Deployment Guidelines – Manufacturing Sector

April 2024

EUROPEAN GREEN DIGITAL COALITION

Funded by the European Union

EUROPEAN GREEN
DIGITAL COALITION

Deliverable name: Deployment Guidelines – **Manufacturing**

Dissemination Level: Public

Published: April 2024

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The European Green Digital Coalition (EGDC) is an initiative of companies, supported by the European Commission and the European Parliament, based on the request of the EU Council, which aims to harness the enabling emission-reducing potential of digital solutions to all other sectors.

The secretariat of the European Green Digital Coalition is managed by the consortium of the European Parliament Pilot Project for the EGDC, funded by the European Commission, namely

the leading associations GeSI, the European DIGITAL SME Alliance, DIGITALEUROPE, ETNO and GSMA, working together with Carbon Trust, Deloitte, Sustainable ICT.

This deliverable has been produced by the consortium of the European Parliament Pilot project for the EGDC.

Global Enabling Sustainability Initiative (Coordinator)	DIGITALEUROPE	European Telecommunications Network Operators' Association	European DIGITAL SME Alliance

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1 Introduction

To help maximise the benefits of ICT solutions with the potential to enable a positive net carbon impact[1], the European Green Digital Coalition (EGDC) European Parliament (EP) Pilot Project has developed a set of Deployment Guidelines. These guidelines provide recommendations for solution developers and providers, as well as considerations for buyers/users of ICT solutions, investors, and policy makers to:

1. Maximise carbon, resource, and energy savings enabled by ICT solutions
2. Minimise solutions' emissions
3. Define metrics and track them to understand solutions' impact
4. Going further: Designing the solution to broaden its reach; and
5. Appropriately consider other sustainability impacts beyond carbon

Six separate sets of guidelines have been developed to cover the six sectors identified as priority areas by the EGDC: Energy/Power; Transport; Construction/Buildings; Manufacturing; Agriculture; and Smart Cities. This specific guidance document focuses on the ***Manufacturing Sector***.

To ensure that the Deployment Guidelines bring benefits to all involved parties and reflect the needs of each sector, the EGDC EP Pilot Project has consulted relevant stakeholders via a series of sectorial workshops, involving parties from each priority sector, including solution developers, end-users, and decision makers.

It should be noted that any reference to carbon or carbon emissions designates emissions of all greenhouse gases.

[1] Digital Solutions with the potential to enable a positive net carbon impact are technologies that can help users avoid or reduce climate-harming greenhouse gas emissions, usually through a reduction or avoidance of resource use (e.g. fuel, electricity, raw materials, etc.).

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1.1 Manufacturing Sector – A Call for Decarbonisation

Decarbonising the manufacturing sector coupled with the digitalisation of the manufacturing environment is essential to the delivery of the Green Deal Industrial Plan for the Net Zero Age. Announced in March 2020, the two pillars to the European Union's Industrial Strategy are transitioning towards climate neutrality and digital leadership. The European manufacturing sector represents on average 800 Mt CO_2e of GHG emissions annually, or 22% of the EU's total emissions [2]. Decarbonising the manufacturing sector would deliver substantial progress in tackling climate change, reducing the pollution of natural environments, preserving biodiversity, and promoting a circular bio-based economy.

Decarbonisation for the sector will require reduction in energy and carbon intensity, and improvement of resource efficiency of manufacturing processes, reduction of waste generation and adoption of circular economy practices and reduction of the contamination of waterways, soils, and the atmosphere.

In this, digital has a big role to play. In an era marked by mounting environmental concerns and the urgent need to combat climate change, maximising carbon, resource, and energy savings has become an imperative for sustainable development. As societies strive to transition to a greener and more resilient future, harnessing the potential of ICT solutions has emerged as a crucial strategy. From resource optimisation, Artificial Intelligence (AI) and Augmented Reality (AR), to using smart sensors and Internet of Things (IoT) technology and 3D-printing, digital technologies are revolutionising manufacturing and offer significant opportunities for carbon footprint reduction for the sector.

To keep on track for a net zero world and reach the European Green Deal's target of a climate neutral economy by 2050, greenhouse gas emissions from the manufacturing sector must decrease further than the 23% realised by the sector since 2008[2].

At the heart of this transformation lies the recognition that ICT solutions possess the ability to optimise resource consumption, minimise waste generation, and enhance energy efficiency across value chain. By harnessing advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and cloud computing, the whole

[2] Eurostat: EU economy emissions in 2021

ecosystem of manufacturing stakeholders can unlock new avenues for sustainability and drive substantial positive change.

