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Hydrogen vs Energy Efficiency: Why Smart Investors Choose Proven Solutions

Green Hydrogen and Choosing Efficient Pathways Over Expensive Alternatives

The unviability of hydrogen's stated role in the energy transition and why hydrogen investments might go up in flames.

ABSTRACT

This paper examines why hydrogen's proposed role in the energy transition should be limited, analysing its inefficiencies from carbon, energy, and financial perspectives. We demonstrate that direct electrification technologies (on-site photovoltaics, heat pumps, battery storage) provide better economics and efficiency for building decarbonization than hydrogen, which has significantly lower round-trip efficiency compared to direct electrification's 90%+. Hydrogen may suit niche hard-to-abate sectors, but using expensive hydrogen infrastructure where electrical alternatives exist wastes resources and ignores the primary energy fallacy of conversion losses.

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Introduction

Hydrogen is, at best, an inefficient solution to a problem created by fossil fuels, and at worst, a red herring.

Hydrogen has long been touted as one of the long-term mainstream solutions to systemic climate change. Amongst the greatest benefits cited are the ability for hydrogen to be produced from numerous methods, an abundance of the raw materials required to make hydrogen, its ability to be stored at length and the fact that it does not produce CO_2 at the point of use. In essence: Hydrogen provides a solution to the shortcomings of other primary energy production methods but acting as a useful carrier of the energy produced.[1]

However, as this paper will discuss, this statement cannot be supported by existing evidence. Hydrogen is energy-intensive to produce, inefficient and far more difficult to store and utilise than has been previously believed. There is no currently available hydrogen pathway, irrespective of whether it uses fossil fuels, nuclear fuels, or renewable technology as the primary energy source to generate electricity or heat is as efficient as using the electric power or heat from any of these sources directly.[2]

The risk of focusing on hydrogen as a solution, despite its general unviability (barring the most niche and specific of applications),[3] is that we overlook existing solutions that are efficient and economical in their contribution to the energy transition. This is especially exacerbated by the potentially ulterior intentions of some of the most prominent hydrogen advocates, who might wilfully obfuscate the wood for the trees in their own attempts to save sunset assets.[4] Despite the flashy claims of these advocates, often on behalf of some of the world's largest oil and gas companies or prominent clients, very little of what has been claimed to be a hydrogen revolution has materialised in the last twenty years. As this paper will discuss, there is a better way, and one which is both effective and investable.

The Diet Hydrocarbon - H_2

What is hydrogen, how is it produced, and who is producing it?

Despite its abundance, hydrogen does not exist in isolation in the environment in any economically extractable manner.[5] Instead, hydrogen is commonly attached to a range of molecules and compounds – perhaps most famously as water, or H_2O. Production is not limited to a singular method but often involves some form of chemical or physical process which strips the hydrogen atoms off the molecules

[1] Veziroğlu, T. Nejat, and Sümer Şahi. "21st Century's energy: Hydrogen energy system." *Energy conversion and management* 49.7 (2008): 1820-1831.
[2] Kreith, Frank, and Ron West. "Fallacies of a hydrogen economy: a critical analysis of hydrogen production and utilization." *J. Energy Resour. Technol.* 126.4 (2004): 249-257.
[3] For example, in its limited use in the decarbonization of the steel industry. Wang, R. R., et al. "Hydrogen direct reduction (H-DR) in steel industry—An overview of challenges and opportunities." *Journal of Cleaner Production* 329 (2021): 129797.
[4] Hunt, Julian David, et al. "Possible pathways for oil and gas companies in a sustainable future: From the perspective of a hydrogen economy." *Renewable and Sustainable Energy Reviews* 160 (2022): 112291.
[5] Osselin, Florian, et al. "Orange hydrogen is the new green." *Nature Geoscience* 15.10 (2022): 765-769.

they are attached to. By far the most common of these processes is called **SMR – or steam methane refining** – in which CH_4 (Methane) is reacted with water to release H_2 and CO_2.

Today, roughly 96% of all Hydrogen is produced via this (or associated) methods, about 3% through an iteration of this mechanism which captures the CO_2 emitted by the process (via carbon capture technologies), and about 1% by green electrolysis, as shown on Figure 1.[6]

