Energizing industry

Generating >€200 billion per year by 2030 through European industrial decarbonization

Content

1. Executive summary

Industrials as an enabler of the energy transition

For the world to limit global warming during this century to 2°C above pre-industrial temperatures—the goal of the Paris Climate Agreement—a comprehensive energy transformation needs to be supported by energy-consuming industrials and energy producers.

This energy transition—from fossil fuels to clean energy—is inevitable and inexorable. How are European energy-intensive industrials supporting this decarbonization push? Most executives are acutely aware of the impacts of the energy transition, yet their industrial decarbonization efforts are falling short in delivering rapid and impactful CO_2 reductions.

Many of these leaders have lacked the evidence that decarbonization can actually create value for their companies. To provide such evidence, and to examine the implications of the energy transition for European industrials, Accenture constructed a study group of 30 companies. We conducted interviews of industry experts, analyses of patents and investments, and of press and broader documentation using natural language processing. We also developed a comprehensive modeling exercise to identify the value to be unlocked by pursuing decarbonization, and the optimal value-generating pathway by industry, along with our recommendations.

Recommendations

Our research found that industrials in Europe have the potential to unlock more than €200 billion per year by 2030. But creating an effective pathway to that value will be a challenge. As part of our discussions with executives for this paper, numerous executives commented that they are ready and able to drive change, but that they need political actors on the team who can create an environment for success. It will be important both for the leaders of industrials and for government leaders to be in sync on this complex transition and to support the transition with required predictability around future cost developments. There is no simple or single solution to decarbonization. Innovation and collaboration between the sectors will be critical, along with a multi-faceted approach. Working in partnership, the sectors can deliver an accelerated—and value-generating—industrial decarbonization.

Actions to be taken by European industrials could include

1. Accelerate action: Take a step-wise approach and start taking immediate action today. Focus on driving efficiency within existing operations, whilst actively exploring new business models.

2. Adopt new technologies now: Many energy-intensive processes have technologies with life cycles that will outlive the target years of climate neutrality aspired to by the European Union. To effectively decarbonize, companies must be adopting new technologies now as part of new CAPEX that offer long-term profitability.

3. Understand where you are compared to the rest of your industry: Start benchmarking against industry peers and leaders to identify areas for improvement.

4. Adopt more expansive carbon pricing initiatives: Most companies already consider carbon pricing as part of major investment decisions. However, this is only the first concrete step. Companies will next face two paths, either (a) allocating carbon costs to departments/business units based on emission generation; or (b) implementing an internal carbon fee which is to be applied to the procurement of any products or services.

5. Pursue joint investments and alliances across the value chain: Cross-value chain alliances and investments can facilitate meaningful reduction of Scope 3 end-use emissions by aligning incentives across the value chain to co-develop innovative, multi-partner solutions.

6. Review and enhance supplier pre-qualification: Supplier prequalification and contracting approaches must be reviewed to ensure that everyone is working with a decarbonization-minded supply base interested in driving down their carbon footprint as part of the supply chain.

7. Self-disrupt and think beyond adjacencies: The sale of commodity products will start to give way to a climate-neutral, usage and service-based economy. Successful navigators will be those that realize the new business models emerging out of:

- Industry convergence—e.g., the provision of syngas and H_2 for further downstream utilization and energy storage.
- Digitization of value chains and deploying increasingly sophisticated analytical capabilities to further understand and monetize data.
- Demand-side management sometimes being the less expensive decarbonization measure than investing in supply-side decarbonization. Decarbonizing through a more demand-side driven approach requires a focus on helping customers design more efficient products, materials and buildings. This risks cannibalizing your market. However, carefully crafted business models not only delight your customers and help them with their decarbonization journey, but also deliver higher margins.

8. Ensure appropriate governance in enabling value-accretive innovation: Successful players have established a strong innovative intrapreneurial culture and innovation governance, enabling them to pivot to new opportunities ahead of their industry peers.

9. Adopt a customer-centric mindset: In our work with industrials, we continue to be impressed by new product innovations. However, many European industrials are still yet to adopt a key thing – a true customer-centric mindset. We often see a focus first on the revenue and operations, with the customer as an after-thought. This must change so that customer insight drives the whole process based on conversations with real customers, understanding why customers behave in a certain way, rather than taking secondary research statistics at face value. Through this, it can be understood that the unresolved needs of customers that can be solved for, without being constrained by current research definitions or market offerings.

Public and private sector collaboration: A critical success factor in decarbonization

We have described a variety of actions that the private sector should consider on this journey toward decarbonization. For successful outcomes, the public sector's role is also critical. Without robust action from the public sector, industrials will be at competitive risk, given the twin burdens of necessary investments and the uncertainty of the pace and scope of technological innovation.

It will be important for governments and industrials to be in sync on this complex transition. At the core of the challenge: industrials need predictability on costs through thoughtful framework that will alleviate some of the transition costs and prevent "carbon leakage"—in which industrials leave the EU or lose business because the energy transition undermines their competitiveness in internationally traded goods.

Targeted public-sector intervention in the areas listed below could, on their own or in combination, help to accelerate industrial decarbonization:

- Implementing a framework that ensures companies are able to successfully internalize carbon's hidden cost;
- Designing policies that avoid penalizing first-movers;
- Setting a precise and robust carbon price mechanism with a significant base price[1], increasing predictably over time as a guide to technological innovation and investment;
- Establishing a framework for emissions reporting in all three scopes (time frames) for all industries where company revenue and/or number of employees exceeds a certain threshold;
- Exploring a European product carbon-labeling standard, akin to that run by the Carbon Trust;
- Leveling the playing field through a carbon border tax to compensate against competing imports from outside the EU—that is, incorporating any hidden costs and thereby preventing carbon leakage;
- Evaluating the potential of quotas to increase the use of low-carbon cement and steel for construction and infrastructure projects, as well as to scale up chemical recycling and circular polymers;
- Stimulating the hydrogen economy on both the supply and demand side through a broad set of measures, including quotas and tax breaks;
- Consolidating and integrating national and regional funding mechanisms into a streamlined single application process.

We believe that, working collaboratively, private and public sectors can deliver an accelerated—and value-generating—industrial decarbonization.

Looking ahead

As we will discuss throughout this document, we see industrial decarbonization in Europe as a significant opportunity for both energy producers and industrial energy consumers. In this paper we will assess the dynamics at play from a technology, investment and supply chain perspective. The question of how industrials can seize upon this opportunity should be an item at the top of the CEO agenda. There has never been more public support—nor more urgency on the part of companies and governments—for an energy transition.

The time to act is now.

2. Introduction – The time for action is now

In this report, we explore the energy transition now occurring throughout the world, and its impact on industrials—companies from the utilities, chemicals, cement, metals and energy sectors. We explore a variety of perspectives, bringing together implications and calls for action for both the private and public sectors.

We see industrial decarbonization as a significant opportunity, with many supply-side and demand-side options already in the money. The future will be shaped by those that take bold and decisive action, understanding the optimal pathway to a sustainable and profitable future. Traditional industry boundaries are being fundamentally challenged (and broken down) as companies develop new business models not only to survive, but to also thrive.

Many non-traditional players will play some role in energy generation and management as barriers to entry fall to all-time lows. But this is not a theme limited to energy. Our research and industry discussions have found evidence of significant industry convergence, and we see this trend accelerating.

However, in enabling pioneers to act, our analysis highlights just how sensitive progress is to an uncertain regulatory environment. As we will demonstrate across this series of reports, there has never been more public support for an energy transition. The time for action is now.

"Corporate strategy has never been more difficult, challenging or exciting than it is today."

Accenture Study Group Executive

What do we mean by "industrials"?

We think of "industrials" as a category that goes beyond the typical "heavy industry" definition. Our broader perspective accounts for both those that provide the energy to the industrials (the energy producers like energy and utilities), and also those that are significant energy consumers (heavy industries like chemicals, steel, metals and cement). This enables us to consider the broader emission implications of European industrial activities, including the required energy supply. Our heavy industry selection is focused on industries where CO_2 abatement will require significant investment to redesign and change existing processes and technologies.

Industrials as an enabler of the energy transition

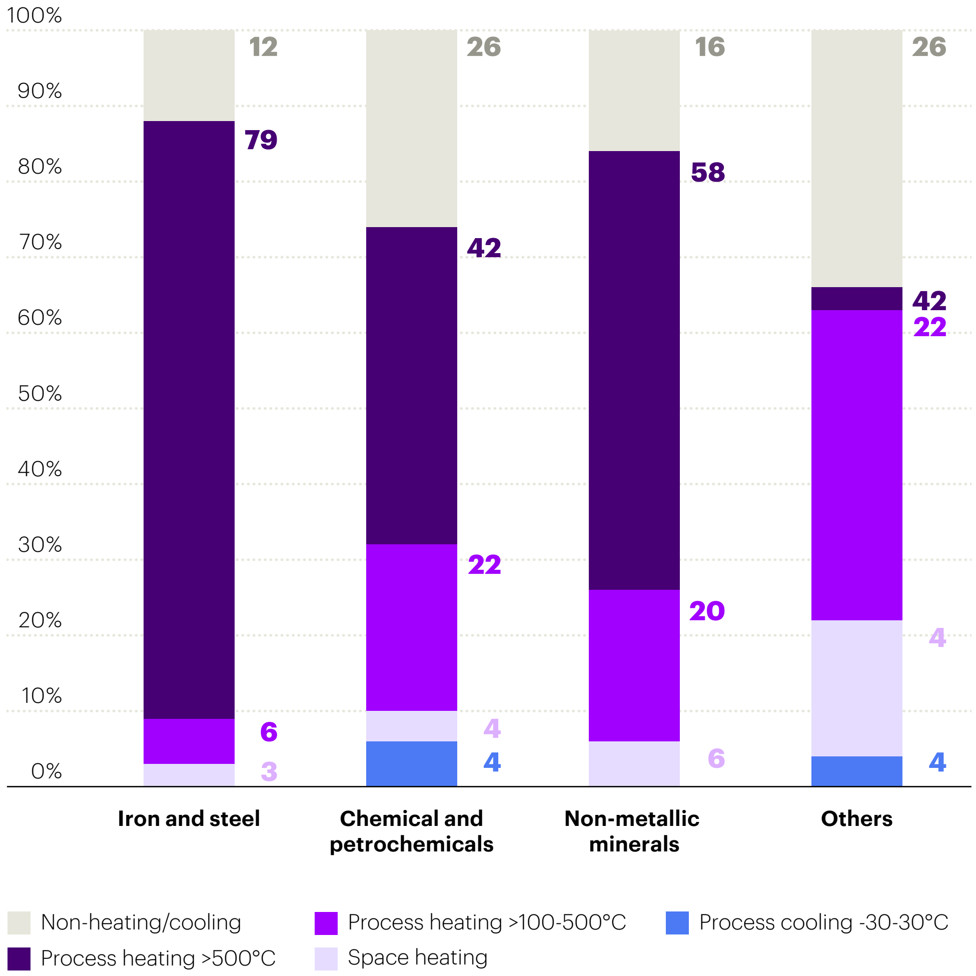
For the world to have any chance of limiting global warming during this century to 2° Celsius above pre-industrial temperatures—the goal of the Paris Climate Agreement—substantial changes need to be made by energy-consuming industrials and energy producers. In the European Union (EU), industrials represent 20 percent of emissions and about 25 percent of final energy consumption.[2] Thus, they are a necessary enabler of the energy transition and decarbonization.

By "decarbonization," we mean a transition to a low-carbon or full-carbon-recycling future. The long-term goal is to transition industries over generations not only to a state where their carbon footprint is zero, but to where they are actually "carbon positive"—an activity or industry that goes beyond achieving net-zero carbon emissions to offering an environmental benefit by removing additional carbon dioxide from the atmosphere.

A complicating factor for the decarbonization of the industrials sector is that these companies require energy for a range of purposes, with most of the energy consumption being used for process heat (See figure 1).

These processes are complex constructs, with adjustments to energy sources often seen as being technically impossible or economically unfeasible. But this is about to change.

Figure 1: Final energy demand for EU28 by temperature level and sub-sector for heating and cooling in industry



Source: Accenture Analysis

It is somewhat reassuring to know that the current energy transition—from a system based primarily on fossil fuels to one based on renewable, CO_2-neutral energy sources—is not the first that humans have been through. In our fairly recent history, we have made several other transitions—from wood to coal, then to oil, and then to natural gas.

Yet, it is certainly true that during this fourth energy transition, energy systems are being more severely disrupted. The corporate imperative is to decarbonize, whilst rapid cost and technology advancements have created unprecedented pressure on industrials to re-invent themselves. These issues are top-of-mind in the C-suite, which needs to pursue decarbonization options and pricing approaches, and then focus on how their companies can raise capital and use it to drive value creation.

Some oil and gas companies have lost billions from their assets due to a bleaker oil outlook. In other cases, decarbonization is driving dramatic cost increases. And underneath it all, raising capital will become increasingly challenging on both the equity and debt side. Analysts from Deutsche Bank recently wrote, in a note to clients, that "Decarbonization has emerged as a key challenge facing the materials sectors. While some of the trends are long term, they matter for equity valuations today."[3] Larry Fink, CEO of BlackRock, Inc., recently delivered a strong warning to business leaders about the climate crisis. He said that his firm will take steps to address the issue across the thousands of companies in which it invests.[4]

Achieving success

As we progressed through prior energy transitions, the focus was consistently on maximizing the power density (watts per square meter). This is the first energy transition that reverses that trend: renewable energy sources carry a lower power density than fossil fuels (See figure 2).

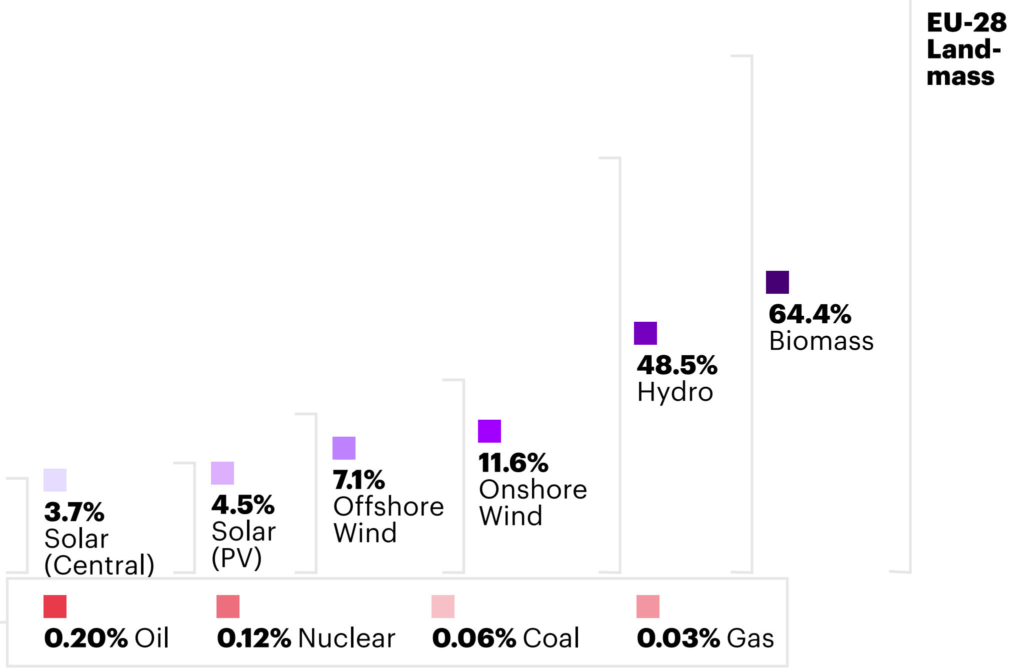
Major adoption of renewables will lead to order-of-magnitude increases in the footprint required to power the world's energy needs. Recognizing this, it is important to develop an energy system that supports decentralized energy generation in spreading out the geographic footprint, whilst continuously innovating and developing new technologies that deliver improved power density.

"We are past the time for talking – if Germany wants to be a first mover or fast follower then the time for action is now."

Speaker at a recent green hydrogen event in Germany

Figure 2: EU28 land mass required if Europe's annual energy needs were domestically produced from a single energy source

The fourth energy transition: A step-change reversal in power density driving the need for decentralized energy production



Offshore wind shown with landmass requirement to allow comparison of power density. Marine, offshore coverage would amount to ~36% of technical potential according to the European Energy Agency

Source: Accenture Analysis[5]

A disruptive point to keep in mind is that this shift reduces barriers to entry for the business of energy generation—for example, fewer geographic constraints, lower CAPEX requirements, and a reduced need for specialized technical expertise. As we will demonstrate, these competitive disruptors are already leading to an acceleration of industry convergence.

However, as we know, this is not simply a regulatory challenge. Many industrials need to fundamentally shift their culture and approach to innovation, embracing a more customer-oriented, "fail fast, learn and redirect" culture. Such a culture seeks to develop new cross-industry solutions in conjunction with broader ecosystem partners—sometimes even those that were once seen as direct competitors.

Following recent dialog about the hydrogen economy and setting of long-term decarbonization targets, the world is long past the time for talk. The future (and capital markets) will reward those that took bold, decisive action in decarbonizing their business.

"We are exploring a lot of new business models and initiatives but our corporate strategy is just not set up to enable us to think and move in the agile manner that some of our industry leaders are rapidly adopting."

