Deployment Guidelines – Energy and Power Sector

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EUROPEAN GREEN DIGITAL COALITION

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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.

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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 policymakers 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 ***Energy and Power 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.).

1.1 Energy and Power Sector – A Call for Decarbonisation

Decarbonising the Energy and Power sector plays a crucial role in achieving global net zero. As energy is used in almost everything, decarbonising this sector is not only important in mitigating its own environmental impact but also holds the key to catalysing broader decarbonisation efforts across all other sectors.

The sector's historical reliance on fossil fuels presents a substantial barrier, requiring a shift in infrastructure, policies, and societal norms. Simultaneously, integrating renewable energy sources into existing grids poses challenges, necessitating technological advancements, innovative storage solutions, and a restructuring of energy distribution models. Overcoming these hurdles will be essential for addressing greenhouse gas emissions mitigation.

As other sectors decarbonise and transition from fossil fuels towards renewables-powered electricity (e.g. electrification of heating and transportation) the shift will cause electricity demand to increase significantly. In order to meet this new demand and continue global decarbonisation, efficiency in electricity generation, distribution and consumption must be increased, and renewable energy must be generated and integrated at scale.

To address these challenges, the implementation of ICT solutions presents a pivotal opportunity. Areas such as the integration of substantial amounts of variable renewable energy, with peak outputs that do not always match demand, necessitate advanced grid management.[2] Using technologies such as machine learning, sensors, and smart meters, ICT solutions can help integrate higher shares of variable renewables into the grid, as well as leverage flexibility platforms to effectively align supply and demand from diverse decentralised sources, such as electric vehicles and connected assets.[3]

Throughout this sector, digitalisation emerges as a key driver for cost reduction, enhanced efficiency, increased grid reliability, and lowered emissions.

[2] https://www.iea.org/energy-system/decarbonisation-enablers/digitalisation

[3] Ibid.

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2 Maximising net carbon impact from the implementation of digital solutions

ICT solutions hold great potential for enabling decarbonisation across sectors. Their integration can revolutionise industries, optimise processes, and reduce carbon emissions. However, it is crucial to emphasize that 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 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 circumstances, 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 future improvement.

On the other hand, 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 an even greater potential inform and enable automation to make behavioural changes obsolete.

Energy and Power Sector

Example

ICT solutions which increase the observability, predictability, and controllability of electricity infrastructure help increase capacity without risking overloading the grid. For example, Dynamic Line Rating (DLR) systems avoid the reliance on uncertain theoretical models by providing real-time assessments and better forecasting of power line capacity through monitoring and tracking the line conditions of the grid. This allows for more electricity to be integrated without having to upgrade the grid and minimises the curtailment of variable renewable energy in congested grids.

By leveraging monitoring and tracking, these ICT solutions can also inform the need for maintenance of electricity grids, facilitating more efficient repairs and improved performance.

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 the solution rollout and installation, significantly enhances users' ability to troubleshoot issues and address queries. By prioritising the provision of post-sale 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.

Energy and Power Sector

Post sales training helps ensure that ICT solutions are properly integrated into existing systems, and that the solution buyers and users have adequate resources to implement and use the solutions.

Example

For solutions in electricity grid management, solution developers should provide support to buyers for proper installation of the solution. This should consider variabilities such as: line characteristics (physical and thermal characteristics of the transmission lines, factors such as conductor type, material, and design) and the impact of local weather conditions. Developers should brief the buyer on how changes in circumstances can impact the performance of the ICT solution. Solution developers should also help provide guidance to end-users (either directly or via the buyer) to train them on how to appropriately use the solution to maximise the enabled benefits.

In addition, solution developers should consider providing any learning materials in the user's native language for ease of communication.

Buyers should support solution developers to create appropriate training programmes. This is particularly important in cases where the solution is deployed at scale and users have not been involved in the purchasing and roll out of the solution. Such training initiatives empower users to utilise the solution effectively and prompt necessary engagements, thereby ensuring sustained and optimal performance over time.

<u>Barriers and Challenges:</u>

There is no guarantee that those trained will be the ones to continue operating the solution during its lifetime. It is important to create a culture of training and have materials that can be passed on to the new users. The onus should be on the solution developers to provide materials that can be easily shared, and the onus should be on solution buyers and users to ensure the new users are properly trained.