However, it is also acknowledged that much of the ability of ICT solutions to contribute to the decarbonisation of manufacturing is dependent on wider shifts within the sector. It will require cooperation with external stakeholders including policymakers, financiers, and other businesses within the field. For instance, for many ICT solutions in the manufacturing sector, the carbon saving potential increases considerably when more energy-efficient 5G networks are available and national electricity grids decarbonise.

To prepare for the transition, stakeholders will have to consider green financing opportunities, both in the near and long-term to implement these solutions. For many companies, the shift will require a significant set of changes for their business model and existing products and services offerings.

Similarly, not all recommendations provided in this document systematically align to short term business interests, some seek to support the sustainable deployment of solutions thereby support positive business impacts over the long term. Recognising the current state of the manufacturing sector, this file, together with the overall methodology will be updated periodically to align with future developments in the wider sector.

The heterogeneity of the manufacturing landscape, which spans from transport, agri-foods, textile, construction materials, metallurgy, or telecoms-component production, is a challenge for the development of deployment guidelines to capture the requirements of such varied production environments. This document has purposefully been developed to capture overarching concerns and concepts of manufacturing processes. This is namely transforming large amounts of primary inputs through processes that consume high amount of energy and generate waste to produce manufactured outputs. This report also considers that manufacturing environments differ widely in their levels of automation and in the level of human interventions required.

2 Maximising net carbon impact from the implementation of ICT solutions

ICT solutions hold great potential for enabling decarbonisation across sectors. Their integration can optimise processes and reduce carbon emissions. However, simply adopting ICT solutions is not enough to achieve maximum decarbonisation potential. The development, deployment, and use of these solutions must be done strategically and purposefully to ensure their effectiveness, maximising co-benefits to the wider community. This requires a comprehensive approach that considers factors such as scalability, performance tracking, and post-sale support to demonstrate results in line with financial and policy-maker expectations.

Below, you will find five key areas to consider and explore in order to help maximise the potential of ICT

solutions:

Monitoring and tracking performance
- To quickly troubleshoot any issues
- To allow for an understanding of performance under different circumstances
- To inform future improvements

Post-sale Training
- Plan for adequate training and support resources to assist users in adopting and troubleshooting the solution.
- Provide documentation, tutorials, and a support system to assist users and address their queries.

Post-sale Support
- Carbon benefits may decrease over time without adequate maintenance and support; support should be provided to ensure lasting positive impacts.

Integration
- Determine how the solution will integrate with existing systems or third-party services
- Consider data exchange to ensure smooth integration

Performance Optimisation and Automation
- Consider the potential of automation.

2.1 Monitoring and tracking performance

To maximise the emissions-reducing benefits of an ICT solution, it is essential to implement robust monitoring and tracking mechanisms to assess its performance. By continuously monitoring the solution's effectiveness, potential issues can be quickly identified and addressed, minimising disruptions and maximising reductions.

Monitoring and tracking also provide valuable insights into the solution's performance under different conditions, allowing for a more comprehensive understanding of its strengths and limitations. For solution developers and buyers, this knowledge can serve as a basis for informed decision-making and helps identify areas for improvement.

Another benefit is that providing solution users with access to usage and performance data empowers them to better understand their consumption patterns and make more informed decisions. Solutions should therefore aim to measure and analyse relevant data and generate feedback that highlights the environmental impact of users' actions and behaviours. This feedback serves as a valuable tool for raising awareness and promoting behavioural change towards more sustainable practices. With clear information about their consumption habits, users can identify improvements such as reducing energy usage, optimising resource utilisation, or adopting eco-friendly alternatives.

Manufacturing Sector

Due to the diversity of the manufacturing landscapes in Europe, in terms of the nature of production lines, their scale, the aging of infrastructure, it is possible that ICT solutions will be applied to very different environments. Therefore, collecting data, and monitoring performance of an adopted solutions is essential for manufacturers to tailor solutions to their operations and maximise their impact through feedback received post implementation.

Barriers to adequate data collection may be the lack of assigned responsibility within the operational teams as well as within-factory control procedures to ensure quality within the data collection process. This should not be seen as utilising resources in a way which is detracting from daily operations. Rather, assigned responsibility reinforces the reliability of data-driven tools and the useability of their outputs, thereby strengthening the overall effectiveness of operations.

2.2 Post-sale training

In the context of maximising the benefits of an ICT solution for emissions reduction, post-sale training plays a key role. Without proper training, users may struggle to fully grasp the solution's features, leading to suboptimal usage and missed opportunities for emissions reductions.

