company justified its decision by citing slower-than-expected development of the hydrogen market and the lack of regulatory changes promised by the government.

The total cost of the Salcos project is around €2.5 billion (€1 billion in state support). Its first phase is already underway.

It involves the launch of a 100 MW electrolyzer, the construction of a direct reduction plant, and an electric arc furnace. However, Salzgitter has postponed the next stages until at least 2028-2029, whereas the investment decision was previously planned for 2026.

Salzgitter is not the first large company to put its plans for decarbonizing steel production on hold.

In June 2025, ArcelorMittal canceled the EAF-DRI project aimed at decarbonizing its plants in Bremen and Eisenhüttenstadt.

The agreement with the German government included €1.3 billion in state aid and required construction to begin by June this year. When announcing its decision, ArcelorMittal pointed to market conditions and the lack of economic viability for green steel production.

Back in November 2024, the company decided to delay its green investment plans in Europe, citing high energy costs along with political and market uncertainty.

The projects on hold included a €1 billion DRI plant for the Gijón cluster in Spain—€450 million of which was supposed to come from government funding—and the decarbonization efforts at its Dunkirk site in France.

In particular, a direct iron reduction plant with a capacity of 2.5 million tons per year and two EAFs were to be built in Dunkirk.

However, later, in May 2025, ArcelorMittal confirmed plans to invest in the first electric arc furnace at this site (cost – €1.2 billion).

The company expressed confidence that by the end of the year, all conditions would be in place to resume the decarbonization plan.

Unavailable hydrogen

At the end of March 2025, Germany's largest steel producer, Thyssenkrupp AG, postponed indefinitely a tender for green hydrogen for its H2 DRI plant in Duisburg (2.5 million tons/year), which had been announced in February 2024.

As the company noted, the proposed price was much higher than expected, and the hydrogen sector is developing slowly.
After ArcelorMittal's decision to cancel its German project, Thyssenkrupp reaffirmed in June that it would move forward with building a green steel plant in Duisburg (the project is expected to cost €3.5 billion).

However, the company noted that the success of the green transformation is possible under economically viable conditions, accessible hydrogen infrastructure, and competitive (affordable) energy prices.

The need for state support

Třinecké železárny Group, the largest steel producer in the Czech Republic, announced at the end of April 2025 that it was postponing the completion date of the largest investment in the plant's history related to the decarbonization process. The company will complete the construction of the EAF and necessary infrastructure no earlier than 2030 instead of the announced 2028.

Until then, active negotiations will be held with the Czech government and the EU to ensure adequate support for the project. According to public sources, it is unlikely that the project will receive state support.
Italy, meanwhile, is discussing fantastic projects for Acciaierie d'Italia (ADI) in Taranto.

There are plans to build three EAFs (total capacity – 6 million tons/year). However, the search for a new owner of the assets is not yet over and is likely to end in disaster. Therefore, these decarbonization plans are also unrealistic and are being postponed.

€1 BLN
will be the state support for the Salzgitter project

A long pause in EU steel industry decarbonization projects

The beginning of the journey

However, there is some good news. At the end of September 2025, Tata Steel finally signed a non-binding letter of intent with the Dutch government to reduce emissions. At its IJmuiden site, the company aims, among other things, to decommission blast furnace No. 7, build a direct iron reduction plant that will initially run on natural gas, and build electric arc furnaces with increased scrap consumption.

The Dutch government has agreed to allocate €2 billion to support Tata Steel Netherlands' (TSN) decarbonization project. In addition, TSN has applied to the EU Innovation Fund for €0.3 billion.

In September 2025, Sweden's SAAB announced the official start of construction of its new "green" steel plant in Luleå (cost: €4.5 billion).

It will replace the current BF-BOF-based production and will have an annual capacity of 2.5 million tons. The plant will be equipped with two EAFs, an advanced secondary metallurgy system, an integrated hot rolling mill, and a cold rolling complex.

The start of operation was announced for the end of 2029, but in June 2025, the company postponed it by 12 months.

The reason was that the power grid reinforcement for the new plant will not be completed as planned.

At the same time, Swedish startup Stegra is looking for alternative financing options after being denied a previously approved grant through the Climate Leap fund. reason for the refusal is that its activities will generate certain emissions when using gas, which is necessary until there are sufficient substitutes. Therefore, the company is reviewing its financing plans.

Stegra is building a large-scale plant for the production of environmentally friendly steel in Boden. It will consist of an electrolyzer, a direct reduction plant, two electric arc furnaces, as well as cold rolling and finishing shops.

Production is expected to start here in the second half of 2026, with the plant reaching full capacity in 2028.

In September this year, Voestalpine launched Austria's largest climate project.

Construction has begun in Linz on Hy4Smelt, the world's first industrial-scale demonstration steel plant that will combine hydrogen direct reduction technology with an electric arc furnace.

The project is being implemented at voestalpine's facilities in cooperation with Primetals Technologies and Rio Tinto. Production is scheduled to start at the end of 2027, with the program due to be completed in 2030. The project is partly funded by Austrian and European institutions.

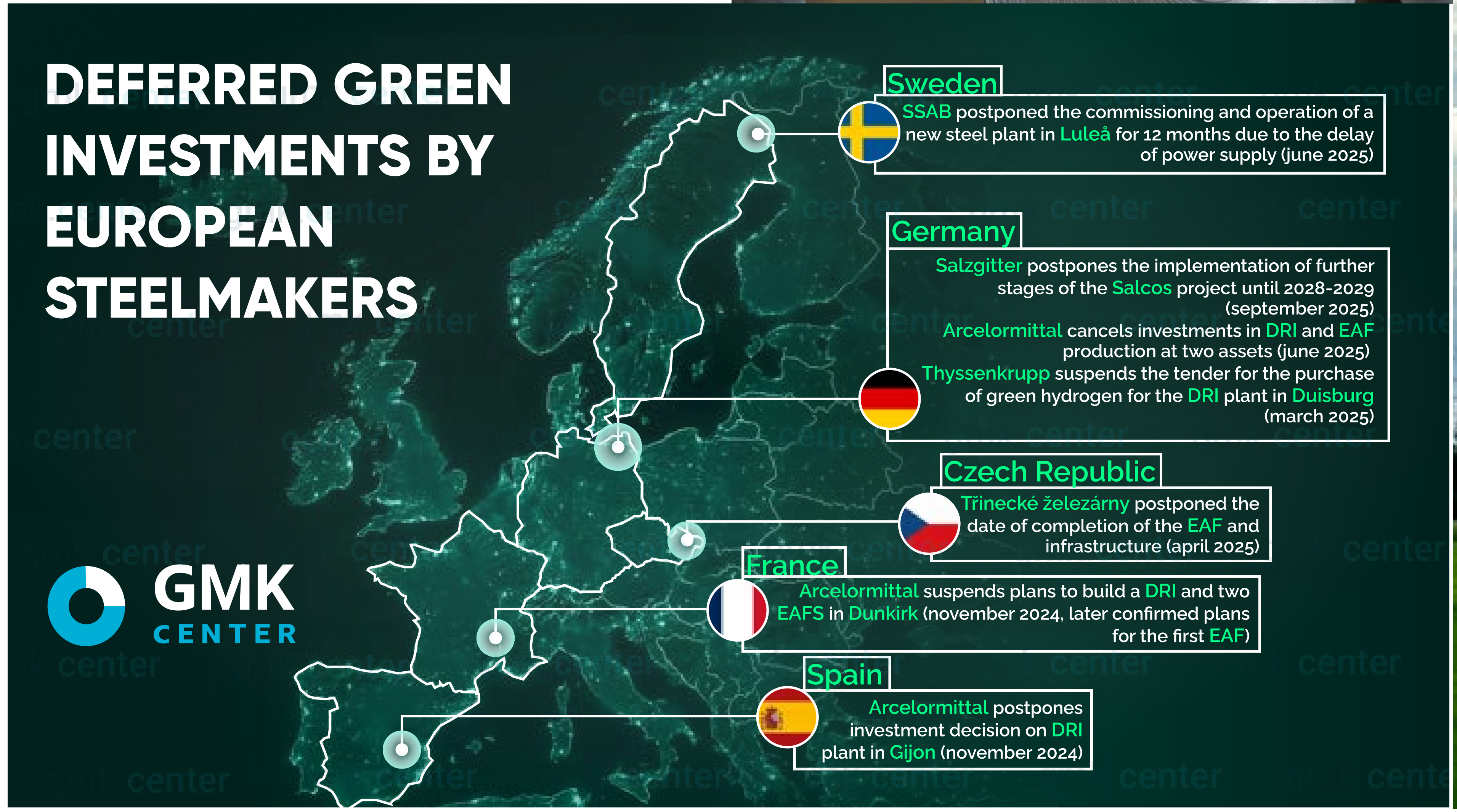
Plans and realities

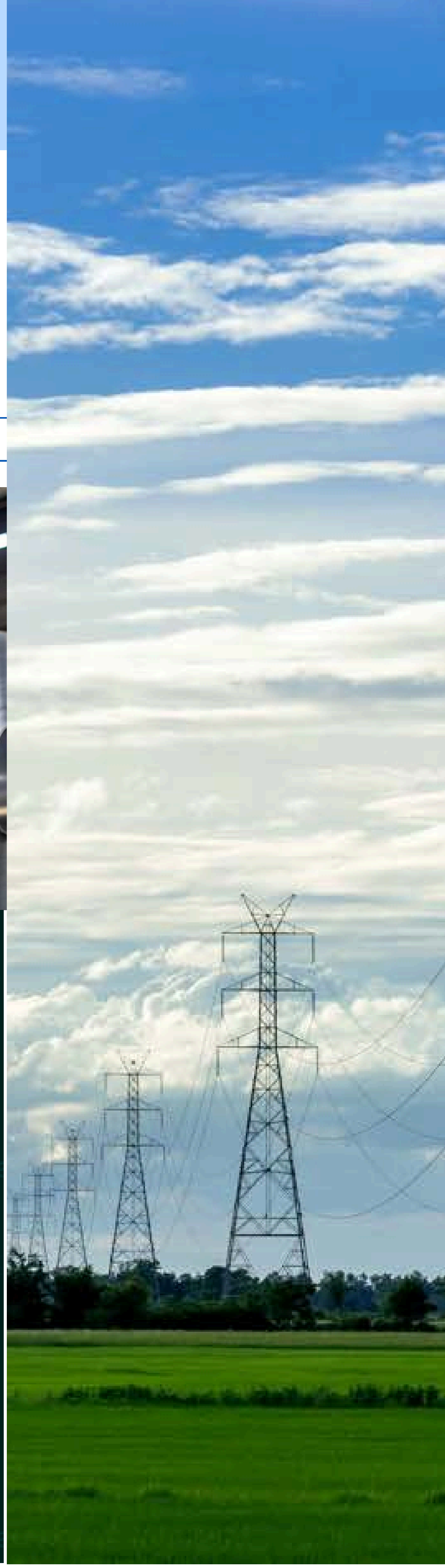
When reviewing their decarbonization plans, companies cite the weak steel market, high energy prices, and slower-than-expected development of hydrogen infrastructure.

Important issues for steelmakers remain the format of new EU protective measures (the current ones expire in July 2026) and the carbon border adjustment mechanism (CBAM), which will be fully implemented from the beginning of next year. In addition, uncertainty remains regarding the green steel market itself.

Even with government support for green projects, steelmakers emphasize that they are unable to cover the costs of transitioning to low-carbon technologies on their own.
«Let's be honest and frank. The days of green steel 'hysteria' are coming to an end. The time has come for technological, investment, and government decisions. The industry needs affordable smart technologies (not hydrogen myths), the industry needs investment, and the industry needs a long-term, clear government policy. It is impossible to rebuild a large sector in 3-5 years based on unavailable hydrogen and "green" premiums.

Different companies will produce green steel in different ways in different countries — some based on scrap, some based on hydrogen, relying on the competitive advantages of individual states and regions» concludes Stanislav Zinchenko, CEO of GMK Center.





Turkey's steel production is currently among the most environmentally sustainable globally

The modern Turkish steel industry took shape in the 2000s driven by the broader industrialization of the country's economy. The authorities had two scenarios. The first was to create large integrated BF-BOF plants.

The second was to build EAF scrap-based plants. Both options had one common drawback: the lack of their own raw material base.

In the first case, they would have had to import iron ore, and in the second, scrap. Therefore, there was no choice of the "lesser evil" here.

Nevertheless, by focusing on the development of EAF steel industry, the government took a very far-sighted step. The average CO2 emissions per 1 ton of finished steel in Turkey is about 1 ton.

In essence, local steel is already green. This means that it does not require as much investment in decarbonization as in many other countries.

The basis for decarbonization

Electric arc furnace production dominated the industry structure even before industrialization. In 2000, EAF accounted for 69% of all capacity, which then amounted to 19.8 million tons.

In 2022, when capacity reached 54.6 million tons, the share of EAF grew to 75%.

Today, the Turkish steel industry consists of 27 EAF plants and 11 IF plants with a total capacity of 41 million tons, and three large BF-BOF plants with 17.8 million tons per year.

These three enterprises generate most of the industry's emissions. However, their share in the total steel production is not that significant.

In 2021, when Turkish steel production reached a record high of 40.4 million tons, greenhouse gas emissions from BF-BOF amounted to 25 million tons, and from EAF-IF – 15 million tons. At that time, the total production volume of BF-BOF plants was 11.5 million tons, and that of EAF-IF plants was 28.9 million tons.

As a result, electric steel plants generate an average of 0.52 tons of CO2 per ton of steel, while integrated plants – 2.17 tons. This is not that much. For example, in India, the figure is 2.54 tons. But this is still higher than the global average of 1.92 tons.

In other words, the decarbonization of the Turkish steel industry will primarily consist of reducing emissions from the Erdemir and Isdemir plants owned by OYAK Mining Metallurgy Group and the Kardemir plant owned by Kardemir Karabuk Demir Celik Sanayi ve Ticaret A.S.

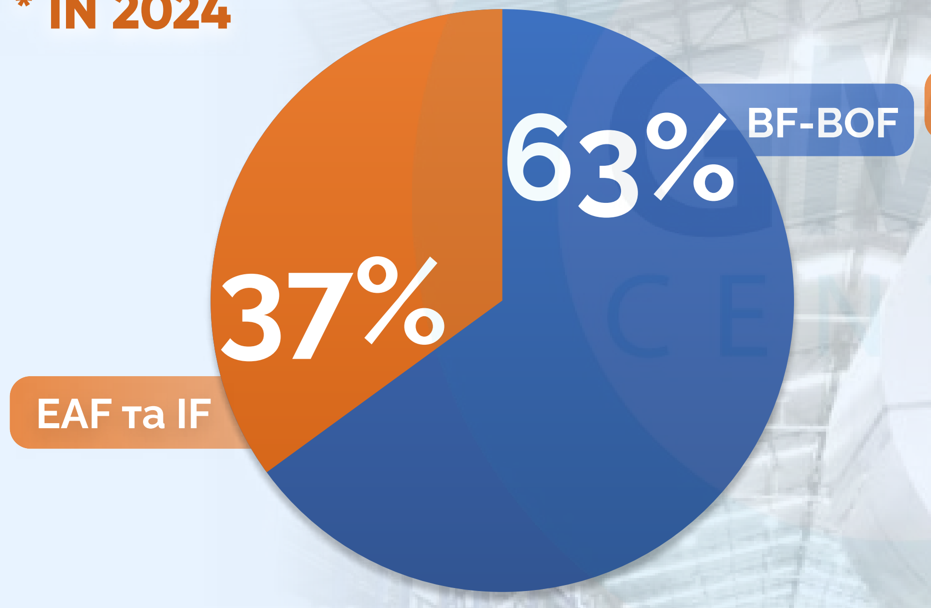
Unlike their EU counterparts, they cannot rely on government subsidies and must instead depend solely on their own investment capabilities.

Therefore, the companies' roadmaps do not imply a restructuring of existing capacities, but only an increase in energy efficiency and the construction of new, conditionally green EAFs. Plans are underway to build EAFs with a combined capacity of 1.4 million tons at the Erdemir plant and 2.5 million tons at İsdemir. These new furnaces are intended to supplement, rather than replace, existing BF-BOF capacities.

Moreover, the new EAFs will run on DRI. Initially, it will be obtained using natural gas, and later (approximately after 2040), when the necessary market conditions are in place, it will be obtained using hydrogen technologies.

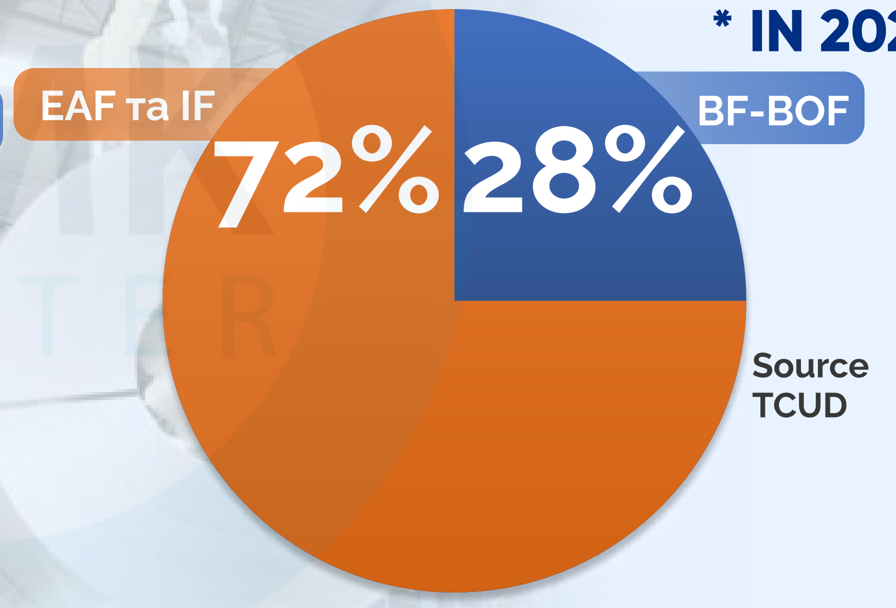
CO2 EMISSIONS IN TURKISH STEEL INDUSTRY BY TECHNOLOGICAL ROUTE*

*** IN 2024**



STRUCTURE OF STEEL PRODUCTION IN TURKIYE*

*** IN 2024**



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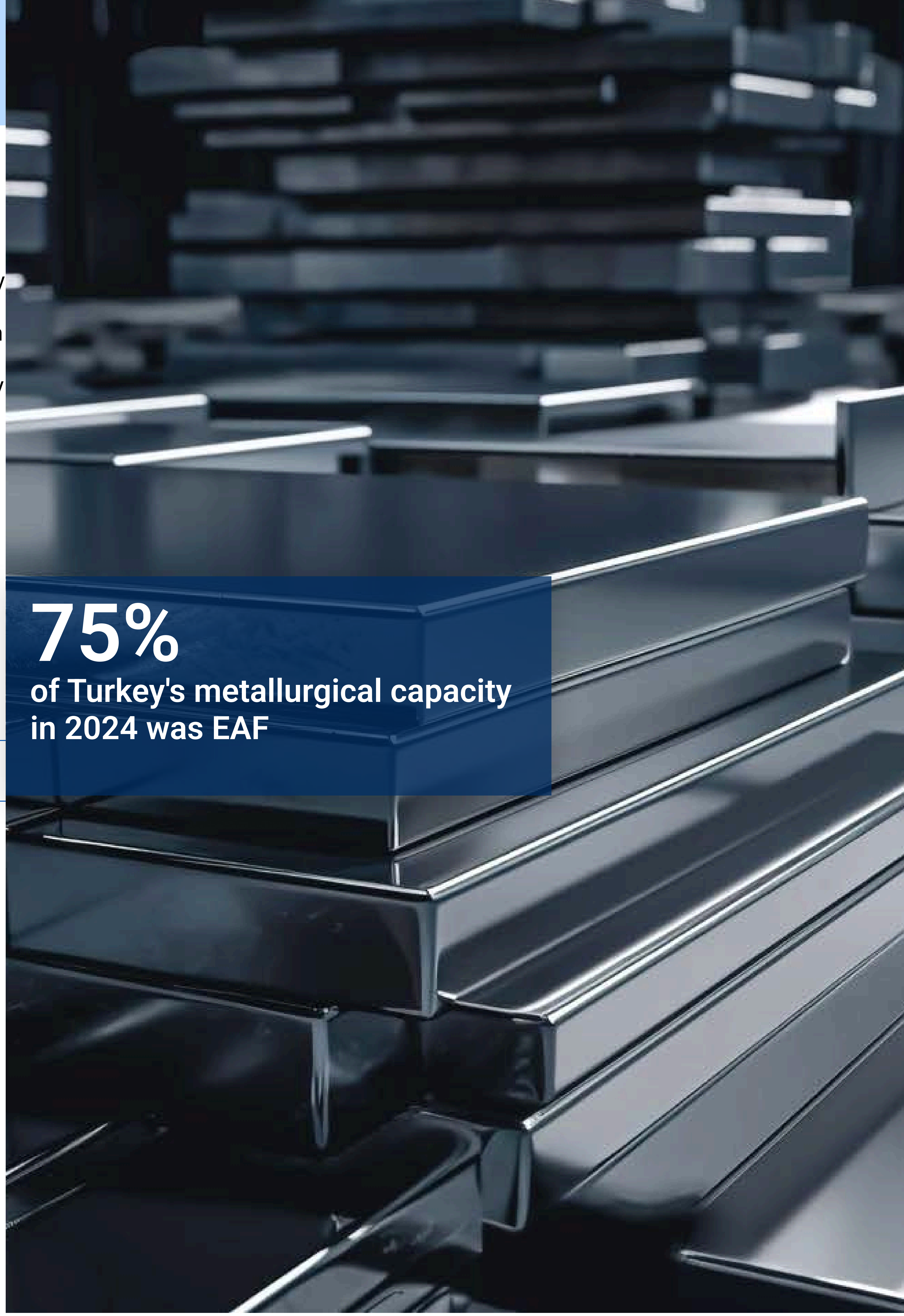


75%

of Turkey's metallurgical capacity in 2024 was EAF

Turkish recipe for green steel

Among the major improvement projects, the following can be highlighted:

- The launch of a new blast furnace at the İsdemir plant with a capacity of 2.8 million tons per year. The key feature is the conversion of increased blast furnace gas volumes into electricity.
- The launch of a new coke oven battery No. 4 with reduced emissions to replace the old batteries No. 1 and No. 2 at the Erdemir plant.
- Construction of solar power plants with a total capacity of 2.04 GW by OYAK Mining Metallurgy; The facilities are located in 12 provinces and will provide clean energy for the İsdemir and Erdemir plants.

Thus, the İsdemir and Erdemir steel plants intend to reduce CO2 emissions by 25% from 2022 levels by the end of 2030 and by 40% by 2040, said Erdemir CEO Niyazi Aken Peker.

OYAK's total investment in the green transformation in 2025-2030 will amount to $3.2 billion.

Of this amount, 70-80% will come from foreign sources of financing.

Also noteworthy is Kardemir's $1.5 billion investment program for 2025-2029.

Under this program, a significant portion of energy consumption will be transferred to renewable energy sources (RES).

In particular, by the end of 2026, the company's RES capacity will reach 250 MW. In 2024, it commissioned a 4 MW solar power plant and a 24 MW wind farm. Therefore, a huge leap forward is expected in the next 1.5 years.

As a result of modernization efforts aimed at improving energy efficiency, Kardemir successfully reduced its CO2 emissions from 3.4 to 2.3 tons per ton of finished steel between 2017 and 2021. And at the end of last year, the company commissioned a comprehensive energy consumption monitoring system, a new step in this direction.

By 2030, Kardemir will reduce emissions by another 15% from current levels, according to Chairman of the Board Ismail Demir.

Turkish EAF plants are advancing at a faster pace due to their technological advantages. For instance, Diler Iron & Steel Industry & Trade Inc., which operates a 1.5 million ton per year facility in Dilovası, has already cut CO2 emissions by 15,000 tons through the commissioning of a 25 MW solar power plant.

In April, CEO Fatih Gekce confirmed plans to expand investments in renewable energy.

The company aims to reduce its Scope 2 emissions by 98% from current levels by 2030 and transition to zero-emission steel production by 2035.

