Green Management Whitepaper

Joint Release: China Mobile Communications Group Co., Ltd., Hong Kong Telecommunications (HKT) Ltd., and Huawei Technologies Co., Ltd.

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We would like to thank all the colleagues and partners who participated in the preparation and release of the white paper, for supporting operators in implementing the green and low carbon strategy, enabling society, enterprises, and the environment to energy saving, carbon emission reduction, digital intelligent transformation, and contributing to sustainable development.

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Executive Summary

This white paper provides an overview about the motivation of Green Management standardization. The primary objective is to outline the scope of the proposal and set the stage for collective actions.

The Information and Communication Technologies (ICT) industry plays a significant role in addressing climate challenges, and this white paper emphasizes the need for sustainable practices within the industry.

1. This release begins by providing a **background** on the relationship between ICT and climate challenges.

2. It highlights the **urgent need** to address these challenges and the role that the ICT industry can play in driving positive change.

3. **Key pillars** of Green Management are introduced, emphasizing the importance of optimizing energy consumption, enhancing network efficiency, and maximize carbon handprint creation.

4. ICT provides digital solution to enable all industries to reduce emission. Using the Vertical Emblement Index (VEI), we can further measure the contribution.

To encourage industry stakeholders to actively engage in pursuing green goals, a proposed Green Management Framework is presented. This framework serves as a guide for organizations to govern, plan, and execute their green initiatives and commitments. By adopting this framework, stakeholders can navigate the path towards sustainability and contribute to the broader global efforts.

The **overarching goal** of this white paper is to foster collaboration and participation in sustainable practices within the ICT industry. By addressing the environmental impact of ICT, we can make significant strides in reducing greenhouse gas emissions, optimizing resource usage, promoting renewable energy adoption, and creating carbon handprints to vertical industries.

In conclusion, this white paper serves as a call to action. Let us embrace the proposed framework and actively engage in pursuing green goals within the ICT industry. By doing so, we can make a tangible impact on the environment, foster innovation, and contribute to a sustainable future.

1. Introduction

1.1 Background

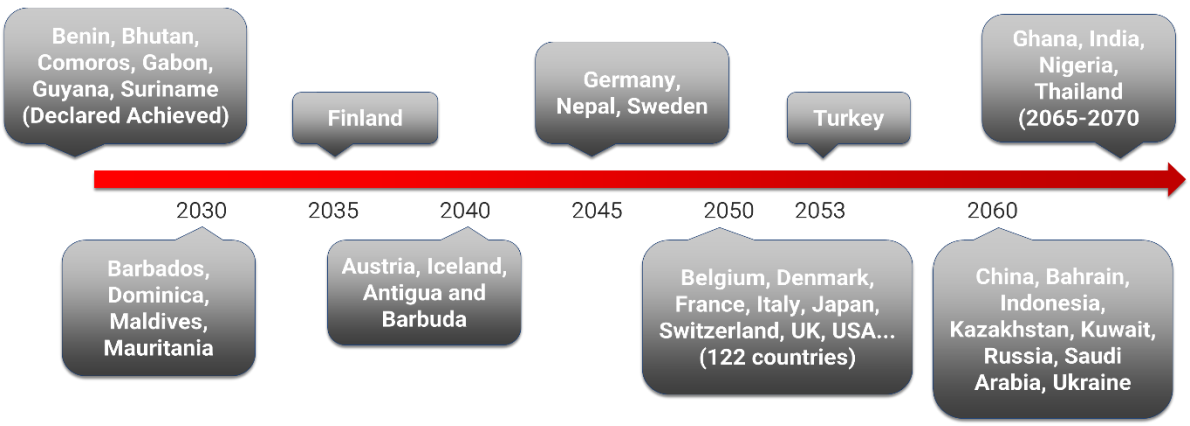
The latest development of global warming is continuing to accelerate. Last year 2023 was the warmest year in the 174-year observational record. This is due to the continued increase in greenhouse gas emissions from human activities. In 2015, Paris Agreement was signed by 196 countries with the goal of limiting global warming to well below 2 degrees Celsius, and preferably to 1.5 degrees Celsius, above pre-industrial levels. We all have a role to play in addressing global warming. By taking action now, we can help to protect our planet for future generations.

The Paris Agreement sets out a global framework for action to reduce greenhouse gas emissions and adapt to the impacts of climate change. Although the agreement is a landmark achievement in the fight against climate change, it is not enough on its own to prevent the worst impacts of climate change. More action is needed from all industries to reduce emissions and adapt to the impacts of climate change.

Significant progress has been made in the realm of standardization, particularly in energy-saving technologies, leading to the emergence of numerous energy-saving standards. However, despite the increasing importance of ICTs in the world and their significant contribution to technology and economic growth, ICTs still require to join their effort to achieve carbon zero and develop necessary green framework and standards to show their commitment. This highlights the need for comprehensive standards in this domain to address the environmental impact of ICT networks together and further promote sustainable practices.

1.1.1 Legislation & Compliance

Legislation and compliance development in the globe varies across countries and regions. Many countries have implemented legislation to address climate change and environmental concerns. By 2022, 148 countries have committed to Carbon Neutrality, Net Zero or Climate Neutral [2]:



Source: https://zerotracker.net/

Actions are taken by enacting or advancing national climate laws. These laws establish legal frameworks and targets to guide the transition towards a low-carbon economy. By implementing comprehensive legislation, ICTs must put resources to fulfill the compliance.

To accelerate progress towards carbon neutrality, adopting more vigorous policies and measures is crucial. ICTs are setting ambitious renewable energy targets, implementing energy efficiency programs, promoting sustainable network development, and supporting research of low-carbon technologies.

1.2 Trends & Insights

1.2.1 The Shift from Labor Cost Reduction to Electricity Cost Reduction

20 years ago, the labor cost was the largest proportion of the OPEX spending and energy cost was minor compared to labor cost. So, for the past 20 years, telecommunication companies have tried to use all sorts of ways to reduce the labor cost through Business Process Reengineering, Digital Transformation, Outsource and Autonomation. Now, the labor cost becomes a minor portion of the OPEX graph. Replacing labor cost is the rise of electricity cost and asset rental cost. With the increase in electricity cost and the and the deployment of 5G technology, it is now the major portion of the OPEX spending. Figure 1 shows a company 'H' OPEX spending for the past 20 years.

