Industrial Decarbonization Roadmap: Pharmaceutical Manufacturer Case Study

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ABSTRACT

DNV GL's Energy Transition Outlook 2020 estimates that final global energy demand in 2050 would be 613 exajoules (EJ)[1] were it not for energy efficiency. Because of energy efficiency efforts, we estimate that global demand will be reduced to 374 EJ in 2050, significantly contributing to global decarbonization. As organizations look to reduce energy and carbon, there is also value in limiting use of materials and water because these actions contribute to CO2 reduction and provide environmental and societal benefits.

For manufacturers, especially those with operations in several continents, we recognize the complexity in having a clear decarbonization roadmap that (i) sets sensible targets linked to science-based target initiatives; (ii) identifies the options to address Scopes 1, 2, and 3; and (iii) chooses a specific future scenario and pathway to achieve net-zero. Adding a water and materials efficiency requirement increases the complexity.

This paper uses a case study of a pharmaceutical manufacturer to demonstrate the analytical tools that can be deployed to assist organizations to develop a roadmap for reducing CO2. The tools will look at (a) scenarios, such as policy changes, current, and future energy, carbon prices, grid mix, and market growth and (b) the choice of options (e.g., energy efficiency, fuel switching, power purchase agreements or PPAs, and offsets) including capital and operating costs, reliability, CO2, water, and materials impacts. The tools will ultimately support manufacturers in their decarbonization pathways through merit-based interventions.

Introduction

To avoid catastrophic climate change and significant disruptions, global warming must be kept below 2°C. In order to achieve this target, it is necessary to reduce greenhouse gas (GHG) emissions from every sector of the global economy including the industrial sector, which is critical to global economic growth. This sector is energy and carbon intensive and contributes to around 30%[2] of global GHGs. Energy efficiency improvements have substantially reduced energy consumption and decreased the carbon footprint of industrial sector. However, to completely achieve net zero in this sector, it is not only critical to push the boundaries on energy efficiency (Scope 1), but also important to find alternatives to fossil fuel and feedstock while also implementing water and material efficiency. At the same time, companies need to address the challenging issue of reducing their Scope 3 emissions throughout their supply chains.

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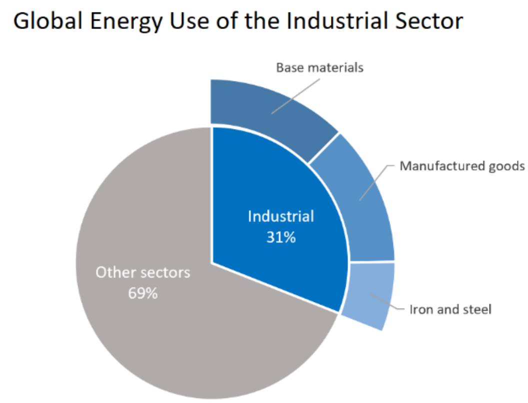
[1] 1 EJ = 10^{18} J.
[2]ETO available online at: https://eto.dnv.com/2020

DNV's 2020 Energy Transition Outlook (ETO) forecasts continued growth in manufacturing energy demand that peaks in 2030 at a level slightly higher than today. The industrial manufacturing sector consumed 133 EJ in 2020, which was 31% of the total energy demand across all sectors of the global economy. Within industrial manufacturing, base materials and manufactured goods each consumed approximately 40% of the manufacturing energy demand, while iron and steel represented the final 20% of manufacturing energy demand. As recycling and efficiencies continue to affect energy demand, the split between the three categories will shift, and by 2050, manufactured goods will use more than half of all manufacturing energy demand.



The ETO predicts energy demand for manufactured goods will increase by 32% until 2050, reflecting the growth in underlying demand from a more prosperous and populated world. Automation and digitalization will change the nature of production while agile supply chains and near-shoring will drive efficiencies. Meanwhile, even with significant efforts—huge energy efficiency efforts, supply and demand side management interventions, emerging technologies, material efficiencies, and automation and digitalization—industrial manufacturing faces more barriers than other sectors to decarbonize and electrify.

Electrification could change existing processes in ways that have the potential to introduce new challenges, specifically when the processes are complicated. The major challenge in reducing emissions comes from replacing feedstock with non-fossil fuel alternatives. This could especially be challenging for steel and cement manufacturing, which requires extremely high process temperatures, though we do see technologies such as Arc Furnaces in use in that sector. Additionally, some of the alternative feedstocks in industrial manufacturing are in the nascent stage of development, many of which are still not yet cost effective and commercially viable.

We recognize the complexities for industrial manufacturers to completely decarbonize and achieve carbon zero includes issues like:

- Understanding their carbon zero objectives
- Setting up science-based targets that align with the objectives
- Identifying options to address Scopes 1, 2, and 3
- Choosing a specific future pathway to achieve net-zero
- Setting-up data collection framework and improvement plans
- Identifying key performance indicators (KPIs)
- Reporting them in real-time to monitor progress

To accomplish the decarbonization goals in industrial manufacturing, planning is key. Along with the planning, there is a need to have analytical approaches and tools to assist organizations in developing and deploying solutions to achieve zero carbon. This paper shows the approaches and tools that could be used throughout the process of achieving net zero. That includes the initial step of defining an organization's decarbonization mission and vision, engaging key stakeholders, defining reduction options, running various scenarios to reflect how emissions evolve over time, reporting KPIs, and finally achieving net zero.

Figure 1 below shows DNV's step-by-step approach of establishing a decarbonization roadmap. In addition, the paper digs deeper and discusses a carbon neutrality roadmap that DNV developed for a pharmaceutical manufacturer for achieving its net zero goal.