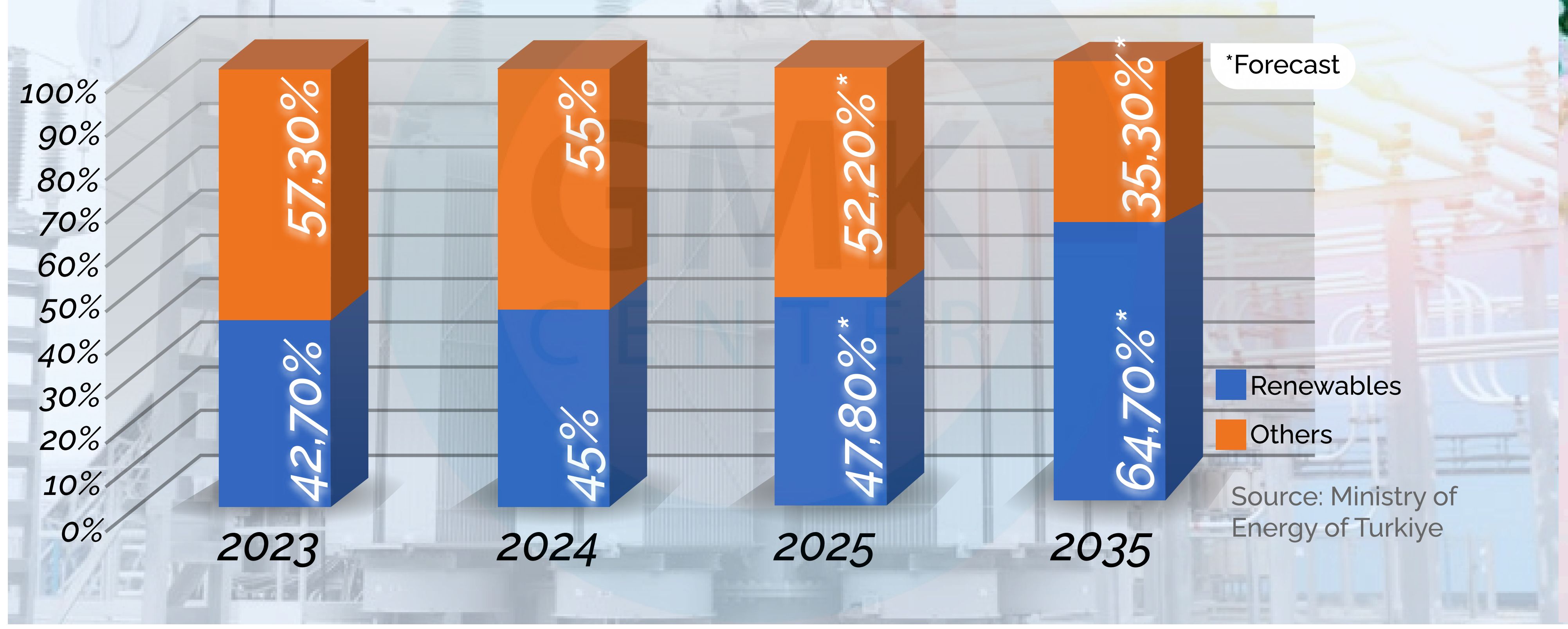
Veysel Yayan, Secretary General of the Turkish Steel Producers Association (TCUD), stated that fully decarbonizing the country's steel industry will require average annual investments of around $1 billion through 2053 – a level of financing that is manageable for domestic producers.

2053 Net Zero

An important driver of decarbonization in the Turkish steel industry will be the launch of the greenhouse gas quota market. The climate law providing for the creation of a national emissions trading system (ETS TR) was adopted by the Grand National Assembly on July 2.

According to the document, emission permits for industrial enterprises, including steel ones, will be sold on the Istanbul Energy Exchange (EXIST). The law also provides for sanctions.

SHARE OF RENEWABLES IN TURKISH ELECTRICITY PRODUCTION*



Source: Ministry of Energy of Turkiye

For example, late submission of emissions reports to the Ministry of Environment, Urbanization, and Climate Change will result in a fine of $12,500 to $125,000.

The total amount of fines for the reporting period cannot exceed $1.25 million. In addition, violators face the blocking of their bank accounts.

The climate law was adopted as part of the nationwide 2053 Net Zero program.

According to this program, the Turkish economy should achieve zero greenhouse gas emissions by 2053.

This seems realistic given the pace of development of alternative energy sources. According to the Turkish Ministry of Energy, this year the installed capacity of hydropower plants should increase by 200 MW to 32.395 GW, solar power plants by 3.844 GW to 22.6 GW, wind power plants by 2.431 GW to 14.8 GW, and geothermal power plants by 2.796 GW to 4.487 GW.

Accordingly, the share of renewable energy sources in the total energy potential will increase.

The expansion of renewable energy in Turkey's electricity mix is outlined in the country's Renewable Energy Roadmap through 2035, prepared by the Ministry of Energy and approved by the government.

Achieving the targets will require $28 billion in investment. Once implemented (alongside the growth of nuclear energy), this strategy will enable not only integrated steel plants (ISPs) but also all EAF and induction furnace (IF) facilities to transition entirely to clean energy sources.

As is well known, nuclear energy is also carbon neutral. Therefore, the authorities attach great importance to its development.

By the end of this year, power unit No. 1 with a capacity of 1.2 GW at the Akkuyu NPP should start operating in test mode.

In total, it will consist of four such power units.In addition, Turkey is negotiating with Russia, China, South Korea, and Canada on the construction of two more nuclear power plants, Sinop and Trakya. It is also negotiating the construction of small modular reactors (SMRs). As a result, the installed capacity of nuclear power plants is expected to increase to 7.2 GW by 2035 and to 20 GW by 2053.Після чого частка атомної енергетики у виробництві електроенергії сягне 30%.

After that, the share of nuclear energy in electricity generation will reach 30%.
This will create the basis for the industrial production of green hydrogen, which will be used in ISP blast furnaces instead of coke.

Turkey's Hydrogen Technology Strategy and Roadmap, adopted in 2023, sets ambitious targets for green hydrogen development. It envisions the installation of 2 GW of electrolysis capacity by 2030, expanding to 5 GW by 2035, and reaching 75 GW by 2053.

This is perhaps the most critical aspect of Turkey's decarbonization strategy. At present, there are no pilot projects in operation. In order to reach the planned target, it is necessary to commission 1 GW of electrolysers per year.

It is also worth noting that to achieve Net Zero by 2053, the primary focus for hydrogen technology deployment in Turkey is the cement industry rather than steel. This is due to the sector's higher annual CO_2 emissions (49 million tons), which exceed those of the steel industry by 22%.
The cost of H2 production in accordance with 2053 Net Zero should decrease to $2.4/kg by 2035 and to $1.2/kg by 2053.

However, it is clear that the Turkish government will not be able to follow Brussels' example and subsidize this production. Therefore, the availability of hydrogen resources in the future is now in question.

Thus, it can be said that the Turkish steel industry has made significant progress towards low-carbon steel. However, there is a serious obstacle on this path in the medium term.

Decarbonization of the industry is receiving strong financial support from the government

The peculiarity of the Japanese approach to the green transformation of metallurgy lies in the understanding of one simple truth. It is not a “headache” of the companies themselves. It is a national task.

Hence the unprecedented tax incentives for market participants. Even in spite of their own huge financial capacity.

EAF-transition and government policy

Japan is the third largest steel producer in the world. At the same time, approximately one-third of production is exported.

Therefore, the contribution of local companies to the decarbonization of the global industry is highly valued.

The Japanese steel industry today is primarily 24 blast furnaces in 12 cities with a total capacity of 83 million tons.

The capacity of electric steel furnaces is considerably inferior, with 37 million tons. Thus, the BF-BOF process route prevails over NG-EAF-scrap based.

In this regard, metallurgy accounts for about 40% of Japanese industry’s CO2 emissions. Even though blast furnace production in Japan is considered to be the most energy efficient in the world.

A vivid illustration of the fact that the possibilities of the best available technologies (BAT) have their limits. And they are not an exhaustive answer to the challenges of green transformation, requiring more radical solutions.

First of all, transition to new steelmaking technologies.

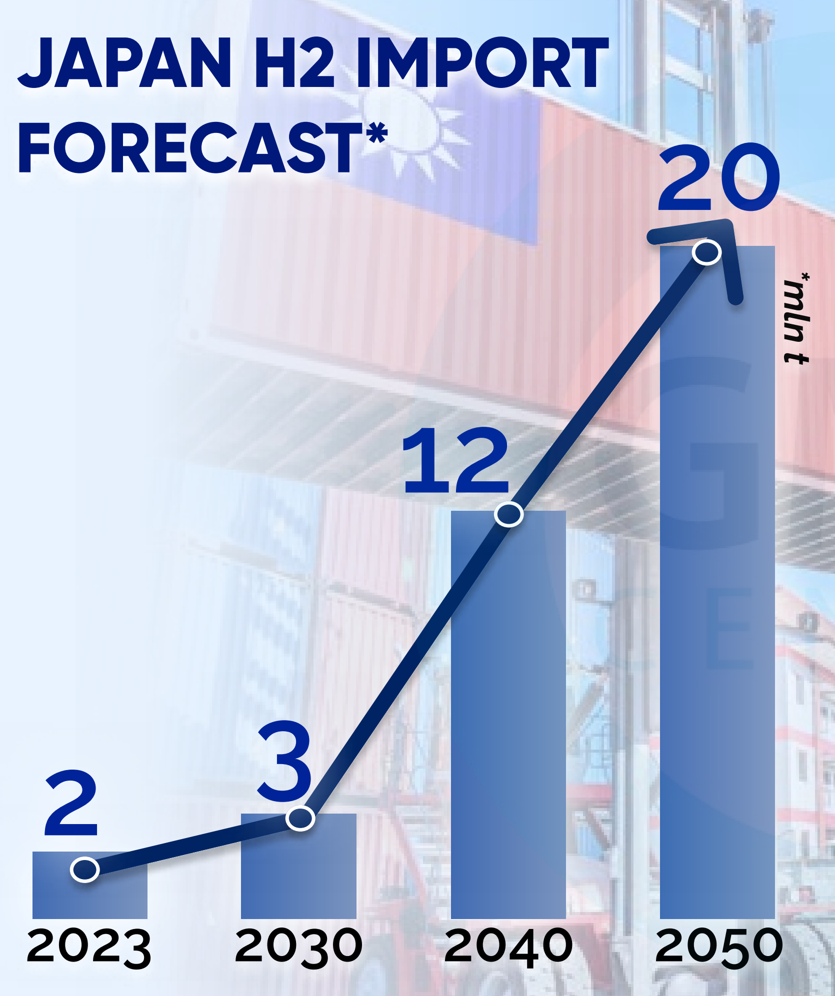
Therefore, unlike most countries, it is not BAT that serves as the main driver of the transition period in the Japanese steel industry. The transition period will last until 2030 and provides for a 30% reduction in CO2 emissions by the base year of 2013, when they reached 200 million tons. The main effect will come from the development of electric steelmaking.

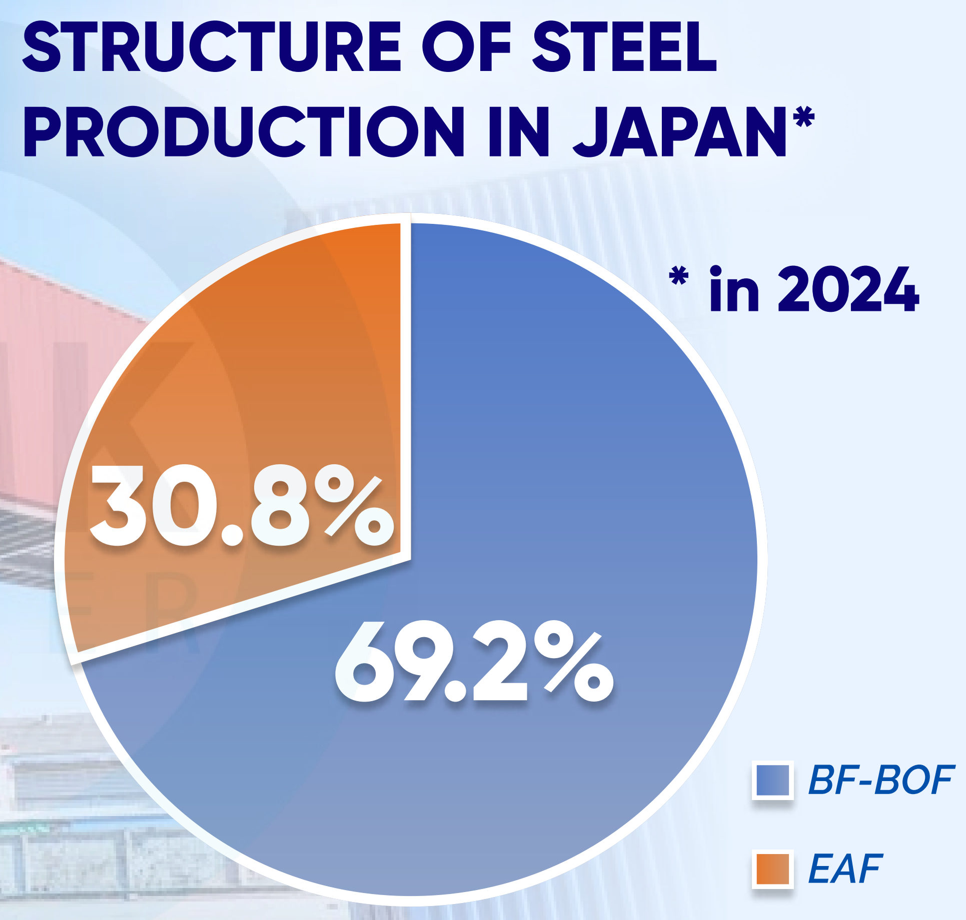
The largest local player, Nippon Steel Corp. in June 2025 announced investment of $6.05 bln in the construction of EAF at Kyushu Works, as well as in the expansion and reconstruction of 2 existing EAFs.

The facilities are scheduled to be commissioned in FY 2029 (ending March 31, 2030), with a total capacity of 2.9 million tons of steel per year.

Second-largest producer JFE Steel Corp. announced in April 2025 the construction of a 2 million tpa EAF at West Japan Works in Kurashiki. Costing $2.2 billion, the facility is scheduled for commercial launch in Q1 2028 FY.

It is important to emphasize the high share of state participation in these projects.





Source: METI

Japanese green steel

For Nippon Steel – $1.75 bln, for JFE Steel – $690 mln. Financing will be provided under the GX Green Transformation Promotion Act.

But no, the government will not spend Japanese taxpayers' money on the EAF.

The funds are being allocated in the form of tax credits. For every ton of green steel produced at the new facilities, companies will receive $149 in tax credits. Subject to a number of conditions:

- Transition from BF-BOF to EAF;
- Production of electric steel with a quality no worse than previously under the blast furnace-converter method;
- Cost of investment projects not less than $81 million, capacity of new EAF not less than 200 thousand tons per year;

Obviously, any even not the largest company easily fulfills these criteria within the framework of green transformation.

The Japanese media called this initiative a «rather generous offer» by the government. And one can agree with them. However, there are also skeptics who are still undecided.

Kobe Steel Ltd., the third-largest steelmaker, announced in May 2025 that it will sequester its decarbonization investment budget for 2024-2026 from $2.09 billion to $1.05 billion.

The company explained that the board made the decision amid concerns from shareholders. They believe that the impact of green transformation and related costs on the competitiveness of future products has not been sufficiently studied.

At the same time, Kobe Steel emphasized its commitment to its previous goal of reducing CO2 emissions by 30% by 2030. But so far, it is the only major player that has not embarked on an EAF transition. The company is still evaluating the possibility of building a new electric furnace to replace the blast furnace at Kakogawa. The project is planned to start after 2030.

In the meantime, Kobe Steel's efforts are focused on increasing the share of scrap in iron smelting feedstock, utilizing biomass for power generation (e/e), and further improving energy efficiency. I.e. on BAT.

Which, as noted, are unlikely to achieve a 30% reduction in greenhouse gas emissions.

Interestingly, the most ambitious targets are set by Tokyo Steel, the largest producer of electric steel. Its emissions are already lower than those of the above companies, about 1.7 tons per 1 ton of finished steel. Including Scope 1 for HRC – 0.683 tons, for HRP – 0.622 tons.

Nevertheless, Tokyo Steel intends to reduce greenhouse gas emissions by 40% by 2030 compared to 2013. It is planned to achieve this by increasing the use of renewable energy sources to 40%.
By the way, Tokyo Steel and other electric steelmaking companies have been disadvantaged by the GX Leadership Act, which prioritizes government purchases of environmentally friendly steel.

It refers to another document that defines «balanced steel» i.e., «low-emission products» produced in the traditional BF-BOF process.

And there is no mention of EAF steel.

It is clear that Japanese officials primarily wanted to provide incentives to decarbonize BF-BOF capacity, which produces the highest emissions and requires huge investments. But this discriminates against companies already producing green steel at no additional cost.

Similarly with the previously passed law on the promotion of green procurement. It also does not explicitly mention electric steel. But it talks about «balanced steel». Discussions on an appropriate amendment to this document are ongoing.

An important incentive that could accelerate the EAF transition would be the introduction of a greenhouse gas emission fee. The CO2 emissions trading market should be operational from 2026. The details of Japan's EAF are still under consultation and have not been formally approved.

Japanese nuances

An important feature of Japanese steel decarbonization is the close cooperation of market participants. Unlike, for example, South Korea, where everyone goes their own way in developing technological solutions.

In 2022, Nippon Steel, JFE Steel and Kobe Steel together with the Japan Metals Research and Development Center formed the Hydrogen Steelmaking Consortium.

The Consortium, supported by the NEDO Green Innovation Fund, has launched the Super Course50 project.

$149/т

deduction from tax liabilities may receive Japanese steelmakers

Its goal is to reduce CO_2 emissions in blast furnace production by 50% by using heated external H_2 together with coke.

As part of Super Course50, a small pilot blast furnace has been built at JFE Steel's Tiba plant.

The facility has now achieved a 33% reduction in emissions compared to conventional units. Research is ongoing.

This implies that Japanese companies do not plan a full transition to EAF by 2050. They explain this by the inability to produce certain types of high-margin steel, including electrical steel, in electric furnaces.

In addition, the strategy is to maximize the use of existing equipment. Whereas EAF will require the construction of new ones along the entire process chain.

At the same time, as Nippon Steel's Executive Director for Environment Hideoki Suzuki emphasized, the use of H_2 in blast furnaces does not imply a complete abandonment of coke.

Therefore, the remaining volume of greenhouse emissions is planned to be neutralized with the help of CCUS.

Nippon Steel is working on the relevant developments. And everything rests on the price of the issue. Now the company has managed to achieve $149/t CO_2 and this is the best achievement of Japanese engineers. But it is obvious that it is too high costs per 1 ton of finished steel.

it is very early to talk about readiness for commercial use.

According to Suzuki, much depends on technical solutions in related industries, primarily in terms of transportation and storage of carbon. And it is very difficult to predict progress.

In turn, JFE Steel is studying the possibility of burying carbon from its facilities in Malaysia.

Another interesting nuance. Japan is one of the leading suppliers of steel scrap to the global market.
Nevertheless, in providing raw materials for future EAF capacities, local companies rely not on this resource, but on HBI/DRI.

- Nippon Steel is developing technology to produce DRI using H_2 from low-grade iron ore (existing technologies use highly enriched material), primarily from Australian deposits. In addition, Nippon Steel has indicated a willingness to share in integrated overseas projects involving iron ore mining, green H_2 and DRI production.
- JFE Steel in its Carbon Neutrality Strategy has also declared a commitment to utilize low-carbon hydrogen-based HBI/DRI. In partnership with Emirates Steel, the company has invested in the construction of a 2.5 million tons per annum DRI plant in the UAE. It is expected that 50% of the production will be sourced for JFE Steel's plants in Japan.

Among large companies, only Tokyo Steel emphasizes the increase of scrap collection in its Roadmap.

Green components: H_2 and RES

Back in 2020, Japan's first 10 MW green H_2 plant came online. Updated at the end of 2024, Japan's Energy Policy Plan (7-SEP) aims to increase H_2 electrolysis capacity to 15 GW by 2050.

Production of green H_2 should grow to 0.3 million tons by 2030 and to 5-10 million tons by 2050. At the same time, a significant part of the resource will still be imported.

Japan already has the necessary infrastructure for such imports. At the end of 2021, construction of a special terminal for transshipment of liquefied H_2 was completed in the port of Kobe. And in February 2022, it received the first cargo from Australia.

At the same time, delivery costs are expected to drop to $2.25/kg by 2030 and to $1.5/kg by 2050. At the same time, Nippon Steel estimates that for large-scale adoption of hydrogen technologies in the steel industry, prices should be no higher than $0.6/kg.

In its turn, the Japan Hydrogen Association (JH2A) believes that by 2050 the steel industry alone will require 20 million tons of H_2 per year, while the total demand of the Japanese economy will reach 70 million tons. In such a case, the announced production and import volumes are clearly insufficient.

Renewable energy in Japan began to develop from the mid-2010s, with the pace of new capacity commissioning accelerating significantly after 2020.

Japanese green steel

Nevertheless, it is the current Prime Minister Shigeru Ishiba who can be called an «energy revolutionary».

The 7-SEP plan adopted by his government has for the first time officially declared a clear commitment to reducing dependence on fossil fuels, which play a key role in the national energy sector. And renewable energy was declared the priority and dominant resource in Japan's energy policy.

In addition, the 7-SEP lifted the taboo on nuclear power development imposed by the authorities in 2011 after the famous Fukushima accident.

Although nuclear power is not classified as green, it is nonetheless a carbon-neutral product that contributes to the decarbonization of the economy, including metallurgy.

Transition Asia Research Center estimates that the EAF transition in Japan will require an additional 3 TWh of green power.

This is 0.5% of total production by 2030 and 5-7% by 2050 to achieve zero-emission steelmaking.

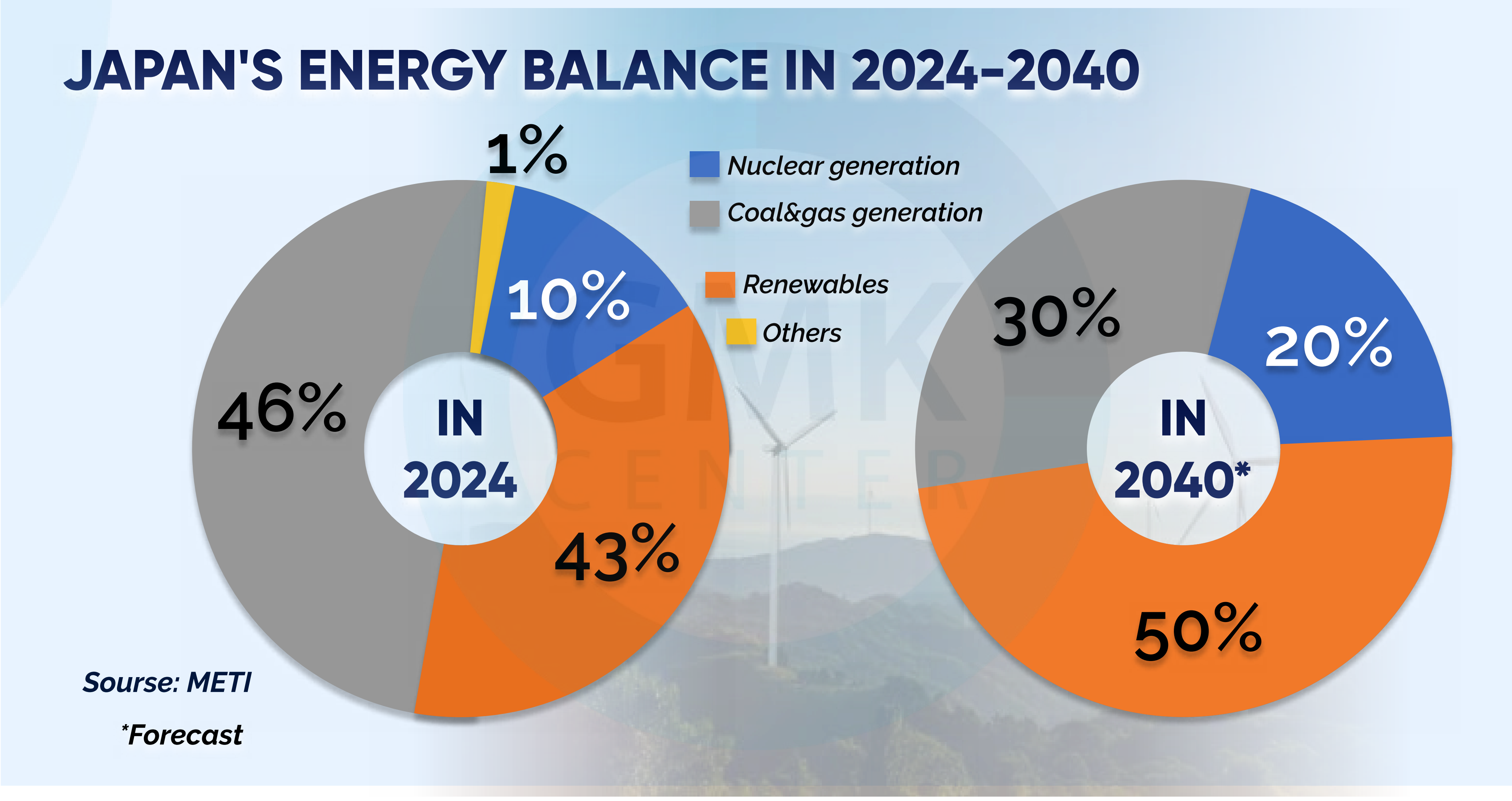
Based on this, the steel industry should be allocated 7-8% e/e of total RES production in 2040. This target is quite realistic.