Another challenge is that users, such as grid operators, that have had an ICT solution integrated into their work may be resistant to change. Training should take this into account and endeavour for to be delivered in an inclusive and engaging manner, showcasing to the users their role in the functioning of the solution, the direct benefits it brings to them in aiding their day-to-day work, and overall positive impacts it can enable for decarbonisation and energy security.

Lastly, there may also be barriers associated with the cost and time commitment of training. 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 maximise 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.

Energy and Power Sector

Examples:

Equipment or System Malfunction in Grid or Renewable Energy Generation: Over time, grid line systems and renewable energy equipment, as well as the ICT solutions themselves, may experience malfunctions or performance degradation. By identifying and addressing equipment malfunctions promptly, ongoing support helps avoid these issues going unnoticed or unresolved, ensuring that the ICT solution continues to operate and provide optimal savings.

Changes in Grid Usage: Electricity grids are dynamic environments, and changes in demand, line capacity, and renewable energy integration will impact operations. Without ongoing support, the ICT solution may not adapt to these changes effectively, leading to energy inefficiencies and reduced savings.

External Changes: New legislation regarding the purchase and sale of energy may impact the distribution and use of energy. For example, in countries where limits are placed on use of energy during expected peak times, buyers/users may require a change in operations. Post-sale support should be provided to help reconfigure the ICT solution to align to the new circumstances and help maintain the solution's effectiveness.

Technological Advancements and Updates: The Energy and Power sector is continuously evolving with advancements in technology. Without post-sale support, the ICT solution may become outdated or incompatible with newer technologies, limiting its effectiveness and potential savings. Ongoing support can help ensure that the solution remains up-to-date, compatible with the latest advancements, and capable of leveraging new functionalities that enhance energy efficiency.

Barriers and Challenges:

Post-sale support can have an associated cost. Policy and government have a role to play providing support for these services, maintenance guarantees, and in preventing obsolescence.

Opportunity:

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

2.4 Integration

ICT solutions are usually integrated into complex systems. Implementing ICT solutions therefore requires careful consideration of how these solutions will interact with existing systems or third-party services. An important step in the integration process is determining how the solution will seamlessly 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.

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For the successful implementation of ICT solutions, coordinating the deployment of infrastructure and devices is essential. Ideally, the selection and implementation of ICT solutions should be synchronised with the design and circumstances of the possible systems it will be integrated into.

For example, Demand-side Flexibility Platforms can be designed for integration without the need for additional hardware. Such a flexibility platform could connect to assets directly via their Building Management Systems (BMS), leveraging existing controls. This approach exemplifies a considerate integration, where solution developers prioritise building upon existing infrastructures and have conducted market research to leverage Building sector policies, such as a mandate to upgrade BMS to higher standards across assets in the region.

Linked in with 'support' provided by solution developers, for seamless integration, pre-sale support should be provided to ensure the optimal functionality and efficacy of the ICT interventions. Prior to purchase, solution developers play an important role in guiding potential buyers towards selecting the right solution tailored to their unique needs. This involves a comprehensive understanding of the buyer's and user's context. For example, in the case of implementing a Demand-side Flexibility Platform, ensuring that the partnering users have the appropriate type of assets and infrastructure in place to participate, and ensuring they have good understanding of the impact a flexibility platform may have on their operations.

Barriers and Challenges:

Assessments of integration should critically consider what the ICT solution is displacing. Continuing the example of Demand-side Flexibility Platforms, in areas in which peak-time energy supply is managed through a bidding system, companies rolling out these flexibility platforms should consider who they might be outbidding. In regions where the peak time supply alternatives are likely to be renewable or low-carbon energy, the outbidding of those sources will lead to little or no emissions savings. Companies pushing Demand-side Flexibility Platforms should aim to target and integrate into markets where the alternative sources of energy supply during peak times are likely to be fossil fuel power plants or other carbon-intensive sources.

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 human intervention and streamlining operations, by enabling real-time monitoring, predictive analytics, and intelligent decision-making. This allows for timely adjustments and optimisations to minimise energy and resource waste. By limiting human intervention, the potential for errors and inefficiencies decreases.

