Decarbonizing practices
in the global chemical industry

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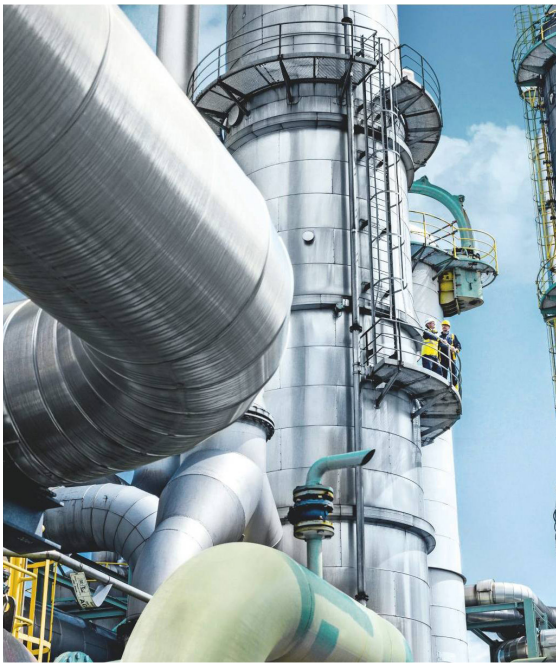
Contents

1 Foreword

This whitepaper examines the current state and trajectory of decarbonization within the global chemical industry. By examining and establishing a baseline on industry action, early, mid- and long-term initiatives can be highlighted to help inform manufacturers and producers in these industries how they can engage and push themselves further towards full decarbonization. This effort also highlights the challenges and complexities on the path towards decarbonization, which is complex and layered. Industrial producers should be looking to the outside to determine how to take best steps from within.

The whitepaper is a joint effort of Siemens AG and Frost and Sullivan.



2 Executive summary

The global chemical industry is a major source of carbon emissions and faces challenges of gaining wide buy-in within a fragmented landscape. However, leading industry organizations have taken critical early steps to decarbonize their footprints. Sustainable feedstocks, heat pumps, electrification, enhanced energy efficiency, and green energy power purchases represent impactful actions that drive decarbonization efforts.

In order to achieve ambitious targets of climate-neutrality, however, even more aggressive efforts are required. Chemicals manufacturers have key processes and solutions available to them, including decarbonization roadmapping, energy consumption optimization, energy infrastructure and supply modernization, and service-based business models. Creating an individualized decarbonization plan per facility or manufacturer and leveraging these key processes is central to a carbon-free, sustainable future for the global chemical industry.

3 Facing the energy transition

The world faces an ever-widening gap between current levels of greenhouse gas emissions and the reduction in levels that must be met in order to mitigate the worst impacts of global climate change. As documented by the United Nation's Emissions Gap Report 2021, the world is currently on track to reach an average temperature rise of 2.7°C, well over the target of 1.5°C. In a globalized, predominantly capitalist economy, the incentives for sustainable growth and profit are often at odds with environmental sustainability.

Fundamentally, however, it is increasingly seen that sustainable economies are reliant on a sustainable environment; industries need raw materials, customers, workers, and transportation and logistics infrastructure that require sustainable and reliable physical and natural environments. The importance of industrial decarbonization to long-term sustainability is well established, and leading organizations are taking bold approaches to improving and reimagining business practices.

Sustainabiity, digitalization, health and wellness, and business models are the four underlying factors for future transformation. Influencing the four models will be the need to build resilience and lower the financial risk for customers.

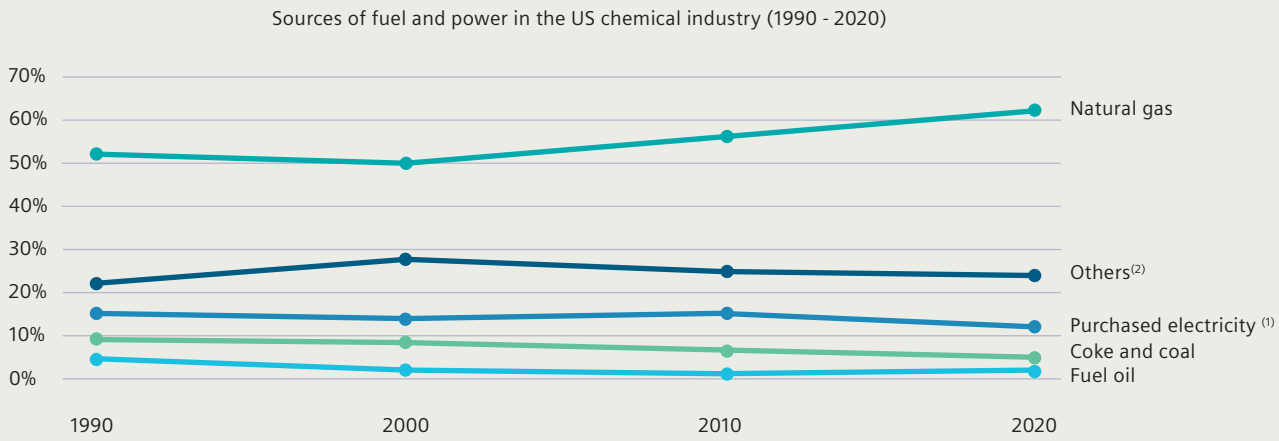
What	Sustainability	+	Digitalization	+	Health and Wellness	+	Business Models
Why	• Emphasis on clean and efficient models of energy usage • Emphasis on reuse, repurpose, and recycling of materials		• Unlock value from siloed information • Better performance, better outcomes, reduced downtime		• Integration of health and wellness with smart building solutions • Improve occupants' safety and productivity		• Better ways of realizing outcomes • Explore added capabilities • Transform current models of operation
How	Decarbonization		AI and ML		Health building certifications		XaaS (Anything-as-a-Service)
	Energy efficiency		Cloud and cybersecurity		Facility management		Outcome-linked models
	Circular economy		Robotics and drones		Compliance monitoring		Shared economy
Influencers	Market policies		Competition		Collaboration		Innovation		Risk mitigation

Figure 1: Key market forces of changes

Current status of decarbonization strategies

Decarbonization strategies within the global chemical industry remains at an early stage overall. Much needs to be done in order to fully achieve decarbonization in regards to Scope 1, 2, and 3 emissions. The global chemical industry is highly fragmented within individual producers and by the actual chemicals produced. At a local level, however, there are efforts to improve energy consumption trends from capturing waste heat to increasing onsite power generation and the use of renewables.