Thus, the Japanese model of metallurgy decarbonization is characterized by a combination of two engineering solutions known today.

These are the EAF transition and the introduction of hydrogen technologies for BF production combined with CCUS.

A prudent government policy, including financial support for the industry, serves as a key to future success.

Providing tax credits to companies may prove to be a much more effective tool than subsidies and grants from the European Commission for European steelmakers.



The industry's green transition relies on manufacturers' own innovations and strong investment resources

The roadmap for decarbonizing South Korea's steel industry envisages achieving carbon neutrality by 2050.

By that time, greenhouse gas emissions from Posco, Hyundai Steel, and Dongkuk Steel should be reduced by 95% compared to the 2018 baseline.

All of them are among the most successful players in the global steel industry, focusing on the production of high-margin products. Therefore, the task seems quite realistic, given the financial capabilities.

Three paths to one goal

Metallurgy is one of the main emitters of CO_2 in South Korea. In 2018, it accounted for 39% of all emissions from national industry – 372.87 million tons, excluding Scope 3. This is due to the significant contribution of BF-BOF plants to the total volume of steel production.

In subsequent years, the share of EAF plants declined even further, exacerbating the problem. Therefore, the industry's decarbonization strategy primarily envisages the partial replacement of existing BF-BOF capacities with EAFs.

And here Posco, the biggest player, will have to make the biggest effort. It has all its steelmaking at BF-BOF.

Moreover, Posco's flagship mill Gwangyang ranked No. 1 in the world in terms of CO_2 emissions (among steel mills) in 2022.

It is much easier for the second largest company Hyundai Steel. It has both BF-BOF and EAF capacity.

Finally, Dongkuk Steel, which rounds off the top three, receives all its steel using EAF. Acc ordingly, its products already fall under the definition of green.

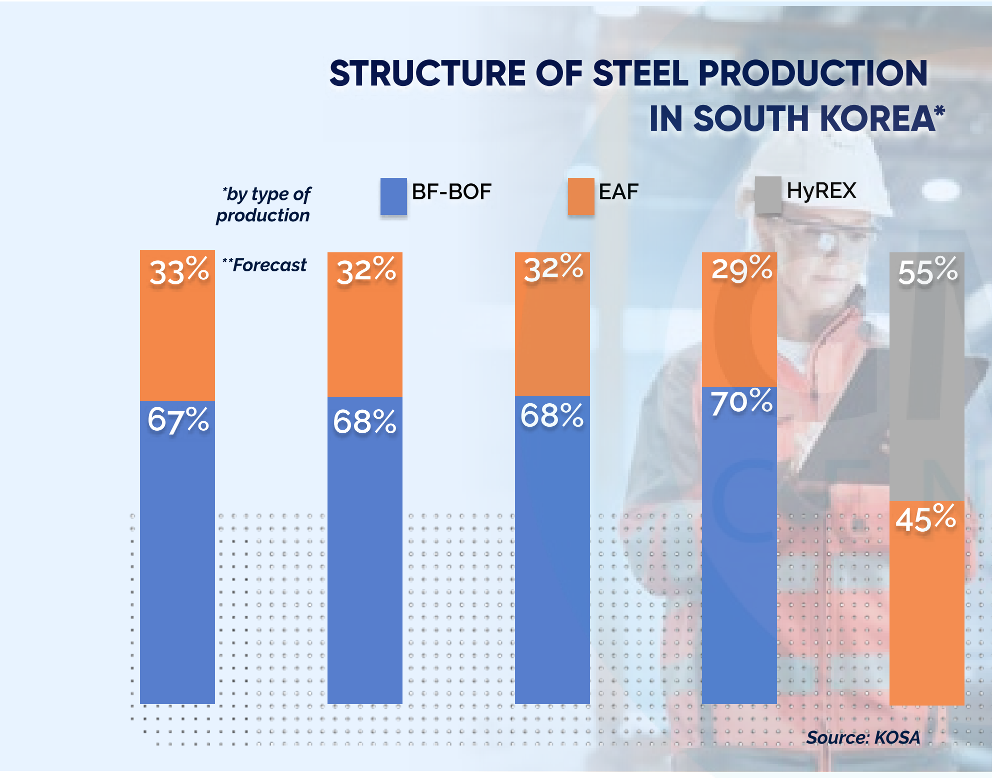
Hyundai Steel also has a decent score. But this is combined data. For BF-BOF, it is 2.2 thousand tons, and for EAF, it is 0.6 thousand tons. In other words, this manufacturer actually has partially green products.

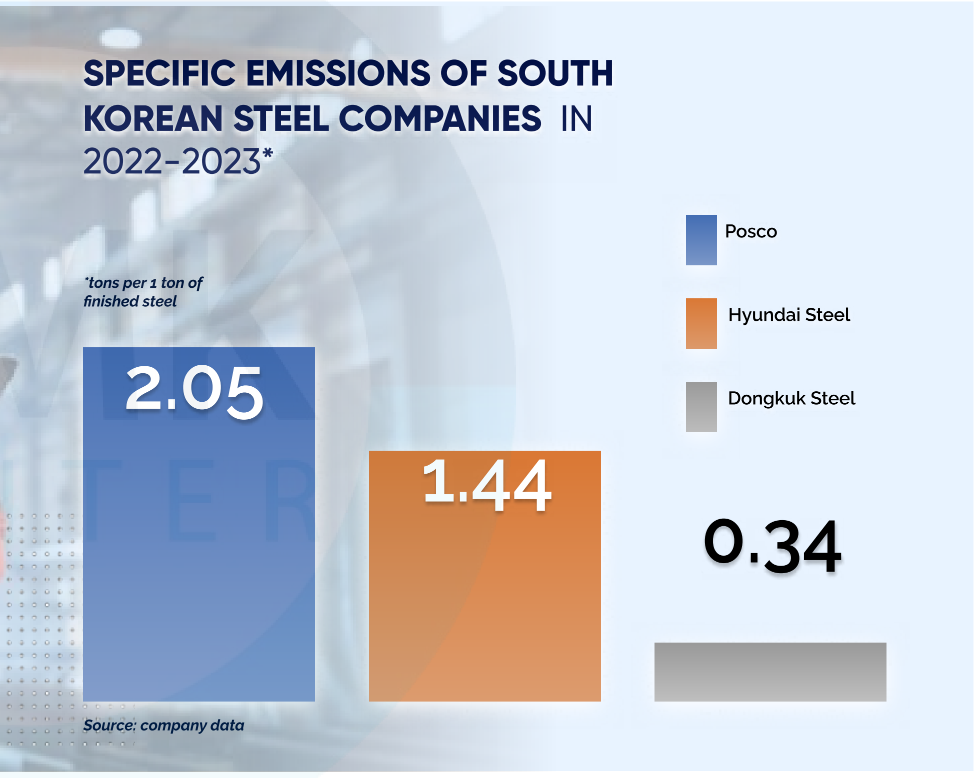
Based on this, it becomes clear which South Korean steelmakers are closer to the Net Zero 2050 target and which are playing catch-up. And why this is the case. Accordingly, each now has its own strategy.

Posco: betting on HyREX

The roadmap for decarbonizing steel production consists of three stages.

- The initial stage will last until 2030. The main focus will be on implementing energy efficiency measures and expanding the use of more environmentally friendly materials (scrap, DRI, HBI), which will reduce the share of pig iron in steel smelting. This should reduce CO_2 emissions by 20% compared to 2018, to 6.3 million tonnes of carbon equivalent.
- The second stage, up to 2040, involves the use of H_2 in blast furnaces to reduce the proportion of coke. CCUS will also begin to be used. In stage 1, the possibility of such projects with carbon sequestration in Indonesia and Australia is being studied. The company has signed relevant memoranda with local oil and gas producers. This will reduce greenhouse gas emissions by 50% compared to 2018, to 3.94 million tons.





- The final stage should be completed by 2050. It involves the transition from BF-BOF to HyREX technology. Its innovation lies in the fact that DRI produced using H_2 and NG is not unloaded or transported anywhere. Right here, in the ore thermal furnace, it is used to produce pig iron. In 2024, the company signed an agreement with Primetals Technologies to develop and supply equipment for a pilot project with a capacity of 300,000 tons per year. Construction will begin after 2030 at the Posco Pohang plant site.

As the company plans to further increase production, it is also investing in new steelmaking capacity. Of course, this will be an EAF.

Construction of a 2.5 million tonne per year facility began in 2024 at the existing Posco Gwangyang plant. It will cost $450 million.

Starting in 2040, steel production at all plants will be 100% powered by green electricity (e/e).

To this end, Posco is upgrading 3.4 GW of equipment at its gas-fired power plant in Incheon for H_2 use.

Hyundai Steel: Hy-Cube to the rescue

Hyundai Steel's steelmaking capacity is evenly distributed between BF-BOF and EAF, with 12 million tons per year each.

By 2030, the company intends to reduce CO_2 emissions by 12% compared to 2018. This is a more modest goal than Posco's. But Hyundai Steel's carbon intensity is also lower.

It is also betting on its own innovations, combined in the Hy-Cube concept. The company is developing a technology (currently in the testing stage) for adding electric steel from EAF to BF.

To this end, it plans to recommission an idle EAF at its Tangier plant with a capacity of 1 million tons per year. As a result, specific emissions from blast furnace production should fall to 1.8 tons of CO_2.

The second stage will begin in 2029 and will be a reverse process. In this stage, pig iron from the BF will be fed into the EAF. This should reduce emissions to 1.4 tons.

The key difference between the two mixing methods is the technology used to purify the steel from impurities.

Other priority tasks until 2030 include:

- reducing electricity consumption at the sintering plant;
- introducing a dry quenching system (CDQ);
- testing H_2 and LNG injection into the BF;
- increasing the share of scrap, DRI, and HBI in raw materials;

It is noteworthy that Hyundai Steel's decarbonization roadmap does not include targets beyond 2030.

At the same time, a similar document from the Hyundai Motors group, which includes Hyundai Steel, provides for a 40% reduction in CO_2 emissions by 2035, a 60% reduction by 2040, and by 100% by 2045.

Given that 60-70% of the steel this automaker purchases is sourced within the group, it is logical to assume that Hyundai Steel will also have to reduce its emissions after 2030. However, there is no direct correlation here, as steel accounts for up to 35% of a car's carbon footprint.

Nevertheless, Hyundai Steel has declared its goal of achieving carbon neutrality by 2050. And in October 2023, it signed a contract with Primetals Technologies to conduct research on reducing CO_2 emissions.

This mainly involves the possibility of using H_2 in blast furnace production.
For electric steel production, the company intends to reduce specific emissions to 0.2 tons through H_2-DRI.

This volume of greenhouse gases is planned to be neutralized using CCUS.
Hyundai Steel will also switch to 100% self-sufficiency in electricity by 2050. To this end, it began construction of a 0.5 GW gas-fired power plant last year.

The company's current production volumes require 2.1 GW. It currently has a 0.1 GW power plant that uses blast furnace gas.

100%
of steelmaking at all Posco plants will be powered by green electricity from 2040

Prospects for South Korean green steel

Dongkuk Steel: decarbonization leader

South Korea's third-largest steel producer already has the lowest emissions. One of its EAFs at the Incheon plant is labeled Eco-Arc.

This unit consumes 30% less electricity than other EAFs due to scrap preheating and a continuous loading system.

Therefore, the company's short-term plans are to build a similar infrastructure for all electric furnaces. This is an innovative component.

In general, Dongkuk Steel divides 2 areas of decarbonization: steel production itself and energy. The latter envisages digitalization of the energy management system at the enterprise until 2030 and replacement of energy equipment with low efficiency.

In the long term until 2050, the production direction includes a transition to H2 plus further digitalization, including AI. The energy direction is scaling up solar power plants.

In this way Dongkuk Steel intends to reduce CO2 emissions:

- By 2030 by 10% compared to 2018, to 277 thousand tons of carbon equivalent;
- By 2040 by 28%, to 223 thousand tons;
- By 2050 by 100%;

Resources for decarbonization

Realization of green plans of South Korean companies is impossible without the resource component – RES, H2 and steel scrap.

These issues are being brought to the level of national incentive and development policies.

By 2050. South Korea intends to achieve a carbon-neutral economy. To this end, 30 coal-fired power plants will be shut down in the country by 2034.

Their share will be taken by renewable energy sources and nuclear power plants. By 2036, 2 nuclear power units of 1.4 GW each plus a 0.7 GW modular power unit will be built.

According to the Basic Plan for the Development of the Electric Power Industry for 2024-2038, the national energy balance will change as follows.

In addition, 12 coal-fired power plants will be converted to alternative fuels. By 2038, hydrogen fuel should account for 6.2% of the energy mix.

Currently, South Korea produces "gray" H2, which has a significant carbon footprint.
South Korea's hydrogen economy roadmap, approved by the Ministry of Trade, Industry, and Energy, envisages an increase in production from 0.22 million tons in 2020 to 1.94 million tons in 2030. Of this, 0.25 million tons will be green H2, 0.75 million tons will be blue H2, and 0.94 million tons will be gray H2. Local companies intend to import an additional 1.96 million tons of green H2.

Obviously, the bulk of it will be used in the power and cement industries, with metallurgy accounting for an insignificant share of total consumption at this stage.

By 2050, the production of green H2 will grow to 3 million tons, and "blue" H2 to 2 million tons.

South Korea plans to purchase 22.9 million tons of green H2 abroad. By this time, the use of "gray" H2 will be completely phased out.

The strength of the South Korean economy is based on developed mechanical engineering. Which, as we know, generates the bulk of scrap collection.

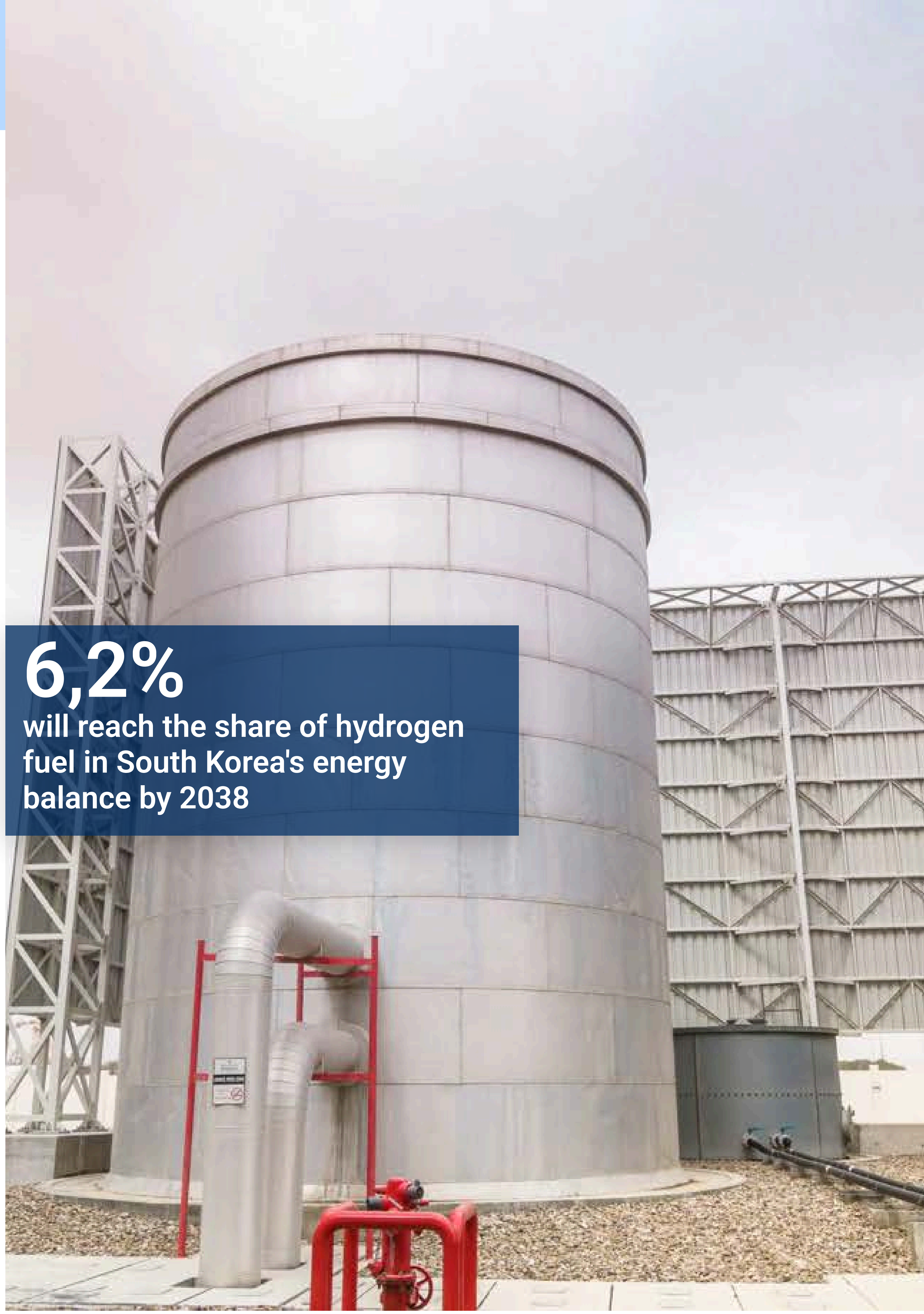
Despite this, South Korea is already a net importer of scrap. In 2024, the volume of foreign purchases amounted to $1.15 billion, according to national statistics. Exports amounted to $305 million.

The total steel scrap market in South Korea in 2024 is estimated at $4.8 billion. Thus, approximately 20% is already accounted for by foreign imports. This share will only increase as new EAFs are built to replace BF-BOF capacities as part of decarbonization efforts.

South Korean steelmakers receive the main flow of imported scrap from Japan. In 2024, it accounted for 60% of foreign supplies.

But even there, manufacturers, primarily Nippon Steel, are planning to switch from BF-BOF to EAF as they strive for carbon neutrality. This means a sharp reduction in export supply in the medium term, as domestic demand for scrap in Japan will begin to grow.

American and Russian scrap will be more expensive due to logistics. Therefore, we can predict restrictions or even a complete ban on scrap exports from South Korea after 2030.



6,2%
will reach the share of hydrogen fuel in South Korea's energy balance by 2038

For now, local steelmakers are trying to expand their own scrap collection base as much as possible.

For example, Posco invested $140 million in this area in 2023-2025, increasing the number of scrap collection centers from 4 to 8.

The company also announced the opening of such centers abroad. Obviously, other South Korean steel producers will follow suit.

Green government policy

The government does not single out metallurgy among other industries and sectors of the economy subject to decarbonization. South Korea was the first country in Southeast Asia to launch a national CO2 emissions trading system in 2015.

Currently, K-ETS covers 79% of all greenhouse gas emissions. However, it does not apply to the steel industry. Steel companies still receive free quotas.

Following market trends, they are creating their own steel eco-brands. Posco has "Posco Greenable" and Hyundai Steel has "HyECOsteel."

However, South Korea does not have an officially developed and approved state standard for green steel (as, for example, in India).

In 2024, it became known that the government had begun consultations with industry representatives on the introduction of the CBA in South Korea. Since then, there has been no information on the progress of the initiative, which is designed to stimulate the transition to carbon-free steel production. However, this does not mean that local companies are completely deprived of state support.

Since the end of 2021, South Korea has had a national green taxonomy, K-Taxonomy. It contains environmental criteria for 69 types of economic activity.

Compliance with these conditions entitles companies, including steel companies, to attract external financing for decarbonization projects on preferential terms.

In particular, they can obtain insurance guarantees from the state-owned Korea Trade Insurance Corporation and the Export-Import Bank of Korea. This reduces the cost of loans. Posco already has experience in this area.

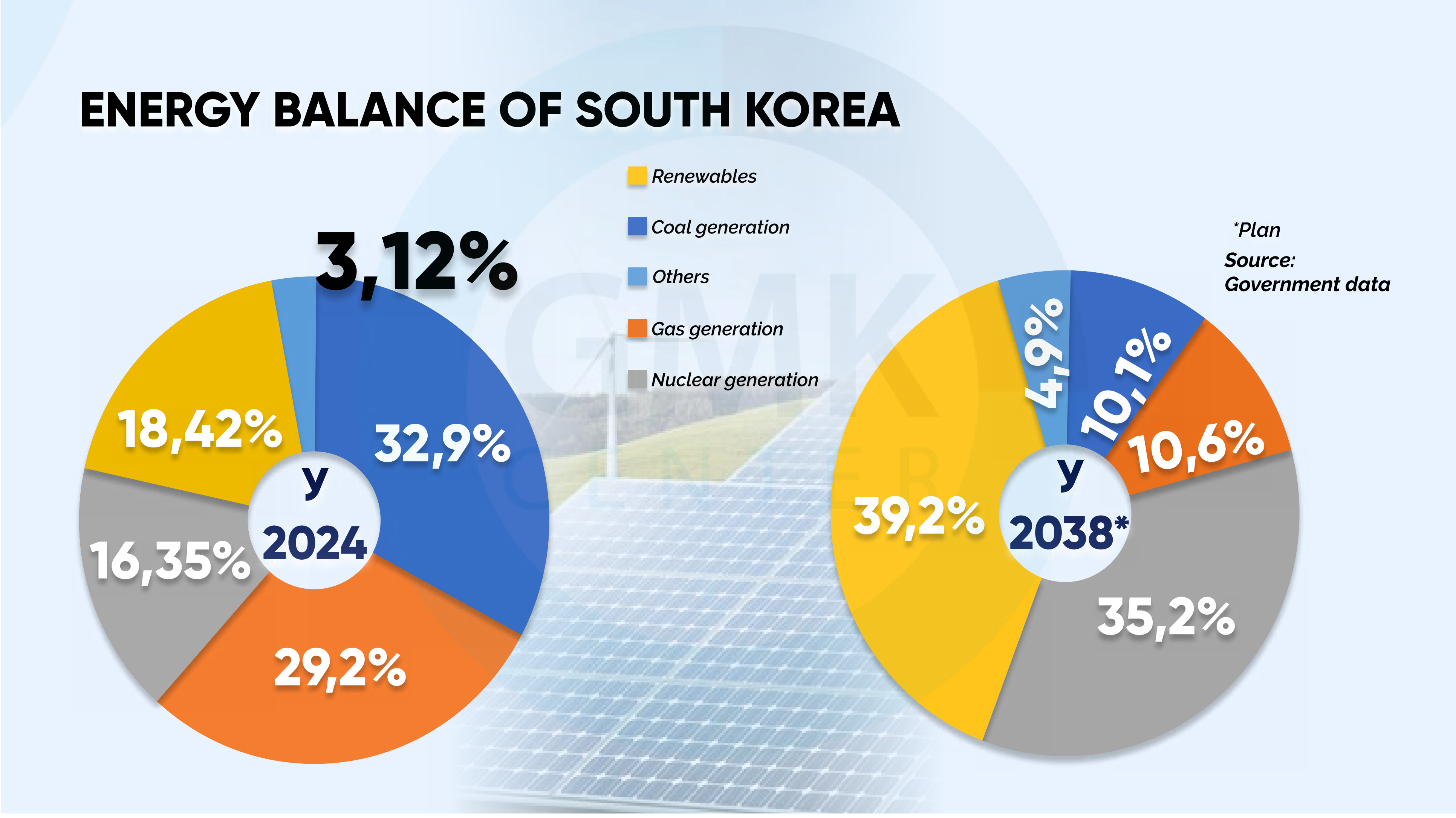
In 2021, the corporation issued $700 million in low-yield green bonds.

