



LIEN Industrial Decarbonisation Guide

March 2026

Aligned with ISO 50100 Decarbonisation of energy
use.

LIEN Industrial Decarbonisation Guide

Aligned with the requirements of ISO 50100 and the LIEN Annual Questionnaire

16 March 2026

Report prepared for SEAI by:

Geno

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Sustainable Energy Authority of Ireland

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1. Introduction

The Sustainable Energy Authority of Ireland (SEAI) has developed this Industrial Decarbonisation Guide to support members of the Large Industry Energy Network (LIEN) who seek practical guidance in developing a systematic approach to the quantification of Energy Related GHG Emissions (ERGE) and the decarbonisation of these emissions.

This version 2.0 represents a major revision that aligns the guide with ISO 50100:2026, which provides a framework and principles for the decarbonisation of energy consumption. The previous version of this document was titled Emissions Evaluation Methodology (EEM). The integration of ISO 50100 strengthens the guide by providing a more structured, internationally recognised approach to decarbonisation planning while retaining the practical, Ireland-specific guidance that LIEN members have found valuable.

1.1 Purpose and Benefits

A well-devised decarbonisation strategy benefits all organisations. These benefits include:

- Business risk mitigation and resilience against regulatory, market and physical climate risks
- Improved public recognition, ESG performance and stakeholder confidence
- Cost reduction through energy efficiency and reduced exposure to fossil fuel price volatility
- Compliance with mandatory and voluntary reporting frameworks including the Corporate Sustainability Reporting Directive (CSRD)
- Enhanced competitiveness through lower operational costs and improved reputation
- Alignment with national climate targets, including the Irish industrial sector target of 35% reduction in direct (Scope 1) emissions by 2030

1.2 Scope of the Methodology

The scope of this guide covers energy-related CO₂ emissions from the combustion of fossil fuels and the consumption of purchased electricity (scopes 1 and 2). It does not currently include process-related greenhouse gas (GHG) emissions or scope 3 emissions.

Data collection and reporting requirements are integrated into the annual LIEN questionnaire and report. Detailed guidance on completing the questionnaire is provided in the accompanying LIEN Questionnaire User Guide.

1.3 Companion Documents

This Guide should be read in conjunction with the following companion documents:

- LIEN Questionnaire User Guide — provides detailed instructions for completing the annual LIEN questionnaire, including data entry requirements for energy consumption, emissions calculations and decarbonisation reporting.
- LIEN Questionnaire (MS Excel spreadsheet).

1.4 Informative References

This Guide is aligned with the following standards and frameworks:

- ISO 50100 — Energy management systems — Decarbonisation of energy consumption
- ISO 50001 — Energy management systems — Requirements with guidance for use
- ISO 14064-1 — Greenhouse gases — Quantification and reporting of GHG emissions and removals
- GHG Protocol Corporate Standard ([ghgprotocol.org](https://www.ghgprotocol.org))
- Science Based Targets initiative (SBTi)
- Carbon Disclosure Project (CDP)
- EU Corporate Sustainability Reporting Directive (CSRD)
- Ireland Climate Action and Low Carbon Development Act 2021

2. Key Concepts and Principles

ISO 50100 establishes a set of guiding principles for organisations undertaking the decarbonisation of their energy consumption. This section summarises those principles and explains how they are applied within the LIEN decarbonisation framework.

2.1 Decarbonisation of Energy Consumption

ISO 50100 provides a framework for organisations to systematically plan and implement the decarbonisation of their energy consumption. It defines a structured approach to reducing energy-related GHG emissions through energy conservation, energy efficiency, energy recovery, fuel switching, renewable energy adoption and low-carbon design. The standard reinforces the principle that direct emission (Scope 1) reductions should be prioritised over indirect emissions (Scope 2).

2.2 Guiding Principles

The following principles from ISO 50100 underpin this LIEN Guide:

Principle 1: Commitment and leadership

Top management shall demonstrate commitment to the decarbonisation of energy consumption through policy, resource allocation, target setting and transparent reporting. Leadership is the single most critical enabler of successful decarbonisation and needs to go beyond policy statements to active sponsorship and accountability.

Principle 2: Integration with business strategy

The decarbonisation of energy consumption shall be integrated into the organisation's overall business strategy rather than treated as a stand-alone initiative. This means embedding carbon considerations into capital planning, procurement, design standards and operational decision-making.

Principle 3: Evidence-based decision making

Decisions shall be based on reliable energy and emissions data, validated baselines and sound analytical methods. Energy performance indicators (EnPIs) and energy baselines (EnBs) developed under ISO 50001 provide an excellent foundation. ISO 50100 emphasises the need for data-driven planning using quantified emissions inventories, modelling of reduction pathways, and verification of achieved savings.

Principle 4: Prioritisation of direct reductions

Organisations shall prioritise actual reductions in energy consumption and direct GHG emissions over market-based instruments, offsets or accounting mechanisms.

Principle 5: Long-term perspective with interim milestones

A credible decarbonisation pathway requires a long-term vision (typically to 2040) supported by interim targets at regular intervals (e.g. 2030, 2035, 2040 or more frequently). ISO 50100 calls for phased planning that adapts to technological, regulatory and market developments.

Principle 6: Transparency and reporting

Organisations shall report their energy-related emissions, targets, actions and progress transparently. This supports stakeholder confidence, regulatory compliance and peer learning within networks such as the LIEN.

Principle 7: Continual improvement

The decarbonisation of energy consumption is an ongoing process. Organisations shall apply a continual improvement approach, reviewing and updating their baselines, targets, action plans and indicators as circumstances change. An energy management system is the ideal foundation for this continual improvement approach.

