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Ingenuity for life

Decarbonization

Addressing decarbonization at the grid edge

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Foreword

This whitepaper discusses decarbonization and how it affects consumers in the commercial and industrial (C&I) sector. It is based on expert insight and market interviews conducted during summer of 2020 and reflects Siemens' and Delta-EE's common view on the topic.

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Executive summary

Decarbonization is a critical transition that is affecting all businesses in the C&I space and is reshaping the foundations of the energy industry. A key driver of this transition is policy, spearheaded on a global scale by the Paris Agreement. In parallel to this, two other pillars transforming the energy landscape, **decentralization** and **digitalization,** are significant enablers of decarbonization, making it more technically feasible than ever before. These technical developments are helping overcome some of the challenges of decarbonization and are expanding the opportunities for optimization and new business models.

This transition is creating urgency for businesses to act. Action is needed to reduce exposure to potential risks from policy-driven **increased operating costs,** from increased energy costs or increased compliance costs. However, decarbonization also creates opportunities that go beyond long-term financial savings: **increased brand reputation, customer preference over competitors and attractiveness to investors** are some of the benefits for businesses who have started decarbonizing.

Consequently, many companies globally have already acted and have implemented decarbonization strategies. The success of any strategy will depend on a clear vision and strong commitment from the business, with responsibilities clearly allocated to those with a dedicated position, most likely the CXO level: **clear targets, clear commitments and a clear budget are key prerequisites.**

Strategies will differ from business to business, but typically will involve specific actions on the **management side,** on the **energy demand side** and on the **energy supply side.** For this purpose, expert support from specialist companies, can be invaluable, as it can help prioritize the right actions across the business and manage some of the risks around project implementation, performance and financing.

Siemens is well-placed to help its customers with their decarbonization goals, due to its coverage of the complete energy cycle from sustainable power generation over low loss power transmission to intelligent distribution and storage and efficient energy use, especially in C&I. Siemens is also implementing its own decarbonization strategy with a commitment to be carbon-neutral by 2030 and reduce its CO_2 footprint by 50% in 2020.

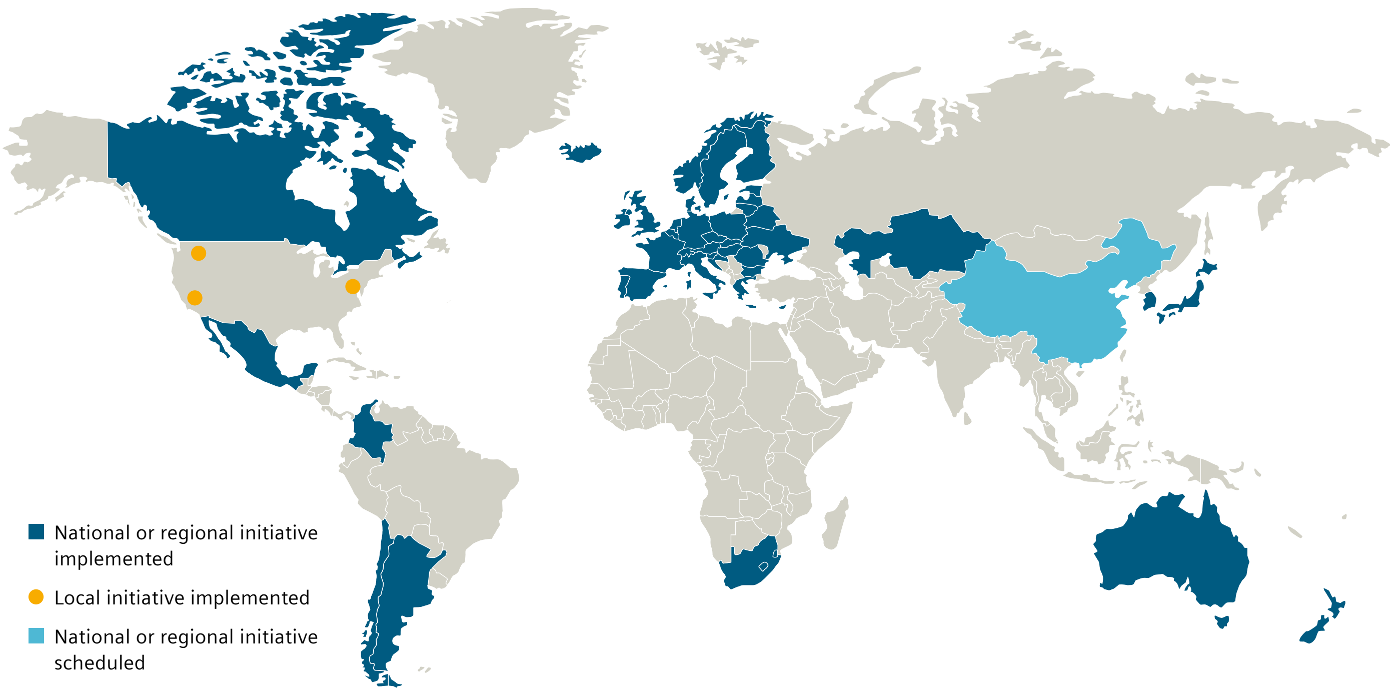
What are the political drivers for decarbonization?