In 2023, Hyundai Motors also secured a $940 million green loan on very favorable terms to build electric vehicle battery assembly plants in the United States.

Obviously, this experience can be used by Hyundai Steel for its projects.

However, despite their enviable financial capabilities, South Korean steel companies prefer not to rush the green transition.

They are building their decarbonization strategies based on a long-term perspective of 25-30 years.



Ill-conceived public policy has created obstacles to the green transition

The UK economy is steadily moving towards zero CO2 emissions. Against this background, its steel industry looks like a clear outsider. However, this is not the fault of local steel companies.

The rules of the game are dictated by the state. That is why the British case looks like an example of how NOT to decarbonize the steel industry.

A problematic transition

Last year was a historic year in the British energy industry. At the end of September, the Ratcliffe-on-Soar power station in Nottingham – the last coal-fired thermal power station in the country – closed.

Wind for the first time became the largest source of electricity (ee) generation, with its share in the energy mix growing by 2% year-on-year.

This means that steel companies can significantly reduce greenhouse gas emissions through renewable energy sources (RES). Nevertheless, until recently, the largest steel companies were present in the top 10 of the UK's biggest CO2 emitters.

Port Talbot mill, owned by India's Tata Steel, is in 4th place with 6.2 million tons in 2023, while British Steel's Scunthorpe mill is in 8th place with 3.3 million tons. The emissions of the entire British steel industry in 2023 are 9.862 million tons.

Why is this so? Because the switch from BF-BOF to EAF scrap based proved too painful for the owners of Port Talbot and Scunthorpe.

The cost of building an EAF at Port Talbot is £1.25bn, at Scunthorpe it is over £2bn, and the investment opportunities of the producers themselves are limited by narrow margins. This, in turn, is a consequence of the weak protection of the domestic market from cheap steel imports.

One should also add the high cost of electricity. Yes, the situation looks better now than a few years ago.

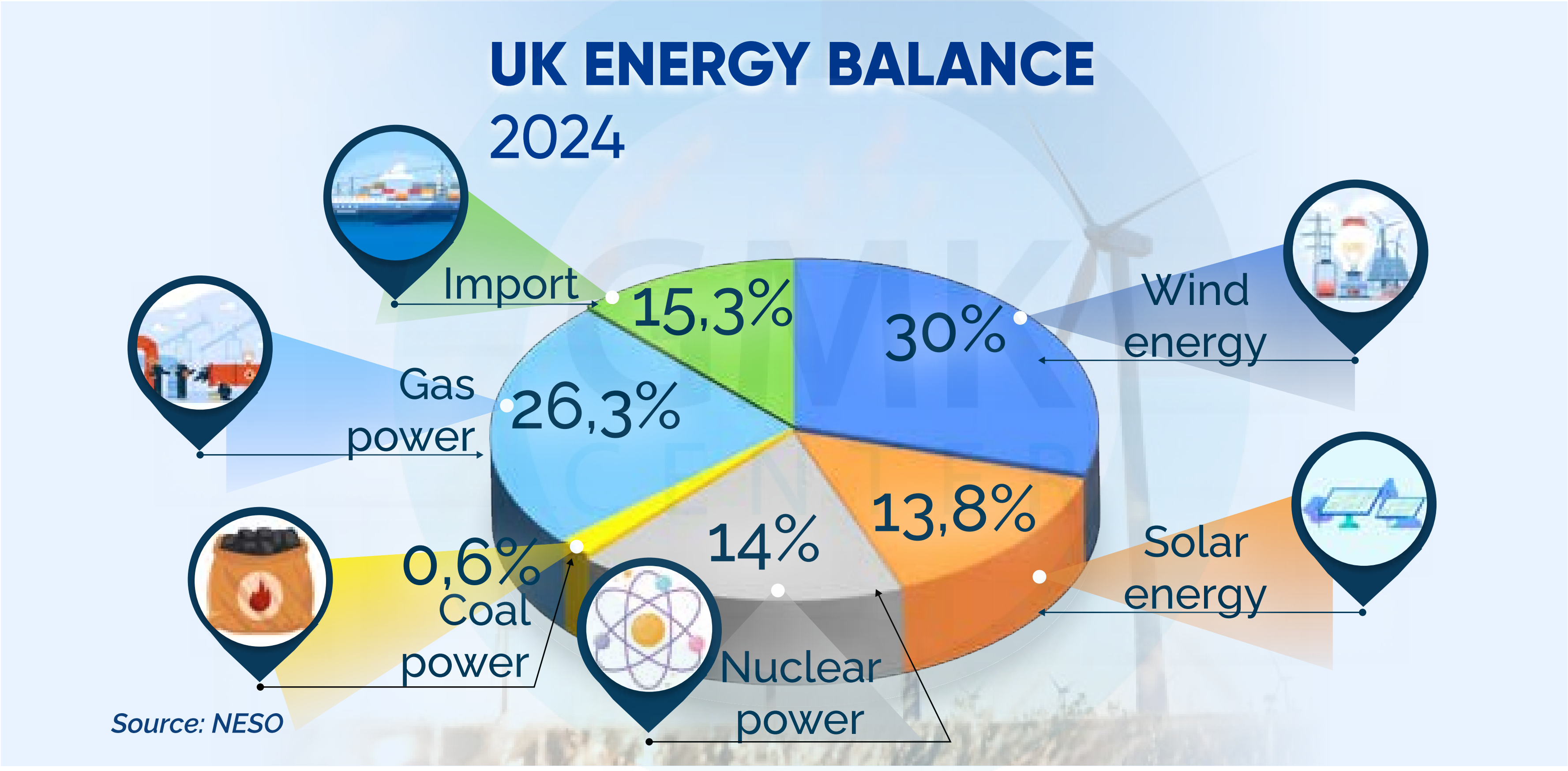
However, even now, green energy in the UK is 60% more expensive than in European countries, according to the UK Metals Council.

That is, the owners of Port Talbot and Scunthorpe have a clear understanding that their investments in the EAF crossing are unlikely to pay off.

But it is also unprofitable to continue operating BF-BOF due to the high cost of CO2 permits. A stalemate situation requiring state intervention. And the state has intervened.

The government agreed to provide £500m to build the EAF at Port Talbot. Plus £80m for a compensation program because the project will result in the loss of 3,000 jobs. From October 1, 2024, blast furnace production at the plant ceased, and the EAF is scheduled to start up in 2027.

Here, the government also offered the owner, China's Jingye Group, £500m for the EAF transition. But the company declined because the government's shareholding would have been less than in the case of Port Talbot: 25% versus 40%.



Source: NESO

UK steel industry: how and why decarbonization failed

As a result, British Steel went into temporary state administration on April 12 this year. At the same time, Secretary of State for Business and Trade Jonathan Reynolds said that the authorities are ready to independently finance the creation of electric steelmaking at Scunthorpe.

He said £2.5bn has been set aside in the Sovereign Wealth Fund for this purpose.

From the point of view of prudent use of public funds, this is a strange decision to decarbonize: to take on the entire £2 billion cost instead of splitting it in half with the Chinese. Who may also have to pay liquidated damages after international arbitration.

Since Jingye Group hired law firm Linklaters in early June to work on recovering the money spent on British Steel.

And it should also be remembered that by taking responsibility for British Steel, the government has "pinned" the problem of future subsidies for its production on the British budget. Since the problem of the high cost of "green" electricity for EAF has not gone anywhere.

But, be that as it may, it can be stated: this year CO2 emissions in the British steel industry will be reduced by almost 70% due to the closure of blast furnaces of Tata Steel UK.

And if the construction of the EAF in Port Talbot and Scunthorpe goes according to schedule, in 2-3 years the UK will completely stop exporting steel scrap. As early as 2024, this amounted to 7.6 million tons.

This is a good reason for Ukrainian officials to think about how to ensure decarbonization of the Ukrainian steel industry in conditions when domestic scrap is already on the verge of shortage. And the availability of imported scrap is getting narrower and narrower.

But let's return to the British steel industry. Since the mid-2000s, steel production in the United Kingdom has fallen by half.

On the one hand, CO2 emissions have also fallen by more than 3 times. On the other hand, this is evidence of systemic problems in the industry unrelated to green transformation.

Deindustrialization is not the path to sustainable development.

The UK's Nationally Determined Contribution (NDC) calls for zero CO2 emissions by 2050 and an 81% reduction (compared to 1990) by 2035.

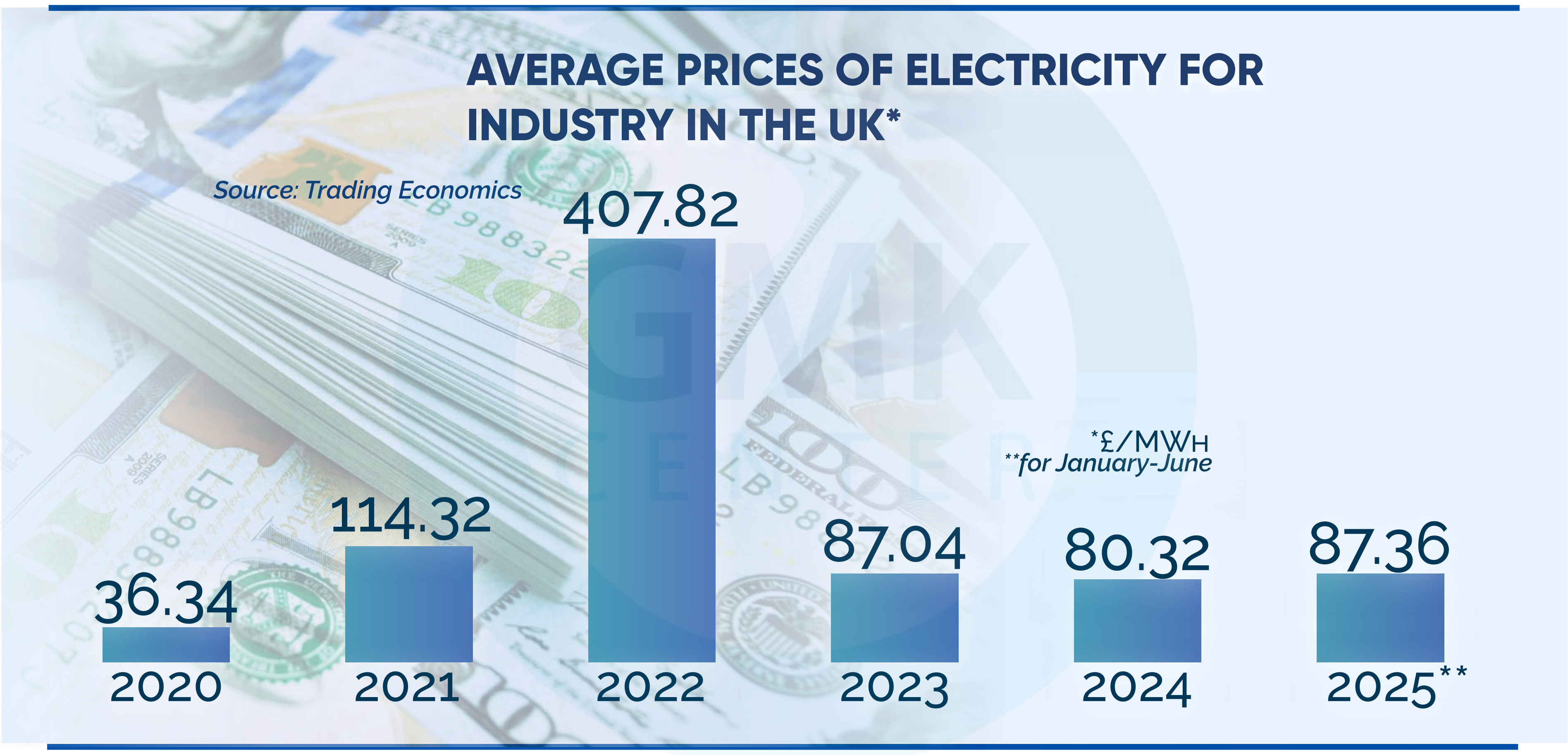
Tata Steel UK and British Steel claim that after the EAF transition their emissions will be at 0.85 tons per 1 ton of steel.

Taking into account that under BF-BOF production they were 2.4-2.6 tons – we can say that the reduction will be about 70%.

But this is already by 2030, if the implementation of projects does not drag on. Further reductions will obviously require the introduction of CCUS.

Other British steel producers are already using EAF and their specific emissions are very low.

For example, GFG Liberty Steel Rotherham, with a capacity of 1.98 million tons of steel per year, has 0.4 tons, according to the company.



UK steel industry: how and why decarbonization failed

7 Steel UK Cardiff (formerly Celsa Steel UK) with a capacity of 1.2 million tons has 0.417 tons, also according to the company.

That is, they have nothing to worry about until 2035. And then – the same CCUS, full transition to RES and H2-DRI.

But so far, producers have no such concrete plans. And some of them are clearly not in the mood for it now.

For example, Liberty Steel's plants in Rotherham and Motherwell have been idle for a year now.

The reason is the debt crisis of Sanjeev Gupta's company. And the consequent lack of working capital for operations.

Tata Steel UK has indicated in its roadmap that it is willing to consider building a 2 million tpa DRI plant – subject to financial support and a favorable business environment.

These include access to competitive natural gas and then to green hydrogen, which is not currently available.

Indeed in the UK there are currently no H2-DRI pilot projects either under development or under implementation.

By comparison, there are 23 such projects in the EU, according to the UK government.

The high cost of electricity in the UK is cited as the reason why companies do not want to invest in this area.

In the case of a complete transition of existing steel mills to hydrogen technologies, 1 GW of capacity is needed to cover their H2 needs.

The UK hydrogen strategy envisages 1 GW by 2025 and 5 GW by 2030. At present, there is no such capacity, i.e. the British have failed to fulfill Stage I. And there are no preconditions to catch up in the next 5 years.

British Petroleum has an interesting project to build a 500 MW HyGreen Teesside plant. This figure was planned to be reached by 2030, and this year the first 80 MW module was to be commissioned.

Products from this plant could have been sourced from British Steel's future electric steel smelter at Lakenby, in the Teesside Industrial Estate.

But. so far this plant is only in British Steel's presentation materials.

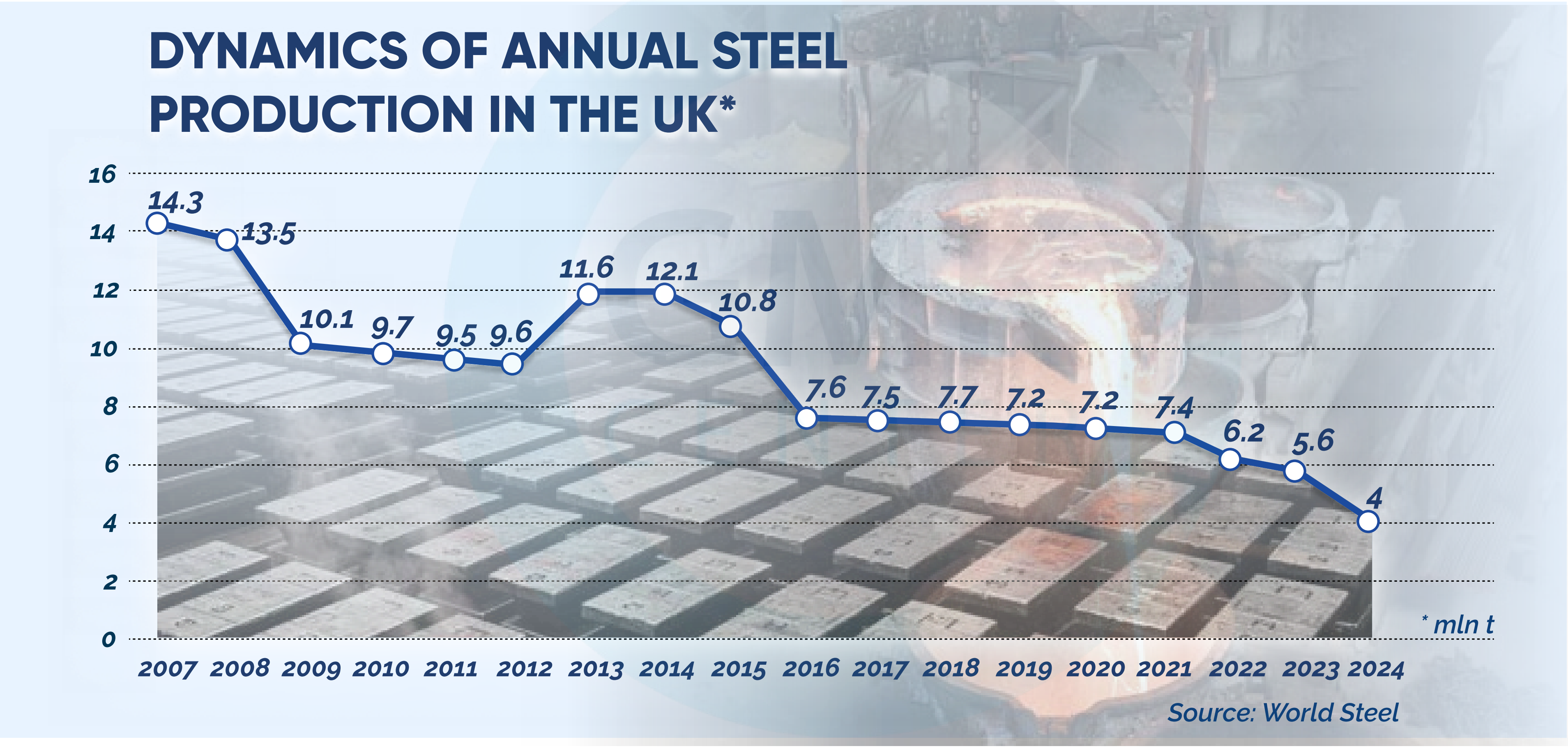
Oh, and British Petroleum officially announced in March this year that HyGreen Teesside has been "frozen" indefinitely.

Similarly with CCUS. Previous governments have twice tried to launch CCUS in the UK. But those programs were canceled in 2011 and 2016.

The current approach, launched in 2018, aims to create 4 CCUS clusters. The fact is that these are too large-scale and expensive projects for a single company.

Therefore, it is proposed to combine a number of industrial companies from different sectors for transportation and storage.

The authorities set a goal of capturing and storing 20-30 million tons of carbon per year by 2030. In December 2024, the Ministry of Energy and Net Zero concluded that the target was not achievable.



UK steel industry: how and why decarbonization failed

It has yet to set revised targets. However, at the same time, in December 2024, the Department of Energy announced the signing of contracts with the first two projects in the East Coast cluster, which includes Teesside and Humberside.

They are expected to be operational in 2028. But it cannot be asserted now that this will be the case, given previous negative experiences.

Even despite the financial support of £21.7 billion over 25 years declared in March 2023 by the British Treasury.

Hope for CBAM

The only thing that is certain is that the announced EAF transition in the UK steel industry will still take place around the announced timeframe.

As noted, there are already opportunities to provide it with clean electricity. The problem of affordability remains to be solved. Because there will be no decarbonization without cheap and affordable electricity.

Only large capacities can provide it. Actually, this applies not only to the UK, but also to other countries. Including Ukraine.
That is why the British government pursues the goal of further expansion of RES infrastructure.

The National Action Plan «Clean Energy 2030» envisages a significant increase in installed RES capacity over the next 5 years. Increasing the supply of green energy should reduce its cost, in line with market laws.

The UK Green Energy Program envisages an increase in capacity by 2030:

- Onshore wind power to 29 GW, up from 15.7 GW in 2024;
- Solar power to 45 GW, up from 18 GW in 2024;
- Offshore wind power to 43 GW, up from 14.7 GW in 2024;

Secondly, the introduction of CBAM UK, scheduled for January 2027, will significantly limit the access of imported steel to the UK market.

Preliminary calculations by British Steel show that in such a case, at the expense of Scope 3, even clean steel from the Gulf will not be able to compete with local steel.

In this case, British producers will be able to increase their sales margins and volumes. This, in turn, will make it possible to painlessly buy green electricity for production needs.

And rising prices for steel products will make it possible to pass these costs on to end consumers.

Green steel: how it will be done in Canada

Decarbonization of the industry in the country is based on four components

Canada has significant advantages for the green transition in steel industry. First of all, it has vast reserves of iron ore – about 6 billion tons. They make it possible to produce carbon-free raw materials for steelmaking.

And not only for our own needs, but also for export.
The country ranks 6th in the world in terms of generation of energy from renewable energy sources (RES), which is necessary for emission-free steel production. Canada's RES potential can be called colossal.

It is mainly hydropower and wind power.
Finally, investment opportunities of steel companies and state support of decarbonization in Canada are at a rather high level.

Adding up these factors, one would expect the local steel industry to move quickly towards net zero. But how is this actually playing out?

Industry summary

Over the past few years, steelmaking in Canada has been holding at roughly the same level. On the one hand, this indicates the stability of the industry and a fairly strong defense of the domestic market against imported steel products. On the other hand, it may indicate stagnation.

In addition to the iron ore reserves mentioned above, the country has large coal deposits, 6.58 billion tons. This predetermined the emphasis on the BF-BOF model for local stee sector.

Despite this, its contribution to the total greenhouse gas emissions of the Canadian industry and economy can be assessed as insignificant.

Almost all major CO2 emitters are located in the province of Ontario. They are integrated BF-BOF mills ArcelorMittal Dofasco, Canada's largest steel producer with an annual capacity of 4.05 million tons, Algoma Steel, Canada's leading producer of hot-rolled and cold-rolled steel with a capacity of 3.2 million tons and Stelco with a capacity of 2.5 million tons. Only Rio Tinto's small 0.6 million tons plant is located in Quebec.

Of these, ArcelorMittal Dofasco and Algoma Steel have opted for the H2-DRI-EAF model, while Stelco is still undecided on a strategy.

Nevertheless, in accordance with Canada's international commitments and the federal government's plans, all steel companies must achieve zero greenhouse gas emissions by 2050.

Company plans

ArcelorMittal's $1.8bn decarbonization project at Dofasco's Hamilton mill starts in October 2022, with a 2.5m tpa DRI plant and a 2.4m tpa EAF.

The equipment will be supplied by Italy's Danieli&CSpA and Tenova SpA.

As part of the project, the old coke battery No. 1 was dismantled at the plant. A new production complex is being built in its place. The modernization of the existing EAF and CCBM is also envisaged. After that, the mill's capacity will be reduced to 3.57 million tons of steel.

Completion of the works was previously planned for 2026. However, this year the local media reported about some delays in the progress of the project. However, it envisages a transition phase until 2028, during which BF and EAF are to be operated in parallel.

DYNAMICS OF STEEL PRODUCTION IN CANADA*

6 BLN TONS
of iron ore reserves in Canada

And the ArcelorMittal Dofasco decarbonization roadmap envisages only a 25% reduction in emissions by 2030. Whereas full implementation of the EAF transition at Hamilton will yield a 60% reduction.

Thus, we can now say that the company is not out of the planned schedule.
The process is going faster at Algoma Steel in Sous-Saint-Marie.

In July of this year the first unit of the new EAF, which will replace the blast furnace production, started its commercial operation.

However, the Algoma project started a little earlier, in 2021, while ArcelorMittal started work in January 2023.

A total of two EAFs with a capacity of 250 tons each are to be built at Sous-Saint-Marie, with Danieli also acting as equipment supplier.

Once the EAF is fully operational, the mill's CO2 emissions will be reduced by 70%. This should happen by 2030. It is worth noting that the pace of construction is constrained by the grid capacity of the local power industry.
The remaining 30% comes from the heating furnaces of the plate rolling complex, as well as leveling furnaces.

These emissions will be reduced by converting the units from natural gas to electricity and synthetic biogas.

It is worth noting that both facilities are connected to the Ontario power grid, where e/e is already 93% carbon-free.

Thus, Canadian steelmakers, unlike their counterparts in most countries, do not need to invest in building their own renewable energy capacity. This means their path to net zero is much faster and shorter. And cheaper.