The availability of comprehensive documentation, tutorials, and a responsive support system during rollout and installation significantly enhances users' ability to troubleshoot issues and address queries. By prioritising the provision of post-sales training, solution developers and providers help users have the necessary knowledge and resources to optimise the solution's performance. Collaboration with higher education institutions to encourage training of green technology engineers could support a sustained supply of skilled labour.

Manufacturing Sector

Post-sale training should enable ICT solutions to be properly integrated into existing systems and ensure solution buyers have adequate resources to implement the solutions and tailor them to the specific environment. This includes ensuring operational teams have the skills and appropriate understanding of the tools to effectively use the solutions as intended. In addition, developers should consider providing any learning materials in multiple languages to ensure the guidance can be effectively communicated to all users.

Barriers to implementation of post-sale training may be the associated cost and time commitment. Whilst there is a short-term burden to a continued training expense, a sustained training programme ensures the workforce are kept up to speed with updates made to software and ensures that potential workforce turnover does not result in reduced understanding of the solution's features over time or reduced efficiency of the solution implementation.

2.3 Post-sale support

Post-sale support after the installation of the ICT solution is another component which can help increase savings. Without ongoing support, the carbon benefits achieved through the initial implementation may decrease over time.

Adequate maintenance and support are necessary to ensure the solution continues to operate optimally, adapt to evolving needs, and deliver lasting positive impacts on emissions reduction. Post-sale support includes addressing technical issues, offering guidance on best practices, assisting in system updates and upgrades, and providing the appropriate replacement parts. This ensures that the ICT solution remains effective and efficient throughout its lifespan, sustaining the desired emissions reductions and maximising the long-term environmental benefits.

Manufacturing Sector

Equipment or System Malfunction: Over time, existing or solution-specific manufacturing equipment and systems may experience malfunctions or performance degradation. Ongoing support driven by regulation helps avoid these issues going unnoticed or unresolved, by identifying and addressing equipment malfunctions promptly, ensuring that the ICT solution continues to operate and deliver optimal savings.

Changes to Operating environments: Broader technological disruptions, disruptions to supply chains, as well as changes to regulations framing waste disposal practices or labour practices may impact the application and use of ICT solutions. Without ongoing support, an ICT solution may not adapt to these changes effectively, leading to resource inefficiencies and increased emissions.

Technological Advancements and Updates: Ongoing post-sale support is required to ensure the solution does not become outdated or incompatible with newer technologies, limiting its effectiveness and potential carbon savings. Ongoing support can help ensure that the solution remains up-to-date, compatible with the latest advancements, and capable of leveraging new features or functionalities that enhance efficiencies.

Opportunity:

This support, along with post-sale training, can also be an opportunity for companies to extend their portfolio of services.

2.4 Integration

Implementing ICT solutions requires careful consideration of how these ICT solutions will interact with existing systems or third-party services. An important step in the integration process is determining how the solution will fit into the current infrastructure, minimising disruptions, and maximising efficiency gains.

Solution developers should assess solution compatibility, identifying potential dependencies, and designing interfaces for smooth interaction between different systems. They should engage with solution buyers and users to understand the case-by-case circumstances and provide guidance accordingly. Solutions buyers and users should work collaboratively with developers and providers to provide insight into their systems and highlight any potential issues or roadblocks.

Manufacturing Sector

ICT solutions in the manufacturing sector may use sensors or other Internet of Things (IoT) devices to monitor resource usage (energy, resources, water), to flag defects on the production. Ideally, solutions are designed so that they allow manufacturers to share data collected on individual sites with other sites, who may use different data-sharing technologies. This would allow manufacturers across different site to share data to establish the most efficient manufacturing set up configurations and maximise carbon savings delivered by the solution.

Internal processes in manufacturing are often confidential which may lead to concerns of confidentiality breaches when sharing data. These should be mitigated through the use of NDAs, as required, for sharing information.

2.5 Performance Optimisation and Automation

Lastly, performance optimisation and automation are components of maximising the potential benefits of ICT solutions. Automation plays a key role in this process by reducing or eliminating human intervention and streamlining operations, by enabling real-time monitoring, predictive analytics, and intelligent decision-making. This allows for timely adjustments to minimise energy and resource waste. By limiting human intervention, the potential for errors and inefficiencies decreases.

Manufacturing Sector

Optimisation and automation can help manufacturers flag issues in the production line as they arise, leading to fewer production delays, better machinery maintenance and less waste of raw materials. Automating processes such as quality control also reduces the need for human intervention on tasks which could present Health and Safety risks.