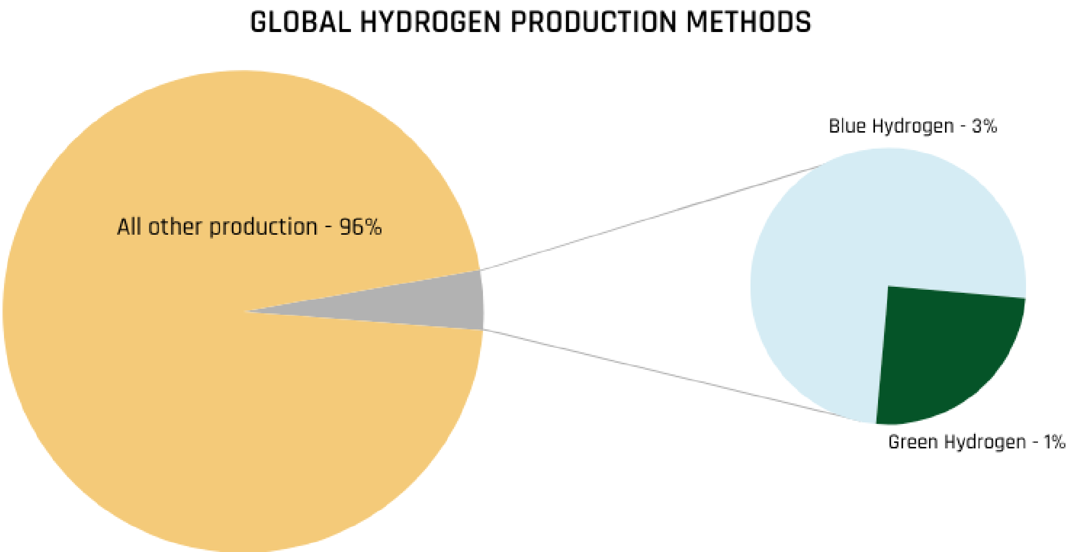

Figure 1: Global Hydrogen Production Methods (Source: IEA 2024)

Not only is methane the primary input for this method of H_2 production, but the hydrogen advocates also foresee a use case of their extensive hydrocarbon process and distribution networks, which risk being stuck as sunset assets as the green transition maintains momentum (especially in the EU). These large-scale projects suit the standard proclivities and strengths of the Oil Majors and allow them to argue for the prolongation of an industry with only the promise of a future where all hydrogen is produced by electrolysis.

The identity of the H_2 as the pretty part of the H_xC_x chain, which comprises all *hydro*carbons, is therefore inseparable from its current reality and future trajectory. The attempt to smear lipstick on the pig of methane, through a process which is well known to produce more CO_2 than simply burning the methane for energy,[7] is an intolerable reality for the current hydrogen economy, as on average, it currently takes 10-12kg of CO_2 just to produce 1kg of H_2 – over four times the carbon cost of burning 1kg of methane.

Even the proposed future state – where hydrogen is produced by green electricity, which is fed to electrolysers, risk diverting both capital and resources to build these electrolysers, as well as electricity from the grid that could be stored and used far more efficiently – both enormous opportunity costs when all is told. The biggest loser in the scenario would be other green energy storage and production

[6] Howarth, Robert W., and Mark Z. Jacobson. "How green is blue hydrogen?." *Energy Science & Engineering* 9.10 (2021): 1676-1687 and IEA (2024), Global Hydrogen Review 2024, IEA, Paris https://www.iea.org/reports/global-hydrogen-review-2024.

[7] Bart Kolodziejczyk, "How to understand the carbon footprint of clean hydrogen", *World Economic Forum,* 2023.

projects, many of which yield far greater returns on capital and carbon reduction than is even theoretically achievable by H_2.[8]

The Inefficiency of H_2

Regardless of production, how well suited is hydrogen to the task of an energy carrier?

As mentioned above, H_2 has difficult optics from a production standpoint. The situation does not improve when the entire round-trip is considered – from production to storage and transport, to end-use. Let's count our losses! Production efficiency varies, but a highly efficient process may achieve something in the range of 85%[9] (or about 80% for the best electrolysis).[10] Unless you consume on-site, the hydrogen will then need to be prepared for transport and storage, which is achievable through 1) Compression, 2) Liquefaction or 3) Conversion to an intermediate molecule.[11]

All of these processes are energy-intensive but given that hydrogen has extremely low energy density at room temperature, they are required in order to store or ship any significant quantities. These processes consume another 6% (for simple compression) to 25% of the initial energy required to create the hydrogen. Finally, there are losses at the point of consumption. These vary greatly from using H_2 in fuel cells (essentially hydrogen batteries) to burning it as a gas for heating, in a combustion engine or as part of a turbine generator. For combustion engines, the picture is not good, with efficiencies of 20-25%. Fuel cells are better at 60-80%[12]. For heating, the picture is also drastically worse than methane – only an efficiency of 69% (as opposed to 88% on average), although with innovation, this can theoretically climb as high as 95%.[13]

In short, the technology to convert power to hydrogen and back to power has a round-trip efficiency of **only 18%-46%**.[14] In comparison, two mature long-duration technologies, pumped-storage hydropower and compressed air energy storage, boast round-trip efficiencies of 70%-85% and 42%-67%, respectively. Batteries, although expensive, boast a round-trip efficiency of 80%-90%.