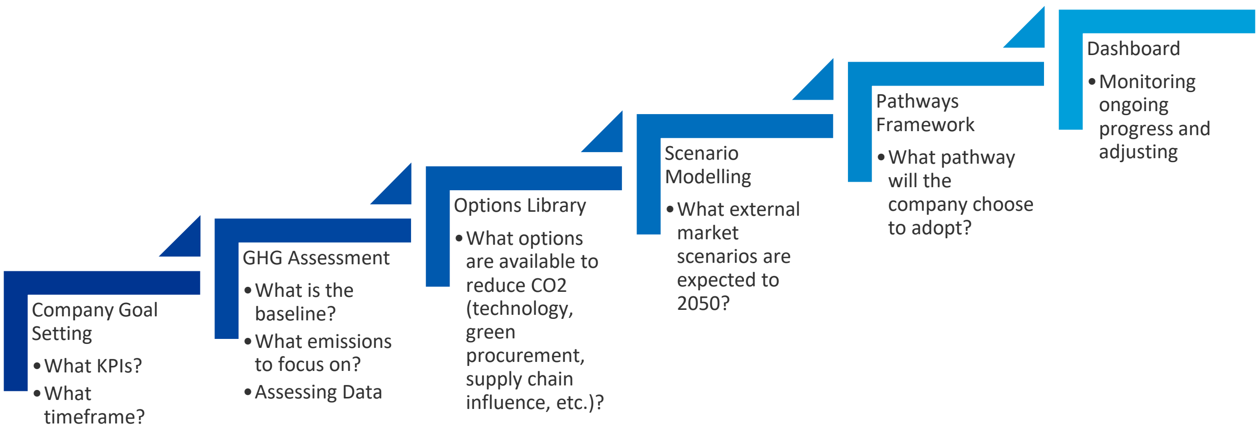


Figure 1. Step-by-step approach of a decarbonization roadmap

DNV recently performed a roadmap to carbon neutrality for a major vaccine supplier that is currently manufacturing many of the COVID-19 vaccines being deployed to fight the global pandemic. Given DNV's experience in the arena, as well as the timely importance of this kind of manufacturing, this paper will reference vaccine manufacturing as an example of industrial decarbonization throughout. Like other industrial-use types, the need to create high temperature hot water and steam for sterilization and other pharmaceutical manufacturing needs make decarbonization especially difficult in these settings.

Company Goal Setting

Company goal setting is the first and foremost step of the decarbonization journey that defines the pillars to the carbon emissions reduction strategies of the organization. The science-based target initiatives (SBTi) to meet carbon reduction goals for an organization should consider a few key principles:

- What does net zero mean for your organization?
- Will the decarbonization journey to net zero keep global warming to well below 2°C and ideally close to 1.5°C, in line with the Paris agreement?
- Is the organization considering the impacts that climate change will have on the supply chain?
- Has the organization considered the long-term strategy and impacts to its business?

The aim is to achieve CO2 reduction. But this will be done differently at each level of the organization. As well as internal drivers, companies need to look at external forces to achieve an effective roadmap. We will also see regional variations in terms of access to technologies (e.g., hydrogen, closed carbon capture, electrification), grid intensity, power purchase agreements (PPAs), etc. We can combine various data sources and tools to help companies identify clear roadmaps to net zero. This process includes bringing together the tools, ideas, and forces presented in Figure 2.

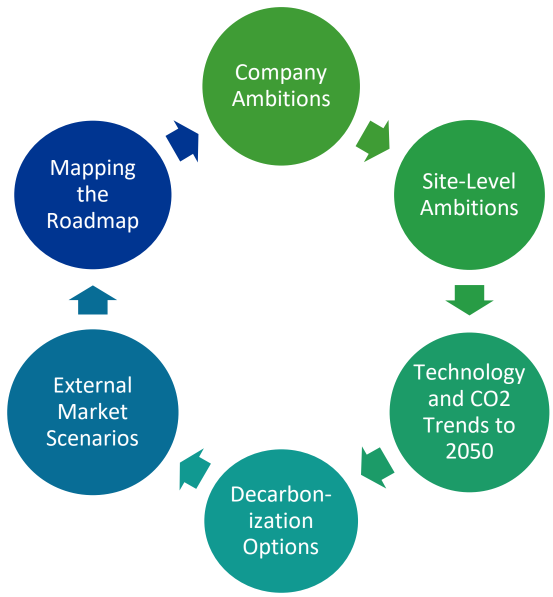


Figure 2. Mapping the course

Companies have various options for CO2 reduction using a variety of internal data shown in Figure 3.

Figure 3. CO2 reduction options

The Paradigm Shift - Carbon Neutral and Zero Carbon Targets

Recently, many corporate and industrial clients have publicly stated carbon neutral or net zero carbon targets. Merck recently announced a goal of carbon neutrality in operations by 2025. Google plans to run on carbon-free energy 24 hours a day, 7 days a week by 2030. In 2021, Pepsico announced a goal of reaching net zero carbon by 2040. It is clear that corporate goals that include a path to net zero carbon or carbon neutral represent a substantial and necessary challenge compared with less stringent previous goals such as 50% reduction by 2030 against 1990 baseline. A change in thinking and approach is necessary within the industrial sector in order to meet the challenge. This is also true for net-zero energy buildings and zero carbon campuses.

Some previous efficiency approaches that work for a vaccine manufacturer planning to reduce emissions, but do not work in a zero-carbon future, include:

- What if I add high-efficiency, condensing gas boilers to save carbon? Dead end.
- If I use combined heat and power for gas turbines, won't that help? Unless you source the biogas, which is an extremely difficult proposition. No, that will not help.
- I only need fossil fuel for this one end use. Then you will never achieve zero carbon.
- What if the lifecycle cost analysis shows a better payback for fossil-fuel-fired systems? Then you have succeeded in saving money but failed to hit your climate goals.

