03.

TRANSITION LEVERS & CASE STUDIES

KEY TAKEAWAYS Chapter 3

To assess the different transition profiles of companies, we designed **a methodology encompassing five levers** a firm can activate to reduce its emissions and align with a below 2°C global temperature increase scenario.
At corporate level, transitioning is multi-faceted involving these different but complementary levers…

Quit/Exit
Exiting an activity because of its highly emissive feature (coal, tar sands) and/or because there are competitive substitutes. Firms can either convert, divest or decommission brown assets.

Diversify
Growing organically, acquiring or merging with less emitting actors to change their business mix (e.g., foray in renewable energy for an Oil & Gas company).

Decarbonize core activities
Investing and implementing new processes, feedstock/fuel changes, R&D expenses in less carbon-intensive processes (incremental or radical innovations).

Offset
Compensating for emissions by buying or developing offsetting projects (VCS, Gold Standard), including natural capital solutions, or by investing in/and developing CCUS projects.

Provide decarbonization solutions
Helping other companies to decarbonize; low-carbon electricity or biofuels providers, an aluminum producer helping with mobility's electrification (lighter cars)

- Our methodology frames **a change management model** that differentiates brown companies into groups depending on whether they need to **transform**, **shrink** or **shut down**.
- In the case studies proposed, we paid heed to **levers mobilization, the governance associated, investments and timeline involved in the transition pathway**. Trade-offs, obstacles, unintended consequences and the impact of the chosen levers on the overall transition of the company are analyzed (results achieved, impact on carbon intensity, foray in new market).

3.1 | OUR FIVE TRANSITION LEVERS

Mapping of the different levers actioned by a sample of companies

	Self-decarbonization (*"greening of"*)				Outbound decarbonization (*"greening by"*)
	Quit/exit some activities	Diversify activities	Decarbonize core activities	Offset your emissions	Greening of (solutions provider)
Ørsted	✓	✓			
drax	✓	✓			
YINSON	✓	✓			✓
ENGIE	✓	✓	✓		✓
TOTAL	✓	✓	✓	✓	✓
NESTE					✓
Shell		✓	✓	✓	✓
SOLVAY		✓			✓
Vestas					✓
RioTinto			✓		✓
CATL					✓

Source: companies' websites and authors

- Mobilizing *to some extent* different levers does not answer the question of **whether it is done sufficiently**, nor if it reflects the overall strategy of the company.
- In the case of the most irreplaceable industries, one expects less activities diversification (e.g., cement producers will not become mobility providers).
- **"Exiting" could be from a source of power supply or a feedstock** (e.g., coal, or palm oil for biomass), **or from a segment of activity or product** (e.g., coal mining for a mining company). Quitting requires to diversify if the company is to survive.
- **Levers are often intertwined.** Decarbonizing core activities has benefits in terms of outbound decarbonization. If a company offers lower carbon basic materials, it lowers the upstream emissions of its customers (a lower emission cement ticks the box "decarbonize core activities" but also "outbound decarbonization" (solutions providers) to real estate companies.

3.2 | OVERVIEW OF CASE STUDIES

- ✓ LEVER #1 | Quit/Exit most climate harmful activities
- ✓ LEVER #2 | Diversify activities & products
- ✓ LEVER #3 | Decarbonize core & hard-to-abate activities
- ✓ LEVER #4 | Offset emissions
- ✓ LEVER #5 | Provide decarbonization solutions

SCRUTINIZED COMPANIES

SIEMENS Gamesa RENEWABLE ENERGY
ENGIE
MAERSK
Ørsted
الإتحاد ETIHAD AIRWAYS
LafargeHolcim
drax
NESTE

Lever #1 | Quit/Exit most climate harmful activities

What does an "exit" strategy mean ?

Change activity and/or business model by divesting or disengaging from some activities (coal), with two alternatives unequally beneficial for climate change: asset disposal/sale vs. decommissioning

What are the activities concerned ?

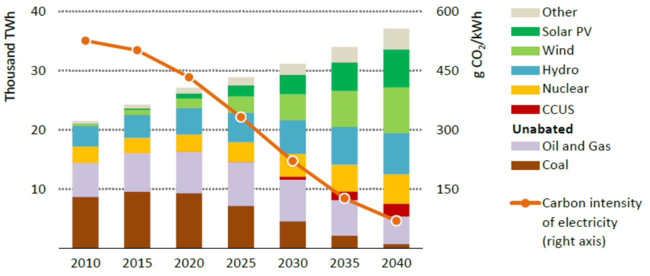
There is no real consensus to define a list of such activities:

- A taxonomy of brown activities could be developed within the EU Taxonomy Framework (it is part of the review clause of the Taxonomy Regulation)
- One bears in mind that **nuances for the same source of energy are necessary**. As an illustration, emissions (scope 1 and scope 2) from oil production can vary significantly, from 20g CO_2 equivalent/per megajoule for Venezuela's production to less than 5g for Saudi Arabia*.

Example of activity: coal power generation

The figure below shows that **unabated coal must be reduced to almost zero in power generation by 2040** according to the IEA's Sustainable Development Scenario (SDS), which is its most ambitious and Paris Agreement aligned scenario.There may be **divergences in terms of the timing and extent of such phase-out ambitions**.

FIGURE | Projected Electricity generation & carbon intensity by source in the Sustainable Development Scenario



* Source: IEA (2018), World Energy Outlook; The Economist (November 2nd 2019), Briefing Saudi Aramco, Stanford University; Rystad

Strategies to exit

1. Asset repurposing: the polluting assets are reused in less carbon-intensive activities
2. Asset decommissioning: the polluting asset is gradually closed
3. Asset disposal: the polluting asset is sold to a third party
4. Asset divestment and spin-offs

Divestment and spin-offs are the fastest way for individual companies to achieve carbon reductions (both in relative and absolute), but they are by definition one-off events and do not reduce overall GHG emissions .

Asset repurposing	Decommissioning	Disposal	Spin off
Drax power plant conversion from coal to biomass and CCGT	Engie decommissioned Hazelwood Power Station in 2017	Engie disposed of its coal-fired assets (e.g. Paiton and Loy Yang B)	A.P. Moller-Maersk spun off its oil and gas drilling unit in April 2019

Focus on the components of "exit lever"

SIEMENS Gamesa RENEWABLE ENERGY

Selling off coal-fired power plants to third parties does not reduce overall emissions: upon the closing of such transactions, assets usually remain in operation and continue to generate emissions under a different owner.

Note that the GHG Protocol requires base year emissions recalculation in case of structural changes. Recalculation of baselines is necessary because such structural changes merely transfer emissions from one company to another without any change of emissions released to the atmosphere. Whether base year emissions are recalculated (excluding the sold assets) depends on the significance of the changes.

As such, a complete decommissioning of the most highly emissive assets is more impactful than a mere change in ownership.

However, we should not judge companies that choose to sell certain assets, as we understand the financial implications of such decisions.

Public authorities should, under specific circumstances, subsidize decommissioning. In any case, disposal has to be reviewed holistically with other steps that a company takes to transition, to determine if it is a one-off event or part of a strategy that is comprehensive and include internal core decarbonization.

Among the Exit/Quit options, the "repurposing" or "redevelopment" of the facilities is probably the most beneficial as it allows to maintain economic activity in the areas, especially to preserve jobs.

As an illustration of "repurposing", Siemens Gamesa has experimented with a new storage solution based on volcanic stones that capture and store heat produced from renewable energy sources. Former coal power plants are reportedly converted for such large-scale and inter-seasonal storage (stones can stay hot for weeks). Thermal fossil fuel power stations can thereby become CO_2 free energy storage plants, combining existing equipment with new technology. This transformation minimizes the negative effects of plant closure with the furnace being replaced by electric thermal energy storage (ETES), while steam cycle and operation processes remain in place.

Ørsted: a pivotal shift from brown to dark green

The Danish oil & natural gas company (formerly Dong Energy AS) **became Ørsted in 2017 following its divestment from upstream oil & gas.** Ørsted's operations include electricity generation from offshore wind & bioenergy, energy storage, renewable hydrogen & technological innovation for decarbonization. It is a market leader in offshore wind (25% of global market share), intends to triple the number of persons it powers from 9.5 million in 2019 to 30 million by 2025.

Power sector's transition opportunities

This case study focuses on the **offshore wind market** (Ørsted's biggest green footprint so far).

- **Offshore wind market** has had an annual growth of 30% since 2010. The volume of potential power generation is estimated at 420,000 TWh per year worldwide (IEA, Offshore Wind Outlook 2019), which is 18 times more than global electricity demand in 2018 (23,300 TWh).
- Prediction of a market growth of 13% per year over the next two decades in IEA's Stated Policies Scenarios.

Ørsted is an **unrivaled leader**: it developed the world's first offshore wind farm in 1991, built the largest wind turbine in 2017 and the world's largest wind farm that came online in 2020.

Governance, timeline & shareholding

- **Planning to exit coal entirely by 2023.** This would see its emissions plunge by 96% (an 83% decrease as of mid-2019) against a 2006 baseline when it used up more than 6.2 million tons of coal.
- **Adopting a science-based target for emission reduction in heat and electricity generation** by cutting back Scope 1 & 2 GHG emissions to 98kWh by 2025 from a 2006 base year, and reducing absolute Scope 3 GHG emissions to 50% by 2032 against a 2018 base line.
- **Embarking on a conversion of its coal-fired plants to sustainable biomass.** In 2018, offshore wind and bioenergy accounted for 81% Ørsted's capital employed.
- **Selling its O&G assets rather than decommissioning it,** meaning that the facilities would keep on generating emissions during their operating life but Ørsted would no longer be liable for those emissions.

How the company opted for the "exit" lever

In 2017, Ørsted decided to **sell its upstream oil and gas business** to Ineos for $1.3 billion.

- Transition process included **a deep rebranding process & change of the business model** from an upstream O&G producer, coal-based electricity & heat generator, to an entirely green electricity & heat generator.
- Ørsted is **a partially State-owned company** and the government has been vocal in terms of the energy transition (public shareholding can be a determinant criteria, *idem* with Engie). As of September 2019, the Danish government owns 50.1% of the company.
- The Danish government must keep a majority share until 2025. Decreasing its participation from the 50% is subject to a new political agreement.

Source: Orsted's company report

Ørsted: a pivotal shift from brown to dark green

The effectiveness of its transition is reflected in its numbers: from 462g CO_2e/kWh in 2006 to 131g CO_2e/kWh in 2018 and striving to reach 10 g CO_2e/kWh through a complete phasing out of coal by the beginning of 2023

EXIT

- Divestment from coal
- Phase out from O&G with a major divestment in 2017 (selling the exploration business for US $1.3bn)

DIVERSIFY

- Develop, build, own, operate & exploit offshore and onshore wind farms and/or turbines.
- Bioenergy (biomass CHP plants and biogas generation)

DECARBONIZE CORE ACTIVITIES

Convert all its coal-fired power plants to biomass-fired power plants (mainly using wood pellets & wood chips) by 2023

OFFSET

Not mentioned by the company

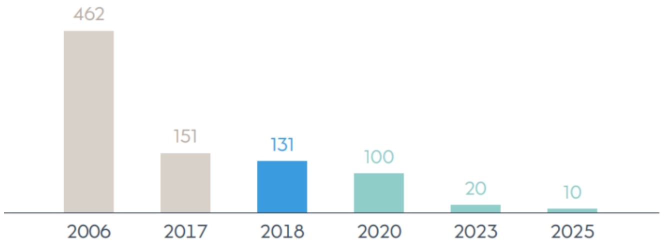
PROVIDE DECARBONIZATION SOLUTIONS

Develop intermittent energies & create scalable Battery Energy Storage System. Create competitive storage systems: Carnegie Road project (Ørsted's first commercial stand-alone BESS).

In a nutshell

- **Is it ambitious?** This strategy matches Paris agreement pledges. The transition has already taken place and the company has almost become a pure green player.
- **Is it consistent?** The pivotal shift occurred in 2017 when the company divested from oil and gas exploration and exploitation, and it has been consistent and progressive over the last five years. It is a good example of consistent, total and radical change in business model.
- **Is it game changing?** Being able to propose scalable and competitive offshore wind facilities and operations makes Ørsted a game changer and contributor to the transition.
- **Is it enough?** Yes it is. A carbon intensity of around 10 gCO_2/kWh is to be reached in 2025 and would make Ørsted an indisputable forerunner.

FIGURE | Ørsted's power carbon intensity
(g CO_2e/kWh)



Source: Orsted's company report

Engie: the impact of exiting coal on the Group's transition

Engie is a French multinational energy utility group in the gas and electricity value chain and operates in 70 countries. **Since 2016, with the "Zero-carbon transition" plan, it has recorded a significant decrease in both absolute and relative GHG emissions** coupled with the installation of renewable capacities in both absolute and relative terms. Engie pledged to align with the 2°C target of the Paris Agreement and its decarbonizing targets have been certified 2°C aligned by the SBTI (Science Based Targets Initiative) in 2020.

