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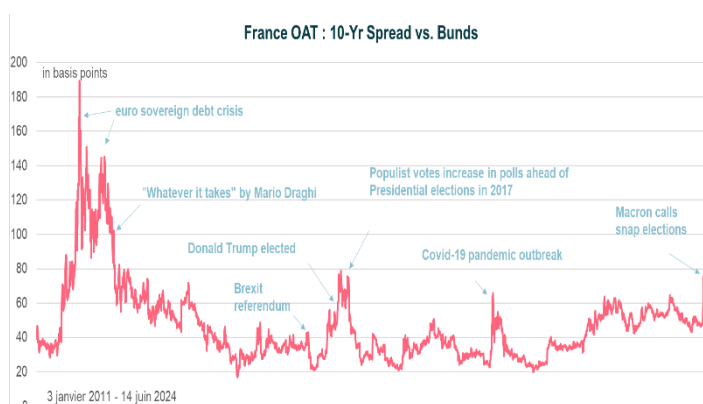
• **Topic of the week: Green Hydrogen, the new "zero-carbon" commodity ?**
by Zouhoure Bousbih,

- Geopolitical developments and the desire to move away from fossil fuels have rekindled interest in green hydrogen. It is a key element in decarbonizing heavy industries that are difficult to electrify;
- Despite this enthusiasm, investments in hydrogen account for only 0.6% of global energy investments, reflecting high production and deployment costs resulting in low demand;
- China has rapidly increased the capacity of its electrolyzers and could become the global leader in hydrogen. Renewable hydrogen also presents an opportunity for fossil fuel-producing countries, but challenges related to water resources, crucial in hydrogen production, could limit their ambitions.

• **Market review: French political risk derails markets**
by Axel Botte

- Political risk in France: OAT spreads at 77 bps and CAC 40 down 6% last week underperform significantly;
- FOMC held rates unchanged, as inflation shows signs of moderating;
- Swap spreads rise, decompression in credit markets;
- The gap between VIX and VSTOXX implied volatility indices highlight the European political risk.

• **Chart of the week**



The spread of the OAT is around 80 basis points. This level recalls the situation that prevailed at the time of fears of a EU exit with the rise of extremists during the 2017 presidential campaign, against the international backdrop of Brexit or the election of Donald Trump.

At the beginning of the 2010s, the sovereign debt crisis and the ensuing banking crisis had caused the spread to skyrocket to 190 basis points before dropping to 140 basis points in 2012, until the famous "whatever it takes" speech by Mario Draghi.

• **Figure of the week**
-0.53%

This is the performance of the French CAC 40 index since the start of the year. The benchmark equity index has erased all year-to-date gains since President Macron called snap elections.

Source: Bloomberg

- Topic of the week

Green hydrogen, the new "zero-carbone" commodity?

The global changes, including geopolitical shifts and the push to move away from fossil fuels, have revived interest in green hydrogen as a new energy source. We propose to provide an update on the developments of this new renewable energy.

What is "green" hydrogen?

"Green" hydrogen is defined as hydrogen produced by separating a water molecule into hydrogen and oxygen, using renewable electricity. This process is very different from those used to produce "grey" or "blue" hydrogen. The table below represents the different production processes of hydrogen.

Green hydrogen is expected to develop rapidly thanks to two key technologies: renewable energy and electrolysis.

Color	GREY HYDROGEN	BLUE HYDROGEN	TURQUOISE HYDROGEN	GREEN HYDROGEN
Process	Gasification or SMR*	Gasification, SMR* with carbon capture (85-95%)	Pyrolysis	Electrolysis
Source	Coal or méthane	Méthane or coal	Méthane	Renewable electricity
Estimated emissions from the production process [CO ₂ éq/Kg]	SMR: 9-11 Gasification: 18-20	SMR: 0.4-4.5	NA	0

Sources: According to the IREA image, Ostrum AM - SMR: steam metal reforming

Depending on the production process, hydrogen can be "green", "turquoise", "yellow" (solar energy) and even "pink" when the electricity originates from nuclear power. The technology used for "turquoise" hydrogen production holds promise for high capture rates (90%-95%) and efficient long-term storage of CO₂ in solid form, potentially better than for "blue" hydrogen. However, methane pyrolysis is still under development, while "green" hydrogen is expected to

develop rapidly, thanks to two key technologies: renewable energy and electrolysis.

What role does it play in the green transition?