Zero carbon is the only logical pathway to have a chance at avoiding climate catastrophe and is also extremely difficult. However, it is in no way insurmountable. Industrial facilities can meet this challenge. All that is required is planning, effective and timely action, and the shift in in the organizational mentality.

Undertaking GHG Emissions Assessment

Scoping – What's In? What's Out?

The first step to inventorying existing GHGs and creating mitigation strategies is understanding what is in scope. Our vaccine manufacturer knows that the fossil fuels it burns on site are part of its emissions, but what about the fossil fuels embedded in the electricity supply? Employee automobile and air travel? How about the emissions of the trucks that deliver the core components that go into the vaccines? What about the emissions at the centers that create and supply precursors and other components used in the industrial process? The plastics, vials, and instruments are all made elsewhere and have associated emissions.

System boundaries and scoping are the key first step for an organization. Making the right long-term decisions is critical because changing the baseline later can be a costly exercise. GHG inventory protocols break things down into Scope 1, 2, and 3 emissions. Figure 4 gives guidance on these scopes.

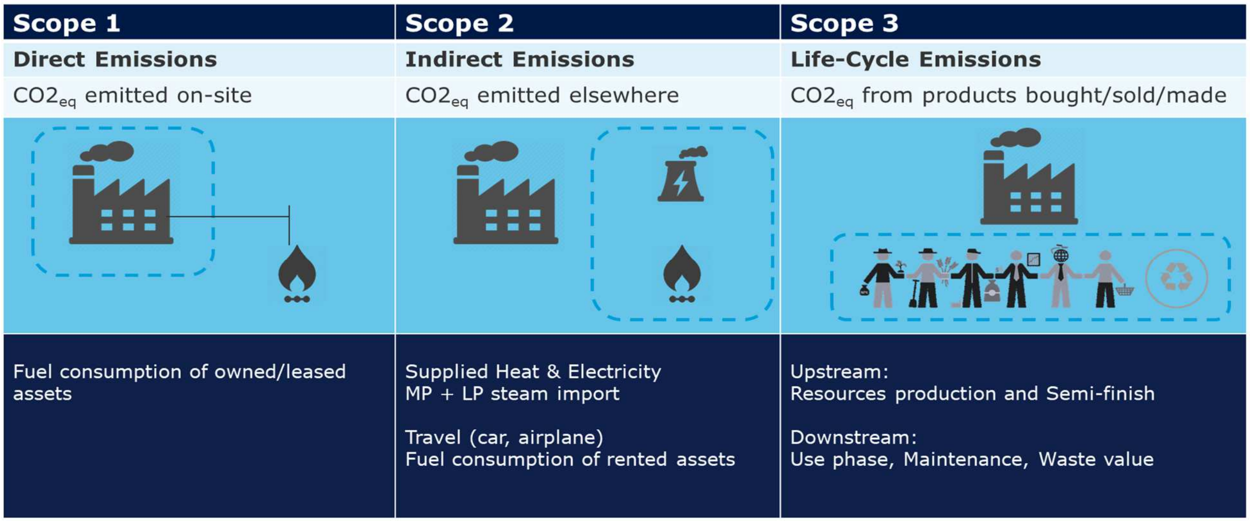


Figure 4. GHG-defined emission scopes

We recommend Scope 1 and 2 to be within the bounds of a GHG inventory and mitigation strategy. Scope 3 is important but reducing emissions of one's upstream and downstream supply chains requires a different approach. While focusing on going to zero on embodied emissions is important, it is best performed as a separate task.

Creating a Baseline

California's Global Warming Solutions Act of 2006[3] provides an example of how GHG reduction goals are formed. The bill requires the state to be 15% below 1990 emissions levels by 2020. The first step in creating a GHG reduction strategy is to perform a GHG inventory. Figure 5 shows our vaccine manufacturer's types and breakdown of emissions:

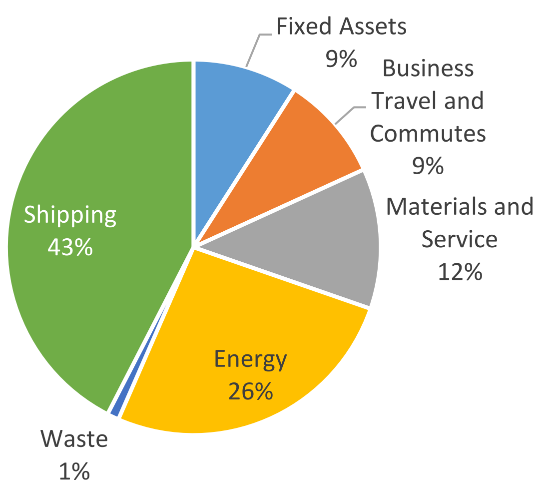


Figure 5. GHG emission inventory of the vaccine manufacturer

[3] https://ww2.arb.ca.gov/resources/fact-sheets/ab-32-global-warming-solutions-act-2006

Accessing Data

To ensure a successful development and implementation of the roadmap, it will be important to engage with key stakeholders and actors, as the strategy will impact on all parts of the business. This is especially true when it comes to establishing access to the data critical in the GHG assessment process. This starts with access to historical and ongoing energy billing data. This data will be fundamental to the Scope 1 assessment. Ensuring all forms of energy consumed at business locations is critical for the Scope 1 mapping to be accurate and successful.

Moving into the Scope 2, the GHG assessment process requires an expanded assessment of energy bought (gas and electricity), energy used by employees in to get to and from work as well as energy used by corporation assets that travel outside of business locations.