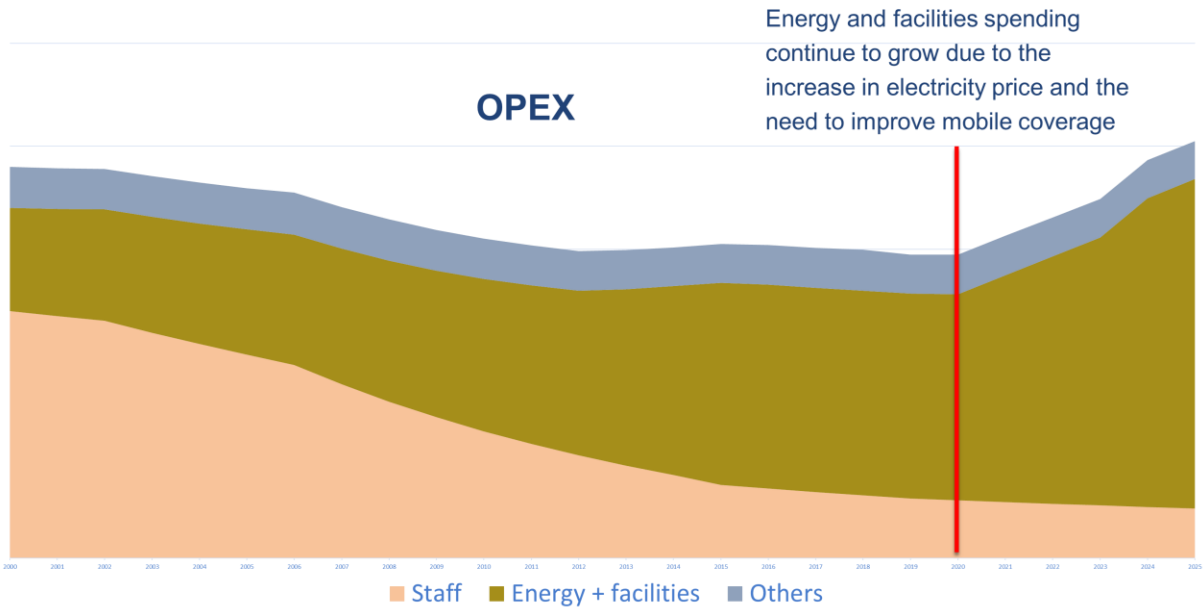


Figure 1: Company 'H' OPEX Spending Change

The world is becoming increasingly reliant on digital services, there has been a significant increase in the demand for reliable and high-speed connectivity. With the imminent rise of technologies like 5G, Internet of Things (IoT), and artificial intelligence (AI), it is estimated that traffic demand will surge by multiple folds in near future. This will further increase electricity consumption and the electricity cost will further increase if ICT will not do anything on it.

1.2.2 The Quest for Carbon Neutrality

Most ICT companies worldwide are required to produce an annual ESG report to show their commitment to environmental protection. Thus, the trend for ICTs to meet carbon neutrality's timeline and target is gaining momentum. Companies are increasingly investing in renewable energy sources to power network infrastructure and data centers, meanwhile adopting energy-efficient technologies to reduce their carbon footprint. Additionally, advancements in ICT hardware and software have enabled more efficient computing and data processing, further contributing to carbon reduction efforts.

Recent achievements, green innovation, and development by ICTs [3-7]

Vodafone

- Committed to carbon emissions to net zero (Scope 1 & 2) by 2030 and across the full value chain (Scope 3) by 2040

- Hosted a customer summit at 2023 London Green Tech Festival to actively engage Business customers about green digital transition.

Orange

- Committed to achieve Net-Zero carbon emissions by 2040

- Energy saving plan in line with the electricity consumption reduction objectives set by the French government

- Develop Orange Sustainable and Circular Ambition for Recertification (OSCAR) program for buying and selling reconditioned equipment

Axiata

- Committed to achieve net-zero carbon by 2050

- Introduced the hybrid system charge discharge battery (CDC) to power BTS in remote locations, resulted in a 54% reduction in diesel consumption

Telefónica

- Committed to achieve Net-Zero carbon emissions by 2040

- Committed 100% of energy from renewable sources by 2030 (In 2022, 100% renewable in Europe, Brazil, Peru & Chile)

China Mobile

- Committed the 30-60 Decarbonization Goals to reach CO2 emissions peak before 2030 and achieve carbon neutrality by 2060, in line with Chinese Government's commitment

- Carried out AI-based energy efficiency management and developed AI-based water-cooling adjustment and optimization in their data centers, core machine buildings, 5G base stations

The industry is actively investing in research and development to upgrade infrastructure and develop innovative solutions that can support the increasing network demands while minimizing environmental impact.

1.2.3 An Overall Approach to Green Management

There are many terms and principles established to approach carbon zero. For ICT, the consideration will be for the time being focused on Energy Saving, Energy Efficiency, Renewable Energy and Non-Renewable Energy. Taking from the Oxford Principles, Energy Saving is having a higher priority to Energy Efficiency. It would also be better not using energy nor create both heat and CO2 emission. In addition, ICT is paying an effort to use renewable energy than non-renewable energy as much as possible.

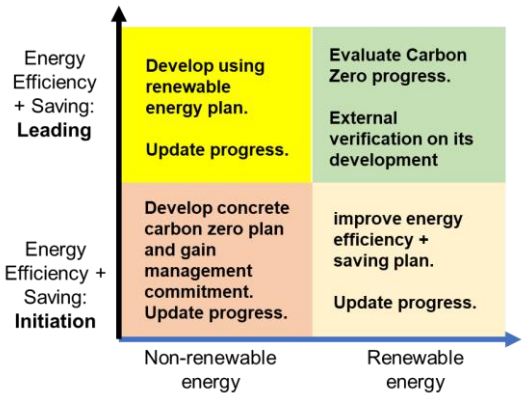


Figure 2: Simple Evaluation Carbon Zero Progress for ICT

Figure 2 shows a very simple diagram to evaluate the carbon zero progress for ICT and provided suggestions at different stages.

It is preferable to use renewable energy instead of non-renewable energy. The target is to have 100% renewable energy.

For 'Energy Efficiency + Saving', here are some tips to evaluate your status:

- **Improve your power factor:** Low power factor may cause your machines to be inefficient, hence consume more electricity than necessary. If you increase your power factor, the machine will be more efficient, hence use less electricity. This will reduce your monthly electricity bills.
- **Turn it off when not in use:** Switch off all equipment that you're not using – turn off computers, printers, monitors, air-conditioners, lights, etc. For equipment in the office, make sure they're switched off after work hours. Consider using laptops! Laptops use up to 80% less energy than desktops?
- **Light up wisely:** Consider installing room lighting controls that will turn lights on and off automatically at set times. Motion sensor lights are also ideal for saving electricity. Clean light bulbs, lamps, and reflective surfaces regularly so they emit more light! Remove unnecessary lamps from spaces that don't need as much light.If you have a flat roof, install skylights for natural lighting!
- **Use your air-conditioning efficiently:** Maintain a temperature of 24 - 26°C. This is a comfortable range, and you'll be surprised it can save you.
- **Get energy audit done:** An energy audit is an inspection, assessment and analysis of electrical energy usage at your premises. From the audit, you should be able to find the best way to utilize your equipment and lighting so you save more. You can train an energy manager or hire an audit company to do the energy audit.
- **Upgrade all outdated equipment with energy efficient replacement:** Replace outdated equipment with energy efficient appliances whenever possible. It might cost more but in the long run, they save you money by using less electricity.
- **Maintain and clean regularly:** Clean your equipment and electrical appliances and/or service them regularly to ensure that they're not dirty and dusty so they run at maximum efficiency. [8]
- **Reuse data center heat:** Data centers consume a significant portion of the world's electricity. In turn, they produce a tremendous amount of heat that's generally wasted. This unwanted byproduct of computer servers can be put to use with the right kind of efforts. The heat could potentially warm up houses, offices, or other facilities. It could also be used to heat underground water systems that run across cities and urban areas. [9]

If your company is actively pursuing all the above initiatives, your company is probably in the high end of energy efficiency and saving.