1. Purchased electricity has a stable share of energy demand in the industry



1. Purchased electricity, historically stable at 14 to 15% dipped slightly to 13% in 2022.

2. Others is assumed to include electricity generated in-house, but ACC does not separate that out.

2. Downstream benefits are said to outweigh energy consumption

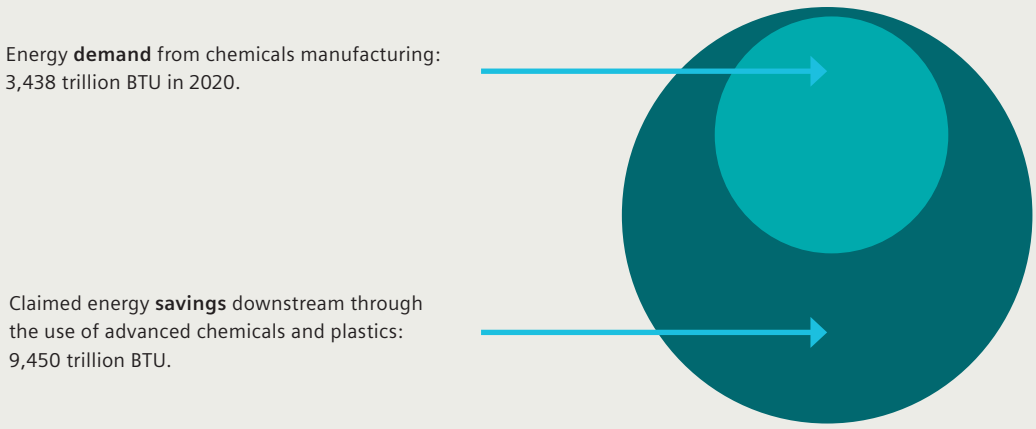


Figure 2: Energy use in the US chemical industry

Actions to further and achieve industrial decarbonization can be summarized through four key initiatives:

- **Decarbonization roadmap:** foundational assessments and action
- **Resource efficiency:** improve energy consumption efficiency and develop circular economies
- **Infrastructure enhancement:** improve assets and infrastructure
- **Innovative business Mmodels:** advanced performance contracting

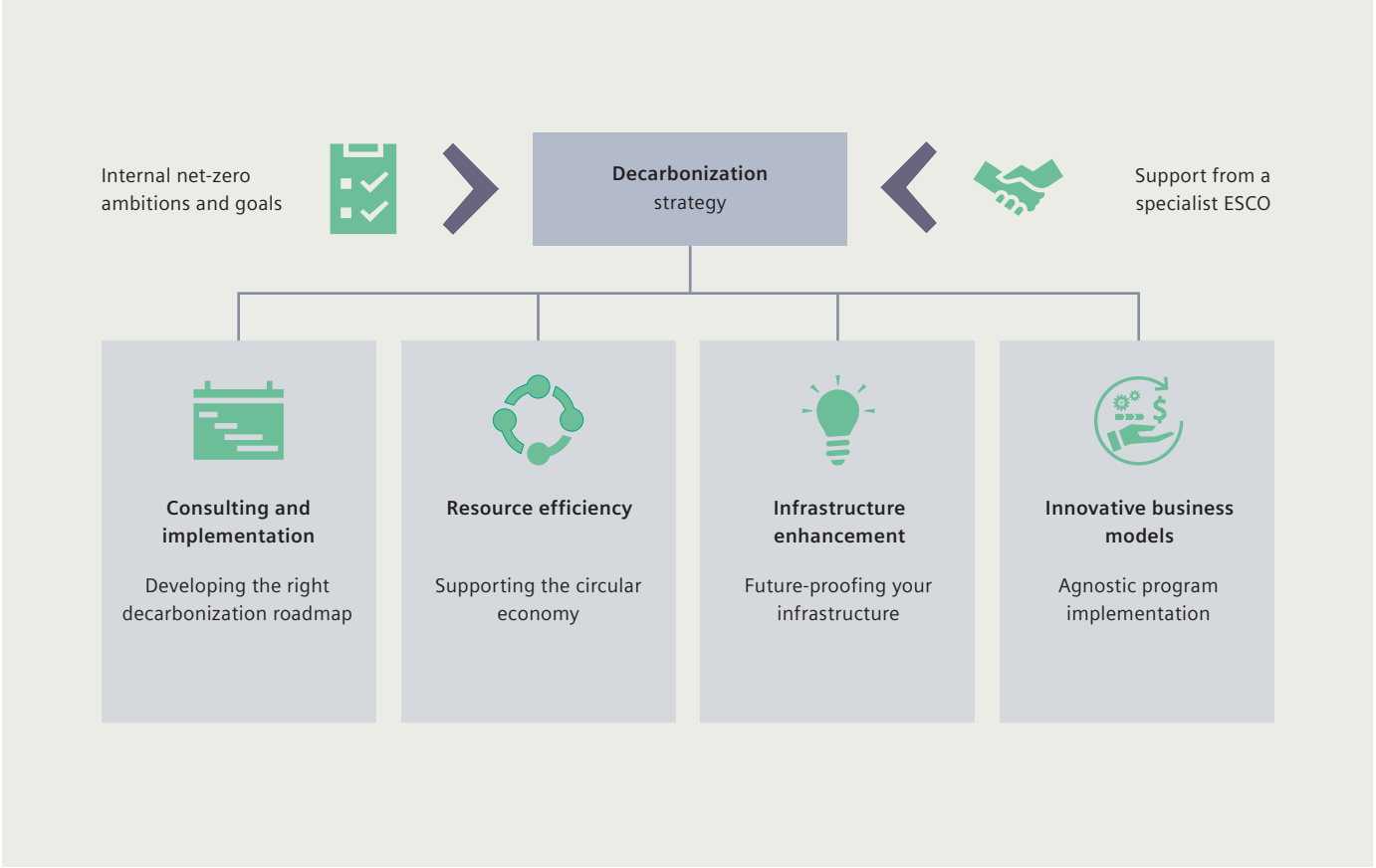


Figure 3: Developing your decarbonization strategy

Every organization will need to adopt a range of measures within each initiative to deliver an effective, holistic means of achieving decarbonization. The specific set of activities, timeline of implementation, and means of verification will be unique; in many cases, industrial organizations and facilities will benefit from third-party assistance to ensure strategies are comprehensive and achievable.

This whitepaper is a step towards understanding the current landscape of decarbonization to help speed up action for all stakeholders.

Decarbonization actions for the chemical industry

The global chemical industry is the world's largest consumer of oil and gas, making it one of the greatest sources of direct carbon dioxide emissions, behind only steel and cement industries (International Energy Agency). The chemical industry, therefore, must be a critical partner in global decarbonization efforts; this is relevant for direct industry practices and for chemical emissions released downstream. Stakeholders in the industry do have a number of key decarbonization actions available:

- **Heat pumps –** leverage heat pump technology to capture heat waste and use it as energy in production facilities;
- **Electrification –** electricity can be used to create heat, displacing fossil fuels, and to generate electrochemical reactions, and;
- **Power purchase agreements (PPAs) –** these agreements can help ensure the generation and use of renewable energy.
- **Sustainable feedstock –** a wide range of plastics can be used as non-virgin feedstock in chemicals production.