FIGURE | The power sector

40%
of global energy-related CO_2 emissions

Influence other sectors' emissions
especially those with significant Scope 2 emissions.

Two main barriers for drastic emission reduction in the power sector

- The steady global electricity demand
- The dominance of coal in the global electricity mix (38% in 2018 *versus* 35.5% for low-carbon technologies)

How Engie opted for the "Exit" lever?

1 By phasing out coal

In 2019, coal capacity represented 4% of the electricity generation capacity (a 55% reduction in Scope 1 carbon emissions occurred between 2016-2019). Decommissioning and asset-disposal have been deployed to exit from coal (Chile, Australia, UK). The CO_2 emissions related to power generation should reach 43 Mt by 2030 (vs. 149 Mt in 2016).

2 By disposing carbon intensive assets

Between 2016 and 2018, Engie generated €16bn through the disposal of these assets (in the USA, India, Indonesia). In 2019, it disposed of its coal-fired power plants in Thailand, the Netherlands and Germany.

3 By pulling back from projects

In Chile, Engie is for instance replacing 1 GW of coal-fired assets with 1 GW of renewable energy.

TAKEAWAYS

- **Companies should be ready to take bold measures** (backing away from already financed projects with some public support).
- **The exit lever can be part of the strategic orientation.** Between 2015 and 2019, coal decreased from 13% to 4% in Engie's energy mix. It also set the target of 58% of renewable energy in the electricity mix in 2030 (28% in 2019).

Source: Engie, "2020 Integrated Report" (April 2020)

Engie: the impact of exiting coal on the Group's transition

Engie targets an 85% absolute direct (scope 1+2) emission reduction for 2050: from 149Mt in 2012 to <20Mt in 2050. The exit lever has been activated radically (see the figure below, the coal capacity declined from 15.1 in 2015 GW to 7.2GW in 2018). The decommissioning & disposal of assets contribute to a large part of the direct emissions reduction.

EXIT

Between 2015 and 2019, coal decreased from 13% to 4% in Engie's energy mix.

DIVERSIFY

Investing significantly in clean gas (hydrogen, biogas, €800m between 2018-2023 to achieve the targets of 10% of renewable gas by 2025, 30% in 2030, 100% in 2050). Engie sets the target of 58% of renewable energy in the electricity mix in 2030 (28% in 2019).

DECARBONIZE

- An 85% absolute direct (scope 1+2) emission reduction for 2050
- A 52% reduction of emissions per kWh of energy production between 2017 and 2030
- A 34% reduction of the emissions linked to the use of Engie's products sold between 2017 and 2030s

OFFSET

Not mentioned by the company

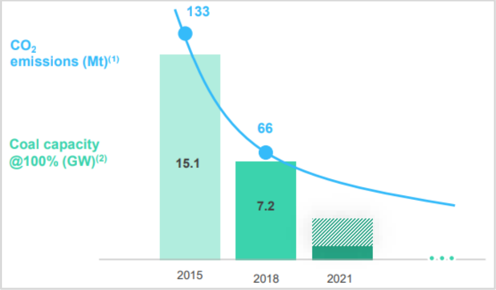
PROVIDE DECARBONIZATION SOLUTIONS

Providing low carbon energy to clients, integrated energy efficiency solutions for buildings and works to offer efficient renewable energy storage systems (power to gas).

In a nutshell

- **Is it ambitious?** According to the Transition Pathway Initiative, its emissions intensity and targets are aligned with the Paris Agreement. The rapid activation of the exit lever was a positive signal (the full assessment is available here).
- **Is it consistent?** Not completely. Engie is not a pure green player yet, though it sets a clear transition plan and builds its strategy on transition opportunities.
- **Is it game changing?** Yes, to some extent. It disposed some of its carbon intensive assets instead of decommissioning it (equivalent to a complete cease). Nonetheless, by making the carbon-neutral transition at the core of the strategy, acting worldwide, the Group offers a sound transition example. .
- **Is it enough?** So far, yes. The company is on the right track and needs to meet its engagements with the same dedication it exited coal.

FIGURE | Coal phase out and CO_2 reduction



Source: Engie's company report

Lever #2 | Diversify activities & products

What does diversification mean ?

Diversification is a well-known business option employed to expand a company's market position. In the context of brown industries' transition, it has an additional application as it could also allow reducing a company's carbon intensity while expanding its activities and growing its revenues.

Diversification is often the first step of a phase-out process to hedge against transition risks in more carbon intensive sectors. The impact of actioning the diversification lever is magnified at scale when done alongside other levers because external growth by itself would do little but merely reduce the carbon intensity of a company without affecting its absolute emissions.

What are the activities concerned ?

- **Horizontal diversification** is a must have in some specific sectors **where there are substitutes**, i.e., more replaceable ones (see the section "are brown companies all equal ?").
- It is not considered activating the diversification lever either if the new product has the same characteristics as the existing one except it is less carbon-intensive to produce.
- We can consider the diversification lever to be activated w**hen the parent company is developing a new business in which it was not previously involved in** as long as it was not its main or predominant business (i.e., it derives the most profit from).

Input Diversification

Input diversification describes a change **in feedstock, fuels or chemicals**. It reduces carbon intensity for a given end-product.

This would not be considered as diversifying in our analytical framework as we strictly linked "diversification" with the offering of new products. Such input diversification rather falls within our "decarbonize core emissions" lever.

Output Diversification

Output diversification describes **the expansion of a company's range of products and services and the reduction of its overall carbon intensity of products sold**. It is this form of diversification that we refer to in our 5-lever framework.

It can be pursued through external growth (inorganic growth) by acquiring new output production capacity from other companies and/or through internal product development.

EXAMPLE OF DIVERSIFICATION

In the oil & gas industry for instance, substitutability varies according to end use, from extremely high for power generation, moderate for passengers' cars, to very limited for air transport or trucks or petrochemicals..

NOT A DIVERSIFICATION STRATEGY

Neste's renewable diesel, obtained through animal fat and hydrogenated vegetable oil processing has the same chemical construction as conventional diesel. This new product development is not considered as activities diversification in our sense but would instead fall under the core decarbonization lever

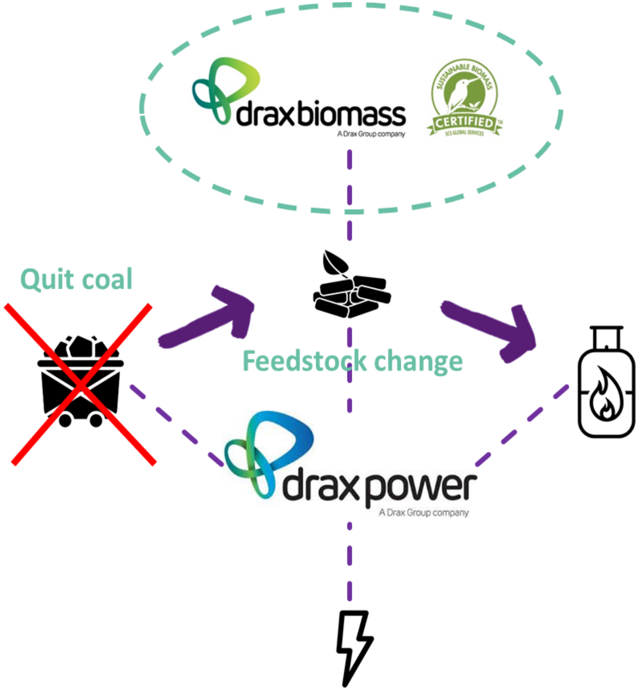
Drax, an example of diversification through input changes

Drax is a British group operating at different stages in the power sector. It historically generated electricity from coal-fired power plants but today provides power from different sources. It is activating the "Exit/quit" lever by phasing out power generation from coal replacing it by biomass and gas in its massive 4,000 MW power plant in Yorkshire (Drax power plant).

It has already **converted 4 out of 6 generating units of its power plant to biomass and will convert the two remaining ones to Combined Cycle Gas Turbines**. Drax Biomass, a subsidiary of Drax group, provides its main power plants with wooden pellets that are manufactured in North America (Louisiana and Mississippi).

The integration of wooden pellets manufacturing (Drax Biomass) and transportation through a Drax group subsidiary is a way to secure wooden pellets sourcing for one of UK's strategic power plants (Drax power station in North Yorkshire).
By converting Drax power station to biomass, **the company decarbonizes its core business**. The point of such conversion is **an input diversification** (switch from coal to wood pellets) & organic decarbonization (historical process-related emission reduction). The company is currently one of the biggest generators of renewable power in Great Britain.
It therefore also activates another lever as **a solution provider as it reduces the scope 2 emissions of its clients.**

By converting two coal-fired electricity production units to biomass in 2017, Drax Group's total Scope 1 carbon emissions decreased by 33.4% between 2017 and 2018 (from 6,296 kt to 4,355 kt of CO_2e) and its intensity by 24% (from 297 t/GWh to 225 t/GWh).



Source: Drax Annual report 2018, Enabling a zero carbon, lower cost energy future.

Oil services companies' opportunistic transition

This pivot from oil & gas services companies that are shifting from oil projects towards lower-carbon activities is mainly driven by the oil prices' environment and a growing pool of low-carbon projects. This strategic shift of skills and expertise toward low-carbon technologies could lead to a cost reduction for low-carbon solutions.

Although triggered by a slump in oil prices, the **pivotal shift of oil & gas services companies** could have tremendous repercussions on low-carbon technologies developments.
It might also be a significant driver of change in the Oil & Gas industry, as skills needed for the industry to prosper are shifting.
According to Haynes and Boone, a law firm, 190 North American Oil services companies filed for bankruptcy between 2015 and September 2019. The slump in oil prices affected directly oil services companies as the decrease in profitability and blurry perspectives made it hard for majors to invest in new projects.

Examples of oil companies' diversification strategy

Fugro, Aker Solutions, Xodus, Subsea 7, TechnipFMC, Saipem are all oil services companies adapting to unstable oil prices environment by diversifying toward low carbon technology projects engineering:

TechnipFMC	TechnipFMC decided to spin off a business that focuses on liquefied natural gas and oil alternatives (bio-fuels etc.).
SAIPEM	Saipem derives 66% of its revenues from non-oil projects (gas, infrastructure and renewables) in 2019 vs 50% in 2016.
FUGRO	Fugro derives more than half of its revenues from non-oil and gas projects while 5 years ago it was about 22%.

Lever #3 | Decarbonize core activities

What does a "decarbonize core" strategy means ?

It refers to the efforts and actions undertaken by a company to **keep offering the same products and services** (for instance steel, aluminum, air mobility) but **with a significantly lower carbon content** (decarbonize core and hard-to-abate GHG emissions). Essentially, one offers the same end-product or service but with reduced emissions. It results from **greater efficiency, new process, technologies or raw materials/feedstocks changes**. It involves dedicated investments in new assets/equipment, process reshuffling as well as dedicated R&D and often ad hoc HR/skills management

What are the activities concerned ?

There is enormous potential for emissions abatement in high emitting industries. As was expounded when we discussed the notion of irreplaceability, **some carbon-intensive sectors cannot be directly/instantly phased out because there are neither existing nor viable substitutes**. Hence the emissions from affected activities and processes need to be deeply decarbonized during their operating life in order to align with climate trajectories.

Three segments to decarbonize

Inputs

- Substituting raw material/ feedstock
- Intermediate products
- Providers

Operating assets

- New assets/ facilities

Management

- Process reshuffling
- HR/skills management.

Research & Development

Example of new technologies to decarbonize

Hydrogen-based direct iron reduction for primary steel production could allow for substitution from coal or natural gas to electricity – if the hydrogen is green (generated from electrolysis). Prevailing industry and expert views suggest that 100% electrolytic hydrogen-based steel production is not sufficiently advanced to allow for economic potential to be exploited before 2030.

Hydrogen fuel could become an attractive option to indirectly electrify industrial high-temperature heat, either *via* direct combustion or blending with natural gas.

The electrification of clinker production using induction or microwave heat, though such technology is at the laboratory stage.

Electro-technologies for process heat, such as infrared and ultraviolet heating, induction melting, and electric boilers offer further potential for electrification across a range of industrial activities.

LIMITS: THE RISK OF THE REBOUND EFFECT

This "rebound effect" (Binswanger, 2001, Brookes, 1990, Khazzoom, 1980, Saunders, 1992) states that **increased energy efficiency often leads to increased energy consumption.**

Although the energy consumption at the micro level (for the individual) goes down, overall energy consumption at the macro level (for societies) increases due to the combined increase in use from all individuals and demographic growth. The rebound effect is particularly relevant for changing towards more sustainable lifestyles - suggesting that it is not sufficient to improve technology without considering behaviour.[1]

[1]: UK Research and Innovation (2007), The rebound effect report (available here)

Focus on energy efficiency

Energy efficiency is considered as the most important lever for industry decarbonization

The IEA estimates that efficiency measures can make out **37% of the decarbonization potential of the Sustainable Development** Scenario compared to the baseline Stated Policies Scenario.