Below are two ICTs showing their effort in progressing to carbon zero environment. [10-11]

HKT

80%of office buildings covered by power meters to optimize energy consumption
Integrated Smart Energy Solution has been utilized to regulate the load of our buildings by achieving close to 10% of enerqy savinqs

10.1% **GHG emissions intensity reduced**

3.3% **energy consumption intensity reduced**

MTN

Reduction of GHG emissions in the year (approximately 13.9% compared to an annual target of 3.5% in pursuit of reaching Net Zero emissions by 2040)
Reducing Scope 1 and Scope 2emissions and greening our energy supply through Project Zero.
Working with our suppliers to reduce Scope 3 emissions

Still, the management of green ICT networks requires more than just energy-saving and energy efficiency uplift technologies. While a lot of effort has been invested into researching energy-saving technologies, it has become clear that these solutions are unique to each manufacturer. Therefore, ICTs should agree on a set of energy-saving measurable standards. Under the common standards, individual ICTs can then implement their green solution and benchmark their outcomes.

To accomplish green and low-carbon business goals, ICTs also need a green management platform that enables visualization and management. This platform should establish key green indexes and monitor these indicators. By monitoring the green indexes through the platform, operators can identify poorly performing indicators, pinpoint corresponding areas or items that require improvement, and provide optimization recommendations through analysis and management. Additionally, operators can analyze trends to formulate measures for continuous improvement and optimization.

With ICTs leading in standards and established platform to support green initiatives, the contribution of ICT to emission reduction in industries is far greater than its own carbon footprint. Global Enabling Sustainability Initiative (GeSI)'s research [12] indicates that the future contribution of the ICT industry in enabling emission reductions in other industries is nearly ten times greater than the emissions generated by deploying it. In addition, it can build ecosystem partnerships to develop a greater business landscape.

1.3. Vision

As the world increasingly recognizes the importance of sustainable practices and environmental responsibility, it is imperative that we address the ecological impact of ICTs and ensure their alignment with global sustainability goals. To this whitepaper, we propose the following initiatives:

1.Joint Formation of Standardization on Green Management:

The industry acknowledges a compelling need for Standardization on Green Management, so a collective call should be made to industry leaders, experts, and relevant stakeholders to collaborate in the development. The standard will serve as a guiding framework to minimize the environmental footprint of ICT networks, promoting energy efficiency, resource optimization, and enablement throughout different industries. By collaborating on the creation of this standard, we can collectively drive transformative change and foster a sustainable digital future. This also aligned with the 4th Principle of 'Oxford Principles for Net Zero Carbon Offsetting' – Industry standards to create net zero aligned carbon offsetting. [13]

2.Creating a Framework for Green Management:

To effectively visualize, plan, and manage the operation of Green Management, this proposal supports the development of a dedicated Green Management Framework. The framework will serve as a guidance for Planning and Execution, suggesting a centralized platform to offer real-time monitoring, analytics, and decision-making tools to optimize the environmental performance of ICT infrastructures. By enabling stakeholders to actively track and evaluate energy consumption, carbon emissions, and other key sustainability metrics, the Green Management Framework will empower organizations to make informed choices and drive continuous improvement in their business and operations.

3.Measurement of ICTs' Carbon Handprint across Vertical Industries:

To measure the positive environmental impact that ICTs have across various vertical industries, a quantification and assessment approach can be used. By assessing the benefits achieved through the adoption and utilization of ICTs, this measurement approach aims to incentivize sustainable practices and encourage further innovation in green technologies. Recognizing the importance of promoting sustainability beyond the ICT sector, it is crucial to extend the measurement of ICTs' positive environmental impact to other industries, ensuring a comprehensive evaluation of their contribution to greenhouse gas (GHG) reduction.

ICT is the locomotive pulling other industries towards carbon neutrality. It enables efficient communication, optimizes resource utilization, and fosters innovation. By harnessing its potential, we can accelerate towards a greener future, where technology drives sustainability and economic growth while minimizing our environmental impact.

2. Green Management Framework

The Green Management Framework is a holistic approach to advance environmental sustainability within the ICT industry. This framework is designed to promote sustainable practices across the entire green ecosystem, with a focus on the areas of governance, planning, and execution. In this section, we will provide a brief description of each item within these pillars, outlining their significance and role in supporting environmental sustainability within the ICT sector.

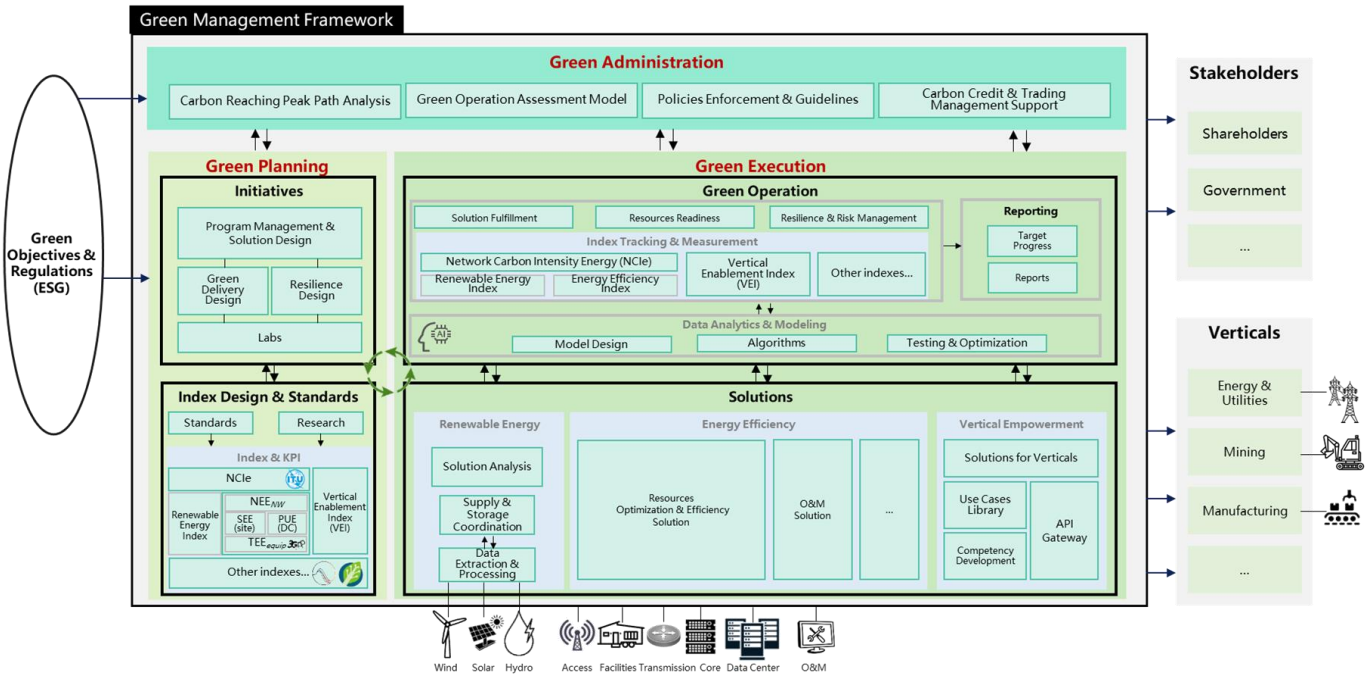


Figure 3: Green Management Framework

2.1 Green Administration

Green Administration empowers organizations to effectively manage and reduce their environmental impact. It fosters a culture of environmental responsibility, drives sustainable decision-making, and positions the organization as a frontrunner in environmental stewardship within the ICT industry. Green Administration incorporates several fundamental components that contribute to the implementation of environmentally sustainable practices within an organization. These components include:

Carbon Reaching Peak Path Analysis: This entails a thorough examination and evaluation of the organization's carbon emissions trajectory to identify and capitalize on opportunities for emission reduction. By comprehending the peak path of carbon emissions, organizations can strategically develop initiatives to minimize their environmental impact and strive towards achieving carbon neutrality.