Energy and Power Sector

Example

On-site renewables in residential or commercial properties help decarbonise energy use and lessen the strain on the electricity grid. However, if not optimised, their potential for emissions avoidance may not be maximised. Approaches such as on-site renewable management with integrated battery storage can help access greater savings, incorporating data analysis and automating actions to minimise the need for human intervention and optimise operations. For instance, during periods of low grid demand with a high proportion of renewable energy in the mix, on-site management systems can be automated to use grid electricity during these periods and dispense any electricity generated from on-site renewables into on-site batteries.

Subsequently, the automated system can then dispense of energy from batteries to use on-site during peak demand (and/or when the grid is carbon-intensive). This automated cycle operates within predefined parameters set by the solution user, establishing hard lines for operational criteria. The result is a more efficient and responsive energy ecosystem, leveraging automation to optimise renewable energy production and decrease emissions.

Barriers and Challenges:

Mismatch of cost and emissions savings: As reduced energy or fuel consumption directly correlates to a decrease in emissions, cost savings and emissions savings often go hand in hand. However, this may not always be the case. ICT solutions often provide multiple benefits and incentives to buyers and users, cost reductions being a key selling point. An automated on-site renewable energy management platform may be programmed to switch to use of the grid when the cost is low and use battery stored renewable energy when the grid electricity is expensive. While low cost is likely to align to when the grid is also at its lower emissions intensity, this might not always be the case. In those instances, the scale of emissions savings may be reduced.

3 Minimising emissions

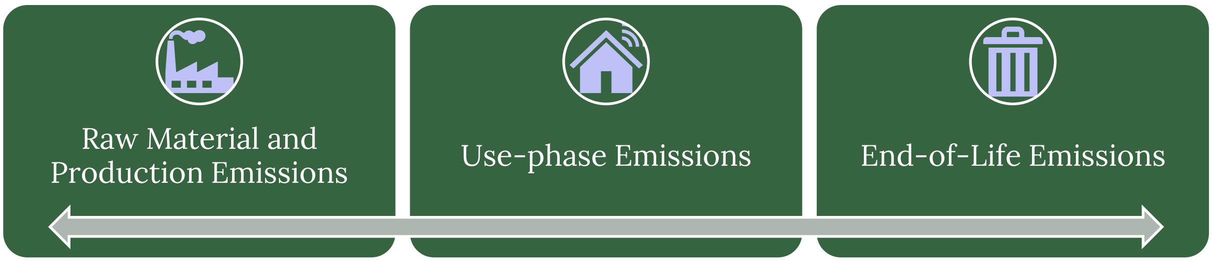
As the focus is often on maximising the net carbon impact potential of an ICT solution, it is critical not to forget the need to minimise the 'cradle to grave' emissions resulting from the deployment and use of that same ICT solution. While ICT can be a force for good, the digital transformation of sectors 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 a 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. Typical hotspots of emissions of an ICT solution 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 materials (including rare earth metals, such as lithium for batteries).
- **Use phase – hardware and software**: During the use phase, ICT solutions consume energy when in operation. This includes 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.

3.1.1 Minimising emissions



Embodied Carbon:

- **Life cycle assessment**: 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. Companies should share life cycle data of their products openly for down-stream supply chain actors to build on these.
    - This however can be quite resource and cost intensive. Policy and industry bodies have a role to play facilitating and incentivising data sharing and providing support for developers to do these assessments.
- **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 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.
    - 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 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?

Energy and Power Sector

Overreliance on digital technologies can lead to increased energy consumption and emissions. Solution providers and developers should consider the environmental impact of ICT solutions and determine when ICT technologies are necessary. For example, ICT solutions increasingly incorporate elements of Artificial Intelligence (AI) to enhance performance. However, as AI can greatly increase the energy intensity of a solution, solution developers/providers should assess the gained benefits (e.g. grid capacity increases) enabled by AI, against the increase in direct energy use of running the AI.

Additionally, ICT solutions in the Energy and Power sector, particularly those deployed at large scale, often require the use of data centres for data management and storage. Solution developers/providers should look to partner with data centres run on renewable energy (PPA or on-site renewables are preferable) and with high energy efficiency.