As highlighted by the IEA (see interview "The instrumental role of industry decarbonization in IEA's sustainable development scenario"):

"*There is no single or simple solution to reach these [climate] goals. Instead, a variety of technologies and policy measures need to be pushed to reach sustainability targets.*

The largest near-term options are in energy efficiency, material efficiency and fuel switching". Both energy efficiency and fuel switching reduce oil and coal consumption by almost a third in 2050, with electricity, natural gas and bioenergy stepping in as substitutes and some use of hydrogen in the iron and steel industries, where pilot projects start around the mid-2020s" .

Source: IEA World Energy Outlook 2019, Table 7.6

Summary of material efficiency strategies in the Sustainable Development Scenario

Design	Manufacturing	Use	End-of-life
Overview			
• Lightweighting. • Reduce over-design, optimise design. • Design for use, long life and reuse.	• Reduce material losses. • Reduce material overuse.	• Lifetime extension and repair. • More intensive use.	• Remanufacture and repurpose. • Direct material reuse. • Recycle.
Steel			
☑ Vehicle lightweighting. ☑ Building design, reduce over-specification and concrete-steel composite construction; modular design for future materials reuse.	☑ Improve steel semi-manufacturing and end-use product manufacturing yields.	☑ Use buildings for longer through refurbishment. ☑ Mode shift to reduce the number of vehicles being produced.	☑ Direct reuse of steel (with highest potential in specific end-uses such as ships). ☑ Recycle.
Cement			
☑ Building design, reduce over-specification and concrete-steel composite construction; modular design for future materials reuse.	☑ Improved construction, including reducing onsite construction waste, reducing cement content in concrete and pre-cast fabrication.	☑ Using buildings for longer through refurbishment.	☑ Concrete reuse.
Aluminium			
☑ Vehicle lightweighting (steel-aluminium substitution) offsets some reductions from other strategies.	☑ Improve aluminium semi-manufacturing and end-use product manufacturing yields.	☑ Mode shift to reduce the number of vehicles being produced.	☑ Direct reuse of aluminium. ☑ Recycle.

☑ High potential ☑ Medium potential ☑ Low potential ☑ Increase in demand

Overview of low carbon innovations for brown industries

Sector	Technology	Type of innovation: Incremental (I) or Radical (R) and technical description	Maturity*	GHG Benefits	Diffusion bottlenecks
All energy-intensive processing industries	Energy efficiency	I/R - Reduce energy consumption through best available technologies in steam, motor, heat pump and combined-heat and power systems	All	Less energy and CO_2 (+)	Costs, lack of awareness and expertise
	Material Efficiency & Recycling	I/R - Reduce the (primary) material intensity of supplying material services through improved product design, product re-use, high-quality recycling, and different business models; includes cross-sectoral symbiosis products	All	Resource efficiency less CO_2 (++/+++)	Low resource vs. high labor costs, requires organizational and technical innovation, lower quality materials
	Carbon Capture and Storage Technologies (CCS)	I/R - Typical end of the pipe technology, can be incremental, but typically needs significant additional space and technology for integration in process design, which can make it radical; needs infrastructure to transport captured CO2	Up to 6	Less CO_2 (++/+++)	Additional energy demand, costs, infrastructure, acceptance by local public

The iron & steel sector's technology options

Sector	Technology	Type of innovation: Incremental (I) or Radical (R) and technical description	Maturity*	GHG Benefits	Diffusion bottlenecks
Iron and Steel	Recirculating Blast Furnace & CCS	R - Currently under R&D (e.g., ULCOS project) needs high integration into existing plants which might need major changes in plant / site setup	4–5	Less CO_2 (++)	Higher energy demand, costs, infrastructure, acceptance
	Smelt reduction & CCS	RR - Makes obsolete coke ovens, BF & BOF of conventional steel factories	3–4	Less CO_2 (++/+++)	Costs, infrastructure, acceptance
	Direct reduction with H2	RR - Makes obsolete coke ovens, BF & BOF of conventional steel factories, but is combined with electric arc furnace; needs H2 supply infrastructure	3–4	Less CO_2 (+++, potentially excess electricity converted to H2	Costs, infrastructure & technology
	Electrowinning	RRR - Makes obsolete coke ovens, BF & BOF of conventional steel factories, needs large electricity supply; technology only on lab scale available	2–3	Less CO_2 (+++ with RES electricity) smaller, probably lower CAPEX	Only available in lab; low coal/CO_2- prices and high electricity prices
Aluminum	Advanced (inert) anodes	I - Avoids oxidation and consumption of anodes and the CO2 emissions resulting from this	3–4	Less CO_2 (++), lower energy demand	Availability of technology, research needed

The example of the shipping industry

Shipping is a key enabler of international trade, accounting for about three-quarters of total freight transport activity. It is also the most energy-efficient way to carry cargo in terms of energy use per ton-kilometer (tkm).

However :

- The shipping industry accounts for around **2.5% - 3% of global CO_2 emissions** according to the IEA.
- The sector's emissions are estimated to **grow around 50% to 250% by 2050** according to different economic and technological innovation scenarios.

Technologies to decarbonize the sector

- Hull shape design
- Sails
- Kits
- Turbines
- Alternative fuels*

No specific technological solution makes consensus over the entire industry. However, small boats are likely to adopt electric propulsion or hydrogen fuel cells. For long distances and larger boats, ammoniac and hydrogen as a fuel, biofuels and synthetic fuels are considered as credible options.

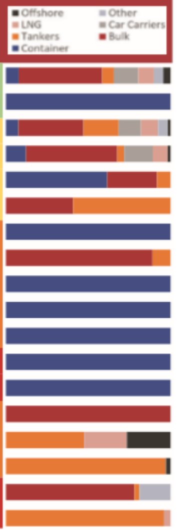
Initiatives to reduce shipping industry's emission

Year	Recent environmental initiatives
2011	**2 international standards developed to improve energy efficiency:** • Energy Efficiency Design Index (EEDI) • Ship Energy Efficiency Management Plan (SEEMP)
2018	**107 members of the International Maritime Organization (IMO) adopted the industry's premier strategy on reduction of GHG emissions:** • By 40% by 2040 against a 2008 baseline • By 70% by 2050 against a 2008 baseline
2019	**100 chief executives in the maritime sector joined with 9 NGOs called the IMO for speed reduction for ships.** • Estimates show this could reduce fuel consumption by 18% if limited from 12 to 11 knots
2020	**The IMO created the global sulphur cap:** • It requires shipping vessels to either use maritime fuels with a maximum sulphur content of 0.5% or install a scrubber to comply with sulphur dioxide emissions regulations.

Assessment of shipping companies by CDP

- CDP assesses the **operational and technical efficiency of companies' fleets** and how their vessel purchasing decisions affect this.
- It analyzes the **capital flexibility of companies** and assesses their **exposure to longer-term market risks for transported commodities.**
- Capital flexibility means companies may be less agile and slower to mobilize in response to future disruption such as climate regulation.

League Table rank	Company	Ticker	Stock exchange	Market Cap Average FY 2018 Q4 (US$bn)	Weighted rank	Transition risks rank	Transition opportunities rank	Climate governance & strategy rank	Fleet breakdown (%)
1	NYK Line [ii]	9101 JP	TSE	3.4	4.89	3	1	2	
2	A.P. Moller-Maersk	MAERSKA DC/ MAERSKB DC	CSE	25.3	5.03	6	2	1	
3	Mitsui O.S.K [ii]	9104 JP	TSE	3.5	6.53	1	3	6	
4	K Line [ii]	9107 JP	TSE	2.2	7.43	5	4	3	
5	HMM	011200 KS	KRX	1.0	8.87	7	8	4	
6	Norden	DNORD DC	CSE	0.6	9.34	9	9	5	
7	OOIL [iii]	316 HK	HKEX	6.0	10.15	11	5	9	
8	U-Ming	2606 TT	TWSE	0.9	10.24	2	10	11	
9	Hapag-Lloyd	HLAG GR	FWB	4.5	10.32	4	6	14	
10	Wan Hai	2615 TT	TWSE	1.2	11.26	12	12	8	
11	Evergreen Marine	2603 TT	TWSE	1.8	11.55	17	7	12	
12	COSCO S.H [iii]	601919 CH/1919 HK	SSE/HKEX	5.4	11.91	8	11	16	
13	Yang Ming	2609 TT	TWSE	0.7	12.40	10	13	15	
14	Pacific Basin	2343 HK	HKEX	0.9	12.46	16	14	10	
15	Teekay	TK US	NYSE	0.3	12.58	18	16	7	
16	Euronav	EURN BB	BXS	1.6	12.72	15	17	13	
17	NS United KK	9110 JP	TSE	0.5	13.86	14	18	17	
18	COSCO S.ET	600026 CH/1138 HK	SSE/HKEX	2.4	13.94	13	15	18	
Weighting						35%	30%	35%	



Source: CDP, Shipping Report

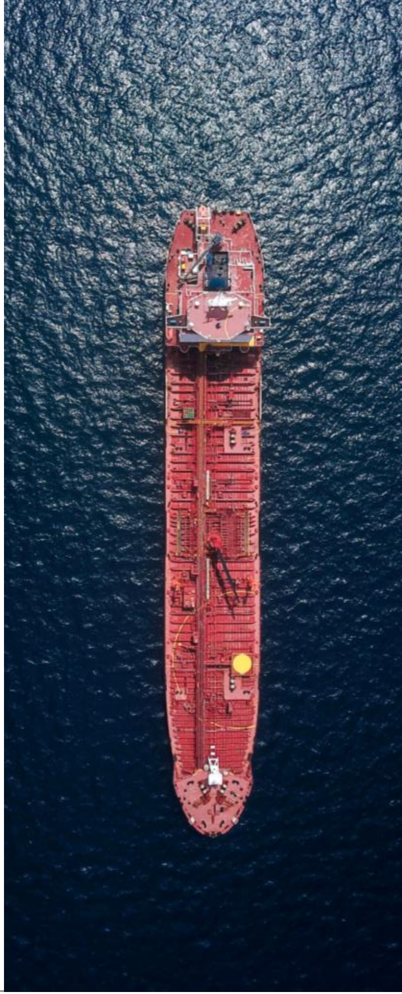
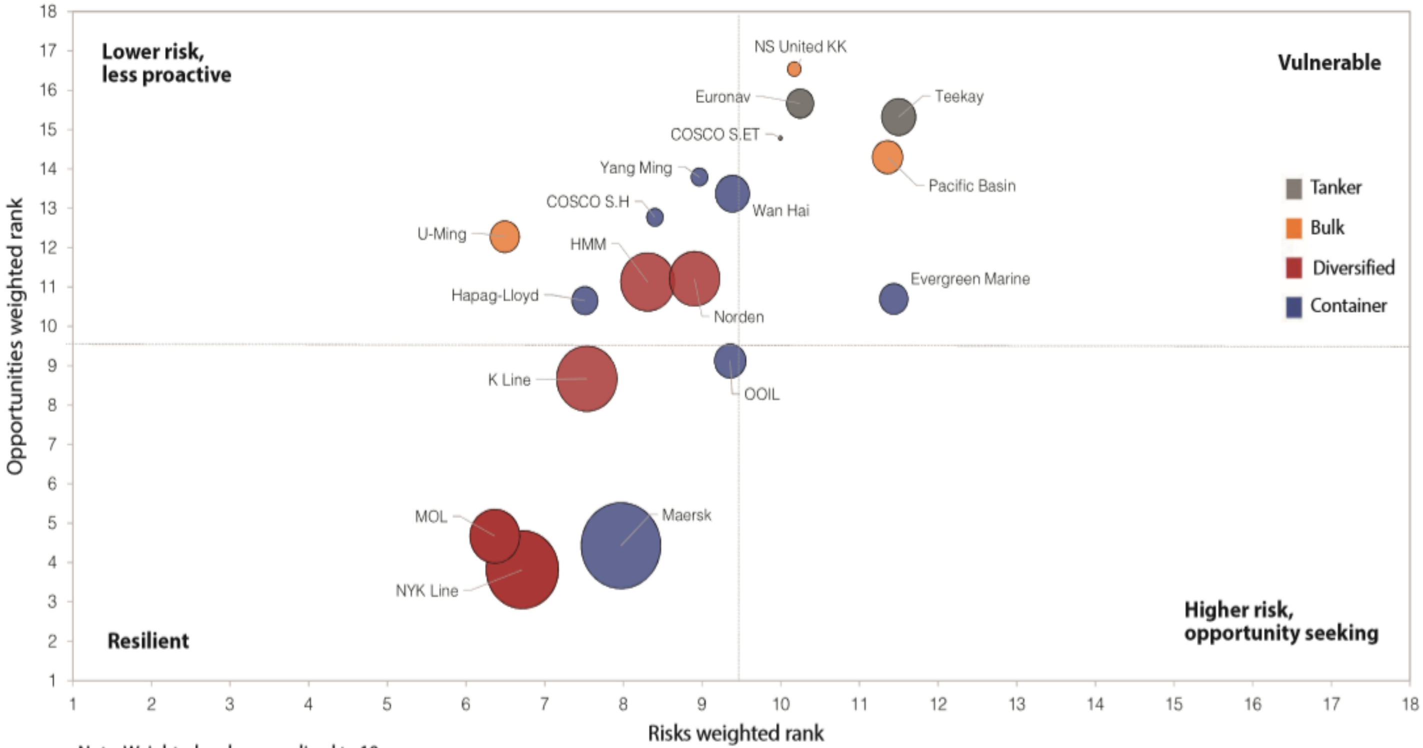


FIGURE | Opportunity vs. risk for low-carbon transition



Note: Weighted ranks normalized to 10.
Bubble size: Larger bubble size = stronger performance on climate governance & strategy.
Source: CDP

Maersk's strategy to decarbonize its core activities

MAERSK

Maersk is the world's largest container shipping company. 65% of its GHG emissions come from its own transportation activities (Scope 1). Its main levers to decarbonize are fuel changes and efficiency measures. As of today, there is no substitute at scale to high-sulphur fuels. Maersk recognizes that massive innovation efforts and fuel transformation are necessary in the 5 to 10 years to come. The company has already reduced substantially its emissions at the cost of $1 billion so far. **It has an intermediate goal to cut absolute emissions by 60% by 2030 (relative to 2008 levels) and aims to be carbon neutral by 2050.**

EXIT

A.P. Moller-Maersk spun off its oil and gas drilling unit in April 2019 after having sold its oil exploration and production business to Total in 2017

DIVERSIFY

Nothing on diversification as the company remains a freight transport provider. We might note that the company is restructuring, Maersk is splitting its freight forwarding and supply chain services subsidiary Damco into two entities.

