Enabling Global Decarbonization through Digital Industry Technologies
Introduction

Decarbonizing our economy is arguably the biggest challenge of our time. It is not just a matter of avoiding climate change, although that alone warrants giving decarbonization the highest possible priority. But even if climate change were not a threat, a society based on fossil fuels will at some point run out of energy. Moving to low-carbon production and consumption models is thus of critical importance to our long-term survival. And we have limited time to act.
While much is made of major advances in renewables deployment in recent years, at a global level, clean energy has barely stemmed growth in the use of carbon fuels. According to the International Energy Agency (IEA), “carbon emissions hit their highest level ever in 2021.” With natural gas supply constraints driving coal-fired energy production in 2022, the current outlook for decarbonization is not good. All sectors of society need to help.

In industry, which is responsible for a fifth of emissions and consumes more than a third of global energy, it is tempting to view decarbonization as a challenge to be ignored or sidelined. In practice, however, it is increasingly becoming an opportunity for rethinking businesses to align with several major financial drivers, such as:

- Complying with government and industry net-zero commitments.
- Tapping into flows of capital targeting sustainable companies.
- Meeting customer demands for sustainability.

Furthermore, because industrial decarbonization depends heavily on improved efficiency, a focus on cutting emissions can also help companies deal with the effects of growing global demand for limited resources. And while many industrial decarbonization pathways seem challenging at first, the reality is that much can be achieved with the application of smart digital technologies.

What follows is a review of how digitalization can help decarbonize products, operations and supply chains, reduce the need for energy and other resources, and contribute to carbon footprint management and business and service model innovation.
Decarbonizing products

An important component of industrial decarbonization is designing products for a low-carbon world. Most of today’s products and infrastructure, from cars to consumer electronics, deliver the bulk of their carbon impact while they are in use, says Gunter Beitinger, Senior Vice President of Manufacturing at Siemens. “We at Siemens are currently working on reducing this significantly by making our, and especially our customers’ products more efficient during their use phase,” says Beitinger.

One example of this is in vehicle electrification, where the lifetime emissions of road vehicles can be minimized by developing battery-based drive trains using renewably produced electricity. This move is leading to new opportunities for automotive manufacturers but also implies a shift in focus away from point product categories and towards models that value collective intelligence.

Siemens defines this as intelligently linking and analyzing data across industrial operations so asset owners can make confident decisions. Collective intelligence provides a seamless flow of data from the real and the digital world to benchmark how sustainable organizations are today and predict what choices will achieve greater sustainability in the future.

In the automotive sector, for example, vehicle electrification is forcing manufacturers to consider value chains that go from raw battery material extraction through to charging infrastructure. This leads to new levels of industrial ecosystem complexity that can only be addressed through digitalization.

Collective intelligence in sustainable industrial innovation

Source: Siemens.
Another result of designing for decarbonization is that it can have a knock-on effect on industrial operations. “This reduction of emissions during the use phase of products can sometimes come at the cost of an increase in efforts and energy use during the production of these goods,” Beitinger says. “For example, a couple thousand photovoltaic cells cause higher energy and resource consumption during the manufacturing and installation phase than a coal-fired power station producing an equivalent amount of power.” It is therefore important to understand the entire impact chain of the product. This requires a system-of-systems approach to industrial processes, looking at products and their environmental impact in a broad context that includes design, production, use, life-time extension and next life.

As such, industries must adopt holistic sustainability indicators that can deliver intelligence into how operations contribute to or detract from sustainability goals, whilst balancing these with growth and profitability. In Austria, for example, the Coca-Cola Hellenic Bottling Company has reduced carbon emissions from its bottling process. Using Siemens digital technology, the bottling firm was able to analyze more than 100 energy consumption data points and cut carbon emissions by 50% between 2010 and 2019.
Industrial decarbonization cannot stop at products and processes. Ultimately, it will also require companies to understand carbon intensity and resource utilization up and down the value chain, from suppliers and distributors to energy producers and recyclers. Such connected industrial ecosystems can gather and act on intelligence from all stakeholders, supporting collective action to improve sustainability performance.

In general, “digitalization is a huge enabler for sustainability, and decarbonization is one of the main aspects of sustainability,” says Eryn Thomas Devola, Vice President of Sustainability at Siemens Digital Industries.

