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HYBRIT: A Hubristic Hydrogen-Based Steel Project

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Abstract

This study critically examines HYBRIT, a Swedish flagship project led by state-owned LKAB to produce fossil-free sponge iron using hydrogen from fossil-free electricity. Framed as central to EU's green transition, HYBRIT promised CO_2 cuts exceeding Sweden's total emissions but faced major technological, economic, and infrastructural hurdles. The analysis situates HYBRIT within broader "moonshot" policies, prone to political enthusiasm, rent-seeking, and neglect of opportunity costs. The project required large-scale hydrogen production, storage, and process adaptation, unproven at commercial scale. Profitability depended on persistently low electricity prices and high CO_2 costs while global competition in green steel intensified. Electricity constraints in northern Sweden further strained feasibility. Political, regional, and corporate interests nonetheless aligned behind HYBRIT, aided by limited scrutiny of state-owned firms. Mounting criticism and shifting priorities ultimately led LKAB to defer its sponge iron plans indefinitely, pivoting toward high-grade ore and critical minerals. The case highlights the risks of mission-oriented policies when political symbolism outweighs technological and market realities.

JEL classification

L20, L52, L70, O38, Q28, Q48

Keywords

green deals, green steel, hydrogen, mission-oriented policies, moonshots, public choice, rent-seeking

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Introduction

Roughly 80% of all iron ore in Europe comes from the Swedish government-owned mining company LKAB. Its high-quality ore is sold as DR-pellets in the world market, and its annual production of some 80 million tonnes is used to produce 40 million tonnes of steel.[1]

Steel production is a significant contributor to global CO_2 emissions, accounting for roughly 8% of the world's total CO_2 emissions.[2] If all steel made from LKAB's iron ore could become fossil free, that would have a sizable effect on total emissions reducing total CO_2 emissions by 56 million tonnes—some 20% more than Sweden's total CO_2 emission.[3]

Potential reductions of such a magnitude paved the way for political entrepreneurship both at the national and the EU level. The iron ore could be reduced to sponge iron, which is mixed with scrap to make steel in electric arc furnaces (EAFs) using hydrogen (H_2) instead of natural gas (CH_4). The waste product would then be water (H_2O) instead of carbon dioxide (CO_2).

Such a project would also fit like hand in glove in the EU Hydrogen Strategy,[4] adopted in July 2020, where it is laid down that the European Commission has identified hydrogen as a key enabler of a climate-neutral Europe by 2050. It is projected that a "potential ¼ of the EU's renewable electricity production will be used for hydrogen production, which in turn would account for up to more than 23% in the 2050 energy mix" (European Hydrogen Observatory, 2025).

The purpose of this study is to describe and explore the mechanisms behind an extensive project in Sweden to implement the EU Green Deal in mining and metal production by analyzing an attempt to create a supply chain for steel-making that eliminates all CO_2 emissions. The analysis will show how the confluence of a number of forces led to a situation where all realism and pragmatism was thrown overboard. Attaining "net zero" in one specific area was given priority over all other concerns such as opportunity costs, possible crowding out of existing activities, technological risks and business risks.

The study is organized as follows. I begin by providing a theoretical and empirical background to "moonshot policies" and green deals. This is followed by three sections where I present and analyze the project and critically evaluate its technological and economic feasibility. In the final section the main conclusions are drawn. In particular, I attempt to explain how this project could come as far as it did despite the many insurmountable obstacles for its execution.

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[1] DR pellets are iron ore pellets designed for use in direct reduction (DR) processes. DR pellets are a key raw material for producing direct reduced iron (DRI) using gas rather than the traditional blast furnace method that uses coal.

[2] https://worldsteel.org/data/world-steel-in-figures/world-steel-in-figures-2024/?utm_source=chatgpt.com. Estimates range from 7.2% (Carbon Brief) to 11% (Our World in Data) of total global carbon emissions (https://www.sustainable-ships.org/stories/2022/carbon-footprint-steel).

[3] Assuming that LKAB's iron ore is used to produce 40 million tonnes of steel per year using the natural gas-based Direct Reduced Iron–Electric Arc Furnace (NG DRI–EAF) method with an average CO_2 emission of 1.4 tonnes per tonne of steel. Assuming that oxygen is removed from part of the LKAB ore using coal in blast furnaces, the reduction in CO_2 emissions would be greater still.

[4] The hydrogen strategy looms large in the EU's Green Deal, where 43% (EUR 430 billion) of the total resources are earmarked for hydrogen-based technologies.

Moonshots and Green Deals

The economic gap between Europe and the United States has been widening since the onset of the 2008 financial crisis. To reverse this trend and boost its competitiveness, the European Union has laid out on an ambitious path aiming to be in the international forefront towards achieving a sustainable "green" economy. To this end, European as well as other Western nations increasingly adopt large-scale industrial policies; hard-won lessons regarding the challenges of successfully implementing interventionist large-scale innovation policies seem to be largely forgotten (Lerner, 2009).