DECARBONIZE CORE ACTIVITIES

Maersk is decarbonizing its core activities through the use of biofuels, efficient management of its fossil fuel consumption and the development of new carbon-neutral propulsion technologies.

OFFSET

Not mentioned

PROVIDE DECARBONIZATION SOLUTIONS

It strives to provide low-carbon transportation (see Maersk - H&M pilot project: the carbon neutral project, using biofuel saving 85% absolute emissions compared to bunker fuel)

In a nutshell

- **Is it ambitious?** Making a highly emissive activity carbon neutral by 2050 is ambitious. Further, it has an intermediate goal to cut absolute emissions by 60% (relative to 2008 levels) by 2030.
- **Is it consistent?** As the company is not diversified across different services, the consistency of disparate actions or initiatives is a less material criteria (although it sold its oil exploration and production business). The company puts an ambitious long-term target but seems quite uncertain on how to reach it.
- **Is it game changing?** Yes, as Maersk is willing to convince the whole industry to follow its journey towards low carbon transportation. It paves the way for ambitious industry transformation. By calling the entire industry to collaborate and invest in R&D toward carbon neutrality, the biggest player of container maritime transportation tends to reinforce its leading position and accompany change through the entire industry.
- **Is it enough?** Well, targets are climate-science aligned but quite uncertain in their achievability. The steepness of the decarbonization curve after 2040 reflects the uncertainty linked with a breakthrough innovation

Source: Maersk reports

LafargeHolcim's endeavor to decarbonize cement production

LafargeHolcim

FIGURE | Worldwide steady demand led to growing absolute GHG emissions (1990-2016)

	1990	2016
Cement production	1.1 Gt	4.2 Gt
Direct CO_2 emissions	1.0 Gt	2.2 Gt
Carbon intensity (in kgCO_2 per ton of cement)	91%	54%
Cement industry's share of global greenhouse gas emissions	2.8%	7%

Cement production is currently the third largest source of CO_2 emissions in the world, after fossil fuels & changes in land use.

FIGURE | Trends in cement production and emissions between 1990 and 2016 (in Mt), then in 2030 and 2050 in IEA 2DS

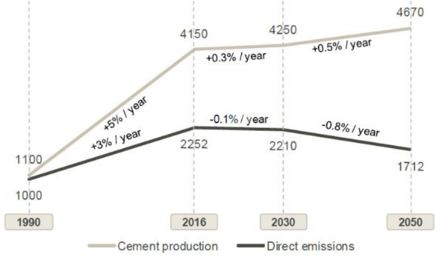


Chart 9– Source: CDP and IEA, reproduced by ODDO BHF Securities

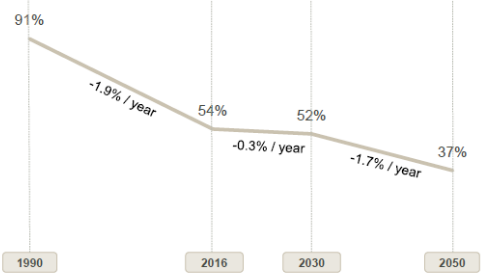
A clear decoupling is necessary between production and direct emissions.

FIGURE | Global average performances (2018) and 2030 and 2050 targets (IEA, 2DS)

Indicator	Global average	2030 target	2050 target
Captured emissions ($MtCO_2$/year)	0.3	14	552
C/K ratio (%)	66%	64%	60%
Alternative fuel rate (%)	6%	18%	30%
Thermal intensity of the clinker (in GJ/t clinker)	3.4	3.3	3.2
Carbon intensity (kg CO_2 net/t cement)	**540**	**520**	**370**

2DS carbon intensity annual average reduction stands at 1.1% between 2016 and 2050.

FIGURE | Carbon intensity between 1999 and 2016, and between 2016 and 2050 in the 2DS scenario



The acceleration in the decarbonization effort after 2030 is not really substantiated (a carbon pricing of ~100€, more realistic by this time, is expected to spur demand for low-carbon products and R&D efforts). In the industry, investment cycles are long, upfront costs high and innovation limited (low product differentiation).

This case study is largely based on the report from ODDO SRI Research (published on 24.06.2019) and titled "Cement industry facing the decarbonization challenge in the 2° scenario". We are grateful to the lead author of this publication, Jean-Baptiste Rouphael (Tel. : + 33 (0)1 55 35 42 44 jean-baptiste.rouphael@oddo-bhf.com).

LafargeHolcim's endeavor to decarbonize cement production

Steady demand led to growing absolute GHG emissions (1990-2016)

LafargeHolcim emitted **561 kgCO_2/ton of cementitious product in 2019** (a 27% reduction compared with 1990 and a 1,4% reduction compared with 2018).

It has an objective of 550 kg CO_2/ton in 2022 and a revised target of 475 kgCO_2/ton in 2030, i.e. -38% compared to the 1990 level (the previous objective of 460 kg CO_2/ton in 2030, i.e., -40% compared to 1990, was lowered).

The EU Taxonomy Draft Delegated Acts threshold (only Scope 1 emission) was set at 498kgCO_2/t. The new Delegated Acts threshold is the average value of the top 10% of installations based on the data collected in the context of establishing the EU Emissions Trading System (EU ETS) industrial benchmarks for the period of 2021-2026.

The company has one of the lowest clinker ratios (72%), thanks in particular to its Indian subsidiary Ambuja (66%).

It outperforms several of its European peers but is behind Asian competitors that benefit from byproducts to lower their clinker ratio.

FIGURE | CO2 intensity of European cement makers in 2018 (kgCO/t of cement) & 2016-2018 average annual growth

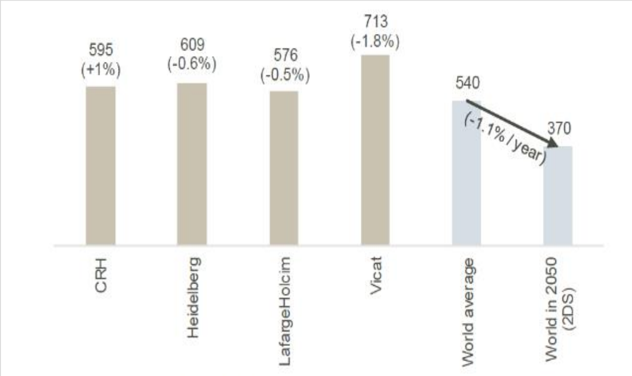
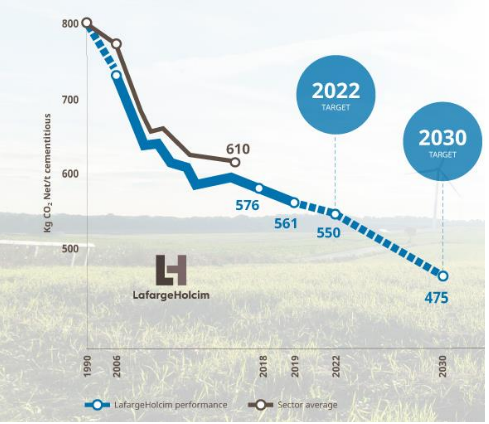


Chart 1– Source: ODDO BHF Securities, based on the IEA and annual reports

FIGURE | LafargeHolcim's 2022 and 2030 targets



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LafargeHolcim's endeavor to decarbonize cement production

LafargeHolcim

The downwardly revised target for 2030 remains 2DS aligned, answering the legitimate question whether the set targets are "enough" from a climate science standpoint.

LafargeHolcim considers multiple scenarios according to potential regulatory developments (high, medium and low variability of regulatory incentives). The company reportedly supports and follows the recommendations from the TCFD. Its subsidiary Ambuja is a member of the Science-Based Target Initiative (SBTi). As a backdrop in 2018, the EU Commission revised its EU-ETS directive to increase the pace of emissions reduction. The total number of quotas will decrease by 2.2%/year starting 2021 against 1.74% now. According to CDP, the company has an internal carbon price >€ 30/t of cement (vs. Vicat: 30€; HeidelbergCement: 20-30€; CRH:15-25€).

EXIT

Nothing mentioned

DIVERSIFY

None, but this is normal as the industry can largely be considered as "irreplaceable".

DECARBONIZE CORE ACTIVITIES

Yes, through clinker substitution and waste-derived fuels and biomass (it currently sources 18% of its energy supply from alternative fuels, low-carbon fuels and biomass)

OFFSET

Demonstration projects in breakthrough technologies for carbon capture solutions, LafargeHolcim has participated in two oxyfuel projects (in Retznei and Le Havre), but they have been suspended due to insufficient European funding.

PROVIDE SOLUTIONS

It offers and markets low(er) emission cement reportedly allowing its customers to reduce their embarked GHG emissions (initial carbon footprint of infrastructures, buildings, high speed train lines made of cement).

Focus on "decarbonize core activities" lever

The main transition lever for the cement industry is unarguably to "decarbonize core emissions". This is because it is a basic material that is largely irreplaceable by its use in various forms of infrastructures such as housing, water distribution network, public transportation, etc.

Process CO_2 emissions and thermal energy emissions account respectively for 50% and 30% of the total GHG emissions generated from the production of one ton of standard Portland cement. The major intervention needed to curb these emissions would be to focus on improving process efficiency and electrifying most operations, but there is currently limited room for the application of electrification as it cannot efficiently produce the high temperature heating (>1450°) required.

Source: Engie's company report

LafargeHolcim's endeavor to decarbonize cement production

KPIs Selection & calibration

Most compelling is that climate benchmarks for a 2°C scenario in the cement industry are not only available for carbon intensity per ton of cement but also for more granular phases of the production (breakdown between process CO_2 emissions and thermal energy emissions).

When looking at competitors and targets calibration assessment, there is one main reason explaining the better performance of Asian cement manufacturing plants compared with European or American ones: lower clinker to cement ratio thanks to byproducts of steel and coal industries.

Synthetic KPIs

Carbon intensity
(kgCO_2/ton of cement)

- LafargeHolcim 2018: **576**;
- World average: **540**;
- World in 2DS in 2050: **370**;
- Existing targets for 2022: **560**
- Existing targets for 2030: **520**.

"Low-carbon products": share of sustainable solutions (% of net sales in 2018), but the impact is captured through the previous KPI.

Sub-KPIs

Cement to clinker ratio
(C/K ratio) as a percentage

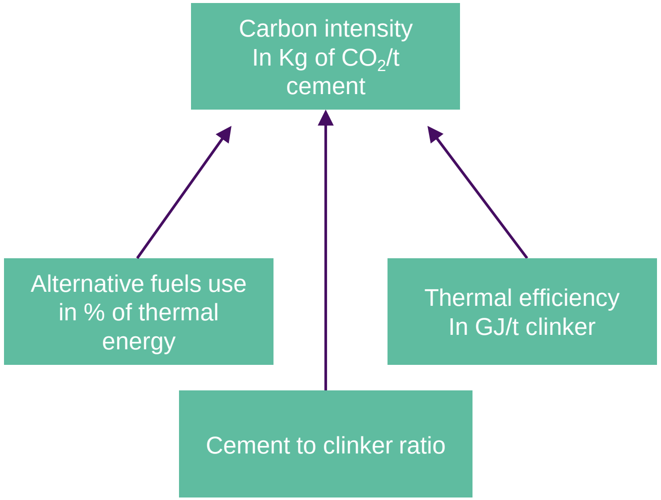
LafargeHolcim: 72% in 2018; world average: 66% and world in 2DS in 2050: 60%

Recycling and circularity: in 2018, it reused 52 million tons of waste materials in its operations, the target for 2030 is set at 80 million tons.