3. Types of Emissions

The GHG Protocol (ghgprotocol.org) has been the world's most widely recognised standard for measuring corporate greenhouse gas emissions since 2001. ISO 14064-1 is based on the GHG Protocol and follows the same methodology. Emissions are calculated by multiplying the activity data (AD) by the relevant emissions factor (EF):

$$\text{Emissions (tCO}_2\text{)} = \text{Activity Data (AD)} \times \text{Emission Factor (EF)}$$

3.1 Scope 1: Direct Emissions

Scope 1 emissions are direct emissions of GHGs from the organisation's operations within its boundaries. For most LIEN members, these are predominantly CO₂ emissions from the combustion of fossil fuels (natural gas, oil, diesel, LPG, etc.). Apart from the cement and fossil fuel processing and extraction industries where process emissions are significant, combustion emissions dominate Scope 1 for Irish industry.

Scope 1 emissions should be given the highest priority in decarbonisation planning as these are the emissions over which the organisation has the most direct influence. This is reinforced by Ireland's Climate Action Plan, which sets a sectoral target for industry of 35% reduction in direct (Scope 1) emissions by 2030 relative to the 2018 baseline. ISO 50100 also reinforces this through its principle of prioritising direct reductions. Achieving the 35% Scope 1 target will require sustained focus on energy demand reduction, thermal energy recovery and fuel switching across Irish industry.

Note: All physical GHG emissions are Scope 1 emissions of some organisation. For example, emissions from the Irish electricity grid are Scope 2 for consumers but Scope 1 for non-renewable electricity generators.

3.2 Scope 2: Indirect Energy Emissions

Scope 2 emissions arise from the generation of acquired and consumed electricity, steam, heat or cooling. For Ireland, these are overwhelmingly from electricity consumption. The GHG Protocol requires dual reporting:

Location-Based Method

Reflects the average emissions intensity of the electricity grid where consumption occurs. The emission factor of the Irish grid is published annually by SEAI and EirGrid. This method captures the physical reality of the average carbon intensity of delivered electricity.

Market-Based Method

Reflects the emissions intensity of the electricity for which the consumer has contractually arranged. This accounts for instruments such as Guarantees of Origin (GOs) and Corporate Power Purchase Agreements (CPPAs).

Both methods are internationally recognised and are used in this guide.

Scope 2 Credibility Hierarchy

Table 1 presents a hierarchy for decarbonising electricity-related Scope 2 emissions, prioritising approaches that provide clear and credible additionality.

Rank	Approach	Additionality	Location EF	Market EF
1	Onsite or private-wire renewable electricity	Clear and credible	0	0
2	CPPA for new RE with supply/demand matching	Clear and credible	Grid EF	0*
3	CPPA for new RE without matching	Clear and credible	Grid EF	0*
4	CPPA with existing/legacy RE projects	Limited	Grid EF	0
5	Guarantee of Origin (GO)	None	Grid EF	0
6	Normal electricity purchasing	None	Grid EF	Supplier EF or residual EF

Table 1: Credibility hierarchy for Scope 2 electricity emission factors

***Note:** EFs allocated to CPPAs for new RE with and without supply/demand matching may be revised in future to account for residual emissions.

3.3 Scope 3: Value Chain Emissions

Scope 3 emissions encompass all other indirect GHG emissions occurring outside the organisation's boundary as a consequence of its activities. These include upstream and downstream value chain emissions and are typically more complex to quantify.

Scope 3 is currently outside the mandatory scope of this guide. However, ISO 50100 encourages organisations to progressively expand the boundary of their decarbonisation efforts to include material scope 3 categories. Organisations are encouraged to begin assessing scope 3 as part of their long-term decarbonisation strategy and in preparation for CSRD reporting obligations.

Note 1: ISO 14064 does not use the concept of scope 3. It divides indirect emissions into five subcategories; organisations must identify and evaluate the significance of all of them and justify exclusions.

Note 2: Scope 3 emissions are outside the scope of this guide. However, ambitious organisations should consider how to reduce the scope 3 emissions over which they have control, e.g. air travel and air transport.

4. Overview of this Decarbonisation Guide

The guide provides a structured, five-step process for developing and implementing a decarbonisation strategy. Version 2.0 enhances each step with requirements drawn from ISO 50100, ensuring that the methodology reflects international best practice for the decarbonisation of energy consumption.

4.1 Terminology

- **Decarbonisation Strategy:** The overall systematic approach taken by an organisation to quantify its baseline ERGE, set targets, develop and implement actions, monitor results and take corrective action.
- **Base year ERGE (E_B):** The base-year energy-related GHG emissions (ERGE) in tonnes of CO₂ (tCO₂) emitted in the base year (2018) or other year as decided by the organisation. This needs to be quantified separately for both Scope 1 and Scope 2.
- **Future ERGE (E_F):** The estimated future ERGE projected for a future year assuming no decarbonisation actions, taking account of changes to activity levels and grid emission factors.
- **Target ERGE (E_T):** The interim ERGE target for ERGE targeted for a specific future year (e.g. 35% reduction of Scope 1 emissions by 2030).
- **ERGE Reduction needed (E_R):** This is the amount of ERGE that needs to be reducing in order to achieve the targets.
- **Future ERGE (E_F):** The ERGE if no decarbonisation actions are taken, i.e. the business as usual ERGE.
- **Emissions Reduction Actions (E_A):** Also referred to as Energy and Carbon Opportunities (ECOs), see below.
- **Projected ERGE (E_P):** This is the ERGE projection based on reductions from emission reduction actions.
- **Energy and Carbon Opportunities (ECOs):** Opportunities to save energy and/or reduce energy-related CO₂ emissions.

4.2 The Five-Step Process

The five main steps of the process are summarised below. Each is described in detail in subsequent sections.