Green Operation Assessment Model: The implementation of a robust Green Operation Assessment Model allows organizations to systematically evaluate and measure their environmental performance. This model assesses various facets of operations, such as energy consumption, waste management, and resource utilization, with the aim of identifying areas for enhancement and informing sustainable decision-making.

Policies Enforcement & Guidelines: The establishment of clear policies and guidelines is imperative for guiding employees and stakeholders in adopting environmentally sustainable practices. These policies ensure that responsible environmental stewardship is firmly integrated into all facets of the organization's operations, ranging from procurement and supply chain management to energy usage and waste reduction.

Carbon Credit & Trading Management Support: Incentivizing carbon reduction efforts, organizations may opt to participate in carbon credit programs or engage in carbon trading. Green Administration provides comprehensive support in managing and leveraging these initiatives, including diligent monitoring, accurate reporting, and effective trading of carbon credits. This enables organizations to offset their carbon emissions, contributing to global efforts aimed at mitigating climate change.

2.1.1 Green Assessment Model

To assess the "greenness" of an ICT company, relying solely on absolute carbon emissions is no longer adequate. As depicted in the diagram on the right, there are additional axes to consider:

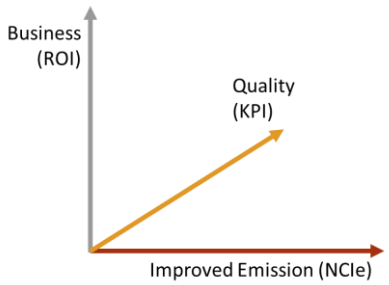


Figure 4: A 3D Green Assessment Framework

Business (e.g. Return on Investment):

Evaluating the environmental impact of an ICT company should not be isolated from its financial performance. Assessing the company's commitment to sustainability should also include analyzing its ability to generate returns on investments made towards green initiatives. This includes evaluating the company's adoption of sustainable practices, resource optimization, and the development of eco-friendly products and services that align with market demands.

Network Quality (Key Performance Indicators)

It is essential to gauge the environmental impact of an ICT company while considering the quality and performance of its network infrastructure. The company's ability to maintain high network quality, reliability, and responsiveness must be balanced with its efforts towards reducing carbon emissions. Evaluating KPIs related to network performance, such as latency, bandwidth, and service availability, alongside green initiatives, provides a comprehensive assessment of the company's environmental efforts.

Improvement of Carbon Emission (e.g. NCIe)

Carbon intensity, represented by Network Carbon Intensity energy (NCIe), is a metric that measures the carbon emissions per unit of network traffic or service provided by an ICT company. NCIe allows for a more accurate evaluation of carbon emissions, considering the overall efficiency and effectiveness of the company's operations. A lower NCIe indicates a higher level of carbon efficiency, reflecting the company's commitment to reducing its environmental impact while delivering network services. More bits with less watt.

2.2 Green Planning

Green planning of ICTs is of utmost importance in the framework of Green Management. It plays a pivotal role in driving sustainable practice within the ICT. It encompasses 'Initiatives' including program development, various sort of design and Labs. It also includes the establishment of green indexes and the setting of sustainability standards.

Effective planning enables organizations to define their sustainability goals, outline strategies, and allocate resources necessary for implementation. In many different industries, these indexes are primarily focused on reducing GHG emissions. This paper aims to explore and target standardization of sustainability indexes for the ICT industry, which has a unique role in driving communication technology advancement and fostering carbon handprint creation for other industries. In the following section, a set of indexes for the ICT industry will be proposed.

Focus on the strategic integration of green energy solutions and environmental friendly practices into the ICT's infrastructure, network expansion, and service delivery. It requires careful assessment, analysis, and implementation of sustainable technologies and practices.

Initiatives

Program Management & Solution Design:

1. Goal Setting and Target Establishment: setting clear and measurable goals and targets
2. Comprehensive Assessment and Baseline Analysis: conducting a comprehensive assessment and baseline analysis of the organization's current environmental performance
3. Integration of Environmental Considerations: incorporating sustainable practices, aim to embed environmental sustainability throughout the organization's activities
4. Problem identification & analysis; Solution Development and Evaluation; Integration and Implementation Planning; Monitoring, Evaluation, and Continuous Improvement

Green Delivery Design**:**

The growing demand for ICT services necessitates network upgrades and the deployment of technologies like LTE and 5G, full-fiber connections, and energy-efficient solutions to meet this demand. In light of these developments, it is crucial for carriers and vendors to prioritize green delivery design and minimize the waste of human and material resources. Several initiatives are being undertaken in this regard, including:

Logistics Optimization: Carriers and vendors are focusing on optimizing logistics processes to minimize transportation-related carbon emissions and reduce fuel consumption. This includes efficient route planning, consolidation of shipments, and the use of eco-friendly transportation options whenever possible.

Redundant Material Reduction: Efforts are being made to minimize the use of redundant material during network deployments. By carefully planning and optimizing resource allocation, unnecessary material waste can be reduced, leading to improved sustainability practices.

Site Visits and Remote Management: Carriers and vendors are leveraging remote management techniques and conducting virtual site visits whenever feasible. This reduces the need for physical travel, resulting in lower carbon emissions and resource consumption associated with transportation.

Tools and Document Digitization: The digitization of tools and documents is being implemented to streamline processes, reduce paper usage, and minimize the environmental impact of physical documentation. Digital tools and platforms facilitate efficient communication, design collaboration, and data sharing, resulting in improved productivity and reduced resource waste.

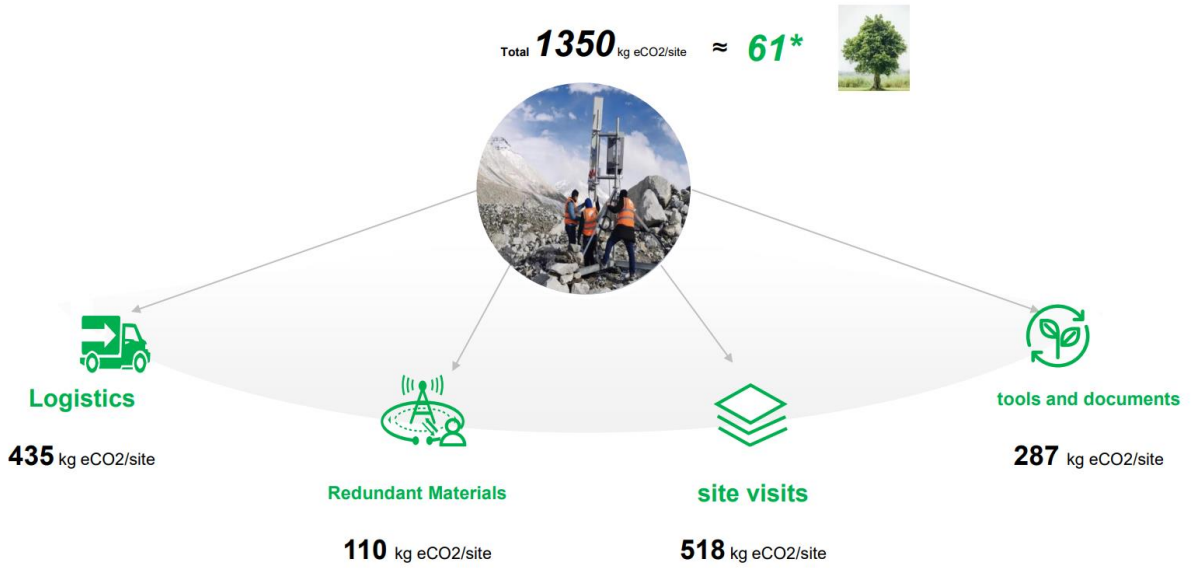


Figure 5: The carbon emission estimated by Huawei about delivering one mobile site in France with equipment shipped from Chin