Table 1 outlines the core sources of data which are typically collected when performing an inventory, and where this data can be found.

Table 1. GHG assessment data requirements

Data Requirement	Where and How to Access
Electricity and gas use data	Accessed via historical energy bills or on-site energy meters. If the building is leased and energy use is rolled into the monthly lease cost, then reports should be collected
Diesel fuel usage for emergency generators and other equipment	Purchase orders are the most reliable data source. Emergency generators can be estimated based on run-time and capacity. Testing typically represents the bulk of usage for emergency generation.
Propane	If propane is used for forklifts or other purposes, purchases should be tracked.
Refrigerants	HVAC systems containing refrigerant and refrigeration systems should be inventoried and any re-charge activities should be tracked in order to include in the inventory.
Vehicle fleet fuel usage	Fleet records of fuel purchases should be available and are collected for accounting. If not, annual mileage can be used as a corollary and multiplied by average miles per gallon.
Employee commute fuel usage	Employee commutes are best captured with surveys focusing on the type of commute, distance from home, how often commute occurs, and efficiency of vehicle used in commute.
Employee airline travel	Airline travel can be collected via re-imbursement information or a survey. A standard megaton of CO2e per mile flown will be applied to the data.

Tracking Progress – Regularly Reassessing the Inventory

When working with our vaccine supplier, we recommend reassessing the inventory on an annual basis. While this requires more work than reassessing every five years, an annual inventory means that staff will be familiar with the process and the data should be easier to collect.

All assumptions and data collection methods should be the same for each year of the inventory. For this reason, it is critical to establish best practices in Year 1. Methods for GHG inventories are constantly evolving. However, careful planning during the first inventory ensures that changes in internal calculation methodology will be rare.

Presenting a Library of Options

Each system that uses fossil fuels in industrial processing requires its own approach to decarbonization, and there are often multiple options for each piece of equipment. At our vaccine manufacturing plant, there were several low-hanging fruits to decarbonize. For example, localized water heaters, small packaged HVAC units, split HVAC systems, and cooking equipment in the cafeteria were all easy to decarbonize with relatively straightforward and vetted equipment alternatives. However, pharmaceutical decarbonization had two big challenges:

- Steam necessary for processes and sterilization can be a challenge with equipment available today. Heat pumps are not designed to produce high-pressure steam.
- Heating loads are substantial in lab environments due to the high amount of fresh air required to ensure airborne contaminants do not harm workers in the space. Air change rates as high as 12 air changes per hour (ACH) are common. By comparison, offices often see rates as low as 2 ACH.

Table 2 presents just a few of the options that were presented to our vaccine manufacturer for review:

Table 2. Example of decarbonization options for vaccine manufacturer

Decarbonization option	Short description
Low-carbon electricity	Low-carbon electricity comes from processes or technologies that produce power with substantially lower amounts of carbon dioxide emissions than are emitted from conventional fossil fuel power generation. It includes low-carbon power generation sources such as wind, solar, hydro- and nuclear power, and largely excludes conventional fossil fuel plant sources, but also a shift from heavy fuel to gas combustion.

Decarbonization option	Short description
Improved waste heat recovery	Recover heat currently wasted (e.g., through condensate heat recovery, preheating input with low-grade heat from used cooling streams, heat grids, fuel cells, etc.)
Energy management system	Changing how energy is managed by implementing an organization-wide energy management system (e.g., ISO 50001 or other programs) is one of the most successful and cost-effective ways to bring about energy-efficiency improvements.
Biomass as fuel	Biomass fuels are used to replace fossil fuels (e.g. directly combusted in steam boilers or turbines), converted into syngas via gasification, or converted into methane via anaerobic digestion.
State-of-the-art HVAC and cleanrooms	By sizing equipment properly and designing energy efficiency into a new facility, a manufacturer can minimise the energy consumption and operational costs of its plant HVAC systems and cleanrooms from the outset.
Long-term process intensification	Deployment of long-term process intensification techniques (e.g., miniaturization and creating synergies between process steps) optimize energy use.
Clustering	Clusters are groups of interrelated industries in a defined geographic area, sharing common markets, technologies, worker skill needs or buyer-seller relationships. By clustering local industries, energy costs are shared, heat and resources are used wisely, and benefits increase. Connecting industrial sites close to each other allows efficient use of energy and materials.
New car policy	Implement a new car policy and engage the staff to use more electrical vehicles (EVs) and cleaner technologies.
Optimizing delivery logistics	Combine customer orders or delivery of raw materials.

Decarbonizing Combined Heat and Power Systems

In the world of green building design, order of operations is a key component to attaining ultra-high performance. Proper site design and orientation is followed by smart envelope design. High-efficiency systems are selected only after the loads of those systems are minimized. Finally, renewable energy generation is designed to meet the requirements of the design that uses half the energy it would have otherwise used. Decarbonizing combined heat and power (CHP) systems can benefit from the same whole systems approach performed in the right sequence.

At our vaccine manufacturing facility, steam is a critical component to sterilization. Most industrial facilities have the need for steam or high thermal demand coupled with the need for electricity and many people immediately consider CHP an elegant solution. It provides a way to cut energy costs while reducing carbon emission by 30%. However, reliance on CHP can also be a trap, making carbon neutral goals nearly impossible. Fossil-fuel powered turbines are not an effective way to eliminate fossil fuel use.