The implication is simple**: a hydrogen-based economy (for sectors that can be directly electrified) needs to build 3-5x more energy generation to deliver the same amount of energy to the consumer**, purely based on the energy cost of production and storage. This does not tackle the litany of other issues, such as persistent leakage and metal embrittlement (the process by which hydrogen weakens metals it contacts), which make H_2 essentially unusable for anything other than rocket fuel - where it is often not always the first choice either.[15]

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[8] Overhyping hydrogen as a fuel risks endangering net-zero goals. (2022). *Nature*, *611*(7936), 426. https://doi.org/10.1038/d41586-022-03693-6
[9] Pashchenko, Dmitry. "Green hydrogen as a power plant fuel: What is energy efficiency from production to utilization?." *Renewable Energy* 223 (2024): 120033.
[10] "DOE Technical Targets for Hydrogen Production from Electrolysis". *energy.gov*. US Department of Energy.
[11] Kusuma, D. (2024, February 27). Hydrogen Hype — A story of energy loss - Danny Kusuma - Medium. Medium. https://dannykusuma.medium.com/hydrogen-hype-a-story-of-energy-loss-f37a592331c8
[12] IEA (2024), Global Hydrogen Review 2024, IEA, Paris https://www.iea.org/reports/global-hydrogen-review-2024
[13] Kreith, Frank, and Ron West. "Fallacies of a hydrogen economy: a critical analysis of hydrogen production and utilization." *J. Energy Resour. Technol.* 126.4 (2004): 249-257.
[14] *Hydrogen technology faces efficiency disadvantage in power storage race*. (2024, August 9). S&P Global Market Intelligence. https://www.spglobal.com/market-intelligence/en/news-insights/articles/2021/6/hydrogen-technology-faces-efficiency-disadvantage-in-power-storage-race-65162028
[15] Mykhalchyshyn, R. V., M. S. Brezgin, and D. A. Lomskoi. "Methane, kerosene, and hydrogen comparison as a rocket fuel for launch vehicle PHSS development." *Spa Sci Technol* 24 (2018): 12-17.

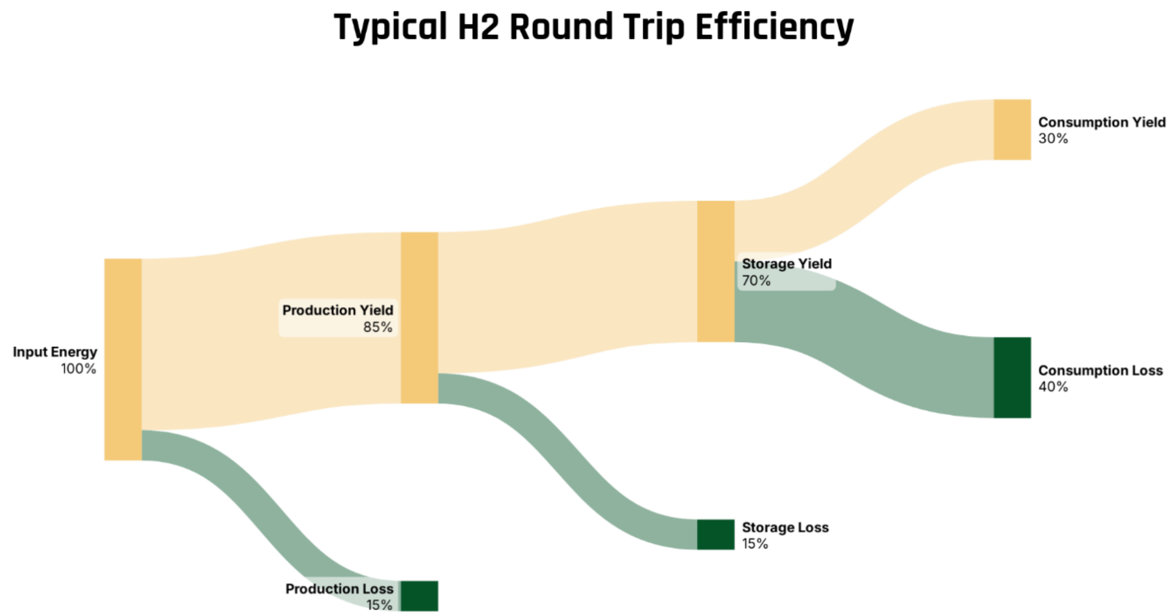

Figure 2: Typical H2 Round Trip Efficiency (Source: Indicative, based on *Renewable Energy and Medium*)

Leakage is worth exploring in further detail, as often glossed over is also the fact that hydrogen itself is an indirect greenhouse gas, with a warming capacity over 12 times worse than CO_2 over a 100-year period.[16] When burned, hydrogen also produces NO_x (Nitrous oxides) as a by-product at roughly the same rate as hydrocarbons (or sometimes more, due to a high flame temperature), which has a heating capacity 273 times worse than CO_2 and notoriously causes acid rain. Given that leakage is expected to range from 3-10% of the total production of Hydrogen in the best case,[17] and up to 20% in the case of liquified hydrogen,[18] these should not be facets that are overlooked.

Altogether, the picture painted is one of chronic waste and inefficiency in all stages of the hydrogen supply chain. **In a world of limited energy, resources and time, it is not a fuel that makes sense.** Economically, wide scale adoption will be a disaster too. The most analogous situation here is the USA's ongoing Stockholm Syndrome with yet another Diet Hydrocarbon – Ethanol.