Global policy to support a transition towards decarbonization

Climate change and its impact on the environment and our way of life have undoubtedly raised concerns and have shifted the political agenda globally towards decarbonization. The Paris Agreement, introduced at the UN climate conference in December 2015, has set the framework for a global response to climate change. Among the key measures that global leaders have agreed on is to keep global temperature increase "well below" 2 °C and to pursue efforts to limit to 1.5 °C. 194 parties and the EU have signed the agreement including some of the world's biggest polluters, which shows the significance of fighting climate change for the vast majority of governments around the world.

More specifically, the EU and its member states have set ambitious goals to reduce greenhouse emissions by 2020 and 2030 as well as achieve carbon neutrality by 2050. To meet these ambitions, different mechanisms and paths are being utilized globally.

Emissions trading schemes or carbon tax initiatives implemented around the world



Carbon pricing initiatives growing in popularity worldwide

Countries around the world are implementing or consider implementing carbon pricing initiatives either in the form of an emissions cap and trade scheme or as a carbon tax. Examples include:

- The EU-ETS which covers emissions in large industries, the power sector, and the aviation sector in EU countries. Started in 2005, the scheme operates as 'cap and trade', which means that a cap is set on a sector's emissions and then the total volume of allowed emissions is distributed to companies as tradable permits. Emissions covered by the scheme decreased by approximately 4% in 2018 compared to 2017. EU-ETS has been continuously evolving to increase the impact it has, with reductions in the allowed emissions as well as more sector and gases included.
- Canada has an ambitious carbon pricing program implemented nationwide (the Output-Based Pricing System) and a fossil fuel carbon tax. Individual provinces can opt out of the federal program by developing their own carbon pricing initiative. British Columbia is one of the provinces operating its own emissions trade scheme (ETS) and carbon tax.
- China has been running several pilot local ETS schemes in cities such as Shanghai and Shenzhen and in 2020 is set to start its nationwide ETS, which will initially be covering only the power sector but gradually be expanded to other industrial sectors.
- In the US, nine Northeastern states currently operate a cap and trade scheme (the Regional Greenhouse Gas Initiative) for power plants. Some states like California have gone further with their own cap & trade programs covering additional sectors.

Europe is the leading region with regards to decarbonization policies, with the European Green Deal expected to spearhead developments in the continent.

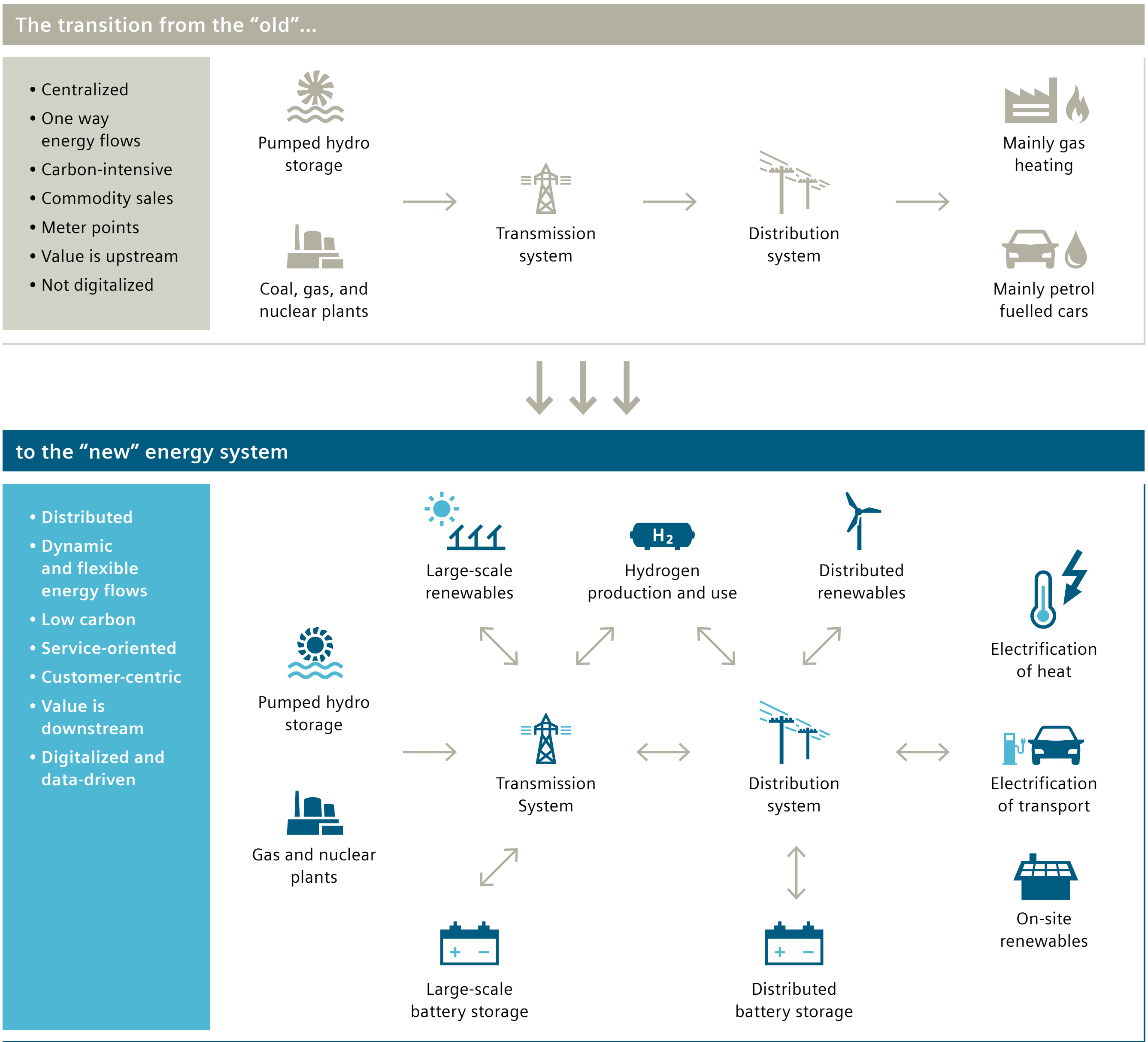
The EU's commitment and policy towards decarbonization is most recently set by the European Green Deal. Introduced in 2019, the European Green Deal has outlined a roadmap of actions that need to be taken for Europe to become carbon-neutral by 2050 and is combined with an investment plan that was presented in 2020. Some of the policy areas that form the focus of the deal are: building renovation, sustainable mobility (electrification of transport & sustainable alternative fuels), sustainable industry (more sustainable production cycles), clean energy, sustainable agriculture, sustainable food systems and hydrogen. It is also likely that the European Green Deal will set a leading example on climate action internationally and will put pressure on to other non-EU players to make more ambitious moves towards decarbonization.