Since many industrial plants already operate mature CHP systems, finding a way to cost-effectively decarbonize these CHP plants is critical to a carbon neutral industrial site. We recommend the following approach, in the following order:

1. Implement efficiency throughout the facility, specifically focusing on efficiency in hot water and space heating use.
2. Remove loads from the plant. For low temperature needs, like building space and water heating, consider heat recovery chillers or air-cooled heat pumps to provide low-cost, fully electrified pathway. Small residential-sized water heaters or cooking equipment on-site might use steam because it is available, but they can easily be electrified. Can non-steam sterilization methods be used for the company's processes?
3. Utilize heat recovery from chilled-water systems, sewer systems, and other heat sources. Heat recovery chillers should be implemented at any site with large-scale simultaneous heating and cooling needs. Look at neighboring sites that might not be owned by the facility. Is there a source of waste heat that could be utilized at your site?
4. Solar thermal systems, especially parabolic trough systems capable of heating water above its boiling point, can provide an opportunity for high-grade heat.
5. Ground-source heat pumps provide a reliable source of heat that could help meet the site loads. These can be expensive to implement but are typically well-received during community relations campaigns.
6. Consider biomass/biogas. Now that the plant has been downsized substantially, there may be half as many CHP engines to operate. Is there a local source of biomass or biogas? If the industrial facility can find wastewater treatment plants, landfills, or agricultural biogas opportunities in the area, installing an anaerobic digester and using the gas via a public-private partnership would be a win-win for the plant and the community.
7. Hydrogen fuel cells are a nascent technology, and hydrogen is still sourced primarily from fossil fuels. These are a promising option in the future but cannot be widely implemented until large-scale hydrogen fuel cells renewable hydrogen is available at scale.
8. Carbon capture may be an option at a pharmaceutical site that has carbon dioxide needs and can capture the gases from the flue.
9. Electrode boilers are the last option if high temperatures are absolutely required and all other choices have been exhausted. They are less efficient than heat pumps and require high electric demand. However, there are grid and decarbonization benefits. When looked at in reverse, the high demand can be considered a dispatchable asset that turns on when renewable energy is overly abundant. If coupled with thermal storage, this system can be a fully electric alternative to traditional gas-fired cogeneration systems.

Running External Scenarios

The objective of this step is to develop a series of scenarios to establish realistic and achievable targets based on SBTi guidelines. The number of scenarios depends on the uncertainty linked to each measure or the likelihood that each measure will be selected. In most instances, DNV run three scenarios to understand how the emissions are likely to change in the future based on external drivers. A scenario is a set of specific conditions that can directly or indirectly affect the ability of the company to reduce its emissions, in one direction or the other. The parameters used to describe these different versions of the future take into account different qualitative assumptions such as international consensus, the international economic context, the availability and price of resources, international agreements on climate change, the attitude of the consumer towards sustainable products and energy efficiency, collaboration between sectors and organizations, and demography.

Since it is not possible to know what the world of tomorrow holds, the use of scenarios is a way of testing the robustness of different pathways. The three different tested scenarios for industrial manufacturing are briefly described below.

Pessimistic Scenario

This scenario represents a future where low global growth is observed and where new international agreements on climate change are struggling to be implemented. The end consumer has no particular interest in products from less energy-consuming or less emitting processes, which does not stimulate innovation and even less the development of new low-carbon process technologies. The price of electricity remains highly unpredictable and only a weak decarbonization of the electricity network is noted. This scenario can be summed up by a future in which decarbonization is clearly not a priority. A growth of 75% of the predicted growth has been considered in this scenario.

Neutral Scenario

Some progress is visible on the appearance of new agreements aimed at reducing emissions. Growth remains in the world. This leads to an increase in energy demand in a market where the supply of low-carbon energy remains limited.

Optimistic Scenario

This future reflects a positive economic climate, bringing with its significant global growth and facilitating access to sustainable products. Research and innovation allow the emergence of major technological breakthroughs with an immediate effect on reducing emissions. A growth of 125% of the predicted growth has been taken into account in this scenario.

Figure 6 shows the three different scenarios and the pathways for each scenario.