Thermal intensity
(GJ per ton of clinker): LafargeHolcim: 3.52 in 2018; world average 2015: 3.40; world in 2DS in 2050: 3.20.

Rate of alternative fuels
(as % of thermal energy): LafargeHolcim: 18% in 2018; World average: 6% ; World in 2DS in 2050: 30%

CHART | Main carbon performance indicators



Case study: aviation

FIGURE | Aviation industry's climate footprint

3%

The sector accounts for around 2.5-3% of GHG emissions globally excluding the effects of radiative forcing *(source: IEA)*

+70%

The sector's fuel efficiency has improved by 70% over the past two decades.

The greenhouse gases emissions of the sector is notably influenced by the **rebound effect.** The world annual traffic doubled between 2003 and 2018 from 4 trillion Revenue Passenger Kilometer (RPKs[1]) to 8 trillions RPKs (source: ICAO[2]).

4.3 billion passengers (6.4% increase year-on-year) and 58 million tons of freight (2.4% increase year-on-year) were carried by airlines worldwide in 2018 (source: ICAO[2]).

FIGURE | The International Air Transport Association (IATA[3]) set out three climate targets

- Improve energy efficiency by 1.5% per year until 2020 (in 2013, this target was raised to 2% per year, until 2050)
- Limit growth of air traffic emissions based on the level reached in 2020 ("neutral growth in CO_2")
- Reduce aviation's net emissions by 50% in 2050 vs 2005 levels.

Source: Aviation benefits beyond borders

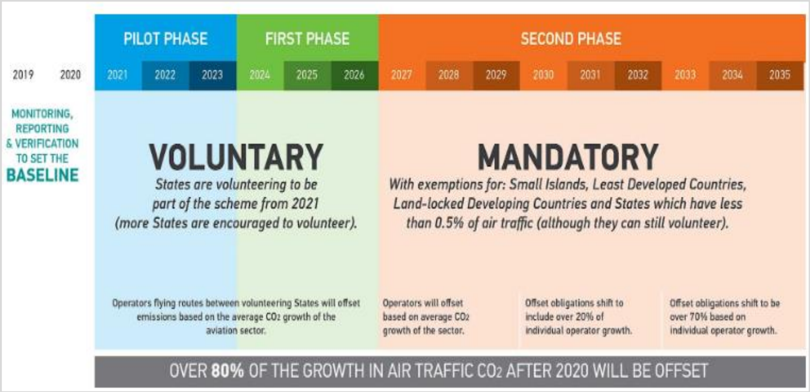
1. Revenue passenger kilometers (RPK) : one revenue passenger-kilometer means that one passenger is carried on one kilometer
2. International Civil Aviation Organization (ICAO) is an agency of the United Nations
3. The International Air Transport Association (IATA) is a trade association of the world's airlines founded in 1945. It has been described as a cartel since, in addition to setting technical standards for airlines, IATA also organized tariff conferences that served as a forum for price fixing

NEW STANDARDS & AMBITIONS

The ICAO adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in 2016. CORSIA is a global regime of market-based measures designed to offset the fraction of CO_2 emissions from international flights exceeding their 2020 level. It requires operators of subject aircraft to purchase carbon credits.

- Aims at reducing almost 2.5 billion tons of CO_2 between 2021 and 2035
- Proceeds from CORSIA could mobilize over $40 billion in climate finance between 2021 and 2035

Timeline for the implementation of CORSIA



Airline companies’ target emissions

- Airlines like Qantas and SAS have set CO_2 emissions reduction targets.
- They both committed to reduce net CO_2 emissions with 50% by 2050 (2005 baseline). SAS has set an intermediary target, aiming to reduce total emissions by 25% by 2030.
- Aircraft and engine manufacturers, such as Airbus and Safran, are developing low-emission aircrafts and propulsion systems compatible with sustainable fuels, contributing to the transformation of the industry.

FIGURE | Aviation targets in term of intensity emission reduction

Targets (gCO_2/RTK)	2019	2024	2025	2030
Turkish Airlines	660	643	640	N/A
IAG	628	572	562	N/A
Etihad Airways	631	574	559	N/A
International Pledges scenario (ICAO)	643	576	559	N/A
2°C scenario (TPI)	624	539	522	430

Source : Green & Sustainable Hub, see our article about Etihad’s $600 million Sustainability-linked Sukuk: the first of many things

EXAMPLE OF ETIHAD AIRWAYS

Etihad Airways, the Abu Dhabi flag carrier, has launched **the first sustainability-linked bond in aviation** in October 2020. The Sustainability-linked bond is tied to one Key Performance Indicator (KPI): a reduction of 17,8% of the emission intensity of its passenger fleet by 2024, against a 2017 baseline of 574 CO_2/Revenue ton kilometers (RTK) for the total fleet.

Etihad Airways has also announced its **willingness to achieve Net-Zero Carbon emissions by 2050** (Scope 1 & 2) and a 50% reduction in net emissions by 2035 in a Sustainability Position Paper published in January 2020, which is more ambitious than the latest IATA target (i.e., **50% reduction in net aviation CO_2 emissions by 2050**, relative to 2005 levels).

Even though Etihad Airways’ 2025 targets for its emission intensity (in gCO_2/RTK) are aligned with the sector’s currently defined targets with the International Pledges scenario’s 2030 target, they are not in line with 2°C scenario targets. According to the TPI (which uses a science-based methodology to assess companies' alignment to the Paris Agreement’s 2°C scenario), companies’ carbon intensity should not be above 539 gCO_2/RTK in 2024 and 522 gCO_2/RTK in 2025 and have to reach 430gCO_2/RTK in 2030 to be aligned with a 2°C scenario.

In 2019, Etihad Airways’ carbon intensity was at 631 gCO_2/RTK in 2019 and is expected to be at 636 gCO_2/RTK in 2020.
As a reminder, the International Pledges scenario is based on current commitments made by the International Civil Aviation Organization (ICAO) and these commitments are known to be insufficient to set the aviation sector on a pathway compatible with the world of to 2°C warming or below, as aimed for by the Paris Agreement.

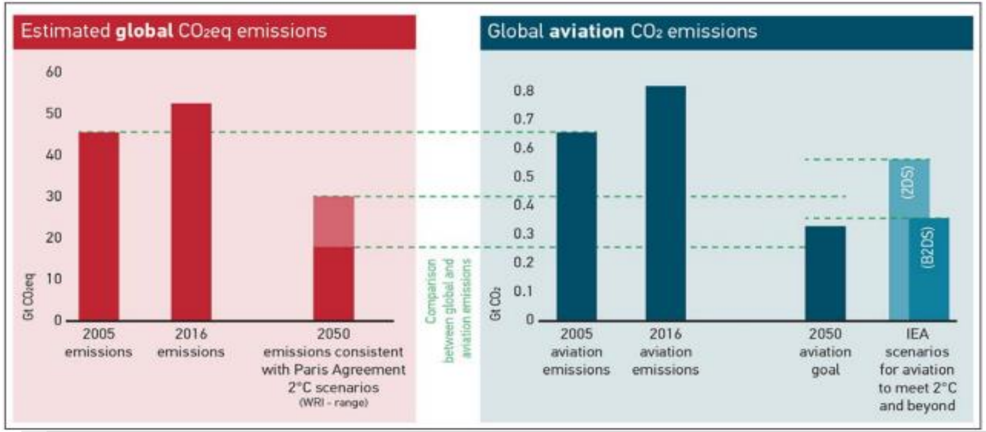
Transition levers for aviation

The aviation industry is a hard-to-abate sector with few substitutes, as time savings from this transport cannot be matched by alternatives modes of transport.
The solution for most of the industry players seems to be the **decarbonization of their core activities.**

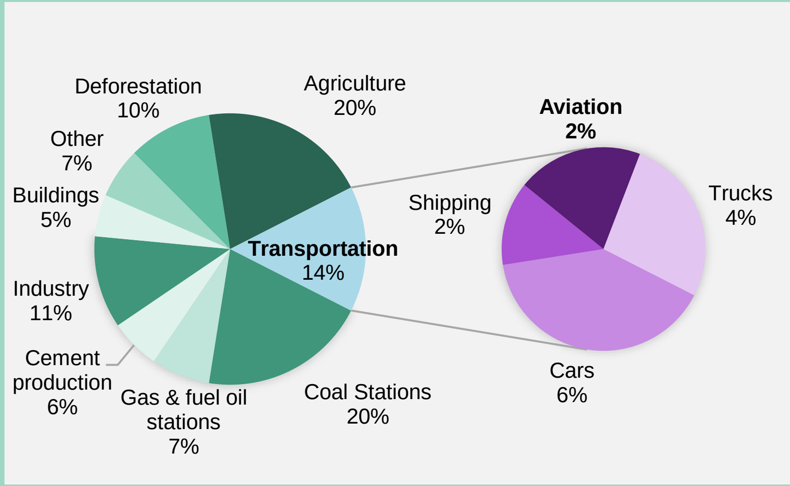
Four decarbonization entry points have been identified for curbing emissions in aviation:

1. Operating efficiency
2. Innovative technologies
3. Sustainable energy fuels
4. Carbon offsetting

FIGURE | Global emissions reduction based on Nationally determined contributions under COP 21 vs Aviation Carbon emissions based on industry target



AVIATION'S SHARE IN GLOBAL GHG EMISSIONS (2018)



Source: **ODDO BHF Corporates and Markets (2019)** Aviation: CO_2 - a threat to the industry's licence to grow

For distances above 800kms. In non-land locked countries, road transport is more competitive for distance under 200 km while depending on the speed of the train, rail can compete and surpass aviation in terms of door-to-door transport for distances comprised between 200 and 500 km.

Transition levers for aviation explained

Levers	Solutions	Potential contribution (ICAO)	Lifecycle CO_2 emissions reduction per aircraft in % (IEA)	Availability & potential year of introduction	Examples & Initiatives
Innovative technologies	**Innovative aircraft technologies** • Electric/hybrid aircrafts	**Notable impact** as the operation of electric or hydrogen aircraft will not be associated with CO_2 emissions from fuel combustion. However, **life cycle benefits** also depend on whether the electricity or hydrogen is obtained from lower carbon sources	Next-generation aircrafts: 30-70%	Airbus E-Fan X (hybrid electric demonstrator) ready to fly in 2021, ambition to bring hybrid or fully electric technology with up to 100 sets in the 2030s **~2035**	Airbus' E-Fan X single-aisle aircraft is said to have a 2MW electric motor and three turbo-generators for a 100-seater craft, while an American start-up Wright Electric claims that it has filed a patent for a 50-seater all-electric aircraft.
Carbon offsetting	**Market-based measures (CORSIA)** – emission increases from international flights will have to be compensated for through carbon offsets	**Complements the other measures** by offsetting the CO_2 emissions that cannot be reduced through use of technological improvements, operational improvements and SAFs with emission units from the carbon market		Pilot phase 2021-2023 First phase 2024-2026 Second phase 2027-2035	None

[i] A320neo family The Airbus A320neo family (neo for new engine option) is a development of the A320 family of narrow-body jet-airliners produced by Airbus. Launched on 1 December 2010, it made its first flight on 25 September 2014 and it was introduced by Lufthansa on 25 January 2016. It is declared to be 15% to 20% more fuel efficient than the A320ceo family. A key contributor to the NEO's performance is Sharklets – which were pioneered on the A320ceo (current engine option). These 2.4-metre-tall wingtip devices are standard on NEO aircraft, and result in up to four per cent reduced fuel burn over longer sectors, corresponding to an annual reduction in CO2 emissions of around 900 tones per aircraft.

