



Framework for Greenhouse Gas Emissions Reduction Planning: Industrial Portfolios



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Introduction

The Framework for Greenhouse Gas Emissions Reduction Planning: Industrial Portfolios articulates a process to help industrial organizations develop a specific, actionable plan to achieve Scope 1 and Scope 2 greenhouse gas (GHG) emissions reduction – an Emissions Reduction Plan (ERP). An ERP covers an entire portfolio of facilities, yet contains enough detail to be practically useful at the facility level. The work required to develop an ERP will enable organizations to:

- Understand and characterize their emissions sources
- Set ambitious and specific GHG emissions reduction goals, such as goals set as part of the DOE's Better Climate Challenge
- Explore emissions mitigation activities
- Understand unique barriers faced by the organization
- Define a workable, phased plan of mitigation activities
- Create strategies for thoughtful implementation of the plan
- Communicate the organization's strategy internally and externally
- Assess progress towards achieving their goals



WHY DEVELOP A GHG EMISSIONS REDUCTION PLAN?

Organizations may find many benefits to developing an ERP. An ERP translates targets into action and ensures members of an organization at all levels understand the resources needed to achieve goals. Some of the potential benefits of an ERP include:

- Offers stakeholders confidence that the organization is committed to sustainability and has the resources needed to turn its ambitious targets into action.
- Describes the key steps an organization needs to take to achieve its emissions reduction targets.
- Aligns decarbonization ambitions with the operational actions needed to achieve them (i.e., capital planning processes, maintenance/replacement decisions).
- Provides confidence in decision-making when opportunities arise, and supports organizations in avoiding decisions that lock in carbon emissions for the foreseeable future by integrating decarbonization principles throughout all organizational practices.
- Analyzes multiple scenarios to aid in identifying the most financially and technologically feasible strategies for the organization.
- Forecasts the financial and personnel resources needed to accomplish the target to secure support at the executive level to implement projects in a comprehensive way, rather than obtaining approval for individual projects.
- Ensures continuity of decarbonization efforts even despite organizational change or staff turnover.
- Prepares an organization to respond to and comply with GHG regulatory and reporting requirements and avoid the associated potential financial penalties.



HOW CAN THIS FRAMEWORK BE USED?

The Framework guides organizations through five milestones to developing an ERP, which can be found in FIGURE 1. It also provides guidance on how to plan for effective, ongoing implementation of the plan. This preview describes each milestone, why it is included in the Framework, and how each milestone proceeds to the next one to fully define a successful, implementable ERP.



FIGURE 1. Framework for Greenhouse Gas Emissions Reduction Planning

The Framework helps organizations develop an ERP that prioritizes action according to FIGURE 2. Using less energy and resources is the top priority, then implementing low-carbon solutions, and lastly, where other options are exhausted, implementing carbon capture for remaining emissions. This is the order in which organizations should prioritize emission reduction measures (ERMs) - but not necessarily the order in which they should implement ERMs. The first two priorities especially can be implemented in parallel. Energy efficiency should always be a priority, however efficiency measures can support low-carbon solutions by reducing the necessary size (and costs) of low-carbon systems.

FIGURE 2. Prioritization of GHG Measures

AVOID OR USE LESS

Resource and energy efficiency Demand flexibility and grid interactivity

PIVOT TO LOW CARBON SOLUTIONS

Electrification Renewable energy Low carbon fuels and feedstocks Low GWP refrigerants Low carbon processes

SEQUESTER UNABATED EMISSIONS

Carbon capture and storage

The output of the framework is an ERP that communicates an organization's strategy for achieving GHG emissions reductions targets. An ERP differs from many other highlevel planning documents, sometimes called climate action plans or sustainability plans, because an ERP is more specific and actionable than these other documents often are. It covers the entire portfolio, but contains sufficient detail to guide specific actions at the facility level. A decarbonization roadmap is another commonly used term and is likely the closest commonly-used term to an ERP. However, there is no accepted definition for these other document types.

