Deployment Guidelines – Smart Cities Sector

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EUROPEAN GREEN DIGITAL COALITION

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Table of Contents

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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 ***Smart Cities***.

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] ICT 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 Smart Cities Sector – A Call for Decarbonisation

A smart city "is a place where traditional networks and services are made more efficient with the use of ICT solutions for the benefit of its inhabitants and business." [2]

Globally, cities are responsible for more than seventy percent of greenhouse gas emissions. With three quarters of Europeans living in cities, decarbonising cities is essential to the EU's climate neutrality target for 2050. By 2030, the European Commission aims to have 100 cities, representing twelve percent of the EU population, be smart cities and reach climate neutrality.[3]

Decarbonising cities will require the improvement of resource efficiency, cleaner ways of transport, optimised energy use, and support of natural ecosystems. "It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings." [2] Achieving these aims in an urban environment necessitates cooperation across households, businesses, and public services.

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 smart traffic lights, ride-sharing and smart parking, to smart waste collection and dimming streetlights, digital technologies are revolutionising the way we interact with the environment and offer significant opportunities for carbon footprint reduction in urban environments.

However, it is also acknowledged that much of the ability of ICT solutions to contribute to the decarbonisation of urban areas is dependent on wider shifts within society and the broader economy. It will require cooperation with external stakeholders including policymakers, financiers, and other businesses within the field. The implementation of these ICT solutions will be driven by collaboration with local governments, industry, universities, and civil society. For instance, for many ICT solutions in the smart cities 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

[2] European Commission: Smart Cities

[3] EU Mission for climate-neutral and smart cities by 2030

require a significant set of changes for their business model and existing products and services offerings. Similarly, not all recommendations provided in this document will always align to budget constraints or business interests in the short term. Recognising the current state of the smart cities sector, this file, together with the overall methodology will be updated periodically to align with future developments in the wider sector.

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 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 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 to inform and enable automation to make behavioural changes obsolete. With clear information about their consumption habits, users can identify improvements such as reducing energy usage, optimising resource utilisation, or adopting eco-friendly alternatives.

Smart Cities

Cities around the world and across Europe vary greatly in terms of physical infrastructure, as well as their populations' behavioural patterns. For instance, congestion is more likely to occur around certain times and some areas, depending on the specific city. It is therefore essential to develop Smart City solutions that are highly adaptable to the area of deployment. A solution that automatically dims streetlights when it detects movement might, for example, measure unusually high energy consumption around a body of water where waves caused by the wind activate the system. In this case the streetlights placed around this area could be adjusted to have a higher sensitivity threshold. On the other hand, if the same solution notices high energy usage in a square in the central part of the city due to non-stop traffic, the emissions resulting from the deployment and running of the solution might exceed its potential savings, warranting its removal there.

2.2 Post-sale training

In the context of maximising the benefits of an ICT solution for emissions reduction, post-sale training provided by both the solution developers and buyer 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/providers and solutions buyers 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.

Smart Cities

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. For instance, if a smart bin solution requires citizens to put their bin in a specific spot, this should be clearly explained. This includes ensuring users have the skills and appropriate understanding of the tools to effectively use the solutions as intended. Moreover, to ensure optimal usage, it is key that roles and responsibilities are clearly defined before rollout of the solution between local government, the solution developer, and users or citizens. For instance, is the city council or the solution developer responsible for marking where to put the smart bins? Finally, developers should consider providing any learning materials in multiple languages to ensure the guidance can be effectively communicated to all users.

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.

Smart Cities

Equipment or System Malfunction: Over time, urban equipment and systems may experience malfunctions or performance degradation, outages, or leakages, especially if exposed to outside conditions. Ongoing support 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 in city development planning: Urban areas are constantly expanding and adapting to new constraints. Changes in development plans, as well as changes in regulation framing the urban density of certain areas, changes to congestion, or infrastructure mitigating the impact of flooding or heatwaves may affect 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: Innovations require ongoing post-sale support to ensure the solution does not become outdated or incompatible with newer technologies, limiting its effectiveness and potential carbon savings. Ongoing support through software and hardware updates 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.

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 also be 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.

Smart Cities

Many ICT solutions in the smart cities sector use sensors or other Internet of Things (IoT) devices to measure and influence variables like traffic flow, use of public services, and the city's resilience to heat, flooding and other weather events. Ideally, solutions are designed so that they allow city planners to share data collected across council borders cities. This would create a broader picture of the urban area and enable coordination on a regional or national level to maximise the carbon savings delivered by a solution or solution type. This may also help with expediating the integration of renewable energy sources into the grid. Moreover, interoperable systems allow for other solutions to build on top of existing technologies, expanding a solution's reach, and maximising its carbon savings.

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.