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 of the introduction of the solution. These negative impacts 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 considers circumstances where the positive climate impacts of the solution could be diminished or reversed and will provide guidance on how to address this.

Energy and Power 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.

- ***Technological upgrading***: The introduction of ICT solutions can create a situation where the energy generation or distribution system becomes dependent on the technology and subsequently upgrade or add new devices more frequently. If frequent upgrades or additions are made without considering the environmental impact, it can result in increased emissions associated with the production, disposal, and recycling of these digital devices.
- ***Lock-in Risk:*** One of the most significant rebound risks identified for ICT solutions deployed in the Energy and Power sector is the risk of incentivising or creating lock-ins. Most countries currently continue to rely heavily on carbon-intensive energy sources, and the transition of the sector to predominately zero emissions sources is one which will take decades. Therefore, the reduction of the impact of fossil fuel sources is one which must be addressed in the interim to decelerate the rate of emissions in the short-term. However, it is very important to note that the reduction in emissions impact of these carbon-intensive energy sources can inadvertently lead prolonged dependence, delaying the decommissioning of fossil fuel sources and shift to cleaner alternatives, and in some cases leading to infrastructure investments which may lock-in net zero incompatible energy generation systems.

It is important to note that rebound effects are impacted by their specific context. Factors impacting them include user behaviour, and the design and implementation of ICT solutions. Solution developers/providers, buyers, and users should carefully consider these rebound effects and adopt measures to mitigate them.

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.

Energy and Power Sector

Tracking of Rebound Effects:
Tracking rebound effects in the context of ICT solutions deployed in energy generation and distribution 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. However, it can be this very efficiency that drives the rebound effect. Developers and providers should therefore conduct thorough assessments of potential rebound effects during the development and deployment phases of their solutions. This includes evaluating the potential behavioural changes and lock-ins that could result from the use of their solutions, and guard against these when possible. How to do this depends on the concrete circumstances and solutions. Developers should also provide guidance and information to solution buyers and users regarding the optimal use of their solutions and highlight the risks of lock-ins, to minimise rebound effects.
2. ***Solution buyers (including deployers such as public bodies, grid operators, utilities companies)*:** Solution buyers, such as public bodies, grid operators, and utilities companies 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. When relevant, buyers should develop a mid-long term decarbonisation plan, putting in safeguards to ensure the use of the solution is not creating a lock-in. Buyers should also engage with users to establish clear performance indicators to track and mitigate rebound effects over time.
3. ***Solution users (employees of solution buyers)*:** The users of ICT solutions in energy generation and distribution have the responsibility to monitor and manage efficient energy generation and distribution. Users should understand the features and functionalities of the ICT solutions in place and make informed choices to minimise rebound effects. They should actively engage in energy monitoring, adopt energy-efficient practices, and utilise the solutions in a manner that aligns with sustainability goals. Observation of rebound effects is challenging, as it requires the identification of negative change relative to before the integration of the solution. This may be particularly hard in the Energy and Power sector, where lock-in risks may not be observed until much later. Therefore, users should also provide feedback to solution developers/providers and solution buyers regarding any observed rebound effects, opportunities for improvement, or identified risks.

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The tracking of rebound effects should involve a collaborative effort among solution developers/providers, buyers, and users. Such a cross-sectorial collaboration needs to be supported by the policy. By establishing clear responsibilities and promoting cooperation, it becomes possible to effectively monitor and mitigate rebound effects associated with the deployment of ICT solutions in the Energy and Power sector.