Moreover, leveraging AI in the decision-making process can aid in selecting the best possible operating conditions – for example, understanding when the blinds should be closed and lights turned on, and having this process by done automatically. By embracing automated solutions, energy savings can be increased, ensuring a more efficient and sustainable decision support process/system.

3 Minimising emissions

As the focus is often on maximising the net carbon impact potential of an ICT solution, it is critical not to forget the need to minimise the ‘cradle to grave’ emissions resulting from the deployment and use of that same ICT solution. While digital can be a force for good, it also has the potential to inadvertently contribute to environmental harm. By prioritising emission reduction strategies, solution developers/providers, buyers, and users can ensure that the benefits derived from an ICT solution are not offset by its carbon footprint. This section of the Deployment Guidelines, therefore, focuses on the need to actively mitigate and reduce emissions associated with the creation, adoption, utilisation, and disposal of ICT solutions.

3.1 Negative direct effects from the solution itself

While emissions from the solution itself may not always be significant compared to the savings it enables, they remain something to be aware of and to minimise. Also referred to as First Order Emissions, typical hotspots for ICT solutions include the following:

- **Hardware and its manufacture**: ICT solutions often have physical hardware components. The production of these components involves the extraction and processing of raw materials, manufacturing processes, and assembly. Emissions hotspots in this phase of a solution's lifecycle include the energy consumption in factories, emissions from chemical processes, and the extraction of rare earth metals, such as lithium for batteries.
- **Use phase – hardware and software**: During the use phase, ICT solutions consume energy for operations, including charging, data processing, and network connectivity. The emissions hotspots in this phase of a solution's lifecycle are primarily associated with electricity consumption.
- **Use phase – network infrastructure**: ICT solutions do not often operate as a standalone. The operation of data centres, telecommunications networks, and other ICT infrastructure requires a significant amount of energy. Data centres, in particular, consume large amounts of electricity for cooling, server operation, and data storage.
- **End-of-life**: Due to limited waste management process and sometimes a lack of understanding of appropriate waste practices by users, e-waste is often disposed of incorrectly causing harm to the environment and costing society valuable natural resources. When ICT solutions reach the end of their life, they need to be adequately disposed of or recycled. Emissions can occur during the disposal process, especially if electronic waste is incinerated or ends up in landfill. If not conducted properly, recycling processes can also generate emissions than would be saved by the reuse of the materials.

    - Important note: As far as software updates are concerned, while some might indeed allow to improve efficiency or compatibility of the solution with other technologies, updates could also lead to early obsolescence of devices. Solution developers and providers should be conscious of this when rolling out updates.

Overall, minimising solution emissions can be quite resource and cost intensive. However, solution developers and providers do not need to be doing of this alone. Solution developers and providers should strive to develop B2B partnerships to work together with

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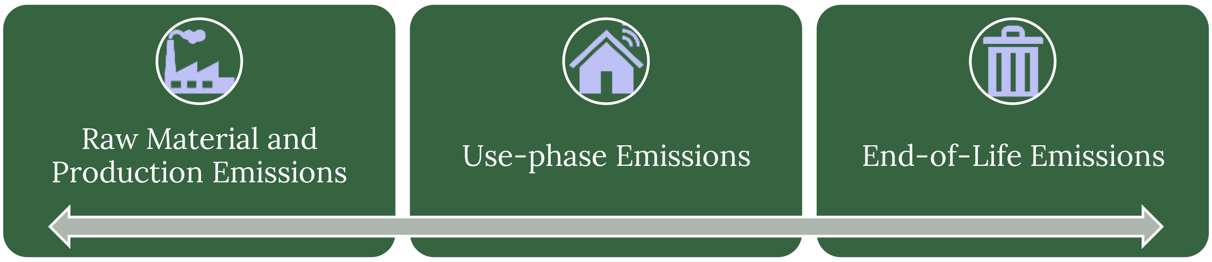
other organisations. Policy and industry bodies also have a role to play incentivising data sharing and providing support for developers/providers to do these assessments and help facilitate B2B and industry wide engagements.

3.1.1 Minimising emissions from the solution



Solution Embodied Carbon:

- **Life cycle assessment**: Ideally developers should conduct life cycle assessments of their solutions to identify and address emissions across the entire life cycle, from production to disposal. This can help optimise the environmental performance of the solutions. Developers should follow leading global standards (such as the GHG Product Life Cycle Accounting and Reporting Standard) or, if there are no in-house capabilities, consult third parties to support.
- **Raw material and production emissions**: Developers should select and work with suppliers that provide sustainable raw materials. They should measure and manage their Scope 3 emissions to reduce the associated production emissions.
- **End-of-Life emissions**: Developers should be designing ICT solutions to be circularity-ready. Integrating circularity involves two main key steps: designing for reuse/refurbishment and implementing effective e-waste management systems. This includes incorporating the possibility for components of the solution to be refurbished or maintained to extend the end of life of devices, as well as establishing collection and recycling programs to ensure proper disposal and recovery of valuable materials. Actions to tackle end-of-life of devices should be incorporated as part of post-sale support of this when rolling out updates.