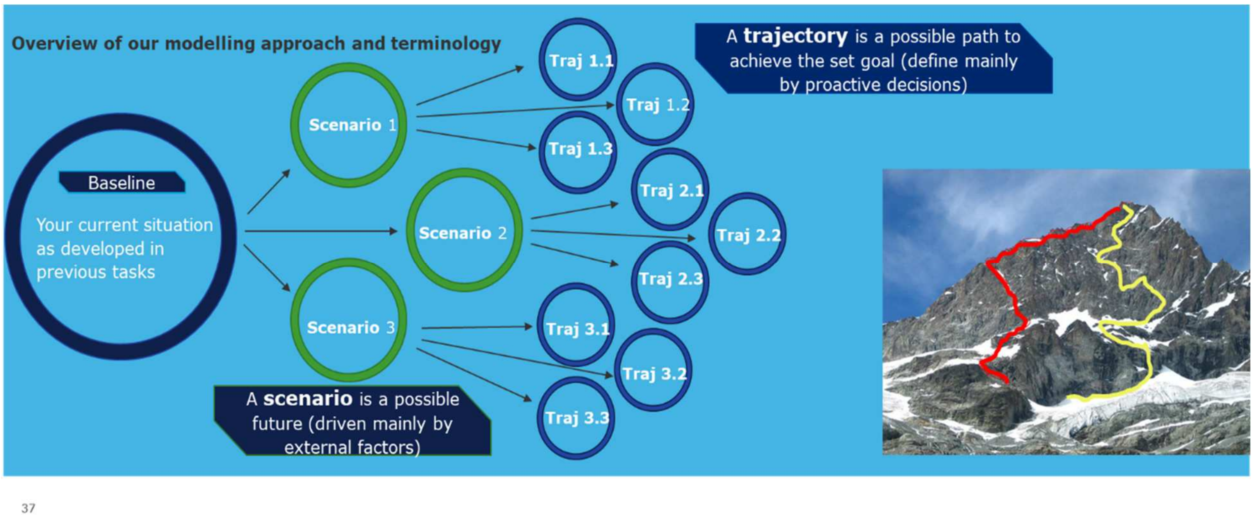


Figure 6. Decarbonization scenarios and pathways

Defining Pathways Model

A pathway represents a particular selection of decarbonization options and the deployment of these options from the base year to the year the organization plans to achieve net zero. This is the task where the rubber meets the road which shows the decarbonization potential of the organization from the reference year to net-zero year. All of the pathways allow us to visualize a combination of options that the organization could deploy over the next decade. Each trajectory is made up of different technological options that are implemented at different levels over time. Each option includes a number of key parameters, such as CO2 reductions, fuel changes, applicability, current adoption (in base year), and deployment. For each of the scenarios described in the section above, we run three trajectories to identify the size of the challenges to achieve the milestones set in the previous step and the needed timeline to implement the decarbonization measures previously identified. Three typical trajectories are described next.

Reference pathway. The reference pathway corresponds to the relative evolution of the company's emissions linked solely to the growth or decline of its activities and a variation in the average rate of emissions from the electricity network linked to the electricity production. It excludes any new specific energy efficiency or emissions mitigating action being implemented. The reference pathway also assumes that the electricity will not be carbon neutral and use the grid factor for carbon emissions related to Scope 2. The pathway will serve as a point of comparison.

Business as usual (BAU) pathway. This pathway consists of a continuous deployment of economically interesting technical options, existing or still to be developed.

Max Tech pathway. The Max Tech pathway consists of a deployment of options allowing the maximum technical decarbonization potential of the company to be reached.

The pathways will lead to different decarbonization levels depending on the hypothetical scenario considered.

Modeling the Pathways

The pathways were constructed by adapting the deployment rate of the options according to the elements described in each scenario. For example, to obtain a specific level of decarbonization in 2030 in the optimistic scenario, the options were typically deployed more quickly and to a greater degree compared to the actions involved in the other two scenarios. The result sometimes shows that the same level of decarbonization can be achieved under a different scenario. This is explained by the fact that the hypotheses of a scenario can have opposite effects (growth and a lot of investments in low carbon solutions in an optimistic scenario or decrease and few investments in low carbon solutions in a pessimistic scenario).

The objective of the modeling, which implies the analysis of the different pathways, is to gather the data collected through different sources and to think in a rather broad way, in the manner in which the emissions generated by the company could be develop by 2030. The model thus makes it possible to indicate the order of magnitude of emission reductions that could be achieved when different technological options are implemented. It also demonstrates what would be the influence of different deployment timings on the results thus obtained.

The first step of the modeling is to model three individual options for each of the scenarios. So, essentially resulting in nine trajectory curves across three scenarios and three pathways. This modelling will take into account a set of parameters such as the adoption and applicability levels, the impacts, etc.

For our pharmaceutical manufacturer we modeled three pathways under each of the three scenarios discussed in the previous section.

Figure 7 shows the three trajectories for the neutral scenario. The figure shows the organic growth of the company will increase the emission from 2020 to 2030 (green line is reference pathway), but the decarbonization projects will deliver the carbon emissions reduction for the BAU pathway (blue line) and for the Max Tech pathway (red line). These emissions reductions have been due to a combination of the 30 decarbonization options identified in the Running External Scenarios section of this paper.

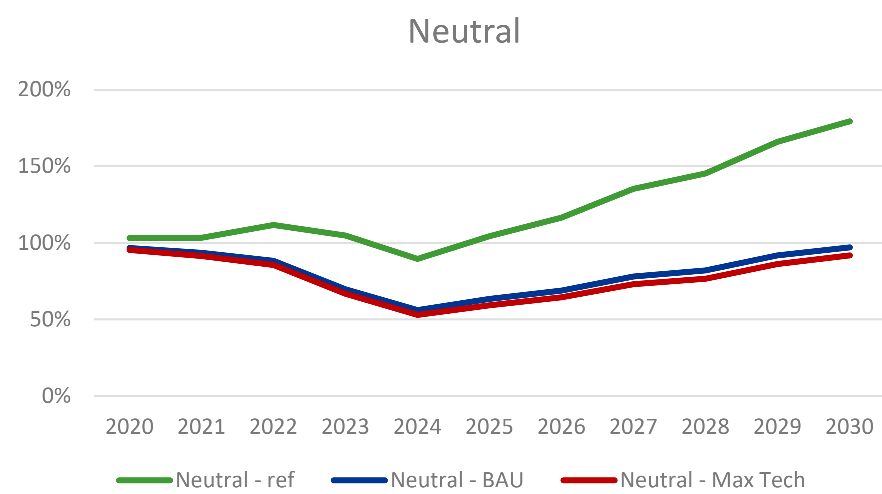


Figure 7. Pathways for neutral scenario

Figure 8 shows the three trajectories for the pessimistic scenario. In this scenario, organic growth would have usually led to an increase in emissions if we refer to the evolution of emissions between 2020 and 2030 for the reference pathway, but a significant increase of GHG emissions is noted due to the following factors: reduction in green certificates (resulting in higher Scope 2 emissions), negative energy shift towards fossil fuels, and some investments with positive impact delayed.