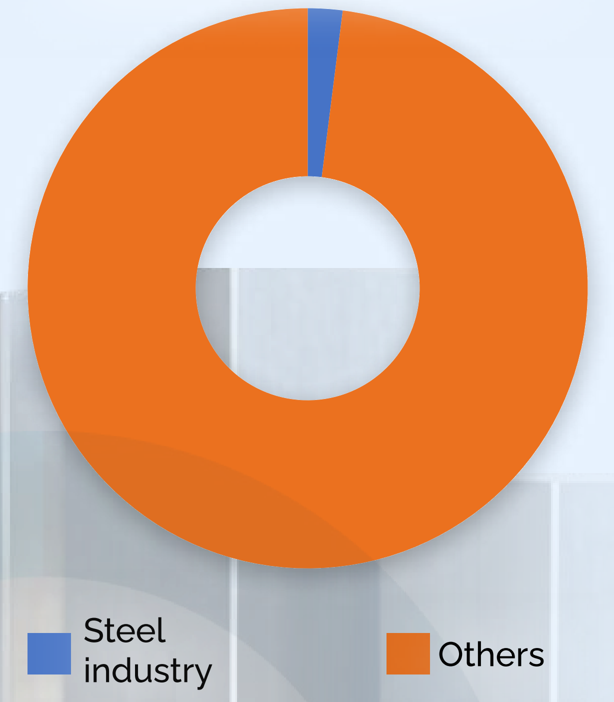
As noted above, Stelco is the only major producer with BF-BOF capacity that does not have an approved decarbonization roadmap. That said, the company did replace liners and modernize BF in 2020.

This is a significant investment and blast furnaces can typically operate for up to 20 years after lining replacement. It follows that Stelco does not plan radical decarbonization measures until 2040, only BAT.

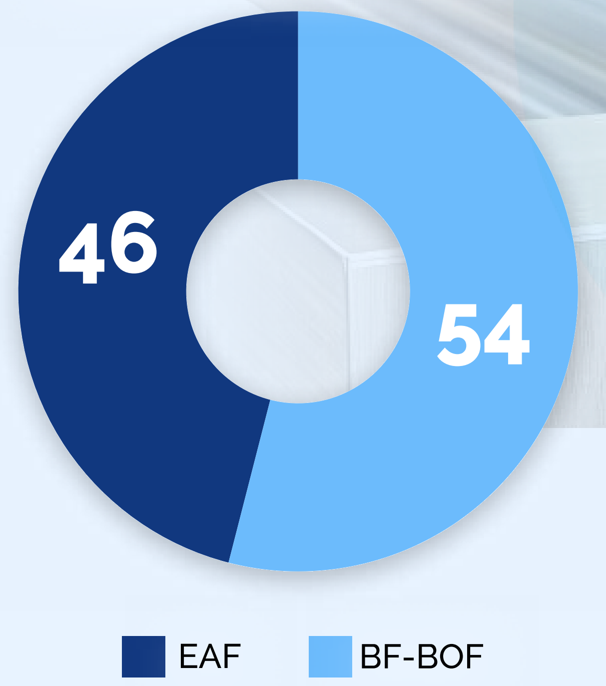
Also, 2 ArcelorMittal Montreal plants in Quebec with a total capacity of 2.4 million tons of steel per year do not have a roadmap with target benchmarks.

But since these plants operate on the EAF, there is really no hurry with their final "greening".

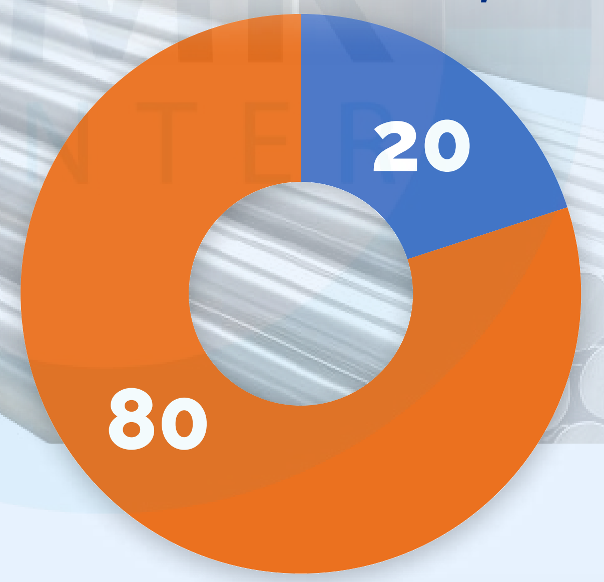
THE STEEL INDUSTRY'S SHARE OF CO2 EMISSIONS IN CANADA'S ECONOMY, %



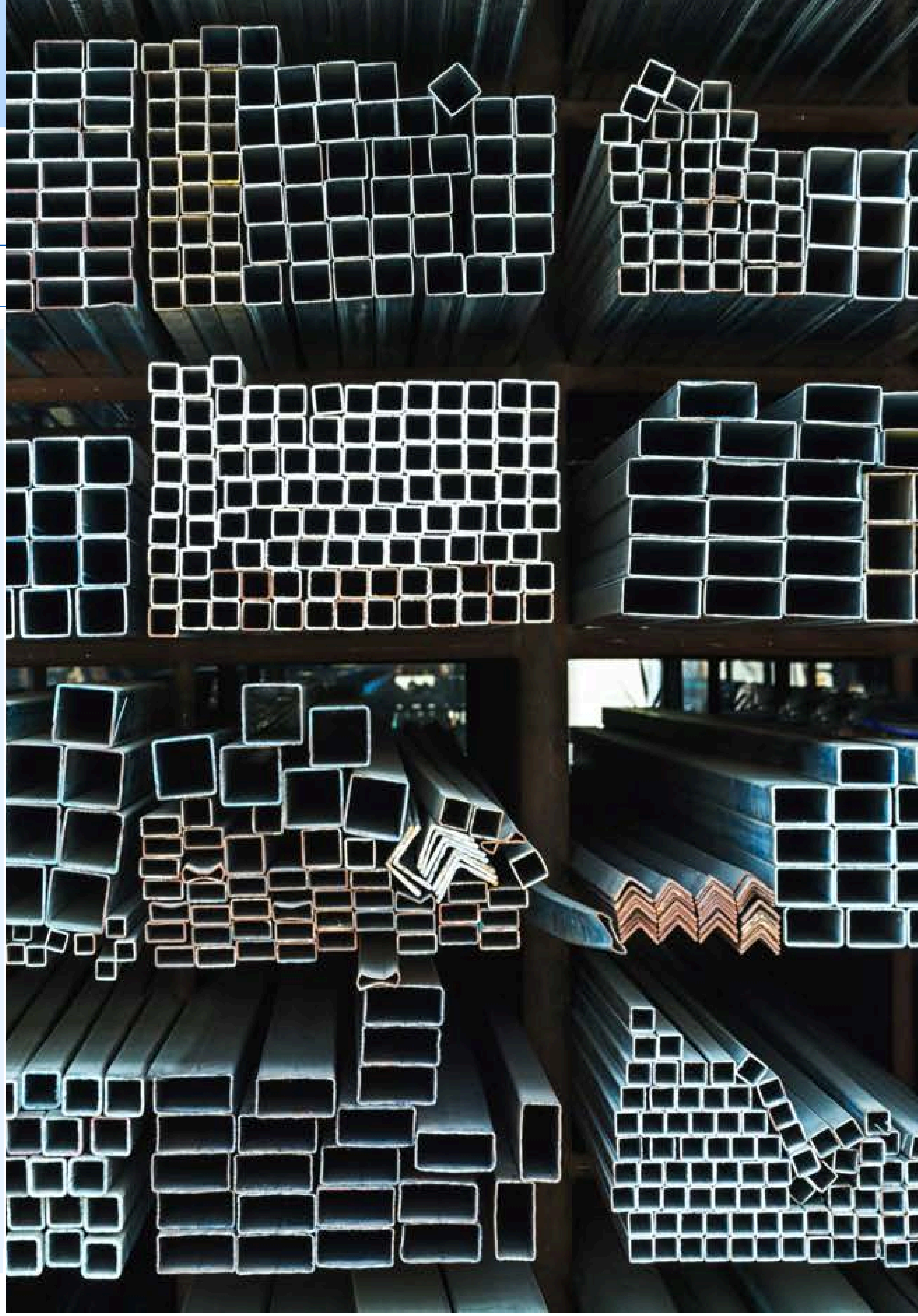
CANADA'S STEEL INDUSTRY BY TYPE OF PRODUCTION, %



THE STEEL INDUSTRY'S SHARE OF CO2 EMISSIONS IN CANADA'S INDUSTRY, %



Source: Lund University



Green steel: how it will be done in Canada

The same applies to Evraz Regina Steel Works in Saskatchewan with a capacity of 1.2 million tons of steel per year and Gerdau in Whitby (Ontario) with a capacity of 1.1 million tons.

Given the small steelmaking volumes at Rio Tinto Iron&Titanium (RTIT) in Quebec, the decarbonization strategy for this facility is optimal. Rio Tinto will convert its furnaces from conventional steel coal to biochar.

Rio Tinto, together with the US Aymium, is building a plant for its production here in Quebec on the site of a former pulp and paper mill. It is scheduled to be commissioned by the end of this year.

This will reduce RTIT's emissions from steel production by 70%. The remaining 30% should be absorbed by Blue-Smelting technology, which provides for preheating of material before melting and utilization of steel gases.

At present, a pilot plant with a production capacity of 40 thousand tons per year is already in operation at the mill.

Resources for decarbonization

Local steelmakers have no problems with scrap supply. The volumes of scrap harvested exceed current needs.

And Canada can even afford to export scrap – 4.9 million tons in 2024, 4.8 million tons in 2023.

But that's for now. Once the EAF transition at Dofasco and Algoma mills is completed, the demand for this resource will increase dramatically. Therefore, we can expect restrictions on its export in the next year or two.

Speaking about DRI-EAF technology, only ArcelorMittal has working plans to build a DRI plant in Canada.

The only operating plant also belongs to this concern. It is ArcelorMittal's Port-Cartier plant located in Quebec with a capacity of 10 million tons of iron ore pellets and 1.65 million tons of DRI.

It currently uses natural gas, with a future switch to green or blue H2 envisioned.

Canada's annual H2 production is currently at 3 million tons. But it is mainly gray hydrogen. The country's largest plant for the production of green H2 with a capacity of 11,000 tons per year was supposed to start operating in 2023.

However, the project operator, the provincial state-owned company Hydro-Québec, has not yet moved to its implementation.

Nevertheless, approved in 2020. Canada's Hydrogen Strategy assumes that by 2050 the country will produce more than 20 million tons of H2. Moreover, the authorities emphasize that it can be not only green but also blue H2 produced from oil and natural gas – resources that the country has at its disposal in large volumes.

In any case, Canada intends not only to fully cover the needs of its economy in hydrogen, but also to establish its large-scale export.

The government expects that by 2050 it will exceed $50 billion in monetary equivalent at an estimated production and transportation price of $1500-3500/t.

. It is now in the range of $5000-12000/t in Canada. Therefore, widespread commercial application of H2 is still quite far away.

The development of H2-DRI production and EAF transition will require additional volumes of green power. In 2023, Canada's RES capacity was 20.4 GW.

At the end of 2025. The Canadian Renewable Energy Association (CanREA) forecasts an increase to 26 GW, by 2050. – To 58 GW.

Therefore, as noted, clean energy is something Canadian steelmakers need not worry about.

Green public policy

A judicious mix of incentives and regulation. This is how the Canadian government's green transition policy can be summarized.

In 2018, the country adopted the Greenhouse Gas Emissions Pricing Act, which, among other things, introduced a CO2 emission fee for industrial enterprises. It entered into force in 2019.

In parallel, from 2022, the government provides manufacturers with a tax credit of 60% of the cost of new equipment for capturing CO2 from the air, and 50% for all other equipment for capturing harmful emissions.

A 37.5% tax credit is allocated for new low-emission equipment for transportation and storage of products.

However, the Canadian authorities have not decided to introduce the SWAM, a duty on imports of products with a high carbon footprint.

Green steel: how it will be done in Canada

In late September 2024, then Prime Minister Justin Trudeau discussed this issue with the head of the European Commission Ursula von der Leyen. But there has been no progress since then.

The reason is the fear of spoiling the already difficult trade relations with the United States, the main foreign economic partner.

According to the Canadian Ministry of Finance, 76% of the exports of local companies with high CO2 emissions go to the US. Therefore, Ottawa does not unreasonably believe that Washington's retaliatory measures will prove too painful for the national economy.

A very important nuance is the targeted use of funds received by the budget from enterprises as payment for emissions. This is the main difference between Canada and Ukraine, where the money from the environmental tax goes partly to the state budget and to the State Energy Efficiency Fund, where it is not, of course, spent on decarbonization.

In Canada, on the other hand, the authorities invest the proceeds from emission fees exclusively in decarbonization projects. For example, the above-mentioned EAF-transition of the ArcelorMittal Dofasco mill, which cost $1.8 billion. Of this amount, $400 million is allocated by the federal government and $500 million is given by the Ontario authorities.

That is, the government's share in this project is 50%. This is quite a lot. For comparison, the declared share of government financing of the EAF transition for the British steel mill Port Talbot is 40%, for the Australian Whyalla Works – 23%. Largely due to this, decarbonization of steel industry in Canada is progressing more successfully than in other countries.

Australian green steel: two vectors

Australia can play an important role in the decarbonization of Asia-Pacific metallurgy

Australian steel companies are taking different paths to achieve carbon neutrality. The first one is based on proven and available technologies that guarantee the result.

The second involves the development of fundamentally new solutions capable of turning the steel market upside down. As a result, some companies already have clear benchmarks for reducing greenhouse gas emissions. Others are still quite uncertain.

In both cases, decarbonization will lead to a structural transformation not only of the steel industry itself, but also of the iron ore industry – the backbone of the Australian economy. Therefore, changes in the industry are receiving serious government support.

The main players in the industry are divisions of large international corporations BlueScope and Liberty Steel. Australian Steel Products Ltd. is part of BlueScope.

It owns Port Kembla Steelworks (New South Wales) with a capacity of over 3 million tons of steel per year. It is a leading producer of flat-rolled products.

Liberty Steel's main asset is Whyalla Works (South Australia) with a capacity of 2.6 million tons of steel, the largest producer of long products.

The combined melt output of these facilities in 2024 amounted to 4.8 million tons. This is down 11% from a year earlier. The decline reflects the problems of the Australian steel industry: high cost of natural gas and weak domestic market protection in the face of aggressive imports from Southeast Asia.

Both mills operate on BF-BOF technology and now have average emissions of 2.07 tons per 1 ton of crude steel.

The owners of the mills are actively pursuing decarbonization as the Australian government aims to achieve a carbon-free economy by 2050.

EAF transition with a question mark

Liberty Steel Australia can be considered the pioneer of the process. It has staked on the EAF transition.

To this end, GFG Alliance, Liberty Steel's parent company, contracted Italy's Danieli in April 2023 to supply equipment and build a 1.6 million tpy EAF to replace the existing BF.

The new furnace will be powered by electricity from renewable energy sources (RES). The project was expected to be completed by the end of this year at a cost of $485 million.

Plans also include the construction of a 1.8 million tons per year DRI plant, here in Waialae.

This facility will produce products from raw materials mined at Liberty Steel Australia's Tamura iron ore plant in New South Wales..

The cost of this project is estimated at $593 mln. Thus the company will solve the problem of resource supply of EAF-production. Which, as it is known, cannot use ordinary iron ore for steelmaking.

The challenge for the project is the limited supply of NG in South Australia, which is necessary to produce DRI.

The construction of a floating LNG terminal at the Port of Adelaide, previously announced by Venice Energy Group, could offset the risks in the first phase. Its representative specified that the facility is aimed at receiving imported LNG. Probably from the Middle East.

In the future, DRI's production at Wyalla is planned to switch to green H2 instead of NG. The hydrogen plant should become a part of the future complex.

Liberty Steel Australia therefore intends to switch to emission-free steelmaking as early as 2030. However, the realization of this plan is in question, based on the difficult situation of the European assets of GFG Alliance.

Liberty Steel, a member of the GFG Alliance, is facing serious financial difficulties after the bankruptcy of its main creditor, Greensill Capital, in 2021. Therefore, the Czech mill Liberty Ostrava was sold to SPV NH Ostrava and SPV NH Koksovna.

Liberty Steel plants in Luxembourg (Dudelange) and Belgium (Liege) have not found any buyers for 2 years, and, apparently, they are close to final closure.

The Romanian steel mill Liberty Galati is in bankruptcy and management has been transferred to a consortium of administrators.

Hence doubts about Liberty Steel's ability to decarbonize its Australian assets by 2030.

4,8 MLN TONS
of steel were produced by Australian enterprises in 2024

Australian green steel: two vectors

A new concept for EAF transition

This option has been chosen by another company, Green Steel of Western Australia (GSWA). This is a new player that has decided to enter the local market in anticipation of the prospects associated with the growing demand for green steel.

Right now, the company does not have its own production facility. But it is building an EAF plant in Kohli with an annual capacity of 450,000 tons. The plant will produce rebar and wire rod. Commissioning is scheduled for 2026-2027.

GSWA is also building a DRI plant in Geraldton. Its design capacity is not disclosed. But it is known that the volume of investments will amount to $1.74 billion.

it is a large enterprise with capabilities far exceeding the company's own needs. Therefore, it is obviously planned to export its products.

The plant in Geraldton will start working on NG-DRI technology, in the future it is planned to switch to H2-DRI. Both enterprises of GSWA intend to use RES energy, i.e. it will be completely green production at once. The equipment for them will be supplied and installed by Danieli.

This is a good strategy with a modern concept. As you know, it is easier for small EAF plants to adapt to market realities and customer demands. They have more flexible marketing compared to large manufacturers.

Well, in the conditions of decarbonization DRI is needed everywhere. And first of all, steel companies in Southeast Asia, which will soon start looking for a replacement for traditional pig iron.

Betting on green iron

BlueScope has chosen a different path. By 2030, the company will reduce CO2 emissions by 12% compared to the base year of 2018 for Scope 1 and 2 and 30% for Scope 3.

This is expected to be achieved by increasing the share of scrap in raw materials to 30% from the current 25.4%.

It also plans to partially replace coal in BF with biochar and ramp up the use of PCI coal dust instead of coke.

In the future, BlueScope will abandon blast furnace production in favor of green iron produced in ESF electric smelting furnaces using H2 and RES. The corresponding technology is currently being developed.

The NeoSmelt project also involves local corporations Rio Tinto and GNR. In December 2024, the consortium selected the Kwinana industrial zone south of Perth to build a 40,000 tpa pilot ESF. It is scheduled to be commissioned in 2028.

The success of the research is difficult to predict. In addition, commercialization of H2-ESF-BOF technology will depend on the availability of green hydrogen at affordable prices.

BlueScope therefore does not set targets beyond 2030 in its roadmap, limiting itself to striving to achieve carbon neutrality by 2050.

The participation of major iron ore exporters Rio Tinto and GNR in NeoSmelt is not accidental. As is well known, they are among the main suppliers to steelmakers in Southeast Asia (SEA).

BF-BOF technology is now predominant almost everywhere there. But the challenges of decarbonization dictate the need to switch to either EAF or hydrogen pig iron production.

This means there is a need for new types of green iron ore raw materials.
For example, DRI. But it is problematic to transport it over the distances separating Australia from China, Japan, South Korea – the properties of the material are lost.

> In addition, according to Geraldine Slattery, Chief Executive Officer of BHP Australia, Australian DRI will not withstand competition.
> «Even with generous political support, the cost of production will be twice as high as in the Middle East or China – and customers are thousands of kilometers away,» she stressed, speaking at the Australia-China Economic Forum in Shanghai in July this year.
> Green iron is another matter.

That is why the third largest iron ore exporter Fortescue is also engaged in a similar project. The corporation has invested $50 million in the construction of an experimental ESF in Christmas Creek (Western Australia).

Its launch should take place by the end of this year.

And now it remains to be seen who will be the first to commercialize the H2-ESF: NeoSmelt or Fortescue? Either way, green iron could indeed become the backbone of the nation's steel exports, given Australia's RES and H2 production capabilities. In fact, it will usher in a new era for the global steel industry.

2,07 TONS

per 1 ton of crude steel are emissions from Australian steel mills

Government support for the green transition

In Q4 2024, the share of coal and gas-fired generation fell below 50% of Australia's total electricity generation for the first time.

And by 2050, it should be completely replaced by renewable energy sources. It is planned to commission 32 GW of new green capacities by 2030. Their share will reach 82%.

Thus, in the near future the energy basis for decarbonization of the economy, including metallurgy, will be created. H2 production, DRI, iron and steel smelting in ESF and EAF – all these processes will be able to use 100% clean electricity.

But every issue has a price. In 2024, the wholesale cost of electricity in Australia will soar by 83%. The reasons: reduced availability of coal power in the context of high demand and grid constraints in electricity transmission.

Obviously, a further increase in the share of renewables in the energy mix will lead to even higher electricity prices. Both for household consumers and industrial consumers. Then, due to economies of scale, the cost of green electricity will start to decrease. But first everyone will have to survive the price shock.

Therefore, the government has provided subsidies for the population in the amount of $300 per household. A total of $3.5 billion is allocated for this purpose in 2025-2027.

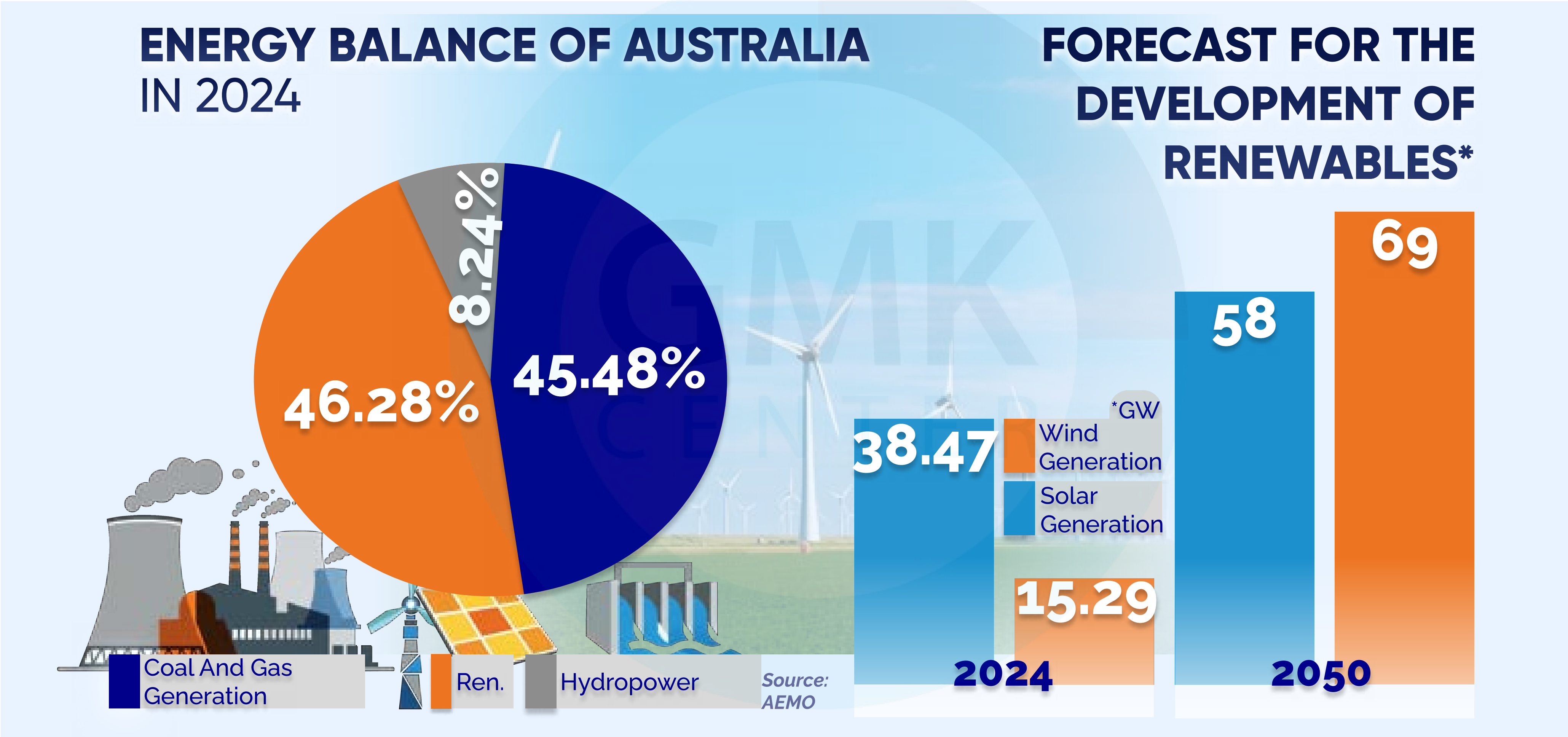
Business will not receive such direct support. However, the authorities will allocate $73 billion for the development of the energy sector.