Transition levers for aviation explained

Levers	Solutions	Potential contribution (ICAO)	Lifecycle CO_2 emissions reduction per aircraft in % (IEA)	Availability & potential year of introduction	Examples & Initiatives
Operating efficiency	**More efficient operations** • Route optimization • Increasing occupancy rate and freight load factor • Onboard weight reduction • Fleet renewal • New-generation aircrafts (e.g. A320NEO)	Even under the most optimistic scenario, ICAO estimates **long-term fuel efficiency improvements to be 1.37% per annum.** 0.98% and 0.39% from technology and operations respectively. This is lower than ICAO's goal of 2% per annum. The IEA states that fast-tracking the renewal in the global fleet could reduce aviation's carbon footprint by nearly 10% by 2030.	• Air traffic management improvements: 5-10% • Increasing utilization: 3% • Early replacements of old aircrafts: 1-9% • Retrofitting existing aircrafts: 4-5% • Engine retrofits: ~15% • New-generation aircrafts: 15%	Existing technology/ solutions, can be introduced in the short-term **~2018 - 2025**	Safran for example has developed an e-taxiing system (unit cost is EUR1 million) that reduces fuel expenditure per flight by 4%.
Sustainable energy fuels	**Sustainable aviation fuels (SAFs)** • Biofuels • Power-to-liquid • LNG • Hydrogen • Electrofuels	In the short term, 2020 scenarios result in a fuel replacement rate up to 2.6% and GHG emissions reduction up to **1.2%.** Until 2050, SAFs are estimated to have the potential to achieve **19% net CO_2 emission reduction.** The share of hybrid solutions in the aviation sector is not expected to become a significant share of worldwide commercial traffic until 2050 according to ODDO BRH.	Synthetic fuels: 13-26% Note: **current biofuel consumption is minimal and insufficient**, compared to IEA's Sustainable Development Scenario – 10% of fuel demand in 2030	Certain technologies need to reach industrial scale production. Others (e.g. hydrogen, non-drop-in) still in development **~2020**	HEFA (Hydroprocessed Esters and Fatty Acids), also called HVO (Hydrotreated Vegetable Oil), is a renewable diesel fuel that can be produced from a wide array of vegetable oils and fats. It has a direct carbon footprint that's about half that of jet fuel (40-50g C02/MJ vs 89g CO_2). The European Union revised the regulation on biofuels' footprint in the REDII directive. It is being advocated that the industry focuses on the development of biojet fuel based on non-food crop. HEFA for example is made from animal fats, recovered oils and vegetable oils and it has a direct carbon footprint that's about half that of jet fuel (40-50g C02/MJ vs

[i] A320neo family The Airbus A320neo family (neo for new engine option) is a development of the A320 family of narrow-body jet-airliners produced by Airbus. Launched on 1 December 2010, it made its first flight on 25 September 2014 and it was introduced by Lufthansa on 25 January 2016. It is declared to be 15% to 20% more fuel efficient than the A320ceo family. A key contributor to the NEO's performance is Sharklets – which were pioneered on the A320ceo (current engine option). These 2.4-metre-tall wingtip devices are standard on NEO aircraft, and result in up to four per cent reduced fuel burn over longer sectors, corresponding to an annual reduction in CO2 emissions of around 900 tones per aircraft.

Initiatives to manage air-transport demand

Airlines companies' initiatives on "flying responsibly"

KLM	The Dutch Flag-carrier (a subsidiary of the AirFrance-KLM Group) launched its "Fly Responsibly" campaign encouraging people to avoid unnecessary flights and rather use alternatives such as trains when possible since June 2019.
WIZZ	Hungarian low-cost airline Wizz Air, calling on the industry to place a "ban on business class travel for any flight under five hours".
norwegian	Norwegian has decided not to offer business class, claiming that this makes it one of the most climate efficient airlines in the world.

Regulatory attempts by Governments to rein in demand

- The Netherlands, Belgium, Luxembourg, Sweden, Germany, Denmark, France, Italy and Bulgaria – released a joint statement in November 2019, calling on the incoming European Commission to "debate aviation pricing, e.g., in the form of aviation taxation or similar policies".

- France had earlier announced an eco-tax on all flights departing the country as a way to raise funds that would finance other modes of transportation.

A DEMAND SIDE APPROACH IS NECESSARY

Comparing aviation against various criteria such as **end-use, substitutability and fairness of access,** the inconvenient truth could be that demand for air travel and freight needs to be contained, or even gradually reduced.

As much as it is necessary to encourage operational efficiency, new technologies and the use of cleaner fuels, **it is crucial to keep in mind the possible "rebound effect"** that could arise should the efficiency gains be passed on to the end-customers.

According to Airbus' Global Market Forecast 2018, an important driver of air travel demand is the "wealth effect" and the overall increase in disposable income. **More than 75% of air travel is for private and leisure purposes**, illustrating how air travel is **more of a luxury than a basic need**.

END-USE SUBSTITUTES FOR AIR TRAVEL & AIR FREIGHT

- **Video-conferencing** can reduce the need for business travel (as evidenced by the COVID-19 pandemic)
- **Domestic air travel or short-haul flights** can be replaced by high-speed railways in non-land-locked or flat geographies with a sufficient demand for transport.
- International tourism, which is a luxury, can be replaced **by local tourism.**
- Certain cargoes can be transported *via* ground or sea transport, which may take longer but is much less emissive.

This is where the "Quit/Exit" lever may enter the toolkit available to the aviation sector for its transition. It goes without saying that **the complete phase out of certain end uses is highly unlikely, and that any reduction is not going to happen overnight**.

Lever #4 | Offset emissions

What does offsetting mean ?

A carbon offset is a compensation of carbon dioxide or GHG emissions resulting from a production or a consumption process. Usually, offsetting is a way to pay for carbon emissions either by buying/selling the right to emit (quotas) under regulatory constraint or by purchasing tradable carbon unit that are project-based. It means that emissions are supposedly reduced somewhere else thanks to the offset.
Companies claim to compensate their missions with carbon dioxide removal solutions by deliberate human activities (e.g., Carbon Capture Sequestration, reforestation), in addition to the removal that would occur *via* natural carbon cycle processes.

Emission Trading Scheme (ETS)

Regulatory ETS

- **Offsets can be bought on carbon markets such as the EU Emission Trading Scheme (EU-ETS)** in order to comply with regulatory caps on the total amount of CO_2 companies are allowed to emit.
- The EU-ETS is based on emission quotas distribution and not backed by projects allowing for material emissions reductions. It is seen as a financial incentive to reduce companies' carbon emissions.
- The greater the cost of CO_2 the less profitable becomes the polluting asset

Voluntary ETS

- **Offsets can be purchased on a discretionary basis, on the voluntary market** to mitigate companies' own GHG emissions.
- As carbon accounting is becoming mainstream, companies are looking for ways to "reduce" their carbon footprint
- **Compensation is often used for marketing purposes** but also to anticipate upcoming regulations.
- The use of offsets is not counted as reductions toward the progress of companies' science-based targets.
- On voluntary markets, **offsets are certified by third-parties according to different standards**
- Voluntary offsets are not yet regulated by any international body but methodologies to comply with basic criteria emerge

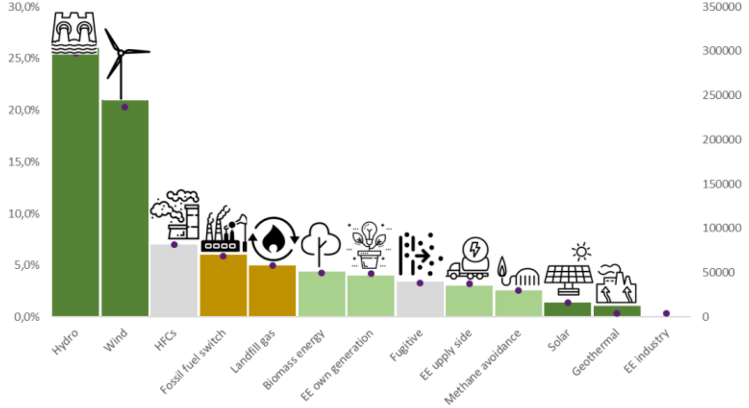
Focus on the Clean Development Mechanism (CDM)

The CDM was reated as part of United Nations' Kyoto protocol in 1995

- $215bn investment in CDM projects in developing countries
- 1bn tons of CO_2 equivalent mitigated since 2004 (Germany's annual GHG emissions = removing 180 million passenger cars from the road
- 5000+ projects registered
- 4500+ organizations involved in the CDM
- Its carbon credits are allowed to be traded on the South Korean ETS, and can also be credited as carbon tax in Mexico and Colombia

Once approved by the clean development mechanism (CDM), a carbon-offset project can be used as carbon credit and linked with emissions trading schemes.

FIGURE | Clean Development Mechanism projects



Source: UNEP DTU

Certified emissions reductions/yearr (%)
Certified emissions reduction/year (absolute)

Bio-sequestration as an offset lever

Bio-sequestration

Bio sequestration is the capture and storage of the atmospheric greenhouse gas carbon dioxide by continual or enhanced biological processes.

- **2 billion tons of CO_2 absorbed per year thanks to forests** (source: FAO)
- The Global Carbon Project (Carbon budget, 2017) estimates that **forestry could have captured up to 29% of human induced emissions** (between the 2008-2017 period)

How can companies manage bio-sequestration offset ?

- Companies must disclose their methodologies while offsetting so that they can be held accountable and avoid double counting. One way that companies can verify and report their carbon offsetting efforts is through third party certifications.

Main certification standards

	Type/standard	Carbon credit name	Credits main users	Projects
	CDM: Offset mechanism under the Kyoto Protocol (Article 12) Project-based & Standardized approach	Certified Emission Reductions (CERs)	Countries that have a reduction commitment under the Kyoto Protocol Private buyers that are covered under an ETS (e.g., EU-ETS) Voluntary buyers	Renewables, Energy efficiency, Coal mine methane, Waste management, Agricultural manure, N_2O abatement, Other industrial gases, Agricultural practice, Afforestation and reforestation
	JI Track 1: Offset mechanism under the Kyoto Protocol (Article 6) Project-based & Standardized approach	Emission Reduction Units (ERUs)	Countries that have a reduction commitment under the Kyoto Protocol Private buyers that are covered under an ETS (e.g., EU-ETS) Voluntary buyers	
VCS	Nonprofit organization Project-based voluntary offset mechanism Approved as a compliance offset project registry for CA cap-and-trade regulation	Verified Carbon Units (VCUs)	Voluntary buyers mainly in the U.S. and Europe Approved Offset Project Registry under the CA ETS	
Gold Standard	Nonprofit organization Project-based, voluntary offset mechanism that can be used as add-on certification to CDM and JI projects or for voluntary projects	Gold Standard Voluntary Emission Reductions (GS VERs) GS CERs for CDM projects GS ERUs for JI projects	Mostly voluntary buyers GS CERs and ERUs Private buyers that are covered under an ETS Few countries that have a reduction commitment under the Kyoto Protocol	Renewables, Energy efficiency, Waste management, Agricultural manure, Afforestation and reforestation

BIO-SEQUESTRATION OFFSET LIMITS

Time mismatch and permanence of storage

- The offset is expected to happen slowly over a future period of time, while the effects of the CO_2 emitted today has a more immediate impact.
- Climate change makes it even harder for trees to live long and “peaceful lives” as increasing extreme weather events (droughts, wildfires) are increasingly accelerating deforestation growing threats. In this vicious circle, CO_2 should not be emitted in the first place rather than being compensated for.

Controversies & mismanagement

- **Land deprivation**: Offsetting projects could mean privatizing entire territories once used by local populations for subsistence agriculture.
- **Radiative forcing** could be increased by tree plantations at certain latitudes.
- Large-scale bio-sequestration: unintended negative consequences such as the **use of limited water resources and biodiversity degradation**.
- REDD+ : a mechanism developed by Parties to the United Nations Framework Convention on Climate Change (UNFCCC). It provides financial incentive for developing countries to reduce emissions from forest degradation. REDD+ currently serves as a vehicle for forestry projects financing, but, its definition of a forest does not **exclude monoculture tree plantations,** it only excludes oil palm plantations.

Criteria for meaningful carbon offset

1. Be additional: the project would not have happened without carbon credits that make it profitable. By contrast, if it would have happened without carbon credits, it is not deemed additional.

2. Be based on a realistic baseline: the baseline estimates what emissions would have been without the project (more efficient stoves vs wood stoves, renewable energies vs coal & gas, etc.).

3. Be independently verified: a qualified third-party (CDM, VCS, JI Track 1, Gold Standard etc.) must verify GHG emissions reductions.

4. Address permanence: in the case of bio-sequestration, wildfires could compromise carbon sequestration permanence. The risk needs to be addressed in order to guarantee carbon sequestration.

5. Do no "net harm" : Projects must not create negative externalities (human health, biodiversity, air pollution etc…). It should rather generate co-benefits.

6. Avoid leakages: An offsetting project could create carbon credits while increasing emissions elsewhere. A reforestation project could displace subsistence agriculture away from native communities.

We have identified six criteria determining the quality and integrity of a carbon offset.
Both companies looking to offset their emissions and investors can rely on them to **maximize the potential impact of the offset and minimize the risk of unintended consequences.**

Carbon Capture and Storage technologies

Carbon capture and storage (CCS): includes applications where the CO_2 is captured and permanently stored
Carbon capture, utilization and storage (CCUS): includes CCS, CCU and also where the CO_2 is both used and stored, for example in enhanced oil recovery or in building materials, where the use results in some or all of the CO_2 being permanently stored (IEA, Sept. 2020)

Investments in CCUS are scarce. Most mainstream 2°C compatible scenarios (at least from the IEA) rely on the large-scale adoption of carbon capture and storage technologies (CCUS) but investments are still lagging.