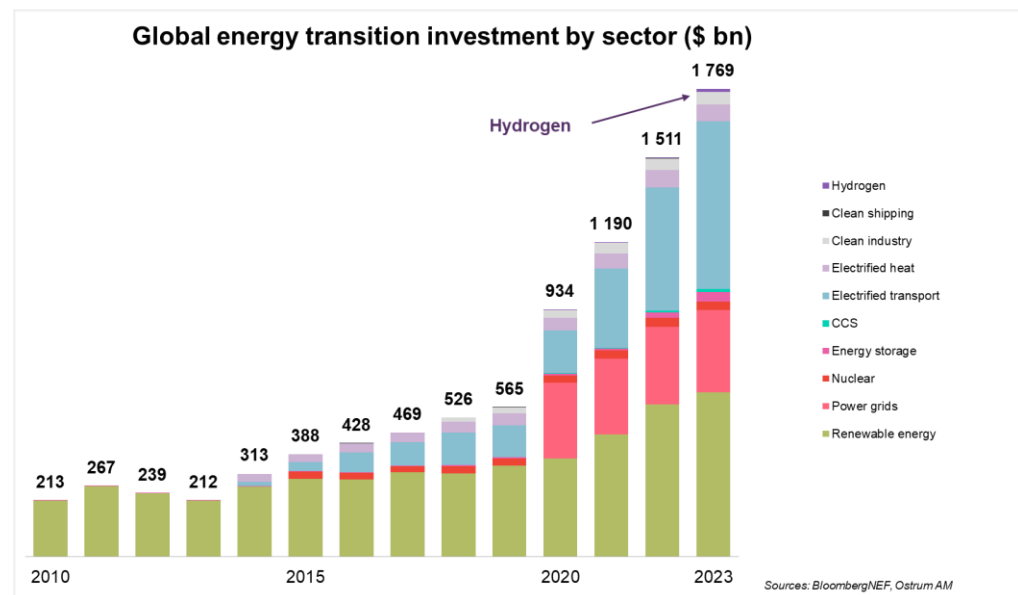
“Green” hydrogen would enable the decarbonization of heavy industry, responsible for 10% of global CO₂ emissions.

“Green” hydrogen is a key element in the energy transition, as it will allow for the decarbonization of hard-to-electrify sectors such as heavy industry, maritime transport and aviation. However, heavy industry is one of the most difficult sectors to decarbonize. This sector encompasses the production of steel, cement, and petrochemical products. Their high-temperature manufacturing processes are responsible for approximately 10% of global CO₂ emissions, more than aviation and automobiles combined. However, the heavy industry has made significant progress in the decarbonization path. In 2023, clean steel represented \$10.3 billion (compared to \$3.5 billion in 2022), accounting for 30% of total investments.

What place does green hydrogen have in clean energy investments?

Despite the interest in “green” hydrogen, it represents only a tiny fraction of global investments in energy transition. In 2023, investments in “green” hydrogen amounted to \$10.4 billion (compared to \$3.4 billion in 2022), accounting for 0.6% of the total, as shown in the graph below.

Despite the interest in “green” hydrogen, it represents only 0.6% of global investments in clean energy.



To achieve a net-zero carbon footprint, investments in “green” hydrogen must reach \$3.4 trillion by 2050. This means that the amount of investments in 2023 represents only 0.3% of the needs. Therefore, there is a need to accelerate

investments to reach the carbon neutrality goal by 2050. However, less than one third of the 1,600 announced projects have materialized due to uncertainty about demand evolution, lack of regulatory clarity, and inadequate infrastructure for transporting "green" hydrogen.

The global regulatory framework is evolving...

The global regulatory framework is evolving. Support measures are materializing in the form of production tax credits and financial backing for hydrogen hubs in the United States, renewable hydrogen mandates in the Renewable Energy Directive (RED III) in Europe and term contracts in Japan. However, regulatory uncertainties persist, such as the definition of requirements to qualify for the inflation reduction allowance (IRA) and tax credits in the United States and the implementation of RED III in European countries, suggesting that these policies have not yet fully impacted the renewable hydrogen market.