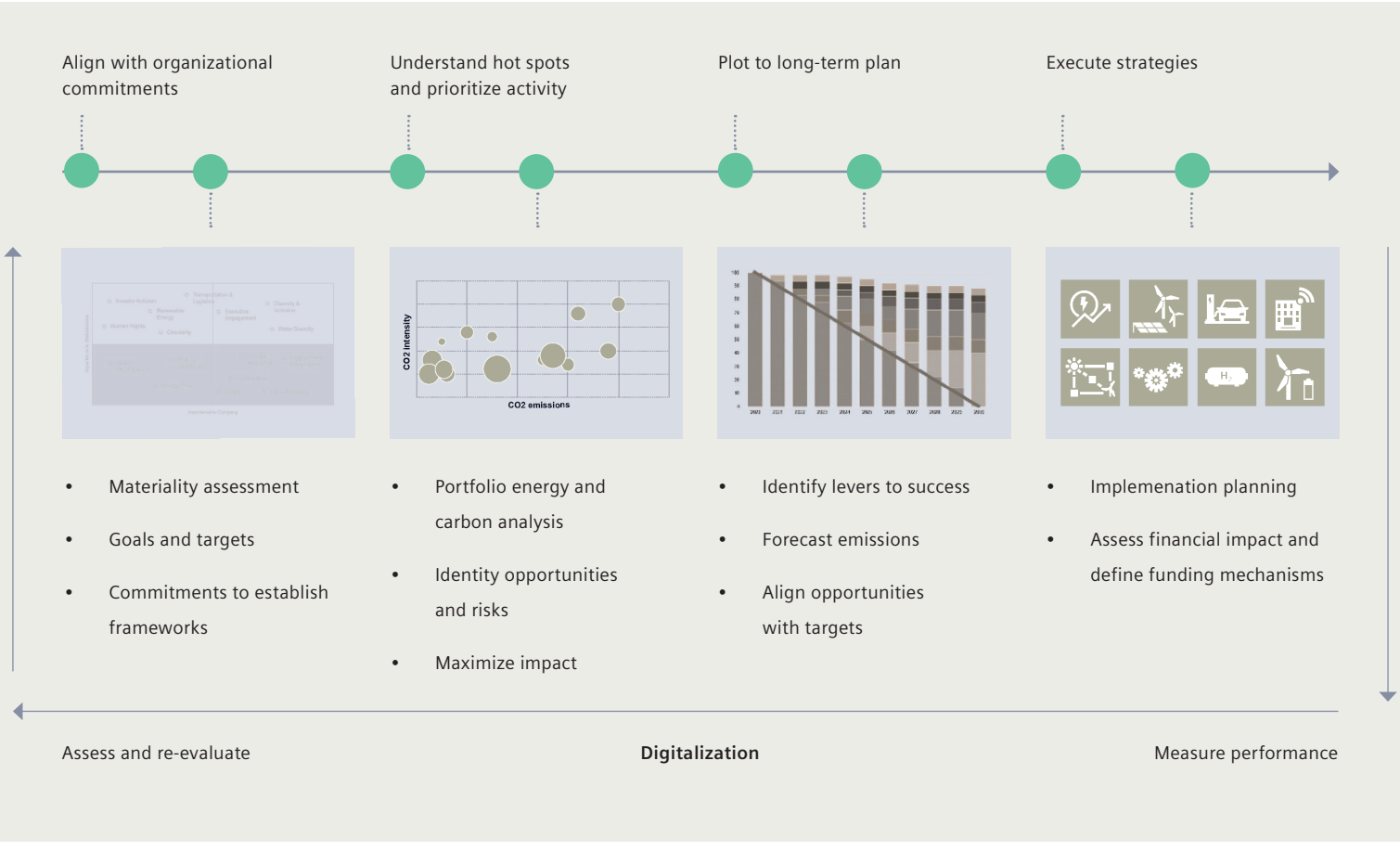


Figure 4: Developing the right action plan

Implementing strategies that leverage the above options represent key activities in the circular economy of the chemical industry. This includes addressing sustainable production and feedstocks, reducing consumption and waste, and improving product durability and longevity. Implementing and successfully delivering on these strategies, however, requires an understanding of challenges and complexities that must be overcome.

Current state and challenges

The critical dynamic that complicates decarbonization within the chemical industry is that it is not uniform. There are thousands of different chemicals produced and the top 10 global chemical producers only account for 8.8% of 2019 global revenues; this high degree of fragmentation makes it challenging to garner full industry buy-in and to develop easily replicable decarbonization strategies.

Figure 5: Key characteristics that distinguish chemicals from other industries

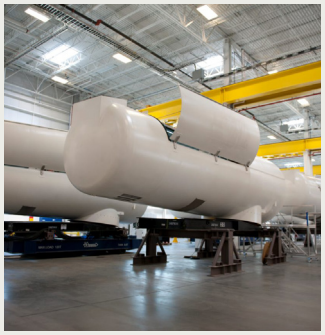
There is also a debate as to whether chemicals used in some products, i.e. insulation, should be viewed differently because they help offset emissions downstream. Within closest reach is a chemical manufacturer's ability to decarbonize their factories and production processes. This effort can become much more complex for companies looking to address upstream Scope 3 emissions from raw materials. Scope 3 emissions are indirectly controlled by chemical manufacturers and, as such, are more challenging to influence. Individual manufacturers select the method that delivers a best business case; looking to use production methods that help reduce the carbon footprint of production is a clear opportunity in decarbonizing against a range of chemicals.

What becomes clear, however, is that a great deal of customization is required for each chemical producer to ensure they have a robust and actionable decarbonization strategy.

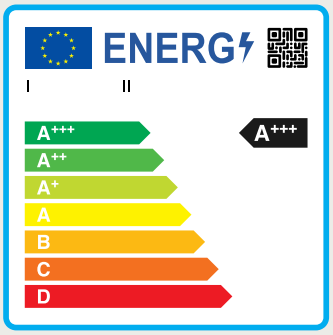
Transition to a more circular economy is a critical decarbonization strategy for many chemical companies. The next graphic shows how chemical companies view circular economy in the context of the wider decarbonization opportunities available to them.

Carbon reduction

1. Chemicals are essential components of renewable energy infrastructure, including both wind turbines and solar cells.



2. Chemicals contribute greatly to the energy efficiency of end-products, for example through insulation materials for homes and refrigerators.



The carbon footprint of many products (calculated via a LCA) is mainly a combination of the energy needed to produce it, and the energy it consumes during its lifetime of use.

The use of energy during the production of chemicals is captured here in trend 3, Sustainable Production.

A chemical company's main application markets have their own balance of priorities between the two.