Step	Title	ISO 50100 Alignment
1	Establish the Base Year ERGE (E_B)	Clause 7: Base year ERGE
2	Set the ERGE Target (E_T)	Clause 8.1: Setting ERGE targets
3	Estimate the Future ERGE (E_F) and ERGE reduction needed (E_R)	Clause 8.2: Estimate Future ERGE and ERGE reduction needed (E_R)
4	Develop and Implement the Emission Reduction Actions (E_A)	Clause 9: ERGE reduction activities

	to achieve the ERGE reduction needed.	
5	Monitor Decarbonisation Progress (E_M)	Clause 10: Monitoring ERGE

Table 2: Decarbonisation planning steps and ISO 50100 alignment

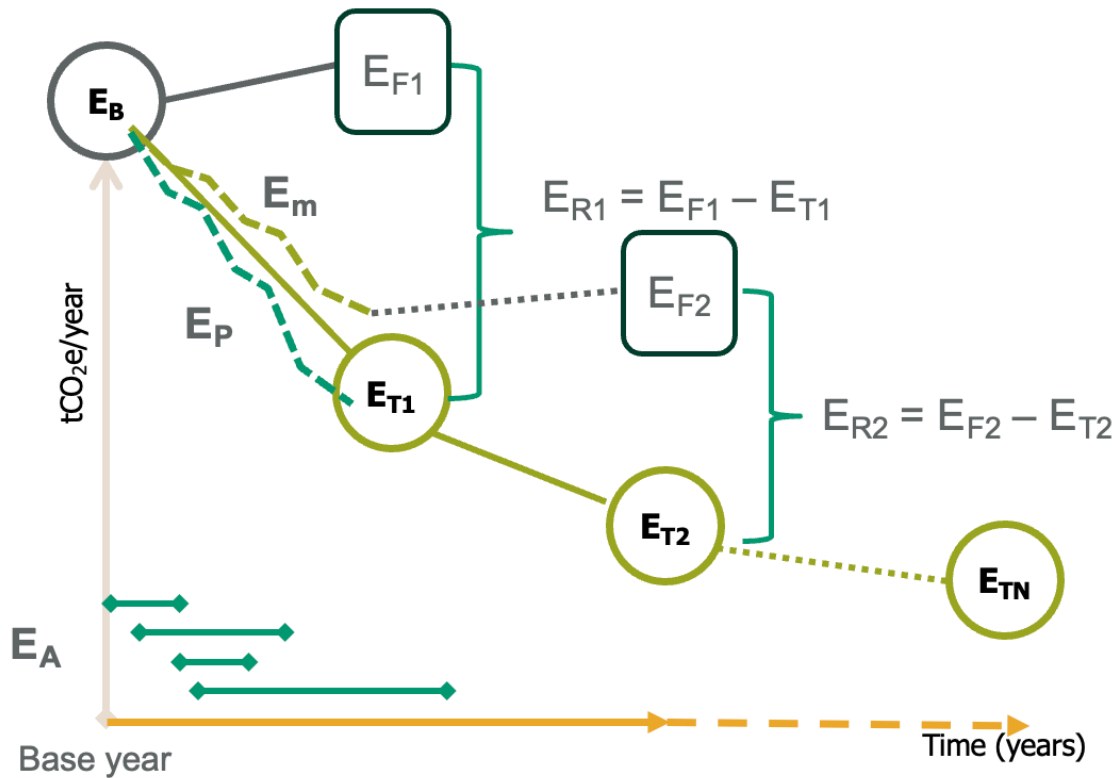


Figure 1 Overview of the decarbonisation planning process

The figure above shows an overview of the main steps in developing the decarbonisation plan. The abbreviations are the same as in Table 2 above with the addition of:

- E_A : These are the emission reduction actions to be undertaken. This is the same as the Energy & Carbon opportunities (ECOs) referred to elsewhere. It is essential that the sum of the results of these actions will meet or exceed the emissions reduction needed (E_R)
- E_P : This is the projected emissions pathway based on the implementation of the various emission reduction actions.

5. Step 1: Establish the base year ERGE

The base year ERGE is the reference point against which all future decarbonisation progress is measured. ISO 50100 requires that organisations establish a comprehensive, verified energy and emissions baseline as the foundation of their energy decarbonisation plan.

5.1 Organisational Boundary

The operational control approach is recommended for this guide. Under this approach, the organisation accounts for all GHG emissions from facilities over which it has full authority to introduce and implement operating policies. This is the most common approach in industrial, commercial and public sectors and is consistent with ISO 50100 guidance.

5.2 Base Year

The base year for the industrial sector in Ireland is 2018, in alignment with the Climate Action and Low Carbon Development Act 2021 and the Climate Action Plan. Where 2018 data is not representative (e.g. due to acquisitions, disposals or unusual operating conditions), organisations may propose an alternative base year with justification, subject to SEAI approval.

Note: Many organisations have already decided on base years which are different from the Irish national base year for the sector. It is desirable that plans and progress take both base years into account.

5.3 Procedure for establishing the base year ERGE

1. Define organisational boundaries using the operational control approach.
2. Quantify all energies consumed in the base year, including electricity and each type of fossil fuel, as the activity data (AD).
3. Obtain the corresponding emission factors (EFs) for each energy source from SEAI published conversion factors.
4. Multiply each energy consumption by its corresponding EF to obtain tCO₂ for each energy source and type.
5. Sum all fossil fuel combustion emissions to obtain total Scope 1 emissions (E_{BS1}).
6. Calculate Scope 2 emissions using both the location-based and market-based (where applicable) methods (E_{BS2}).
7. Sum Scope 1 and Scope 2 emissions to obtain the total base year ERGE (E_{BT}). Note that Scope 1 and Scope 2 need to be managed separately but it may also be of interest to see the total effect.
8. Document all data sources, assumptions and calculation methods.