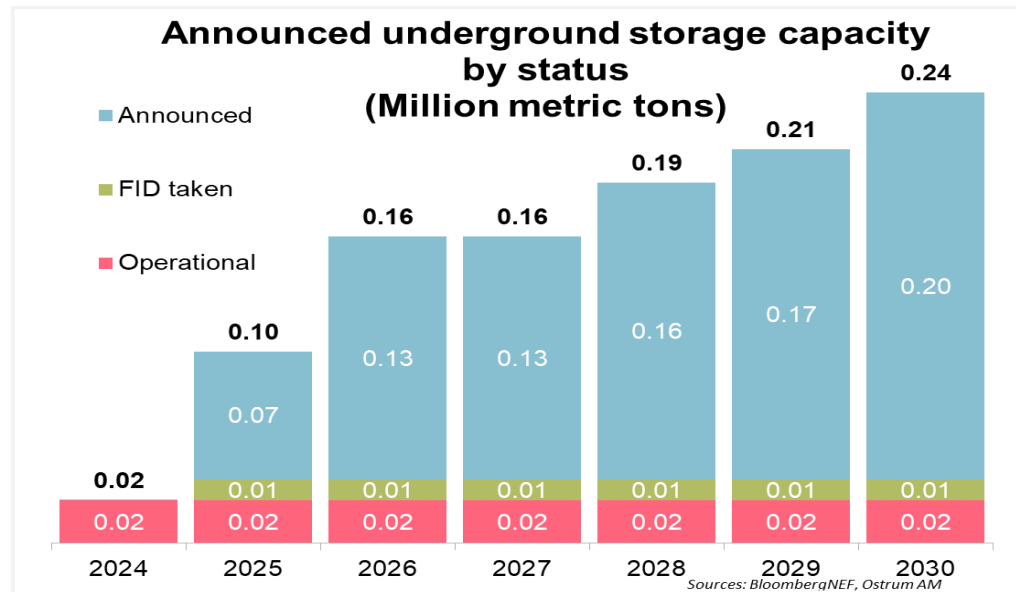
... But the costs remain high

Green hydrogen projects are accelerating, but high deployment costs are hindering their realization. This is related to the inherent issues of hydrogen. 95% of the hydrogen produced today is polluting.

To make this hydrogen "clean," the following challenges will need to be addressed:

- Chemical properties: Hydrogen cannot be transformed into a liquid, which complicates its storage and transport, as it is an odorless and highly flammable gas;
- High energy consumption: Hydrogen requires a lot of energy to be produced, at 66 kWh per kg. This explains its limited use as an energy source;
- Economic cost: Hydrogen has a higher cost per kWh of transported energy than the market prices of electricity.

Due to the volatile nature of hydrogen, transport and storage networks are critical for a continuous supply of green hydrogen. However, progress has been limited. Underground storage proposals, effective for storing large amounts of hydrogen, will total 0.24 Mt (8.6 TWh) by 2030, representing only 1.3% of production, as shown in the graph below.



Costs and cost projections have increased significantly, especially for green hydrogen. If built today, the estimated actualized cost of renewable hydrogen production would range between \$4.5 and \$6.5 per kg, representing a 30% to 65% increase. This rise is attributed to various factors, including higher labor and material costs, higher costs for building electrolyzer facilities, a 3 to 5 percentage point increase in capital costs and a more than 30% rise in renewable energy costs.

However, by 2030, the cost of producing renewable hydrogen is expected to decrease, ranging from \$2.5 to \$4.0 per kg, thanks to technological advancements in electrolyzers, manufacturing economies of scale, design improvements and reduced renewable energy costs. In this perspective, "green" hydrogen could follow a similar trajectory to that of solar panels.

Demand: the “chicken and egg” problem

The "chicken and egg" problem refers to the situation where it is difficult to determine what should be the priority: investing in a technology or infrastructure before it becomes economically viable, or waiting for it to become economically viable before investing. For "green" hydrogen, investors may hesitate to commit to projects until profitability is assured. This creates a vicious cycle where initial lack of investment delays technology development, making it harder to justify future investments.

Heavy industry and long-distance transport currently represent less than 0.1% of the current demand for "green" hydrogen!

Demand is crucial to stimulate investment in renewable hydrogen. It is increasing but remains concentrated in traditional applications. According to the International Energy Agency, emerging applications in heavy industry and long-distance

transport currently represent less than 0.1% of the demand for "green" hydrogen, but are estimated to represent a third of global demand for renewable hydrogen by 2030, within the scope of carbon neutrality by 2050. More and more countries are developing national strategies and implementing concrete policies to support research and innovation. However, delays in the implementation of these policies and the absence of demand-stimulating policies hinder the expansion of the production and use of "green" hydrogen.

Hydrogen Strategies for Key Players

China is the leading consumer [24 million tons] and global producer of hydrogen, mainly produced from coal [3%-5% of its coal consumption]. The country has launched numerous green hydrogen projects and is advancing the use of fuel cell electric vehicles. China could exceed its 2024 target for green hydrogen production of 200k tonnes, with an estimated production of 220K tonnes for this year. This remarkable progress is linked to the increase in its electrolyzer capacity to 1 GW, putting it on track to dominate the global green hydrogen market.

China could quickly dominate the global green hydrogen market.