Circular economy

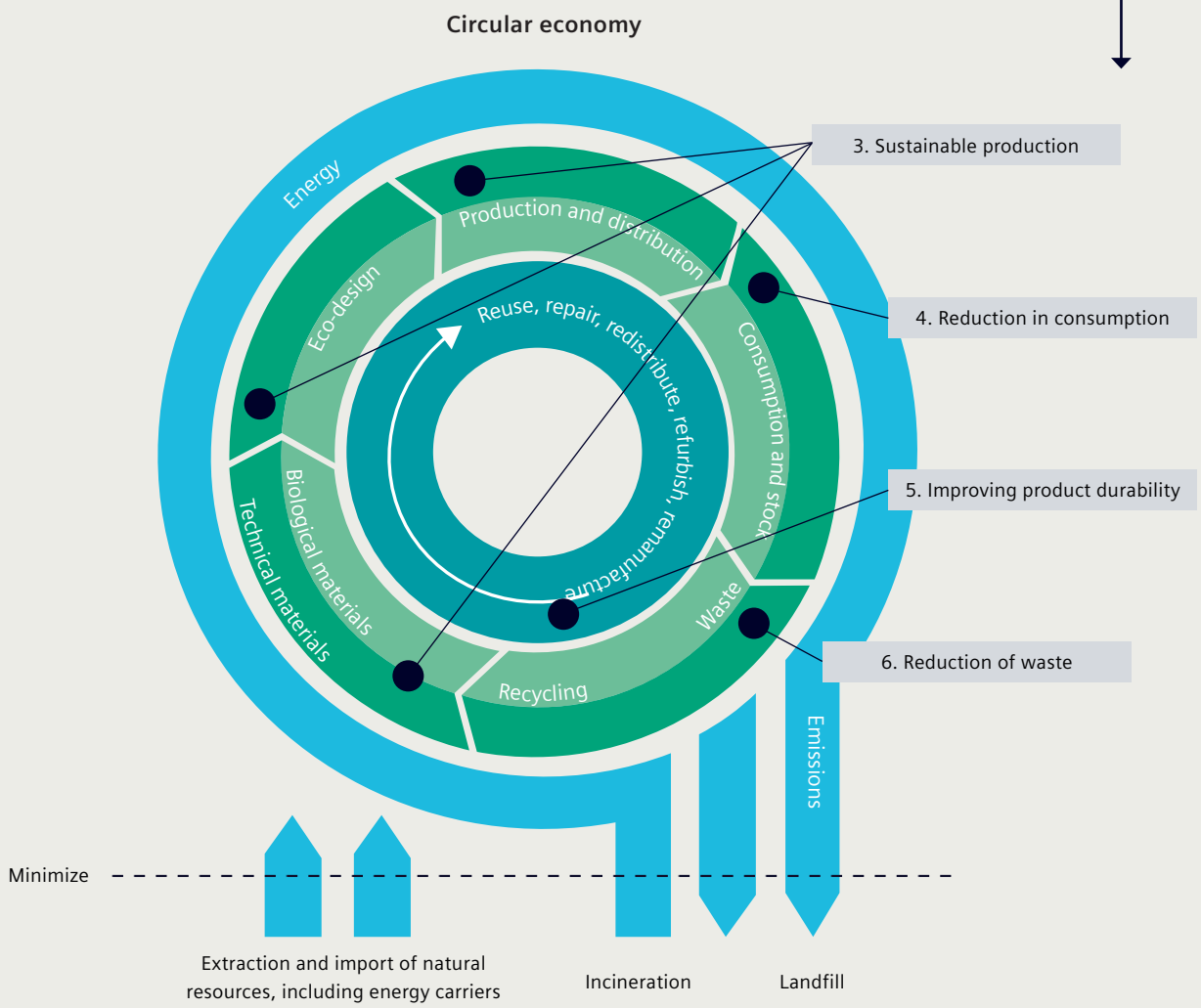


Figure 6: Decarbonization via a circular economy for chemicals

Critical processes and footprint to decarbonize

Decarbonization efforts in the global chemical industry are focused on five key areas: product development, energy management, manufacturing operations, the circular economy, and the supply chain. During product development, organizations can select existing or help develop new chemicals that will have lower energy requirements. Throughout manufacturing and in energy management, consumption can be targeted for reductions or fossil-fuel derived energy can be replaced with renewable and green energy.

There are benefits in electrochemistry processes that can improve energy footprints in the global chemical industry. In the supply chain, especially for companies that buy chemicals as ingredients, chemical manufacturers can look to decarbonize those Scope 3 emissions in agreements and raw materials.