All the data needed to calculate the Base year ERGE is included in the LIEN annual questionnaire. Refer to the LIEN Questionnaire User Guide for detailed instructions on entering energy consumption and emissions data. Emission factors for Ireland can be found at: <https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/>

5.4 ISO 50100 Enhancement: Baseline Data Quality

ISO 50100 emphasises the importance of data quality in establishing a reliable ERGE quantification. Organisations should:

- Use metered or invoiced data in preference to estimated data wherever possible
- Document the uncertainty associated with each data source
- Establish a data management process to ensure consistency of future data collection
- Consider having the base year ERGE independently verified, particularly for organisations with public reporting obligations

6. Step 2: Set the ERGE Target

Setting ambitious but achievable targets is central to a credible decarbonisation strategy. ISO 50100 requires that targets be time-bound, quantified, based on evidence, and consistent with a long-term decarbonisation trajectory.

6.1 Target-Setting Framework

Targets are typically developed on a top-down basis by deciding long-term and interim absolute emissions reduction targets in percentage terms. These percentage reductions are converted to ERGE targets values in tCO₂ by applying them to the Base year ERGE.

Example: A 35% reduction target for Scope 1 by 2030 becomes an emissions target of 65% of base year Scope 1 ERGE by 2030.

The basis of targets can come from multiple sources:

- National target: 51% reduction by 2030 and carbon neutrality by 2050 (Climate Action Plan)
- Sectoral target: 35% direct (Scope 1) emission reduction for industry by 2030 — this is the primary target for LIEN members' Scope 1 emissions and should be the central focus of decarbonisation planning. This should be the primary target for LIEN members.
- EU target: 55% reduction by 2030 and 90% by 2040
- Corporate targets: frequently the basis in multi-site organisations
- Science-based targets: validated through the SBTi for 1.5°C alignment

6.2 ISO 50100 Requirements for Target Setting

ISO 50100 specifies that ERGE targets shall:

1. Be expressed as absolute emissions for a specific year, e.g. Scope 1 target of 1000 tCO₂ in 2030.
2. Include interim milestones at regular intervals (recommended: at least every 3 years) to provide accountability and enable course correction.
3. Cover all scopes within the organisation's boundary.
4. Be reviewed at defined intervals and updated in response to material changes in the organisation or its operating context.
5. Take account of national or sectoral targets.

Note 1: Targets can also be developed bottom-up by identifying available decarbonisation opportunities and aggregating their projected impact. In practice, the most robust target-setting approach combines top-down ambition with bottom-up feasibility analysis.

Note 2: National and sectoral targets are based on the concept of carbon budgets. A carbon budget is the cumulative amount of carbon dioxide (and equivalent greenhouse gases) that your organisation can emit over a defined period while remaining consistent with a specific climate target — most commonly limiting global warming to 1.5°C or 2°C above pre-industrial levels. Think of it like a financial budget: just as you have a limited pool of money to spend before running a deficit, the

atmosphere can only absorb a finite amount of carbon before warming exceeds a dangerous threshold. For your organisation, this translates into a total emissions "allowance" that must be allocated carefully across operations, supply chains, and growth plans over time. Once the budget is spent, any further emissions contribute directly to overshooting the climate target, making early and sustained reductions far more valuable than last-minute action. Understanding your carbon budget is therefore not just an environmental exercise — it is a strategic planning tool that shapes investment decisions, operational priorities, and long-term risk management.

Recommended Target Structure for LIEN Members

Milestone	Target Year	Reduction	Notes
Interim 1	2030	35% for Scope 1 from 2018 base. Scope 2 target to align with Irish grid target	National target; 35% Scope 1 reduction for industry Use WAM for Grid target, included in LIEN Tool.
Interim 2	2035	Organisation-specific	Bridge target to maintain momentum
Interim 3	2040	Organisation-specific	Consider EU 90% target as a basis.
Long-term	2050	Full decarbonisation	Aligned with EU and national carbon neutrality targets

Table 3: Recommended target milestone structure

7. Step 3: Estimate the Future ERGE (EF)

The future ERGE represents the business-as-usual emissions trajectory, accounting for expected changes in operations but excluding any planned decarbonisation actions. Understanding the future ERGE is essential for determining the scale of the decarbonisation challenge and for quantifying the impact of individual actions.

This needs to be completed separately for Scope 1 and for Scope 2.

7.1 Factors Affecting the Estimation

The E_F will differ from the E_B due to various factors:

- Organisational growth: additional buildings, sites, production lines or increased activity levels
- Contraction: decreasing activity levels, site closures or production changes
- Product and process changes: new products, reformulations or process modifications
- Grid decarbonisation: the expected reduction in the Irish electricity grid emission factor over time, reducing Scope 2 emissions for all consumers
- Regulatory changes: new requirements that may affect energy use patterns

7.2 ISO 50100 Enhancement: Scenario Analysis

Consider developing multiple scenarios to account for uncertainty in future projections. At minimum, the following scenarios should be considered:

1. Central case: the most likely business-as-usual scenario based on current plans and trends.
2. High-growth scenario: reflecting potential expansion that would increase the decarbonisation challenge.
3. Low-growth scenario: reflecting potential contraction that would reduce absolute emissions but may also reduce available capital for decarbonisation investments.

Where normalised energy baselines (EnBs) have been developed under ISO 50001, these provide an excellent foundation for estimating future energy consumption resulting from changes in activity levels. The statistically valid range of the relevant variables should be respected.

Assumptions made in these projections should be documented and reviewed at least annually. The interaction between grid decarbonisation and the organisation's own Scope 2 trajectory should be explicitly modelled. The grid has a target to decarbonise by 80% by 2030, the latest projections are included in the LIEN questionnaire and are updated annually.

7.3 ERGE Reduction needed (ER)

To estimate the ERGE reduction needed, i.e. the quantity of emissions that need to be decarbonisation, subtract E_T from E_F .

$$E_R = E_F - E_T \text{ in tCO}_2/\text{year}$$

This needs to be calculated for each scope separately.