The framework was developed in coordination with industry design and operations professionals and owner representatives to document the emerging industry practice of portfolio-level emissions reduction planning. While the framework outlines methods and processes based on that collaboration, organizations are encouraged to adapt the ERP Framework to align with organizational goals. Consider the following strategies when using this framework:

Take actions such as pilots or "low-hanging-fruit" projects to reduce GHG emissions throughout the planning process, even before the plan is fully documented.

- The milestones outlined in this framework (FIGURE 1) are designed to be flexible and do not need to be completed in seq
- The methods to achieve each milestone in the framework may vary.
- The final ERP deliverable may not be a single document; it could be part of a larger climate strategy, and some components may be housed outside of the ERP.
- This framework can be used to support the development of the scope of work for external consultants (as needed) or guide the process for inhouse development, depending on staff expertise and capacity.
- The framework can be used in conjunction with tools that support the development and execution of the Emissions Reduction Plan. Potential tools include environmental, social and governance (ESG) tools for GHG inventory development and reporting, software to identify emissions reduction opportunities through automated data analysis, project tracking and capital planning tools, and ongoing commissioning tools such as energy management and information systems (EMIS).

MILESTONE 1: Establish Greenhouse Gas Inventory and Scope of Work

PURPOSE

The purpose of this milestone is to understand all sources of an organization's GHG emissions and to define the scope of work for the emissions reduction planning process itself. It includes stakeholder engagement; developing a GHG emissions inventory management plan, GHG reduction target, and scope of work; and defining evaluation criteria for the plan.

Identify and engage stakeholders – When identifying stakeholders to engage, consider who will be needed to support the planning effort, approve the ERP, and support plan implementation. Stakeholders should develop a relationship early in the process and define expectations for future involvement. Personnel from various parts of the organization may be needed to bring an adequate range of expertise to help identify, quantify, plan, and support the implementation of decarbonization efforts. If necessary, this step also includes identifying external support. Executive leadership and finance teams can help provide clarity on decision making process and financial mechanisms and metrics required to assess the business case for decarbonization projects. Sustainability and project management teams can identify opportunities and provide risk assessments, and understand regulatory and reporting requirements.

In addition to internal stakeholders, it may be useful to engage external stakeholders at this point, such as representatives of local communities, utilities, local and state government, and more. Doing so can help organizations uncover new strategies (for example, identifying a nearby source of renewable natural gas) and solidify external support for implementation of the ERP (for example, permitting needs, community awareness and acceptance, or utility incentives). Engaging these stakeholders early on will benefit organizations in the long run by helping identify opportunities or by avoiding spending resources analyzing unrealistic strategies.

Establish a greenhouse gas inventory management

plan – Develop and document standardized data management processes and methods to collect, quantify, verify, and roll up emissions data from the facility level to the portfolio level to create a GHG inventory. Many organizations may have already completed a GHG inventory and have these processes in place; it may be worth revisiting them for completeness, however. Inventories should follow the Greenhouse Gas Protocol and cover all significant sources of GHG emissions. At a minimum, inventories must include all direct emissions from sources owned or operated by the organization, such as boilers, furnaces, and vehicles (Scope 1) as well as indirect emissions associated with purchased energy such as electricity (Scope 2). In addition to energy-related emissions, Scope 1 emissions may also include non-energy emissions, such as direct process emissions from certain industrial processes or leaks of fluorinated gases or other GHGs. Indirect emissions that occur in the value chain, both upstream and downstream, may also be included (Scope 3). Having a clear understanding of which sources of energy account for the largest portion of GHG emissions can help identify opportunities to strategically reduce GHG emissions. For example, organizations with significant Scope 2 emissions may prioritize renewable electricity generation, whereas those with predominantly Scope 1 emissions may need to prioritize electrification or lowcarbon fuel switching opportunities.