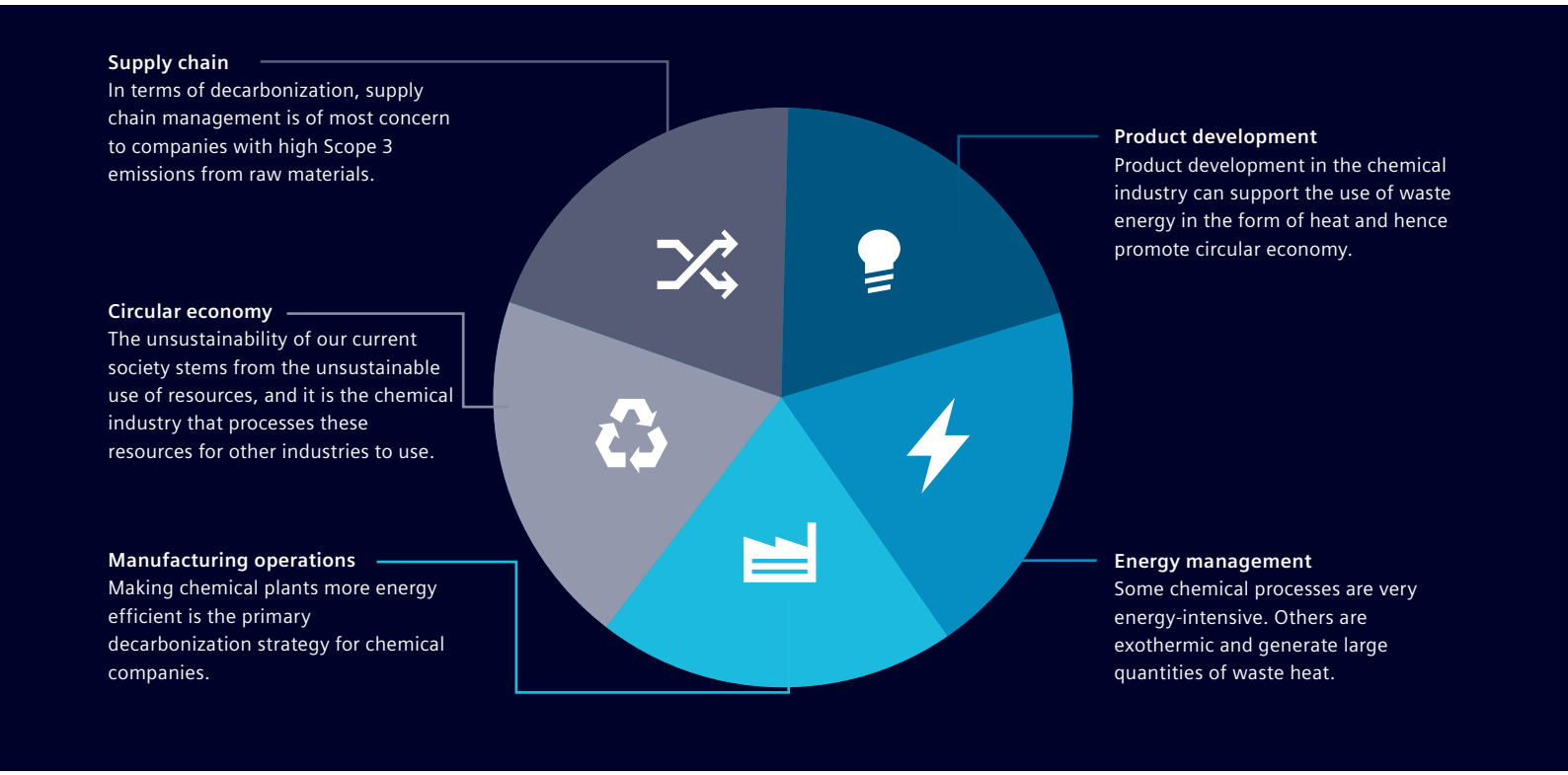


Figure 7: Decarbonization in the chemical industry

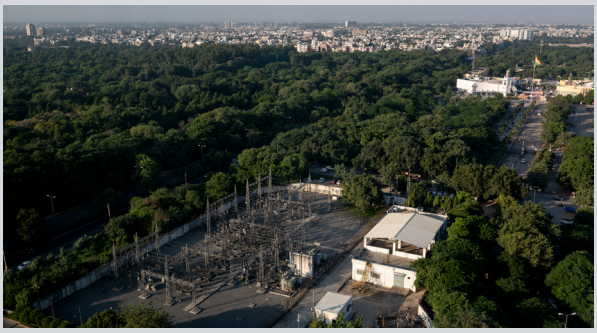
In targeting these processes for decarbonization, manufacturers can advance towards a carbon-neutral and net-zero carbon future.

- **Decarbonization roadmapping:** energy audit, distributed energy systems, building performance optimization, energy procurement and supply services
- **Energy consumption optimization:** simulation and modeling software for quick assessment of renewable integration, digitalization and connectivity for performance optimization and CO_2 management, asset performance over supply and demand to optimize resource efficiency
- **Energy infrastructure and supply modernization:** grid consulting, improve sustainability via conversion of excess renewable power to hydrogen, load shifting and load shedding for efficient peak load management
- **Service-based business models:** energy efficiency as a service, energy saving performance contracting, PPA green energy supply, decarbonization as a service

Case studies and regional initiatives

The snapshot examples presented below outline key steps organizations in Belgium, Germany, the Netherlands, and the UK have taken to reduce consumption and optimize energy use, as well as grow the use of sustainable feedstock in their production processes.

Tata Europe (UK)
In 2019 Tata announced a carbon capture and utilization (CCU) demonstration plant that will capture CO_2 and use the emissions as feedstock in the production of sodium bicarbonate. A key driver of this policy change is that Tata Europe's site in the UK has historically been the largest single user of liquid CO_2 in the UK. It presents a step change in the facility's local operations and increases its sustainable footprint through an impactful decarbonization effort.



BASF (Belgium, Germany)
BASF has committed to becoming climate-neutral by 2050, with a focus on full electrification, using renewable energy sources. Initial efforts are focused on plants in Antwerp, Ludwigshafen, and Schwarzheide. Efforts will focus on improving asset and process energy efficiency and the purchase of green energy from third parties. Waste heat already supplies 45% of steam requirements and BASF plans to increase this further.

DuPont
DuPont is focused on achieving greater energy savings and efficiency. The organization aims to achieve a 23% reduction in energy consumption over 10 years. Key to this is an effort to make the company's Delrin® Renewable Attributed polymer with as low a carbon footprint as possible. To deliver on this ambition, DuPont aims to ensure the polymer is created from 10% biofeedstock from waste, production uses 100% certified renewable electricity, and steam is sourced from municipal waste energy recovery.

Sustainability potentially has the highest impact on the way you do business and on delivering growth in the chemicals industry.

53%
Resource and materials substitution

46%
Decarbonization

40%
Use of renewable energy sources

...are among the factors that are expected to have the greatest impact on business in the coming years.

4 Solutions and services that support decarbonization

The global chemical industry reviewed in this whitepaper has established important initiatives to reduce energy consumption, increase the use of renewable energy, and adopt greater rates of electrification.

Energy solutions and services delivering decarbonization are based on a strategic approach, utilizing value-stacking to exploit the full potential rather than execute isolated activities to optimize energy generation and sourcing, energy efficiency, supply security and reliability, or business and asset performance. This ensures the delivery of a positive impact right from the start and in the long-term for the entire organization.