[16] Sand, Maria, et al. "A multi-model assessment of the Global Warming Potential of hydrogen." *Communications Earth & Environment* 4.1 (2023): 203.
[17] Alsulaiman, Abdurahman. *Review of hydrogen leakage along the supply chain: Environmental impact, mitigation, and recommendations for sustainable deployment*. No. 41. OIES Paper: ET, 2024.
[18] Hydrogen emissions from a hydrogen economy and their potential global warming impact – JRC

What We Can Learn from Ethanol

How an analysis of another well-intentioned environmental initiative can help us stop history repeating itself. This is another 'environmentally friendly' fuel that is inefficient to produce, and when analysed holistically, can be argued to have zero environmental benefits at all.

Ethanol biofuel in the USA has a long and complex history, heavily intertwined with policy, economics, and environmental aspirations. Initially touted as a solution for energy security, rural economic development, and environmental concerns, a critical analysis reveals a more nuanced and often problematic reality. While ethanol enjoys widespread use and significant government support, its actual benefits are questionable, and its negative impacts are substantial.

Like hydrogen, it is essentially an energy carrier – sunlight produces corn crop, which is then intensively processed to produce Ethanol, which is then blended with petrol. As one might imagine, this process is particularly inefficient – disregarding the fact that photosynthesis itself (if we are to argue that the land could be better used for solar) is roughly 10% efficiency, the processing required to create Ethanol is also extremely intensive, leading to extremely low efficiencies.

This means that, similar to Hydrogen, Ethanol is an expensive solution. In order to be economically viable at its level of production efficiency, the ethanol industry recovered roughly US$45 billion in subsidies between 1980-2011,[19] at a **carbon offset cost of roughly $750 per metric ton.[20]** Even today, although direct subsidies have ended, Ethanol is mandated in fuel mixtures and is estimated to increase the price of petrol by up to $1 per gallon, when accounting for the lower relative energy density of ethanol. Due to this, there are billions that are poured into corn farming and ethanol refining by the consumers and regulators alike - essentially to service an ethanol tax imposed unilaterally on fuel users to prop up what is ostensibly a failed idea. Altogether, this **deprives private and public wallets of valuable resources, which could be spent on undertaking productive methods of emissions reduction.**

We also see that today, the interests of ethanol and gasoline are united against electrification.[21] By allowing Ethanol to flourish as a complementary industry to hydrocarbons, we have created a system of incentives that have prolonged the useful life of petroleum products and stolen time, attention and resources away from economically viable, efficient solutions. Solutions, such as energy efficiency and demand-side reduction.

The Hydrogen Ladder

Where and when it makes sense to use Hydrogen

Michael Liebreich's Hydrogen Ladder[22] provides a crucial framework for understanding where hydrogen makes economic sense in the energy transition. The ladder ranks applications from "unavoidable" uses

[19] David Shepardson (December 24, 2011). "Congress ends corn ethanol subsidy". *The Detroit News*
[20] "Using Biofuel Tax Credits to Achieve Energy and Environmental Policy Goals" (PDF). Congressional Budget Office
[21] Hill, Jason. "The sobering truth about corn ethanol." *Proceedings of the National Academy of Sciences* 119.11 (2022): e2200997119.
[22] Liebreich. (2023, November 15). Hydrogen Ladder Version 5.0 - liebreich. Liebreich. https://www.liebreich.com/hydrogen-ladder-version-5-0/

where no alternatives exist, through "uncompetitive" applications where direct electrification, biogas or other solutions offer superior economics. At the top of this ladder sit industrial applications like ammonia production for fertilisers and steel manufacturing, **where hydrogen serves as a chemical feedstock rather than an energy carrier.** These represent the clearest cases for green hydrogen deployment, as no viable electrical alternatives currently exist for these chemical processes.