Even though the European Green Deal will be the driving force for regulation and actions towards decarbonization at the European level, it is still unclear how it will translate to national action plans within each member state. EU countries are responsible for national policies and measures to limit emissions which need to be in line with EU targets. So far Germany has been one of the countries leading in terms of ambition and policy measures. Most recently the country's National Hydrogen Strategy was announced which sets out hydrogen technologies as a core component of the country's decarbonization strategy, particularly for heavy industries and aviation. In addition, Germany will be introducing a carbon pricing system from 2021 for emissions from transport and buildings. The system will work as a cap and trade system and will cover emissions in buildings and of energy and industry facilities that are not included in the EU-ETS scheme. Despite Germany's direction, decision makers around Europe are debating whether an emissions trading scheme like EU-ETS or a carbon tax is a more effective decarbonization option.

What technical developments are making decarbonization more feasible?

Introduction

Several developments in technology are enabling decarbonization. These are often triggered or accelerated by relevant policy support, but ultimately enable the emergence of new concepts such as the **grid edge:** the interface between the grid and the consumer and the technologies that connect to it. The main technology trends affecting the energy system are discussed below.



1. The transition from the "old" to the "new" energy system

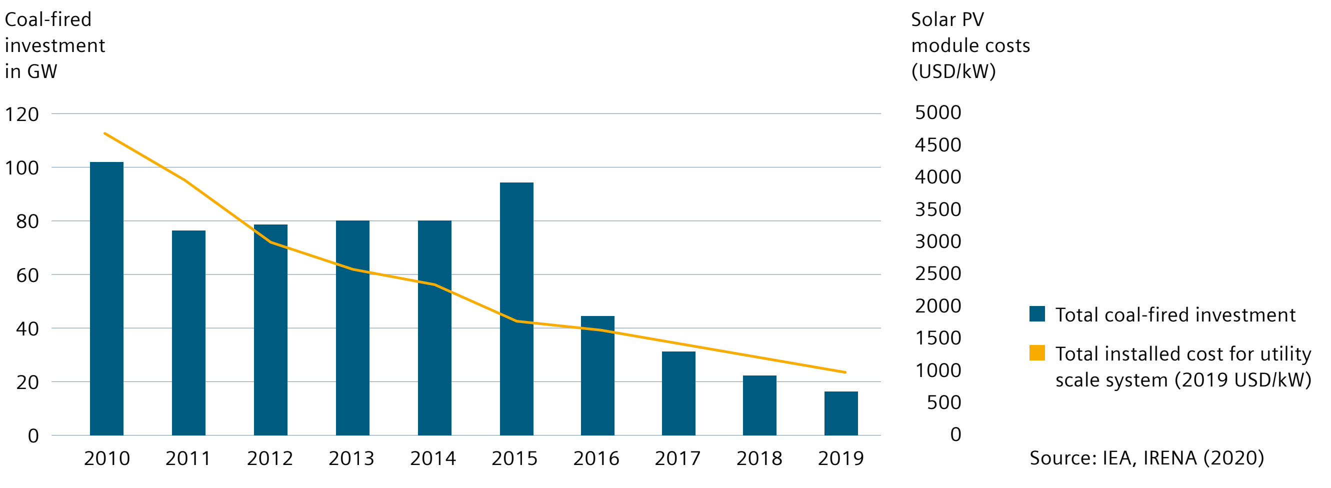
There has been a gradual shift from the prevailing model of large-scale, centralized and carbon-intensive power generation to small-scale, decentralised, low-carbon power generation. This is becoming apparent, when looking at the rapid decrease in global investment in coal plants and at the surge of investment in renewable energy. The surge in renewable energy deployment, comes along with a significant fall in their installation costs, at the point where large-scale renewable generation is cheaper than a fossil fuel plant.