Smart Cities

Most processes in Smart Cities are automated. However, there may still be some parts that are still dependent on manual measurements and data interpretation. Solutions can contribute to further efficiency gains by further optimising processes through robotics, streamlining decision-making through AI, or forecasting through precise monitoring. For instance, a solution that uses semi-autonomous robotics to clean the city's streets would be more efficient if it visits neighbourhoods that are more prone to litter build-ups more frequently. Similarly, a solution that uses AI to more effectively redivert rainfall functions better if links to weather forecasting.

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, 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 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

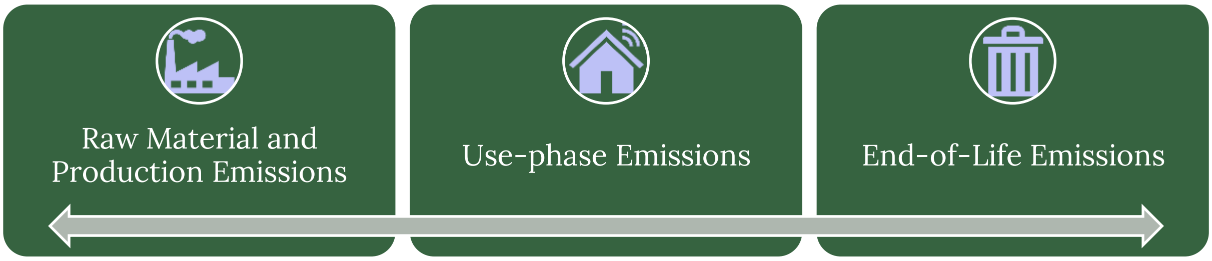
While emissions from the solution itself may not always be significant compared to the savings it enables, they remain something to be aware of and to minimise. Typical hotspots of emissions of an ICT solution include the following:

- **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 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.

3.1.1 Minimising emissions from the solution



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.
- **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.

- 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.

<u>Operational Carbon:</u>

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?

Smart Cities Sector
Those rolling out ICT solutions in cities should seek opportunities to partner with and utilise innovations happening in the area to decrease the direct impact of the use of the solution. For example, urban areas often have unused or underutilised roof space, which can be repurposed as space for solar panels. Businesses and local councils deploying the ICT solution can look to partner with these spaces to install solar panels and use the energy generated to power the ICT solution, minimising the negative emissions impact.
Excessive use of digital technologies can lead to an unnecessary increase in energy consumption and emissions. 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. fuel

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and energy reductions in a fleet) enabled by AI, against the increase in direct energy use of running the AI.

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.

Smart Cities 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 Urbanisation:** The efficiencies brought about by ICT solutions can stimulate urban growth, leading to expanded infrastructure and increased energy consumption, potentially resulting in a net increase in carbon emissions. It's crucial to consider the balance between urban development and sustainable resource management to ensure that cities remain environmentally responsible and resilient.
- **'Out of sight, out of mind':** smart automated systems can streamline various tasks, making them more efficient. However, this can lead to individuals becoming less aware of their impact. For example, smart waste management solutions can optimise waste collection routes and schedules. However, if these efficiencies can lead to people generating more waste because they believe it will be effortlessly managed, it can result in increased waste volumes and associated environmental impact.
- **Behavioural changes and increased demand for carbon-intensive activities:** by increasing efficiency and ease, ICT solutions deployed in smart cities may inadvertently

lead to negative behavioural changes. For example, smart parking systems in urban areas can help drivers easily find a parking spot, avoiding unnecessary fuel wasted driving around in search. However, if these systems make it very convenient for drivers to park, it could incentivise people to drive to urban areas who would have otherwise taken public transport or cycled.

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 through energy-efficient practices and user awareness and education.

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.

Smart Cities Sector

Tracking of Rebound Effects:

Tracking rebound effects in the context of ICT solutions deployed in smart cities sector 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 should conduct thorough assessments of potential rebound effects during the development and deployment phases of their solutions. This includes evaluating the potential behavioural changes and impacts on fuel and energy consumption 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 to minimise rebound effects.

2. ***Local Government/Councils:*** Local government, often the solution 'buyers' in cities, 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. Local Government should establish clear performance indicators to track and mitigate rebound effects over time. ICT solutions deployed in public areas to benefit the public, as opposed to this deployed in a closed environment such as in a factory, can be both very susceptible and reliant on the public's behaviour change. Changes in behaviour, for example travelling patterns, should be closely monitored, to assess to overall success of the deployment.

The tracking of rebound effects should involve a collaborative effort among solution developers/providers, buyers/local government, users/city dwellers. 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 agriculture 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 energy-efficient behaviours, rebound effects can be avoided or mitigated.

Here's how each stakeholder can contribute to avoiding or mitigating rebound effects:

1. **Solution developers/providers:**
    a. <u>Solution design:</u> Developers can incorporate features that automate processes and limit human intervention, reducing the potential for labour and energy-intensive behaviours. For example, implementing robotics and AI to automate processes.
    b. <u>Supporting users by increasing user awareness and providing training</u>: Users should receive appropriate training and education to understand the potential rebound effects associated with ICT solutions. This can include information on energy or resource consumption hotspots and behaviours to promote energy and resource efficiency and avoid unintended rebound effects.