The funds are intended for laying new power grids and modernizing existing ones. This should remove the problem of grid limitations, increase the dispatch capacity of the energy system and the availability of electricity for industry.

In addition, the H2 industry will receive strong state support. According to the National Hydrogen Strategy, approved in July 2024, tax credits of $2000/t are provided to green H2 producers from 2027. This type of subsidy will remain in effect until 2040.

Given the current average cost of $5000/t for Australia, according to the Department of Energy, Environment and Climate Change, this is quite significant.

Nevertheless, taking into account the consumption of 58 kg of H2 per 1 t of DRI, this product is 74% more expensive than conventional iron ore. The same economies of scale should reduce its cost.
By 2050. Australia plans to produce a minimum of 15 million tons of green H2 per year, and a maximum of 30 million tons.



The first interim target is set for 2030. – 0.5 million tons, for 2035 – 1.5 million tons. The required electrolyzer capacity for 2030 is 3 GW and for 2050. – tentatively 150 GW.

By expanding production, the cost of H2 should fall to less than $1000/t by 2050. At these prices, exports to Japan and South Korea, which are planning significant hydrogen imports to decarbonize their economies, become feasible.

Also as part of the strategy, the federal government is providing $327 million through the Hydrogen Energy Development Fund to establish hydrogen hubs in New South Wales, Queensland, South Australia, Tasmania and Western Australia. Other existing initiatives that can be utilized by the meth companies include the following:

- The National Renewable Energy Fund (NRF) is allocating $1.96 billion to fund renewable energy and low-CO2 technologies. This category includes Liberty Steel and BlueScope decarbonization projects, as well as the GSWA project. An additional $650 million is being directed to value-added resources.
- This program is available to NeoSmelt and Fortescue;
- The Australian Renewable Energy Agency (ARENA) administers $197 million in programs to support the transition to renewable and low-emission technologies and energy efficiency;
- The Federal Government's Green Iron Investment Fund, established in March 2025 as part of the Future Made in Australia plan, has received $1 billion in equity funding for decarbonization projects in the steel industry;

It is important to emphasize that these are not mere declarations of intent, but quite working initiatives. For example, Liberty Steel Australia was able to obtain $63.2 million from the federal government and $50 million from the state of South Australia to build the EAF in Wyalla.

This is more than 20% of the project cost. The federal government announcement indicates that in total up to $500 million from the Green Iron Fund is being allocated to Liberty Steel. Apparently, the amount includes the H2-DRI plant project.

Thus, the Australian steel industry has all the prerequisites for successful decarbonization due to the huge resource potential in the field of RES and H2, as well as strong government support.

However, additional measures will be required from the government in the form of tariff protection for the domestic market, similar to the European CBAM. Without them, the future of the industry is in doubt even after the completion of the green transition.

32 GW
of new green capacity is planned to be commissioned in Australia by 2030

Local players rather than global companies can ensure the success of Brazilian metallurgy decarbonization

Brazil's steel sector could easily be green by now. As recently as 2023, 93% of all electricity (e/e) generated here was from renewable energy sources (RES), according to the Global Energy Monitor.

The country also has the world's second largest reserves of high-quality iron ore (Fe60-67), which does not require additional beneficiation. Finally, it has a fairly well-developed gas production. Plus the possibility of importing gas from neighboring Argentina.

Thus, everything is in place to build a Middle Eastern model where 100% of steel is smelted using NG-DRI-EAF technology with average emissions of 1.3-1.4 tons of CO2 per 1 ton of finished steel products. However, EAF in Brazil now accounts for only 24% of steel capacity.

The remaining 76% is BF-BOF. Moreover, local steelmakers have to import all the coal and coke needed for their operation.

As a result, average CO2 emissions in Brazilian metallurgy amount to 1.7 tons. And it is problematic to reduce them for a number of reasons.

On the periphery of public policy

Why have EAFs not become widespread in Brazil? First, because of the lack of a resource base.

Scrap collection volumes are relatively small and, strange as it may sound, there are no DRI plants here.

And this is despite the huge investment opportunities of Vale SA corporation, the world's largest exporter of iron ore. The situation looks paradoxical. But.
DRI production here is unprofitable because of the high cost of natural gas. According to the Brazilian research center Energy Transition, the country ranks 3rd in the world in terms of gas prices.

Only Sweden and Finland are more expensive. And difficult production conditions are not the most determining factor. The main problem is the lack of a gas market.

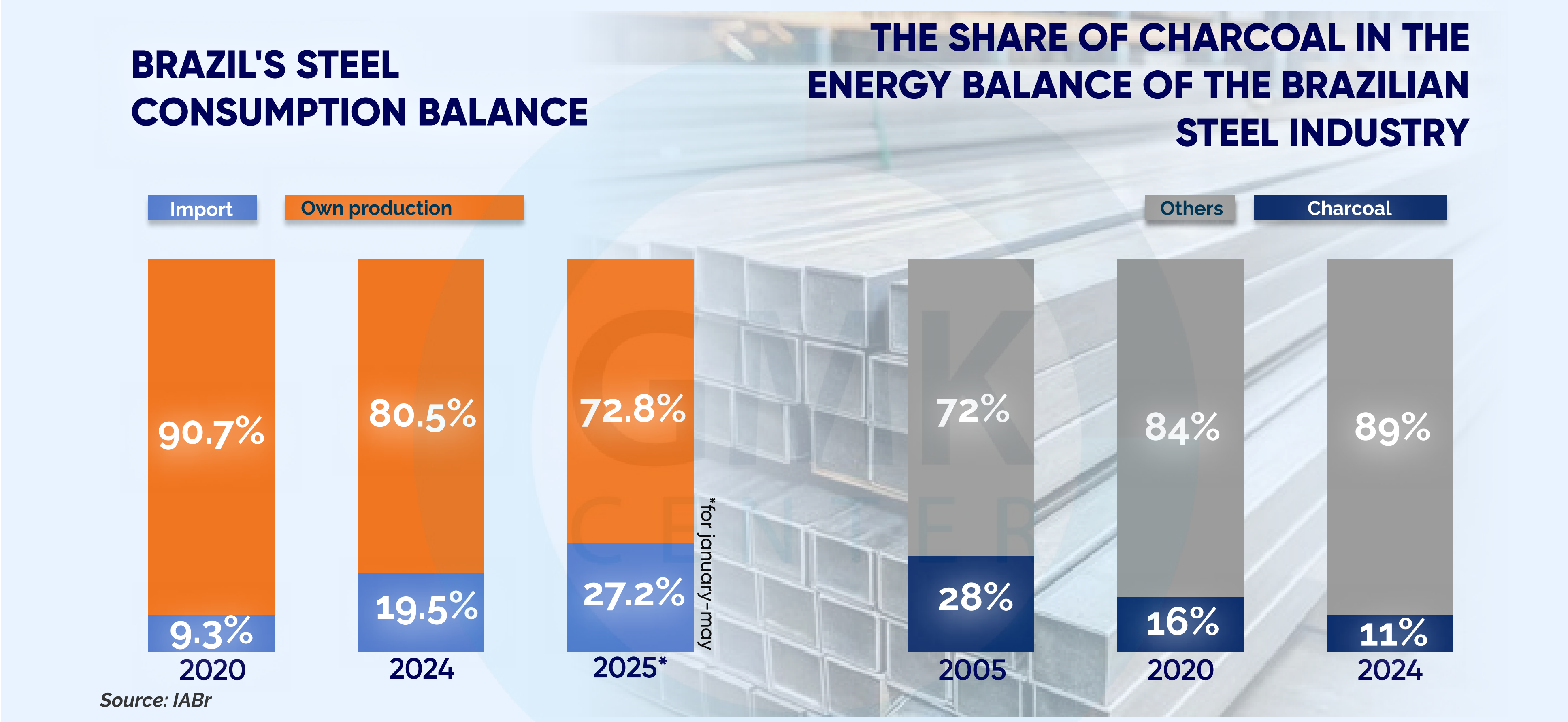
The state corporation Petrobras is an absolute monopolist in the field of supply. Accordingly, metallurgists cannot count on competitive prices. Plus extremely high taxes.

They account for about 26% of the gas price for consumers. That is why Vale is investing in the largest complex to produce 12 million tons of DRI/HBI per year in Saudi Arabia. And Ternium is planning a DRI plant in Mexico, but not in Brazil itself.

Second, EAFs allow higher quality steel to be produced. But it costs more than blast furnace-converter technology.

Therefore, it cannot compete with cheap imported steel products. This is exactly what foreign BF-BOF mills supply, mainly from China. Now they can do it unhindered, as there is practically no tariff protection of the domestic market.

Thus, in 2024, steel imports to Brazil soared by 24% to a record 6.23 million tons. Of this, 92% came from China.



And this is not an ad hoc surge. This is a multi-year trend.

Accordingly, Brazilian producers have no incentives to increase the share of EAF in total production.

This means that there are no prerequisites for growth in demand for DRI, the main raw material for electric arc melting of steel.

The next question is why is this happening? Probably the reason is that the steel sector accounts for only 4% of Brazil's CO_2 emissions. Whereas the agribusiness sector accounts for 65%.

Therefore, steel is not among the priorities in the national decarbonization policy, which aims to achieve a carbon-free economy by 2050.

Brazilian President Luiz Inácio Lula da Silva has repeatedly stated in public speeches the need for green steel production in the country.

However, the 2024 Industrial Decarbonization Action Plan does not directly address the steel industry.

Brazil's updated October 2023 National Emissions Document (NDC) does not identify specific mitigation measures or emission targets for the steel industry.

Company plans

Brazilian steel companies' decarbonization plans are quite conservative and based on the availability of local resources.

- ArcelorMittal Brasil, the largest producer, has pledged to reduce emissions by 10% by 2030 compared to the base year of 2018. This is to be achieved by increasing the use of scrap and natural gas in BF, as well as optimizing the use of charcoal;
- The second largest producer Gerdau has not set emission reduction targets at all. However, it is precisely this company that can afford to take its time. Its average emissions are 0.93 tons of CO_2 – because steel is smelted in the EAF and 73% of the raw material is scrap. Gerdau is also highly energy efficient and uses charcoal;
- Ternium aims to reduce its CO_2 emissions by 20% by 2030. This will involve increasing the use of scrap and RES, improving energy efficiency, and partially replacing coal with charcoal;
- Large flat-rolled steel producer Usiminas will reduce emissions by 15% by 2030 compared to 2019. The same instruments as Ternium will be used. Usiminas has invested $538 million in 2024 to modernize the BF at the Ipatinga mill, which accounts for 70% of the company's emissions;
- CSN Corporation will reduce greenhouse gas emissions by 10% by 2030 and 20% by 2035 compared to 2018 through operational efficiency improvements. CSN Group has implemented H_2 blowing into a kiln at its cement plant in the US as a pilot project. And now the developer, UTIS, will try to adapt this technology for blast furnace production in Brazil. CSN's iron ore division will reduce CO_2 emissions by 30% by 2035 and 100% by 2044;
- Vale Corporation will reduce Scope 1 and 2 greenhouse gas emissions by 33% by 2030 compared to 2017. By 2050. – By 100%. Including by increasing the use of RES to 100% compared to 84% in 2024. In 2022, the corporation launched the 766 MW Sol do Cerrado (Minas Gerais state) SES, one of the largest in Latin America. Other areas of decarbonization include replacing coal in sintering furnaces with biochar. Vale intends to reduce Scope 3 CO_2 emissions by 15% by 2035. Ways to achieve this: electrification of road and rail transportation, use of bioethanol and biodiesel as automotive and marine fuels.

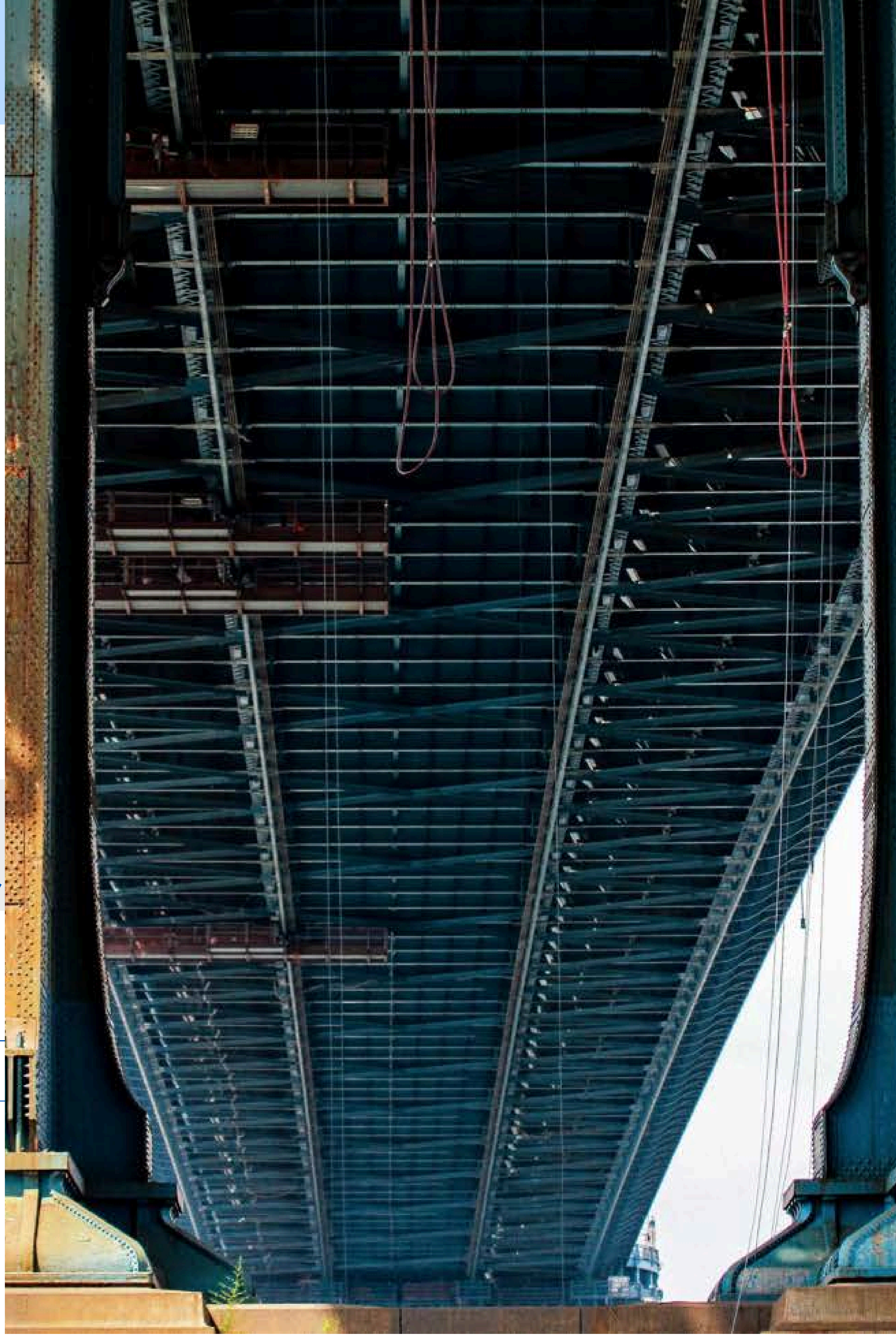
The problems are growing

Most Brazilian steel companies either do not declare carbon neutrality at all, or do not have medium- and long-term strategies to realize this goal.

And more ambitions are still held by local players rather than global ones.

> «We are not going to set goals that we cannot achieve,» said Marco Polo de Mello Lopes, executive director of the Brazilian Steel Institute (IABr).

In mid-August, Gerdau announced it was cutting back on investments due to the influx of Chinese steel.



According to CEO Gustavo Werneck, the decision reflects unfair competition from foreign producers, as well as the government's lack of trade protection measures to block the supply of subsidized steel from China.

Gerdau had already closed a plant in Minas Gerais in the first half of this year and laid off 1,500 employees. The company's other plants are operating at capacity, Werneck emphasized.

If steel imports to Brazil continue to grow, the company will have to resort to additional layoffs, he said.

At the same time, Gerdau will expand its operations in the U.S., given the more stable and predictable conditions in the North American market.

Obviously, this makes it really difficult for Brazilian companies to plan and implement decarbonization. The question is about the survival of the industry. And it is its own government that has driven it into such conditions.

It is possible that Brazilian officials consider the local steel industry to be "green" enough as it is. The average emissions from steelmaking are 1.7 tons of CO2. But this is only partially true.

The lower figure is due to BF's use of charcoal instead of metallurgical coal. However, not everyone shares this view.

For example, in the European Union, this material is not considered as environmentally friendly because of the emissions from its production, as well as the impact on the climate from deforestation.

According to the European assessment methodology, the average CO2 emissions in Brazilian metallurgy are 2.0 tons. And, for that matter, abandoning coal chips in favor of charcoal in blast furnaces is a huge step backward, a return to the technologies of the 18th century.

And we must also take into account the narrowing of charcoal utilization possibilities within the framework of forest protection policies. Therefore, in any case, companies cannot rely on this resource in the long term.

Ukraine: a reason to think

It can be assumed that the Brazilian authorities are in no hurry to close their steel market with duties because of the low cost of local products.

According to Energy Transition, the country ranks 3rd in the world in terms of cheapness of metallurgical production, thanks to its reserves of high-quality iron ore.

But this is due to the BF-BOF mills. Which in the process of decarbonization should be closed and EAF plants should be built instead. Or convert to hydrogen technologies together with CCUS. Both options require huge investments – $29.19 billion, according to IABr calculations.

The question arises: where will metal companies get such funds from, if they are up against cheap imports in the domestic market? In such a case it is possible to compete only with low sales margins.

And, accordingly, low profitability. But this is not all. Pretty soon, the investment opportunities of Brazilian steelmakers will shrink even more.

On December 12, 2024, Law 15.042/2024, which introduces a nationwide greenhouse gas emissions trading system (SBCE), came into force in the country.

The preparatory phase will last until December 12, 2028. Until that date, companies are only required to report their CO2 emissions. After that, they will have to pay for their emissions. This is likely to make BF-BOF production unprofitable.

It is worth noting that a similar situation is developing in Ukraine. Both countries have sufficient iron ore resources for the steel industry. But there is a shortage of scrap required for EAF transition.

The EU market is as important to the Ukrainian steel industry as the American market is to the Brazilians. And access to these markets is severely restricted.

For Brazil – by Trump's current duties, for Ukraine – by the prospect of the European EAF.

Therefore, Ukrainian metallurgists are also facing the need for decarbonization. Here, too, the authorities continue to work on launching a greenhouse emissions trading system (GET).

But at the same time, as in Brazil, the domestic steel market is very much under pressure from imports. Consequently, Ukraine's steel industry risks being trapped in the same trap as in Brazil.

GCC countries can play an important role in decarbonizing global steel industry

The absence of BF-BOF capacities allows companies in the Gulf Cooperation Council (GCC) countries to already produce low-emission steel, with average emissions of 1.13 tons of CO2 per ton of finished product.

And they have everything they need to transition to completely low-carbon production: huge investment resources plus enormous potential for renewable energy. If anyone in the world is going to be the first to succeed, it will be the GCC countries.

But they can do even more. And they can do it now. Cheap electricity plus virtually free natural gas, which reserves are incredible, is what allows the Gulf states to take the lead in global DRI production.

The main sales market could be the European Union, where, after the introduction of CBAM, replacing pig iron with low-carbon raw materials for steelmaking will become acute issue.

Step 1: complete transition to renewable energy sources

Despite similar starting opportunities, the pace of decarbonization in the GCC countries varies significantly.

Saudi Arabia and Bahrain have declared their intention to achieve zero CO2 emissions in their economies by 2060, while the UAE and Oman aim to do so by 2050. Qatar and Kuwait, on the other hand, have set more modest targets: a 25% and 7.4% reduction in emissions by 2035, respectively.

The volumes of planned investments also vary.

Saudi Arabia's Vision 2030 national strategy has earmarked $186.5 billion for renewable energy production and distribution projects by 2030. Meanwhile, the UAE government will spend $63 billion on these goals by 2050.

Accordingly, steel companies in the GCC are developing roadmaps based on national guidelines. Currently, the Gulf's steel industry consists entirely of EAF plants, which mainly use DRI for steelmaking. Even flat products at the Saudi Arabian Al-Ittefaq Steel Co. (ISPC) are produced from electric steel.

The absence of coal in the technological chain results in low CO2 emissions. Saudi Arabia's ISPC and Hadeed emit 1.4 tons per 1 ton of finished steel, Qatar Steel emits 1.34 tons, Emirates Steel has 0.67 tons (Scope 1 and Scope 2), and Oman's Jindal Steel Sohar has 1.05 tons. This allows GCC steelmakers to present their products as green. Given the global average of 1.37 tons for the DRI-EAF process, they are in a pretty good position. But there is still room for improvement.

Вкрай низький вуглецевий слід в Emirates Steel пояснюється тим, що компанія використовує 86% електроенергії з відновлюваних джерел (ВДЕ).

Emirates Steel's extremely low carbon footprint is due to the fact that the company uses 86% of its electricity from renewable sources (RES). Qatar Steel, on the other hand, has not yet used them in its production. And the company's roadmap for 2022-2026 does not even include any plans in this regard.

Hence, the twofold difference in emissions. Meanwhile, it is clear that a complete transition to RES is a task for the near future for all GCC steel producers.
This does not seem to be a difficult task, given the enormous financial resources in the Gulf countries and their natural potential.

The level of solar radiation in the region is 2,200-2,500 kWh/m2, one of the highest in the world. It is an ideal combination for the development of solar energy. And it is developing. But everywhere in different ways.

- The capacity of renewable energy sources in Saudi Arabia in 2024 was 4.5 GW. By the end of 2026, the construction of 11 more solar power plants with a total capacity of 11.4 GW is planned to be completed. By 2030, the share of renewable energy sources in the overall energy balance should reach 50%. One of the largest projects under development is the Al Shuaiba 2 solar power plant with a capacity of 2.03 GW.
- The capacity of renewable energy sources in the UAE in 2024 was 6.3 GW, accounting for 27.8% of the energy balance. By 2030, this figure will grow to 32%. However, it could increase even more if the authorities ensure the implementation of landmark projects: the construction of two solar power plants in Abu Dhabi, each with a capacity of 1.5 GW, and the sixth phase of the MBR solar park with a capacity of 1.8 GW.
- In April this year, Qatar opened a complex of two solar power plants with a total capacity of 0.875 GW. The project cost $630 million. As a result, the total renewable energy potential reached 1.675 GW. By 2030, it should increase to 4 GW, mainly due to the construction of the 2 GW Dukhan solar power plant. It is scheduled for completion in 2029. After that, the share of renewable energy in Qatar's energy balance will increase to 35%.
- In Oman, two solar power plants, each with a capacity of 500 MW, began operating this year. The share of renewable energy in the energy balance has reached 10%. In June this year, the country's Ministry of Energy announced the launch of two projects to build two wind farms (Oman is the only country in the region with the potential to develop wind energy) with a total capacity of 2 GW.

- They are scheduled to be commissioned at the end of 2027. By 2030, the share of renewable energy sources should grow to 30%.
- Bahrain's National Renewable Energy Action Plan envisages reaching 5% of renewable energy sources in the energy balance in 2025 thanks to the construction of the Shams Al-Dour solar power plant. This is the first such facility in the kingdom. By 2035, this figure will increase to 10%. For now, Bahrain's energy sector is 100% gas-powered.
- In 2022, Kuwait received only 0.3% of its electricity from renewable energy sources, with a target of 5%. Meanwhile, by 2030, it should reach 15%. Currently, the country has only one 30 MW solar power plant in Al-Jahra, which only began operating this year. The media reported on a proposal by a group of investors to build a 5 GW solar power plant complex in Kuwait. However, the initiative did not find support from the authorities.