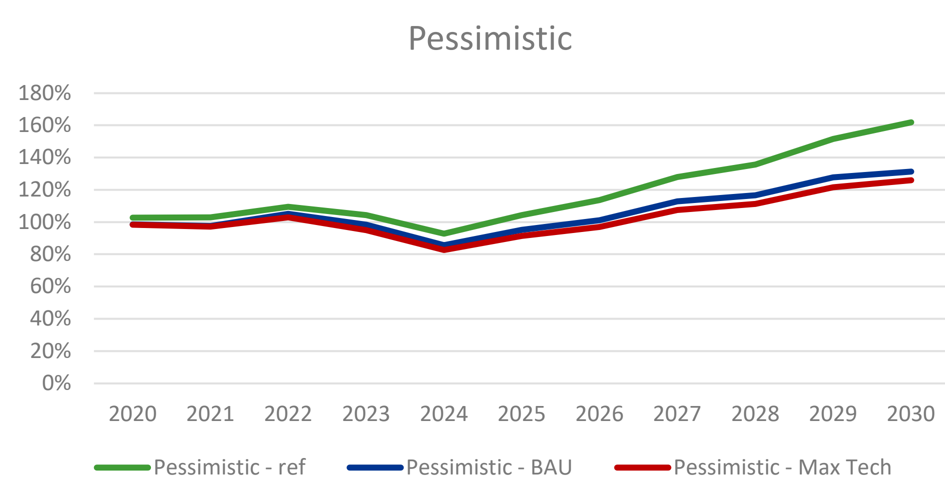


Figure 8. Pathways for pessimistic scenario

Figure 9 shows the three trajectories for the optimistic scenario. Although organic growth would have usually led to an increase in emissions if we refer to the evolution of emissions between 2020 and 2030 for the pathway reference, the carbon reduction projects will deliver carbon emissions reductions for the BAU pathway, and for the Max Tech pathway. On the other side, more investments to offset the emissions will be needed.

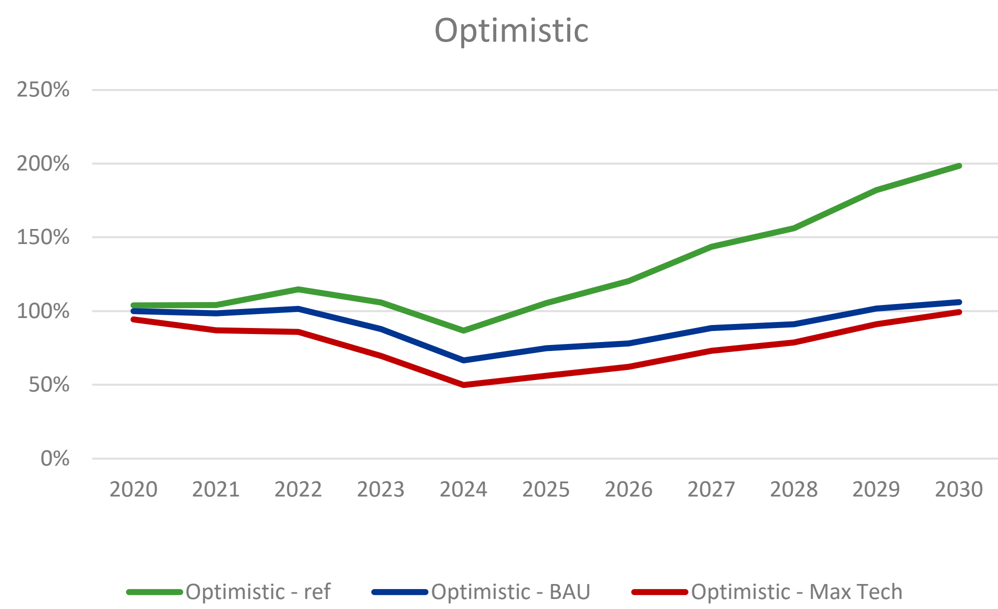


Figure 9. Pathways for optimistic scenario

While the pharmaceutical company will continue to look for opportunities to improve the energy efficiency of the manufacturing facilities and to further develop low carbon solutions, the following options were identified in all three scenarios as key additional focus areas up to 2030 to cut back the emissions:

- Low-carbon electricity
- State of the art cooling system
- Energy management system
- Improved waste heat recovery
- State of the art steam systems
- New CHP
- More efficient process equipment and devices
- Clustering
- Optimize delivery routes
- Environmental criteria for tendering processes

Those options will support the manufacturing to deliver on the carbon footprint target while delivering financial benefit to the company.