2. Technology helping overcome some of the challenges relating to the integration of renewable energy resources into the new energy system

The increasingly larger share of solar and wind in the energy mix, is creating challenges around their integration into the system, as their power output is more intermittent and less controllable than the technologies they displace. This is why the role of technologies that help that integration and stabilize the system is so important. The answer to the question of system stability is a complex one and will most likely require a combination of solutions. Some key recent developments include:

- Reducing costs of battery storage.
- The emergence of the demand response market, which increases the system's flexibility on the load side.
- The move towards electrification of heat and transport, that not only provides an alternative to traditional carbon-intensive methods, but also adds further flexible electrical loads in the system.
- Production of hydrogen using excess electricity from renewable energy resources gaining increasingly more support in the decarbonization agenda.

Coal-fired investments versus PV module costs (2010–2019)



Source: IEA, IRENA (2020)

3. Digitalization is a key element of the new energy system

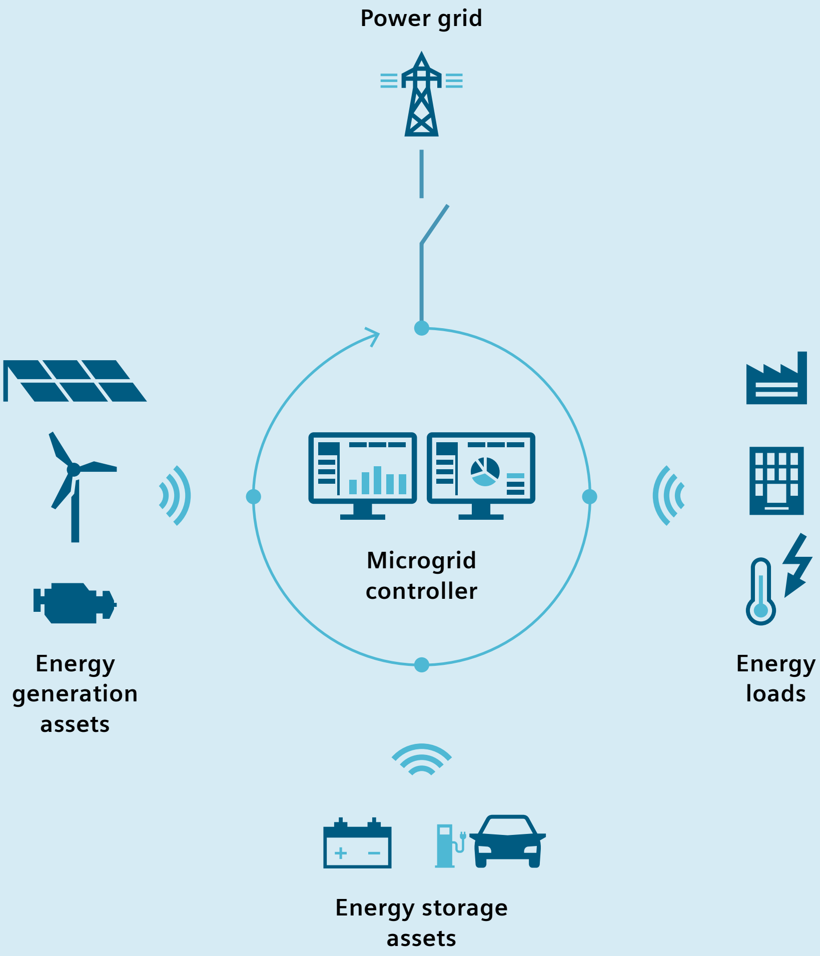
Digitalization is accelerating the energy transition, increasing the viability of using green and distributed technologies, giving more control over customer energy use, and enabling the emergence of new business models and energy services. Some examples of how digitalization has the potential to radically change the energy system are discussed below and are very different from the simplistic operation of the traditional energy system.

Use cases where digitalization is enabling different applications, business models and enhances carbon savings

Digitalization enabling microgrids

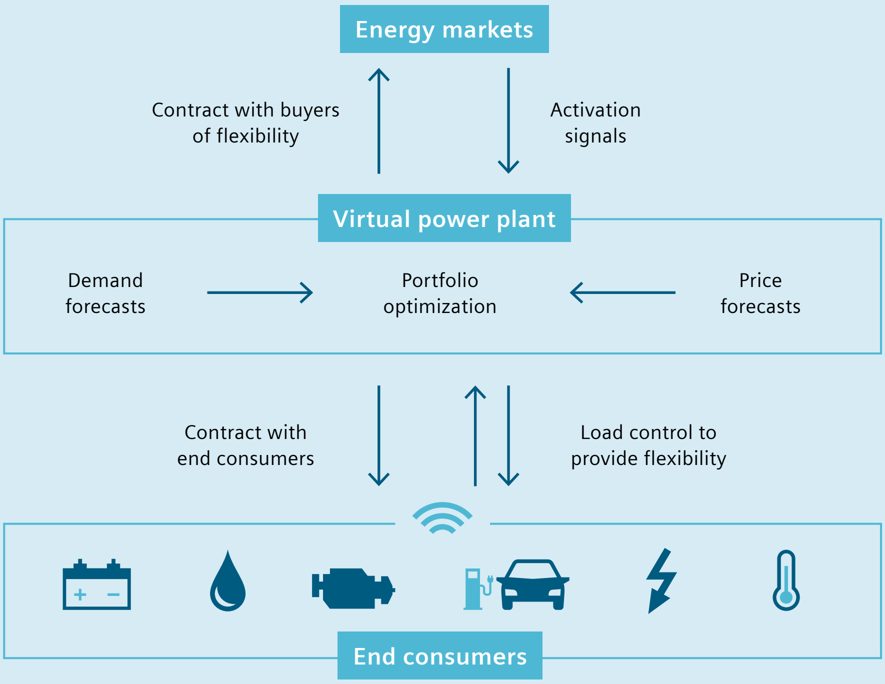
Microgrids are small energy systems, containing both energy sources and consumers, in which production and consumption of energy are largely balanced. Balancing is ensured by a microgrid controller, which also untaps potentials for innovative business models. Microgrids may be connected to the power grid or operate off-grid and can cover several forms of energy (e.g. power, heat cooling).