Set GHG emissions reduction targets – Publicly reported GHG targets provide transparency, accountability, and credibility to emissions reduction efforts. They also help organizations accurately measure and quantify emissions reductions. Setting ambitious GHG emissions targets may help increase support from senior management and secure funding for internal GHG reduction opportunities.

Define GHG emissions reduction targets relative to a baseline year representing typical operations, with clear deadlines. Organizations may set multiple targets on different time scales – long-term, ambitious goals (e.g. net-zero emissions by 2050) combined with interim goals on shorter time scales (e.g. 50% reduction by 2030). Some organizations may prefer to wait to set their GHG emissions reduction targets until after more information is uncovered in Milestones 2 and 3, "Categorize Portfolio" and "Assess Measures." This may be useful in developing ambitious yet reasonable targets. An ERP should always be developed with all targets in mind, since the strategies to achieve short-term targets may not necessarily set an organization up to achieve their long-term targets cost-effectively.

Targets should be set with buy-in from corporate leadership, and should be aligned with other strategic goals. For example, in the process of setting a GHG emissions reduction target, organizations may also set an energy intensity reduction target or a renewable electricity procurement target. Whether aligning with pre-existing targets or setting new ones, these targets must be weighed simultaneously as the overall GHG target is defined as they may impact progress towards the GHG target. The same is true for sub-targets that apply to specific subsets of the organization, for example, targets that apply to a specific region or business unit. At this stage, corporate leadership should also determine, if applicable, any guidelines for achieving the goal, such as enacting a requirement to achieve the target without the use of GHG emissions offsets, or setting a maximum marginal cost of abated emissions for emissions reduction projects. However, organizations must be cognizant of these constraints, as they may preclude certain emissions reduction pathways. For example, if emissions reduction projects have a maximum simple payback period, this could prevent organizations from pursuing high-impact, long-payback projects that will help them meet their target.

Define GHG Emissions Reduction Plan scope of work -

PLAN

Define the scope of work for the ERP development process and outline what task swill be included in an ERP. Plan and assign staff time and financial resources required to complete these tasks. If sufficient in-house expertise is not available, plans for identifying, vetting, and hiring external contractors may be necessary as well. Key elements of an ERP are shown in TABLE 1. Some are core elements of an ERP that all industrial organizations should include. Others are optional, but recommended to be included where applicable, depending on organizational characteristics and priorities.

TABLE 1. Elements of an Emissions Reduction PlanScope of Work

В	GHG Inventory
CO	Portfolio characterization
	Internal stakeholder engagement
	 Plant-level and/or system-specific emissions assessments
	Scenario development and assessment
	 Clean energy strategy – procured electricity and/or onsite generation
	Project prioritization
	Analysis of potential funding sources
	• • • • • • • • • • • • • • • • • • • •
БD	Fleet emissions reductions
Z	Fugitive and/or process emissions analysis
Σ	External stakeholder engagement
≥	Resiliency/climate risk assessments
С С	Energy storage assessments
	 Carbon capture, utilization, and storage studies
	 Studies, pilot projects, and/or demonstrations of new technologies

Define evaluation criteria – Working with internal and external stakeholders, define specific evaluation criteria to assess and select projects and scenarios to reduce GHG emissions. Evaluation criteria may include:

- Emission reduction potential
- Capital/operating costs
- Workforce requirements
- Availability of financing
- Technology availability
- Safety
- Reliability
- Product quality and/or certification of products
- Throughput
- Assessed risk
- Market positioning
- Impacts to production schedules

Emission reduction potential is the amount a given project, measure, or scenario will reduce GHG emissions, relative to the baseline. In general, this should be the primary metric considered by plan developers; functionally, it is the metric that defines success or failure of the plan. Emission reduction potential of individual projects will likely depend on what other projects are implemented (e.g., electrifying a thermal process will have a greater emission reduction potential if the facility is powered by renewable electricity). Other considerations will be important as well, depending on organizational priorities.