This is particularly true of decarbonizing energy use. An abundance of fossil fuels has made many of today’s industries wasteful of energy and lacking visibility into where energy comes from and goes to. Improved data collection and analysis can help overcome this issue. One tool that is increasingly being used in this context is the digital twin, a data-based model of both a product or asset, and its production, that can be used to simulate changes that could help reduce emissions throughout the lifecycle.

“Being able to replicate that real world in the digital world, with a comprehensive digital twin, you’re able to get real-world monitoring and up-to-date data to inform the digital twin and simulate the impact of changes. You can then make decisions much more agilely, and reduce your energy usage,” Devola says.

Efficiency is often seen as complementary to renewable energy adoption in terms of aiding decarbonization efforts, but should instead be seen as a prerequisite, says Beitinger. “At the level of inefficiency that we operate now, the planet just can’t provide enough renewable carbon sources to maintain us,” he notes. “Efforts to increase efficiency are therefore necessary to reach a level of carbon consumption where the planet can continuously provide them.”

Digitalization has an essential role to play in helping industry reduce energy-related emissions on three fronts, Beitinger says. These are:

• Optimizing energy consumption across all products and production processes.
• Electrifying the energy system so more processes and assets can be powered directly by renewables.
• Enabling a shift away from fossil fuels to low-carbon alternatives such as renewably produced hydrogen.
Beyond improving efficiency and helping enable a transition to low-carbon energy sources, digitalization can play an important role in enabling more efficient resource utilization overall. Resource utilization is often linked to emissions, so reducing the use of resources often delivers a decarbonization dividend as well as saving costs.

One much-commented example of this was the move to virtual meetings that came about because of the lockdowns introduced to halt the spread of COVID-19 from 2020 onwards. This move, enabled by digital technology, led to a significant drop in resource-intensive business travel, contributing to a record annual decline in carbon emissions.

Digitalization can deliver even more profound transformations across industrial sectors, says Devola, by allowing the impact of new products and processes to be analyzed cost-effectively at scale within a digital twin. “With the simulation tools that are available today, we can try hundreds of designs—things you wouldn’t have taken the risk on in the past because of the cost in time and resources,” Devola says.

Digital tools can create more value while reducing dependence on limited resources, by helping industrial players to:

- Reduce harmful emissions and use renewable energy sources across the value chain.
- Incorporate new materials and additive manufacturing into design and production.
- Use fewer raw materials and reduce waste across the product lifecycle.
- Reuse and recycle materials from products and production.
- Minimize wastewater and chemical utilization in plants.

Furthermore, there is already a rich ecosystem of digital tools that industrial players can tap into for improved resource utilization. Siemens, for example, has solutions that support industrial companies throughout their digital journeys from strategy definition, product design and supply chain creation to production engineering and execution then use and services.
Managing carbon footprints

Management consultant Peter Drucker once famously said: “If you can’t measure it, you can’t manage it.”

This is particularly true of carbon emissions, which are invisible and often hard to assess. “The main issue is that we currently don’t have the necessary transparency over the emissions in our supply chain,” says Beitinger. “We have a very hard time incentivizing our suppliers to reduce product-related emissions if we don’t get reliable figures from them. Since our suppliers don’t get reliable carbon data from their suppliers, they can’t provide reliable product carbon footprints for what we purchase.”

Digital tools can help industrial companies in a range of ways. SiGREEN, a Siemens platform, is one such tool that can enable reliable tracking of a product’s carbon footprints across the supply chain. By effectively utilizing a suite of digital tools, companies improve their ability to:

• Identify and quantify carbon reduction opportunities based on data from shopfloor, logistics and supply chains.
• Measure where carbon emissions occur and aggregate data along the value chain.
• Track targets and meet requirements with specialized reporting and dashboards.
• Predict the carbon footprint from production and products, using simulation.
• Quantify carbon footprints and manage high emissions sources.
• Implement targeted reduction measures across the value chain.
While much of the current digital transformation is rightly concerned with improving efficiency and reducing emissions from existing processes, digitalization can also contribute to deeper shifts. One trend that is heavily supported by digitalization is the move towards service- rather than product-based business models.