The European Union has released a strategy focusing on renewable hydrogen, aiming to install 40 gigawatts of renewable hydrogen electrolyzers by 2030.

India has set a goal to become a global platform for the production and export of green hydrogen, with plans to make the use of green hydrogen mandatory for certain industries.

Japan aims to become the world's first "hydrogen powerhouse," with significant investments in hydrogen technologies and mobility goals for fuel cell electric vehicles.

South Korea aims to become a global leader in the production and deployment of fuel cell electric vehicles, with ambitious goals for hydrogen use in cities and urban areas.

The United States, the world's second-largest consumer and producer of hydrogen, has enacted legislation aimed at accelerating the development of clean hydrogen technology, with the ambitious goal of reducing the cost of clean hydrogen to \$1 per kilogram within a decade.

What about fossil fuel-exporters countries?

Green hydrogen offers an attractive opportunity for oil and gas-exporting countries to diversify their economies in response to the evolving markets for low- or zero-carbon fuels and energy carriers. These countries already have

Fossil fuel-producing countries have an advantage in transitioning to green hydrogen, particularly due to their established energy export infrastructure.

established energy export infrastructure (ports, pipelines, and storage facilities); a skilled workforce familiar with producing, converting, and handling energy fuels and gases; and existing energy trade relations, giving them a competitive advantage in this emerging sector.

North Africa has opted for the development of exports directly linked to the growth of European infrastructure. Energy partnerships have been established by Germany with countries such as Morocco, Saudi Arabia, and the United Arab Emirates. The Gulf countries are also positioning themselves as key hubs in hydrogen production, such as Oman, Saudi Arabia, and the United Arab Emirates. However, hydrogen production is a conversion activity, not extraction, allowing it to be produced in many places, limiting its potential profitability compared to that generated by fossil fuels, which currently represent 2% of the global GDP. Furthermore, as the costs of green hydrogen decrease, new participants will enter the market, making hydrogen even more competitive. This could affect the current comfortable budget outlook of fossil fuel-producing countries.

Challenges related to water resources

Water resources are crucial in the hydrogen production.

While current discussions primarily focus on the economic aspect of hydrogen, emphasizing costs and technical barriers, very little attention is given to concerns about the raw materials needed to produce clean hydrogen.

Freshwater is crucial in the hydrogen production process, requiring approximately 9 liters to produce one kilogram of green hydrogen and 12 to 19 liters for one kilogram of blue hydrogen. This is particularly relevant for arid Gulf countries positioning themselves as key hubs for hydrogen. To meet the demand for freshwater, the extension of desalination facilities is often the preferred solution. However, current desalination is not an environmentally sustainable solution due to the dispersion of by-products into the seas and the dependence on fossil fuels to power the facilities.

The advantages of producing hydrogen through methods such as electrolysis with carbon capture and storage lie in its potential to offer a clean energy solution, contributing to decarbonization and energy security in the sustainable transition. In the context of partnerships between European countries and Gulf countries, this omission seems to be driven by concerns that such a requirement could exclude various relevant supply regions in the Middle East.

Conclusion

The growing interest in green hydrogen as a new renewable energy source highlights economic and technical challenges, as well as those related to the use of freshwater in its production, and the implications for arid regions around the globe. Governments need to pay greater attention to these environmental issues by supporting the development of sustainable solutions addressing these challenges.

Zouhoure Bousbih

- **Market review**

French political risk derails markets

The announcement of early legislative elections has plunged the markets into uncertainty, leading to a clear underperformance of French stocks and bonds. Meanwhile, the Fed is scaling back the expected rate cuts, but the dollar continues to be seen as a safe haven.

Alas, political risk once again looms large over the global financial markets. Following the abrupt adjustment of the South African and Mexican currencies in response to recent elections, the announcement of early legislative elections in France has resulted in a marked underperformance of French assets. The CAC has relinquished all its gains for the year, and the OAT spread, previously impervious to the credit rating downgrade by S&P, now hovers close to the 80 bp threshold. The euro plunges beneath \$1.07 in reaction to the political uncertainty, permeating credit markets through a widening of swap spreads. The trend of tightening spreads by rating reflects tensions focused on sovereign and investment grade. In Japan, the BoJ remains a mere spectator of the yen's weakness (158 to a greenback), while conceding the need to curtail JGB purchases.