Accenture Study Group Executive

3. A perfect storm of push and pull levers is emerging

The current decarbonization situation for European industrials

The energy transition is inevitable and inexorable. The primary issues that European industrials should consider are the speed of the transition, the impact it will have on their companies, and the effort and costs required to successfully deliver on the decarbonization imperative.

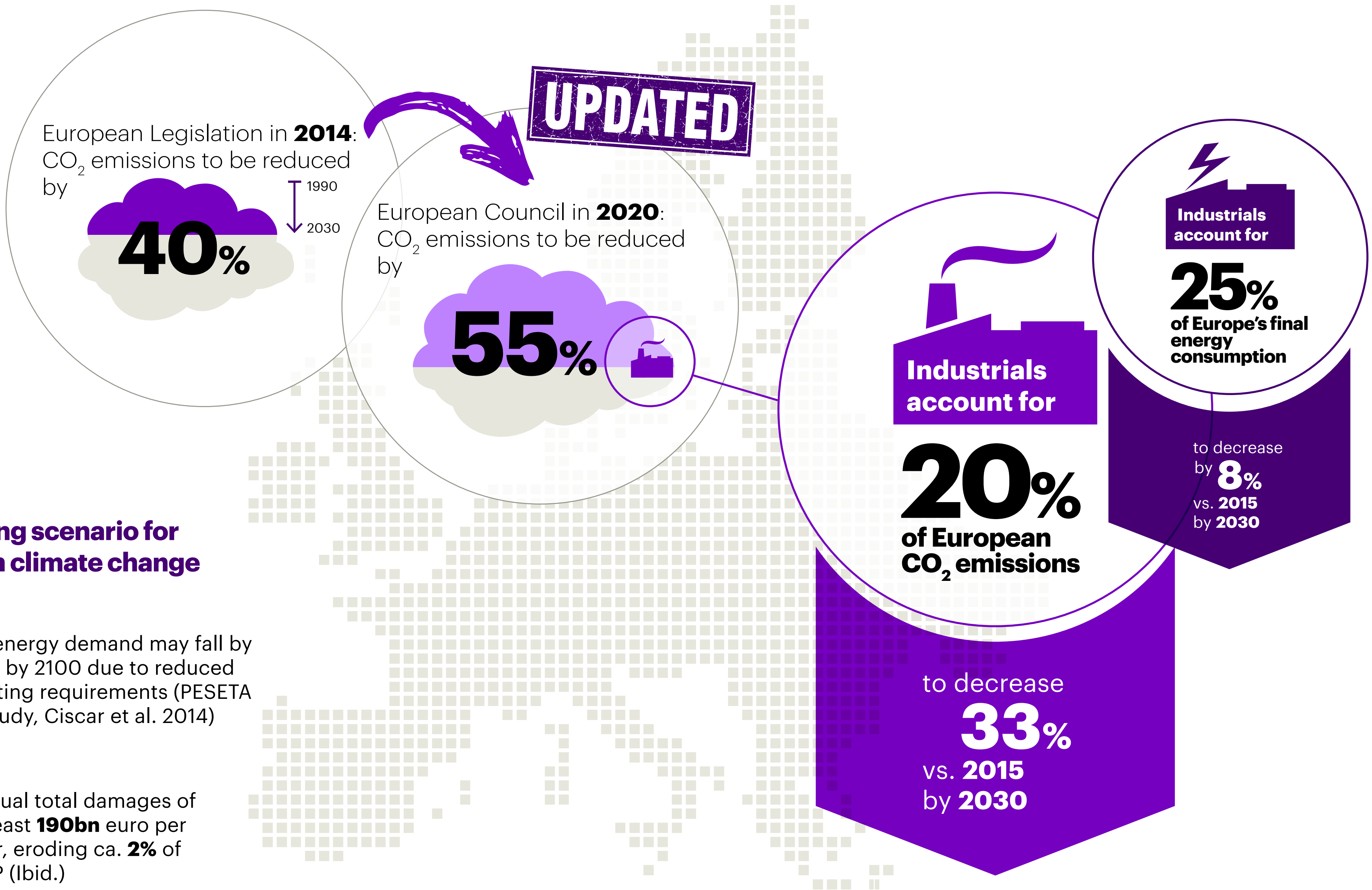
At the national level, European member states have united around the need for action, mandating that should any member state fail to reach its national CO_2 reduction goals for 2030, they must buy emission allocations from other member states that have surpassed their goals. This could well happen across numerous European member states unless greenhouse gas reduction is accelerated in non-ETS (Emissions Trading System) sectors.

In addition, a 2030 target for reducing energy consumption is to achieve a 32.5 percent efficiency improvement in primary energy consumption, compared to a baseline scenario with no efficiency improvements. Renewables' share in EU-wide final energy consumption should grow to at least 32 percent by 2030. This target is binding at the EU level and is defined in the 2018 revision of the Renewable Energy Directive.[6]

With industrials representing 20 percent of EU emissions and about 25 percent of final energy consumption, they are a key enabler of the energy transition and decarbonization. However, the need to deliver a required 33% decrease in CO_2 emissions by 2030 is daunting (See figure 3), and puts unprecedented pressure on industrials, driving new levels of industry convergence.

The energy transition is inevitable and inexorable. The primary issues that European industrials should consider are the speed of the transition, the impact it will have on their companies, and the effort and costs required to successfully deliver on the decarbonization imperative.

Figure 3: European industrial decarbonization



Do-nothing scenario for European climate change

13%

EU energy demand may fall by **13%** by 2100 due to reduced heating requirements (PESETA II Study, Ciscar et al. 2014)

2%

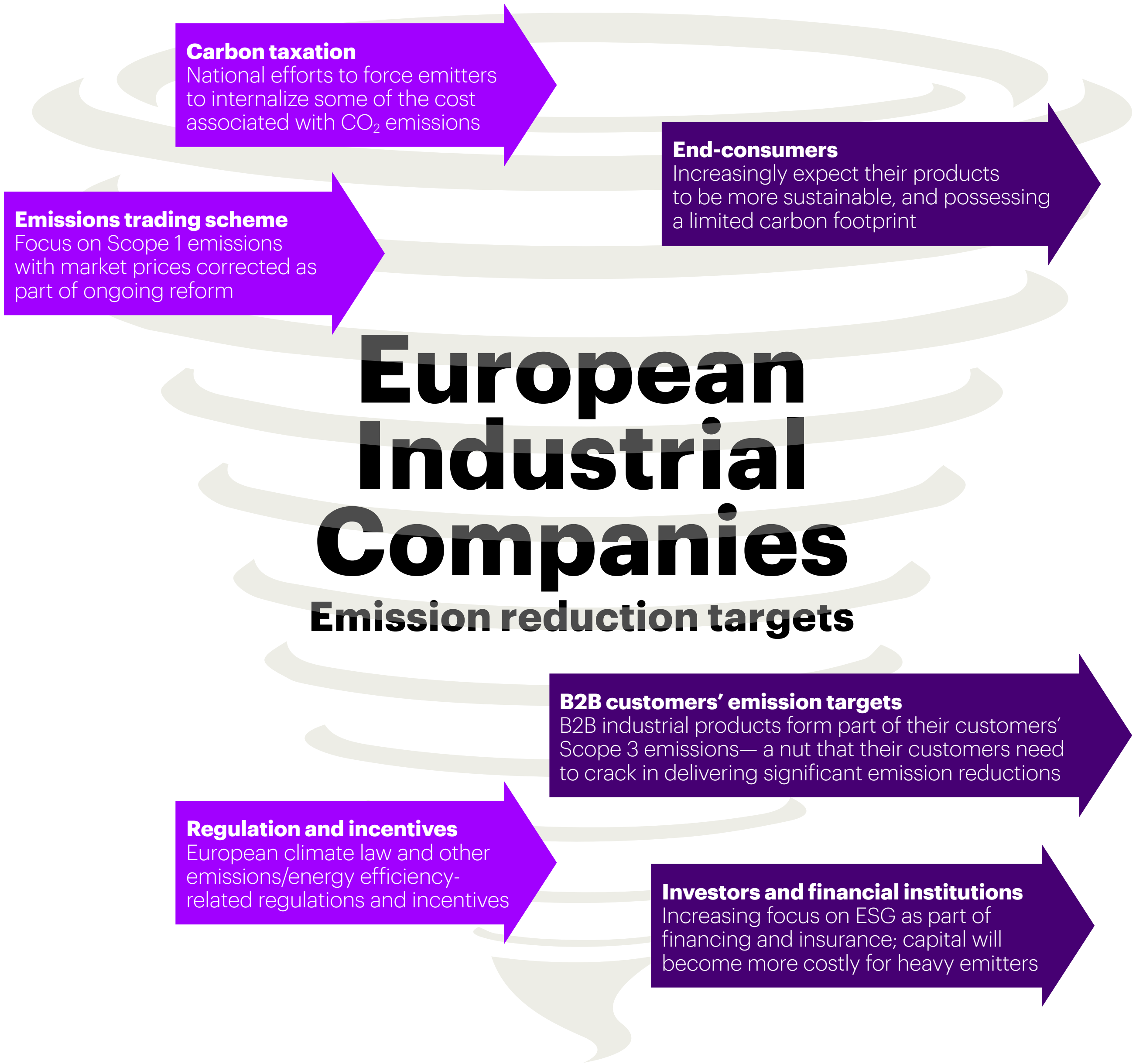
Annual total damages of at least **190bn** euro per year, eroding ca. **2%** of GDP (Ibid.)

Source: Accenture Analysis

Push and pull influences on European industrials

Pressure continues to build on European industrials from two sides: Entities like regulators and governments are "pushing" for change, while groups like consumers and investors are "pulling" at companies to change by altering their buying and investment plans (See figure 4).

Figure 4: Push and pull levers for decarbonization



Push levers include:

Carbon taxation

These are national efforts to force emitters to take on some of the external cost associated with GHG emissions. Today, there is ever-growing pressure to implement a European-wide carbon taxation program as we look to deliver a more unified approach in forcing consideration of external costs into capital allocation decisions.

Emissions trading scheme

Such a scheme focuses on Scope 1 emissions with market prices corrected as part of reforms. As of late 2020, the cost for one ton of CO_2 as part of the European Emissions Trading Scheme (EU ETS) is ~4x what it was just two years ago (approximately €25/MT) with market consensus that prices must, and will, go up. It's more a question of whether they will go up sufficiently without intervention in delivering the required decarbonization.

Other regulation

This includes the European Climate Law and other emission and energy efficiency-related regulations that are mandating change in order to help deliver on the EU's climate goals for 2030 and beyond. Companies need support from regulators. The changeover to climate-friendly processes and products is associated with high strategic uncertainty for companies in areas such as technological progress, energy costs and regulation. This means that a robust and forward-looking regulatory framework must be created that makes the conversion of the energy system both cost-effective and predictable for industrial energy consumers.

Pull levers include:

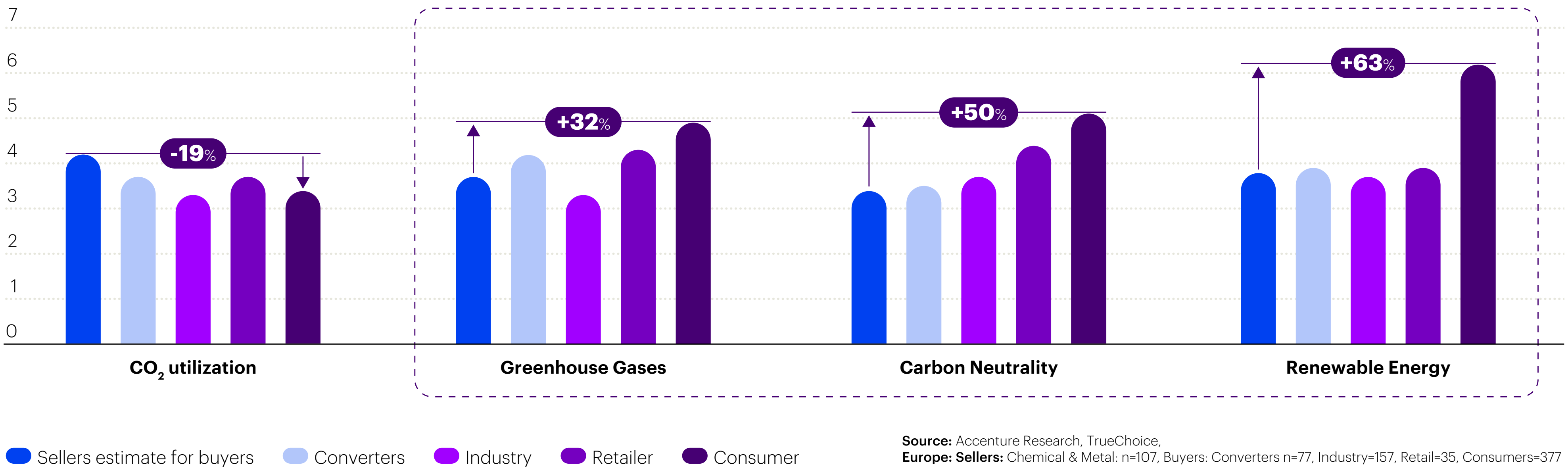
End consumers

Corporations are seeing where consumers are putting their money—increasingly into eco-friendly products and brands—so companies are changing practices to meet new demands. Consumers are looking for products to be more sustainable and to achieve a smaller carbon footprint.

Accenture's Buyer Value study[7] conducted in May 2020 found that renewable energy is not only regarded as important by European consumers, but that consumers are willing to pay over 5 percent more for energy from renewable sources. Meanwhile, a 2020 study by the Carbon Trust found continued levels of support for carbon labeling on products across all countries, with two-thirds of consumers saying they think it is a good idea.[8] Unfortunately, European industrials are underestimating the perceived value of decarbonization at consumer-facing businesses (See figure 5).

Figure 5: Industrials underestimate the importance and perceived value of their industry customers and the consumers

Perceived Value – willingness to pay, dollarized value in % – seller under / overestimate buyers' value in %

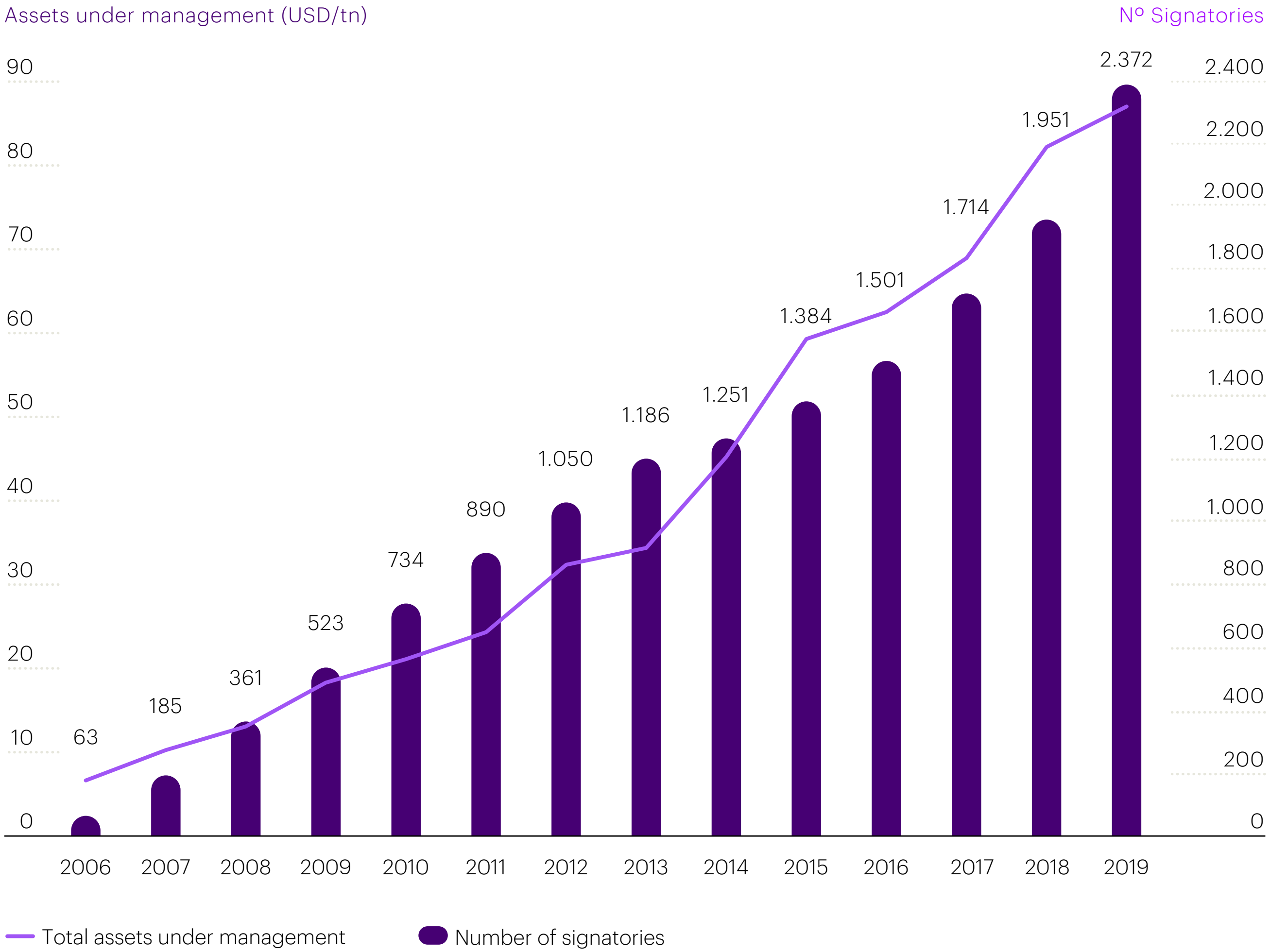


Source: Accenture Research, TrueChoice,
Europe: Sellers: Chemical & Metal: n=107, Buyers: Converters n=77, Industry=157, Retail=35, Consumers=377

B2B customers' emission targets
Industrial sellers in the chemical and metal industry overestimate their customers' perceived value for carbon dioxide utilization while underestimating it regarding carbon neutrality, GHG reduction and the use of renewable energy – up to a factor of 60 percent underestimation. Foresighted customers are engaging business-to-business customers in their efforts to reduce CO_2 emissions.