The COVID-19 pandemic further cemented this trend from 2020 and onwards as the European Commission introduced a temporary framework for state aid to allow unprecedented flexibility. Direct grants, loans, tax breaks, and guarantees were now allowed. Following the pandemic and Russia's invasion of Ukraine in 2022, the EU further amended and extended the Temporary Crisis and Transition Framework (TCTF). This included increases in aid ceilings (i.e., magnitudes allowed for each company or sector) and a broadened mandate for offsetting high energy prices and subsidizing the green transition.

The framework, initially intended to end in 2020, has been extended several times and includes provisions effective at least until the end of 2025. The TCTF was replaced by the Clean Industrial Deal State Aid Framework (CISAF) in June of 2025 and remains in force until 31 December 2030. The CISAF "helps Member States to easily support the development of clean energy, industrial decarbonisation and clean technology" (European Commission, 2025).

This renewed embrace of state-led capitalism deserves a thorough analysis within a broader economic context (Henrekson et al., 2024a; Wennberg & Sandström, 2022), especially since such policies are skillfully marketed under terms such as "mission-oriented innovation policy" and "the entrepreneurial state."

Influential public intellectuals (e.g., Mazzucato, 2021; Rodrik, 2022) argue that, just as the Apollo program boosted the U.S. economy, similar "moonshot" projects should be launched in other areas, combining public and private resources to tackle issues such as homelessness or cancer. Henrekson et al. (2024b) identify several interrelated reasons why these large-scale top-down missions are likely to fail: missions cannot solve highly complex problems and are susceptible to rent-seeking and special interest capture; policymakers are subject to self-interest and lack essential information for effective mission planning; market competition is disrupted when targeted support creates harmful incentives and moral hazard; and opportunity costs tend to be ignored or underestimated.

HYBRIT and Green Steel

In 2020 LKAB (jointly with steelmaker SSAB and the government-owned electricity producer Vattenfall) inaugurated its pilot plant for direct reduction of iron ore using hydrogen.[5] The pilot plant was announced as the first step in the huge project named HYBRIT (Hydrogen Breakthrough Ironmaking Technology). EU President Ursula von der Leyen did not miss this

[5] SSAB is a public company and Sweden's largest steel producer. Since 2021 LKAB has a 16% voting share, which makes it the de facto controlling owner of SSAB.

opportunity to boost the project in her September 2020 State of the Union Address (European Commission, 2020):

> Two weeks ago in Sweden, a unique fossil-free steel pilot began test operations. It will replace coal with hydrogen to produce clean steel. This shows the potential of hydrogen to support our industry with a new, clean, license to operate. **I want NextGenerationEU to create new European Hydrogen Valleys** (bold in original) to modernize our industries, power our vehicles and bring new life to rural areas.

For Swedish politicians, government agencies and LKAB's management team, the project was also extremely attractive. Politicians could praise themselves for a project that would result in huge reductions in CO_2 emissions, environmental agencies would have a project where they could join forces with the politicians, and the LKAB leadership saw an opportunity to be both virtuous and expansionary by adding an additional step in the value chain by making fossil-free sponge iron instead of DR pellets their end product. LKAB asserted that this would increase their turnover by 200% (LKAB, 2022a). A major political advantage of the project was that it, despite its enormous scale, could be financed through a combination of retained earnings from LKAB's mining operations and earmarked subsidies from the EU.

There were several additional factors at play. Historically, the northernmost part of Sweden, rich in natural resources and hydroelectric power, has felt exploited by the south, and this project was said to be a key part of "the reindustrialization of Norrland."[6] Last but not least, the project required an enormous amount of fossil-free electricity, 70 TWh to be precise, which is more than half of total electricity consumption in Sweden (134 TWh in 2024). As a result, potential suppliers of machinery, equipment, and construction services saw enormous business opportunities and joined forces with the political sphere in pushing the project.

The Project

The part of the value chain from mine to finished steel that currently emits the most CO_2 is the production step between iron ore and iron where the oxygen is removed from the ore. This step has predominantly been carried out in blast furnaces where coal is used both as an energy source and as a means of removing the oxygen from the ore. Approximately 70% of all steel globally is produced in this way. The method currently results in 2.3 tonnes of CO_2 emissions per tonne of raw steel produced (Somers, 2022; Institute for Energy Economics and Financial Analysis, 2022).