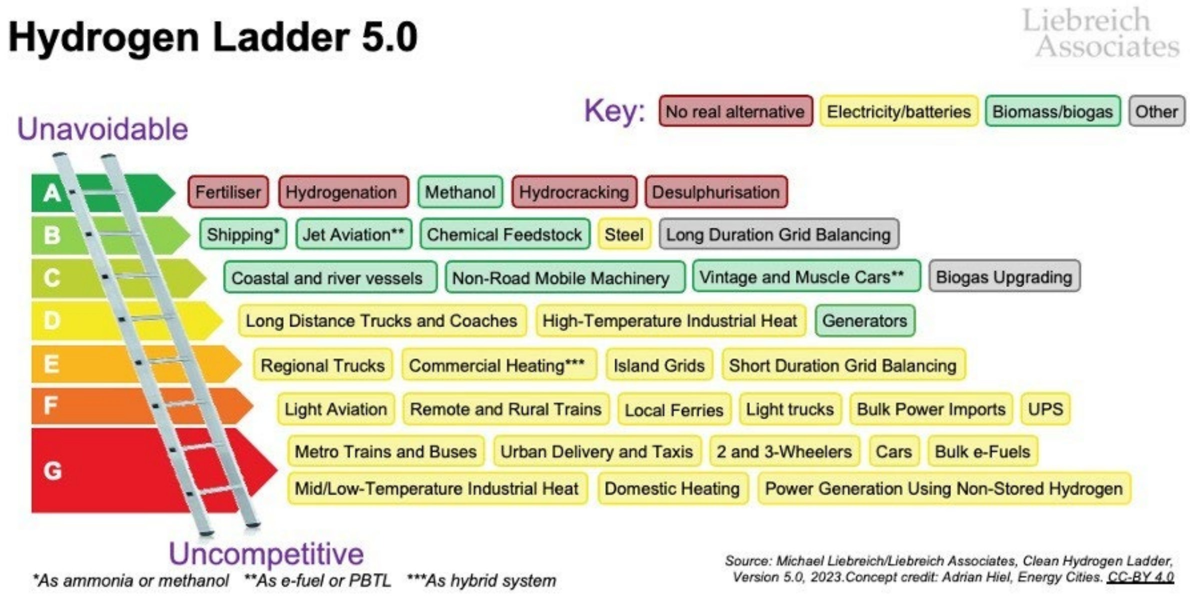

Figure 3: Hydrogen Ladder 5.0 (Source: Michael Liebreich Associates, Clean Hydrogen Ladder Version 5.0)

Unlike solar PV and batteries where the core technology represents most system costs and benefits from dramatic manufacturing scale improvements, hydrogen production faces structural limitations because electrolysers account for only around one third of the cost of green hydrogen with the remainder split between electricity costs (already on their own declining curve) and heavy engineering components – components like compressors, tanks, valves, pipes that are mature industrial equipment with limited cost reduction potential, meaning even if electrolysers became free, hydrogen would remain expensive due to these irreducible infrastructure and energy input costs.

The economics of hydrogen become even challenging when considering international transport. Germany's strategy to import liquid hydrogen from Canada and Namibia illustrates this problem starkly. Liquefying hydrogen requires cooling to -253°C, and requires massive energy consumption to achieve liquification, before accounting for boil-off losses during shipping and the return journey of empty vessels.[23] This makes imported hydrogen significantly more expensive than locally produced alternatives, and highly impacts the round-trip efficiency described above.

Beyond essential industrial feedstocks, the only combustion application where hydrogen may prove economically justified is in backup power generation during **"Dunkelflaute"** events—extended periods of low wind and solar generation. Here, hydrogen's ability to provide long-duration storage could complement batteries, though even this application faces competition from emerging technologies like iron-air batteries and improved grid interconnection.

[23] Tongtong Zhang, Joao Uratani, Yixuan Huang, Lejin Xu, Steve Griffiths, Yulong Ding, Hydrogen liquefaction and storage: Recent progress and perspectives, Renewable and Sustainable Energy Reviews, Volume 176, 2023.

The fundamental challenge remains that green hydrogen production requires substantial renewable overcapacity, **as electrolysers must run at high utilisation rates (typically >4,000 hours annually) to amortise their capital costs**,[24] yet renewable generation must prioritise grid supply. This creates a paradox where economical hydrogen production requires both abundant excess renewable capacity and consistent operation – conditions rarely aligned in practice.

The Economics of Hydrogen Investment

A challenging industry that is currently unviable without subsidies

The risks of pursuing an H2-based decarbonisation strategy are clear; It is an expensive, highly subsidised and uneconomical choice for large-scale application in the green transition. If the stated global goal of 422GW of electrolysis production were to actually be met, this would require around US$1.3 trillion in subsidies to be economically viable.[25] In a recent estimate, Bloomberg NEF now expects that there are *"few places in the world where we expect clean hydrogen to compete with the grey variety by 2050"*,[26] and have flagged that ***'meeting any return expectation will depend on regulations such as carbon pricing, and subsidy for the foreseeable future'.*** Even with substantial subsidies, Hydrogen projects also suffer from a lack of credible long-term offtake agreements, as illustrated by the abandonment of the Akura blue hydrogen project in Norway, or the cancelled RWE-Equinor Hydrogen pipeline, due to unviable market dynamics[27] – despite using cheaper blue hydrogen rather than sustainable green Hydrogen.

Return calculations reveal the scale of the economic challenge. Achieving a modest 10% unlevered internal rate of return requires hydrogen prices of **$8 per kilogram**,[28] nearly triple the current grey hydrogen costs. When competing directly with natural gas, this is over 10 times the cost per kg in a non-household application.[29]

The current investment climate for hydrogen, therefore, highlights its three key poisonous limitations to forming a stable investment in the context of its broader role in the energy transition:

1. **Regulatory Risk:** Firstly, the inability of the market to survive without subsidies creates obvious bureaucratic and political risks and project vulnerability
2. **Market Risk:** Secondly, the sheer level of competitiveness with existing energy sources and storage methods has created an utterly barren market, one which is especially devoid of fixed-price long-term contracts
3. **Resource Risk:** Thirdly, electricity is a key input to the production and storage of green hydrogen. The high utilisation rates required to amortise electrolysers require constant energy input, which, without a dedicated supply, creates a clear input resource risk.

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[24] IRENA (2020) Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5 ˚C Climate Goal. International Renewable Energy Agency.