Investors and financial institutions
Industrials that wait too long to take decarbonization seriously will find that raising capital will become more challenging on both the equity and debt sides. Governments (Article 2.1 of the Paris Agreement) as well as investors (See figure 6) are focused on allocating capital in such a way that it supports European climate goals and the broader investment portfolio environment, social and governance (ESG) enhancement targets. In fact, according to a 2019 FTSE Russell survey, 82 percent of investment firms are currently implementing or evaluating ESG considerations as part of their investment strategy.[9]

Figure 6: Growth in investors signing up to the Principles for Responsible Investment (PRI)



Sources: Accenture Analysis, Principles for Responsible Investment

4. Innovation is focused on driving industrial scale and lowering cost

To examine the implications of the energy transition for European industrials, and better understand progress to date, Accenture Research constructed a study group of 30 companies that serve as the basis of our analysis throughout this report.[10]

Analysis of patent activities

A part of our research, we analyzed the use of emerging technologies among the industries selected for our study (see Appendix). We focused on patents filed in the US, Europe, Japan and South Korea. Through this analysis, we found that innovations in the areas of electrolysis and catalysts are increasingly focused on delivering economic advantage (See figure 7).

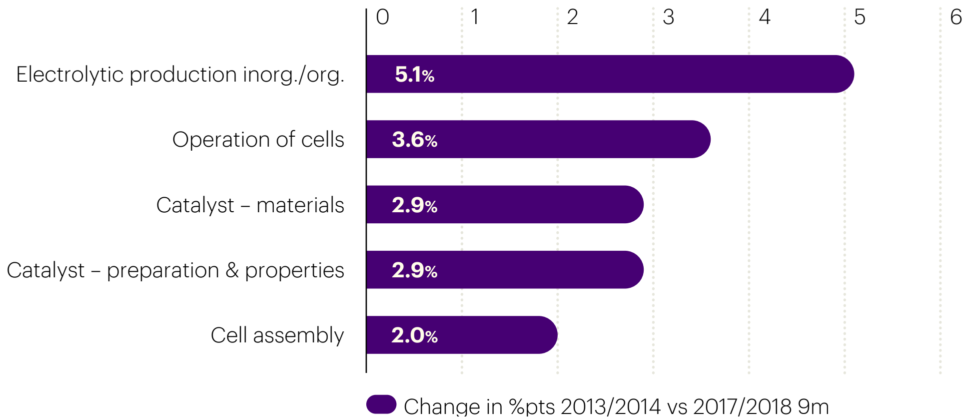
These technologies are not new, but they have emerged as core technologies in the face for effective and rapid industrial decarbonization. Catalysts and electrolysis play pivotal roles in creating alternative ways to create hydrogen in a way that is cost-competitive and green. These technologies substitute the CO_2-intensive steam methane reforming or by capturing CO_2 and turning emissions into valuable feedstock.

CO_2 can either react with green hydrogen, creating chemical products, or it can be transferred electrochemically to syngas and olefins. These technologies offer ideal storage and a capturing basis for the transition to a renewable energy future, and also actively reduce emitted CO_2.

Patent analysis shows that the shift to electrolysis is a key enabler for these ways to decarbonization because it helps avoid fossil-fuel-based energy, and impacts fossil feedstock, as well. Green syngas generation will experience a revival because it is the common basis for methanization and chemical products. Catalysts play a crucial role for electrolysis itself, as well as for the subsequent chemical production, based on electrolytically generated feedstocks.

These shifts are driving sector coupling across industries, with (1) utilities generating renewable energy; (2) chemicals, industrial equipment companies, and other project developers producing green hydrogen; and (3) CO_2-emitting industries serving as a feedstock supplier.

Figure 7: Rising share of patents emphasizing cost and economic advantage of selected technologies. Increase of references in % pts



Patents filed after September 2018 were not yet fully published at the time of analysis

Source: Accenture Analysis of data from DWPI from Derwent Innovation (© Clarivate 2020), excluding utility models

Electrolysis
- Key technology for POWER-2-X
- Industrial scale

New catalysts
- Activating CO_2
- Activating electrode surface

Recent innovations are driving down unit costs while also improving the efficiency and system longevity of electrolyzers. These developments, combined with economies of scale, are a critical gateway into low-cost hydrogen production. They are a turning point in decarbonizing European industry.

5. Significant cross-industry investments in industrial decarbonization

As part of our research we wanted to better understand how industrials target decarbonization, whether through in-house R&D, or through investing in and/or even acquiring relevant technologies to speed up the process. In exploring investments we considered ventures, start up activity as well as mergers and acquisitions.

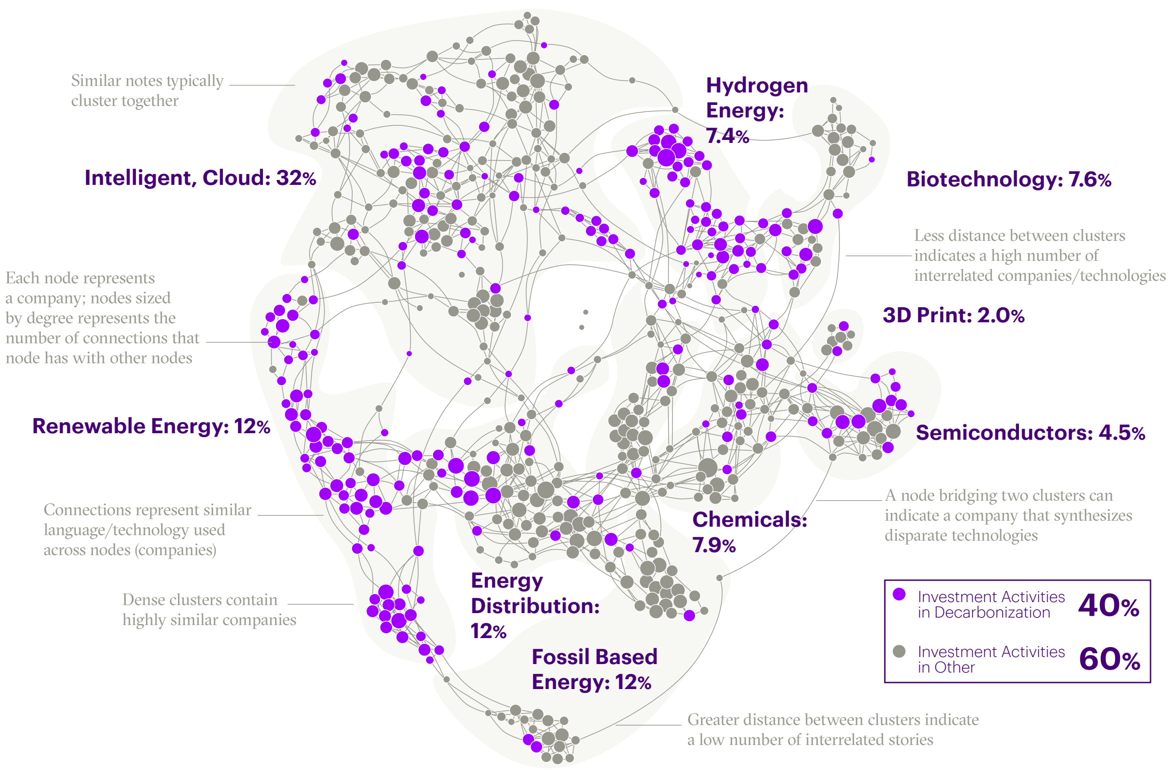
Ventures: Embracing new technologies from the beginning

A deep dive into the study group's investments over the past five years found that 40 percent of that investments were linked to decarbonization efforts – not only covered by renewables and hydrogen, but also through intelligent management, including cloud, energy management, blockchain, IoT, mobility, and consumption data (See figure 8).

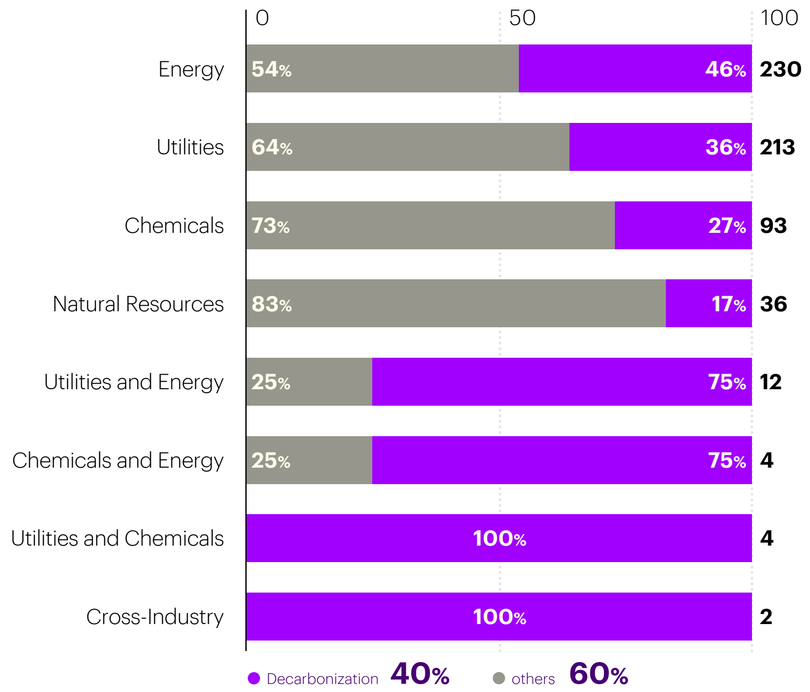
Energy and utility companies are focusing investments on new transformational businesses around intelligent cloud, whilst the energy industry is moving into chemicals, hydrogen production, and biotechnology.

Utilities and chemical companies in our study group are investing in hydrogen, whilst chemical companies are starting to move beyond their core business, investing in technologies such as semi-conductors, 3D printing, and biotechnology.

Figure 8: Investment activities of analyzed European industrials in the past five years



Share of study group's investments allocated to decarbonization efforts



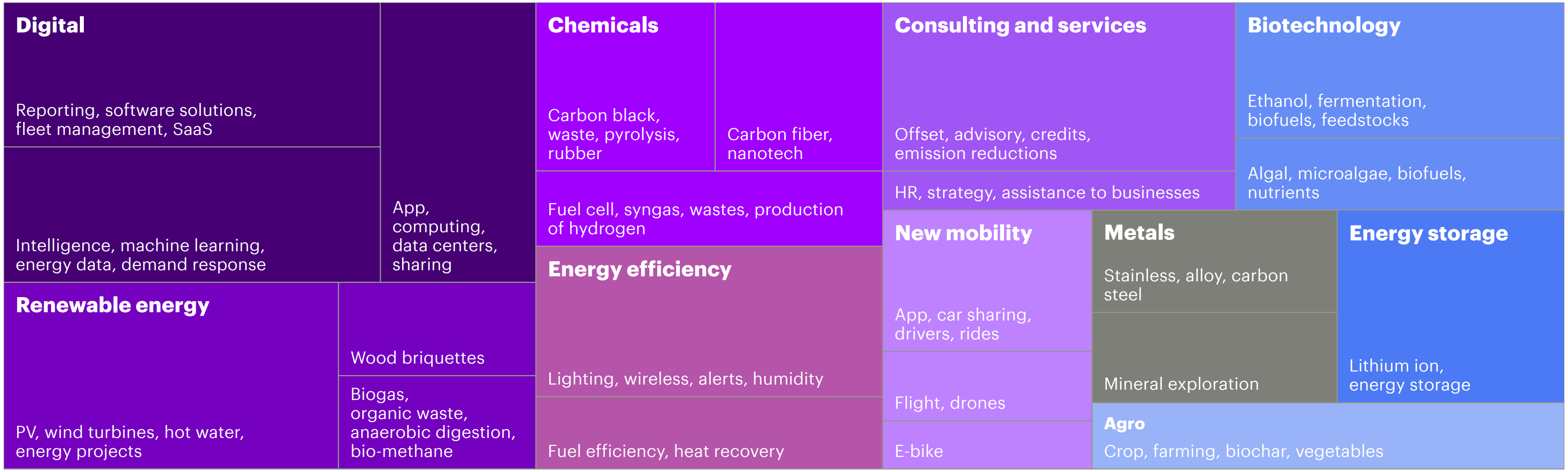
Source: Accenture Analysis based on Quid®

Start-up scene: Decarbonization – digital and industrial support

As decarbonization becomes an increasingly attractive commercial opportunity, many start-ups are entering the market. With a significant focus on combining decarbonization with digital service offerings, these services are tightly linked to managing renewables, efficiency, mobility and consulting services.

Investments in new decarbonization start-ups are already bearing fruits, as study group companies find large-scale applications which combine new technologies from the start-ups with the market access, relationships, and other capabilities of the study group. Over the next page, we highlight some startups of the past couple of years which have particularly impressed us (See figure 10). Moreover, an increasing number of start-ups are venturing into new materials (such as metallo-ceramic compounds and bio-based), carbon-neutral solutions such as closed-loop recycling, and platforms for connected energy solutions. It's worthwhile to note that, while unit costs in some areas are falling (e.g., LOCE) and will continue to fall, traditional business models at the same time are getting squeezed in terms of their ability to earn their capital costs. This calls for a laser-sharp focus on corporate and technology strategy to occupy new profit pools in the emerging business landscape.

Figure 9: Start-ups founded since 2005 that are focusing on decarbonization



Source: Accenture Analysis

Figure 10: Study group interaction with select startups

Solidia

Cement and concrete technology company producing less energy-intensive, faster curing as well as CO_2 binding cement.

Air Liquide | BASF | BP | LaFarge Holcim | Total

Sunfire

Production technologies for synthetic crude, fuels and hydrogen from renewables as well as off-grid power solutions.

Engie | Total

Adaptricity

Software solution offering grid modelling, simulations, operations and automation on an integrated platform.

Enel | E.ON

2008 | 2010 | 2012 | 2014 | 2016

Orcan

Modular energy recovery units generating electricity from industrial and heavy-duty mobility waste heat.

Air Liquide | E.ON

Akselos

Physics-based, digital twin software solution for new asset design, operations monitoring and predictive maintenance.

E.ON | Shell

Sterblue

Digitization of energy asset inspection using drone technology and integrated data storage and analysis.

innogy

Source: Accenture Analysis

Mergers and acquisitions: Industries are converging and positioning themselves to capture emerging value pools

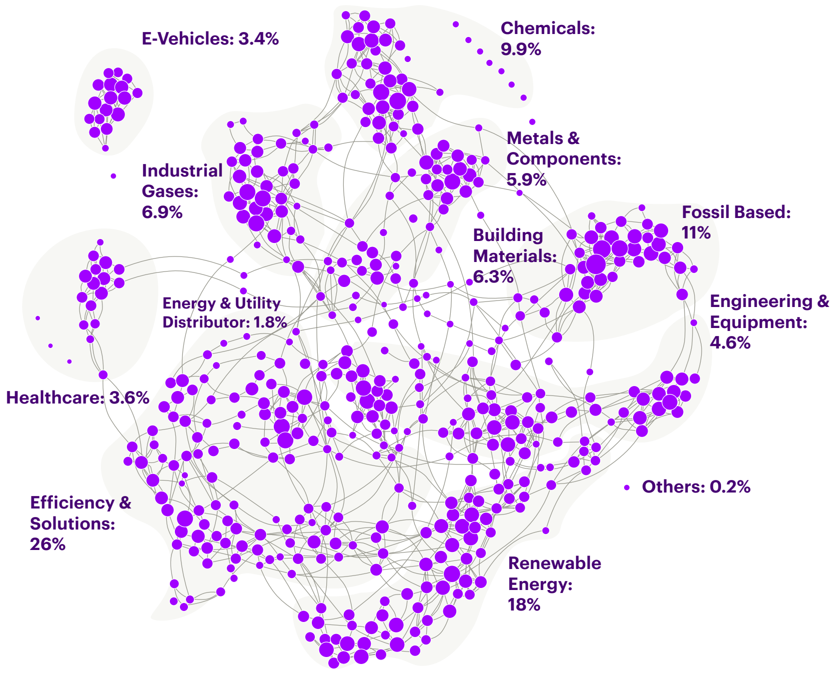
Decarbonization efforts are clearly on companies' growth agendas. Since 2015, about half of all acquisitions made by companies in the Accenture study group have focused on efficiency and solutions, renewable energy, and electric vehicles, one third are focused on decarbonization efforts. (See figure 11)[9].