Despite being essentially a microcosm of a conventional energy system, microgrids have the potential to reduce the overall CO_2 content of the energy supply.

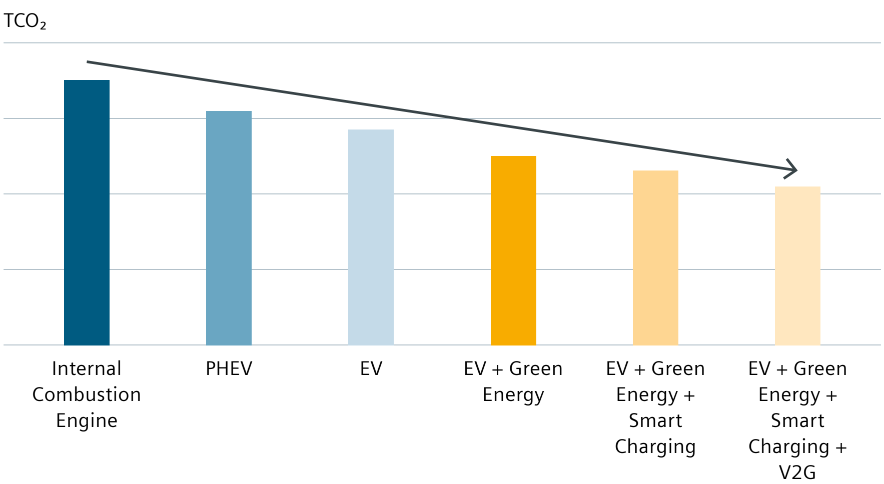


Virtual power plant business model

Virtual power plants are platforms that are the combination of hardware and software that allow an operations center to manage generation assets or load reduction covering more than one consumer site. They therefore act as intermediaries between consumers, who have flexible energy loads and network operators, who use their services to manage loads and flows on their systems. Typically, this requires the installation of hardware on consumer sites that allows control via a cloud-based software platform.



Lifecycle carbon emission trends in e-mobility



E-mobility has the potential to provide significant carbon savings throughout the lifecycle of the vehicle. This is further enhanced when combined with methods enabled by digitalization: supplying the vehicle only with "green" electricity, smart charging, and vehicle-to-grid solutions (where the EV can also supply electricity to the grid). This creates significant potential for businesses with large vehicle fleets.

What are the current opportunities and risks for businesses?

Decarbonization: both a risk and an opportunity

The journey towards a decarbonized future will affect all businesses. The transition will present several challenges and opportunities; therefore, every business should take the energy matter seriously and begin planning its future strategy. While the risks are more evident, there are many opportunities associated with companies who have set-to or managed to decarbonize.

What are the opportunities?

Decarbonization offers opportunities to businesses that are not only tied to risk avoidance.

- As decarbonization is driven in its foundations by societal concerns, achieving carbon goals can present an opportunity with regards to **customer preference**, especially as the importance of environmentalism in society increases going forward. For example, companies trying to decarbonize their supply chain may choose different suppliers depending on carbon performance or consumers may show preference to products that were manufactured in an environmentally friendly way.
- There are also clear wins to be made with regards to **brand reputation.** Companies are now monitored and ranked with regards to their sustainability targets, leading to the emergence of lists such as the Dow Jones Sustainability Index. These marketing and branding opportunities are often translated in stronger position in the capital markets around the world.
- The more environmentally sustainable a business is, the more **attractive it becomes to investors.** For example, in the real estate market for commercial buildings, good performance with regards to building environmental certificates, such as LEED and BREEAM, has shown to positively influence the value of the property.

What are the risks?

The main risks for businesses are policy-driven increased operating costs. This can take many different forms such as:

- **Energy prices,** including taxes and levies, that have been rising steadily over the last decade, because of the cost to transition the energy system. This increases pressure on businesses to reduce their energy consumption and at the same time make significant OPEX savings.
- **Penalties or increased costs for non-compliance with policy direction.** The importance of CO_2 emissions within policy initiatives is increasing. For example, there are on-going discussions around expanding emission trading schemes beyond major consumers. In any case the price of EU-ETS has almost tripled since 2018, which signifies the risks of exposure to more annual costs for large consumers.

Although the future of policy interventions and their extent is difficult to forecast, it is hard to envision policy-driven pressure to relax in the future. Therefore, an early move towards decarbonization presents an opportunity to “future-proof” businesses as environmental regulations become stricter.

What are the main risks and opportunities?

Opportunities

- Alignment with societal concerns that influence consumer preference
- Improved brand reputation
- Stronger position in global sustainability indices and the capital markets
- More attractive to investors

Risks

- Increasing OPEX costs due to rising energy prices
- Exposed to policy changes particularly carbon tax / ETS
- Impact to brand reputation
- Increasing costs for policy compliance to avoid penalties

What can companies do to decarbonize?