An alternative way to remove oxygen from iron ore is to use the NG DRI-EAF method using sponge iron, which consists of between 90 and 95% pure iron. The production process requires high quality iron ore; the iron content must be at least 65% and preferably above 67%. Currently, natural gas is used in sponge iron plants. For this reason, most sponge iron plants are located in regions with good access to cheap natural gas, such as the Middle East, Iran and Russia (Midrex, 2023). This process of removing oxygen from the ore causes CO_2 emissions of 1.4 tonnes per tonne of steel (the commonly cited industry average), which is 40% less than in blast furnaces. As the need to reduce carbon emissions has become more important, demand for sponge iron has increased.

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[6] Norrland is the northernmost, largest and least populated of the three traditional lands of Sweden. It cover almost 60% of the land area but harbors a mere 11% of Sweden's population.

LKAB's HYBRIT project (HYdrogen BReakthrough Ironmaking Technology) aims to revolutionize the iron and steel industry by replacing fossil fuels with hydrogen produced by means of fossil-free electricity. The project is a collaboration between LKAB, SSAB, and Vattenfall and was launched in 2016. The goal is to create a completely fossil-free value chain from iron ore to finished steel. By using hydrogen instead of natural gas in the reduction process, CO_2 emissions are significantly reduced, with water as the only by-product. In 2020, a pilot plant was opened in Luleå (a city located at the very north of the Baltic Sea) to produce sponge iron using fossil-free hydrogen. The plant has shown that the process can work, at least on a small scale. However, whether it will work at an industrial scale remains to be seen.

The long-term plan that was launched meant that, over a period of 25 years, LKAB would transition from being a company whose end product was DR pellets to having sponge iron as its end product (LKAB, 2021).

LKAB estimates the total cost of the project at SEK 400 billion when fully developed. This does not include the costs of investments in electricity production and the associated grid. These investments are at least of the same magnitude (Blomgren, 2024). Together this makes it by far the most extensive project in Sweden's modern industrial history both in absolute terms and relative to the country's GDP. If the project fails, it is difficult to see any alternative use for the volumes of weather-dependent electricity in the region.

Technological feasibility

LKAB has no experience whatsoever of any of the technologies in question or of running such extensive projects. If one list the specifics of their overall plans for sponge iron production, the overall technical challenges and risks become abundantly clear.[7]

LKAB would commit itself to building hydrogen production based on electrolysis on a scale never achieved, nor proven to be technically feasible or economically viable. According to LKAB's own narrative, their process would be unique and thus highly valuable for the company as well as for Sweden. However, this was not the case at all. Two examples are sufficient to disprove any assertion of this sort.

ArcelorMittal, the world's third largest steel company with industry experience dating back to 1902, initiated its hydrogen-based steelmaking efforts in 2019. In June 2025, following six years of R&D and experimental production, ArcelorMittal announced the cancellation of their plans for hydrogen-based steelmaking, citing high energy costs, insufficient infrastructure, and uncertainties regarding the long-term profitability of hydrogen-based steelmaking (Zadeh, 2025). The legendary German steelmaker ThyssenKrupp, whose history dates back to 1802, is pursuing fossil-free steel production using hydrogen through its flagship initiative, the tkH_2Steel project. In 2023 the company received EUR 2 billion funding from the EU for its decarbonization project (Thyssenkrupp, 2023). However, in March 2025 the company paused its hydrogen procurement tender due to higher-than-expected price indications for hydrogen.

[7] A similar situation applies to Stegra (formerly H2 Green Steel), which is a start-up company with owners and management with no previous experience of the relevant technologies, steel production and iron and steel markets. This project is evaluated in this volume by Johansson and Kriström (2026).

Instead, they plan to use natural gas in the foreseeable future at least until 2037 (Bolotova, 2025).

Since the industrial process is continuous, while the electricity required for hydrogen production was mainly intended to come from weather-dependent sources (in practice, wind power), a significant hydrogen storage facility is needed to cope with periods of deficient wind. LKAB's experimental storage facility is a mere 100 m^3 (e.g., a cube where each side is 4,54 meters or a sphere with a diameter of 5.76 meters). At a pressure of up to 250 bars the facility can store 2 tonnes of hydrogen. But if there is going to be sufficient hydrogen stored to withstand close to one week of little or no wind, a storage is needed that is at least 1,000 times larger.[8] However, no hydrogen storage facility on such a scale has ever been built or demonstrated to be technically feasible or economically viable (Sundén 2023, Vattenfall, 2022). Nevertheless, LKAB (2025a) announced in early 2025 that "HYBRIT's pilot project for hydrogen gas storage has now been completed and reported to the Swedish Energy Agency. The results show that it is technically possible to store fossil-free hydrogen gas for producing fossil-free iron and steel on an industrial scale" (HYBRIT, 2025).

A third major challenge is to build many capital-intensive sponge iron plants powered by hydrogen on a scale that has never been done before and with a technology that has not yet been demonstrated to be commercializable and industrializable. As yet, there exists no industrial scale sponge iron production equipment customized to use hydrogen instead of natural anywhere (Sundén, 2023, 2024a).