8. Step 4: Develop and implement ERGE reduction actions (E_A)

Once the base year ERGE, target ERGE, and ERGE reduction needed for each scope are established, the organisation develops and implements the specific actions needed to bridge the gap. ISO 50100 refers to this as the decarbonisation plan and provides a structured approach to action planning, prioritisation and implementation. The LIEN Decarbonisation Tool in the LIEN questionnaire develops this pathway for each scope.

8.1 Step 4A: Develop a carbon balance

A good starting point is to develop an energy and carbon balance that quantifies emissions from all parts of the organisation's activities and compares their relative impacts. This is analogous to the identification of significant energy uses (SEUs) under ISO 50001. A Pareto analysis typically reveals that 20% of emission sources account for 80% of emissions. This can be visualised as a Sankey diagram.

8.2 Step 4B: Develop the Decarbonisation Pathway

The 3 R's Hierarchy

The fundamental decarbonisation process follows the hierarchy of Reduce, Reuse and Refuel. ISO 50100 reinforces this prioritisation. One of the main reasons to prioritise Reduce and Reuse in advance of Refuel is to minimise the amount of energy being consumed prior to investing in measures to supply that energy from alternative sources. This is particularly important for achieving the Irish industrial sector target of 35% reduction in direct (Scope 1) emissions by 2030. It is also essential to maximise the financial benefits of decarbonisation for most organisations.

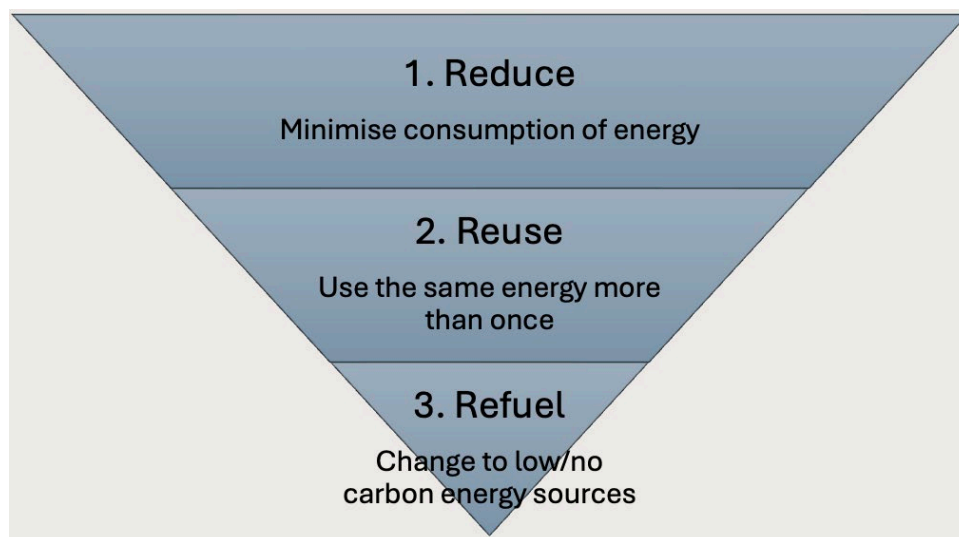


Figure 2 The 3 R's of decarbonisation actions

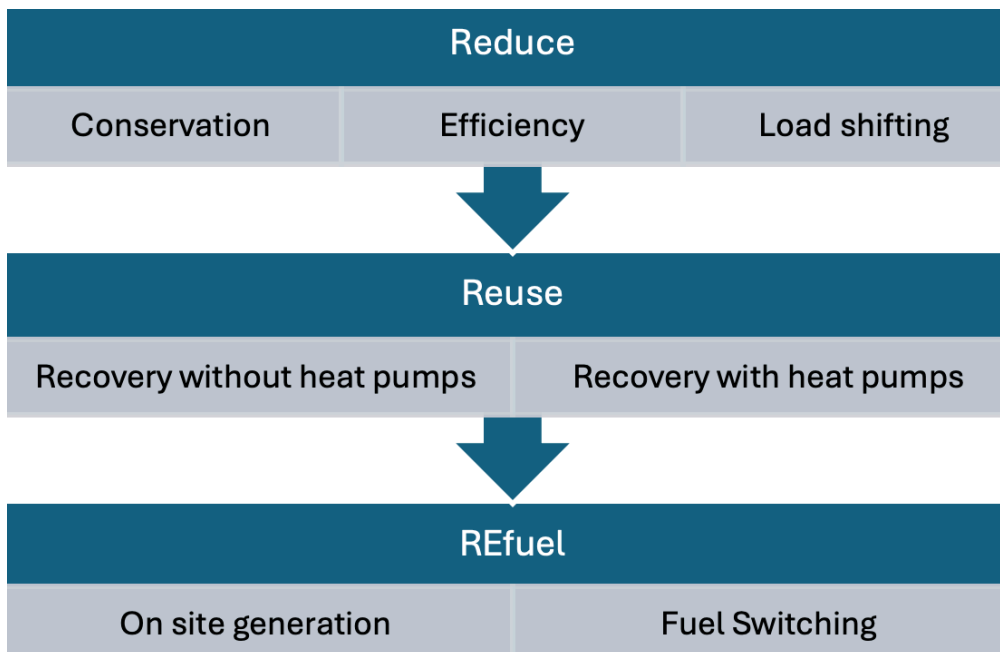


Figure 3 ERGE reduction action categories fitted to the 3 R's

Reduce: Energy Demand Reduction

This is typically the fastest and lowest-cost category of action, and is particularly important for reducing Scope 1 emissions from fossil fuel combustion towards the 35% industrial sector target. Reduce encompasses three aspects:

- **Energy Conservation:** low-cost or no-cost operational changes that reduce energy demand, typically with a simple payback of less than one year. Examples include challenging operating requirements, boiler combustion optimisation, HVAC setpoint adjustments, compressed air leak repair, retro-commissioning and schedule adjustments. Operational control as required by ISO 50001 is a significant energy conservation process and is perfectly aligned with energy conservation.
- **Energy Efficiency:** capital investments (CAPEX) that reduce energy demand, typically with a simple payback of more than one year. Examples include upgrading automation systems, enhanced insulation, variable speed drives, LED lighting, oxygen trim on burners and high-efficiency motor replacement.
- **Load Shifting:** adjusting the timing of energy consumption to optimise the use of lower-carbon energy sources or to reduce peak demand. Examples include shifting electrical loads to periods of high renewable generation on the grid, battery storage, thermal storage to decouple heat generation from heat demand, and demand response participation.