Delivering energy intelligence across the energy value chain

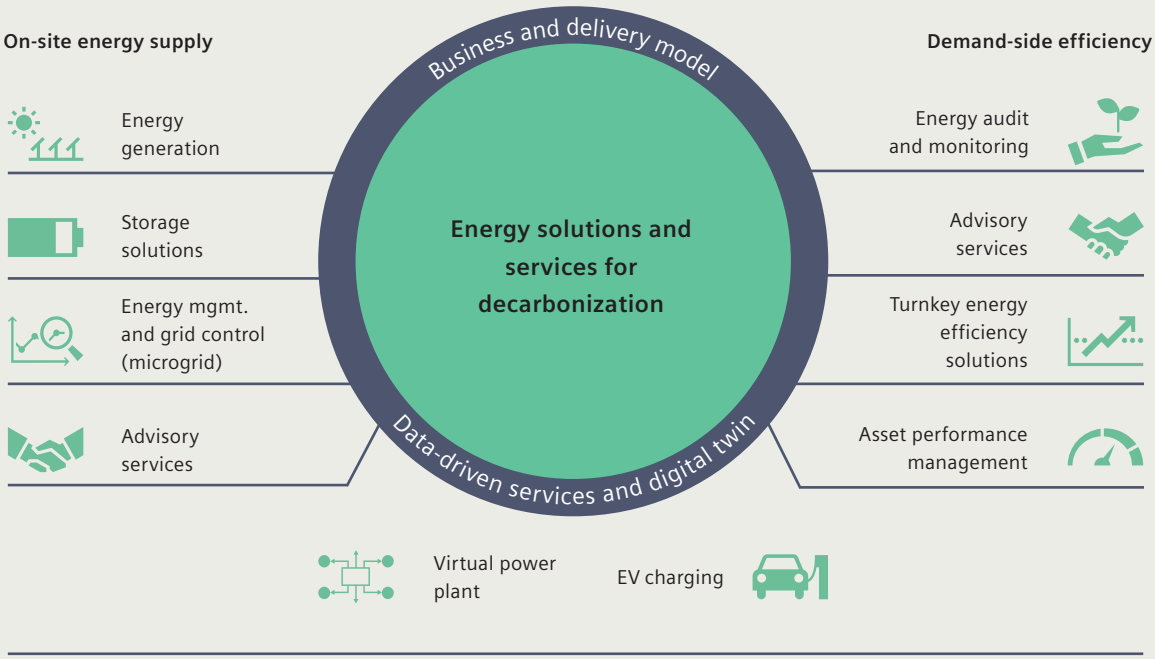


Figure 8: Energy solutions and services for decarbonization

Demand-side efficiency

Demand-side efficiency is based on a thorough energy audit and performance data monitoring for compete transparency of the energy utilization and asset performance. In a first step, energy efficiency solutions reduce the overall energy consumption and optimize the energy efficiency of the entire facility.

In addition, asset performance management ensures the reliable and efficient performance of all business assets, and advisory services help select the best suitable solution design and business model.

On-site energy supply

Local energy solutions are based on sustainable generation of power, heat and cooling with a maximized share of renewable energy sources.

In combination with powerful energy storage solutions, e.g. electrical storage or hydrogen storage, an on-site solution provides flexibility and allows for a maximum share of renewable energy.

Energy management and grid control tools ensure a reliable and efficient control of energy supply, usage and storage – and new profit streams by connecting the local energy solution to the energy market or managing it as part of a virtual power plant.

All the solutions are supported by advisory and consulting services – from initial assessment and concept and design, to engineering, procurement and construction to operation, services and maintenance of the running system.

These are critical components in moving towards decarbonization. Power purchase agreements that deliver green, renewable energy support these activities and provide industrial customers with a faster-to-implement method of reducing carbon footprints. Additional efforts in capturing and using waste heat and the creation of circular economies are also core components of many strategies.

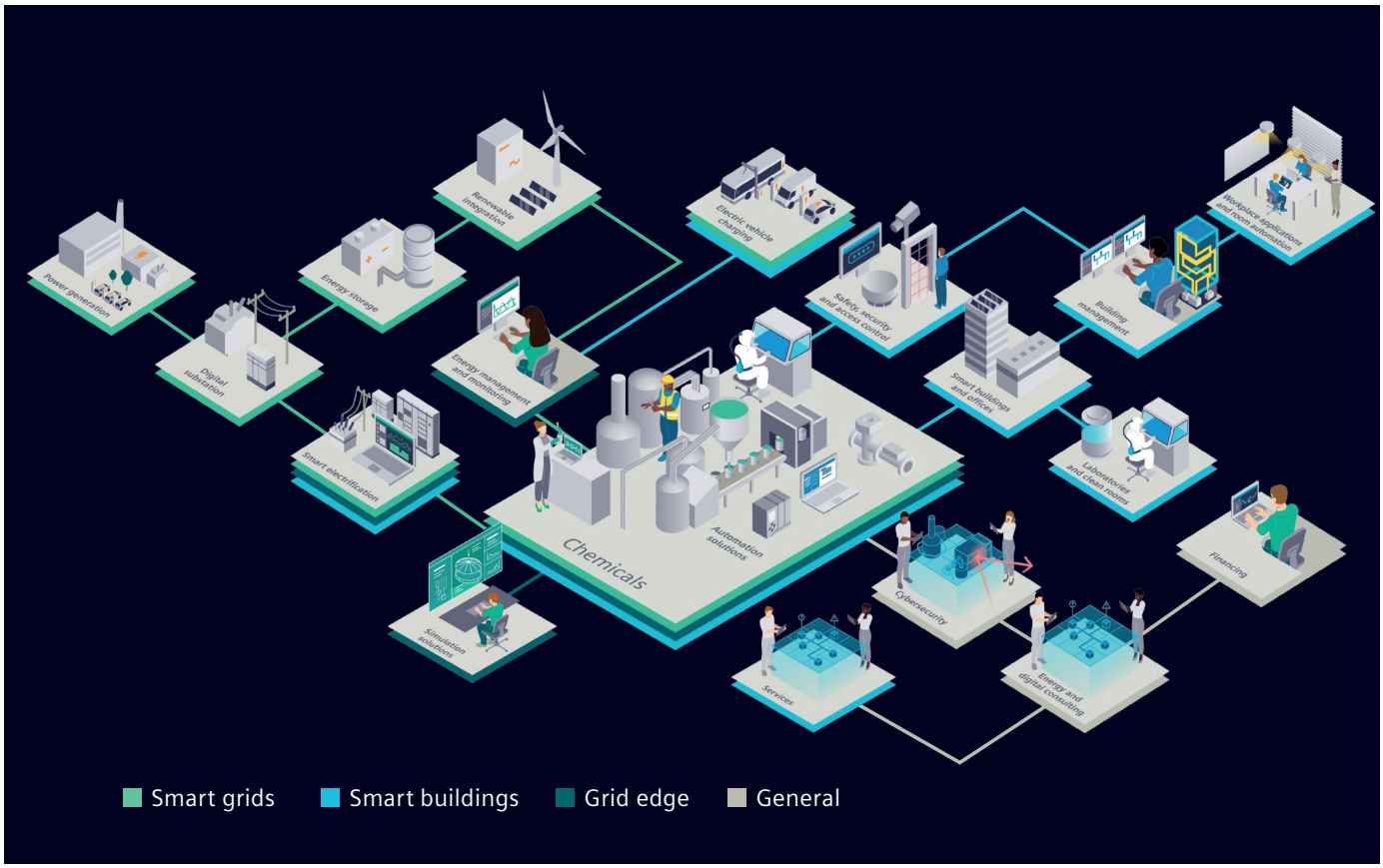


Figure 9: Holistic solutions and services for the chemical industry

Business models and digital services

The technical implementation of solutions and services delivering decarbonization is supported by data-driven services and digital twin technologies.

Depending on the customer situation and goals the best suitable business model is selected:

- Customer financing of a project is based on milestone payments during the implementation and therefore cash negative. It requires capital investment and leaves the ownership of the asset and the performance responsibility with the customer.
- A deferred payment agreement is a performance contract which optimizes CAPEX efficiency. It is based on a payment plan with positive cashflow financed from the project savings and requires no initial investment. The ownership of the asset remains with the customer, who can shift the responsibility for operation and maintenance and the solution performance to the solution provider with a respective agreement.
- X-as-a-Service models allow organizations to profit from project benefits regarding energy supply, equipment and facility maintenance for a service fee. They offer greater value through their holistic nature and significantly reduce the time to profit from system optimization – without capital investments and without taking over responsibility for new assets or systems.