Overall, minimising solution emissions can be quite resource and cost intensive. However, solution developers and providers do not need to be doing of this alone. Solution developers and providers should strive to develop B2B partnerships to work together with other organisations. Policy and industry bodies also have a role to play incentivising data sharing and providing support for developers/providers to do these assessments and help facilitate B2B and industry wide engagements.

Operational Carbon:

Use-phase emissions:

- **Energy-efficient design**: Developers should prioritise energy efficiency in the design of their solutions, ensuring that the solutions consume minimal energy while delivering the desired functionalities. This can include optimising algorithms, reducing standby power, and using energy-efficient components.
- **Partners:** When developing a solution, it is important to consider who to partner with and the impact of their contribution. If your solution will use the cloud/data centres, what is the impact of this? Do the cloud/data centres run on renewable energy?

Manufacturing Sector

- Reducing upstream emissions associated with the production of the solution hardware components can be achieved by regular maintenance of the systems, to optimise its use-life.
- Reducing emissions associated with the use-phase of the solution can be achieved by integrating on-site renewable energy generation to the production site to reduce the carbon intensity of the electricity consumed.
- If applicable, retaining the additional heat or thermal energy generated by the ICT solution for district heating purposes could further reduce the impact.

3.2 Minimising rebound (negative indirect) effects and other potential negative impacts on the climate

Increases in emissions from the introduction of a solution can come not only directly from the solution itself, but can be the result of unintended consequences, often driven by behavioural change. These negative higher order effects are known as Rebound Effects, and typically occur as effects that cause an increase in consumption due to improved efficiency of resource use, for example, an efficient product is cheaper to operate, and hence more is consumed. The improved efficiency is not limited to cost, but can be any resource, such as materials, time, cost, or space.

This subsection will take stock of circumstances where the positive climate impacts of the solution could be diminished or reversed and will provide guidance on how to address this.

Manufacturing Sector

A rebound effect is the increase in emissions occurring as result of the introduction of the ICT solution, often driven by behavioural changes in demand for carbon-intensive goods or activities.

Common rebound effects to look out for are outlined below:

- **Increased energy consumption due to extended use and overcompensation for energy savings: ICT** solutions that improve energy efficiency result in energy savings. However, operating teams might respond to these savings by increasing the daily or weekly running time of machinery, offsetting some or all of the initial gains.
- **Increased manufacturing output:** The efficiencies that may be brought about by ICT solutions can help grow the output of a manufacturing site. Boosted business performance may help businesses increase in size, which ultimately may lead to a net increase in carbon emissions. Depending on the nature of the manufactured product, increased output may also have negative impacts of promoting over-consumption.

3.2.1 How can rebound effects or negative impacts be avoided or mitigated?

While rebound effects will often be outside of the direct control of solution developers, it is important for prevention and mitigation processes to be put in place. Developers, providers, buyers, and users of ICT solutions should consider how to minimise rebound effects throughout the solution lifecycle. Not considering this can lead to the diminishing or reversal of savings enabled by the ICT solution.

Manufacturing Sector

Tracking rebound effects in the context of ICT solutions requires collaboration and shared responsibility among different stakeholders. The responsibilities can be divided as follows:

1. ***Solution developers/providers***: Developers and providers of ICT solutions have a primary responsibility to design and offer solutions that prioritise energy, fuel and resource efficiency. They should conduct thorough assessments of potential rebound effects

influenced by user behaviour during the development and deployment phases of their solutions. Developers should also provide guidance and information to solution buyers and users regarding energy consumption and the optimal use of their solutions.

2. ***Manufacturers***: Solution buyers, play a role in ensuring the effective monitoring and management of rebound effects. They should consider the possible ways in which rebound effects may materialise in the different circumstances for which they are purchasing the ICT solutions. Buyers should then engage with users to establish clear performance indicators to track and mitigate rebound effects over time.

Avoidance or Mitigation of Rebound Effects:

To mitigate the impact of rebound effects relating to the risks of enabling over-consumption, manufacturers should consider creating direct feedback loops where applicable, such as take back policies in the clothing industry. Extending the use life of products is also an important consideration, for instance by designing products to enable the replacement of parts which see the most wear should be considered by manufacturers in the case where they are producing their own products. It is acknowledged that product design considerations would not be relevant to the case of outsourcing manufacturing to a third party which would limit control over the entire product value chain.