Reuse: Thermal Energy Recovery

Most energy consumed by an organisation is ultimately converted to heat and discharged as waste. Recovering and reusing this waste heat is highly effective at reducing Scope 1 emissions from fossil fuel combustion and also for reducing electricity demand. Organisations should systematically map waste heat streams and evaluate recovery potential before investing in new energy supply. Reuse encompasses two categories:

- **Heat Recovery without Heat Pumps:** direct recovery of waste heat at or near its original temperature using heat exchangers, economisers, recuperators, blowdown heat recovery, flash

vessels and process integration (PINCH analysis). This is typically the most cost-effective form of heat recovery.

- Heat Recovery with Heat Pumps: recovery of lower-grade waste heat and upgrading it to a higher, more useful temperature using electrically driven heat pumps. This enables the reuse of heat that would otherwise be too low in temperature for direct recovery, and can significantly reduce Scope 1 emissions by displacing fossil fuel heating.

Refuel: Transition to Alternative Energy Sources

Once energy demand has been minimised through Reduce and Reuse, the remaining energy needs should be met from low-carbon or renewable sources. This is the critical step for eliminating remaining Scope 1 emissions from fossil fuel combustion. Refuel encompasses two categories:

- Onsite Renewable Energy Generation: installation of renewable energy technologies on or adjacent to the site, including solar photovoltaic (PV) panels, wind turbines and solar thermal systems. Onsite generation provides the clearest additionality and can reduce both Scope 1 and Scope 2 emissions.
- Fuel Switching: replacing fossil fuels with lower-carbon or zero-carbon alternatives. Examples include electrification of thermal processes (electric boilers, electric steam generators), biofuels and biomass for heating, or biogas and green hydrogen as a fuel. Air source and ground source heat pumps fall under this category. Market based methods such as Corporate Power Purchase Agreements (CPPAs) also fall under this category.

Marginal Abatement Cost Curve (MACC)

A Marginal Abatement Cost Curve (MACC) is a powerful tool for visualising and prioritising decarbonisation actions. A MACC plots individual abatement measures in order of their cost per tonne of CO₂ avoided (€/tCO₂) on the vertical axis, against their cumulative abatement potential (tCO₂/year) on the horizontal axis. Each measure is represented as a bar whose width corresponds to its abatement potential and whose height represents its marginal cost. Measures that generate net cost savings (negative cost) appear below the horizontal axis, while those requiring net investment appear above it.

The figure below presents a hypothetical industrial MACC aligned with the 3 R's hierarchy. The measures are colour-coded: green for Reduce, orange for Reuse, and blue for Refuel. This ordering reinforces the strategic logic of the 3 R's:

- **Reduce** measures (green) appear on the left of the curve, where costs are lowest or negative. Energy conservation and efficiency actions such as compressed air leak repair, LED lighting, VSD motor upgrades and insulation improvements typically generate net cost savings through reduced energy bills, while delivering immediate abatement. These should be implemented first.
- **Reuse** measures (orange) occupy the middle of the curve at low to moderate cost. Flue gas economisers, process heat exchangers and industrial heat pumps recover waste thermal energy that would otherwise be lost, directly reducing Scope 1 fossil fuel consumption. These measures become progressively more cost-effective as energy prices rise.
- **Refuel** measures (blue) appear on the right of the curve at higher cost but with significant abatement potential. Onsite solar PV, electrification of heating, biomass and green hydrogen represent the transformational investments needed to eliminate remaining emissions once demand has been minimised. By implementing Reduce and Reuse first, the scale and cost of Refuel investments are significantly reduced.

Figure 1: Hypothetical Industrial Marginal Abatement Cost Curve (MACC)