These solutions enable our customers to take control of their energy supply and business performance.

Global manufacturers also look towards advanced equipment and process efficiencies to reduce carbon footprints of facilities. This includes LED lighting and new equipment with lower energy consumption. These actions should become a global standard in industrial facilities to deliver on quick carbon reduction gains. These early successes should be reinforced and replicated among industry peers.

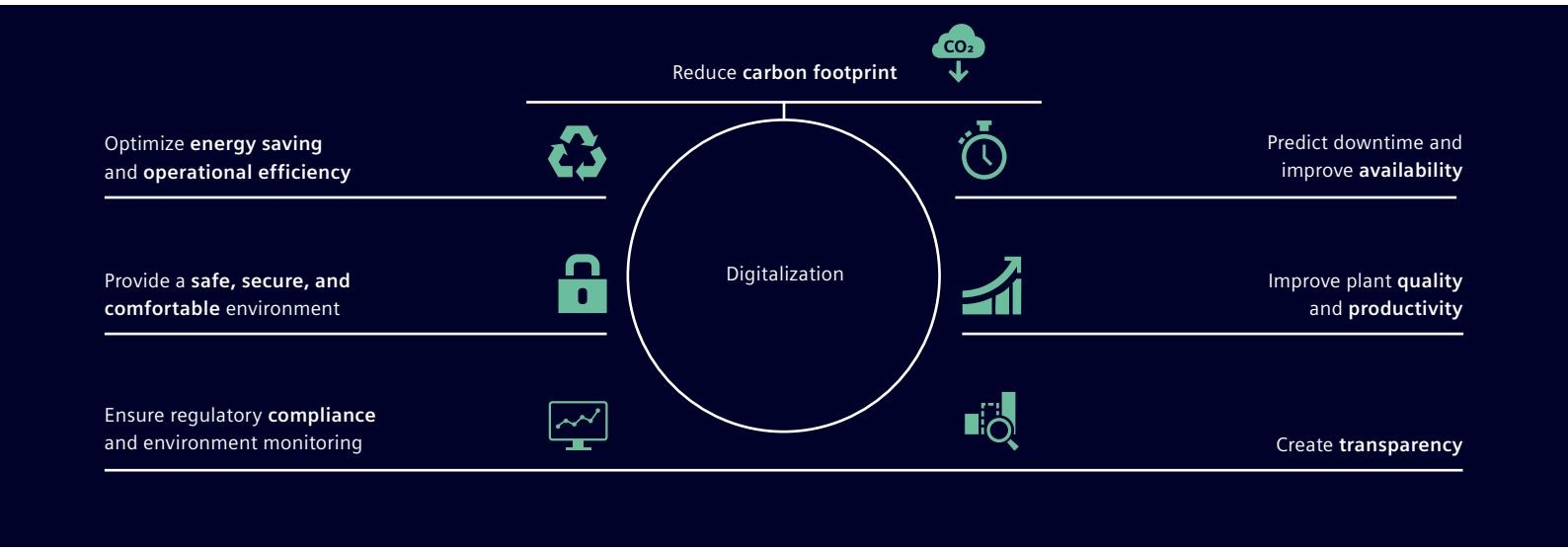


Figure 10: Taking advantage of digitization to get ahead of your competition

Regional and local challenges in implementing the solutions and services for decarbonization

At a local level, however, there are regions that experience renewable energy supply challenges and higher economic costs in these initiatives. This is further complicated by a fragmented competitive landscape that is more greatly influenced by local conditions. As a result, regional and local landscapes can be highly variable. Regions and localities may require structural assistance and incentives in order to help drive decarbonization activity.

External third-party support can also help manufacturers in these locations navigate these complexities to identify near-term opportunities as well as long-term initiatives that reflect changing local conditions to keep decarbonization initiatives running.

5 Conclusion and the way forward

Achieving economic change at the speed and completeness required to successfully respond to the world's decarbonization mandate requires focus and investment at a scale never seen before; this reinforces the need to act as a community and leverage partners to ensure critical success. The successes stemming from current initiative by global manufacturers need to be replicated globally. Increasing energy efficiency, driving renewable energy consumption, greater electrification, and facility improvements in efficient LED technology and energy-efficient process equipment are all actions that must be embraced throughout industries.

1. Focus on Scope 3 emissions in addition to Scope 1 and Scope 2 emissions

In order to meet ambitious global targets, and to achieve sustainable industrial activity through decarbonization, a greater and deeper effort must be made to reach these goals. This requires industrial manufacturers to go deeper on Scope 1 and Scope 2 decarbonization initiatives while pushing into strategic Scope 3 emissions reductions. Pushing into Scope 3 emissions reductions will require greater engagement with upstream and downstream partners, which is complex, but necessary in order to deliver sustainable industrial economies.