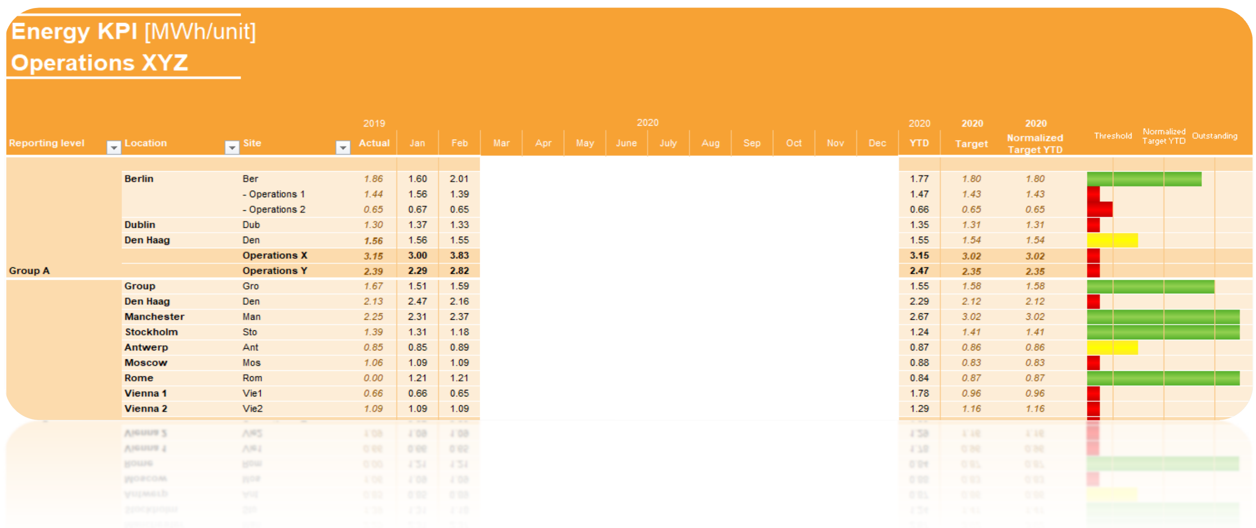
Dashboard to Track Progress

Management thinker Peter Drucker has often been attributed with the quote that "you can't manage what you can't measure." In other words, without clear established KPIs, you cannot quantify progress and address your process to produce desired outcome. Hence, it is critical to have KPIs defined and tracked to be successful in the decarbonization journey.

Some of the agreed upon annual carbon reduction KPIs for the pharmaceutical company described in the paper were:

- GHG emissions in million metric ton for scope 1, 2, and 3
- Waste disposed in million kilograms
- Energy use in million gigajoules
- Water withdrawal in million cubic meters
- Hazardous waste disposed and recycled in million kilograms

Figure 10 shows a typical digital dashboard that is used to track and report carbon reduction KPIs. Carbon reduction KPIs for an organization are typically decided during the goal-setting phase and based on the organization's sustainable goals and scope of the decarbonization.



Energy KPI [MWh/unit]
Operations XYZ

Reporting level	Location	Site	2019 Actual	2020 Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	2020 YTD	2020 Target	2020 Normalized Target YTD	Threshold	Normalized Target YTD	Outstanding
	Berlin	Ber	1.86	1.60	2.01											1.77	1.80	1.80			
		- Operations 1	1.44	1.56	1.39											1.47	1.43	1.43			
		- Operations 2	0.65	0.67	0.65											0.66	0.65	0.65			
	Dublin	Dub	1.30	1.37	1.33											1.35	1.31	1.31			
	Den Haag	Den	1.56	1.56	1.55											1.55	1.54	1.54			
		Operations X	3.15	**3.00**	**3.83**											**3.15**	3.02	3.02			
Group A		**Operations Y**	2.39	**2.29**	**2.82**											**2.47**	2.35	2.35			
	Group	Gro	1.67	1.51	1.59											1.55	1.58	1.58			
	Den Haag	Den	2.13	2.47	2.16											2.29	2.12	2.12			
	Manchester	Man	2.25	2.31	2.37											2.67	3.02	3.02			
	Stockholm	Sto	1.39	1.31	1.18											1.24	1.41	1.41			
	Antwerp	Ant	0.85	0.85	0.89											0.87	0.86	0.86			
	Moscow	Mos	1.06	1.09	1.09											0.88	0.83	0.83			
	Rome	Rom	0.00	1.21	1.21											0.84	0.87	0.87			
	Vienna 1	Vie1	0.66	0.66	0.65											1.78	0.96	0.96			
	Vienna 2	Vie2	1.09	1.09	1.09											1.29	1.16	1.16			

Figure 10. Dashboard Reporting of KPIs

Conclusions

To achieve climate stabilization and reach zero emissions by 2050, it is critical to decarbonize the industrial sector. Not all organizations will be able to achieve this goal at the same pace but with top-to-bottom engagement, thoughtful planning, effective tracking, and ongoing efforts, the goal is attainable.

Achieving decarbonization in the industrial sector will require a range of different interventions both on the supply and on the demand side. Supply side opportunities will include various energy efficiency technologies, direct carbon capture, renewable generation of electricity, and hydrogen technology for process heating and chemical feedstock. Similarly, some of the demand-side approaches include reducing material waste, optimizing process equipment, using emerging technologies in the production process, using low carbon material, substituting high-carbon materials, and circular economic interventions such as enhancing longevity and improving reusability and recyclability. Even with availability of state-of-the art technologies, it still may be challenging for organizations to achieve net zero without proper planning and targeted approaches.

As discussed in this paper, planning is key to achieve decarbonization that includes establishing the organization target of GHG reduction, setting up timeline of for attaining the target, and identifying potential solutions that can be implemented to achieve the target. Along with planning it is critical to have established approaches and tools to help industrial organizations achieve their decarbonization goals in terms of collecting and assessing appropriate data, defining right baseline, establishing scenarios, defining carbon zero pathways, selecting technology options, modeling various trajectories, and track and monitor KPIs. The case study described in the paper shows how careful planning and use of proper approaches and tools helped the pharmaceutical company to establish a roadmap to support their decarbonization ambitions.

References

DNV Energy Transition Outlook 2020. A global and regional forecast to 2050
Climate Strategies and Metrics. https://eto.dnv.com/2020

World Resource Institute, UNEP-FI and 20 investing portfolio carbon initiative, Christopher Weber and Mark Fulton, WRI Consultant, August 26,2015

Decarbonization of industrial sectors: the next frontier, McKinsey & Company report, June, 2018

Understanding Industrial Investment Decision Making, Russell Christopher and R. Young, Report Number IE124, October 2012

Electrification & Decarbonization: Exploring U.S. Energy Use and Greenhouse Gas Emissions in Scenarios with Widespread Electrification and Power Sector Decarbonization, Steinberg, Daniel D. Bielen, J. Eichman, K. Eurek, J. Logan, T. Mai, C. McMillan, A. Parker, L. Vimmerstedt, and E. Wilson National Renewable Energy Laboratory