MILESTONE 2: Categorize Portfolio

CATEGORIZE

MEASURES

PURPOSE

INVENTORY

The purpose of this milestone is to identify and categorize facilities within a portfolio based on various characteristics, including identifying those with the highest potential to reduce GHG emissions. In addition to characterizing the portfolio by magnitude of emissions, organizations should select other useful characteristics to sort or order their portfolio. This allows an organization to direct its focus, understand commonalities across the portfolio, and identify key metrics they can use to benchmark performance. Finding commonalities via a methodical portfolio characterization will ultimately enable organizations to quickly scale implementation of decarbonization projects via repetition of successful strategies across similar systems or facilities.

Select characteristics for the portfolio – List and sort facilities and processes based on emissions and other distinguishing features. This helps visualize and prioritize decarbonization efforts and uncovers commonalities across the portfolio. Some key characteristics organizations might consider:

- Total GHG emissions (ton CO2e) and/or emissions intensity¹
- Total energy use (MMBTU)

PLAN

SCENARIOS

- Facility type and/or product streams
- Location
- Ownership structure
- Energy market and utility
- Carbon intensity of electric grid
- Systems or processes
- Availability of funding and incentives
- Equipment vintage, expected lifetime, and/or replacement schedule
- On-site fossil fuel combustion (% energy use or total MMBTU)
- Staff capacity
- Disadvantaged communities

As commonalities and patterns are discovered, implementation can easily be scaled portfolio-wide. For example, a multi-facility organization could have several plants which manufacture similar products and utilize similar processes – the same strategies may be leveraged to decarbonize each facility. As another example, organizations may choose to phase upgrades in groups based on pre-existing capital planning, reinvestment, equipment end-of-life, or deferred maintenance schedules. This minimizes disruption and can avoid locking in future emissions.

¹This is the most important dimension on which to characterize

the portfolio. It is expanded on in subsequent steps.

Identify and quantify GHG emissions for Significant

Greenhouse Gas Emitters (SGEs) – Identify the largest GHG emissions sources (also known as "significant GHG emitters" or SGEs) both at the facility level and at the equipment/process level. SGEs could be individual, discrete pieces of equipment, such as a boiler, or could be sources from processes or equipment that, while individually small, are distributed widely enough to be significant, such as refrigerant leaks from chillers or air conditioners.

Once SGEs are identified by estimation first, accurately determine the energy consumption and GHG emissions for these systems. Identify key variables that determine performance of SGE systems and collect, analyze, and track performance data.

Benchmark SGEs – Benchmark SGEs relative to similar systems to gauge performance. This can be done internally (e.g. across facilities within the same portfolio) or externally, depending on data availability. In the absence of reliable data on comparable systems, SGEs can instead be benchmarked against their own past performance. Benchmarking can be used to identify best practices and ideal operating conditions as well as opportunities for performance improvement.

Select systems for further analysis – Decide which systems and facilities in the portfolio to prioritize. Generally, this means prioritizing SGEs – though organizations may prioritize based on cost, location, ease of technology piloting, scalability, or other characteristics. These priorities may depend on the organization (e.g., appetite for risk), the current policy environment (e.g. state, local, or utility policies, programs, and incentives that encourage organizations to prioritize emissions reductions in certain regions), or market conditions (e.g. relative fuel prices).



BENCHMARKING CAN BE USED TO IDENTIFY BEST PRACTICES AND IDEAL OPERATING CONDITIONS.



MILESTONE 3: Assess Measures

INVENTORY CATEGORIZE

PURPOSE

Through this milestone, an organization completes both facility-level and portfolio-level emissions reduction assessments to identify and quantify projects and operational practices to reduce emissions. This two-fold approach provides broad coverage of the variety of different strategies organizations may use to achieve their emissions reduction goals.

MEASURES

SCENARIOS

PLAN

FIGURE 3. Steps in a Facility-level GHG Emissions Reduction Assessment



Identify RMs

1. Determine Scope

Identify the scope of the assessment, including which processes and which emissions sources will be considered (negligible sources may be appropriate to ignore in some cases). From the inventory completed in Milestone 1, gather relevant data on facility energy consumption and individual production processes needed to calculate emissions.