Illustrative decarbonisation measures categorised by the 3 R's hierarchy

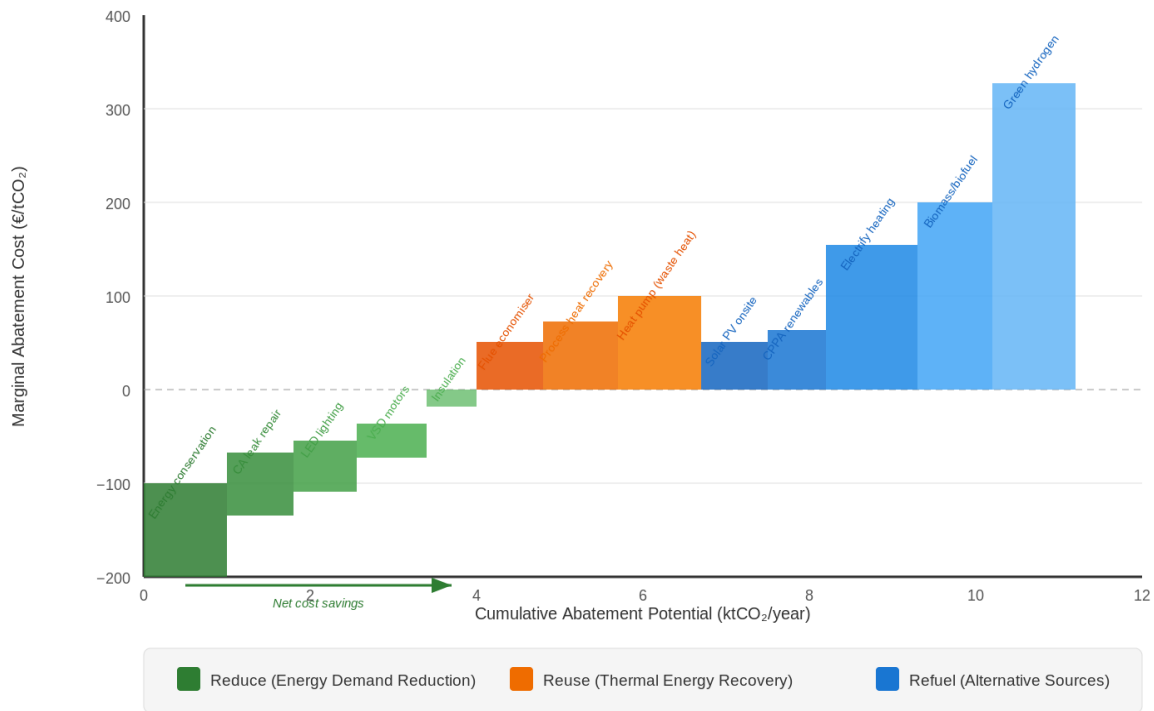


Figure 4 Marginal Abatement Cost Curve

The MACC demonstrates that a significant portion of industrial decarbonisation can be achieved at negative cost (savings) through Reduce and Reuse measures. LIEN members are encouraged to develop their own site-specific MACC as part of the decarbonisation planning process. This provides a clear evidence base for investment decisions and enables the sequencing of actions in alignment with the 3 R's hierarchy and ISO 50100's principle of prioritising direct reductions.

Note 1: An organisation can also show the position of its targets on the MACC curve, often showing that the 2030 target can be met while simultaneously reducing costs.

Note 2: Consider also that any measure where the marginal cost is less than the cost of carbon emissions is also likely to be a cost reduction measure.

Note 3: The values shown in the figure above are hypothetical and for illustrative purposes only. Each organisation should develop its own MACC based on site-specific data including actual energy costs, available technologies, capital costs and site conditions. The SEAI Decarbonisation Tool in the LIEN questionnaire supports this analysis.

8.3 ISO 50100 Enhancement: ERGE Reduction Action Planning

ISO 50100 requires that the energy decarbonisation plan include:

- A prioritised portfolio of ERGE reduction actions with estimated costs, timelines and expected emissions reductions
- Identification of interdependencies between actions (e.g. actions that may reduce the impact of others if implemented in a different sequence)
- Assessment of technical readiness and technology risk for each action, particularly for emerging technologies such as high-temperature heat pumps, green hydrogen and carbon capture

- A financial plan that links decarbonisation investments to available funding mechanisms, including SEAI grants, accelerated capital allowances and EU funding programmes
- Designation of responsibilities for each action and a governance structure for oversight
- Contingency planning for actions that may not deliver expected results

Carbon Accounting Measures

For completeness, two carbon accounting measures are described. These do not directly reduce GHG emissions but may form part of an organisation's broader strategy.

Guarantees of Origin (GOs)

A GO is an energy certificate defined in EU Directive 2009/28/EC that labels energy from renewable sources. The limitation of GOs is that they do not promote additionality and do not physically reduce emissions — they trade existing renewable energy. Organisations with high ambition should view GOs as an interim measure while more substantial actions are developed.

Carbon Offsetting

ISO 50100 is clear that offsets should only be considered for genuinely residual emissions that cannot be eliminated through any feasible means. Offsets shall not be used as a substitute for direct emission reductions. For this reason, offsets are not counted towards meeting the decarbonisation targets in this guide or in ISO 50100.

8.4 Step 4C: Implement the Decarbonisation Actions

This is the most important step in decarbonising an organisation. Only through implementing ERGE reduction actions will emissions actually be reduced. ISO 50100 emphasises that implementation requires adequate resources, clear accountability, effective project management and a culture that supports change.

Regular Review of Actions

Decarbonisation actions should be reviewed and updated at least annually. The technology landscape is evolving rapidly: high-temperature heat pumps, green hydrogen, advanced energy storage and CCUS are becoming increasingly viable. These technologies are not required to meet 2030 targets for most LIEN members. As energy and carbon prices evolve, the financial case for actions will change. ISO 50100 requires that the transition plan be treated as a living document, updated to reflect new opportunities, technological developments and changes in the organisation's circumstances.

Note: Traditionally, investment decisions are based on financial return criteria. However, as with safety and environmental investments, there will be cases where decarbonisation measures should be implemented even where they do not meet the usual financial thresholds. ISO 50100 encourages organisations to adopt broader evaluation criteria that include carbon pricing, risk mitigation value and strategic alignment.

9. Step 5: Monitor Decarbonisation Progress

Monitoring progress and comparing the ERGE trend against targets is essential for evaluating the effectiveness of implemented actions and for taking corrective action when progress does not meet expectations. ISO 50100 requires a robust monitoring, measurement and evaluation framework.

9.1 Monitoring Procedure

1. Collect all activity data for the reporting period. An annualised trend (rolling 12-month sum of Scope 1 ERGE and of Scope 2 ERGE updated monthly) enables more frequent monitoring than an annual cycle.
2. Update emission factors from the SEAI national database.
3. Calculate Scope 2 emissions using location-based and additionally, if required, market-based methods.
4. Plot annual emissions against the baseline and target trajectory to visualise progress.
5. Analyse variances between actual and planned performance and identify root causes and take corrective action.
6. Report results to management and update the decarbonisation plan as needed.