The numbers point to the industries facing the highest disruption in the next decade: energy and utilities. Interestingly, acquisitions by leading European chemical, cement, and metal companies are primarily focused on growing the core business (at 50 percent or more), whilst utilities and energy companies are targeting transformational acquisitions, focusing on communications & high-tech (including IT), as well as services primarily targeting energy efficiency (a logical move when considering demand-side management as a way to drive decarbonization).

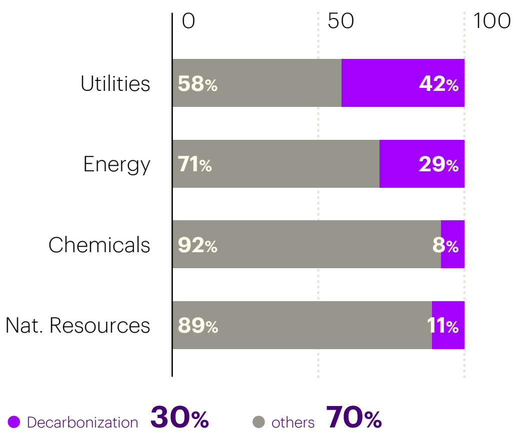
Additionally, energy companies are pushing into the utilities business by targeting renewable energy generation. Utilities, in turn, are striving to position themselves closer to consumers by pursuing e-vehicle service and energy support or smart grid/home by extending its their focus to increase efficiency, services and renewables share.

Many questions remain. Energy companies are clearly taking steps forward with regard to decarbonization, but are they moving quickly enough, given where they need to be by 2030—less than a decade away? To help answer this question, we will now explore challenges and hurdles in accelerating the energy transition and decarbonization efforts amongst European industrials.

Figure 11: European industrials – Acquisitions over the past five years



Percentage of acquisitions focused on decarbonization



"Decarbonization" includes

- Carbon dioxide, CO_2, carbon, emission
- Wind, solar, renewable, tidal
- Battery, electrolysis
- hydrogen, H_2
- Recycle
- Greenhouse gas

Source: Accenture Analysis based on Quid®

6. A jungle of uncertain technology options amidst some fundamental challenges

As companies and policymakers discuss how they can move at a faster pace toward decarbonization goals, several challenges and uncertainties need to be addressed:

1. **A fragmented regulatory environment throughout the global, regional trading blocks and national economies**
2. **Infrastructure challenges to cost effectively deploy and scale new technology**
3. **Cost inhibitors and uncertain price development of key technologies**
4. **Uncertainty around development and scaling of key technologies**

Fragmented regulatory environment

One of the challenges that European industrials face with regards to their decarbonization efforts is that the regulatory environment in Europe is fragmented and no unifying strategy exists to incentivise investments of small and medium businesses as well as and large corporations. However, in progressing regulation, regulators do not need to work out the answers to everything now. Instead, they should work with industry to jointly find sensible solutions as the energy transition progresses, thereby enabling industry to move at a controlled pace.

A 2020 Institute of International Finance (IIF) survey recognized a number of challenges around regulatory mandates:

- The uncertainty around mandatory energy transition measures such as emissions tracking and reporting has led to corporations introducing "shadow" carbon pricing—a market-driven trend to compensate for uncertain future regulatory developments.
- Companies' risk management frameworks increasingly include the identification and assessment of climate-related risks and opportunities.
- Progress is being made on reporting Scope 1 and 2 emissions. However, there is little consensus on how to measure Scope 3 emissions effectively.
- There is increasing concern (two-thirds among the survey) about policy fragmentation undermining future certainty and improvement as national regulators introduce a plethora of different accounting and measurement standards.

Other indicators show that regulatory and financing challenges need to be overcome:

- A potentially unifying strategy for Europe is the EU's recently published "European Green Deal" that forms a central package of 50 individual measures and aims at a climate neutral energy supply by 2050. It addresses, both explicitly and implicitly, various industries (e.g., power generation, transmission and distribution); as well as transportation and process industries (e.g., chemicals)[3]. The deal has come under scrutiny because its €1 trillion budget may not suffice to cover the costs of necessary future investments[11].
- Some countries such as Germany, France and the UK are adopting their own additional climate strategies with the aim of moving at a faster pace with the energy transition.
- Recently, in June 2020, Germany set out to become a global leader in hydrogen technology and announced a national hydrogen strategy. It's focused on establishing hydrogen as a multi-purpose energy carrier and essential to achieve "sector coupling"—for example, in power-to-X, feedstock for chemicals, transportation by fuel cells, and fuel for heavy industry.[12]

Infrastructure challenges

Infrastructure updates are necessary to harness efficiencies of new technologies. But these updates cannot keep up with the rapid technological progress, as it can take 10 to 15 years to build out the required power and gas infrastructure. One example is Germany's North-South Grid expansion to supply the south with northern wind power, the costs of which are ever-increasing. A major cause of long development periods is regulation and public policy.[13] Regional fragmentation of policies is a challenge to planning and investment, whilst less complexity and long-term regulatory/policy security is a prerequisite for enabling meaningful and timely capital investments.

"Both the European and German hydrogen strategies are underwhelming and do not commit to delivering anywhere near the hydrogen required to deliver the much needed industrial decarbonization."

Accenture Study Group Executive

Cost inhibitors and development

Although European industrials are making commitments, it is unclear whether these are substantial enough to truly stimulate the required progress necessary for a large-scale energy transition. The challenge that most industrials are battling is ascertaining where to invest their capital in cost-effectively decarbonizing, while still maximizing shareholder value.

Figure 12: Restrictive decarbonization costs today (2020)

	Marginal abatement cost:	EUR/tnCO_2
Steel	Gas-fired steel DRI/Midrex	5
	CCS new-build for Steel/TGR	144
	DRI EAF (grid electricity)	-3,633
	DRI EAF (PPA)	-3,523
	Steel recycling EAF (grid electricity)	111
	Steel recycling EAF (PPA)	-550
	Iron reduction -H2 based (in the iron blast furnace)	47
	Iron reduction with Biomass*	n.a.
Syngas	Catalytic steam reforming – optimized catalysts (digital/AI)	-68
	Dry reforming of methane with CO_2 to CO-rich syngas*	n.a.
Hydrogen	Electrolysis to replace SMR (grid electricity)*	n.a.
	Electrolysis to replace SMR (PPA)	261
	SMR + CCS for blue hydrogen production	16
Methanol	Methanol with Electrolysis (grid electricity)	n.a.
	Methanol with Electrolysis (PPA)	n.a.
Olefins/ethylene	Steam crackers with E-furnace (grid electricity)	2,779
	Steam crackers with E-furnace (PPA)	452
	MTO Ethylene/propyl. via methanol from syngas*	n.a.
	MTO Ethylene/propyl. via methanol from electrolytic syngas*	n.a.
	MTO Ethylene/propyl. via methanol from electrolytic syngas (PPA)*	n.a.
Chlor-Alkali	Chlor-Alkali Electrolysis – PPA	-550
Cement	Clinker production (gas-fired, calcin. without CCS)	36
	Clinker production (gas-fired, calcin. with CCS)	110
	Clinker production efficiency	20
	Clinker-to-cement with electricity (grid) + material conversion efficiency	-1
	Clinker-to-cement with electricity (grid) + energy efficiency	-104
	Clinker-to-cement with electricity (PPA)	-554
	Cement-to-concrete injecting liquid CO_2*	n.a.

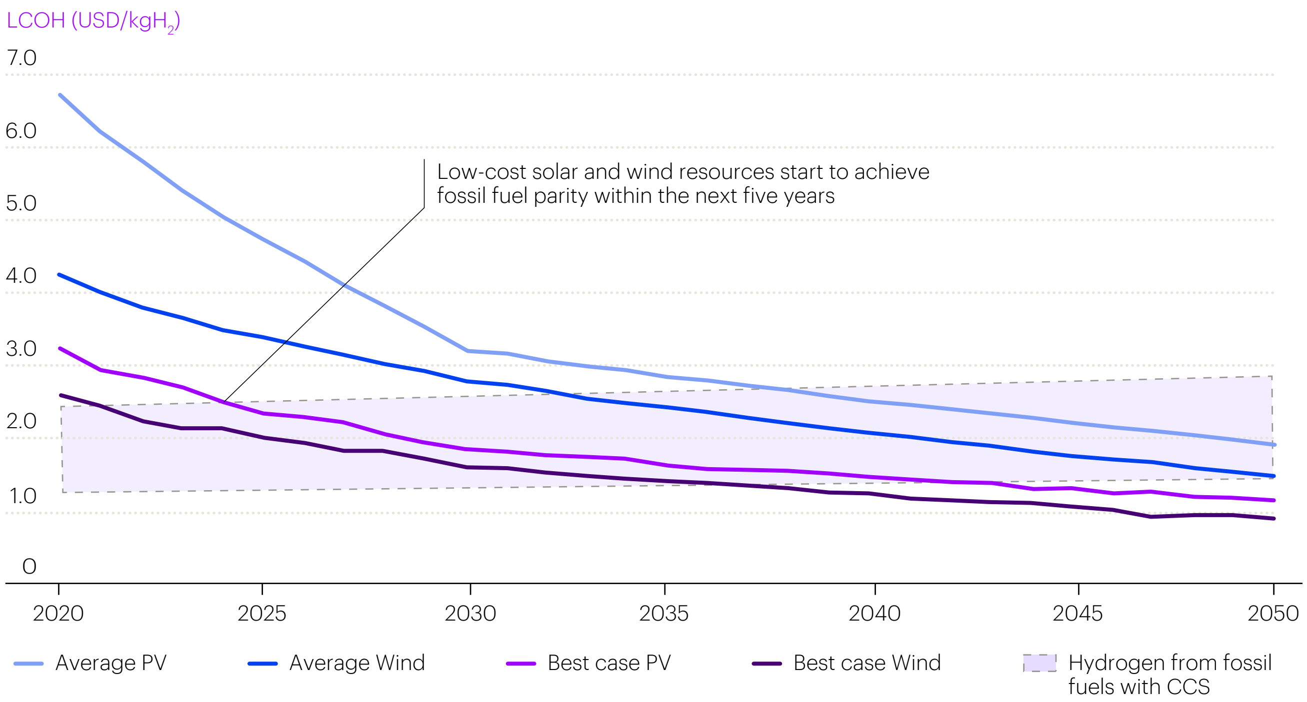
Source: Accenture Analysis

* No direct reduction of level 1 / level 2 CO_2 emissions

Important cost inhibitors currently still stand in the way of full industrialization of certain key technologies such as green hydrogen, although costs in that area are dramatically decreasing:

- Large, fossil-fuel-based investments at the beginning of their lifecycle have to pay off before green/renewable replacements can be found. For certain technologies—e.g., blast furnaces in steel manufacturing—conventional fuels can already be replaced partially by hydrogen to produce clean(er) steel and contribute to emissions reduction.
- The pace of efficiency gains achieved during the fourth energy transition is unparalleled: prices of wind power and PV have dropped significantly with PV prices falling 80 percent in the last 10 years alone. In 2015, wind power undercut coal for the first time and turbines have nearly tripled in power output since then (largest turbine in 2015: 5GW; largest in 2020: 14GW). Such investment opportunities should not be missed again as we continue the current energy transition into the hydrogen economy, e-fuels and energy storage.
- Projections show that the levelized cost of energy (LCOE) of hydrogen will drop by more than 60 percent over the next 10 years, making hydrogen use cases increasingly competitive versus incumbent solutions (See figure 13).

Figure 13: Hydrogen production costs from solar and wind vs. fossil fuels



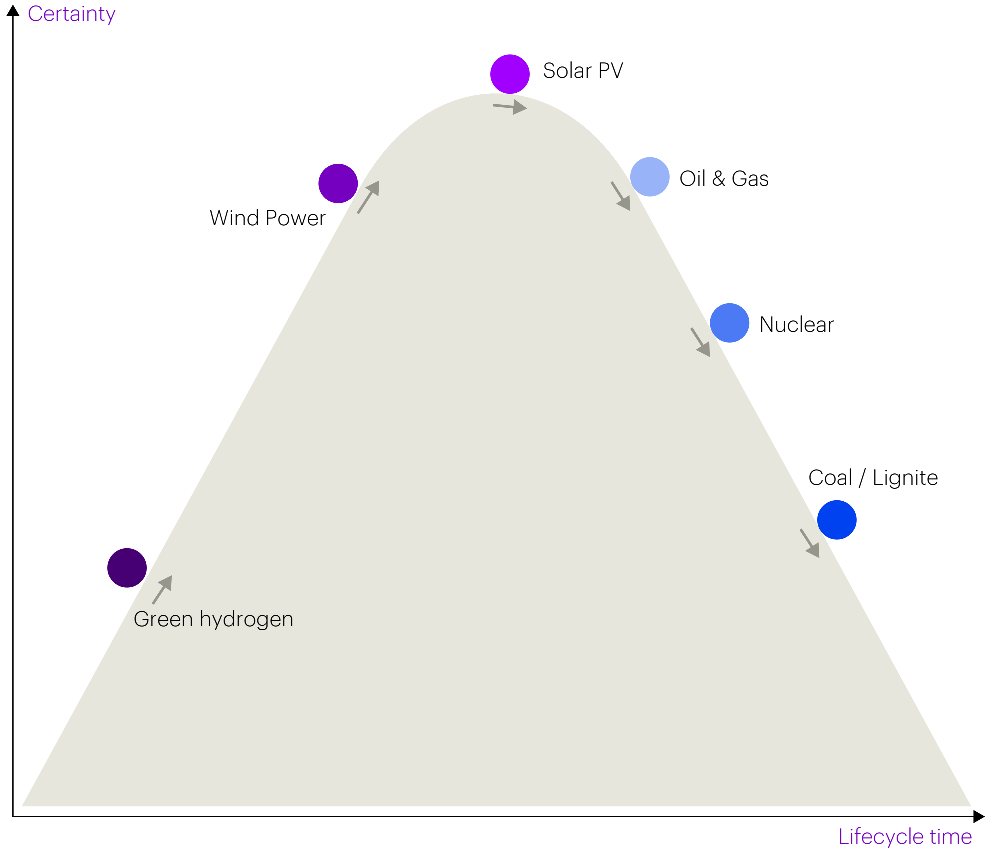
Note: Remaining CO_2 emissions are from fossil fuel hydrogen production with CCS.
Electrolyser costs: 770 USD/kW (2020), 540 USD/kW (2030), 435 USD/kW (2040) and 370 USD/kW (2050).
CO_2 prices: 50 USD/tn (2030), 100 USD/tn (2040) and 200 USD/tn (2050).

Source: IRENA

Uncertainty around technology development

Uncertainty around new technologies has always contributed to the phase-in and phase-out of energy sources. We can learn from previous energy transitions (e.g., from coal to oil) and show that changes in demand and consumption reduce uncertainty around technology and further accelerate learning curves around technologies. In the meantime, uncertainty around the future of coal is increasing, signaling its phase-out. Wind power and hydrogen are becoming established cornerstones in energy supply, and uncertainty around hydrogen should be lower with cost reduction projections on the horizon (See figure 14).

Figure 14: Illustrative uncertainty of energy sources through their lifecycle time



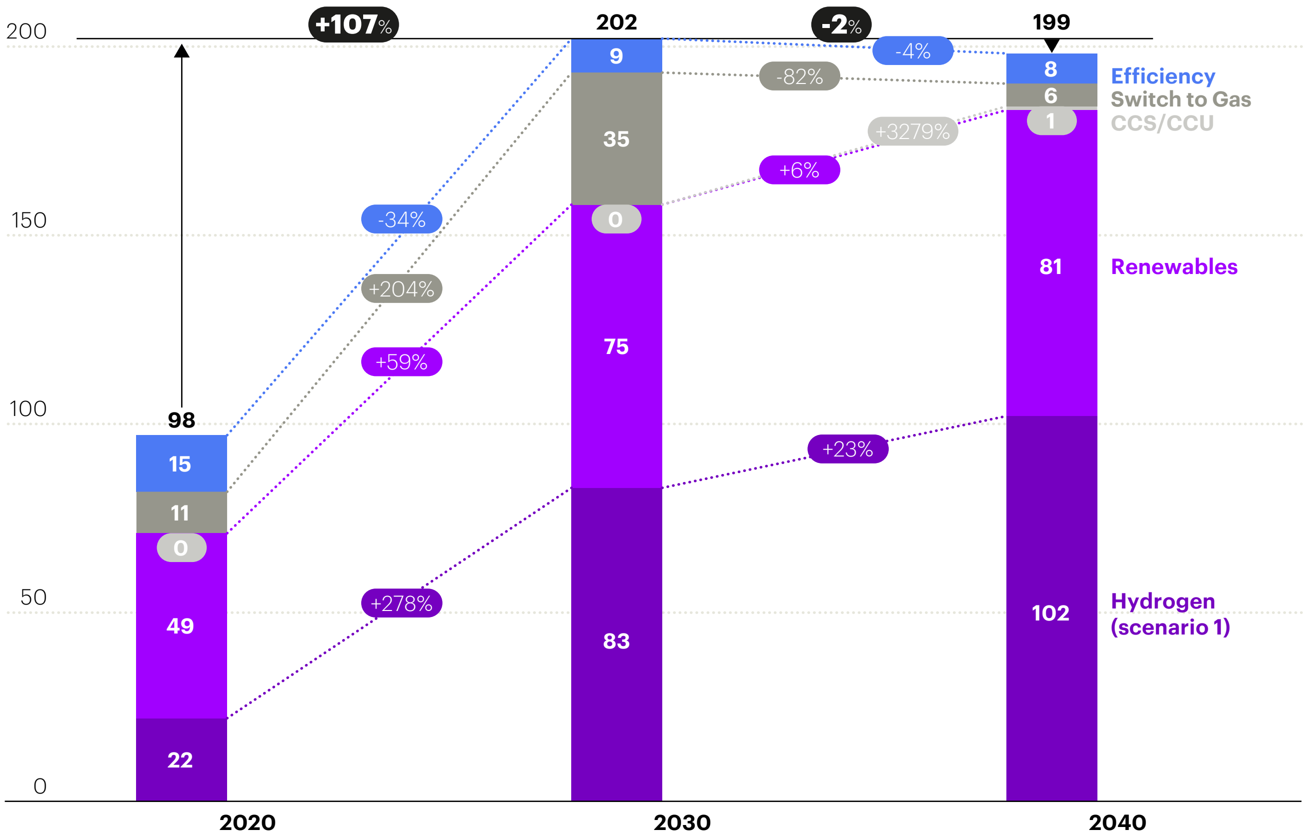
7. Significant value to be unlocked for European industrials by 2030

Massive value can be unlocked through decarbonizing the heavy industries in Europe.