Annual CCUS investment has consistently accounted for less than 0.5% of global investment in clean energy and efficiency technologies. (IEA, Sept. 2020). For a sectorial case study, see our case study on LafargeHolcim.

At the current rate of technological progress, carbon capture might be the only cost-effective way for certain industries to decarbonize their production processes in the near term.

Carbon capture can be technologically feasible as several pilot projects demonstrate (see Drax case study) but remains in its infancy. Often, **projects are not economically viable without public support. Further, sequestration is not yet mastered**, going against the hypothesis of a **timely transition**.

There is scientific and commercial hesitation vis-à-vis CCS

CCS' only intrinsic value resides in reducing CO_2 emissions to comply with upcoming climate change regulations (CCUS is different as it involves the "use" of the carbon sequestrated, but as today, there are little viable "use cases", an example is the injection in concrete, with new method storing CO_2 in it, see carbon curing developed for instance by Aramco). It feels like adding a technology on top of a system that set up the problem (climate change) in the first place. This paradox is called **incremental innovation** in sociotechnical system*. It is opposed to radical innovation: transcending a sociotechnical system to reinvent a new one. **There is therefore an opportunity cost** in building incremental carbon dioxide removal technologies instead of developing other less emissive radical new technologies.

The EU Taxonomy Technical Report from the Technical Expert Group assumes that CCS is eligible for green financing if it enables an economic activity in the manufacturing sector to meet its screening criteria (e.g., gCO_2/KWh threshold).

It depends on the activity for which CCS would be implemented. CCS is eligible to green financing if substantial mitigation impacts can be demonstrated by reducing emissions towards meeting the activity criteria: the use of CO_2 for enhanced oil extraction would not qualify. To be eligible to green financing on a coal power plant, CCS would have to demonstrate that the plant could reach zero emissions by 2050. CCS for gas-fired power plants may qualify but is subjected to the requirement that fugitive emissions across the gas supply chain need to be measured rather than estimated.

*Sociotechnical system: refers to interactions between society's complex infrastructures and human behavior.

INTERVIEW

NATURAL CAPITAL FINANCE ROLE IN THE TRANSITION

GAUTIER QUÉRU
Fund Director, Land Degradation Neutrality Fund Member, Mirova

EDIT KISS
Director of Development and Portfolio Management, Althelia Funds

" *The land use sector is instrumental to the 2°C target and climate emergency.* ***Nature based solutions represent 50% of the near-term mitigation opportunity (by 2020) and 37% of the longer-term 2030 mitigation opportunity.***

" ***We need to increase and secure stable demand for sustainable agroforestry with the help of corporates****, that can act as off takers of the sustainable agriproducts from the "responsible value chains" financed by the LDN Fund.*

" ***Nature-based solutions are gathering momentum and appear to be at a similar stage as renewable energies were 15 years ago.***

" ***The production of agricultural goods, such as meat, soya (for animal feed), palm oil, corn, is the first driver of tropical deforestation****.* *Furthermore, a significant share of this agricultural commodity production is intended for exportations. High income countries thereby "import deforestation".*

On the zero-deforestation commitments I would just say that the issue is still that ***all these players making these commitments but do not want to pay a premium for the sustainable attributes and/or for the external externalities like carbon*** *so it is not helping with the financing gap/business case unless they start looking at it more holistically.*

The full interview is available here

Lever #5 | Provide decarbonization solutions

Another way brown industries can contribute to climate change mitigation is to **provide products and solutions to reduce the environmental footprint of other industries**. The EU Taxonomy Regulation acknowledges the potential impact and categorizes them as "*enabling activities*". They can be either long-term or short-term, depending on whether they enable **low-carbon activities** or other activities that are "**transitioning**". A few examples of green solutions provided by GHG intensive industries are presented in the table below.

"Brown" sectors	Enabling solutions	Enabled sectors
Steel production	Steel is used in the manufacturing of **wind turbines** for electricity generation, which replaces other more emitting sources of energy such as coal or natural gas. **Every part of a wind turbine depends on iron and steel**. Components include cast iron, forged steel rotor hub, electrical steel parts, generator, tubular towers etc. *For instance, ArcelorMittal identifies wind and solar energy as its market sub-segments and provides solutions for these industries.*	**Power generation**
Oil & gas	Oil & gas companies can develop **Sustainable Aviation Fuels (SAFs) produced from renewable feedstock such as waste or biomass**. Compared to traditional jet fuel, SAFs helps to **reduce lifecycle CO_2 emissions** in the aviation industry, where there are few low-carbon alternatives currently. According to BP, SAFs can produce **up to 80% fewer emissions than conventional jet fuel over its lifecycle**. *Neste (covered in a detailed case study later in the section) is an oil refining and marketing company that produces such SAFs.*	**Aviation**
Rubber tire production	According to data from the European Commission, tires account **for 20-30% of the total energy for a moving vehicle due to their rolling resistance**. By producing more fuel-efficient tires, tire manufacturers can help cars reduce their rolling resistance, **use less fuel** and emit less over the lifetime of the tire. *Many tire manufactures like Bridgestone, Michelin and Nokian Tires are developing tires with lower rolling resistance as a lever in their sustainability strategies.*	**Transportation**
Construction	The design and materials used in building construction and renovation affect the **energy efficiency of the building over its in-use lifetime**. During the buildings' operational phase, **space heating and cooling, water heating and lighting consume energy**, and hence contribute to GHG emissions reduction. Materials that increase the **thermal insulation of buildings such as foam glass, PU and XPS** decrease the need for space heating. The use of more efficient space and water heating equipment (e.g., heat pumps) also contributes to energy efficiency of buildings.	**Buildings & Real Estate (operational phase)**

Greening by solutions

One difference between the "greening of" and "greening by" levers is the way GHG emissions can be analyzed. **For companies providing solutions for other industries, it goes beyond Scope 1, 2 and 3 GHG emissions reduction of their own activities.** It also includes the measure of "**avoided emissions**". Avoided emissions are measured compared to a less favorable reference case. The World Resource Institute released a working paper about avoided emissions, providing a framework for estimating and disclosing GHG emissions impact of a product relative to the situation where that product does not exist.

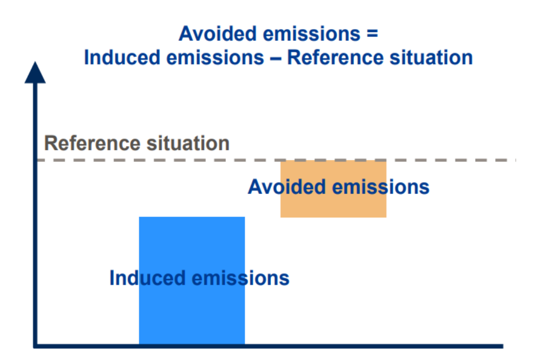
Companies engaging in the "greening by" lever often report the **emissions avoided**, or **the emissions reduction** of their customers.

There can be **potential shortcomings to analyzing these emissions**:

- **There are no international standards to account for and report avoided emissions**. Industries or companies had to develop their own approach. Depending on the reference situation chosen, there is a risk of an **overestimation** of the expected GHG emissions of the reference situation, resulting in an **overestimation of avoided emissions**.
- **We should not forget the absolute GHG emissions induced**, which continually deplete the carbon budget. The Science Based Targets Initiative (SBTi) view avoided emissions to fall under a **separate accounting system** and do not take them into account when reviewing science-based targets of companies.

When assessing a company, it is necessary to adopt a **holistic view and try to consider all the impacts of its business**. Transitioning is not blindly using one sole lever; often several levers can be activated **simultaneously** to achieve maximum GHG emissions reduction. On top of avoiding emissions by providing solutions, more can be achieved if it also decarbonizes its own activities.

Conversely, if the reference situation can be avoided entirely by quitting a certain activity, then option to quit/exit should be thoroughly examined.



Neste: a provider of decarbonization solutions

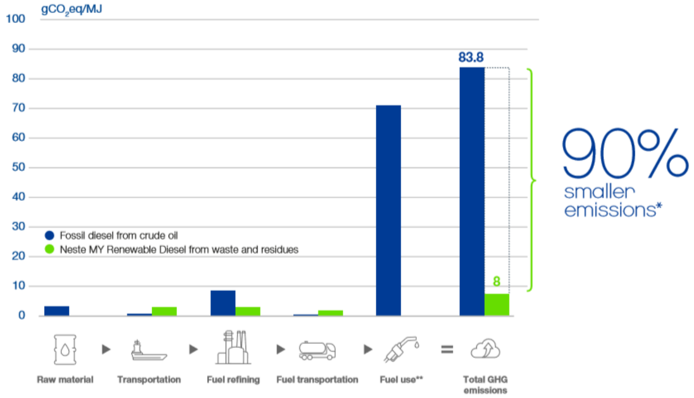
Neste is a downstream oil company but is also a major producer of biofuels (the world's largest producer of renewable diesel).
It has developed a lower-carbon solutions portfolio for road transport, aviation, bio-based plastics & polymers (for a more sustainable petrochemical industry).

How & why the lever examined has been actioned by Neste?

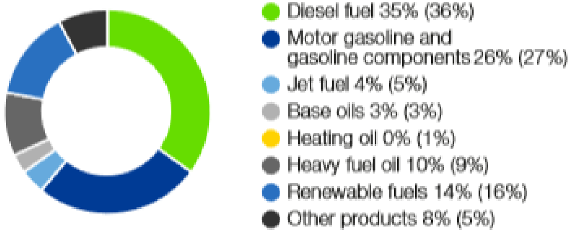
- Development of a technology based on the hydrogen treatment of **vegetable oils (HVO) and waste animal fat to create renewable diesel** called "NEXBTL". As a byproduct, the technology can also be used to create **renewable gasoline and bio propane**.
- Creation of "MY Renewable Diesel", a biodiesel produced from renewable raw materials (waste fats, residues and vegetable oils), delivering **a 90% reduction in total GHG emissions** compared with fossil fuel-based diesel (see charts). It can be used in the chemical industry as a raw material for renewable plastics or solvent in paints.

Governance, timeline, investments around its lever mobilization

- **Government shareholding** : the Republic of Finland holds 35.96% of Neste's total share capital (as of 31 July 2019). No other shareholder holds more than 10% of shares.
- **Commitment to sustainable palm oil as raw material in anticipation of criticisms** relating to biofuels (100% certified, through the Indonesian Sustainable Palm Oil, ISPO; the International Sustainability & Carbon Certification, ISCC; & Roundtable on Sustainable Palm Oil, RSPO).
- **Unintended and detrimental consequences as it stresses demand on palm oil** and spurs competition for land use. Palm oil accounted for 17% of renewable raw material usage in 2018.
- **A 69% GHG reduction on average due to palm oil** when refined into Neste MY Renewable Diesel. In January 2019, Neste's deforestation risk management performance was evaluated within CDP Forests program as belonging to the leading performers' Leadership-class.
- EU compliant International Sustainability and Carbon Certification (ISCC) compliance of Neste's renewable products refineries.



Sales by product from in-house production, %



Source: Neste reports

Overall impact of this lever on the transition of the company and next steps

- Slightly modified from Neste MY Renewable Diesel (blended with fossil for sector's requirements), Neste MY Renewable Jet Fuel™ provides the aviation industry with biofuel, helping to decarbonize the industry. Even though 17% of its biofuel was generated from palm oil in 2018, the company generated 83% of its biofuels using waste as its raw material.

- Neste helps its customers to reduce their GHG emissions by providing renewable fuel (7.9 Mt CO_2e avoided in 2018). However, renewable fuel only accounts for around 14-16% of sales in 2018, conventional refining activities representing the rest.

- In January 2019, Neste reached the leading performers' "A List" in the CDP Climate Change assessment. Only 126 companies globally were awarded with the 'A List' placement, Neste being the only energy company to disclose its forest footprint as part of the CDP Forests program

FORWARD-LOOKING TARGETS

Circularity

- Use of waste plastic as a raw material for fuels, chemicals and new plastics
- A target of more than 1 Mt of liquefied waste plastics annually from 2030 onwards as a raw material for its fossil refinery to reduce crude oil dependence (for illustration, 1Mt represents nearly 4% of the discarded plastic waste currently generated in Europe)

Emissions reduction

- A target of an annual **14 Mt CO_2e reduction by 2023** & an annual **20Mt CO_2e avoidance of scope 3 emissions** by 2030 (vs.7.9 Mt CO_2e in 2018). However, it does not disclose any target for other business lines (diesel fuel, motor gasoline,…)
- Neste communicates in terms of avoided emissions (against a counterfactual/baseline, which is "traditional products used by customers), and not reduced emissions. Regrettably, the company does not have a public target on carbon intensity reduction per MJ delivered. Greater clarity between reduced and avoided emissions would be a plus in the company's communication.
- Employees or executive's remuneration incentives to achieve climate related targets
- Neste discloses energy efficiency targets and aims at reducing energy consumption by **500 GWh** during 2017-2025 (for comparison, 2017 consumption: 12.3TWh, such reduction is meant to be achieved through existing facilities improvement such as wastewater treatment plants at Porvoo and Rotterdam Refineries and the commissioning of the new combined heat and power plant scheduled for commissioning in 2019 in Porvoo). No information is provided on alignment strategy and scenario analysis.