2. Identify ERMs

Examine the facility's energy use, production needs, operational characteristics, and other factors to identify ERMs. Depending on the facility and the processes involved, ERMs may include adopting energy efficiency, electrification, renewable fuels and energy sources, and carbon capture strategies.

3. Evaluate and Prioritize Options

Evaluate the potential impact and feasibility of the identified ERMs by analyzing the costs, benefits, and risks associated with each. Co-benefits should also be assessed and quantified whenever possible. Often, ERMs can yield additional improvements to safety, productivity, product quality, waste reduction, and more. Simple cost analysis may dissuade organizations from implementing ERMs that in reality show strong returns when assessed using comprehensive financial tools and analysis. While prioritizing the ERMs, take into consideration other important parameters such as the regulatory requirements for GHG emissions in the region and scalability/replicability. It is important to recall that the emission reduction potential of an individual ERM is likely to be affected by which other ERMs are implemented concurrently and how the organization procures energy over the course of an ERM's duration (e.g. expected grid emissions factor over the lifetime of electrical equipment). Facility-level ERMs can be classified into four technology pillars, as outlined in <u>DOE's Industrial Decarbonization</u> <u>Roadmap</u>. The four pillars are summarized below in TABLE 2, along with a non-exhaustive list of examples.

TABLE 2. Technology Pillars of Industrial Decarbonization

Technology Pillar	Benefits	Examples
Energy Efficiency	 Most cost-effective option for emissions reductions in the near term Opportunities always exist 	 Strategic energy management approaches and energy management systems Efficiency of energy support systems such as process heating, steam, compressed air, pumps, fans, process cooling, etc. Waste heat reduction, recycle, and recovery options Smart manufacturing and advanced data analytics
Electrification	• Leverages advancements in low-carbon electricity from both grid and onsite clean generation sources	 Electrification of low and medium temperature thermal systems using different electrotechnologies Electrification of high-temperature range processes Replacing thermally driven processes with electrochemical ones Electrification of fleet or onsite transportation such as forklifts
Low Carbon Fuels, Feedstocks, and Energy Sources (LCFFES)	 Reduce combustion associated emissions for industrial processes 	 Use of fuel-flexible thermal systems Integration of hydrogen fuels and feedstocks into industrial processes The use of low-carbon energy sources such as solar thermal, waste heat sources, etc. The use of biofuels and bio feedstocks Switching fossil fuel vehicles to blended or pure low carbon powered vehicles Use of secondary materials as a feedstock to offset primary materials
Carbon Capture, Utilization, and Storage	 Capture generated CO₂ and use it to make value added products, or store it long-term 	 Post-combustion chemical absorption of CO₂ Use of processes to utilize captured CO₂ to manufacture new materials Using membranes for CO₂ separation

Portfolio-level GHG Emissions Reduction Assessment -

Conduct a portfolio-level GHG emissions reduction assessment to identify, quantify, and prioritize ERMs that are implemented, led, and/or approved at the portfolio level, such as strategic energy management, clean energy procurement, demand management/load flexibility, circular economy strategies, or strategic business changes. This can also help companies understand the risks and opportunities associated with transitioning to a low-carbon economy. Some examples of portfolio-wide ERMs include:

Cross-cutting energy efficiency improvements such as upgrading HVAC systems, lighting, compressed air systems, steam systems, and insulation, or implementing a corporate-level strategic energy management plan.

- Clean energy from purchased clean electricity via power purchase agreements, green energy tariffs, renewable energy credits, and other mechanisms. On-site clean energy may also be handled at the portfolio level in some cases.
- Low-carbon transportation options for fleet vehicles (on- and off-site use) such as electric or green hydrogen fuel-cell vehicles.
- Demand flexibility and grid interactivity strategies can reduce scope 2 emissions by reacting in real time to conditions on the grid. Specifically, organizations can shift demand to times when the carbon intensity of grid power is at its lowest (or times when onsite renewable generation is highest), either by modifying when certain activities are performed, or by using grid-interactive battery storage systems.