Economic feasibility

The prospects for LKAB to make its sponge iron production profitable are bleak. The challenges stem both from the raw material markets and from the product markets they will operate in. First, the various technological challenges described above translate into increased uncertainty regarding the project's economic viability.

Sponge iron is mainly produced in regions with good access to cheap natural gas. The use of natural gas leads to high CO_2 emissions. In the future, these emissions will incur costs as they are covered by EU emissions trading rules.[9]

It is more expensive to produce sponge iron using hydrogen than natural gas, even when the costs of CO_2 emissions are included (Sundén, 2024a). Only if the price of CO_2 is very high and the price of electricity is very low can hydrogen-based sponge iron become competitive. Compared with regions with access to cheap natural gas, Norrbotten therefore has no decisive competitive advantage. A large number of new sponge iron factories are also being built and planned in regions with access to cheap natural gas. In some cases, they are being built with the

[8] According to LKAB's own estimate (LKAB, 2022b). Sundén (2023) estimates that the storage must be up to 3,000 times larger (at a temperature of 20 °C and a pressure of 250 bar).

[9] To prevent production from moving outside the EU and prevent non-EU producers from gaining competitive advantages on the EU market, a border adjustment mechanism that prices the emissions of imported iron and steel products—the Carbon Border Adjustment Mechanism (CBAM)—will be introduced. This will function as an import tariff. The level of the tariff will be determined by the price difference of emission allowances within the EU and the region from which the products are imported.

option of using hydrogen should hydrogen become sufficiently cheap in the future. Other factories are planning to capture and store the CO_2 (Sundén, 2024a).

Alternative methods

There are a great many other projects and pioneering technologies with the aim of producing steel without giving rise to CO_2 emissions. The Green Tracker (Vogl et al., 2025) reported 99 publicly announced low-carbon steel projects worldwide in May 2025.

One method that is already widely used is the replacement of coal with biochar (a type of charcoal) from eucalyptus in blast furnaces. According to the company behind the technology, Aço Verde do Brasil, CO_2 emissions per tonne of steel are reduced by 99% (Rostas, 2022; Iwarson, 2023). In Sweden, for example, two technologies are being developed to become fossil-free. FerroSilva uses forestry residues, biogenic carbon, to produce synthesis gas, which in turn is used to produce fossil-free sponge iron. GreenIron H2 intends to use hydrogen gas in the same way as LKAB but states that the process will be significantly more energy and cost-efficient than the one LKAB is developing.[10]

Yet another example of a pioneering technology is smelting reduction and smelting electrolysis, which is still at the pilot stage. The advantage over other processes is that they can produce pure iron more or less directly from any type of iron ore. This chemically pure iron can then be fed to electric arc furnaces for precision production of all types of low- and high-quality steel. Unlike in the traditional process, CO_2 emissions can be significantly reduced, and unlike the technologies that rely on sponge iron, high quality iron ore is not needed.

The pressure to make the blast furnace technology fossil-free has also intensified and will continue to intensify over time. There are many possibilities, but it has not yet been possible to demonstrate that the technology can be completely fossil-free. To reduce emissions, steel companies seek to change the composition of material inputs. This includes increasing the share of higher quality iron ore, using more scrap steel, mixing in hydrogen, or using biochar. Other companies are developing technologies to capture emissions for recycling, storage or use in other processes. Whether and how quickly blast furnaces can reduce their emissions on a larger scale is still unclear.

In short, additional business risks arise from the fact that pioneering technologies have been shown to work at the pilot stage, and that research and development to reduce CO_2 emissions in blast furnaces is increasing and slowly demonstrating the feasibility of reducing emissions.

Electricity: Availability and price

A major argument used by the project's advocates was an alleged surplus of fossil-free hydroelectric power in northernmost Sweden. However, the total annual production of hydroelectric power in Norrbotten County, which makes up 25% of Sweden's land area, averages a mere 14 TWh per annum and the electricity demand of the many "green" projects in the north is almost one order of magnitude greater. For instance, H2 Green Steel (renamed

[10] See Jafri et al. (2022) for a research overview of different decarbonization technologies in the iron and steel industry.

Stegra in 2024) is a startup planning to make fossil-free steel using hydrogen and the Spanish fertilizer company Fertiberia has plans to build a plant to produce fossil-free fertilizer in Luleå. If realized, those two projects would need roughly 20 TWh of electricity per year.