4 Measuring net carbon impacts

Metrics are essential to support the solution's value proposition and to assess benefits and impacts. This section will provide guidance on which metrics to use and/or how to select them and can also address pitfalls to avoid in the process of selecting and communicating metrics.

4.1 Selecting the most relevant metrics

Different stakeholders care about different metrics. For example, solution developers might focus primarily on energy/fuel savings, whereas customers might focus more on reduced input costs. Focusing communication on metrics that matter to solution developers but don't matter as much to their clients or financial backers may lead to limited adoption. To optimise the deployment of a solution, understanding what metrics matter most to solution users and other stakeholders is key.

On the other hand, tracking the right metrics to be able to quantify the net carbon impact and understand the positive environmental potential of a solution is crucial to aid the path to sectoral decarbonisation. Some suggestions for relevant metrics for pre and post implementation are discussed below.

4.2 Pre-implementation metrics

What needs to be measured before implementation to establish a baseline from which to measure the solution's benefits?

To understand the benefits enabled by ICT solutions, key metrics must be defined and tracked. It is key to start tracking the relevant metrics before the implementation of the solution to allow for a reliable comparison between the before and after scenario. Without this, establishing a baseline and evidencing the positive impact of an ICT solution may be difficult and will likely need to rely on high-level assumptions. It is the combined responsibility of solution developers/providers, buyers, and users to work in collaboration to track the current scenario before the implementation of the solution.

Procedures should be put in place to normalise this practice. For solution buyers and users, tracking the current conditions and impact allows them to better understand their own current environmental impact and identify key hotspots for emission reduction. Without understanding the current conditions, it is harder to know what needs to be reduced, and by how much. On the other hand, solution developers/providers should encourage this practice and request this information pre-sale or at sale. Not only will this data help them better deploy the solution for the buyers and users but will also help them better understand and quantify the impact.

Manufacturing Sector

To quantify the solution's impact, it is important to measure datapoints as accurately as possible before its implementation. The specific metrics to track depend on the solution type, but common metrics to track for the sector include:

- **Resource use:** For solutions that optimise the use of resources, including raw materials and energy use, pre-solution measurements should be taken on these, as well as possible areas or moments of high resource use. These may be measured against output, e.g. [kg of input aluminium/kg output product] or [annual kWh electricity/kg output product] or against operations floor area, e.g. [kWh /m2], or unit of measurement, e.g. [kg input discarded / kg output produced].

- **Variability:** To ensure the reliability of data points before implementation of the solution, it is important to measure data over a longer timeframe, typically several years thereby monitoring and accounting for any seasonal fluctuations.

While tracking this information may present a cost in the short run, the data could be leveraged to support other business functions in the medium to long-term, including in procurement.

4.3 Metrics to track during and after implementation

To quantify and evidence the net carbon impact of an ICT solution, please see below suggested metrics to track during and after implementation. These metrics should align to those measured pre-implementation and should ideally also be metrics of interest for solution developers, buyers, users, and financial backers so that this data can be used to inform tracking beyond emissions reductions.

Manufacturing Sector

Resource use optimisation: Measure the quantity or quality of each optimised resource type before, during, and after implementation of the solution and correlate these to output, area use or unit of measurement to assess increased efficiencies.

Renewable energy integration (before and after): Evaluate the integration of renewable energy sources in the production site, such as solar panels. Monitoring the share of renewable energy used in the site pre-implementation of the ICT solution helps assess its effectiveness.

4.4 How to track effectively

Effective tracking of the deployment of ICT solutions requires careful consideration. To track their implementation, several key factors should be taken into account. Please find below the recommended checklist to follow:

Manufacturing sector

Checklist:

- **Clearly defined metrics**: Define the specific metrics and indicators that will be tracked to assess the performance and impact of the ICT solution. Ensure that these metrics align with the goals and objectives of the solution and are measurable and quantifiable.
- **Baseline assessment:** Establish a baseline assessment of the manufacturing site, production output before the deployment of the ICT solution. This provides a reference point for comparison and enables the measurement of the solution's effectiveness in achieving improvements. According to the methodology the baseline should be the market average. If it is impossible to measure against the market average, it should be considered what measurement adjustments must be made.
- **Data collection and monitoring systems**: Implement robust data collection and monitoring systems to gather accurate and reliable data on energy consumption, emissions, operational performance, occupant feedback, and other relevant parameters. Automated systems or sensors can help streamline data collection processes.
- **Timely and continuous tracking**: Initiate tracking efforts from the very beginning, ideally during the pre-deployment phase, to capture the baseline data. Continuously track and monitor the performance and impact of the ICT solution over time to assess its long-term effectiveness.
- **Long-term measurement**: The impacts of the ICT solution may evolve and change over time. It is important to monitor and measure the effects of the solution beyond the initial deployment phase to understand its sustained performance and identify any potential deviations or trends.
- **Avoiding tracking pitfalls**: Be cautious of common pitfalls in tracking, such as relying solely on self-reported data, inadequate data validation and verification processes, or inconsistent data collection methodologies. Implement rigorous quality control measures and ensure data accuracy and reliability.
- **Stakeholder engagement**: Clearly define roles and responsibilities for tracking among different stakeholders involved, including solution developers/providers, facility managers, industry associations and policymakers. Collaborate closely with stakeholders to ensure effective data collection, monitoring, and reporting.
- **Continuous improvement**: Utilise the tracking results to identify areas for improvement, optimise the performance of the ICT solution, and inform future decision-making processes. Regularly review and update the tracking methodologies and metrics to align with changing goals and emerging best practices.

5 Going further: designing the solution to broaden its reach

While it is important to focus the deployment and implementation of each ICT solution on maximising of carbon benefits, it is important not to forget the impact of scalability. The more instances of deployed and scenarios of use, the greater the overall carbon benefits. Solutions are often designed with a specific use case in mind – however, sometimes making small design or development changes can make the solution usable in more scenarios and circumstances.

5.1 Relevance across potential use cases

When deploying ICT solutions to maximise their impact in decarbonisation efforts, it is important to consider their relevance and potential use cases. ICT solutions should not be limited to specific sectors or large-scale applications but should aim to be versatile and adaptable to various use cases. This approach ensures that the benefits of digitalisation reach a broader spectrum of industries and applications, including use by small and medium-sized enterprises (SMEs).

By designing ICT solutions with scalability and flexibility in mind, solution developers/providers enable their relevance across diverse sectors and empower small players, like SMEs, to embrace sustainable practices. This might involve developing user-friendly interfaces, providing customisable features, and offering affordable implementation options. By making ICT solutions relevant to as many use cases as possible, their potential can be unlocked across the entire economy, accelerating decarbonisation efforts at scale, and fostering a more inclusive and sustainable future.

Manufacturing Sector

The most impactful solutions are designed to be used across various manufacturing applications. For instance, a solution that monitors the energy use of an automobile manufacturer should be compatible to a range of machinery and ensure parameters can be adjusted to apply to other production ranges such as aviation or train line production.

Below is a list of questions for solution developers to consider during the design phase of an ICT solution, to broaden the scope and use of solutions.

This section of the Deployment Guidelines aims to stay high-level, and it should be noted that these questions are only meant as a thought starter.

Technology and Infrastructure – Questions:

- How dependent is the solution on the availability and reliability of other technologies and infrastructure (e.g. mobile telecom grid, broadband network, electricity grid, roads, etc.)?
- Is the required infrastructure widely available in the markets where the solution will be deployed?
- Can the solution still work in areas where that technology/infrastructure is not as available/reliable?
- If not, would it be feasible and/or relevant to make the solution more adaptable to cases where those technologies and infrastructure are not available or reliable?

People – Questions:

- Does the solution require local labour skills for optimal implementation and after-sales/maintenance? (This is especially relevant if improper implementation and/or maintenance can lead to reduced carbon benefits.)
- If a lack of available skilled labour could lead to reduced carbon benefits, is there a way to prevent or mitigate this through solution design?

Physical environment – Questions:

- Is the solution limited to certain geographical and climatic conditions?
- Can the solution be adapted to work in a wider variety of geographic and climatic conditions?

Financial, business and policy environment – Questions:

- In the markets where the solution is intended to deploy, are there any financial, business and/or policy barriers (e.g. mobile data tariffs, regulatory barriers such as tariffs for importing technology and parts, licensing…) that would significantly hamper deployment?
- If so, would it be feasible and relevant to design out some of these barriers (e.g. using materials subject to lower tariffs)?