- Circular economy and material efficiency strategies can obviate GHG emissions by minimizing emissions from materials processing and handling. For organizations developing ERPs that include Scope 3 emissions, circular economy approaches can also drastically reduce embodied GHG emissions both upstream and downstream.
- Beyond-the-fenceline solutions: Organizations may also explore an array of opportunities that lie outside of their direct control, such as district energy or energy sharing with neighboring organizations. For example, external organizations could have waste heat streams that cannot be feasibly recovered for internal use, but could reduce thermal demands at a nearby industrial facility. Co-located industrial facilities could also consider co-owned solutions to provide utilities such as compressed air, steam, or combined heat and power to multiple facilities at once. Nearby landfills could provide a manufacturer with a source of landfill gas to offset fossil gas usage.
- Strategic business changes could include development of brand-new products or manufacturing processes that inherently produce fewer emissions or require less energy. For example, a chemical company might develop a new catalyst to reduce the energy required to carry out a chemical reaction, or they could choose to instead begin producing a different product entirely to serve the same end-use market, for example, transitioning to make equipment that utilizes lowerglobal warming potential refrigerants.

Effective portfolio-level emissions reduction requires coordination and collaboration across multiple stakeholders, including facilities, regional suppliers and utilities. This can be challenging, particularly when there are divergent priorities and interests.

Once again, the emission reduction potential (and other factors such as cost) of portfolio-level ERMs will be heavily dependent on the other ERMs implemented. For example, strategic energy management can reduce portfolio-wide energy use and reduce the amount of renewable electricity an organization needs to purchase to account for all of its usage. Such interdependencies make the subsequent milestone, scenario development and evaluation, crucially important to understand and predict an organization's future progress. However, the "assess measures" stage will likely uncover some "no-regret" actions, such as instituting a strategic energy management program or installing certain energy efficiency projects. An organization need not wait until the plan is completely finished to begin implementing such measures.



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INVENTORY CATEGORIZE MEASURES SCENARIOS

MILESTONE 4: Develop Scenarios

PURPOSE

After identifying and assessing ERMs in Milestone 3, an organization can now combine, scale, and phase ERMs across the portfolio to create emissions reduction scenarios. Decarbonization scenario development plays a crucial role in determining the overall impact on an organization's GHG emissions. By developing and analyzing multiple scenarios, organizations can compare the costs and benefits of each and select a pathway that best meets their needs. It also enables organizations to understand the interplay of different combinations of ERMs. The approach to developing GHG emissions reduction scenarios is as follows: 1. Establish Scenario Parameters: Determine the scope (i.e., which emissions sources to include), GHG targets and timelines, and descriptions/goals of each scenario (e.g. high electrification scenario, moderate energy efficiency scenario, etc.).

PLAN

- 2. Estimate Future Portfolio Changes: Project future business development (acquisitions, sales, or expansions) and changes to production rates and product mix to ensure a viable path to achieving GHG goals despite growth.
- **3. Review Emission Reduction Measures:** Review the opportunities identified in facility- and portfolio-level assessments. Collect data on technology/equipment availability, deployment year, cost, implementation effort, etc.
- **4. Define Scenarios:** Develop several distinct scenarios with different combinations and phasing of ERMs. Scenarios may also vary based on different projections of external factors such as technology costs or changes to the GHG intensity of grid power.
- **5. Evaluate Scenarios:** Evaluate scenarios to estimate emissions reductions, costs, and benefits of each scenario.

Scenario inputs to develop multiple scenarios – Inputs to scenarios include facility-level ERMs and corporate-level cross-cutting strategies (both defined in Milestone 3), as well as how measures are phased over time and estimated changes to the portfolio size (e.g., addition or closure of facilities). Organizations should align their scenarios with capital planning, reinvestment, major equipment end-of-life, or deferred maintenance planning timelines. Other inputs may include estimated timelines for technology development or cost reduction, supply chain projections, or possible future regulations/policies related to GHG emissions.