Introduction to Scope 1, 2 and 3 emissions

According to the Greenhouse Gas Protocol, carbon emissions from a business can be classified into three scopes:

- **Scope 1 emissions** are direct emissions from owned or controlled sources, e.g. fuel combustion on site to provide heat, company vehicles, etc.
- **Scope 2 emissions** are indirect emissions from the generation of purchased energy, e.g. the CO_2 content of the consumed electricity.
- **Scope 3 emissions** are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions, e.g. emissions relating to business travel, purchased goods, waste generation, etc. Scope 3 emissions typically represent the highest share of a company's carbon footprint.

What does a decarbonization strategy look like?

Reducing emissions is not going to be a simple task, as there is a wide variety of actions and routes that can lead to decarbonization, different from business to business. The first step for companies should be to carve out a long-term energy strategy.

Internally this may be led by a dedicated team or person – this is what has led to the emergence of of the position of Energy strategist/specialist. In any case, more and more energy-related decisions are being made at a CXO level at companies. **Dedicating the responsibility in a clear way up to the top of companies for all aspects relating to decarbonization, beyond just documenting the commitment, can have a significant impact in the overall success of the transition.**

Beyond internal leadership, input from specialist companies, can be invaluable, as their knowledge and breadth of expertise will ensure that the focus is on the right actions that will have the biggest impact.

Actions on all scopes can be grouped in three different types: on the management side, on the energy demand side and on the energy supply side.

A. Actions on the management side

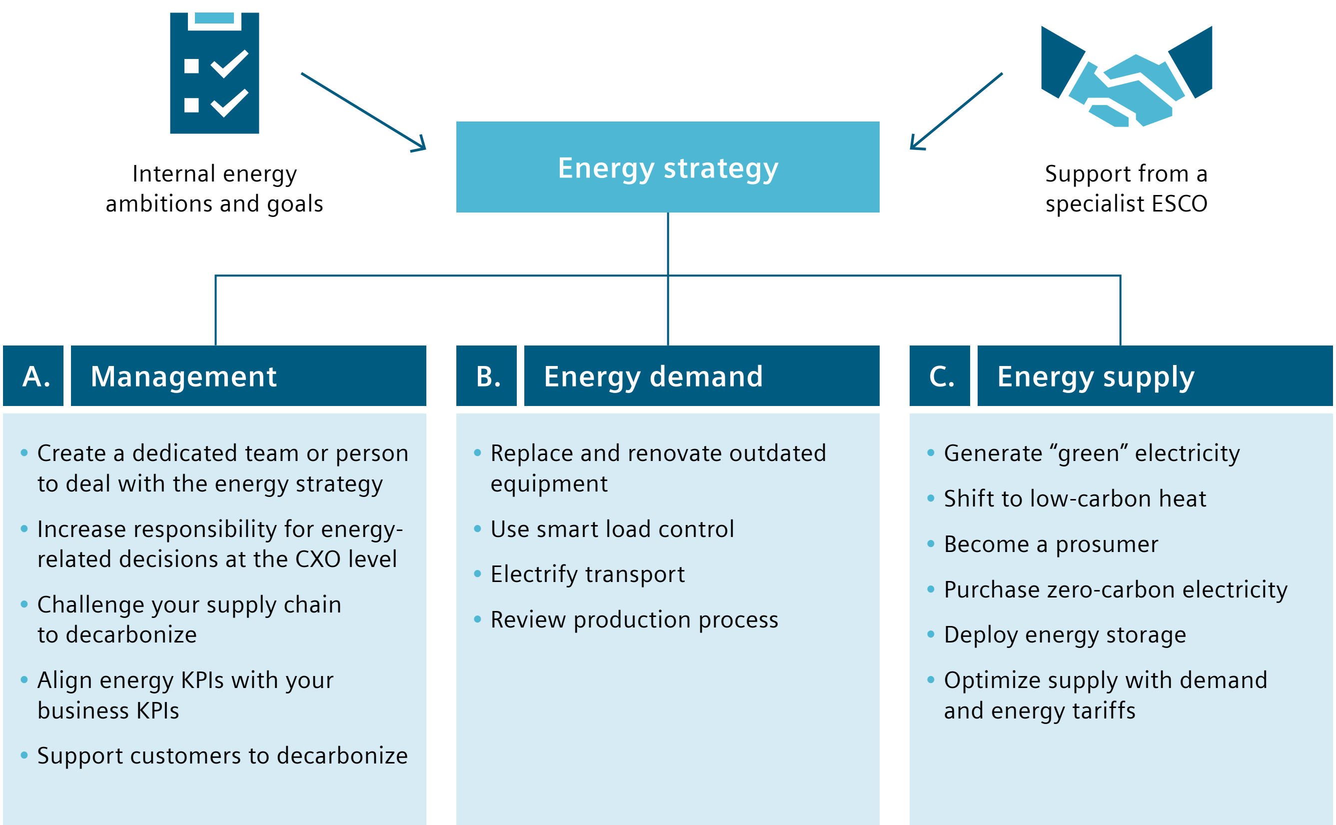
These actions will typically be overarching and strategic, for example:

- **Assigning responsibility to an energy specialist internally,** to ensure a realistic overall strategy is defined and successfully implemented.
- **Alignment of energy KPIs with business KPIs,** to make sure that energy indicators are being considered when measuring overall business success.