2. **Solution buyers** (including local government):
    a. <u>Assessing risks and increasing user awareness</u>: Solution buyers should consider the possible ways in which rebound effects may materialise and assess the risks in each of the users/uses for which they are purchasing a solution. Buyers should establish regular reviews and performance monitoring of the deployed solutions to track impact and assess any rebound effects. Like solution

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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: Local Government/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.

c. Continuous monitoring and feedback: Local Government/Buyers should engage in regular monitoring of the impacts of the solution, with particular focus on wider behaviour change impacts. These observations can be used to inform the guidance put out to educate the solution users (city dwellers/residents/solution users), and if fed back to solution developers/providers it can help improve solution development to better mitigate rebound effects.

d. Behaviour modification and education: Local Government/Buyers should actively incentivise energy-efficient and sustainable practices. Regular reminders and feedback mechanisms can help users/residents/city dwellers modify their behaviours to mitigate rebound effects. Local Government should lead awareness campaigns, to inform users of these rebounds, and policy makers should incentivize solution developers/providers to incorporate awareness messaging into their solution. For example, in the case of a city-wide smart parking system, this may come in the form of raising awareness of the negative impacts of increased unnecessary journeys and highlighting the benefits of public transport. Local government can run an awareness campaign, while solution developers can integrate awareness messaging into their app (e.g., 'Click here to find out how to use smart parking sustainably')

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.

Smart Cities 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 and area of application (e.g. transport). Overall, for the sector of Smart Cities in particular it is important to track and assess behaviours and patterns of city dwellers or of those managing city systems. This will allow you to have visibility of the key drivers of emissions and allow to much better understand how these behaviours change when the solution is introduced.

For specifics of pre-implementation metrics to track for solutions related to transport, buildings and construction, energy and power, manufacturing, and agriculture, please refer to the specific Deployment Guidelines.

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.

Smart Cities Sector

In the context of cities, the main metrics to track outside of those specific to the solution area (e.g. specific metrics to track for a transport solution) is changes in behaviour and patterns. Unlike most other sectors, the users of ICT solutions in smart cities may encompass a wide dynamic group of people, which can vary day-by-day, and range from children to the elderly, locals to tourists, and people with ranging abilities. This makes it crucial to understand changes in patterns and why they have changed, to understand the efficacy of the solution.

For specific metrics to track regarding a transport system, buildings, energy, manufacturing, or agriculture, please refer to the specific deployment guidelines.

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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:

Smart Cities 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 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. 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, changing in behaviour and user patterns, emissions, operational performance, user feedback, and other relevant parameters. Automated systems or sensors can help streamline data collection processes. For smart cities, it is particularly important to monitor behavioural change of those using/engaging with the solution. ❖ **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, local government, city employees, and city dwellers. 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.
- **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.

Smart Cities Sector

Examples:

Public Transport App which integrates various modes of public transport options. Ensure the app is scalable by integrating with emerging transportation modes like bike-sharing programs.

Smart Parking system in cities made adaptable to support electric vehicle charging stations. 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 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.[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 have help identify and improve environmental impacts, particularly around

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

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.

Waste

Positive

ICT solutions can provide opportunities for waste reduction in cities. These can come both in the form of enhancing knowledge and awareness through ICT solutions or providing smart waste collection and management. Working in concert, these solutions empower city dwellers to adopt more sustainable practices and streamline a more efficient waste system, leading to reduced waste generation and decrease of waste sent to landfill.

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 to city 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

Like with waste, ICT solutions can help manage areas of water consumption in cities, such as effective leak detection, improving city wide water management and helping mitigate water scarcity risks.

Negative

ICT solutions in the cities 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 city construction or events, 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

Making public spaces more accessible: ICT solutions can be designed with inclusivity in mind, catering to the needs of diverse users, including those with disabilities or special requirements. Real-Time Transit Information application that provides real-time information about public transportation schedules, delays, and accessible routes make it easier for individuals with disabilities to plan their journeys and reduce the anxiety associated with unexpected disruptions. Route planning systems can cater to individuals with mobility impairments, such as wheelchair-accessible routes and information on accessible points of interest.

Negative

Increased connectivity of public spaces runs the risk of excluding non-technology literate individuals from public services, such as senior citizens or modest households, who may not have access to ICT hardware or equipment.

6.3 Health and safety impacts

Positive

Improved health: ICT solutions like traffic management systems and intelligent transportation networks can help reduce traffic congestion, leading to decreased stress for commuters and improved air quality.

Improved safety: more tracking and monitoring around in cities can have positive impacts on road safety and effectively tackling street crime.

Negative

However, increased surveillance can also lead to a decrease in public privacy. Placing of sensors and cameras might become problematic if not handled carefully.