[25] Odenweller, A., Ueckerdt, F. The green hydrogen ambition and implementation gap. *Nat Energy* 10, 110–123 (2025). https://doi.org/10.1038/s41560-024-01684-7

[26] BloombergNEF. (2025, May 22). *Five energy transition lessons for 2025*. BloombergNEF.

[27] Foelber, D. (2025, January 27). *Equinor, Shell cancel European hydrogen megaprojects*. ESG Review./

[28] Energy, T. S. (2024, January 18). *Green hydrogen: the economics?* Thunder Said Energy.

[29] Natural gas is typically not priced per KG but per KWh. To convert, we assumed 10.987 Kwh per m3 of Natural gas, a mass of 0.76 Kg per m3 and a price of 0.06 per KWh.

The scale of capital required for green hydrogen infrastructure dwarfs other clean energy investments while delivering inferior returns. This is also clearly illustrated by the reality that in 2023, only roughly 2% of announced green hydrogen projects made it to Final Investment Decision, according to UBS.[30] The investment community's verdict is clear: **hydrogen represents the highest-risk, highest-subsidy-dependency clean energy sector,** with JPMorgan describing "*continually wilting prospects for the hydrogen economy"* as costs rise rather than fall and additional investment risks are not adequately compensated by returns.

This economic reality reinforces that hydrogen should be reserved for applications where no alternatives exist, rather than being deployed broadly across sectors where direct electrification offers superior efficiency and economics. The vision of a "hydrogen economy" must give way to a more nuanced understanding of hydrogen as a niche solution for specific industrial needs.

The Promise and Potential of Energy Efficiency

> As a question about the efficient allocation of resources, there is undoubtedly only one answer to the question of what provides the most bang for your buck, without even a smidgen of flammability.

While this paper has focused on exploring the inability of Hydrogen to fulfil its stated role, there is undoubtedly a need to re-evaluate our current energy system, especially in light of the rapidly changing energy landscape of the green transition. Energy efficiency represents the single largest measure to avoid energy demand in the Net Zero Emissions by 2050 Scenario,[31] and is the natural counterargument to any high-cost supply-side energy solutions, such as H_2.

The energy system's demand-side opportunity provided here is utterly enormous - The European Commission estimates that the overall transformation investment gap for both public and private investments in residential and business energy efficiency stands at a staggering €185 billion per year.[32] Other estimates conclude that this is not enough, reporting that **the EU needs to at least double current energy efficiency investments to €281 billion annually** for buildings and industry from 2021-2030 to achieve climate and energy targets.[33] When taking into account the total required amount for the full decarbonisation of buildings, the amount required swells to €434 billion a year, according to a study by Institut Rousseau, commissioned by EU lawmakers.[34] This opportunity extends across all sectors – from residential rooftop solar to large-scale C&I projects.

The problem is particularly acute for residential renovations, where current renovation rates of between 0.2% to 0.5% of building stock renovations per year fall short of the national targets of 2% to 3%[35]

[30] What's holding back Europe's green hydrogen projects? (2024, November 19). UBS Investment Bank.
[31] *Energy efficiency 2024 – analysis - IEA*. (2024, November 1). IEA. https://www.iea.org/reports/energy-efficiency-2024
[32] "The potential for investment in energy efficiency through financial instruments in the European Union", *European Commission and European Investment Bank,* 2020.
[33] European Commission: Fraunhofer ISI, ICCS-NTUA and Viegand Maagøe, *Report on the evolution of financing practices for energy efficiency in buildings, SME's and in industry – Final report*, Publications Office of the European Union, 2022.
[34] Institut Rousseau. (2025, April 7). Road 2 Net zero EN - Institut Rousseau.
[35] *National building renovation plans*. (n.d.). Energy. European Commission.

The EU has identified this opportunity – and committed to it. The "Energy Efficiency First" principle is now an intrinsic part of the EU Green Deal,[36] which compels legislators to "take utmost account in energy planning, and in policy and investment decisions, of alternative cost-efficient energy efficiency measures to make energy demand and energy supply more efficient". Not only in writing, but the actions of EU legislators in also implementing the Green Deal have clearly shown adherence to this principle, with the Energy Efficiency Directive and the Energy Performance for Buildings Directive being amongst the first pieces of legislation to be reformed under the Fit-For-55 package. The simple fact is, more than any other form of investment into the energy transition, Energy Efficiency makes the most commercial and practical sense to tackle first.