Or affect Scope 3 emissions, for example:

- **Challenging the supply chain to decarbonize,** as this will affect the carbon content of any purchased good.
- **Supporting customers to decarbonize,** leading to overall less carbon related to business output.

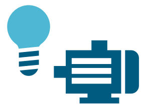
What are the typical actions that allow businesses to reach their decarbonization goals?



B. Actions on the energy demand side

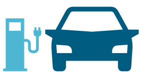
Any intervention on the demand side will typically target Scope 1 and 2 emissions. A key goal of these actions is energy savings, which will be translated into carbon savings and eventually OPEX savings.

Some typical actions on the demand side include:



Replacing and renovating outdated equipment is one of the most standard forms of increasing energy efficiency in a facility. The interventions can be anything from a basic upgrade to LED lighting to a more sophisticated upgrade to electric motors and their drives in a manufacturing facility or improvements in the efficiency of a building's HVAC system.

Using smart load controls that utilize digital solutions to go beyond just monitoring a facility's equipment. With the right control and automations, a business can have significant energy savings, while modern BEMS can go as far as simulating the facility and how it reacts to load changes.

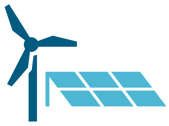


Electrifying a business' transport fleet can significantly reduce Scope 1 emissions, especially when combined with smart charging solutions.

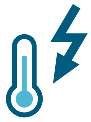
Reviewing production process. This refers to any energy savings that are a result of adjustments in parts of a production process, e.g. lowering the temperature of steam in a process without compromising overall process quality.

C. Actions on the energy supply side

The emissions mainly targeted here are Scope 2. Some typical actions on the supply side include:



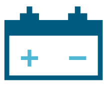
Generating "green" electricity on site, which involves power generation with low-carbon technologies, like solar PV, wind power, bioenergy, etc.



Shifting to low-carbon heat, can result in a drastic decrease in Scope 1 emissions. Decarbonizing heat is one of the biggest challenges that the energy industry is facing currently. Efforts are focused on increasing the efficiency of the supply (e.g. with a CHP system), electrification of heat (low or high temperature heat pumps depending on application) or decarbonizing the fuel source (e.g. moving from natural to "green" gas).

Become a prosumer in the energy markets, i.e. generate excess electricity that can be sold to the energy markets. This is a typical way that businesses can even achieve carbon "negativity" on the supply side, which is used to offset carbon from other parts of the business. It also helps to tap into new revenue streams from the commercialization of the excess energy.

Purchasing zero-carbon electricity, involves signing-up for green tariffs with suppliers or signing power purchasing agreement with a renewable energy generator leveraging the guaranties of origin for the energy consumed.



Deploying energy storage on its own is not necessarily providing carbon savings but can enable carbon savings when used as an optimization asset (e.g. optimizing power flow of on-site generation).

Optimizing supply with demand and energy tariffs, while on-site generation on its own already provides significant carbon reduction, this can be further enhanced by optimizing with other energy elements, from a basic storage and PV installation, to the holistic solution provided by microgrids. This can also be combined with energy tariffs adaptation, which can further optimize costs and carbon savings.

How can businesses minimize the risks from their decarbonization actions?

CAPEX requirements are often cited as the key barrier to the implementation of decarbonization projects. Businesses also often find it difficult to manage the risks around project execution, performance, and financing. For example, a project not performing as intended will not generate the expected savings, which will impact the overall return of investment and eventually have repercussions on the overall business.

ESCOs, like Siemens, have reacted to this with the business model of **"X-as-a-Service,"** which is an alternative model to traditional CAPEX investments that is growing in popularity over the last decade. There are different versions of these models depending on the targeted service, but "X" can typically be a variety of energy-related offerings: heat, energy, energy efficiency, lighting, carbon neutrality, etc. Regardless of what exactly is offered, the service typically is a financing solution that allows consumers to implement energy-related projects without CAPEX cost, therefore freeing up capital for core business.

For example, under an Energy Efficiency as a Service Agreement, the two parts will agree on recurring service payments, where the OPEX reduction from energy savings will be greater than the service fee payments, creating a win-win situation. The performance and execution risks are handled by the ESCO, which will typically own the equipment as there is no transfer of ownership. This further guaranties savings and therefore accelerates the achievement of decarbonization goals.

Main benefits from an X-as-a-Service Agreement

- No CAPEX requirements
- Cash-flow neutral
- Minimizing execution, performance and financing risks
- Accelerating decarbonization achievements

Summary of achievements, targets, and actions by some industry leaders

	Google	Microsoft	BMW
	Carbon-neutral since **2007**	**Carbon-neutral** since **2012**	**42%** **reduction in CO_2 emissions** since 1995
	100% powered by **renewables** since 2014	**100%** powered by **renewables** since 2017	**100%** of European plants powered by **renewables** since 2018
Future targets	**Maintain or improve energy efficiency in data centers** 2x as energy-efficient as a typical data center	Be **carbon negative** by **2030**	**Reduce CO_2 emissions** in EU fleet by at least **50%** by 2020
Actions	✓ Machine learning to improve energy efficiency in data centers ✓ Smart energy management systems for data centers ✓ LEED certification for offices	✓ Pilot at Seattle's data center powered by fuel cells using natural gas ✓ Carbon offset projects ✓ Recycling of e-waste	✓ Power from CHP plants at various manufacturing sites ✓ Optimization of production processes ✓ More electrified models in fleet

Decarbonization case studies

By 2030 most business will have already set-out a long-term energy and decarbonization strategy, because of the ever-increasing risks for businesses missing out on opportunity to decarbonize. Other companies will be able to already demonstrate a lot of success and achievements in their decarbonization transition.