Combining inputs to develop multiple scenarios -

There are different technical approaches to scaling the results from facility-level assessments to the broader portfolio. The scaling should identify which measures are related to specific categories and apply emissions projects appropriately. This process may include scaling using:

- Energy system type (steam, process heating, etc.)
- Energy use intensity
- Equipment capacity
- Facility location
- Available space

Context will dictate which method is most relevant – e.g. organizations may initially scale electrification projects in regions where the grid's emissions factor is the lowest, or they may prioritize fuel-switching in systems that currently use higher carbon intensity fuels, such as coal.

The phasing (or timing) of different ERMs will depend on factors such as:

- Technical feasibility
- Cost-effectiveness
- Availability of resources
- Regulatory environment (e.g., fuel switching and safety regulations)
- Market conditions
- Grid electricity decarbonization projections
- Other sustainability goals

The scenario development approach is illustrated by the example in FIGURE 4. To develop multiple scenarios and evaluate their alignment with the organization's needs, different technical strategies can be tested such as the level of energy efficiency, electrification, low carbon fuels & energy sources, and carbon capture. FIGURE 4 illustrates four possible example scenarios for an organization that implements the four pillars in different combinations and orders. The different scenarios exhibit different pathways to achieving goals, with different cumulative emissions and interim progress.



BY DEVELOPING AND ANALYZING MULTIPLE SCENARIOS, ORGANIZATIONS CAN COMPARE THE COSTS AND BENEFITS OF EACH AND SELECT A PATHWAY THAT BEST MEETS THEIR NEEDS.



INVENTORY CATEGORIZE MEASURES SCENARIOS PLAN



FIGURE 4. Portfolio-level Emissions Reduction Scenarios

Business-as-Usual (BAU) Scenario – This could involve business-as-usual improvement in energy efficiency and limited adoption of clean energy, low-carbon fuels (green H2, biofuels, etc.), and commercially available

electrification technologies.

Scenario 1 – In this scenario, an example organization assumes a higher rate of energy efficiency improvements, switches to electrotechnologies by 2025 even if the clean electricity is not available until 2030-35 in their regions, and switches to low-carbon fuels for the remaining thermal systems in 2035 and beyond. It also assumes adoption of CCUS in later years to achieve net-zero by 2050.

Scenario 2 – In this scenario, the organization assumes a higher rate of energy efficiency improvements, switches to low-carbon fuel thermal systems with dual-fuel capability (fuel-flexible burners) in 2025 even though sufficient volume of green hydrogen is not available until 2030, and switches to electrotechnologies for the remaining thermal systems in 2030 and beyond. It also assumes adoption of CCUS in later years to achieve netzero by 2050. Scenario 3 – In this scenario, the company assumes a higher rate of energy efficiency improvements, installs CCUS systems on their furnaces in 2030 when the technology becomes available, switches to low-carbon fuel thermal systems in 2035 when sufficient/reliable volume of green hydrogen is available, and switches to electrotechnologies for the remaining thermal systems in 2040 and beyond.

In many cases, GHG emissions reduction scenario development encourages companies to think about innovation and research in low-carbon technologies and practices. It is extremely challenging to achieve net-zero targets in most industrial subsectors without innovative new technologies, so most scenarios will rely in some part on technologies that are not yet commercially available. The scenario development process can help drive investments in R&D to develop and commercialize the cleaner energy sources, energy-efficient processes, and sustainable materials needed to achieve goals.