Thus, there are clear leaders in the region in the field of decarbonization of steel indudstry, and there are laggards.
This is directly related to government policy on the development of renewable energy.

Step 2: transition to hydrogen

The raw materials for DRI production in the Gulf countries are imported iron ore and local natural gas, of which there are enormous reserves. Therefore, the region is a world leader in this field.

Accordingly, a significant share of CO_2 emissions in the countries' steel production comes from DRI production – 0.89 tons per ton.

Therefore, the next stage of decarbonization will be the replacement of natural gas in heating furnaces with hydrogen.

Currently, Saudi Arabia, the UAE, and Oman have officially approved roadmaps for the development of hydrogen infrastructure.

The latter holds regional leadership in H2 production: it is home to 5 of the 10 largest existing and future plants in the Middle East, which are to be commissioned by 2030.

The Oman Vision 2040 program envisages $140 billion in investments in the hydrogen economy by 2050. This will enable the production of at least 1 million tons of green hydrogen per year by 2030, up to 3.75 million tons by 2040, and up to 8.5 million tons by 2050.

In this way, the sultanate will not only meet the needs for the complete decarbonization of its industry, including steel sector, but will also be able to export this resource. First and foremost to the European Union.

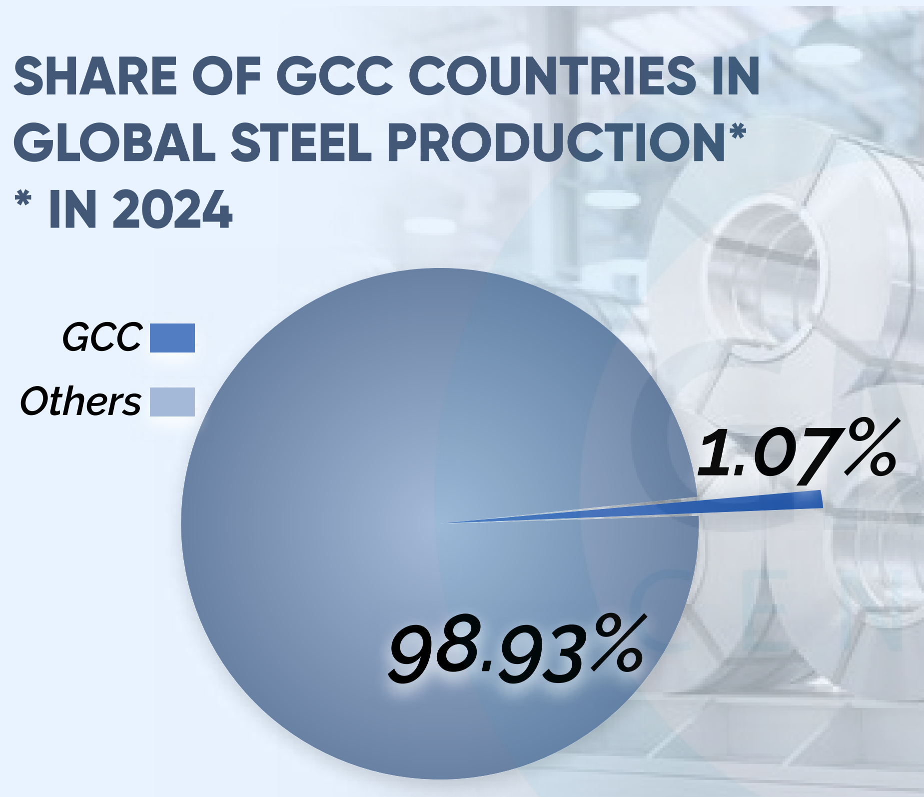
The UAE plans to produce 1.4 million tons of H2 per year by 2031, with production growing to 15 million tons by 2050.

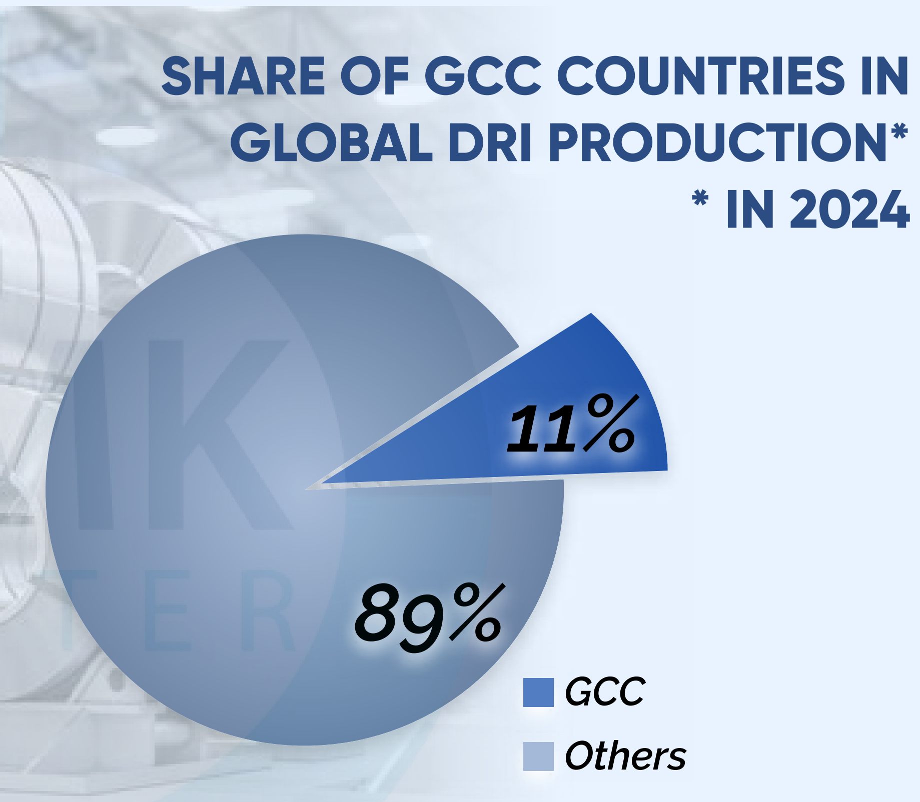
By 2031, the construction of two hydrogen plants powered by renewable energy sources will be completed there. By 2050, the number of plants will increase to five.

Saudi Arabia intends to produce 1.2 million tons of green hydrogen by 2030. By 2050, the kingdom has a much more ambitious goal: to cover 37% of global demand for H2.

The first project to decarbonize industry is currently being implemented there.

However, it does not relate to steel sector, but to the production of mineral fertilizers. We are talking about the $5 billion NEOM project, which includes a 4 GW green energy complex and plants for the production of green H2 and green ammonia. The first products are expected to hit the market in 2027.





Source: World Steel

0,89 TONS

of CO_2 are the average emissions of plants in the GCC in the production of DRI

There is currently no H2 production in Bahrain and Kuwait, while Qatar has an annual capacity of 1.2 million tons, but this is gray hydrogen, without carbon capture.

Step 3: CO2 capture and new projects

The GCC has enormous potential for CCUS. We are talking about depleted oil and gas wells, which are convenient for storing solid carbon after CO2 capture and utilization.

There is no need to spend money on setting up special storage facilities. However, this is not yet a very attractive option for the local steel industry.

The reason for this can be seen in the example of the largest regional economy.
Such a wide range, from $11 to $76/t, is explained by the varying degrees of CO2 concentration in flue gas.

It is highest in the production of mineral fertilizers. Therefore, its capture is not particularly difficult.

In contrast, during steelmaking, CO2 is produced in a very dilute form. Accordingly, this entails additional costs for its collection.

Therefore, there is currently only one active CCUS project in the regional steel industry. It is being implemented by Emirates Steel in conjunction with the oil and gas corporation ADNOC.

The CCU facility is located at the Al-Reyad steel plant and can capture up to 800,000 tons of CO2 annually.

The carbon obtained is then transported for burial at ADNOC's oil fields in Rumaythah and Bab.

The next project is expected to be that of Oman's Jindal Shadeed, which will begin in 2023.

. It involves the construction of a facility for capturing and processing CO2 into solid carbon with a capacity of 2,700 tons per year.

This will neutralize 700,000 tons of greenhouse gas emissions annually. The equipment is scheduled to reach its design capacity in 2027.

It is also worth noting that, unlike India, where the principle of "build first, decarbonize later" applies to steel capacities, all new steel mills in the GCC are immediately designed with carbon neutrality in mind.

- Jindal Shadeed is building a plant to produce 5 million tons of green steel per year in Dukma. The production will use green H2 and renewable energy sources. Construction is scheduled for completion in 2026.
- Saudi Aramco and the Saudi Arabian Public Investment Fund, together with China's Baosteel, are building a plant with a capacity of 1.5 million tons of steel sheet per year. Its equipment (EAFs and DRI modules) will be compatible with hydrogen without the need for additional modification;
- Brazil's Vale will build a large complex in Saudi Arabia to produce 12 million tons of CBI per year in the Ras-al-Khair industrial zone. In January of this year, Vale signed an agreement with local authorities to lease land for this purpose. Initially, production will run on natural gas, and later on H2.
- Bahrain Steel plans to increase DRI production to 24 million tons by 2028, compared to 12 million tons in 2019. Of this additional volume, 4 million tons are intended for the future steel mill of India's Essar Group in Ras-al-Khair. The company also plans to build a plant with a capacity of 5 million tons of DRI per year.
- Emirates Steel is set to launch a new plant with a capacity of 2.5 million tons of DRI per year in 2027. Construction was initially planned to be completed by March 2026. The deadline was then pushed back, likely at the request of the Japanese side. It is expected that about 50% of future production will be supplied to the new JFE Steel plant in Japan.

AVERAGE COST OF CO2 CAPTURE BY ENERGY AND INDUSTRY SECTORS IN SAUDI ARABIA*

Source: King Abdullah University of Science and Technology

800 TONS

of CO2 annually can capture the region's only facility operating CCU

Challenges and risks

At the end of May this year, Bloomberg reported on NEOM's difficulties in selling its products.

According to its sources, the operating company has only managed to contract half of its future production volume. In this regard, the launch date for commercial operation of the project will most likely be postponed to a later time.

Obviously, finding buyers for green steel is no easier than finding buyers for green ammonia. This explains the caution of local steel companies in promoting hydrogen technology.

So far, it is only operating in the pilot stage at the Emirates Steel plant in Abu Dhabi. Electrolyzers with a total capacity of 2.1 MW are installed there. They produce 350.4 tons of green H2 per year.

The product is immediately fed into the furnaces, where the DRI process takes place. This is the only project of its kind in the MENA region. And at the moment, there are no prerequisites for its scaling.

The GCC steel market is characterized by a high degree of openness. The only protective measure in place is a 10% anti-dumping duty on rebar in the UAE.

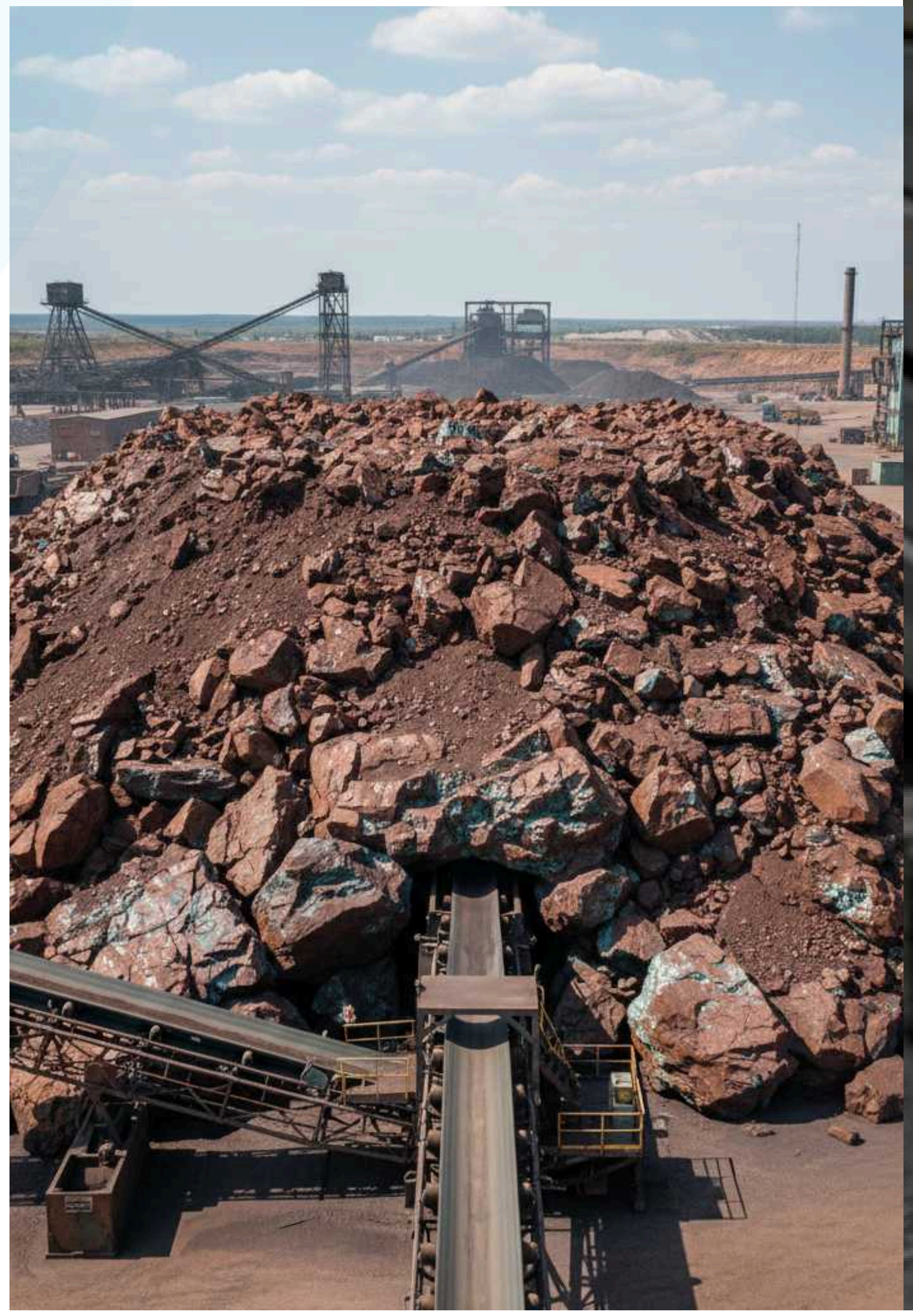
This means that local producers of low-emission steel have to compete with cheaper products from Southeast Asia, produced at BF-BOF plants.

And they cannot withstand this competition.

In the first half of July, Saudi mills' offers for commercial billets were at $496/t EXW (after a $16/t decrease compared to June). Meanwhile, Chinese importers were ready to supply at $456-465/t SFR.

Therefore, if anyone needs to urgently introduce CBAM, it is the GCC, not the European Union. In this case, the green transformation of the Gulf's steel sector could accelerate significantly.

The situation could also change dramatically if Saudi Arabia (and other GCC countries following suit) manages to achieve its goal of reducing the cost of producing green H2 to below $2/kg by 2030.



Countries in the region can compete with the Gulf as a supplier of resources for decarbonizing eurometallurgy

The economic potential of the North African states is based on the same resources as in the GCC: plenty of sunshine and oil and gas.

However, there is still less oil and gas here than in the Gulf. And this affects the investment opportunities for Egypt, Algeria, Libya and Tunisia in moving towards a carbon-free economy, including steel industry.

As for Morocco and Mauritania, there is virtually no oil and gas. There are, however, significant iron ore reserves. So do Libya, Algeria, Tunisia and Egypt. Therefore, the structure of regional metallurgy is identical to that formed in the GCC.

These are exclusively EAF-plants operating on locally produced DRI. That is, at this stage it is quite green production.

And very soon North African DRI will be in great demand in the EU, after the introduction of CBAM from January 2027.

Then the European steelmakers will need a replacement for pig iron smelted in BF. This sets the trends for the steel industry in North Africa.

DRI Driver

In recent years, North African countries have been increasing steelmaking due to strong demand for long products from the construction sector. But at the same time, DRI production is growing at a faster rate. This indicates its high export potential.

It will increase further in the future. This will be facilitated by the implementation of SWAM in the EU from January 2027, which is very soon.

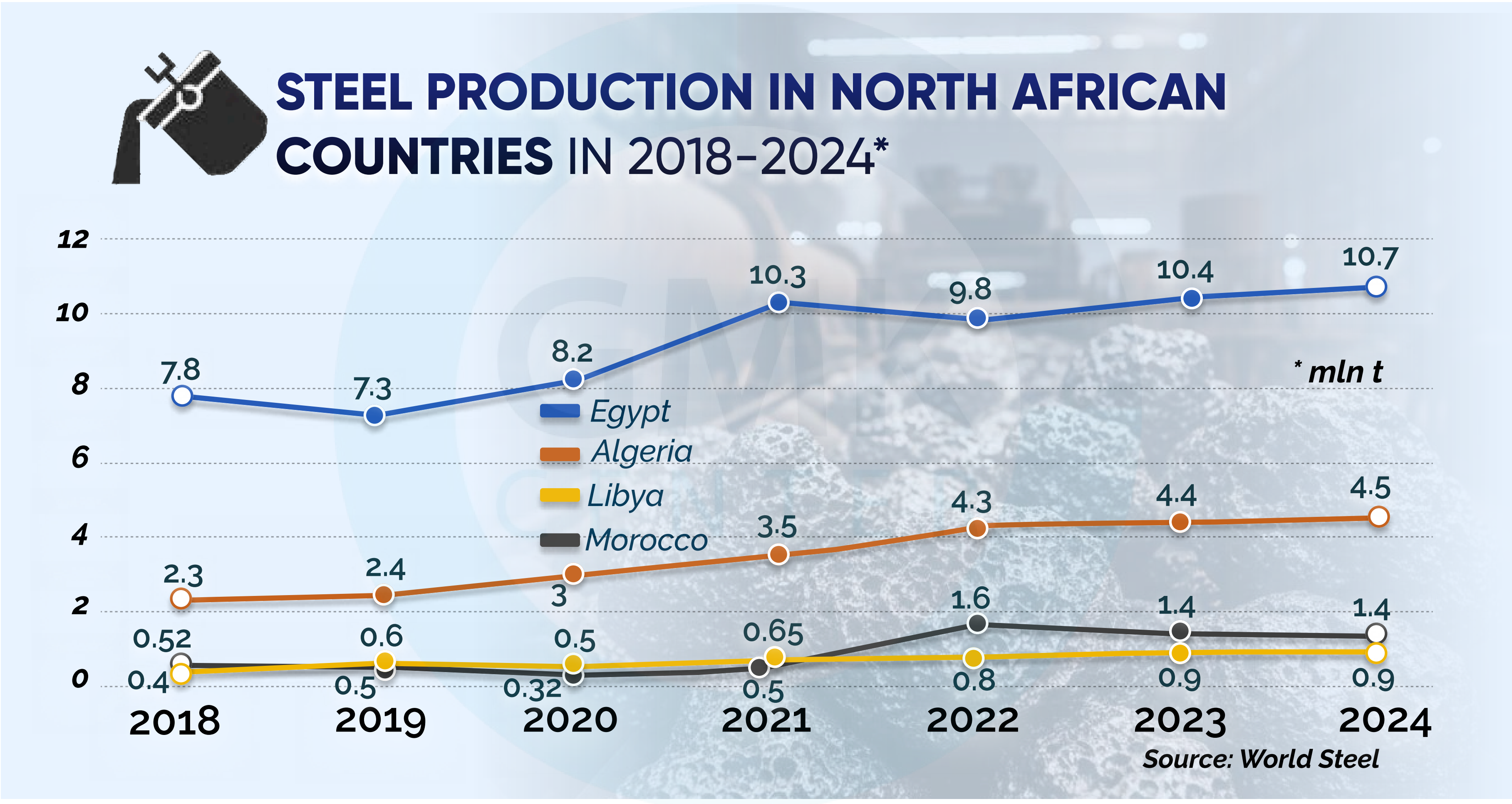
At that time, Euro steelmakers will need to replace pig iron with a low-carbon material for steelmaking to avoid additional costs. North African NG-DRI is well suited for such purposes.

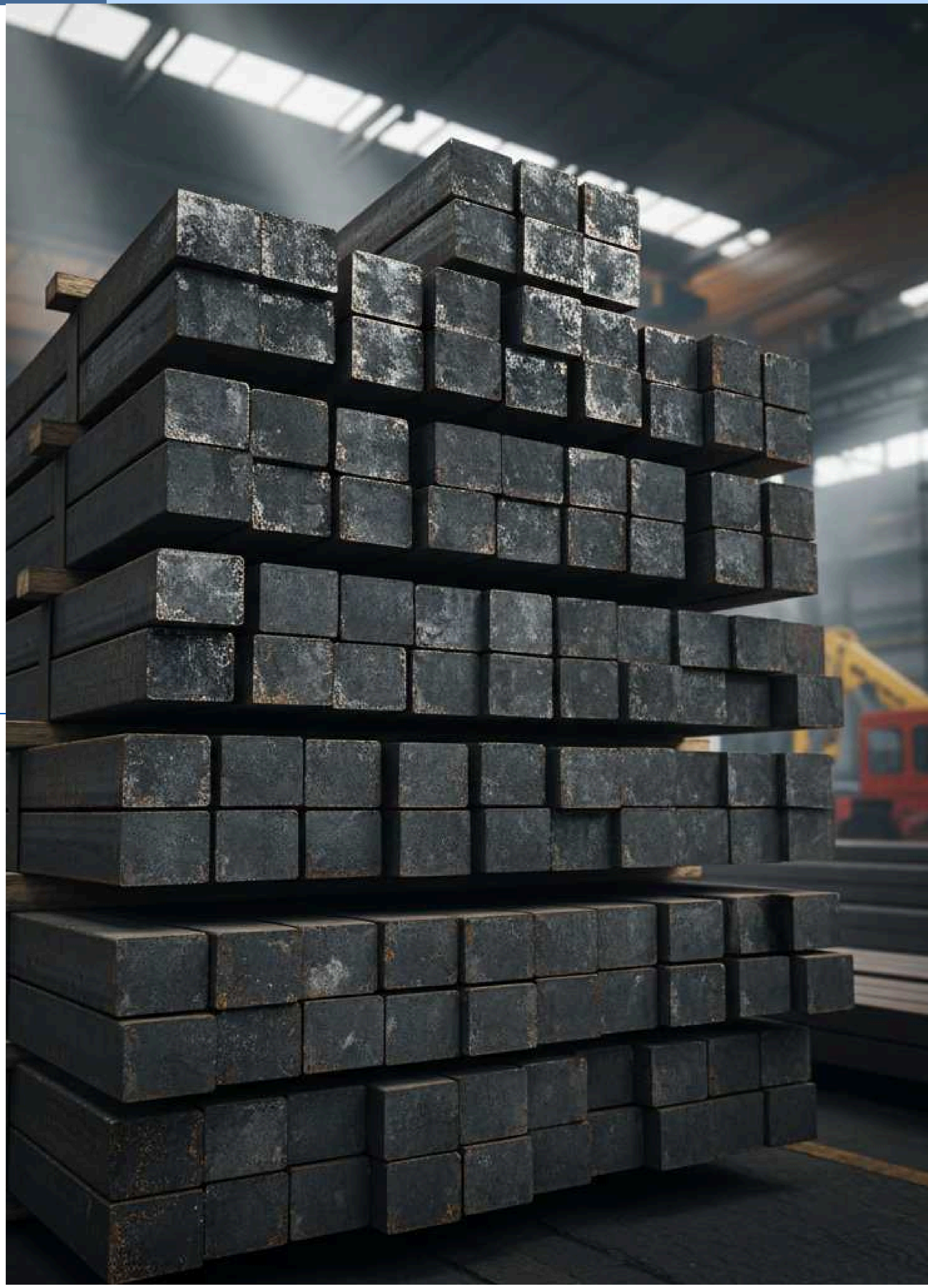
And it has a serious advantage in competing with Middle Eastern NG-DRI, due to the geographical proximity of Egypt, Algeria, Morocco, etc. to Europe compared to the Gulf region.

First, it gives consumers cheaper logistics. Secondly, less Scope 3 due to lower CO2 emissions during transportation.

Therefore, a number of new projects are now being prepared in the region.