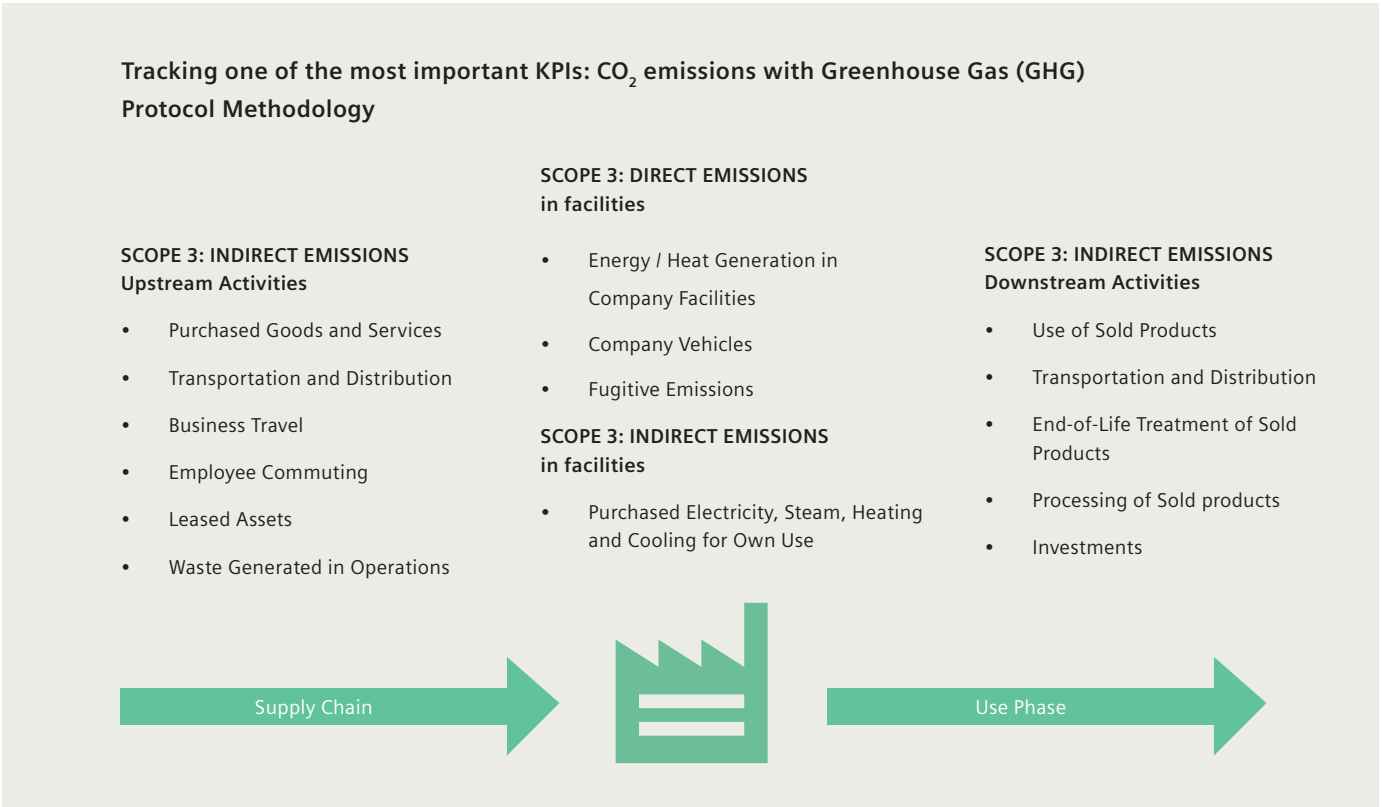


Figure 11: CO_2 emissions with Greenhouse GAS (GHG) Protocol Methodology

2. Focus and invest on technology developments

Thanks to available technologies such as renewable energy sources, energy storage, forecasting, data analytics, and building management services, it is possible to optimize operations, decrease energy usage and create significant energy and resource savings. Energy management solutions incorporate this to deliver on the sustainability goals of the organization and at the same time support the financial side of the business and foster growth.

A holistic approach to sustainability measures ensures that measures are not implemented based only on individual payback time and ROI, but also based on their cross-synergies, allowing positive impacts to start earlier and also slower and less effective measures to be implemented, so that the highest total effectiveness can be achieved.

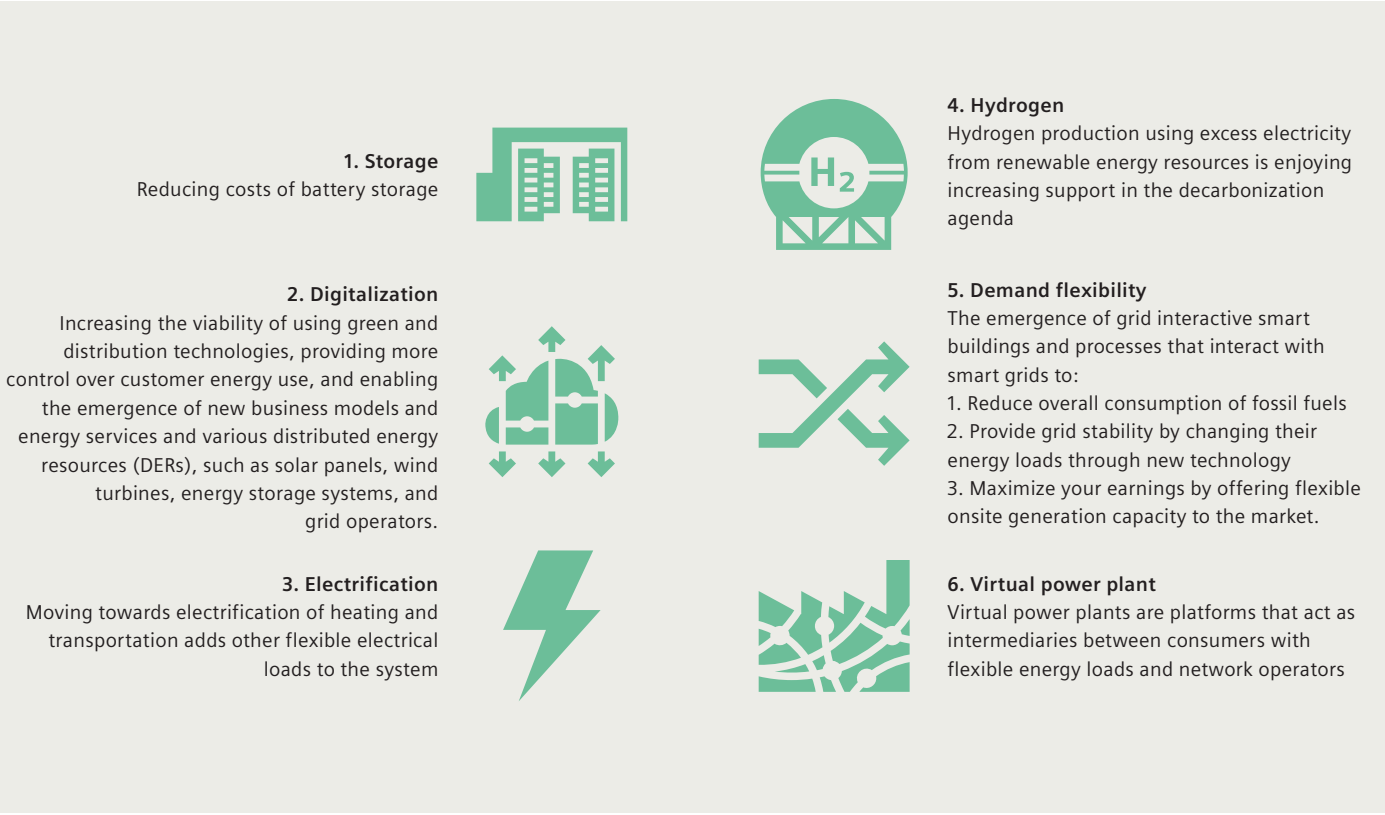


Figure 12: Technology developments around renewable systems

3. Engage in the industrial community

Engaged industrial organizations exist throughout the world; their activities help form a blueprint for others to follow and from which to expand decarbonization activities. Engaging in the industrial community is critical to delivering success.

In addition, looking outside of the industrial community for further strategy and innovation success is key; this includes bringing in third-party partners to help evaluate facilities and organizations, to develop actionable strategies to push organizations towards decarbonization, and to monitor and confirm success.

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Our passionate commitment to growth starts with our Growth Pipeline Dialog, an all-hands approach that puts your management team in a room with our growth experts, addresses your top challenges, identifies areas of disruption, and develops tailored roadmaps and go-to-market strategies.

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