NESTE

EXIT
In July 2019, Neste signed an agreement to sell its fuel retail business of 75 fuel stations in Russia to focus on its strategic priority: "Neste MY Renewable Diesel".

DIVERSIFY
Neste does not diversify as it sticks to its core-business and decarbonizes it through input/feedstock diversification.

DECARBONIZE CORE ACTIVITIES
It decarbonizes the final-use of products with renewable diesel developments. It is also switching part of its electricity supply to wind power at its Rotterdam refinery (no numbers available).

OFFSET
Not mentioned by the company

PROVIDE DECARBONIZATION SOLUTIONS
The patented technology (NEXTBTL) helps to develop fuels from waste, residues & hydrogenated vegetable oil. The products which mimic conventional fuels chemical structure helps the decarbonization of the transportation sector.

In a nutshell

- **Is it ambitious?** Neste intends on growing its renewable fuel production capacity and reach a 20Mt CO_2e annual scope 3 emissions reduction by 2030. This is ambitious but Neste does not disclose any information regarding its conventional fuel refining activity.
- **Is it consistent?** Neste's transition strategy is overall consistent, as it is strategically orienting its activity towards renewable diesel generation from waste and residues. However, the bulk of its activities is still highly emitting. It is concerning that the company does not address any decarbonization targets regarding its conventional refining activities.
- **Is it game changing?** By introducing a mix of technologies (Neste MY Renewable Isoalkane, Neste MY Renewable Propane, i.e. 100% bio-LPG) and providing renewable fuels at an industrial scale, the company contributes to the refining industry transformation. To offer fuels with similar features is clearly a strong transition driver. It introduces a substitute to conventional diesel.
- **Is it enough?** Not for the moment, highly emissive activities of the company are not addressed with the same importance as renewable fuels although the latter represent 14% of its sales, it is not sufficient to say that the company is really transitioning on the short run. Indeed 86% of its activity remains highly emissive.

3.3 | A FOCUS ON THE AMBIVALENT ROLE OF GAS

Sensing gas' potential contribution to climate change mitigation

Two main benefits of gas-fired plants amid transitioning energy systems

1

Versatility & flexibility : combined cycle gas turbine (CCGTs) can play various roles. **CCGTs can be run for baseload and/or peak load purposes,** depending on either immediate grid constraints or the structure of the given country's or region's power generation mix.
In the absence of large-scale, commercially viable electricity storage solutions, **CCGTs' balancing role has been made even more pivotal since the development of renewable energies which are intermittent by nature.**

2

Substitution for more CO_2 intensive fossil fuels in the power sector amid transitioning energy systems. In the recent trends of the European power sector, one finds two specific types of coal-to-gas switches triggered by the implementation of climate change-centric environmental policies:

- Carbon price-driven coal-to-gas switch (UK, Germany) following price developments at the Emissions Trading Scheme level
- Coal supply-driven coal-to-gas switch (Spain in 2019)

In Western Europe (France, Germany, Italy, Spain, United Kingdom), gas-fired plants can be seen as key enablers of the freshly-launched national coal phase out policies.

Natural gas substituting for more carbon-intensive fossil fuels in power generation mixes is not by nature a distinctive feature of the energy transition.
The "shale revolution" in the US in the early 2000s is an ambiguous case:

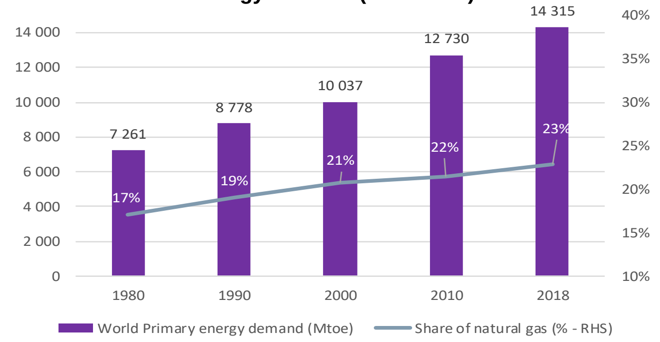
- It triggered a massive coal-to-gas switch in the electricity sector over the past 10 years…
- …in a still highly hydrocarbon-dependent economy, with no overarching plan to transition towards a zero-carbon energy system and dependence on hydrocarbon exports.

In the case of Saudi Arabia, the increased role of natural gas in the domestic energy system can even be seen as having optimized oil rentierism.

The share of CCGTs growing to 58% in 2018 (from 50% in the early 2000s) at the expense of oil…

- …can be seen as having allowed a more efficient use of hydrocarbons resources in the perspective of increased oil exports as well as a growing plastics & petrochemical sector.

FIGURE | Share of gas (%) in world primary energy demand (1980-2018)



Source: IEA (WEO 2019)

Emerging forms of gas can make existing gas infrastructures compatible with a low-carbon economy

Biomethane and “green” hydrogen offer new avenues to accelerate the world economy’s decarbonization

“Green hydrogen” is produced by zero-carbon electricity-powered electrolysis & aims at:

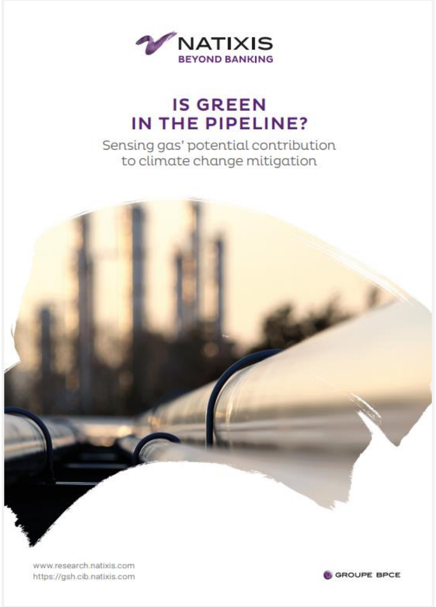
- **Taking advantage of the chemical properties of hydrogen (zero CO_2 emission upon combustion) to extend its use** to sectors / activities based on the combustion of fossil fuels, in particular hard-to-abate sectors such as long-haul mobility;
- **Decarbonizing the production of hydrogen** (Scope 1 & scope 2 emissions) **to reduce the overall carbon footprint of sectors / activities using it as feedstock.**

Biomethane is a near pure form of natural gas& brings indirect climate benefits (production associated with removal of GHGs). **The molecule can be safely injected into existing gas infrastructures:**

- Its development does not involve any **retrofitting/repurposing of existing gas infrastructures**
- Existing networks & storage sites can safely play a direct role in the progressive substitution of this molecule for natural gas

Green hydrogen, and to a lesser extent biomethane, are both plagued by high production costs relative to natural gas due to:

- Current **lack of economies of scale** for both molecules
- For green hydrogen, high CAPEX (electrolyzer and high storage cost) & OPEX (electricity)



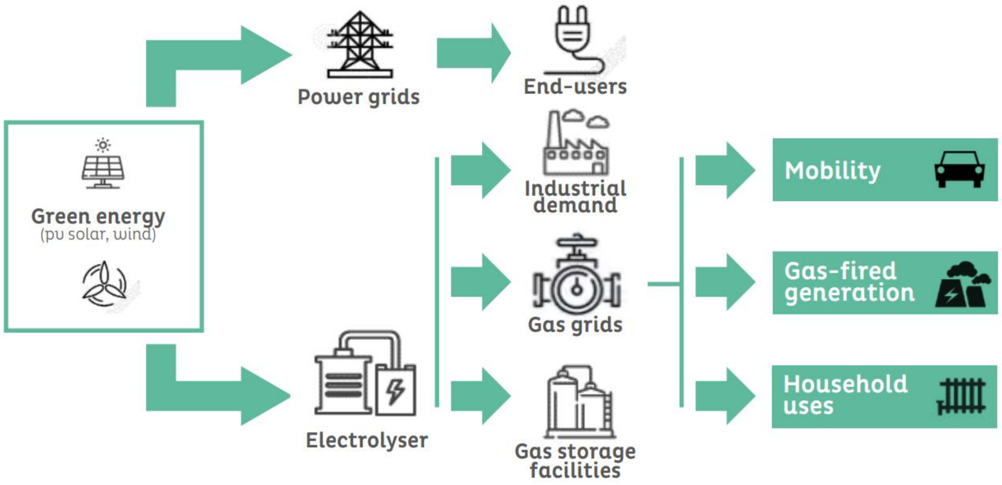
See our full report “What role for natural gas in the transition towards a low-carbon economy?”

Biomethane and “green hydrogen” offer new avenues to accelerate the economy’s decarbonization

CHART | Four theoretical benefits of green hydrogen

Gradually decarbonize the current energy uses of natural gas up to certain limits (hydrogen cannot be safely injected in existing gas infrastructures generally in excess of 10%/20%)	Decarbonize hard-to-abate **sectors (industry & mobility), either as feedstock or as** energy carrier
Help manage the intermittency of renewable energies (“power-to-gas” paradigm)	Pave the way for the integrated management of electricity & gas value chains

CHART | Simplified overview of the potential green hydrogen value chain



See our full report “What role for natural gas in the transition towards a low-carbon economy?”

Through the integration of low-carbon gases, existing gas infrastructures can actively tackle the asset stranding risk

At this stage, due to technical & economic reasons, "domestic" gas infrastructures seem most able to respond to some challenges raised by the development of biomethane and green hydrogen.

Gas networks are capable of transporting energy over long distances at very low cost, hereby offering the best solution to gas transport from a techno-economic perspective

They can transport & deliver very large quantities of energy. Their current sizing does not constitute an obstacle to any rapid growth in low-carbon gas blending

Gas networks have intrinsic flexibility thanks to the use of pressure adjustment, offering at this stage, the possibility of safely injecting quantities of low-carbon gas at any time

In almost any developed country making use of natural gas for residential heating purposes, **existing gas networks have been developed in the perspective of an exhaustive yet tight coverage of the entire territory**, enabling a broad & homogeneous decarbonization of the end uses of natural gas

Early involvement in the emergence of biomethane & green hydrogen offers gas infrastructure operators/owners an **almost free option** for the time being to manage disruptive technology changes:

Adaptation CAPEX required for injecting biomethane and, for the time being, hydrogen into existing infrastructure are almost zero.

With regard to hydrogen, adaptation CAPEX should remain very limited for **at least 10 years**.

The technical elements above also suggest that the **developments of biomethane & hydrogen can be jointly managed** and therefore **without potential conflicts** between the two molecules at least in the next 10 years.

Through involvement in projects around biomethane & green hydrogen, **gas infrastructures can participate in the development of responses to certain technical limitations raised by the electrify-everything approach**, particularly in the mobility sector.

Sensing the ''transitional'' nature of gas assets/ downstream uses

The discussion on the role of natural gas in the energy transition calls for nuanced conclusions

1. In the absence of a systematization of the use of carbon capture and sequestration (CCS), **the use of the molecule for energy purposes will not make it possible to achieve carbon neutrality by 2050**.

2. On the other hand, **gas offers a key lever for exiting coal, alone or in addition to renewable energies.**

3. **Better still, the use of existing midstream gas infrastructure for the development of low-carbon gases can create a continuum until a low-carbon economy is achieved**.
By playing this role, these infrastructures can promote the emergence of disruptive technologies while limiting the stranded costs for the owners of the infrastructures & the final cost of electricity borne by the consumer.

Overall, the EU taxonomy sees a limited role of the current uses of natural gas for electricity generation and heating in a low-carbon economy, unless CCS is massively deployed. However, it highlights the potential role of low-carbon gases as far-reaching decarbonization agents.

As a result, **the EU Taxonomy draws an implicit distinction between the molecule itself** (with direct and/or indirect carbon footprint from extraction to final use) **and the various associated infrastructure assets forming the sectoral value chain** (gas pipelines, storage cavities, LNG trains). The underlying stance is that in some specific instances, these infrastructure assets can enjoy potential use and preserved economic value in a low-carbon economy.

By 2030, natural gas has **a key role to play in exiting coal and oil in electricity generation**, mainly in geographical areas (Europe, North America, Japan and, to a lesser extent, China and India) where the existing asset base is sufficiently diversified to allow trade-offs between fuels (i.e., using existing natural gas assets to displace coal and oil assets whenever possible).

Past this horizon, **assuming that CCS has still not shown any sign of attaining commercial maturity by** 2025, developing the existing asset base in its current configuration (Upstream, Midstream, CCGTs) **would have no environmental justification,** and would in fact perpetuate the carbon lock-in of economic systems.

In parallel, and probably until 2040-2050, gas infrastructures would play a crucial role in helping the biomethane & green hydrogen industries attain maturity, without prejudging to begin with, which of these would impose itself as the decarbonization agent of choice.