- In Mauritania, state-owned SNIM, the second largest African iron ore miner, together with the CWP Global consortium intends to build a DRI plant with an annual capacity of 2.5 million tons. The plant will be located in the AMAN industrial zone, where a combined 5.5 GW (Stage I) WES and SES and a green H2 plant are also planned. That is, it will be a completely carbon-free production;
- In Egypt, a 2.5 million tons DRI plant is planned to be built at a cost of €1 billion with a subsequent increase to 4 million tons. The plant will be powered by equipment from Germany's SMS Group in the Suez economic zone;
- In Algeria, local company Copresud, together with Italian consortium CEIP Scarl, are planning a €1 billion DRI plant, without specifying the potential capacity. It is likely to be of the order of 2.5 million tons, similar to the Egyptian project;





- In Libya, Turkey's Tosyali Holding, together with local state-owned company SULB, intend to build the world's largest DRI plant with an annual capacity of 8.1 million tons. SMS Group received the order for equipment supply;
- In Libya, state-owned company LISCO intends to build a DRI plant with annual capacity of 2 million tons. The equipment supplier will be Italy's Danieli;
- In Morocco, as part of the $32 billion Moroccan Offer initiative, local company Nareva has declared its intention to produce H2 DRI along with green ammonia;

In addition, there are opportunities to increase DRI output at existing plants. For example, Algerian Qatari Steel Co.

in 20222 announced an expansion from 2.5 to 5 million tons by early 2026.

Existing and future DRI plants are potential drivers of demand for green H2 and have the potential to accelerate the development of the hydrogen industry in North Africa. And hence the complete transition to carbon-free steelmaking in the region.

Green potential

Today, Egypt's Elmarakbysteel is the leader in this aspect. Its CO2 emissions are only 0.62 tons per 1 ton of finished steel. The other companies do not disclose data.

But it is estimated that their figure is about 1.4 tons per 1 ton of steel products, based on total industry emissions and steel production.

Let us remind you that Emirates Steel, the greenest steel company in the GCC, has greenhouse emissions of 0.67 tons per 1 ton of steel. At the same time, 86% of electricity used in production is obtained from renewable energy sources (RES).

By comparison. Egypt's Ezz Steel, the leading producer in North Africa, has only 12%.

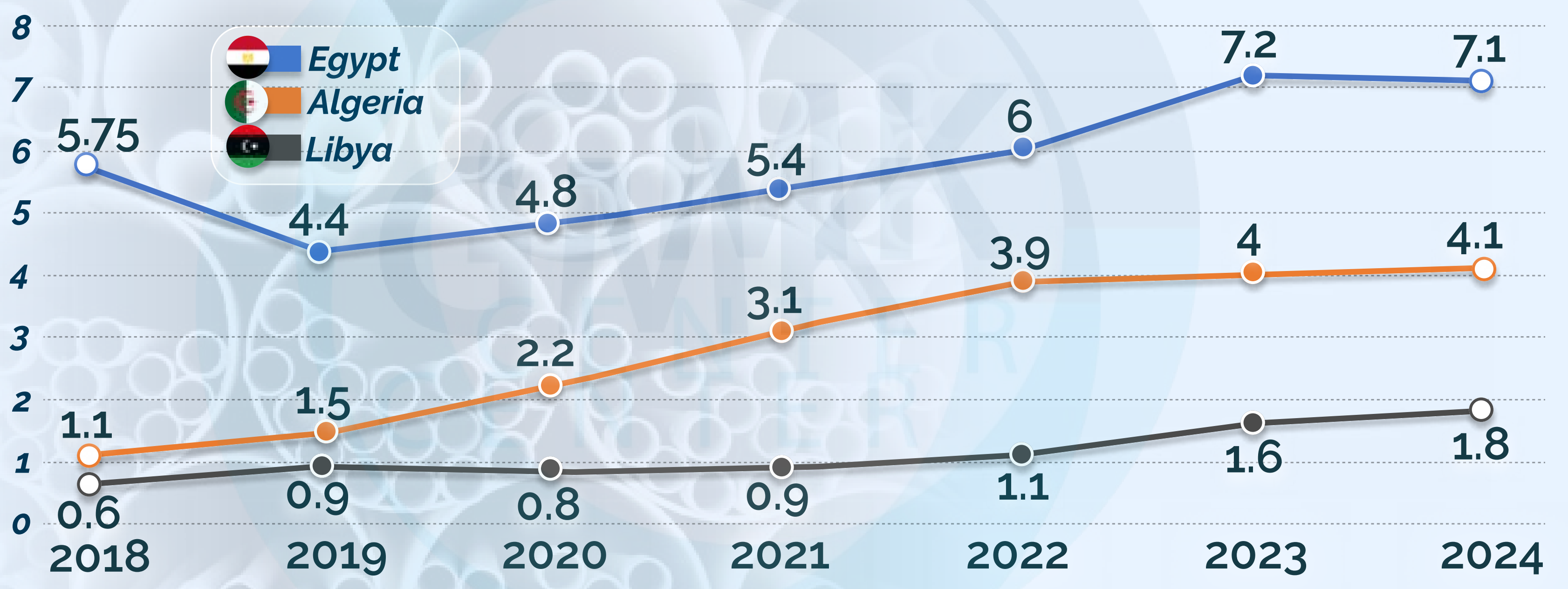
Therefore, further decarbonization of the steel industry in Egypt, Algeria, Tunisia and Morocco directly depends on the development of green energy.

Almost all countries have ambitious programs in this sector.

- Egypt plans to increase the share of RES in the energy mix from 20% in 2022 to 42% by 2030 and to 58% by 2024. The government's portfolio contains 16 projects for the construction of wind and solar power plants with a total capacity of 55 GW. All of them are at different stages: from memoranda of understanding to practical implementation;
- Algeria's National Renewable Energy Plan envisages capacity increase from 4.5 GW in 2020 to 22 GW in 2030, of which SES accounts for 10.5 GW and WPP for 4 GW, plus 2 GW for electricity storage;
- Libya plans to increase the capacity of WPP from 0.6 to 1 GW in 2020-2025, SES from 0.3 to 0.8 GW. This will increase the share of RES in the energy mix from 7% to 10%. The National Strategy for Sustainable Energy envisages the growth of green capacities up to 4.1 GW by 2035. Their share in the energy balance will amount to 25%;
- The Tunisian government sets the task to increase the share of RES in the energy balance up to 35% by 2030, compared to 3% in 2024. In 2035 the indicator should reach 50%, by 2050. – 100%. At the same time, the installed capacity of RES will increase from 0.4 GW in 2021 to 4 GW in 2030. Currently, the authorities have approved concession
- projects for 2.2 GW;
- Morocco's Renewable Energy Action Plan envisages an increase in the share of RES in the energy mix to 52% by 2030, compared to 7.1% in 2021. The installed capacity of RES in this case will increase from 1.9 GW to 16.3 GW;

Mauritania does not have an approved government strategy for renewable energy.

DRI PRODUCTION IN NORTH AFRICAN COUNTRIES
IN 2018–2024*



Source: World Steel

0,62 TONS
of CO2 are emissions from the greenest steel company in North Africa

North African green steel will soon be in demand in the EU

But the International Energy Agency (IEA) estimates that the implementation of the planned green H2 projects will require the creation of 16 GW of renewable energy capacity by 2030.

The use of green hydrogen is the next important step towards a carbon-free future.

Not only in steel sector, but also in power generation, cement industry, fertilizer production, etc.

Taking into account the enormous potential for RES development (the level of solar radiation in the region is 2000 kWh/m2), all the countries of North Africa without exception claim to be a supplier of green H2 for the European Union. The EU, in its turn, emphasizes its interest in such projects.

- The national hydrogen strategy of Egypt contains 2 scenarios, basic and green. In the first case by 2030 it is planned to ensure production of 1.5 mln. tons. of “blue” H2, by 2040 – 5.6 million tons. In the second case – 3 million tons by 2030 and 5.8 million tons by 2040. Thus, these options differ only in the speed of implementation at the first stage. The baseline scenario envisages export of all H2 produced by 2030, and by 2040 the figure should increase to 3.8 million tons. This will require deployment of 13 GW of electrolysis capacity. To supply them with green electricity, 19 GW of RES capacity is needed;
- The energy intensity of Algeria’s hydrogen industry should reach 40 TWh by 2040, of which 10 TWh will be used for domestic consumption. At the same time, it is planned to produce over 1 million tons of green H2 by 2040, the rest volume – blue H2.
- Mauritania’s strategic roadmap envisages production of 20.1 million tons of H2 by 2050. Of this, 12 million tons of green H2 and 8.1 million tons of blue H2. The government has initiated 4 green hydrogen projects with a total energy potential of 85 GW. This is expected to give Mauritania up to 1.5% of the global H2 market and up to 1% of the global green steel market by 2050;
- Tunisia’s National Green Hydrogen Strategy has set a target of producing 8.3 million tons of H2 per year by 2050, of which 6.3 million tons will be exported, mainly to Europe. This would require 90 GW of renewable energy capacity. Green H2 exports should reach 0.3 million tons by 2030 and 1.6 million tons by 2040;
- Morocco’s Roadmap for Hydrogen Industry Development envisages an energy intensity of 14 TWh by 2030, of which 10 TWh will be used to support H2 exports, 4 TWh for domestic purposes. This requires 6 GW of renewable energy capacity. By 2050, a fairly wide range of 154-307 TWh is projected. The government has approved $32 billion worth of green H2 investment projects;
- Libya’s National Sustainable Energy Strategy makes reference to the possibility of using RES to produce green H2. Pilot projects are expected to be launched by 2030. No specific production targets are given;

Blue hydrogen production in North Africa will require the deployment of a CCUS industry that can also be utilized in steel mills.

As in the Gulf countries, there are good prerequisites here: the availability of a large number of depleted oil and gas wells suitable for carbon storage.

But so far there are not even pilot projects in this area. Local oil and gas producers are conducting relevant studies.

3,8 MLN TONS

of blue H2 Egypt plans to export by 2040

North African green steel will soon be in demand in the EU

Risks and prospects

The Gulf countries rely on their investment resources in the process of economic decarbonization (development of RES and H2 production). North African states do not have such broad opportunities.

Therefore, their projects are tied to foreign financing. These are the African Development Bank, the European Investment Bank (EIB), the European Bank for Reconstruction and Development, and the World Bank.

They express their willingness to lend to green projects in northern Africa. But in fact, these are far from the volumes required.

For example, the total cost of green transition programs in Egypt until 2030 is $246 billion. – As of June this year, the EIB has allocated $312.6 million for these purposes.

Yes, there are other international financial institutions (IFIs) listed above. However, it is clear that their support does not even come close to matching the needs.

It is also important to remember that MFI money is a loan. They will have to be paid back, and with interest. Therefore, the payback on green projects is critical for North African countries.

They simply cannot afford to act like Saudi Arabia. Which launched the construction of the $8.4 billion NEOM industrial complex, which includes the production of green ammonia and hydrogen, a power plant and related transportation infrastructure – without any firm guarantees of sales.

According to media reports, the operator Air Products has now managed to contract only half of future production.

Obviously, at some point this investment will still pay off. And the Saudis can wait. But the North African states will not be able to wait.

To be more precise, their creditors are unlikely to want to wait. Hence the limited amounts of green financing from their side.

For Libya, there are additional risks, as the country is still unable to emerge from the chaos of the civil war that began back in 2011.

The last escalation of hostilities dates back to May of this year.

- In the 2020s, only small pilot projects in various sectors are possible;
- In the 2030s – scaling up green electricity and H2 production to industrial volumes. At the same time, almost all the resulting products are exported to the EU;
- In the 2040s – active use of green resources on the domestic market to ensure a carbon-free future for local industry, including metallurgy;

This scheme is entirely satisfactory to North African steel producers, as their products now already meet green criteria.

$246 BLN

total cost of green transition programs in Egypt by 2030

Decarbonization of Ukraine's steel industry: the European way

Access to European financing instruments is a key condition for decarbonization

Transition to emission-free steelmaking is a non-alternative for the Ukrainian steel industry.

The main driving factor is Ukraine's integration into the EU and harmonization of regulations, standards, plans and targets.

Ukraine is determined to undertake a green transformation of its industry, but even without the war this was not easy.

Now it is simply impossible if we rely only on our own resources.

Current situation and plans of the companies

At present, two enterprises of Ukrainian steel sector are working on the EAF-scrap based route. These are Interpipe Steel (Dnipro) and Dniprospetsstal (Zaporizhzhya).

Specific CO2 emissions at Interpipe are 1.288 tons per 1 ton of seamless pipes and 1.307 tons per 1 ton of railway-wheel products. Dneprospetsstal has this figure of 1.7 tons. Therefore, they meet the current European criteria for green steel.

The rest are integrated mills of ArcelorMittal Kryvyi Rih (AMKR), Zaporizhstal and Kametstal (Kamianske) of Metinvest group and Dnipro Iron and Steel Works (DMZ) of DCH group, which have a total of 13 blast furnaces. Their average emissions are 2.3 tons of CO2 per 1 ton of steel, i.e. the potential for reduction is quite large.

To realize it, most of the enterprises have chosen the EAF-transition model.

- Zaporizhstal plans to build an electric steelmaking complex (ESC) with a capacity of 3.3-3.8 mln tons per year.
- Kametstal will build an ESC with a capacity of 3.2 mln tons.
- At DMZ it was announced to build an ESC without specifying the capacity. The facility is currently being designed.

AMKR Combine did not declare such large-scale transformations.

At the same time, the international experience of the parent company shows that it has followed the DRI-EAF path at all its European plants.

Therefore, it can be assumed that ArcelorMittal will decide such a strategy for the Ukrainian enterprise.

This allows AMKR to retain the benefits of vertical integration. In any case, the realization of such plans will start after the war, now they are put on pause.

Due to the limited steel scrap resource in Ukraine, significant volumes of low-carbon iron ore, DRI and HBI will be required to operate future EAF facilities.

Therefore, Metinvest Group has plans to develop its production on the basis of its own mining enterprises in Dnepropetrovsk region.

Two DRI modules for 2.5 million tons per year each are expected to be built there.

AMKR may also build two DRI-modules of 2.5 million tons each. According to GMK Center analysts, the mill may decide such a path based on the experience of its parent company ArcelorMittal.

Initially, these plants will use natural gas as a reducing agent, with a switch to H_2 possible in the distant future.

The raw material will be locally produced iron ore pellets. Back in 2020, Metinvest's Central Mining and Processing Plant started producing products that are suitable for further DRI production.

In the future, the project can be scaled up to other Minings.

As a result, the future DRI capacity will not only ensure the operation of Ukrainian enterprises, but will also allow exporting up to 2 million tons per year of low-carbon iron ore to the European market.

At the same time, both nominal capacity and utilization of steelmaking units will decrease.

The EAF transition and the emergence of the DRI industry require huge additional volumes of green electricity.

Therefore, some steel companies are planning to create their own generation.

- Metinvest will build two power plants with a total capacity of 37 MW at Kametstal and Central Mining and Processing Plant. The cost of the project is $18.1 mln.

2 MLN TONS

of DRI Ukrainian producers will be able to export to the EU annually

- DCH announced the construction of a 40 MW power plant. The facility will be located on the site of DMZ coke plant, which is supposed to be decommissioned and dismantled.

The remaining enterprises can use third-party sources of renewable energy.

This will be one of the main directions of further decarbonization, along with increasing energy efficiency of steel and rolling production.

For example, Interpipe has already quadrupled the share of green electricity in its total consumption: from 7% in 2010 to 28% in 2024.

As a result, its Scope 2 emissions fell from 0.264 tons of CO_2 per 1 ton of pipe products in 2010 to 0.117 tons in 2024. For railway-wheel products – from 0.365 tons to 0.121 tons.

Renewable energy in Ukraine developed rapidly in the pre-war period. After the outbreak of war, the process slowed down, but did not stop.

The state strategy for post-war recovery Plan Ukraine Facility envisages further growth of RES capacity, taking into account the huge potential in solar and wind energy.

It is also planned to develop nuclear energy – construction of power units 3 and 4 at Khmelnytskyi NPP.

The implementation of these tasks will make it possible to provide Ukrainian steel companies with 100% environmentally friendly electricity.

Interpipe intends to reduce CO_2 emissions by 26% by 2030 compared to 2023 in the seamless pipe segment by further increasing the share of renewable energy sources in its energy consumption, as well as a number of other measures.

For railroad-wheel products, it is 25%. Other steel companies do not set such clear targets.

Impact of government policy

According to GMK Center estimates, the Ukrainian steel industry needs $12 billion in capital investments to achieve climate neutrality. Obviously, steel companies will not be able to accumulate such a resource on their own.

Taking into account that reduction of greenhouse emissions is not a problem of an individual industry, but a national task, state participation in decarbonization seems quite logical.

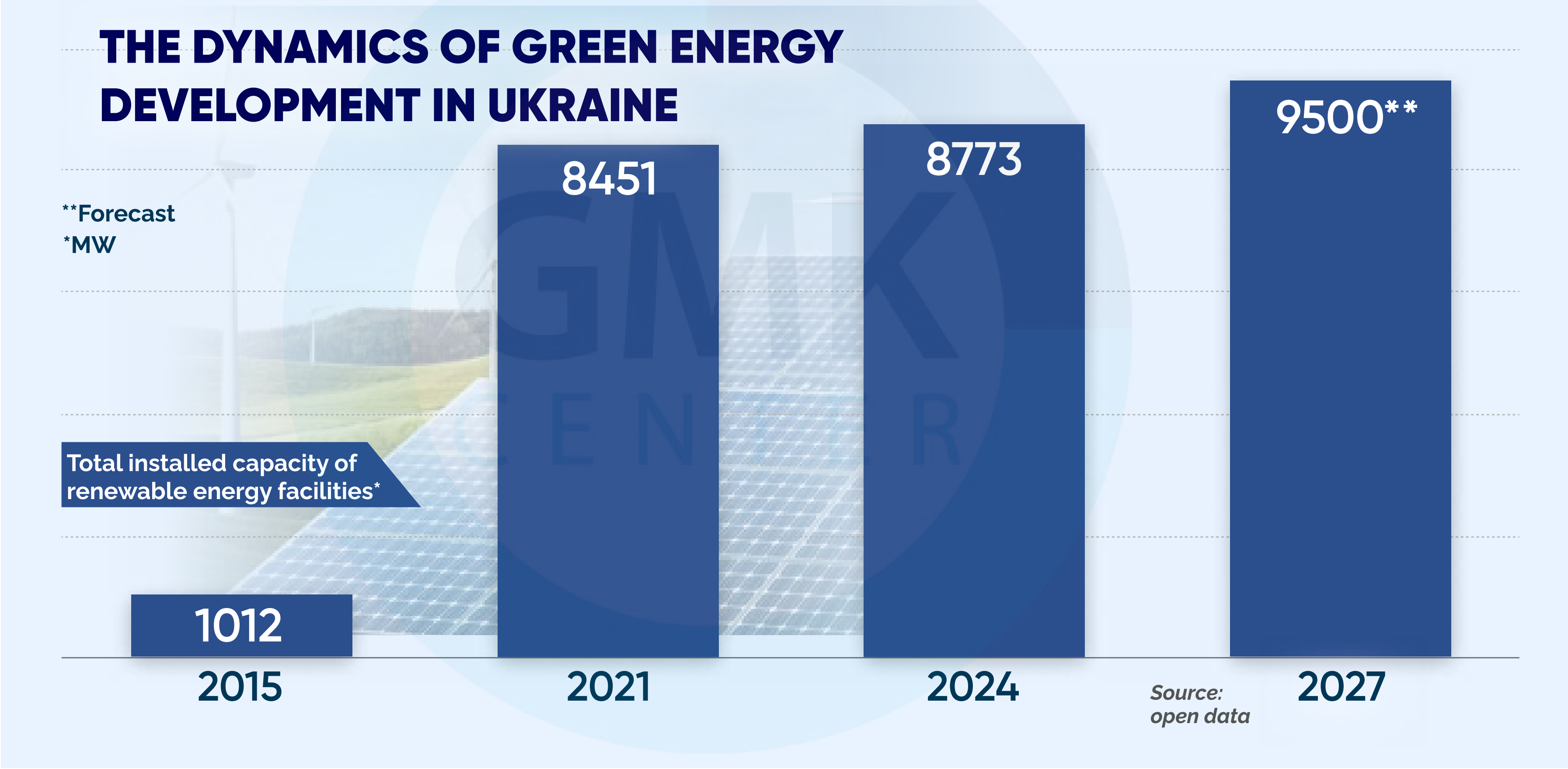
In Canada, the government is providing 50% of the funding for the above-mentioned $1.8 billion EAF transition project for the Dofasco steel mill.

The funds come from the federal and provincial budgets. This is the same money that the company previously transferred there as payment for greenhouse emissions.

Ukraine also levies a similar tax on industrial enterprises.

But these funds, unlike in Canada, go to the general fund of the state budget and are spent on current needs.

Therefore, firstly, it is necessary to establish the targeted use of environmental payments. But even in this case, according to Andriy Tarasenko, Chief Analyst of GMK Center, it will not be possible to finance decarbonization in full.



Decarbonization of Ukraine's steel industry: the European way

One can also refer to the experience of Japan, where the government provides tax credits of $149 for each ton of green steel produced at facilities that were built as part of the decarbonization of steel mills.

This includes both new EAFs to replace BFs and hydrogen steel industry. Obviously, under the current conditions, when more than 50% of the Ukrainian state budget deficit is financed by external financial aid, this is not a very realistic option for the industry.

That is why Ukrainian steel companies critically need to get access to European instruments. Such as the Fair Transition Fund, the Innovation Fund, grants and preferential financing for green transition projects. This requires reaching appropriate agreements at the highest political level.

«The issue of access of enterprises directly to European funds looks logical. Firstly, by reducing CO2 emissions Ukrainian industry and Ukraine as a future EU member make a contribution to the EU climate goals.

Secondly, the majority of decarbonization costs (from 70 to 80%) will be spent on the supply of equipment from leading European manufacturers such as Danieli (Italy), Primetals (Austria), SMS (Germany)», – commented Stanislav Zinchenko, CEO of GMK Center.

The next problem requiring government intervention is the protection of the domestic market from unfair steel imports.

The lack of effective barriers on its way is the main challenge to decarbonization in Brazil, Australia, the UK, and the EU.

This sharply narrows the opportunities for steel companies to green up production, and sometimes simply nullifies them, as local players are forced to compete by reducing the profitability of their sales.

The same can be said about Ukraine. According to the State Customs Service, imports of long steel products in January-June 2025 increased by 62.6% year-on-year – to 128,000 tons. Of this volume, 59% was supplied from Turkey.

Analysis of the situation shows: where there is strong tariff protection of the domestic market, steelmakers are confidently moving towards carbon neutrality. For example, in the USA, Canada, Japan, South Korea and Turkey.

Finally, the cost of electricity for industry. Currently, in Ukraine, it is one of the highest in Europe.

In the first half of the year, electricity prices here have already surpassed neighboring countries such as Poland, Romania, Hungary, and Slovakia. They are 34% higher than in Germany and 3.5 times higher than in Sweden.

This is explained by the significant damage to the energy infrastructure caused by Russia's attacks. Yes, it is an objective factor. But nevertheless, the largest Ukrainian steel mill AMKR before the war, electricity accounted for 7% of the selling price of its products.

Now this share has increased to 20%.

Other enterprises have similar situation. What will happen after the EAF-transition, when the indicator reaches 50% or even exceeds it? Complete loss of competitiveness and production curtailment.

But is this the goal of decarbonization?
Thus, a realistic and stable cost of electricity is both a prerequisite for supporting the current operating activities of Ukrainian steel mills and a guarantee of their green future.

This can be achieved by introducing a price ceiling for energy-intensive enterprises and long-term contracts with fixed rates, as well as by strengthening price competition between state-owned energy producers. This, in turn, requires appropriate decisions at the governmental level.

«There are two main obstacles to decarbonizing Ukraine's steel industry: the price of energy and access to finance.

The current energy price makes the economics of low-carbon projects inefficient, although before the war the figures may have looked acceptable. If the situation does not change, it will be unprofitable to implement decarbonization projects in Ukraine.

The second point is that domestic plants cannot finance multi-billion dollar projects on their own. Given the post-war budget priorities, the state will be unable to provide sufficient funding for decarbonization.

Therefore, the only way is access to European decarbonization financing funds. If these two problems are not solved, decarbonization will simply end with the closure of plants,»

summarized Stanislav Zinchenko.