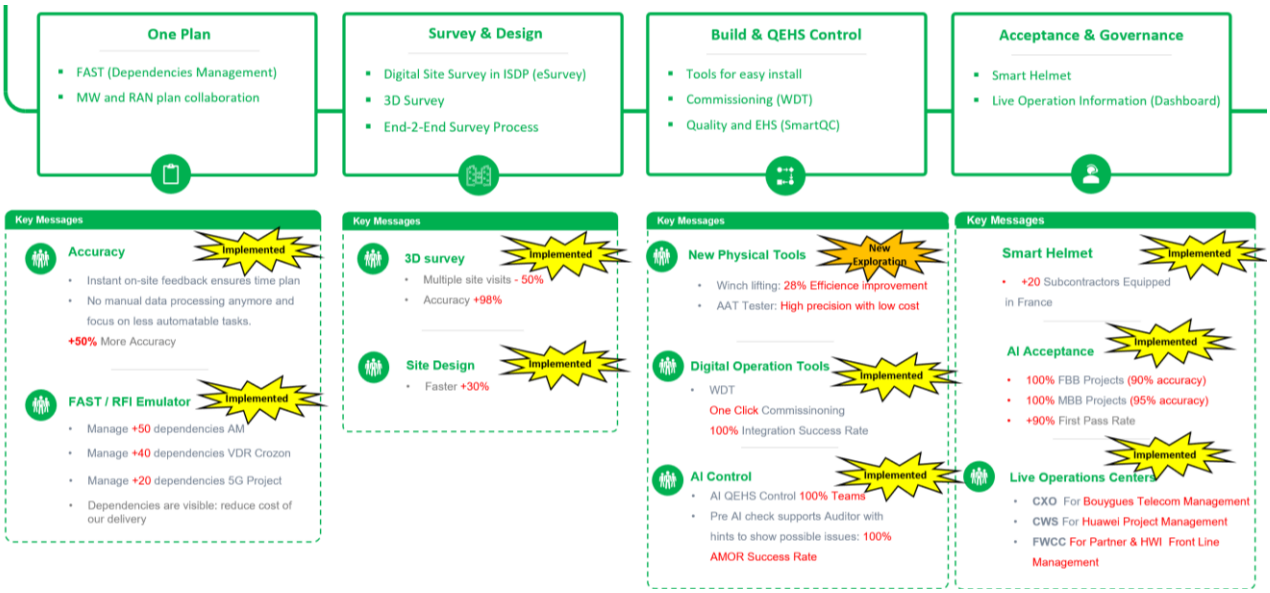


Figure 6: Green Delivery Solution Deployed by Huawei Significantly Saved Carbon Emission

To achieve the desired outcomes, intelligent digital tools and procedures can be implemented. For example, digital planning and collaboration platforms can optimize resource management and transportation options. Additionally, digital survey and commissioning features can streamline procedures and documentation, minimizing wastage and the need for physical visits. In the above case demonstrated by Huawei, 50% or more carbon emission can be saved by green delivery solutions.

By adopting these measures, carriers and vendors can be greener, enhance operational efficiency, sustainability, and contribute to the goals of the ICT industry.

Resilience Design:

Each organization is unique. The way organizational resilience is implemented is also unique. According to the International Consortium for Organizational Resilience (ICOR), studies have shown that there are common attributes and behaviors demonstrated by organizations that have survived and thrived during times of change and uncertainty. Resilience for ICT is fundamental.

Figure 7: The Model for Increasing Organizational Resilience is based on ISO 22316: Security and Resilience – Organizational Resilience Principles and Attributes

Resilience Design is of paramount importance for ICT networks to meet the demanding and complex connectivity requirements of contemporary applications. Network incidents, such as network or system downtime, can have significant impacts worldwide. These incidents can result in service disruption, economic losses, safety security risks and damage to reputation.

When ICT companies strive to embrace greener practices and comply with sustainability requirements, they face the challenge of modernizing equipment and reconfiguring their networks. These changes do come with potential risks to network stability and availability. Resilience design is crucial to ensure a smooth transition without compromising network stability. Balancing the pursuit of greener practices with the need for network resilience and availability requires a meticulous approach that considers the technical aspects, operational implications, and overall risk management. Considerations for network resilience design shall include:

Resilience Target	Resilience Level	L1	L2	L3	L4	L5
Expected Target	No. of incidents tolerable	0	1	2	3	4
Toleration Target	Business Impact	>30%	≤30%	≤20%	≤10%	≤5%
	Business Restoration Awareness	Days	Hours	Minutes	Seconds	Miliseconds
Adaptation Target	Impact Area	Entire Network	Entire Network	BGP area	IGP area	Single Site
Restoration Target	Network Restoration Ability	Very weak	Weak	Strong	Very Strong	Very Strong
	Fault Detection Ability	Very weak	Weak	Strong	Very Strong	Very Strong

Figure 8: A Resilience Measurement Model by Vendor 'H'

1. Model for Resilience Level and Standards: Establish a model that defines the desired level of resilience and sets appropriate standards, ensuring the network's ability to withstand and recover efficiently from incidents.

2. Assessment, Simulation, and Impact Forecast: Conduct comprehensive assessments, simulations, and impact forecasts to identify vulnerabilities and develop strategies for mitigating the impact of network incidents. Improvement actions according to the assessment and evaluate the success through KPI measurement. Execute this periodically for continuous improvements.

3. Improvement and Mitigation Measures: Implement measures to enhance network resilience, such as redundant systems, failover mechanisms, and rapid response protocols, minimizing downtime and ensuring efficient recovery.

4. Network Monitoring with Resilience Design: Continuously monitor network performance and incorporate resilience design principles to proactively identify and address potential issues before they escalate into incidents. Utilize Network Operations Support Systems (NOSS) and even Digital Twins of the network to provide full visibility for monitoring and examination prior to implementing changes.

Labs**:** play a crucial role in this process by conducting experiments, developing prototypes, and testing new ideas; contribute to the advancement of sustainable practices, the adaptation of new clean energy sources, the optimization of resource utilization, test the new equipment or integrated green solutions and verify expected results.

2.2.1 Green Indexes for ICTs

GHG Emission is the most common index used to measure the environmental impact of ICTs. However, it is no longer sufficient to address the growing sustainability challenges faced by the industry. While ICT technologies continue to grow, it is important to enhance their efficiency and minimize their carbon footprint. Therefore, it is necessary to develop additional sustainability indexes that account for the multiple environmental impacts of ICTs.

Here is a figure showing the measurement of environmental impact of a typical telecom network, which involves a layering of indexes that encompass different aspects of the network, infrastructure, and operations. The first layer is the Equipment Layer, which utilizes the Telecom Energy Efficiency (TEE) to measure the energy efficiency of individual network equipment; The second layer is the Infrastructure Layer, which utilizes the Site Energy Efficiency (SEE) and Power Usage Efficiency (PUE) to measure the energy efficiency of sites and data centers; The third layer is the Network Layer, which utilizes the Network Energy Efficiency (NEE) to measure the overall energy efficiency of the entire network; The fourth layer is the Operations Layer, which utilizes the Network Carbon Intensity Energy (NCIe) index to measure the carbon intensity of data transmission across networks; The fifth layer is Vertical Enable Index (VEI) to measure the reduction of emission contributed by adapting effective ICT solutions. Overall, this layering system provides a more logical understanding of sustainable development of green ICTs, which considered not only the development of telecom system, but also the environmental impact.