Sundén (2024b) analyzes the significant electricity demand arising from the planned operations of LKAB, SSAB (a new EAF steel works in Luleå), Stegra, and Fertiberia in Norrbotten County. Their combined electricity demand was expected to reach 20 TWh by 2026, rising to 40 TWh by 2030 and 90 TWh by 2050. The analysis shows that unless electricity production increases accordingly, electricity prices will rise sharply throughout the Nordic region. Sundén estimates that if the companies' plans for 2026 were realized without a corresponding increase in electricity production, electricity prices would rise sharply in all electricity areas in the Nordic region. The price increase would be greatest in northern Sweden. There, prices were expected to rise by just over 170%, while the price in the Nordic region as a whole was expected to increase by 77%. Such price increases would be far higher than the companies had anticipated in their calculations.[11]

Thus, it is clear that the argument of an alleged surplus of fossil-free hydroelectric power in northernmost Sweden is untrue. HYBRIT's entire electricity demand will have to be covered by investments in new capacity.[12]

In this context it is noteworthy that it was not until 2023 that Sweden changed its policy on nuclear power and decided that it could be a constituent part in the green transition. The change was codified into law effective from January 1, 2024.[13] This means that the implicit plan was to cover the required 70 TWh of electricity almost exclusively through a massive expansion of land-based wind power in northern Sweden.

Fahlén et al. (2026) estimate that the cost of electricity from land-based wind power will be at least double compared what is claimed in the analyses by the Swedish Energy Agency. Based on actual experience, they conclude that the investment cost is higher, the service life is shorter, maintenance is more expensive, and the capacity factor is lower than projected. This leads to a production cost at the power plant level that is approximately twice as high as estimated by the Swedish Energy Agency.

In addition, there are costs at the system level, where the differences between power types are significant: costs for connection to the grid, transmission costs, and costs for balancing power and energy storage systems such as batteries required when there is insufficient wind. When the share of wind power exceeds 20%, the system cost increases rapidly, and even at that level, the system cost can be as high as the power plant cost (Manzolini et al., 2024).

[11] Profus' and Nordeuropeiska energiperspektiv's (Nepp) forecasts for electricity market prices also indicates a sharp rise, albeit slightly lower than Sundén's (Odenberger et al., 2024).

[12] In fact, Stegra has only managed to secure half of its future electricity need (as of August 2025), despite requiring a mere one-fifth of the electricity that HYBRIT will need (Energinyheter.se, 2024).

[13] The most important change was that the energy policy target was changed from the electricity system being 100% renewable by 2040 to being 100% fossil-free. Hence, instead of being totally phased out by 2040, nuclear power is now considered a central part of Sweden's climate transition and future energy mix.

If electricity production from wind power were to increase by 70 TWh to cover HYBRIT's long-term need, this would dramatically increase the weather-dependent share in the production mix. It is far from clear that it would then be possible to guarantee the functioning of the system throughout the year (Fahlén et al., 2026).

Which Factor(s) Will Absorb the Premium on Fossil-Free Steel?

Competition in the fossil-free segment of the steel market will be fierce when all companies make the transition. The premium for fossil-free steel is therefore not expected to be particularly high. Competition is also fierce for input goods. As European steel companies switch to scrap-intensive electric arc furnaces, demand for steel scrap is also expected to increase. To secure access to steel scrap, major global steel producers have started buying scrap companies. The supply of tradable steel scrap is therefore uncertain. This leads to price risks for steel companies such as SSAB and Stegra, as their access to scrap is outside their value chains.

High-quality ore and steel scrap are strategically important in the steel industry's transition to decarbonization. The demand for these raw materials will therefore increase over time (Sundén, 2023). High-quality ore of the type LKAB produces is only available in limited quantities, which will lead to higher prices as demand increases. This is good news for LKAB. The company has streamlined the production of its ore over many years, and the premium of their ore will be increasingly higher and the profitability of continuing to sell only ore can be expected to be high. The resource that is most limited in supply will command the highest price or return in the market.

In essence, the principle of the scarcest factor getting the premium highlights the fundamental economic concept that limited resources drive up their value in the market. Thus, an economic analysis based on first principles strongly suggests that any premium on fossil-free steel will accrue to suppliers of scrap and the high-quality ore required to make sponge iron.

Analysis and Discussion

Given the many obstacles and risks I have discussed, the obvious question is to ask how the project could ever leave the drawing board.

Most importantly, the project was perfectly aligned with the *zeitgeist* of politicians and the respective agencies at all levels from the highest echelons in Brussels down to the municipalities concerned in northernmost Sweden. Second, as LKAB was expected to be able to largely finance its massive investment by means of positive cash flows from its mining operations and subsidies earmarked to the green transition (that would otherwise be granted to other companies), the central government budget would not be directly affected.

Third, numerous companies, including the highly influential wind power industry, saw huge business opportunities as suppliers of equipment and services in connection with the enormous investments required.