Under this paradigm, already seen in niche applications such as copying and printing, a product becomes a platform for service delivery rather than a customer asset. Such models benefit the manufacturer by extending the lifespan of customer relationships and improve sustainability by prioritizing the longevity of an asset over the production of new assets. Service-based business models can also help with the adoption of digital tools by industry.

UK-based Knauf Insulation, for example, was able to benefit from energy savings of more than 12 gigawatt-hours a year and an annual reduction of more than 5,000 metric tons of carbon emissions, without capital expenditure, thanks to a service-based deal with Siemens. Under the terms of the agreement, the bill for Siemens’ technology and services was paid out of savings achieved by the manufacturer.
Implementing decarbonization programs

The Knauf Insulation example demonstrates how digitalization transformation can be delivered flexibly across industrial sectors, eliminating the risks usually associated with large IT or infrastructure projects. Furthermore, many industrial companies are already implementing digital transformation programs for a variety of reasons other than reducing carbon emissions. Typical stages in an industrial digitalization roadmap include:

- Using digital models to optimize the three traditional drivers of time, quality and cost into real-world outcomes.
- Increasing adaptability and agility with digital models, to explore and accommodate factors such as customization and rapidly changing market conditions.
- To explore how to advance sustainability goals in balance with growth and profitability.

Because of the need to harness collective intelligence for improved sustainability, most digitalization programs will begin with a consulting engagement to assess the current state of data collection and analysis.
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The value of digitalization is amply illustrated by the results achieved at the Siemens Electronics Works Amberg in Germany. This is a manufacturing site that sees 350 production changeovers per day and serves a portfolio containing roughly 1,200 products. The site has been used as a testbed for a range of digital tools, including:

- Blockchain-based end-to-end product carbon footprint management.
- Artificial intelligence-based planning and process automation tools.
- Digital nameplates for paperless product documentation.
- A digital twin for holistic energy management analysis.
- Dynamic value stream analysis of carbon flows.
- Carbon modelling.

The collective intelligence made available through these tools have allowed Siemens to increase factory output 16 times while reducing absolute energy consumption by more than 20%.
Outlook and conclusions

Siemens believes the three biggest challenges keeping industrial companies from using digitalization to accelerate a shift to low-carbon operations are:

- Transforming business models, because traditional business models usually focus on short-term financial value instead of creating long-term value by making sustainability and circularity profitable.
- Tackling ecosystem complexity, because industrial operations consist of silos of people, processes and tools that lack standardization and are often disconnected.
- Getting from data to decisions, because many companies do not know how to effectively leverage data to define sustainability targets and optimize operations.

Nevertheless, making bold and strategic choices to tackle these issues can create significant opportunities for industrial enterprises. According to the consulting firm Accenture, companies that pursue value driven by both sustainability and digital technologies are 2.5 times more likely to be among tomorrow’s strongest businesses.

This is because digitalization and decarbonization are increasingly correlated with bottom-line benefits. The concrete and aggregates manufacturer Hanson, for example, was able to reduce downtime and noise pollution and cut annual energy bills at its cement works in Ketton, England, by around £86,000 (§99,000 at today’s rates) just by replacing an aging cooling system with new equipment.

The energy savings were enough to pay for the investment in new equipment after just a few months. Similarly, Siemens has been able to reduce the carbon footprint of one of its factories, in Sweden, by 72% while reducing waste overall by 90%. More examples are set to follow as industry increasingly realizes the value of more efficient operations. “People have been doing these types of improvements for a very long time,” says Devola. “They weren’t necessarily calling them sustainability improvements.”

What is different now, she says, is that incremental changes have largely been taken care of. Rather, companies should now focus on accelerating digitalization and automation efforts to deliver the collective intelligence needed for sustainable business strategies. This can be achieved through taking a system of systems approach and ensuring a lifecycle view of a product, whilst connecting industrial ecosystems and implementing holistic sustainability indicators and KPIs.

Moving to low-carbon production and consumption models is one of the central enablers for combating the threat of climate change, but time is fast running out. Through focusing on high-impact areas, such a digitalization, companies hold the ability to accelerate decarbonization within shortening time horizons and, ultimately, strengthen the potential for society to overcome the defining challenge of our time.
References

6. Ibid.