This transition is already happening, and some of the leading companies in decarbonization already have plenty of achievements to show. The graph above summarizes some of their achievements, targets, and shows some of the actions that helped making this transition possible. It is worth mentioning that even very ambitious targets, will most likely require some simple actions on a smaller scale, for example in their headquarters buildings. These projects can be replicated by smaller scale businesses, which is important as decarbonization is something that will affect all businesses regardless of scale or sector.

An interesting example of such a project is the microgrid currently operating at **Siemens Corporate Technology North American Headquarters,** in Princeton, New Jersey, which could be replicated by customers interested to improve their building's energy efficiency, carbon footprint and resilience.

While this project targeted a specific commercial building, reducing its carbon footprint was in alignment with Siemens global policy, which has committed to be carbon-neutral by 2030 and reducing its CO_2 footprint by 50% in 2020.

Beyond practically providing a new energy source to the headquarters, the new system can serve as a platform for researching and demonstrating new technology for commercial building and microgrid operation.

Another example is using distributed energy generation with a high-efficient CHP plant in an **automotive industry,** which wanted to progress its own strategic energy and sustainability goals, along with compliance with EU emissions trading scheme and ISO 50001.

With the deployment of an energy center consisting of two CHP systems, the business managed to reduce its CO_2 emissions by 5,000 tons per year, while also making savings of €1,900,000 per year. The system also improved transparency in operational management and provided secure energy supply for production.

Project highlights from Siemens Princeton Island microgrid in New Jersey

Project goals

- Increase building energy efficiency
- Reduce CO_2 emissions through on-site renewable energy generation
- Alignment with Siemens global decarbonization policy and carbon footprint goals

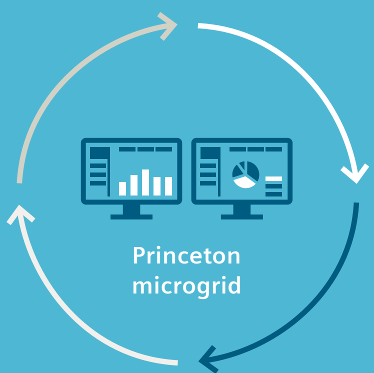
The solution

A holistic microgrid with renewable energy source capable of island operation, fully integrated with the building automation system

How it works?

Solar PV installation:
The panels generate the main source of energy for the facility and act as a roof shielding parked automobiles. The solar panels currently supply 60% of the facility's energy, while using the local power grid for the balance of energy generation.

Integration with the building management system:
Using digital twin simulation, the building's energy consumption can be optimized and can forecast how changes in the load will affect microgrid management.



Energy storage:
The energy storage system can give resiliency in the facility for about two to three hours hours under normal building load.

EV charging points integration:
Multiple EV charging stations located in the facility's parking lot are integrated into the microgrid.

Recommendations

You must act now to avoid risks and take advantage of the opportunities:

Decarbonization is happening now, and the political and technical drivers are only accelerating it. Every business will be impacted by this in the long-term which gives the chance for early movers to take advantage of the opportunities and more time to mitigate the risks of non-compliance.

Take responsibility internally for your decarbonization strategy:

The success of any strategy will largely depend on a strong commitment and responsibility from every business, best allocated to the CXO level with a dedicated position: clear targets, clear commitments and a clear budget are key prerequisites.

Get expert input from an ESCO, like Siemens

There is a wide variety of actions that can reduce your carbon emissions, which makes it difficult to prioritize the most impactful actions and to bring them together in the most effective way. Expert input can prove invaluable, especially from someone like Siemens who is active across the complete energy cycle from sustainable power generation to intelligent distribution and storage, and efficient energy use in C&I.

Focus initially on Scope 1 and 2 emissions

For most businesses, Scope 1 and 2 emissions will be easier to focus on initially. Actions taken to address Scope 1 and 2 emissions will typically involve financial benefits either in OPEX reduction or revenue generation.

Consider holistic approaches for optimization gains

Some decarbonization actions can provide further carbon reductions, when optimized with the wider energy system. For example, combining EVs with smart charging or bringing together on-site renewable generation assets into a microgrid, can enhance the sustainability benefits beyond what they would be if considered in isolation.

Abbreviations

BEMS	Building energy management systems
C&I	Commercial and industrial
ESCO	Energy Service Company
ETS	Emissions Trading System
EU-ETS	European Union – Emissions Trading System
EV	Electric vehicle
GHG	Greenhouse gas
HVAC	Heating, ventilation and air conditioning
KPI	Key performance indicator
LED	Light Emitting Diode
PV	Photovoltaic
V2G	Vehicle-to-Grid

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Delta-EE is a leading European research and consultancy company providing insight into the energy transition. Their focused research services include Connected Homes, Electrification of Heat, Electric Vehicles, New Energy Business Models and Local Energy Systems. They provide consultancy for clients including network companies, policy makers and utilities. Delta-EE's mission is to help clients successfully navigate the change from 'old' energy to 'new' energy.

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