Massive value can be unlocked through decarbonizing the heavy industries in Europe. Despite the uncertainty of future prices for CO_2 emissions and green electricity, Accenture analysis supports the position that, with most realistic scenarios, the annual net value of industrial decarbonization will nearly double between 2020 and 2030 (from €98bn to €202bn), and then stabilize by 2040 (See figure 15).

Figure 15: Total net value evolution by solution

Total net value evolution by solution (best in class*) in bn EUR



0 = N/A due to e.g. negative or very small initial value

*including best-in-class solutions with positive value only

Source: Accenture Analysis

Accenture's industrial decarbonization model

However, the value to be unlocked will strongly depend on what technology options are chosen to replace the incumbent solutions. To compare the different new technology options—each with its own pros and cons—Accenture developed an industrial decarbonization model quantifying the net value of each new technology option in comparison to the incumbent solution. The net value consists of multiple components:

- **Levelized added cost (EUR) of the new technology** compared with the incumbent solution (including annualized capex over the asset lifetime, as well as the annual costs for material/feedstock, O&M and energy/fuel costs).
- **Non-energy related CO_2 emission reduction** potential (tn CO_2) versus the incumbent solutions—e.g., emissions from production processes.
- **Energy-related CO_2 emission reduction** potential (tn CO_2) compared with the incumbent solution.
- **CO_2 price** (EUR/tn CO_2) from fuel combustion or CO_2 intensity of the generation mix behind the used electricity.

As a result, the total levelized cost increase or levelized cost savings (EUR) are compared with the avoided CO_2 costs (EUR), resulting either positive net value in a given year (e.g., the new technology is more valuable than the incumbent technology, suggesting a rationale to switch) or negative net value (the new technology is less valuable than the incumbent).

In the next step, we then ranked the new technology solutions by their net value for each of the individual incumbent solutions and selected the "best in class" by case. Finally, the best-in-class solutions were aggregated into a mutually exclusive annual total net value across the industries to depict the total value at stake.

Different scenarios depicting total net value are based on two key scenario variables:

- CO_2 price: varying between 35 and 50 EUR/tn CO_2
- Green electricity price: wholesale electricity price from wind or solar, varying between 15 and 30 EUR/MWh Best-in-class technologies

Methodology details

Accenture's decarbonization value modeling, based on more than 3,000 input datapoints, analyzes the cost reduction potential from applying new energy technologies in selected heavy industrial sectors in Europe. The model addresses expected changes in industrial sector supply and demand (tons of steel, cement and chemicals; tkm of industrial road freight; m^2 of building heating) and the impacts in energy consumption (coal, oil, gas, heat, electricity) while comparing selected technology solutions (e.g., hydrogen-powered iron reduction) based on the production costs, energy costs and emission costs to estimate the most attractive alternative to incumbent energy technologies (e.g., coal-fired steel production).

Best-in-class technologies

To better understand the emerging trends, Accenture then categorized the best-in-class technologies with similar characteristics, moving ahead in two steps.

Step 1: "No regrets" solutions

Today's leading solutions in industrial decarbonization, with proven financial value in multiple sectors, will continue to play a major role over the next decade.

Efficiency: Midsize and maturing.
Efficiency improvements in industrial processes can make an impressive difference in both costs and emission reductions, but are likely to reach limits in the long term, with the processes starting to reach an optimized level of efficiency. Continued focus on increasing interoperability between industrial processes and collaboration across internal functions will facilitate further unlocking of value.*

Switch to gas: Valuable but stagnating.
The move to natural gas from more carbon-intensive technologies is especially prominent in power generation (from coal-fired to modern gas-fired baseload generation) and steel production (gas-fired facilities using, e.g., Midrex technology provide competitive options especially with potentially increasing CO_2 prices. However as a fossil fuel, natural gas may not see long-term growth in comparison to zero-carbon solutions, which enjoy the advantage of decreasing technology costs while being decoupled from the increasing CO_2 prices.

Definitions of solutions

- **Efficiency:** reducing consumption (e.g., energy or materials).
- **Switch to gas:** for example, replacing coal, oil or petrol with natural gas (as material or feedstock).
- **CCU/CCS:** capturing and storing CO_2 emissions underground, or using them as feedstock for materials.
- **Basic electrification without decarbonisation**: replacing industrial processes requiring physical combustion of fossil fuel (e.g., coal, natural gas or oil) with processes using electricity from the grid based on the average power generation mix.
- **Renewable power:** electrification using electricity from renewable sources (e.g., wind or solar through PPAs), or replacing average grid electricity with electricity from renewable sources for existing electrified processes
- **Hydrogen:** Replacing industrial fossil-fuel feedstock (e.g., oil with hydrogen), or replacing fossil-fuel-based hydrogen production processes with green electrolysis based on renewable energy sources.

* Together Makes Better – How To Drive Cross-Function Collaboration" (Accenture Industry X.0, 2019/2020)

Step 2: "Next-frontier disruption" solutions

Emerging technologies which have mostly not yet reached their break-even point of financial attractiveness depending on multiple factors including CO_2 prices and energy prices.

Carbon capture and utilization (CCU) and carbon capture and storage (CCS): Selective technology.
Reaching positive net value by 2030, carbon capture utilities and -storage are losing in competitive advantage in multiple industries to renewable power and hydrogen when considering both cost and emissions reduction advantage. However, relevance remains in selected areas such as cement clinker production where an integrated CCS facility not only captures carbon from the fuel combustion but also in the calcination process.

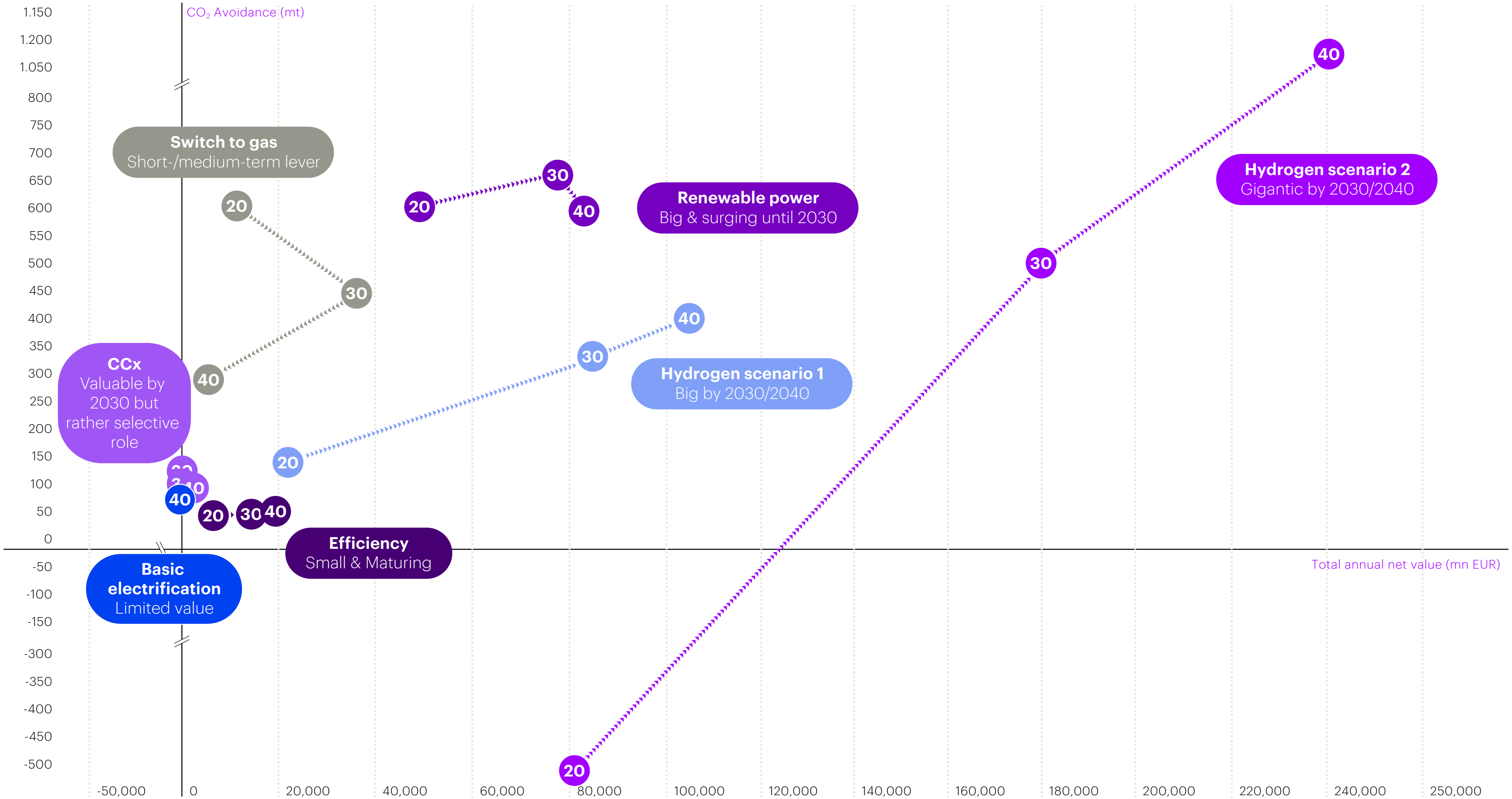
Basic electrification without decarbonisation – Limited Net Value.
Simply electrifying processes may reduce the direct fossil-fuel combustion, but will ultimately increase emissions without a shift to renewable power (given share and CO_2 intensity of fossil fuels within the current energy-source mix). Especially in higher process heat use-cases, the total avoided final CO_2 costs may not justify the switch to relatively cost-intensive electrification only – but will require a direct switch to fully renewable electrification (see next solutions).

Renewable power: Big and maturing.
There is significant potential, because of sheer scale, for renewable power (Basic electrification without decarbonisation + renewable power supply) to replace fossil-fuel-powered processes with zero-carbon electricity—including also those using CCU/CCS—providing in the future both absolute cost advantage and emissions reduction.

Hydrogen: The next big thing.
In industrial operations alone, the move to hydrogen presents a major opportunity, with potential scale of CO_2 reduction similar to switching to gas by 2040, while providing more value in the market. In an extended hydrogen scenario 2, including non-industrial buildings replacing 10 percent of the natural gas-based heating needs with hydrogen by 2030 to 2040, both value and CO_2 reduction potential are huge.

By comparing the solutions over the timeframe of 2020 to 2040 for both their net value and their potential CO_2 emission reduction, we observed multiple patterns for scaling and growth (See figure 16).

Figure 16: Overview by solutions (best in class)



Notes:
Hydrogen scenarios:
Scenario 1: building heating only including industrial sector (CO_2 savings from replacing natural gas)
Scenario 2: building heating also including residential and commercial sectors
Only best in class technology alternatives (to remain MECE), including positive business cases only

Source: Accenture Analysis

Winning technologies

Looking into the best-in-class solutions by industrial process in more detail sheds light on the actual technologies behind these (See figures 18/19.) Checking the most likely winning technologies for 2030 by industrial processes, the dominant solution "renewable power" demonstrates the high value of low-cost, zero-emission wind and solar energy.

- **Switching the source of electricity** in already electrified industrial processes from traditional average grid electricity into zero-carbon electricity is particularly attractive. These processes include steel manufacturing (Electric Arc Furnace, or EAF) used in areas such as direct reduction iron (DRI) and steel recycling, supplied by a power purchase agreement (PPA) with wind- or solar-park operators. The switch is also possible for chlor-alkali electrolysis, where the current process is still largely based on electricity from the average power generation mix.
- **A full green electrification** through a leapfrog from fully non-electrified processes to electrification of processes with green power may mean no major disadvantage in net value—for example, replacing incumbent gas-/oil steam crackers for olefins production with a steam cracker with an e-furnace powered by green electricity.
- Finally, **greenifying power generation** itself plays a critical role in the move to renewable energy. While replacing the bulk of baseload coal generation will continue to require gas-fired power plants, a substantial part could be replaced by for instance offshore wind combined with battery storage. This could come with no financial disadvantage, considering the avoided costs of CO_2 emissions. Also, during most times of the year, traditional gas-fired peaker power plants can face stiff competition from offshore wind combined with local battery storage, driven by rapidly decreasing costs for these technologies.

A key winning technology area involves **green hydrogen**, which can unlock major business value by replacing steam methane reforming in the hydrogen production process itself, whilst unlocking reductions in energy and process-related CO_2 emissions for a range of applications, including:

- Heavy road transport of industrial goods is likely to profit from FCEV (fuel cell electric vehicle) technology by replacing diesel and natural gas with engines powered by hydrogen.
- Hydrogen for heating promises emissions reduction with hydrogen replacing part of natural gas used in heating industrial buildings alongside process heat.
- Also, in the iron reduction during steel manufacturing, H_2 can replace coal as the reducing agent, compared to the established coke/coal-based reduction blast furnace in the alternative route producing direct reduced iron (DRI).
- Finally, hydrogen provides an attractive long-term power storage option for large-scale renewables (thereby avoiding current production losses), reducing curtailment beyond what can be enabled by battery storage that is limited to just four to five hours.

In addition to generating value in each segment, decarbonization can also reduce the exposure to mostly imported fossil-fuel commodities by 35 percent (Coal, 81%; natural gas, 12%; oil, 100%).

Green hydrogen – a cornerstone of industrial decarbonization

Accenture's research shows, that all carbon-neutral strategies of heavy industrials are closely tied to green hydrogen.

Although the production of green hydrogen has historically been seen as a bottleneck, significant technical, commercial and regulatory progress is being made. At a recent European hydrogen event, the CEO of a world-leading electrolyser company made the comment that if people are still concerned about green hydrogen CAPEX costs, then they clearly need to update their financial models.

Through our work with green hydrogen players across the world, we would strongly agree. Commercial applications are rapidly emerging on the global stage, and many industrial-scale projects have been initiated in the past year, targeting significant scale in the next decade (See figure 17).

"Although we have never historically engaged in our own supply of commodities for our production, we are considering entering the hydrogen supply business, producing in low production cost countries (e.g., Africa/Middle East) for transport into Southern Europe."