Fourth, since neither LKAB nor Vattenfall are public companies, they are not subject to the normal daily scrutiny of a large number of stock-market and equity analysts. As a consequence, the announced plans were not questioned, and the reasoning and calculations were not scrutinized in detail. Without a stock exchange listing, the public does not receive a market assessment of the companies' plans in the form of a share price that combines all the external assessments made by thousands of independent analysts and investors.[14]

The fact that LKAB is owned by the Kingdom of Sweden creates a double problem. First, LKAB has a significant informational advantage over the handful of bureaucrats at the Ministry of Finance who are responsible for overseeing the company. These officials neither have the time nor the competence to review LKAB's plans in the way that would have been the case had the company been public. Second, appointments to the board of LKAB are not to a sufficient degree based on the special knowledge required to run a highly competitive international mining or steel company. Especially when the crucial decisions regarding HYBRIT were taken, the competence and experience of LKAB's board members differed significantly from its competitors. It is particularly noteworthy that the Chairman of the Board at that point in time was a former Prime Minister. In 2024, he was succeeded by a former Minister of Finance.

Conclusions

The original plan to convert all iron ore produced by LKAB into sponge iron using hydrogen manufactured from water and fossil-free electricity in northernmost Sweden would have been the largest industrial project in Sweden's modern industrial history both absolutely and relative to GDP.

The analysis in this essay indicates that both the technological and business risks were unacceptable. Therefore, the plans should never have left the boardroom. The various factors raised in the second section together shed explanatory light on how HYBRIT project could garner so much positive attention and political support despite the high technological and economic uncertainty.

Most importantly, the project turned out to fit perfectly as a flagship in the green transition for all parties involved. To no small extent, politicians and government officials are governed by self-interest (Muldoon & Yonai, 2023). Given the *zeitgeist* and the adamancy by which the green transition was touted both at the EU and the national level, HYBRIT constituted a political opportunity of extraordinary proportions (Schnellenbach, 2024).

Moreover, the northernmost part of Sweden, rich in natural resources and hydroelectric power, has felt unduly exploited by the south, and this government-owned project could be marketed as a way to repay part of the historical debt to the north. Doing so was facilitated by the fact that, despite the enormity of the investment, the government envisaged that the project could be financed by a combination of earmarked subsidies and positive cash flows from LKAB's mining operations.

Furthermore, potential suppliers of machinery, equipment and construction services, who saw enormous business opportunities, joined forces with the political sphere. Finally, strong concern for the environment and climate change also paved the way for a public debate where few scholars, policymakers and journalists raised concerns. A person who expressed skepticism ran the risk of being dismissed as a "climate denialist," which made dissent costly, socially, politically, and economically.

[14] This is also true for Stegra.

In light of the growing criticism leveled against the project,[15] policymakers were slowly becoming aware of the lack of realism and exorbitant risks involved. The challenge was to find a politically acceptable reason for terminating the project, preferably without saying so outright.

The government and thus the owner of the project, represented by State Secretary Lars Hjälmered, announced at a conference in May 2024 that LKAB was facing several difficult challenges: moving the Kiruna city center, start mining deeper than anyone has ever done (down to 2,000 meters), open a new mine containing both iron ore and rare earth metals, extract phosphorus from the cinder, and make all current processes fossil-free. Mr. Hjälmered then concluded that overcoming these challenges should be prioritized. In practice, this meant that the HYBRIT project had to be put on hold.[16]

LKAB has now also changed its strategy. Although they still talk about producing fossil-free sponge iron in the future, they no longer say when. The revised mission statement (July 9, 2025; LKAB, 2025b) clearly reflects what Mr. Hjälmered said at the conference in May 2024: "The high-grade ore we already sell has a relatively high premium. This, combined with the valuable [rare] earth metals and phosphorus we also can produce, gives us the perfect conditions to lead the transformation towards a carbon-free iron, mineral and steel industry." The mission statement no longer contains any timeline and dates for the production of sponge iron using fossil-free hydrogen.

Hence, in the light of criticism, politicians have managed to save face, the company has been able to make an honorable retreat, and for the citizens of the Kingdom of Sweden a likely economic disaster has been averted.

References

Blomgren, J. (2024). Elförsörjning till de planerade industriprojekten i norra Sverige [Electricity supply to the industrial projects in northern Sweden]. In M. Henrekson (Ed.), *De norrländska stålsatsningarna – frälsare eller gökunge* (pp. 189–213). Stockholm: Samhällsförlaget. https://www.ifn.se/media/oyebba5z/2024-henrekson-de-norrl%C3%A4ndska-sta-lsatsningarna-fra-lsare-eller-go-kunge.pdf

Bolotova, J. (2025). ThyssenKrupp puts hydrogen tender for future DRI plant on hold due to high prices. *DJJ*, March 27. https://djj.com/thyssenkrupp-puts-hydrogen-tender-for-future-dri-plant-on-hold-due-to-high-prices/

Energinyheter.se (2024). Uniper och Stegra ingår sexårigt elavtal för grön industriomställning [Uniper and Stegra sign six-year electricity agreement for green industrial transition]. November 27. https://www.energinyheter.se/20241127/32310/uniper-och-stegra-ingar-sexarigt-elavtal-gron-industriomstallning

European Commission (2020). State of the Union Address by President von der Leyen at the European Parliament Plenary. https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_20_1655

[15] See the collection of contributions in Henrekson (2024a).