All the data needed to monitor decarbonisation progress is included in the LIEN annual questionnaire. Refer to the LIEN Questionnaire User Guide for guidance on reporting actual emissions data and to the Decarbonisation Tool Guidance for updating progress against the decarbonisation plan.

9.2 Types of Decarbonisation Indicators

Primary Indicator: Absolute ERGE

The primary indicator is absolute ERGE (tCO₂/year) compared with the base year ERGE. Only through absolute reductions will the impact of the climate emergency be addressed. This is the indicator against which LIEN targets are measured.

Secondary Indicators

Normalised Energy Performance Indicators

Normalised energy and carbon indicators account for factors affecting consumption (e.g. production volume, weather, etc.). These are required by ISO 50001 and increasingly used in industry, they provide insight into underlying efficiency, performance, and energy waste. However, they do not necessarily reflect changes in absolute emissions. An organisation can improve its normalised performance while absolute emissions increase due to growth.

Their benefits include enhanced technical understanding of energy drivers, improved estimation of savings from ECOs, and verification of implemented measures, together with supporting the identification of ECOs.

Bottom-Up Performance Indicators

Bottom-up indicators quantify the energy savings and CO₂ reductions from individual ECOs. Summing completed ECOs demonstrates continual improvement and enables assessment of whether planned actions will meet targets. Limitations include the exclusion of unquantified operational improvements and the inability to capture increases in consumption elsewhere.

Intensity-Based Indicators

Intensity indicators (e.g. tCO₂ per unit of production or tCO₂ per euro of revenue) can be misleading when used in operational monitoring and shall not be used as decarbonisation indicators. They are valuable in design and procurement contexts — for example, specifying low-carbon equipment — but in operations they can mask increases in absolute emissions.

Note: *One sector where carbon intensity is a valid primary metric is electricity generation. Reducing the carbon intensity of the grid reduces Scope 2 emissions for all consumers.*

9.3 ISO 50100 Enhancement: Performance Evaluation

ISO 50100 requires that the monitoring framework include:

- Defined monitoring frequencies appropriate to each indicator (at minimum annual, with monthly or quarterly recommended for key metrics)
- A process for verifying the accuracy of emissions data and calculations
- Regular management review of decarbonisation performance, integrated with EnMS management review where ISO 50001 is implemented
- Internal auditing of the decarbonisation strategy and transition plan
- A corrective action process when actual performance deviates significantly from the planned trajectory
- External reporting to SEAI through the annual LIEN questionnaire and, where applicable, to other stakeholders through sustainability or CSRD reports

10. Using an Energy Management System (EnMS) to Manage Decarbonisation of energy consumption

Many industrial organisations already operate an EnMS, whether certified to ISO 50001 or not. An effective EnMS provides an excellent foundation for decarbonisation. ISO 50100 explicitly builds on the ISO 50001 framework and recommends that organisations leverage existing EnMS structures. The following outlines how each element of the EnMS supports the decarbonisation strategy.

10.1 Context of the Organisation

The impact of energy-related GHG emissions on climate is a critical part of the context in which energy management operates. Geopolitical instabilities, evolving regulations (including the CSRD and EU Emissions Trading System), carbon border adjustment mechanisms (CBAM) and Ireland's sectoral targets (35% for industry) all shape this context. ISO 50100 requires that the decarbonisation of energy consumption be embedded within the organisation's understanding of its operating environment and stakeholder expectations.

10.2 Leadership

Committed leadership from top management is the single most critical success factor. ISO 50100 requires that leadership go beyond policy statements to include active sponsorship, adequate resourcing, accountability mechanisms and transparent public commitments to decarbonisation. Good leadership includes funding innovation, supporting measured risk-taking and celebrating milestones.

10.3 Planning

The energy action planning process in ISO 50001 is fully aligned with the developing decarbonisation action plans. The change in emphasis for decarbonisation is to prioritise the elimination of fossil fuels, not merely their efficient use. ISO 50100 calls for integrated transition planning that considers the full hierarchy: Reduce, Reuse and Refuel.

EnPIs developed under ISO 50001 provide the analytical foundation for decarbonisation monitoring, while the primary decarbonisation indicator remains absolute emissions.

10.4 Support

Training, competence, awareness and communication elements of the EnMS should be extended to cover decarbonisation. Staff at all levels need to understand how their roles contribute to the organisation's energy decarbonisation efforts.

10.5 Operations

Operational control requirements for energy performance improvement are identical to those for decarbonisation. Two extensions are needed:

- Energy-efficient design (EED) should evolve to carbon-efficient design (CED) — for example, a heat pump may be preferred over a more efficient fossil fuel boiler
- Procurement should account for lifecycle GHG emissions in addition to energy performance

10.6 Performance Evaluation

Internal audits and management reviews under the EnMS should be extended to cover decarbonisation performance indicators, target progress and the effectiveness of the transition plan. ISO 50100 recommends that decarbonisation progress be a standing item on the management review agenda.

10.7 Improvement

Continual improvement applies equally to decarbonisation as to energy management. The Plan-Do-Check-Act (PDCA) cycle of identifying ERGE reduction actions, evaluating them, implementing the most effective ones and verifying results is the mechanism through which both energy performance improvement and decarbonisation are achieved in practice. ISO 50100 emphasises that the improvement process should explicitly consider whether actions are consistent with the long-term decarbonisation trajectory, not just whether they deliver short-term savings.

11. SEAI Annual Publication of Industry CO₂ Emissions Data

Annual publications generated using data collected from LIEN members will include:

- Overall combined LIEN emissions for the reporting year compared with the 2018 baseline, reported under both location-based and market-based methods. As LIEN membership may change from year to year, baseline data may require adjustment to maintain comparability.
- Projected 2030 combined LIEN emissions and progress towards achievement of 2030 targets.
- Aggregated performance against the target milestone structure (2030, 2035, 2040).