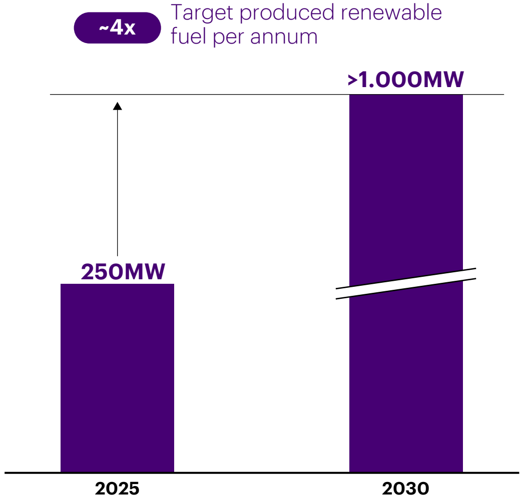
Accenture Study Group Executive

Figure 17: Examples of European green hydrogen projects significantly scaling over the next decade

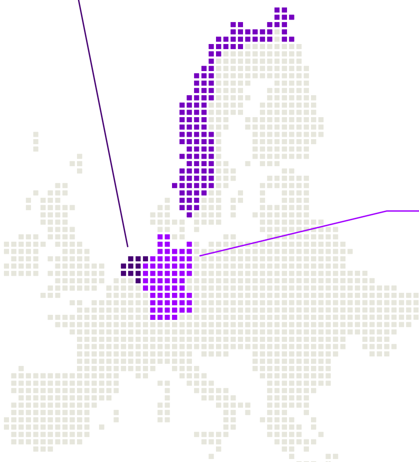
Port of Rotterdam

Several cross-industry partnerships/ initiatives focused on replacing the production of grey hydrogen at the Port of Rotterdam

Project #1 partners: Port of Rotterdam, TKI Energy & Industry. Others include Nouryon, Shell, Yara, OCI Nitrogen, Gasunie, DOW Chemical, Ørsted, Frames, ECN, the University of Utrecht and Imperial College London
Project #2 partners: Port of Rotterdam, Nouryon, BP



- Oil and gas producers and distributors
- Transmission & Distribution
- Electricity
- Cement
- Steel
- Chemicals
- Other industry
- Government
- Academia
- Renewable Energy

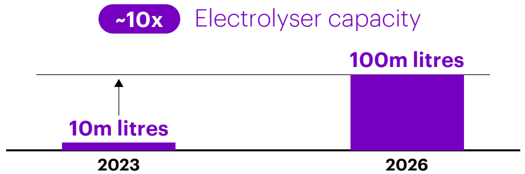


Norsk e-fuel

- Oil and gas producers and distributors
- Transmission & Distribution
- Electricity
- Cement
- Steel
- Chemicals
- Other industry
- Government
- Academia
- Renewable Energy

Europe's first commercial plant for hydrogen-based renewable aviation fuel

Project partners: Sunfire GmbH; Climeworks AG; Paul Wurth SA and Valinor

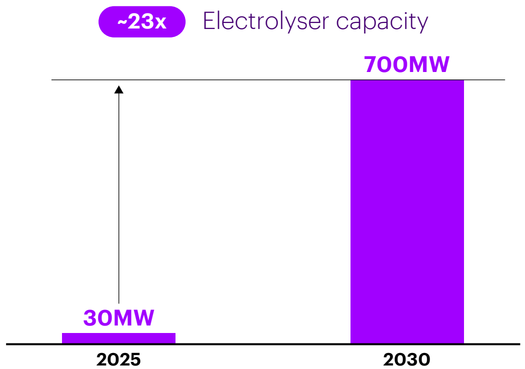


Westküste 100

- Oil and gas producers and distributors
- Transmission & Distribution
- Electricity
- Cement
- Steel
- Chemicals
- Other industry
- Government
- Academia
- Renewable Energy

Cross-industry partnership to develop the hydrogen economy on the west coast of Schleswig-Holstein in Germany

Project partners: EDF Germany, Holcim Germany, OGE, Ørsted, Raffinerie Heide, Stadtwerke Heide, thyssenkrupp Industrial Solutions, Thüga, Region Heide development agency and the Westküste University of Applied Science



Source: Company and project websites, press releases

Figure 18: Best-in-class alternative technologies, 2030

	Technology tradition	Technology alternative "winner"	Key lever	Emission reduction in mn tn CO_2	(%)	Marginal abatement cost (Eur/tnCO_2) Excl. avoided cost of CO_2	Net value (bnEUR) Incl. avoided cost of CO_2 (Eur/tn CO_2)
Transport	Industry ICE road heavy duty (diesel)	Industry FCEV/hydrogen fueled road heavy duty	Hydrogen	77	100%	-743	61
Power	Coal-fired generation – existing	Gas-fired baseload generation – new	Switch to Gas	365	60%	-36	31
	Coal-fired gen. – existing (replaceable by offshorewind + battey	Wind offshore + battery storage to replace part of coal	Renewable power	445	100%	-7	25
	Coal-fired gen. – existing (replaceable by utility-scale solar + battey)	Solar utility-scale + battery storage to replace part of coal	Renewable power	159	100%	26	4
	Gas-fired baseload generation – existing	Wind onshore gen. (no storage) to replace gas	Renewable power	161	100%	-58	17
	Gas fired peaker generation	Wind offshore gen. + battery storage	Renewable power	18	100%	-476	10
	Gas fired peaker generation (seasonal storage needs)	Wind offshore gen. + hydrogen storage (seasonal storage use only)	Hydrogen	0	100%	-326	0
Building heating and lighting	Industry building heating with gas/process heat	Industry building heating recovery in ventilation/aircon	Efficiency	37	25%	-82	5
	Industry building heating with gas after best efficiency	Industry building heating with gas +10% H_2 incl. best efficiency	Hydrogen	15	10%	69	0
	Industry building lighting – power conventional	Industry building lighting – modernized	Efficiency	0	15%	-713	0
Steel	Coal-fired steel production (BFO)	Gas-fired steel DRI/Midrex	Switch to Gas	84	60%	5	3
	Steel production from iron (BOF)	DRI EAF (PPA)	Renewable power	2	21%	-3523	6
	Steel production before efficiency	DRI EAF (PPA+ efficiency)	Efficiency	0	0%	0	0
	Coal-fired steel recycling	Steel recycling EAF (grid electricity)	Renewable power	90	96%	121	-6
	Steel recycling EAF (grid electricity)	Steel recycling EAF(PPA)	Renewable power	5	47%	-550	3
	Coal-fired steel DRI (coal reduced)	Iron reduction – H_2 based (in the iron blast furnace)	Hydrogen	54	52%	47	0
Chemicals	SMR – catalytic (syngas production)	Catalytic steam reforming – optimized catalysts (digital/AI)	Efficiency	30	15%	-68	4
	SMR – catalytic (hydrogen production)	Electrolysis to replace SMR (PPA)	Hydrogen	100	100%	-13 100	6
	Methanol production with Syngas + catalyst	Methanol with Electrolysis (PPA)	Hydrogen	0	0%	0	2
	Steam cracker – oil-fired (olefins)	Steam crackers with E-furnace	Renewable power	4	100%	452	-2
	Steam cracker – oil-fired (ethylene)	MTO Ethylene/propyl. via methanol from electrolytic syngas (PPA)	Hydrogen	0	100%	0	13
	Chlor-Alkali Electrolysis (grid electricity)	Chlor-Alkali Electrolysis – PPA	Renewable power	23	100%	-550	14
Cement	Clinker production without efficiency	Clinker production (coal-fired), calcin. with CCS)	CCU/CCS	109	69%	51	0
	Clinker production	Clinker production efficiency	Efficiency	0	1%	-467	0
	Clinker production	Clinker-to-cement with electricity (PPA)	Renewable power	4	100%	-554	2
	Cement-to-concrete traditional	Cement-to-concrete injecting liquid CO_2	CCU/CCS	1	27%	0	0

Key lever Renewable power · Efficiency · Hydrogen · Switch to Gas · CCU/CCS

TOTAL FOSSIL-FUEL DEPENDENCE
-35%

TOTAL VALUE AT STAKE
+202 bn EUR

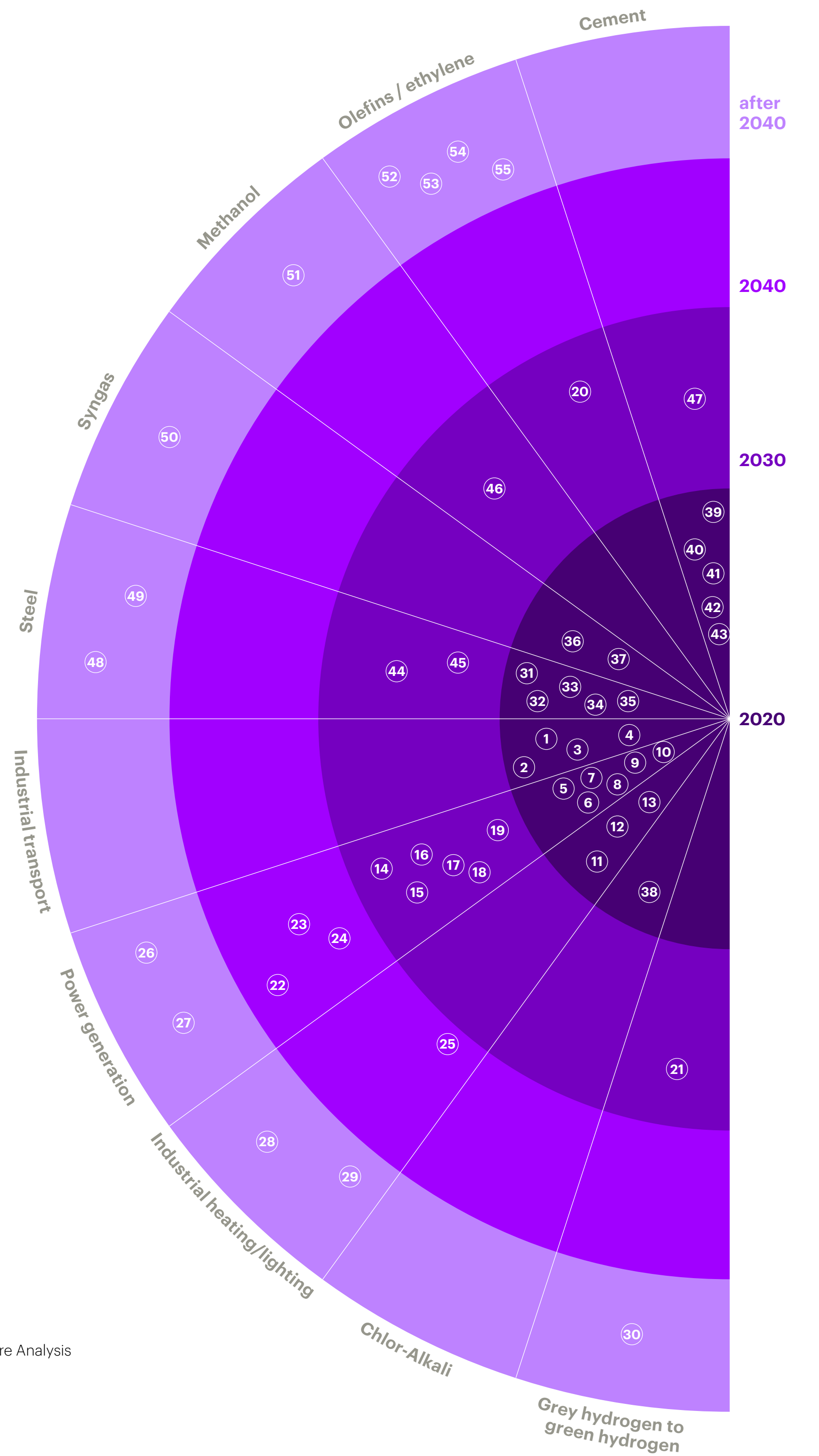
Source: Accenture Analysis

Figure 19: Tipping points by technology alternatives

Year in which net value of alternative technology exceeds incumbent technology

	Industrial transport
1	Ind. ICE road heavy-duty + efficient engines
2	Ind. ICE road heavy-duty + fleet optimization
3	Ind. NG-fueled road heavy duty (NGV)
4	Ind. FCEV/hydrogen-fueled road heavy duty
	Power generation
5	Gas-fired baseload generation – new
6	Gas-fired generation + efficiency
7	Wind onshore generation (no storage) to replace gas
8	Solar utility-scale generation (no storage) to replace gas
9	Wind offshore generation + battery storage
10	Solar utility-scale generation + battery storage
14	Coal-fired generation + CCS (retrofit)
15	Wind offshore + battery storage to replace part of coal
16	Solar utility-scale + battery storage to replace part of coal
17	Wind offshore generation (no storage) to replace gas
18	Wind offshore generation + hydrogen storage
19	Wind offshore generation + hydrogen storage (seasonal storage use only)
22	Biomass-fired generation
23	Gas-fired generation + CCS (new-build)
24	Gas-fired generation + CCS (retrofit)
26	Coal-fired generation + CCS (new-build)
27	Solar utility-scale generation + hydrogen storage
	Industrial heating/lighting
11	Ind. building heating with gas + efficiency
12	Ind. building heating recovery in ventilation/aircon
13	Ind. building lighting- modernized
25	Ind. building heating with gas + 10% H_2 incl best efficiency
28	Ind. building heating with power
29	Ind. building heating with distributed generation
	Chlor-Alkali
38	Chlor-Alkali Electrolysis – PPA

	Grey hydrogen to green hydrogen
21	Electrolysis to replace SMR (PPA)
30	Electrolysis to replace SMR (grid electricity)
	Steel
31	Gas-fired steel DRI / Midrex
32	DRI EAF (grid electricity)
33	DRI EAF (PPA)
34	DRI EAF (PPA+efficiency)
35	Steel recycling EAF (PPA)
44	CCS new-build for Steel / TGR
45	Iron reduction – H_2 based (in the iron blast furnace)
48	Steel recycling EAF (grid electricity)
49	Iron reduction with Biomass
	Syngas
36	Catalytic steam reforming – optimized catalysts (digital / AI)
37	Dry reforming of methane with CO_2 to CO-rich syngas
50	CoalGasification- Syngas green-electricity-fired
	Methanol
46	Methanol with Electrolysis (PPA)
51	Methanol with Electrolysis (grid electricity)
	Olefins / ethylene
20	MTO Ethylene / propyl. via methanol from electrolytic syngas (PPA)
52	Steam crackers with E-furnace (grid electricity)
53	Steam crackers with E-furnace (PPA)
54	MTO Ethylene/propyl. via methanol from syngas
55	MTO Ethylene/ propyl. via methanol from electrolytic syngas
	Cement
39	Clinker production (gas-fired, calcin. without CCS)
40	Clinker production efficiency
41	Clinker-to-cement with electricity (grid) + material conversion efficiency
42	Clinker-to-cement with electricity (PPA)
43	Cement-to-concrete injecting liquid CO_2
47	Clinker production (coal-fired, calcin. with CCS)



Based on Net Value considering levelised production and energy costs, and an assumed CO_2 price of 50 EUR/tnCO_2 for 2030 and 2040. Estimated averages for Europe, while likely variance between individual countries.

Source: Accenture Analysis

Sensitivity to external factors

Indeed, it is important to note that the overall net value of industrial decarbonization is sensitive to external market drivers. According to Accenture scenario modeling, a change in CO_2 emission prices has an overall strong proportional impact on the total net value. The net value is also highly sensitive to changes in oil prices and industrial production volumes while, on the other hand, price changes for natural gas do not seem to have an impact on the total net value in the same proportions. Further decreases vs. currently projected prices for green electricity also have only a minor impact, while higher-than-expected prices for green power will disproportionately influence the business case for green hydrogen production, and accordingly the overall net value associated with industrial decarbonization (See figure 20).

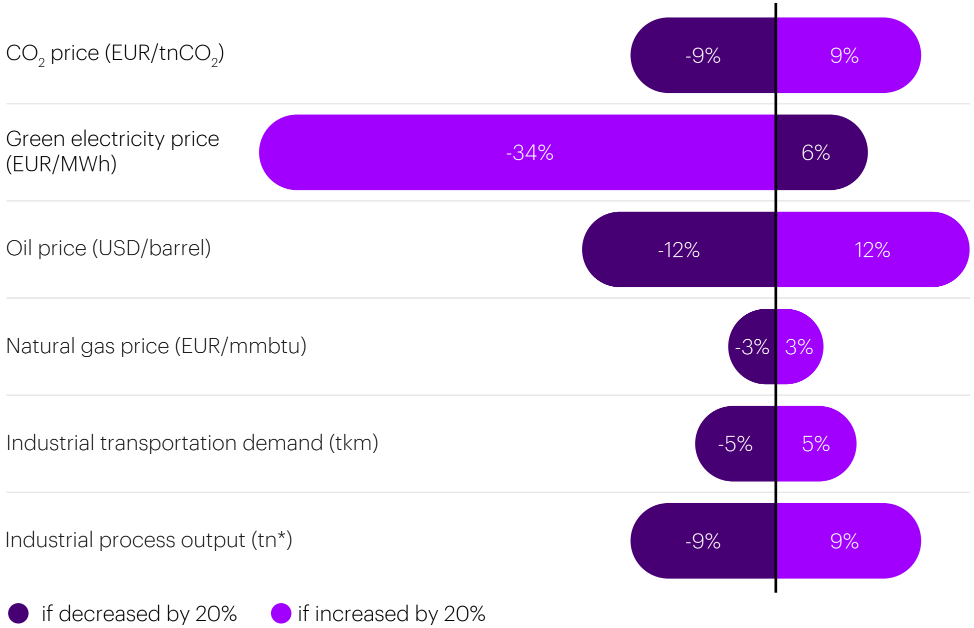
Demand-side decarbonization: The need for business model innovation

A fundamental drop in process output is one of the most effective levers for net value, indicating a significant role for demand-side decarbonization. This presents both a threat and an opportunity. Reducing demand is inherently cannibalizing current value pools. However, astute energy transition navigators recognize that managing the sensitivity of value calls for business model innovation in enabling the following:

- Expanded participation in the circular economy.
- Shift toward service-orientated business models where commercial models are not primarily driven by quantity consumed, but instead are also focused on helping customers drive efficiency and building an ecosystem of services around their products.
- Downward integration into activities of value for end-customers.

Figure 20: Sensitivity of decarbonization value to external factors

Impact on 2030 total Net Value (bn EUR impact) from 20% increase/decrease in selected factors



* steel/cement/chemicals production output, also affecting parts of power generation

Source: Accenture Analysis

8. Impact of industrial decarbonization on European industrials' supply chains

As we continue supporting our clients with industrial decarbonization and the broader energy transition, we will explore the implications across a variety of topics.