The benefits and timing of these investments are numerous and forceful. Now more than ever do we see a confluence of factors, from the ongoing climate emergency, the war in Ukraine and the need for energy security,[37] and more recently, the looming threat of global economic disruption[38] which are causing businesses and governments to accelerate their participation in the Renovation Wave.[39] The EU has also recently expressed an interest in accelerating Member States' deployment of funds earmarked for the green transition, hoping to push more funds to security and the green transition.[40]

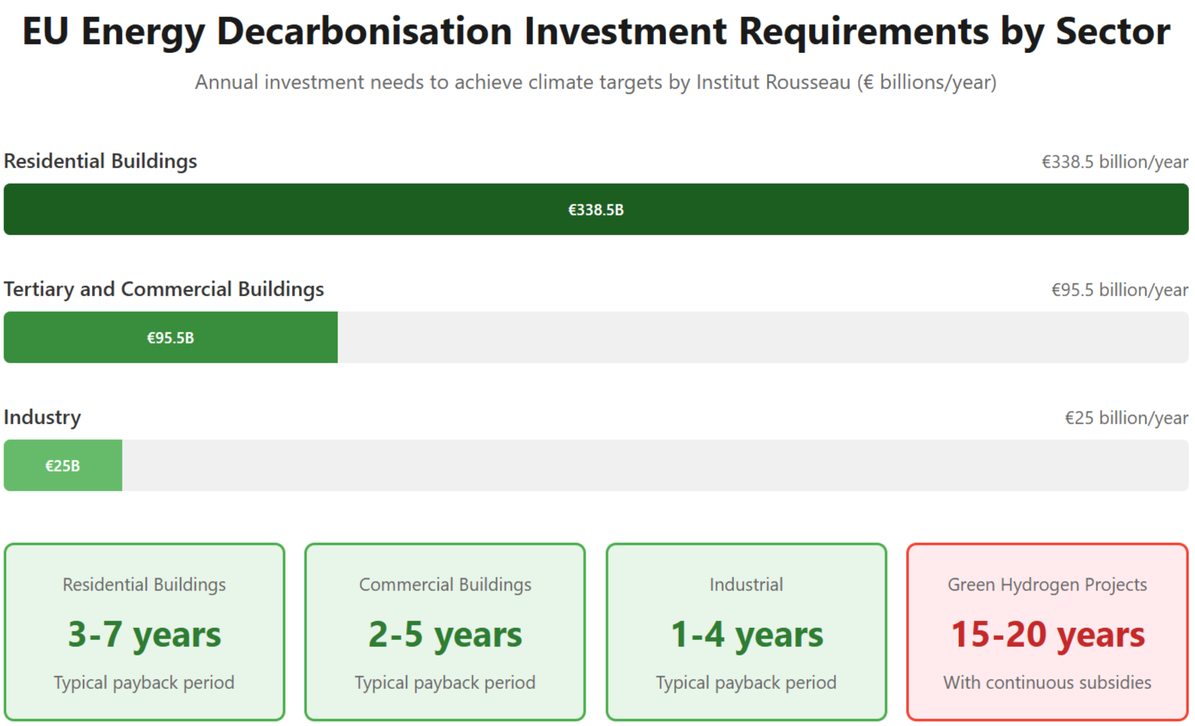

Figure 4: EU Decarbonisation Investment Requirement by Sector (Source: Institut Rousseau)

[36] *Energy efficiency first principle*. (n.d.). Energy. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-first-principle_en
[37] *EU action to address the energy crisis*. (n.d.). European Commission. https://commission.europa.eu/topics/energy/eu-action-address-energy-crisis_en
[38] Chávez, S. (2025, April 3). Your guide to Donald Trump's 'reciprocal' tariffs. *Financial Times*.
[39] European Commission, "A Renovation Wave for Europe", COM/2020/662 final, 2020.
[40] Sorgi, G. (2025, January 31). Commission to loosen rules on how countries deploy unspent EU cash. *POLITICO*. https://www.politico.eu/article/commission-to-loosen-rules-on-how-countries-deploy-unspent-eu-cash/

The Energy Efficiency Investment Landscape

A mature solution with real investment opportunities

The scale of energy efficiency investment required presents an enormous opportunity for investors to participate in the single largest component of Europe's energy transition. Energy efficiency presents a mature, de-risked investment category offering superior stability and predictability. Key aspects to energy efficiency investment, in contrast to Hydrogen, are:

- **Non-Reliance on Subsidiaries:** Most Energy efficiency projects are economically viable without the need for any subsidy schemes, eliminating complexity and risk
- **Mature Technologies and Proven Solutions:** Energy efficiency projects rely on proven technologies, such as rooftop solar, insulation or LED lighting, which are abundantly available, highly reliable and hugely scalable
- **Fixed-Income Characteristics:** Payments are typically structured based on availability, not on market sales.
- **Liability Matching:** The consistent cash flow profile aligns perfectly with the needs of long-term liability holders such as pension funds or life insurance companies.

Solas Capital stands out as **the European expert specialising in structuring financing solutions for energy efficiency business models**. Projects financed successfully by Solas Capital include a wide range of demand-side reductions across the full spectrum of energy users: from residential offtakers and public buildings to large industrial clients.

Case Study Highlight – Resalta

In December 2024 Solas Capital won the Environmental Finance Impact Infrastructure Project of the Year Award[41] for financing Resalta's energy retrofit of a Slovenian school and health center. This project provides a compelling case study demonstrating how targeted energy efficiency financing delivers measurable returns, achieving 757,387 kWh in annual energy savings and 351,390 kg CO2e emissions reduction. The project consisted of comprehensive upgrades (insulation, windows, HVAC, lighting) while enabling budget-constrained public institutions to access improvements without upfront costs, improving learning environments and advancing decarbonization goals.