In the United States, the FOMC has maintained the status quo on rates at 5.50%. The median FOMC rate projections for 2024 indicate only one cut this year, but the most cited scenario includes two movements. The decline in CPI to 3.3% in May and the weaker contribution of service prices constitute the first glimmer of hope on the inflation front after three upward surprises. Import and production prices also indicate moderation. Furthermore, the labor market continues its normalization. The gradual increase in unemployment will thus empower the Fed to act, likely as early as September. Europe follows in the footsteps of the United States by announcing an increase in tariffs on Chinese electric vehicles. China will retaliate with similar measures and maintain a weak yuan, especially as the BoJ does not seem capable of halting the yen's descent. Protectionism and competitive devaluations are two sides of the same deleterious trade policy. Germany, ensnared in the grip of European tariff proposals, witnesses its hopes for export recovery wane.

In the financial markets, flows into U.S. money market funds reflect risk aversion. Over \$6 trillion is currently parked in the least risky funds. The T-note (4.20% at the weekly close) benefits from reallocations from Europe to the United States and US disinflation. The Bund (2.35%) remains the local safe haven, but political risk also justifies a reduction in exposure to European interest rate sensitivity. The resulting steepening of the curve is accompanied by a significant widening of the 2-year swap spread. The French spread approaches 80 bp. Italian debt trades at 160 bp. This tension impacts credit valuations (especially subordinated finan-

cials), even though the average Euro IG spread only widens by 2 bp against the swap. The compression of spreads on indices reflects stress centered on IG. In the stock markets, American technology (+2.8%) masks a lackluster market. The quoted volatility gap between the VSTOXX (20.5%) and the VIX (12%) is indicative of risk asymmetry. The European market is down 4% for the week, with the CAC 40 plunging 6%.

Axel Botte

- Main market indicators

G4 Government Bonds	17-Jun-24	1w k (bp)	1m (bp)	2024 (bp)
EUR Bunds 2y	2.78%	-31	-21	+37
EUR Bunds 10y	2.39%	-28	-13	+37
EUR Bunds 2s10s	-38.8bp	+3	+8	0
USD Treasuries 2y	4.71%	-17	-11	+46
USD Treasuries 10y	4.24%	-23	-18	+36
USD Treasuries 2s10s	-48.1bp	-7	-7	-11
GBP Gilt 10y	4.07%	-25	-5	+54
JPY JGB 10y	0.94%	-11	-6	-30
€ Sovereign Spreads (10y)	17-Jun-24	1w k (bp)	1m (bp)	2024 (bp)
France	61bp	+5	+13	+7
Italy	154bp	+14	+23	-12
Spain	91bp	+14	+18	-5
Inflation Break-evens (10y)	17-Jun-24	1w k (bp)	1m (bp)	2024 (bp)
EUR 10y Inflation Swap	2.22%	-6	-3	+9
USD 10y Inflation Swap	2.46%	-10	-11	+4
GBP 10y Inflation Swap	3.68%	-6	-7	+15
EUR Credit Indices	17-Jun-24	1w k (bp)	1m (bp)	2024 (bp)
EUR Corporate Credit OAS	122bp	+13	+11	-16
EUR Agencies OAS	73bp	+18	+16	+3
EUR Securitized - Covered OAS	70bp	+13	+9	-9
EUR Pan-European High Yield OAS	378bp	+47	+30	-21
EUR/USD CDS Indices 5y	17-Jun-24	1w k (bp)	1m (bp)	2024 (bp)
iTraxx IG	65bp	+12	+14	+7
iTraxx Crossover	335bp	+40	+45	+21
CDX IG	54bp	+4	+5	-3
CDX High Yield	346bp	+12	+18	-10
Emerging Markets	17-Jun-24	1w k (bp)	1m (bp)	2024 (bp)
JPM EMBI Global Div. Spread	395bp	+9	+23	+11
Currencies	17-Jun-24	1w k (%)	1m (%)	2024 (%)
EUR/USD	\$1.071	-0.502	-1.454	-3.0
GBP/USD	\$1.267	-0.471	-0.236	-0.5
USD/JPY	JPY 158	-0.374	-1.256	-10.5
Commodity Futures	17-Jun-24	-1w k (\$)	-1m (\$)	2024 (%)
Crude Brent	\$82.7	\$1.1	-\$0.9	8.6
Gold	\$2 321.1	\$10.2	-\$94.2	12.5
Equity Market Indices	17-Jun-24	-1w k (%)	-1m (%)	2024 (%)
S&P 500	5 432	1.58	2.42	13.9
EuroStoxx 50	4 856	-3.19	-4.11	7.4
CAC 40	7 512	-4.84	-8.03	-0.4
Nikkei 225	38 102	-2.40	-1.77	13.9
Shanghai Composite	3 016	-1.16	-4.38	1.4
VIX - Implied Volatility Index	13.22	3.77	10.26	6.2

Source: Bloomberg, Ostrum AM

Additional notes

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