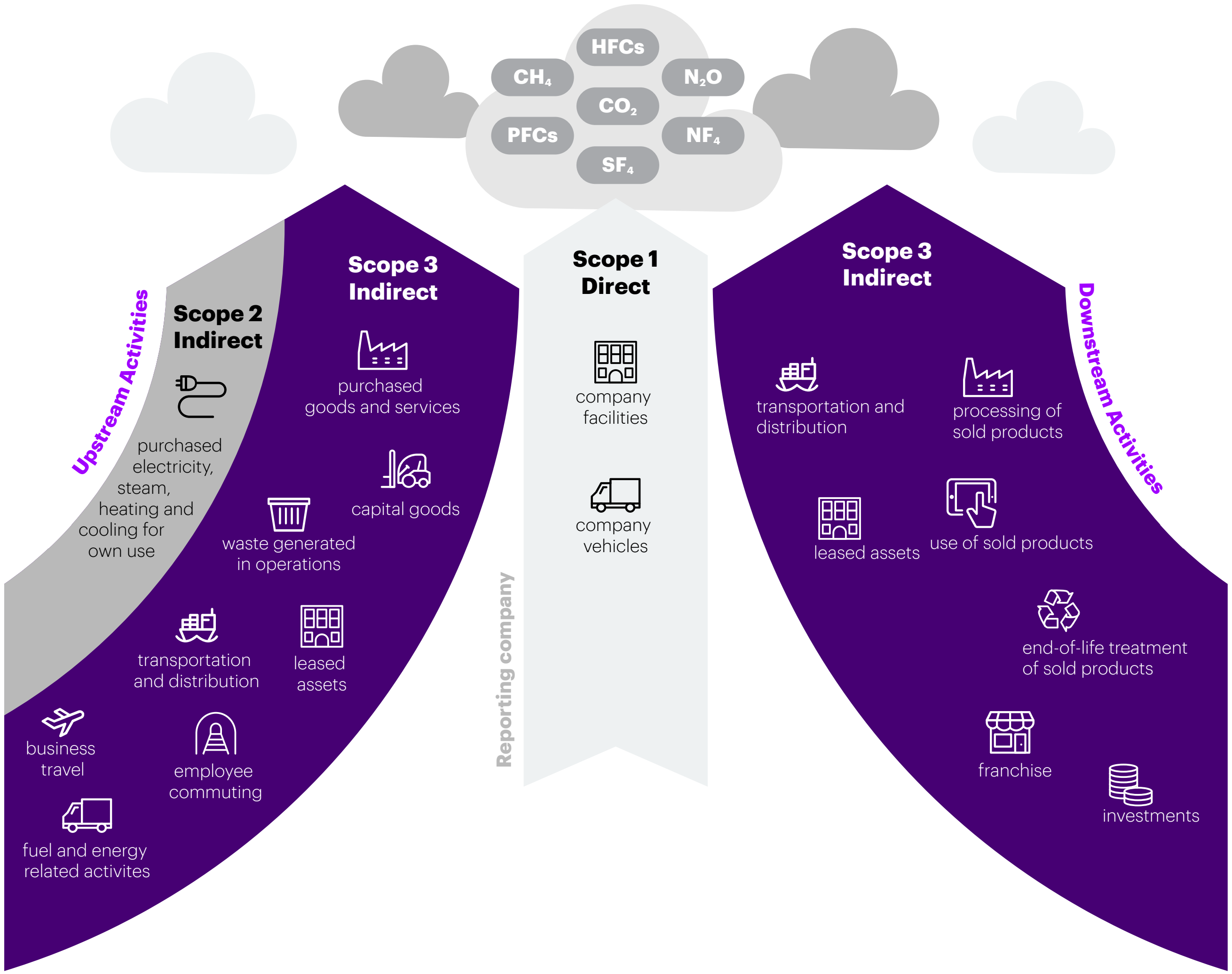
In a subsequent paper, we will explore the broader strategic implications across threats and opportunities, and what this means for the future of European industry's business models. We will do this based on our experiences and inside perspectives from discussions with industrial executives. As part of this first report, however, we will focus on the implications for supply chains and the implications of this initial modeling exercise.

Supply chain emissions are on average 5.5 times higher than a corporation's direct emissions (See figure 21).[14] Reducing this will be key to achieving a meaningful industrial decarbonization effort.

From our interviews of leading industrial executives, we identified two key decarbonization themes related to supply chains:

- Driving transparency around supply chain emissions
- Working with supply chains to reduce emissions

Figure 21: Overview of GHG protocol scopes and emissions across the value chain



Driving transparency around supply chain emissions

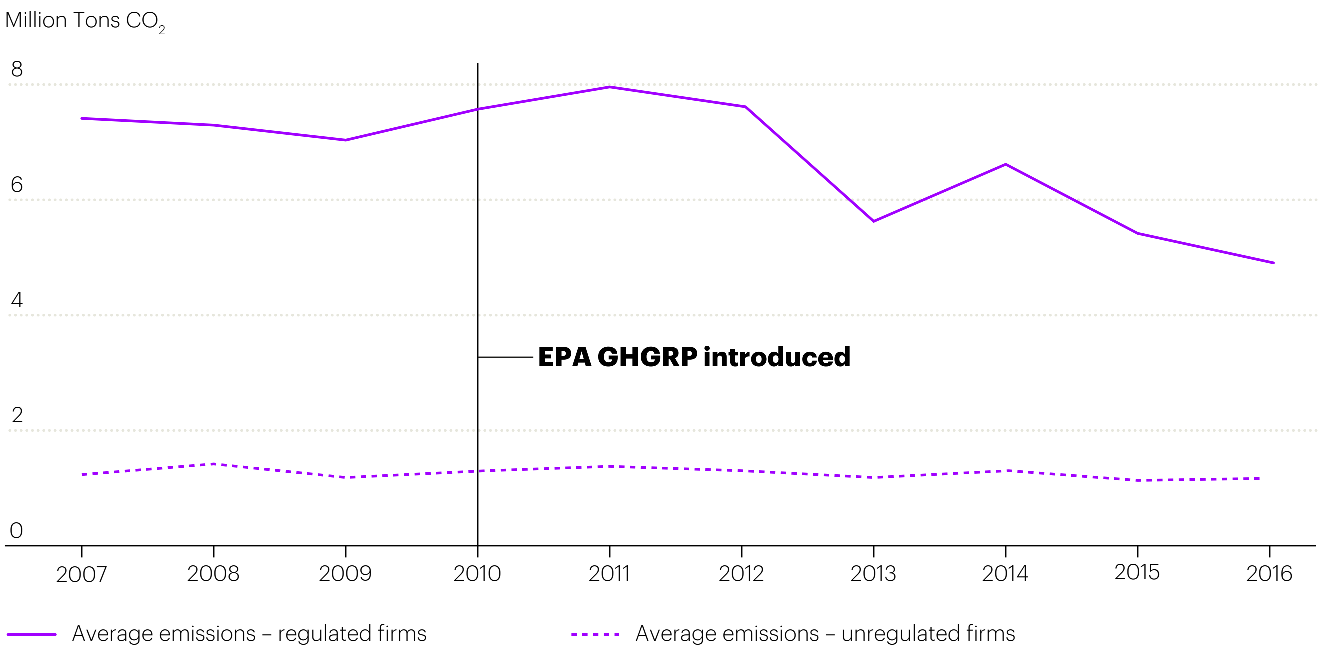
Currently, mandatory reporting requirements are limited, and focused only on scope 1 emissions, with no mandatory reporting of scope 2 and 3 emissions (See figure 22). Instead, companies may choose to voluntarily disclose such emissions.

As Peter Drucker once wrote, "If you can't measure it, you can't improve it." Mandatory emissions reporting has proven to be an effective measure for forcing emission measurement and, in reverse, providing the transparency to industrials about where to most effectively work on their emissions footprint. Consider, for example, the US's Environmental Protection Agency's GHGRP program, which mandated emissions reporting for carbon-intensive factories. As Figure 23 shows, the program led to a meaningful drop in emissions vs. unregulated firms.[16]

Figure 22: Overview of current European emissions reporting requirements

			Direct	Indirect	
Category	**Name**	**Industry**	**Scope 1**	**Scope 2**	**Scope 3**
Voluntary	CDP	All	•	•	optional
	TCFD	All	•	•	optional
Mandatory	EU ETS	Utilities, industry, aviation, etc.	•		
	Non-Financial Reporting Directive	All large public-interest companies with more than 500 FTE[15]	optional	optional	optional

Figure 23: Introduction of EPA GHGRP



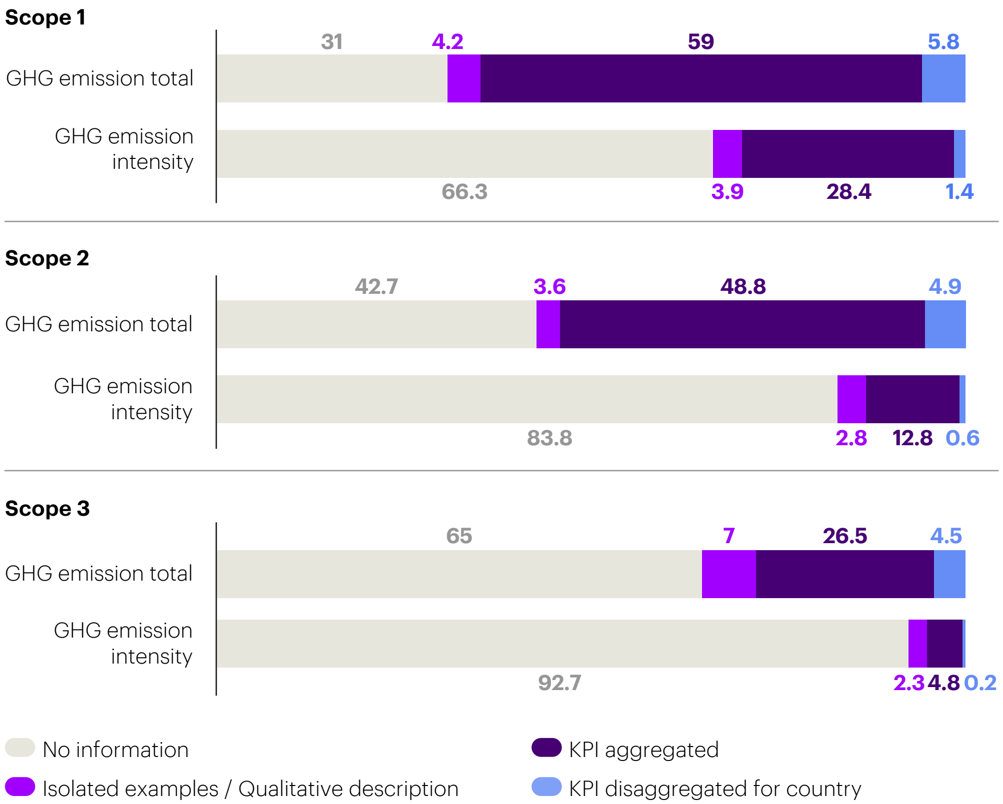
Although the EU has its Non-Financial Reporting Directive (NFRD), it too loosely defines reporting requirements in its current form. A European Securities and Market Authority study found that out of 1,000 EU companies, a third did not report GHG emissions (See figure 24).[17]

A consultation of the NFRD is underway. We believe that reporting of Scope 1-3 emissions must be mandated. From our conversations with industry, many executives are focused on significantly increasing visibility into their supply chain emissions over the next five years.

In delivering on this, Accenture sees a clear need to drive transparency and make emissions reporting easier in supporting:
- Transparency around progress of companies in decarbonizing their products/services relative to the rest of the industry.
- Development of carbon taxation and incentive systems that reward industrials actively pursuing decarbonization, both in terms of operations and supply chains.
- Companies' voluntary and/or mandatory disclosures across scope 1-3 emissions.
- Development and adoption of an admin-light European-wide carbon disclosure labelling initiative.

Current methods to calculate Scope 2 and Scope 3 emissions rely upon assumptions made using estimated data or relying on each company reporting their emissions in a consistent manner for the data to be useful.

Figure 24: Alliance for Corporate Transparency results on GHG emissions disclosure (in %)



A limiting factor is that this data is not maintained by any central authority or on any central repository. Today's supply chains are operating in the dark just as businesses, consumers and regulators are demanding greater oversight into supply chains—from ethically sourced goods to low-carbon products. Far greater information is sought to enable businesses and consumers to make informed choices about where they source their products.

Being able to store this data in a secure and auditable central repository—whilst simultaneously maintaining its openness for inspection by business, consumers and regulators—will be key to ensuring that the data contained within is used effectively to drive businesses forward to a lower-carbon future (See figure 25 on page 55).

Such a system would enable manufacturers to map end-to-end supply chain journeys to share with customers to demonstrate the origin, transportation and processing that has occurred for the end-product, as well as its associated carbon cost. Consumer-facing web or mobile applications can be created to allow customers to quickly and easily visualize the data on offer. This additional information unlocks new possibilities for manufacturers to market goods created from low-carbon supply chains as premium products in the market.

Conveying this data in an easy-to-understand format is key, and we strongly believe that efforts should be made to create a simple and universal carbon-labeling initiative that provides an at-a-glance view of the carbon produced, whilst minimizing the data collection and analysis efforts of each individual company.

Working with supply chains to reduce emissions

As industrials increasingly face pressure to reduce scope 3 emissions, industrials are working with their supply chains to reduce their carbon footprint. In driving a meaningful decarbonization, efforts must be accelerated, both across the existing supplier base, and for new suppliers.

New suppliers

New suppliers can be screened and incentivized appropriately using two key measures:

1. Supplier pre-qualification
In managing supplier risk, pre-qualification is a procurement norm. However, only a small number of supplier pre-qualifications adequately assess the carbon footprint of potential suppliers. We see a clear role for the adoption of the ISO 14020 series in helping suppliers signal a meaningful commitment to sustainability, in helping industrials manage their sustainability risk.

2. Appropriate commercial model with KPIs
We see it as important to establish a commercial model from the outset which incentivizes not only continuous cost improvement and innovation, but also penalizes suppliers who fail to reduce the carbon footprint associated with their product/service supply (per mutually agreed-upon scaling).

Existing suppliers

Although it is relatively easy to adjust vetting of new suppliers, partnering with existing suppliers to drive down Scope 3 emissions brings a unique set of challenges. Often there are long-term supply agreements, where driving down carbon emissions would not be mutually accepted without price renegotiation.

As and when supply agreements come up for renewal or renegotiation, we believe that companies will need to:

- Add in renegotiation triggers should CO_2 prices vary outside of a pre-defined range/scale.
- Incorporate carbon footprint as part of the negotiations, agreeing upon baseline and then an annual scope 3 CO_2 reduction target for the product that must be met.

Prior to this, we believe that government will need to play another meaningful, but temporary, role in correcting for the current market failure which enables companies to not internalize the cost of their carbon footprint. The form of this is clearly in the purview of policy makers, although our thoughts are that companies would be forced to report on their CO_2 emissions per unit of product/service, being incentivized to deliver reductions against this baseline over the subsequent three to five years.

The challenge will be that in certain industries, this incentivization will not be enough, requiring either cost absorption, or pass-through of cost to customers. In the buyers' value survey referenced earlier, consumers are willing to pay a slight premium for a low carbon footprint. We are a strong advocate of carbon product-labeling initiatives in supporting partial pass-through.

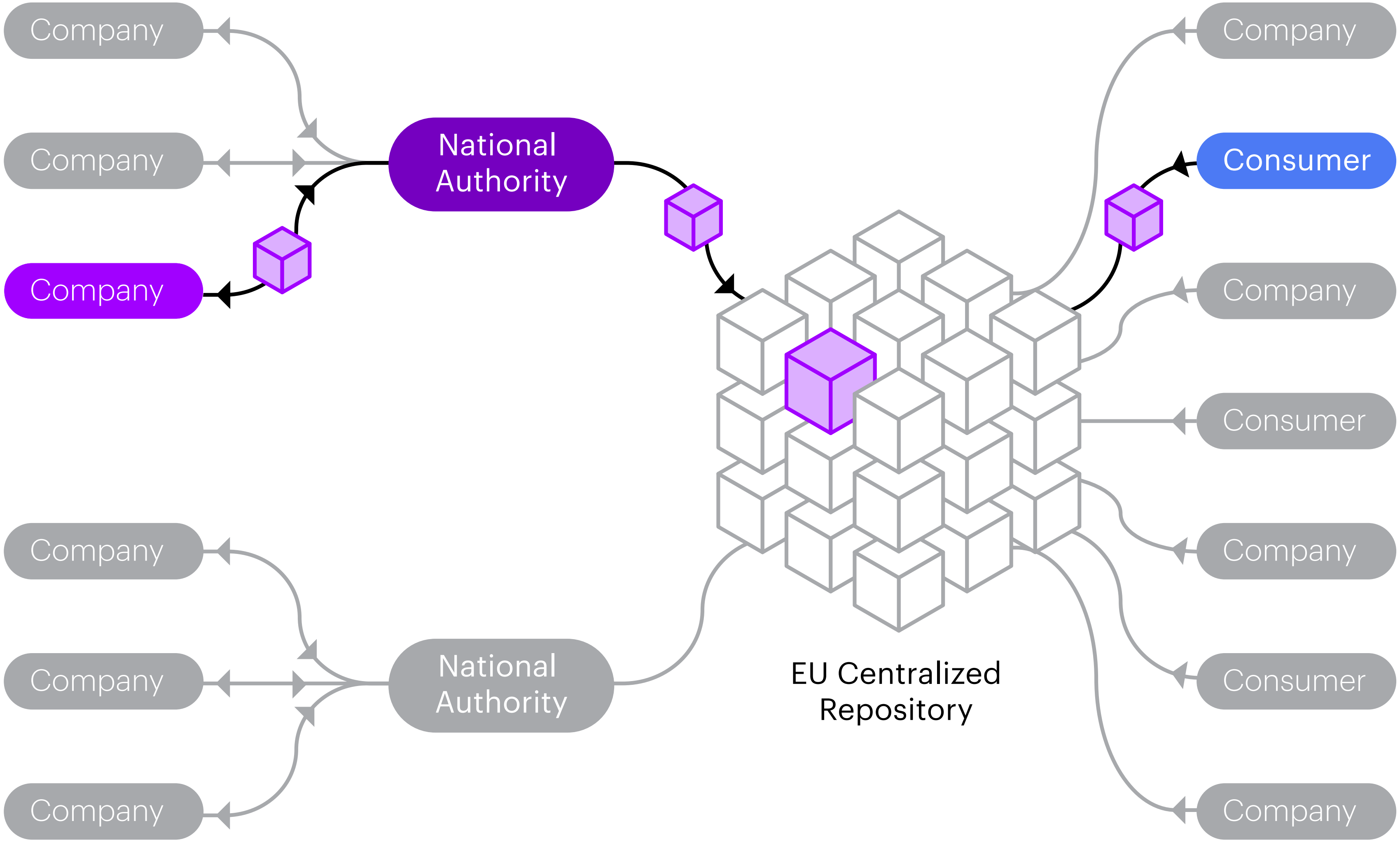
However, we also feel that efforts are currently too fragmented, leading to confusion and significant duplication of effort (failing to leverage economies of scale). Moreover, there are often complaints that the certifications criteria are being diluted, leading to increasing criticism of the value of obtaining certain certifications There are 231 European eco-labeling initiatives being tracked by Ecolabel Index as of October 2020.[18]

In addition to working with suppliers to decarbonize, we also predict an increase in the use of corporate carbon offsetting activities to simply offset supply chain emissions. Energy companies such as BP, Shell, and Eni have made significant commitments, with Shell investing about $300 million in forestry over the next three years. Shell sees this as not only a way to meet climate targets, but also as a new business opportunity.