Avoidance or Mitigation of Rebound Effects:
Rebound effects can be avoided or mitigated through a combination of approaches involving solution design, awareness, and prevention. By incorporating preventive measures through solution design, promoting awareness among users and buyers, and encouraging environmentally conscious decisions, rebound effects can be avoided or mitigated.
Each stakeholder group can contribute to avoiding or mitigating rebound effects in the following ways:

4. **Solution developers/providers:**
    a. Solution design: Developers can incorporate features that automate processes and limit human intervention, reducing the potential for energy-intensive behaviours.
    b. Supporting buyers and users by increasing awareness and providing training: Buyers and users should receive appropriate training and education to understand the potential rebound effects associated with ICT solutions.
5. **Solution buyers** (including deployers such as public bodies, cities, and companies):
    a. Assessing risks and increasing user awareness: Solution buyers should consider the possible ways in which rebound effects may materialise and assess the risks in each of the uses for which they are purchasing the solution. Buyers should establish regular high-level reviews of the identified rebounds, to assess materialisation, and performance monitoring of the deployed solutions to track impact and assess any rebound effects. Like solution developers and providers, solution buyers should engage with users to raise user awareness to the risks of rebound effects, and provide appropriate training and incentives to avoid or mitigate the potential rebound effects.
    b. Collaboration with developers: Buyers should also bring to the attention of solution developers/providers any identified rebound effects, to raise awareness and seek their expertise in mitigating potential impacts. This collaboration can lead to the development of tailored solutions and continuous improvement.
6. **Solution users:**
    a. Continuous monitoring and feedback: Users should provide feedback on the performance of the solutions and savings to solution buyers, who can feed this back to the solution developers/providers, sector-wide representation, and policy.
7. **Regulator/Governance/Policy:**

a. Energy industry organisations and government environmental bodies should lead sector wide efforts to collate and analyse these rebounds.
b. Where potential for rebound effects has been identified, the system should work to actively prevent these. This is particularly important for the Energy and Power sector, where increased efficiencies in energy generation and distribution could lead to lock-ins of energy generation power plants and pipelines not compatible with net zero. Governments and regulators should develop policy to disincentivise and prevent these lock-ins.

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. Policy should introduce requirements to track relevant metrics for businesses and any other organisation operating energy-consuming infrastructure; as per scope 1 and 2 accounting rules.

Energy and Power 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:

- Energy sources
- Annual/monthly energy/fuel consumption; and/or resource use
- Areas of high energy/fuel consumption; and or/ resource use
- Fluctuations in electricity generation and why they happen

Market alternatives transformation of the infrastructure without the ICT solution

4.3 Metrics to track during and after implementation

To quantify and evidence the net carbon impact of an ICT solution, please see below the suggested metrics to track during and after implementation. These metrics should align with 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.

Energy and Power Sector
Renewables:
1. Change in grid capacity (before and after): Evaluate the change in capacity and change in the integration of renewable energy. a. And have an understanding of the change in capacity enabled by the expected market alternatives: e.g. uprating (modifying an electrical line's characteristics to increase capacity). 2. Rate of renewable energy integration (before and after): Evaluate the integration of renewable energy sources into the grid, such as solar panels. Monitoring the share of renewable energy used in the grid pre-implementation of the ICT solution helps assess its effectiveness.
Grid Management and Energy Distribution:
1. Change in electricity grid carbon-intensity (before and after): Measure grid intensity and the role the solution has played in managing this. 2. Management of peak times and use back-up reserves: Evaluate the change in peak time demand and frequency, and the need to use back-up reserves. 3. Leakage or inefficiencies leading to loss: collect data on loss in the grid from inefficiencies, before and after the integration of the solution.
• *Note*: with all these metrics it is also important to track any other changes that may be affecting these changes, to be able to separate variabilities from savings caused by the implementation of the ICT solution.

4.4 How to track effectively

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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:

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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 energy generation and distribution system's performance 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. To align with best practice, the baseline should represent market average. Please refer to the Methodology (how to quantify net carbon impact) for specifics.
- Data collection and monitoring systems: Implement robust data collection and monitoring systems to gather accurate and reliable data on energy consumption, emissions, operational performance, user 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, utilities companies, grid operators, and users across all sectors. Collaborate closely with stakeholders to ensure effective data collection, monitoring, and reporting.
- Continuous improvement: Utilise the tracked 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.
- Policy: Implement efficient rules to establish baseline data.

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.

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Example

When implementing smart grid technologies, developers can design solutions that are not confined to large-scale applications but are adaptable to mini or micro grids which may be used in rural or remote areas. By prioritising scalability and flexibility in the design, these ICT solutions become relevant across diverse sectors, enabling a broader impact.