[16] Scandinavian Institute for Public Policy (2025).

European Commission (2025). Clean Industrial Deal State Aid Framework (CISAF). https://competition-policy.ec.europa.eu/about/contribution-clean-just-and-competitive-transition/clean-industrial-deal-state-aid-framework-cisaf_en

European Hydrogen Observatory (2025). EU Hydrogen Strategy under the EU Green Deal. https://observatory.clean-hydrogen.europa.eu/eu-policy/eu-hydrogen-strategy-under-eu-green-deal

Fahlén, P., Henrekson, M., & Nilsson, M. (2026). In pursuit of a green transition—electricity at any cost? Forthcoming in M. Henrekson, C. Sandström, & M. Stenkula (Eds.), *A Green Entrepreneurial State? Exploring the Pitfalls of Green Deals*. Cham. Springer.

Iwarson, T. (2023). "Brasilien – störst på träkol och först med fossilfritt stål." *ATL*, May 26. https://www.atl.nu/brasilien-har-redan-fossilfritt-stal.

Henrekson, M. (Ed.) (2024). *De norrländska stålsatsningarna – frälsare eller gökunge*. Stockholm: Samhällsförlaget.

Henrekson, M., Sandström, C., & Stenkula, M. (Eds.) (2024a). *Moonshots and the New Industrial Policy: Questioning the Mission Economy*. Cham: Springer. https://doi.org/10.1007/978-3-031-49196-2

Henrekson, M., Sandström, C., & Stenkula, M. (2024b). Seven reasons why mission-oriented innovation policies seldom work in practice. *Economic Affairs*, *44*(2), 354–362. doi.org/10.1111/ecaf.12654

HYBRIT (2025). HYBRIT: Large-scale storage of fossil-free hydrogen gas successfully proven. https://www.hybritdevelopment.se/en/hybrit-large-scale-storage-of-fossil-free-hydrogen-gas-successfully-proven/

Institute for Energy Economics and Financial Analysis (2022). The facts about steelmaking: Steelmakers seeking green steel. https://ieefa.org/sites/default/files/2022-06/steel-fact-sheet.pdf

Jafri, Y., Ahlström, J. M., Furusjö, E., Harvey, S., Pettersson, K., Svensson, E., & Wetterlund, E. (2022). Double yields and negative emissions? Resource, climate and cost efficiencies in biofuels with carbon capture, storage and utilization. *Frontiers in Energy Research, 10*, Article 797529. https://doi.org/10.3389/fenrg.2022.797529

Johansson, P.-O., & Kriström, B. (2026). Green industrial megaprojects: A welfare economics perspective. Forthcoming in M. Henrekson, C. Sandström, & M. Stenkula (Eds.), *A Green Entrepreneurial State? Exploring the Pitfalls of Green Deals*. Cham: Springer.

LKAB (2021). Varför koldioxidfri järnsvamp? [Why carbon-free sponge iron?]. https://lkab.com/nyheter/varfor-koldioxidfri-jarnsvamp/

LKAB (2022a). Snabbare takt och högre mål i LKAB:s omställning mot en hållbar framtid [Faster pace and more ambitious targets in LKAB's transition towards a sustainable future]. https://mb.cision.com/Main/11419/3532814/1568943.pdf

LKAB (2022b). HYBRIT: Nästa milstolpe nådd – pilotanläggningen för vätgaslagring i drift. https://lkab.com/press/hybrit-nasta-milstolpe-nadd-pilotanlaggningen-for-vatgaslagring-i-drift/

LKAB (2025a). HYBRIT: Storskalig lagring av fossilfri vätgas framgångsrikt bevisad [HYBRIT: Next milestone reached—pilot plant for hydrogen storage now operational]. https://lkab.com/press/hybrit-storskalig-lagring-av-fossilfri-vatgas-framgangsrikt-bevisad/

LKAB (2025b). Our strategy for the future. https://lkab.com/en/what-we-do/our-strategy/.

Lerner, J. (2009). *Boulevard of Broken Dreams. Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed—and What to Do about It*. Princeton, NJ: Princeton University Press.

Manzolini, G., Binotti, M., Gentile, G., Picotti, G., Pilotti, L., & Cholette, M. E. (2024). Actual cost of electricity: An economic index to overcome levelized cost of electricity limits. *iScience*, *27*, 109897. https://doi.org/10.1016/j.isci.2024.109897

Mazzucato, M. (2021). *Mission Economy: A Moonshot Guide to Changing Capitalism*. New York, NY: Harper Collins.