"We believe that, over time, we will be building a business, because these carbon credits will become more valuable as carbon becomes more constrained."

Maarten Wetselaar, Shell's director of gas and new energy[19]

Figure 25: A potential blockchain-based ecosystem for total carbon management



9. Recommendations

In the previous chapters we looked at the impacts of decarbonization on European industrials, not only from a value perspective, but also from a supply chain point of view. In this chapter, we'll look at what companies can do in response.

As part of our discussions with executives for this paper, numerous executives commented that they are ready and able to drive change, but that they need political actors on the team who can create an environment for success.

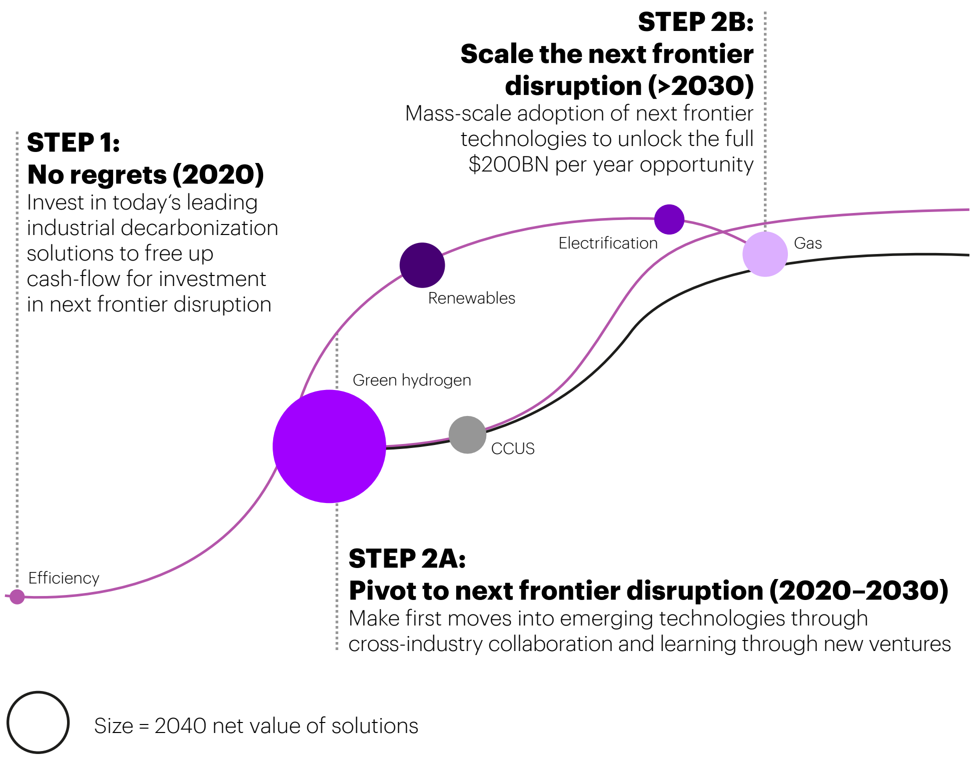
It will be important both for the leaders of industrials and for government leaders to be in sync on this complex transition and to support the transition with required predictability around future cost developments.

There is no simple or single solution to decarbonization. Innovation and collaboration between the sectors will be critical, along with a multi-faceted approach. Working in partnership, the sectors can deliver an accelerated—and value-generating—industrial decarbonization.

Actions to be taken by European industrials could include

1. Accelerate action: Take a step-wise approach and start taking immediate action today. Focus on driving efficiency within existing operations, whilst actively exploring new business models (See figure 26).

Figure 26: Accenture's step-wise industrial decarbonization approach



Source: Accenture Analysis

2. Adopt new technologies now: Many energy-intensive processes have technologies with lifecycles that will outlive the target years of climate neutrality aspired to by the European Union. To effectively decarbonize, companies must be adopting new technologies now as part of new CAPEX that offers long-term profitability (See figure 27).

3. Understand where you are compared to the rest of your industry: Start benchmarking against industry peers and leaders to identify areas for improvement.

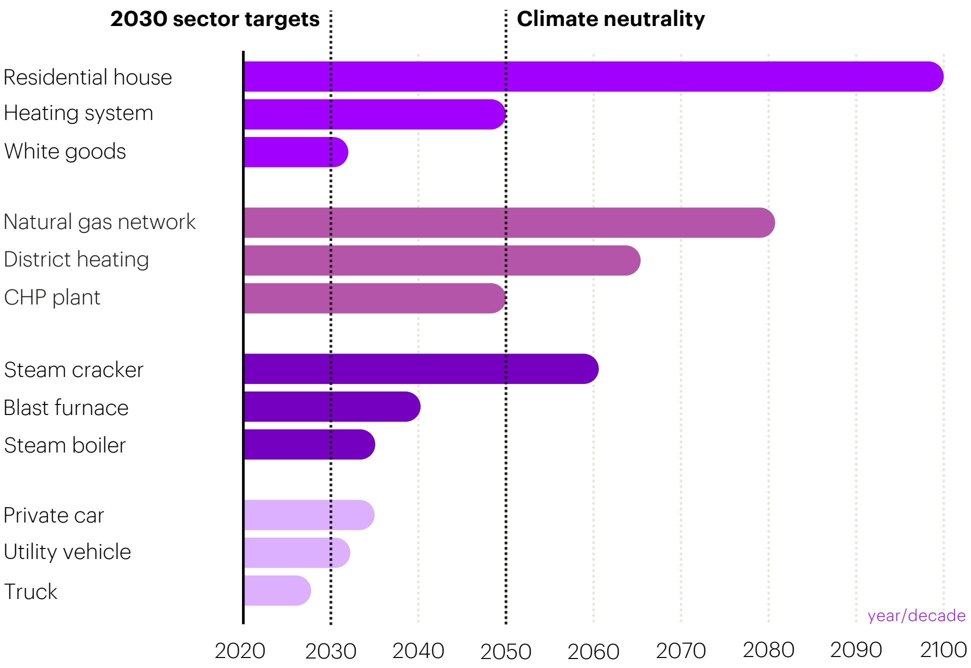
4. Adopt more expansive carbon pricing initiatives: Most companies already consider carbon pricing as part of major investment decisions. However, this is only the first concrete step. Companies will next face two paths, either (a) allocating carbon costs to departments/business units based on emission generation; or (b) implementing an internal carbon fee which is to be applied to the procurement of any products or services.

Regarding carbon fees, several key principles and considerations should be kept in mind:

- Revenues will be ring-fenced for a decarbonization investment fund. Also consider a potential allocation into some form of 'strategic supplier decarbonization fund' whereby select suppliers receive reimbursement for emission reductions.
- The carbon fee may be used as a basis for negotiations with suppliers. Regardless of the contract value decrease that may be negotiated, the full carbon fee must be passed through into the decarbonization investment fund.
- Such an initiative will need to be phased in over time because prospective suppliers will need to start calculating emission footprints for their products and/or services.
- In driving pressure for adoption across existing and prospective suppliers, cross-industry leaders should commit to adopting internal carbon fees along the same timelines

5. Pursue joint investments and alliances across the value chain: Cross-value chain alliances and investments can facilitate meaningful reduction of Scope 3 end-use emissions by aligning incentives across the value chain to co-develop innovative, multi-partner solutions

Figure 27: Operating lifetimes of individual goods and technologies built in 2020



Source: Agora Energiewende, 2020

6. Review and enhance supplier pre-qualification: Supplier prequalification and contracting approaches must be reviewed to ensure that everyone is working with a decarbonization-minded supply base interested in driving down their carbon footprint as part of the supply chain.

As and when supply agreements come up for renewal or renegotiation, companies will need to:

- Add in renegotiation triggers should CO_2 prices vary outside of a pre-defined range/scale.
- Incorporate carbon footprint as part of the negotiations, agreeing upon baseline and then an annual Scope 3 CO_2 reduction target for the product that must be met.

Many companies are committing to increasing their ESG supplier audits. Rather than focusing on conducting internal audits of their suppliers, we recommend cross-industry collaboration in developing public/private sector cross-industry signaling mechanisms to avoid having each company duplicate efforts. We recommend the development and adoption of a single European-wide carbon labeling initiative with a standardized audit process.

7. Self-disrupt and think beyond adjacencies: The sale of commodity products will start to give way to a climate-neutral, usage and service-based economy. Successful navigators will be those that realize the new business models emerging out of:

- Industry convergence—e.g., the provision of syngas and H_2 for further downstream utilization and energy storage.
- Digitization of value chains and deploying increasingly sophisticated analytical capabilities to further understand and monetize data.
- Demand-side management sometimes being the less expensive decarbonization measure than investing in supply-side decarbonization. Decarbonizing through a more demand-side driven approach requires a focus on helping customers design more efficient products, materials and buildings. Naturally, this risks cannibalizing your market. However, carefully crafted business models not only delight your customers and help them with their decarbonization journey, but also deliver higher margins.

8. Ensure appropriate governance in enabling value-accretive innovation: Successful players have established a strong innovative intrapreneurial culture and innovation governance, enabling them to pivot to new opportunities ahead of their industry peers.

9. Adopt a customer-centric mindset: In our work with industrials, we continue to be impressed by new product innovations. However, many European industrials are still yet to adopt a key thing – a true customer-centric mindset. We often see a focus first on the revenue and operations, with the customer as an after-thought. This must change so that customer insight drives the whole process based on conversations with real customers, understanding why customers behave in a certain way, rather than taking secondary research statistics at face value. Through this, it can be understood that the unresolved needs of customers that can be solved for, without being constrained by current research definitions or market offerings.

Public and private sector collaboration: A critical success factor in decarbonization

We have described a variety of actions that the private sector should consider on this journey toward decarbonization. For successful outcomes, the public sector's role is also critical. Without robust action from the public sector, industrials will be at competitive risk, given the twin burdens of necessary investments and the uncertainty of the pace and scope of technological innovation.

It will be important for governments and industrials to be in sync on this complex transition. At the core of the challenge: industrials need predictability on costs through thoughtful framework that will alleviate some of the transition costs and prevent "carbon leakage"—in which industrials leave the EU or lose business because the energy transition undermines their competitiveness in internationally traded goods.

Targeted public-sector intervention in the areas listed below could, on their own or in combination, help to accelerate industrial decarbonization:

- Implementing a framework that ensures companies are able to successfully internalize carbon's hidden cost;
- Designing policies that avoid penalizing first-movers;
- Setting a precise and robust carbon price mechanism with a significant base price[20], increasing predictably over time as a guide to technological innovation and investment;
- Establishing a framework for emissions reporting in all three scopes for all industries where company revenue and/or number of employees exceeds a certain threshold;
- Exploring a European product carbon-labeling standard, akin to that run by the Carbon Trust;
- Leveling the playing field through a carbon border tax to compensate against competing imports from outside the EU—that is, incorporating any hidden costs and thereby preventing carbon leakage;

- Evaluating the potential of quotas to increase the use of low-carbon cement and steel for construction and infrastructure projects, as well as to scale up chemical recycling and circular polymers;
- Stimulating the hydrogen economy on both the supply and demand side through a broad set of measures, including quotas and tax breaks;
- Consolidating and integrating national and regional funding mechanisms into a streamlined single application process.

We believe the private and public sectors, working collaboratively, can deliver an accelerated—and value-generating—industrial decarbonization

“There is a competitive advantage in Germany, where industrials pursue intertwined innovations across value chains (given physical proximity of industry). To take advantage of this, both German and European regulators need to take urgent action.”

Study Group Executive

“We see the US as a highly competitive country for green steel production. Unless European regulators take rapid action, we fear that Europe will lose its competitive advantage.”

Study Group Executive

10. Looking ahead

As we've advocated throughout this document, we see industrial decarbonization in Europe as a significant opportunity for both energy producers and industrial energy consumers. In this paper we have assessed the dynamics at play from a technology, investment and supply chain perspective.

The question of how industrials can seize upon this opportunity should be an item at the top of the CEO agenda. There has never been more public support—nor more urgency on the part of companies and governments—for an energy transition.

The time to act is now.

Appendix

Table 1: Industry study group

	Industry	Company
1	Cement	HeidelbergCement
2	Cement	LafargeHolcim
3	Chemicals	Air Liquide
4	Chemicals	Borealis
5	Chemicals	Covestro
6	Chemicals	Evonik
7	Chemicals	INEOS Group Holdings
8	Chemicals	Johnson Matthey
9	Chemicals	Linde AG
10	Chemicals	LyondellBasell Industries
11	Chemicals / Energy	BASF & Wintershall Dea
12	Energy	Royal Dutch Shell
13	Energy	BP
14	Energy	Eni
15	Energy	Equinor
16	Energy	OMV
17	Energy	Repsol
18	Energy	Total
19	Steel	ArcelorMittal
20	Steel	Norsk Hydro
21	Steel	Salzgitter AG
22	Steel	ThyssenKrupp
23	Steel	Voestalpine
24	Utilities	E.ON
25	Utilities	Electricité de France
26	Utilities	Enel
27	Utilities	Engie
28	Utilities	RWE
29	Utilities	Uniper
30	Utilities	Vattenfall AB

References

[1] Accenture assessed the implications of a carbon tax on European industries, estimating that a carbon-price floor of about 30 EUR/MT on European industrial emissions could be an effective starting point

[2] IEA (2020). Final energy consumption includes all energy used in end-use sectors. It excludes energy industries themselves as well as energy transformation. Industry sub-category includes all industry consumption excluding energy used for industrial transport or non-energy uses (e.g. in the chemical industry).

[3] https://www.proactiveinvestors.com/companies/news/923289/decarbonisation-trends-lead-deutsche-bank-to-downgrade-bhp-and-upgrade-rio-tinto-923289.html

[4] https://www.nytimes.com/2020/01/14/business/dealbook/larry-fink-blackrock-climate-change.html

[5] https://www.energy.eu/publications/a07.pdf

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN

[7] https://www.accenture.com/_acnmedia/PDF-138/Accenture-Chemical-Customers-Buy-More-Pay-More.pdf

[8] https://www.carbontrust.com/resources/product-carbon-footprint-labelling-consumer-research-2020

[9] https://russellinvestments.com/-/media/files/us/insights/institutions/governance/2019-annual-esg-manager-survey-results.pdf

[10] See Appendix Table 1: Industry study group for entire list of companies

[11] https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_24

[12] https://www.cleanenergywire.org/factsheets/germanys-national-hydrogen-strategy

[13] https://www.handelsblatt.com/politik/deutschland/energiewende-stromtrassen-verteilernetze-deutschlands-probleme-beim-netzausbau/20827146.html

[14] CDP, Global Supply Chain Report, 2019. https://www.cdp.net/en/research/global-reports/global-supply-chain-report-2019

[15] EU rules on non-financial reporting only apply to large public-interest companies with more than 500 employees. This covers approximately 6,000 large companies and groups across the EU, including listed companies, banks, insurance companies and other companies designated by national authorities as public-interest entities (https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/company-reporting/non-financial-reporting_en)

[16] https://www.diw.de/documents/dokumentenarchiv/17/diw_01.c.680028.de/sfrp_policybrief2_disclosure_en.pdf

[17] https://www.responsible-investor.com/articles/eu-enforcement-authority-exposes-the-short-comings-of-the-implementation-of-non-financial-reporting-regulation

[18] http://www.ecolabelindex.com/ecolabels/?st=region%2Ceurope. Retrieved 19th of October 2020

[19] https://www.shell.com/media/news-and-media-releases/2019/shell-invests-in-nature-to-tackle-co2-emissions.html

[20] Accenture assessed the implications of a carbon tax on European industries, estimating that a carbon-price floor of about 30 EUR/MT on European industrial emissions could be an effective starting point

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