Residential and Industrial Energy Users – Paul Tech and Quanta

Solas Capital stands out as the leading expert on structuring financing solutions for Heating as a Service (HaaS) business models with residential customers. A stand-out example is Solas Capital's partnership with **Paul Tech AG**[42] to deliver heating system optimisation and savings to customers at a large scale across a wide range of residential buildings, while structuring the debt to deliver stable cash flows to investors. This expertise gives Solas Capital access to the residential segment (which accounts for about two-thirds of all building emissions in the Union) of the growing €149 billion

[41] https://www.environmental-finance.com/content/awards/impact-awards-2024/winners/impact-project/investment-of-the-year-infrastructure-(not-including-renewables)-ssef-and-resalta.html

[42] Solas Sustainable Energy Fund Finances PAUL Tech's Energy-Efficient Heating Solutions in Germany - Energy Efficiency I Solas Capital I Zürich

investment gap between the required EU building renovation goals and the current level of building decarbonisation investment.[43]

Industrial projects are amongst the most complicated to achieve. Despite this, Solas Capital has implemented a range of stand-alone large-scale industrial projects as well as a number of framework agreements focusing on anything from large-scale rooftop solar to increasing the efficiency of industrial processes at food processing plants. A key highlight here is Solas Capital's framework with **Quanta Energy**[44] to finance self-consumption solar PV projects for leading automotive manufacturers in Europe. One such investment, a 16.3MW self-consumption solar PV installation for a major European automotive manufacturer, is one of the largest such installations in Europe and will deliver the same emissions reduction as taking 18 million cars off the road, via a total of 28.1 thousand bifacial solar PV modules. Industrial consumers represent over one quarter of final energy consumption in the EU, presenting an unparalleled opportunity for energy efficiency projects.

These projects have proven themselves to be bankable, scalable investments which contribute meaningfully to the energy transition, and are Art. 9 SFDR and EU Taxonomy compliant, satisfying increasingly stringent ESG mandates. Investing in diversified energy efficiency projects through specialised asset managers provides institutional investors with a strategic advantage: achieving attractive risk-adjusted returns while playing a crucial role in accelerating the energy transition and ensuring European energy security.

Conclusion

> The best Kilowatt hour of energy is the one we don't use

As this paper has hoped to have shown, green hydrogen is still currently only a beautiful illusion – a potentially dangerous distraction from an opportunity writ large in the form of technologically ready and economically feasible energy-efficient investments. These investments present a rare triple-win: they simultaneously address climate goals, enhance energy security, and deliver financial returns. The timing is also right – A trifecta of surplus EU funds, an enhanced energy security focus, and macro-economic incentives for consumers and business to hedge energy costs provide a compelling investment case for energy efficiency, all while being supported at the highest level by recently clarified EU regulations and the promise of unlocked funding.

While the EU and national governments can contribute, financial institutions and investors are also required to participate to close the investment gap and accelerate the transition to a more efficient, secure, and sustainable energy system. Given the attractive profile and range of possible investments, the question investors should be asking themselves is: **why not?**

[43] *How to finance the European Union's building decarbonisation plan.* (2025, May 28). Bruegel | the Brussels-based Economic Think Tank. https://www.bruegel.org/policy-brief/how-finance-european-unions-building-decarbonisation-plan
[44] Solas Capital Expands Solar PV Partnership with Quanta Energy - Energy Efficiency | Solas Capital | Zürich

About Sebastian Carneiro

Sebastian Carneiro is the Chief Executive Officer and Co-founder of Solas Capital AG, a specialised investment advisory firm that pioneers financing solutions for decentralised energy efficiency and behind-the-meter assets across Europe. Sebastian has over 15 years of experience in project finance, including his previous role as Director at Europe's largest private energy efficiency fund. As a CFA Charterholder and engineer by trade, Sebastian is driven by developing innovative investment solutions that accelerate the deployment of green assets and make the energy transition a reality.

About Robert van Breda

Robert van Breda is an Investment Analyst at Solas Capital's Dublin office. He holds an MSc in Law and Finance and an LLB in Law from Trinity College Dublin. His two years at Solas Capital have equipped him with a broad understanding of the challenges faced by sustainable investors and the legal and financial expertise to develop solutions to these novel problems.

About Solas Capital

At Solas Capital we provide specialised financing solutions for demand-side energy projects, bridging the gap between institutional investors and high-impact energy efficiency projects. Unlike traditional renewable energy investments focusing on supply, we specialise in reducing energy demand at scale—an often-overlooked but equally important pillar to reach Net-Zero.

We prioritise the building sector—responsible for 40% of Europe's energy consumption—and industrial efficiency, providing capital to project developers to offer zero upfront cost solutions. Our team of experts structures funding solutions for distributed energy transition projects across Europe, delivering cost savings while reducing fossil fuel dependence.

Our asset-backed private credit strategy offers investors fixed-income like returns from EU Taxonomy eligible assets while accelerating Europe's transition to a carbon-neutral economy. We firmly believe that the best energy is the energy we don't use.

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Disclaimer

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