6 Beyond greenhouse gas emissions: wider sustainability impacts

This section aims to take stock of the solutions' impacts beyond its effects on the climate, and to provide general guidance on how to mitigate negative impacts. As the focus of these guidelines is climate benefits, this 'wider impacts' section is intended to be high-level rather than specific guidelines. Its purpose is to highlight potential positive impacts beyond emissions sayings that can be enabled by ICT solution, while also helping stakeholders identify a range of potential negative impacts so that these can be prevented or mitigated before they arise. Where possible, solutions should adhere to the 'Do No Harm' principle.[3]

Possible areas to consider when assessing wider impacts of the solution:

Environmental impacts beyond carbon	Economic and Social impacts	Health and Safety Impacts

6.1 Environmental impacts beyond carbon benefits

Beyond carbon, ICT solutions have the potential to have both positive and negative environmental impacts. Through the enabled monitoring, optimising, and automating, ICT solutions have help identify and improve environmental impacts, particularly around waste and water. However, the ICT sector can sometimes be overly tech-optimistic, assuming that digital innovations will inherently lead to positive outcomes and this optimism can overshadow critical issues such as the short lifetime of digital devices, the generating of electronic waste, and posing safety concerns. Below are a few examples to help prompt and guide stakeholders (developers, buyers, and users of ICT solutions) to explore the non-carbon sustainability impacts of ICT solutions.

[3] Please refer to the EGDC Net Carbon Impact Methodology for the definition and discussion of the Do No Harm Principle.

Waste

Positive

ICT solutions in the manufacturing sector can help better manage resource flows through improved traceability. This could help locate where resource loops can be closed and contribute to finding destinations in other manufacturing processes.

Negative

While designing an ICT solution to reduce carbon emissions, developers might overlook choices that do not directly affect the carbon impact but may still have a negative effect on the environment. For instance, the use of certain plastics as a material component can have a lower emissions footprint than many metallic components. However, given many plastics are hard to recycle, they tend to end up at landfill or in the natural environment, with considerable consequences for nature and local biodiversity. Capturing the wider environmental consequences of an ICT solution is challenging, but completing the appropriate lifecycle analysis will help solution developers and users to more accurately assess the end-to-end carbon impact of a solution.

On the other hand, electronic waste has also become a pressing environmental issue, as the proliferation of digital technologies leads to an increase surplus of discarded electronic devices. This increase is in part a result of a lack of ICT solutions being upgradable or repairable. Therefore, it is important that ICT solutions incorporate this into their deployment, to allow them to evolve with the changing requirements and advancements in technology and better align with the lifespan of buildings.

When solutions do reach their end-of-life, if they are disposal is not properly managed the negative consequences can be very high. Improper disposal of e-waste poses significant environmental and health risks, as most electronic devices contain hazardous materials. Many regions lack proper recycling infrastructure, and as a result, a considerable portion of e-waste ends up in landfills or is informally processed, often in developing countries with more limited environmental regulations. There is a critical need for comprehensive and sustainable e-waste management strategies. This includes promoting the extension of product lifespans, encouraging responsible recycling practices, and designing electronics with eco-friendliness and ease of recycling in mind. Users should also be educated about the importance of recycling e-waste, to raise awareness of and promote the proper handling and recycling of electronic devices.

Water

Negative

Some manufacturing processes require water for production processes, cleaning, cooling or transporting products. ICT solutions should be weary of contributing to water depletion or pollution, which can have significant impacts on the neighbouring biodiversity, as wells as the local community's provision of potable water, and nearby fisheries.

6.2 Economic and Social Impacts

Beyond climate and environment, ICT solutions should do no significant harm in any other ESG areas, including in economic or social matters. ICT solutions should consider how they affect the composition of the labour market and should be weary of not impacting any demographic unfairly.

Negative

Many processes in the manufacturing sector are still performed or checked through manual labour. Automation may mean certain jobs are made redundant, reducing (local) employment in the short term. While the solution itself may create new employment, either to support the implementation of the solution itself or by allowing the client farm to grow, it is likely to require upskilling. Solution developers, users and buyers should consider ways of mitigating these job displacements, e.g., by engaging with local government to offer upskilling training.

Positive

Decarbonising the manufacturing sector also generates economic opportunities and fosters job creation. The increased efficiencies that are realised with the implementation of an ICT solution drive innovation, technological advancements and move employment to areas of the economy where there is most potential to grow. This can be of benefit to economic activity within a community and spur economic development.

6.3 Health and safety impacts

Finally, developers should consider how their solution may affect health and safety.

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The use of ICT solutions could help to better monitor and control manufacturing processes, which can help identify potential safety hazards and pro-actively prevent accidents. However, the introduction of new technology in a manufacturing environment also comes certain risks. The deployment of a new solution can lead to a learning curve for employees which can increase the risk of accidents and injuries during the initial stages of deployment. Therefore, developers should provide adequate safety protocols and procedures to mitigate any potential health and safety risks and make sure employees are properly trained.