MILESTONE 5: Define GHG Emissions Reduction Plan

MEASURES

SCENARIOS

PLAN

PURPOSE

INVENTORY CATEGORIZE

In this final milestone, organizations create the ERP and define how the organization's emissions targets will be met and the timing of key emissionsreducing activities, assign responsibility to key stakeholders, outline financing plans, and communicate next steps. Once comlete, the ERP is not a static document; it will be a dynamic, living document that organizations reference frequently and revisit periodically to ensure it is timely and meets their needs. Assess scenarios and select pathway – After developing multiple emissions reduction scenarios (Milestone 4), assess which one best meets organizational needs using the evaluation criteria defined in Milestone 1, selecting it as the emissions reduction pathway. This will be a pathway that not only satisfies expected emissions reductions, but also optimizes additional criteria as much as possible based on organizational priorities.

Update organizational standards and procedures – Review and update existing organizational standards and procedures (e.g. standard operating procedures, procurement practices, project evaluation criteria, and training programs) to align with the selected ERP pathway. For example, GHG emissions may become a key evaluation criteria for all capital projects. Create new standards and procedures as needed to encourage implementation (e.g., an internal price of carbon).

Define financing and project deployment schedule – Decide on preferred financing mechanisms (and their phasing) to fund ERMs. This may depend on project type and organizational preference, and should account for annual budgeting cycles and financing availability. There is a variety of options, including operation and capital funds, traditional financing/loans, performance contracting, and green bonds. Investigate utility, state and federal grants (such as those established by the Inflation Reduction Act and the Bipartisan Infrastructure Law), rebates, and incentives as well. Project deployment schedules may also depend on technology availability, projected grid emissions, and other factors.

Secure final buy-in from stakeholders, and release plan -

To facilitate overall communication, establish an ERP steering committee comprised of a diverse set of the organization's leaders – executives from operations, engineering, finance, sustainability, and legal. This will help coordinate organizational efforts, identify implementation issues and slowdowns, provide necessary resources to enable timely implementation, and foster organizational buy-in and commitment. Share the draft ERP with all key stakeholders, update it to reflect their feedback, and get final approval from the steering committee and executive leadership. The approved ERP should be communicated by leadership throughout the organization.

Ongoing Implementation

Setting an emissions reduction target and developing a plan is not the end goal of emissions reduction planning. The motivation for developing a plan is to make sure actions are being taken and there is progress toward the goal, so implementation strategies should be considered from the beginning stages of plan development. Key implementation strategies include developing a work plan, setting data collection procedures, knowledge-sharing, and periodic reassessment.

Develop work plan – Develop a work plan for the ERP that outlines actions, sets timelines, and assigns personnel and capital. This provides accountability for the projects being implemented. Quantify risks and constraints for ERMs to predict potential delays in implementation. Build in time and resources for analysis, design, implementation, testing, and training for new projects.

Measure and verify GHG emissions reductions – Establish a procedure for quantifying emissions reduction. Most commonly, organizations report their GHG emissions reduction based on the reduction in fuel consumption or refrigeration leaks. Companies can also conduct project-based GHG emissions reduction accounting according to "The GHG Protocol for Project Accounting" standard. This accounting method can be used for emissions reduction for a particular project to assess the actual reduction. This provides vital feedback to inform future efforts and even potential ERP revisions. Organization leadership should regularly communicate implementation progress and status towards the goals.

Document and share key learnings from project implementation – Document and share experiences with project implementation rigorously and regularly. This allows for the discovery of best practices and makes similar projects easier to complete in the future. Documentation of information such as project specifications, employees involved, vendors and subcontractors, cost, and savings can help inform similar future projects. This can also inform ERP

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updates and adjustments to timelines, actions, roles, and prioritization for future projects.

Continuous evaluation of circumstances and

revision of ERP – The ERP should be updated every 3-5 years to account for changing factors like the constant development of technologies, new policies and incentives, changes in fuel costs, changes to the grid mix, updated portfolio growth models, or new business models and strategies. Periodic revision ensures that ERPs continue to meet organizational needs and goals; however, constant (e.g. annual), complete revision is likely unnecessary and can waste organizational resources (personnel, capital) on excessive planning rather than actual implementation.



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