These systems should also be designed with user-friendly interfaces that cater to the specific needs of diverse users. These systems can offer customisable features, allowing businesses or local communities to tailor the solution to their unique energy requirements and constraints.

Solution providers can focus on offering affordable implementation options, making it feasible for smaller players to embrace sustainable practices. This inclusive approach ensures that the benefits of digitalisation extend beyond large systems, contributing to a more widespread and effective decarbonisation across the sector.

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 may 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 savings that can be enabled by ICT solutions, 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[4].

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 can 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

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

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generating of electronic waste, and posing safety concerns. Below are a few examples to help prompt and guide stakeholders to explore the non-carbon sustainability impacts of ICT solutions.

Waste

Positive

ICT solutions can provide opportunities for waste reduction through early detection of maintenance needs (avoiding damage leading to waste), and by enabling the avoidance of large-scale infrastructure changes which could otherwise cause excessive waste.

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 infrastructure.

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, which 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

Positive

ICT solutions which increase efficiencies in energy generation and distribution, can also have a positive impact on water management and use.

For example, some solar thermal power plants may use mirrors to concentrate sunlight onto a small area to produce steam that drives the energy generating turbines. This produces high temperatures, and water is often used as a cooling medium for condensing the steam back into liquid water. ICT solutions deployed to increase efficiencies in this area may also help optimise water usage, to decrease over-use. This is particularly important in areas where there is water scarcity.

Negative

ICT solutions in the Energy and Power sector should be weary of any negative direct effects on the neighbouring environment, including solutions that may negatively impact biodiversity, soil health, waterways, or the use of natural resources. For instance, a solution that provides on-site water extraction and use from nearby water sources for cooling in energy generation, should take into consideration how its implementation affects fish and other aquatic life. Similarly, the installation of physical equipment should not hinder natural pass-throughs preventing wildlife from crossing habitats.

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.

Positive

Decarbonising the Energy and Power sector also generates **economic opportunities.** Transitioning to a low-carbon economy requires a skilled workforce capable of implementing energy-efficient generation and distribution and developing renewable energy infrastructure. Solution developers, users and buyers should consider ways of mitigating these job displacements, e.g., by engaging with local government and companies to offer upskilling training.

Availability of electricity: as countries decarbonise, buildings, transport, and manufacturing will transition from liquid fuels and natural gas to electricity-using technologies, which will place increased demand for electricity. By improving areas which increase grid capacity and integration of renewable energy into the grid, ICT solutions can help increase the availability of electricity, help minimise peak times requiring the use of back-up fossil fuel powerplants and help avoid blackouts.

Affordability of energy: Linked to the point above, by increasing efficiencies and integration of renewables, ICT solutions can help lower the price of energy.

Negative

Not taking into account social or demographic context can lead solutions developed for green purpose to fall short. For example, digital enable solar powered cooking stoves can address the issue high emissions from cooking, where the primary energy source is fossil fuel based. However, there are limitations to these stoves, as they often take much longer to heat up and will not work at night. If a well-rounded assessment of the context of use of stoves is not done, these stoves may be rolled out and soon after be discarded as they might not be fit for purpose in some circumstances and social contexts.

Human Rights Violations: Electronic waste is not the only concern when it comes to the impact of hardware, the extraction of raw materials and the manufacturing of components of an ICT solution can also be linked to human rights violations throughout the supply chain.

6.3 Health and safety impacts

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

ICT solutions can help improve safety at energy generation sites and distribution networks by providing real-time monitoring, enhanced communication, and predictive capabilities. For example:

- Drones equipped with cameras and sensors can perform aerial inspections of pipelines and electricity networks, identifying safety issues like unstable structures or unsafe working conditions in hard-to-reach areas.
- Other types of real-time monitoring of electricity generation, such as IoT enabled sensors and wearable devices with integrated automated alerts, can warn relevant personnel if unsafe conditions are detected, facilitating quick responses to mitigate risks.
- ICT solutions can also be used to provide safety training and e-learning courses, and AR and VR technologies can be used for safety training and simulation exercises, allowing workers to be trained virtually to handle hazardous situations safely, enhancing their knowledge and preparedness before encountering such scenarios in the field.