Midrex (2023). 2022 World Direct Reduction Statistics. Charlotte, NC: Midrex Technologies, Inc.

Muldoon, J., & Yonai, D. K. (2023). A wrong but seductive idea: Public choice and the entrepreneurial state. *Journal of the International Council for Small Business*, *4*(4), 1–11. https://doi.org/10.1080/26437015.2023.2182730

Odenberger, M., Unger, T., Kofoed-Wiuff, A., Gaballo, F. & Wråke, M. (2024). Modellanalyser av den svenska elprisutvecklingen till följd av en omfattande elektrifiering. Nordeuropeiska energiperspektiv. Nepp and Profu. https://energiforsk.se/media/33096/nepp-elprisutveckling-till-foljd-av-omfattande-elektrifiering-2024-01-30.pdf

Rodrik, D. (2022). An industrial policy for good jobs. Washington, DC: The Hamilton Project, Brookings. https://drodrik.scholar.harvard.edu/files/dani-rodrik/files/rodrik_-_an_industrial_policy_for_good_jobs.pdf

Rostás, R. (2022). "Brazil at steel decarbonization crossroads: Charcoal, gas short-term options." *Fastmarkets*, 21 mars. https://www.fastmarkets.com/insights/brazil-at-steel-decarbonization-crossroads-charcoal-gas-short-term-options/

Scandinavian Institute for Public Policy (2025). De norrländska stålsatsningarna: Frälsare eller gökunge? [The steel projects in northern Sweden: White knight or cuckoo in the nest?]. Malmö. https://www.youtube.com/watch?v=1UhjMb24a50&t=8328s

Schnellenbach, J. (2024). A behavioral economics perspective on the entrepreneurial state and mission-oriented innovation policy. In M. Henrekson, C. Sandström, & M. Stenkula (Eds.), *Moonshots and the New Industrial Policy: Questioning the Mission Economy* (pp. 61–76). Cham: Springer. https://doi.org/10.1007/978-3-031-49196-2_4

Somers, J. (2022). *Technologies to Decarbonise the EU Steel Industry*. Luxembourg: Publications Office of the European Union. https://publications.jrc.ec.europa.eu/repository/handle/JRC127468

Sundén, D. (2023). Från brunt till grönt – bedömning av satsningarna på fossilfritt stål i Norrland utifrån ett teknik- och marknadsperspektiv [From brown to green—Assessment of fossil-free steel initiatives in Norrland from a technology and market perspective]. Malmö: Scandinavian Institute for Public Policy. https://policyinstitutet.se/wp-content/uploads/2023/11/Rapport-Fran-brunt-till-gront-Final2.pdf

Sundén, D. (2024a). Lönsam eller kostsam? Lönsamhetsbedömning av de svenska satsningarna på fossilfritt stål i Norrland [Profitable or costly? Profitability assessment of Swedish investments in fossil-free steel in Norrland]. Malmö: Scandinavian Institute for Public Policy. https://policyinstitutet.se/wp-content/uploads/2024/01/Rapport-Lonsam-eller-kostsam-240115.pdf

Sundén, D. (2024b). Till vilket elpris som helst? Bedömning av effekterna på den nordiska elmarknaden av satsningarna på fossilfritt stål i Norrland [At any electricity price? Assessment of the impact on the Nordic electricity market of investments in fossil-free steel in Norrland]. Malmö: Scandinavian Institute for Public Policy. https://policyinstitutet.se/wp-content/uploads/2024/01/Policyinstitutet-Till-vilket-elpris-som-helst-1.pdf

Thyssenkrupp (2023). EU approves €2 billion funding for Thyssenkrupp's decarbonisation project. https://www.newcast.com/en/Media_News/News/EU_approves_%E2%82%AC2_billion_funding_for_Thyssenkrupp_s_decarbonisation_project

Vattenfall (2022). HYBRIT: Världsunikt bergrumslager för fossilfri vätgas invigs i Luleå [HYBRIT: World-unique underground storage facility for fossil-free hydrogen inaugurated in Luleå]. https://group.vattenfall.com/se/nyheter-och-press/pressmeddelanden/2022/hybrit-varldsunikt-bergrumslager-for-fossilfri-vatgas-invigs-i-lulea

Vogl, V., et al. (2025). Green Steel Tracker. Stockholm: Leadership Group for Industry Transition (LeadIT). https://www.industrytransition.org/green-steel-tracker/

Zadeh, J. (2025). ArcelorMittal halts German green steel project amid economic challenges. *Discovery Alert*, June 25. https://discoveryalert.com.au/news/arcelormittal-green-steel-project-cancellation-2025/

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