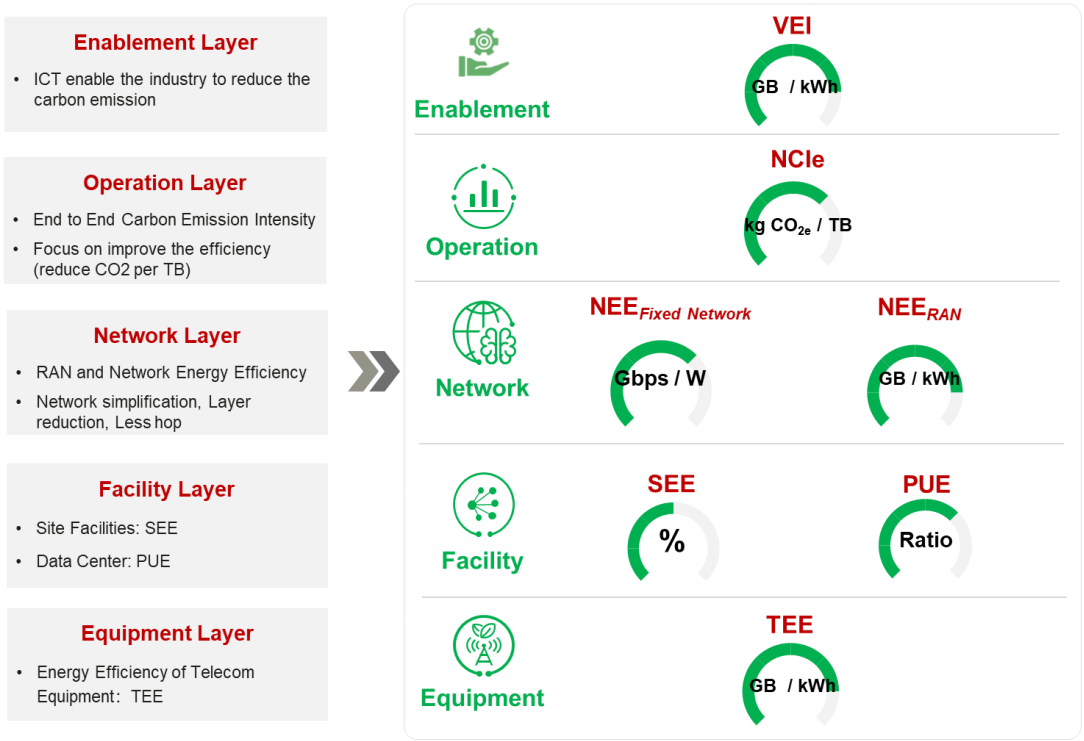


Figure 9: Five-layer Index System for Green Management for ICT

Among the four-layer index system, there are four indexes to be highlighted and will be introduced further: Network Carbon Intensity Energy (NCIe), Network Energy Efficiency (NEE); Site Energy Efficiency (SEE), and Vertical Enablement Index (VEI). The NCIe measures the carbon intensity of data transmission across networks; the NEE and SEE measure the efficiency of energy usage at the network and site level, while the VEI is used to express the effect that ICT enable other industry's carbon emission reduction.

Network Carbon Intensity Energy (NCIe)

The NCIe [1]. It is a key indicator defined in ITU-T Recommendation L.1333, which is a standard for measuring the environmental impact of ICT networks. NCIe is calculated as the amount of carbon dioxide emitted per unit of data traffic.

The NCIe index can be used to track and benchmark the environmental impact of ICT networks and identify opportunities to reduce their carbon footprint. For example, ICT organizations could use the NCIe index to identify networks or data centers that are consuming a lot of energy and take steps to improve their efficiency.

The formula for calculating the NCIe index is as follows:

$NCIe = EC_{total}(kWH)*CF_{av}(kg\ CO_2e/kWh) / DV_N(TB)$

where:

- ECtotal is the total energy efficiency of the network
- DV_N is the data volume of the network
- CFav is the average carbon emission factor

To improve NCIe, three key strategies can be employed. The first is to improve energy efficiency, which involves reducing the amount of energy required to transmit data (per TB) across the network. The second strategy is to reduce the emission factor, which involves using cleaner and more sustainable energy sources to power the network. The third is the improvement of network performance. Here is a figure illustrates the two strategies:

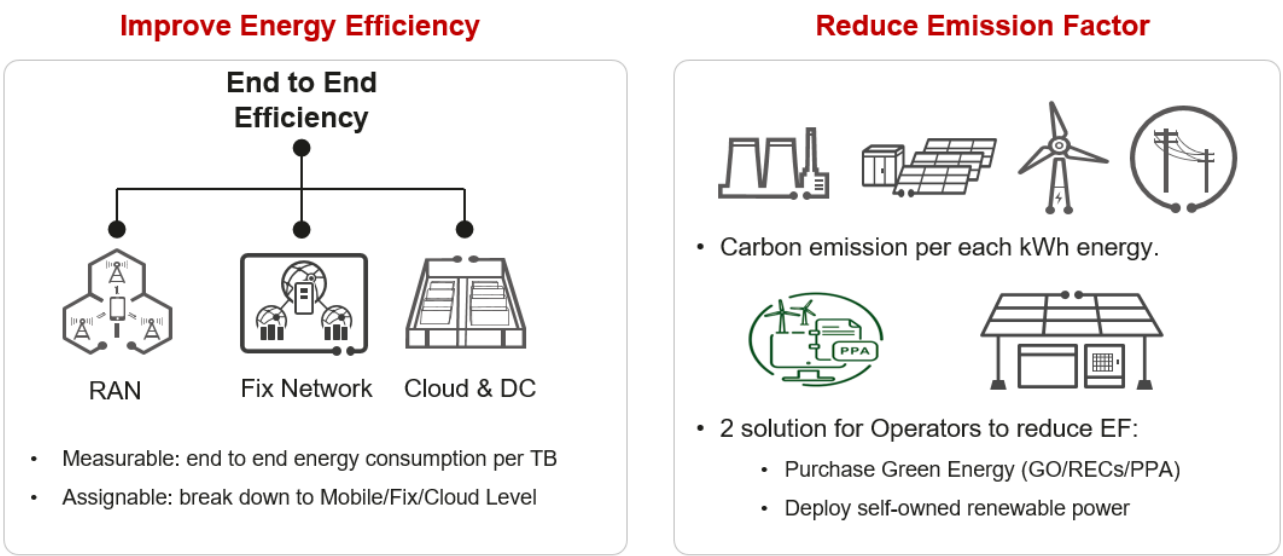


Figure 10: Measure and Improve the end-to-end NCIe

Network Energy Efficiency index (NEE)

The Network Energy Efficiency index (NEE) is an important measure of the overall energy efficiency of an entire network. By improving the energy efficiency of the network, the NEE index can be increased, ultimately reducing the environmental impact of ICT networks. While the network performance is bonding with every daily life nowadays, considering only the efficiency is not adequate, a continuous pursue both optimal energy efficiency and user experience shall be part of the measurement. Here is the formulae:

NEE = Total Data Volume / Total Energy Consumption × $Factor_{coverage}$ × $Factor_{experience}$

Where

$Factor_{coverage}$ = Actual Qualified Coverage Ratio / Target Qualified Coverage Ratio

$Factor_{experience}$ = Actual Average User Throughput / Target of Average User Throughput

$$= \frac{Total\ Mobile\ Traffic\ (GB)}{Total\ Energy\ Consumption\ (kWh)} \quad \Rightarrow \quad = \frac{f(Mobile\ Traffic, Coverage, Experience)}{Total\ Energy\ Consumption\ (kWh)}$$

Improve mobile network energy efficiency

- Improving wireless site efficiency (coverage & capacity)

Improving coverage efficiency

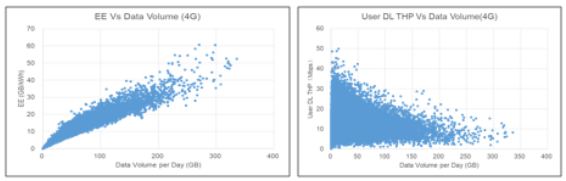
Improving site capacity

- Network-wide energy saving features

Multi-dimensional energy-saving features

Multi-dimensional energy efficiency

- Confliction between energy efficiency and user experience:



Higher traffic => higher energy efficiency

Higher traffic => poorer user experience

Evolution:

- More objective: wireless network capacity & performance
- More comprehensive: multi-dimensional factors such as energy efficiency, user experience, and coverage
- More prospective: mid- and long-term network evolution

Figure 11: Measure and improve the Energy Efficiency of Mobile Networks

Site Energy Efficiency index (SEE)

The Site Energy Efficiency index (SEE) is a measure of the overall energy efficiency of a network site:

SEE = EC_{CT} / EC_{MN}

where:

EC_{CT} is the Energy Consumption of the telecom equipment

EC_{MN} is the Energy Consumption of the mobile network, OR

EC_{MN} is the Energy Consumption of the whole site, including the support equipment like the rectifier, power storage, security lights, air conditioning, etc.

The above metric gives an indication of Site Energy Efficiency (SEE) in terms of how big fraction of energy is used for actual telecommunication equipment. However, site scenarios are complex. Sites have different sizes and types and the telecom equipment types are also different. The composition and scale of the support equipment are also multivariable. Therefore, the SEE values vary greatly. Sites with low energy efficiency and sites with energy efficiency to be improved cannot be directly recognized. Therefore, further research and experiment is required on the universality of the preceding metric in actual scenarios.

Here is a figure illustrates how the Energy Efficiency of a typical site can be measured.

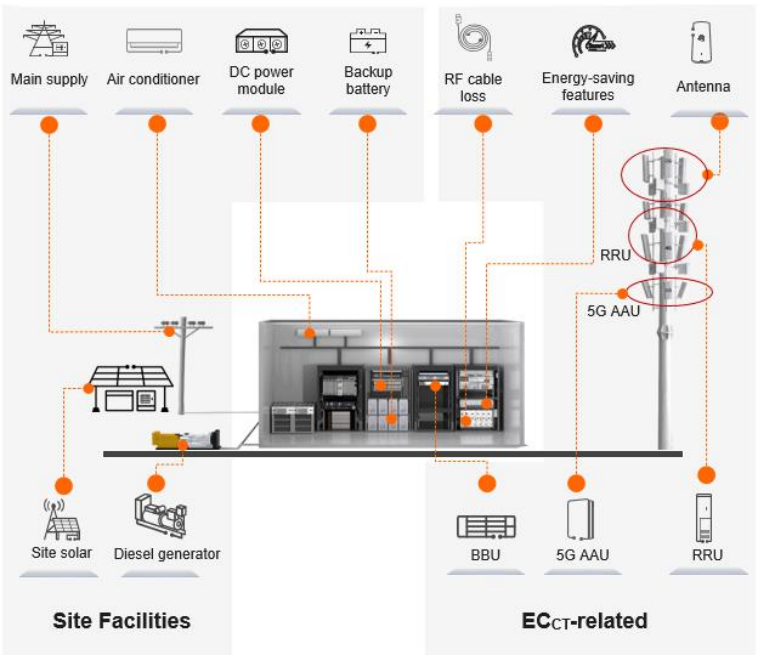


Figure 12: Measure site energy efficiency for a Mobile Network

Vertical Enablement Index (VEI)

For the enablement scenario, the main indicator is the vertical enablement index

We assume: The object is unit product or service. Enablement carbon emission reduction is an indicator to describe the difference between the carbon emissions without the enabling carbon reduction solution (i.e. baseline scenario) and the carbon emissions of the enabling carbon reduction solution.

Vertical Enablement Index is the Ratio of the enablement carbon emission reduction to the carbon emissions of the enabling carbon reduction solution, reflecting the carbon emission reduction degree for other industries enabled by ICT

$VEI = (CE_{BS}-CE_{ES}) / CE_{ES}$

Where:

VEI is the vertical enablement index which indicates the carbon emission reduction degree and effect for other industries enabled by ICT

CE_{BS} is the carbon emission of the baseline scenario

CE_{ES} is the carbon emission of the enablement emission reduction solution

2.3 Green Execution

Implementation of green energy initiatives and the ongoing management of sustainable practices within the ICT. It focuses on translating the strategic plans into tangible actions and ensuring their successful implementation.

Green Operation:

Fulfillment: Implementing the environmentally friendly solutions and considering sustainability throughout the process.

Evaluation & Assessment: Network evaluation, customer assessment and technology assessment etc, enable companies to identify strengths, weaknesses, and areas for improvement

Resilience & Risk management: Systematic process of identifying, assessing, and mitigating potential risks associated with environmentally friendly practices. It involves identifying risks specific to green operations, evaluating their potential impact, and implementing measures to manage or minimize those risks

Index Tracking & Measurement: Continuous tracking on defined indexes from Planning stage. They are used to measure progress and review its effectiveness.

Reporting:

Target Progress: Accurately measuring and transparently reporting the company's environmental performance and progress towards achieving sustainability goals related to resource efficiency, carbon emissions reduction, and adoption of eco-friendly practices

Reports: Provide comprehensive information on the company's environmental initiatives, performance, and progress, showcasing its commitment towards sustainability and accountability

Data Analysis & Modelling:

Model design: Incorporation of environmentally friendly practices and sustainable principles throughout the entire operational framework, ensuring minimal environmental impact and optimal resource efficiency

Algorithms: Discover patterns, trends, and insights from environmental data, enabling informed decision-making and the identification of opportunities for optimizing resource efficiency and reducing carbon emissions

Testing & Optimization: Systematic evaluation and refinement of environmentally friendly practices, technologies, and processes to maximize resource efficiency

2.3.1 Green Management Platform

A centralized platform is highly valuable for ICTs to manage their green initiatives, goals, measures, and detailed operations. Such a platform can provide a centralized hub for monitoring, coordinating, and optimizing sustainability efforts within an organization. Here is an example incorporated with the green governance, planning and the indexes:

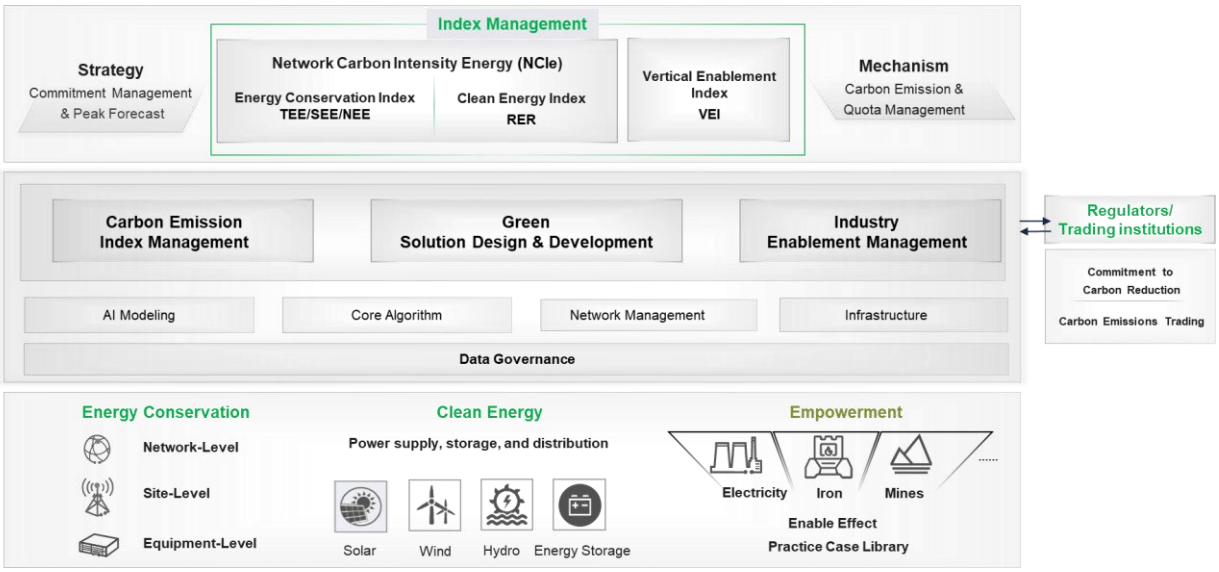


Figure 13: A Centralized Platform for the Green Management

Huawei has deployed a Green Network Evolution with Digital-twins Platform (GNED) since 2022, incorporating the elements from the framework in Figure 13. The platform enables the collection of key data, including traffic, service quality, and energy consumption information from network and equipment. This data provides carriers with enhanced visibility, manageability, and actionable insights for intelligent operations on energy efficiency. In addition, the platform can be capable for solution development and capex planning, empowering carriers to optimize their investments and achieve greater efficiency and sustainability.

Furthermore, the platform can be interconnected with carbon emission regulators, trading institutions, and vertical industries to support regulatory requirements and facilitate wider societal efforts towards digital transformation and carbon emission reduction.

2.3.2 Green Solutions

Green Solution refers to a set of sustainable practices and technologies that are designed to promote sustainability, particularly in the ICT industry. This includes the use of renewable energy sources, the adoption of energy-efficient technologies and practices, and the implementation of vertical enablement solutions to other industries. These practices and technologies are developed from the experience of ICTs in implementing those solutions.

Renewable Energy:

Solution Analysis: Process of assessing the viability and potential advantages of integrating sustainable energy sources into telecom infrastructure to minimize reliance on non-renewable energy

Supply & Storage Coordination: Strategic management and optimization of renewable energy resources to ensure a reliable and efficient supply of clean energy for various applications, example is the use of smart grids and battery energy storage systems to capture excess energy generated from renewable sources

Data Extraction & Processing: Data analysis techniques are employed to derive insights and inform decision-making for optimizing renewable energy systems, such as gathering real-time data from solar panels or wind turbines to monitor energy production)

Energy Efficiency:

Resources Optimization & Efficiency Solution:

Key principle that focusing on maximizing the usage of resources while minimizing waste and environmental impact; it could be achieved through multiple channels:

- Network: Optimize the use of energy resources in network infrastructure, equipment, and operations to minimize energy consumption
- Site: Strategies implemented at a telecom site, base station or data center, could be usage of energy-efficient equipment to increase efficiency
- Equipment modernization: Replacement of outdated or inefficient equipment, such as computer servers and cooling systems; deployment of smart power management systems
- Data center solution: Implementing measures such as efficient cooling systems, virtualization, and optimizing server utilization to reduce energy consumption and maximize efficiency of data center operations
- Employee Management: Provide staff with proper training and education to engage employees' green practices in daily operations

O&M Solution: optimizing the performance of green network systems by using innovative technologies such as digitalization, automation, and AI to monitor and manage performance, detect and fix problems, and make the best use of resources to reduce energy consumption and carbon emissions

2.3.3 Vertical Enablement

The ICT industry has a crucial role in facilitating emission reductions and advancing sustainability across diverse industry verticals. Leveraging their expertise, ICT companies should harness their own experiences to drive development and contribute to the enablement of sustainability practices within these verticals.

Solutions for Verticals: Services offer to vertical industry, like digital transformation, cloud virtualization, IoT system, automation, or AI, eventually reduce carbon footprint

Use Cases Library: A collection of best practices and insights gained from self and B2B deployment experiences.

Competency Development: Providing training and consultancy to personnel in other industries to enable them to adopt and implement green solutions or sustainable practices.

API Gateway: A centralized ecosystem that connects diverse systems and technologies, including those related to green solutions or sustainable practices, to improve efficiency and reduce environmental impact.

Examples of Vertical Enablement to other industries:

Digital Transformation

Paperless: cloud storage, digital signatures, and collaborative platforms to manage documents electronically, minimizing the need for physical paper-based processes

E-commerce platforms: provide online marketplaces to sell products and services

Digital payment solutions: mobile wallets and payment gateways, these contactless payment methods enable secure and convenient transactions

Virtualization and Edge Services

Virtualization: Allows multiple users or customers to share physical resources such as servers, storage, and networks. This increases efficiency and flexibility in resource allocation.

Edge Services: Edge virtualization brings computing resources closer to end-users. Allows faster processing and customization, enabling real-time services like virtual/augmented reality and autonomous vehicles. Faster and more reliable applications that require low latency can be rollout.

Smart Cities

Help develop smart cities by technologies like sensors, 5G coverage and automation:

IoT devices apply sensors to collect data, enabling cities gain valuable insights into patterns, trends, facilitating informed decision-making.

5G technology enhances connectivity by providing ultra-fast and low-latency communication

Optimize energy usage, traffic management and waste management, leading to more livable cities.

In addition to enabling sustainability practices, ICT offers significant opportunities for other industries to reduce carbon emissions and create positive environmental impacts, often referred to as "carbon handprints." By leveraging digital technologies, industries can optimize resource utilization, streamline processes, and implement innovative solutions that lead to substantial carbon footprint reductions. For instance, through advanced data analytics and real-time monitoring, ICT enables industries to identify energy-intensive areas, implement energy-saving measures, and optimize transportation routes, thereby reducing carbon emissions throughout the value chain. Furthermore, ICT solutions facilitate remote collaboration, telecommuting, and digitalization of services, reducing the need for physical travel and resulting in additional carbon savings. By embracing ICT's enablement, industries can actively contribute to global climate goals, demonstrating their commitment to sustainability and fostering a greener future for generations to come.

Use case in mining Industry:

Intelligent Mining Site

A trial involves one of the largest steel company in western China. In collaboration with China Mobile and Huawei, the 5G+ Intelligent Mining Innovation Base has been established to promote the formulation of industry standards for intelligent mining.

The overall solution for the 5G unmanned mining site consists of three parts: "terminal," "network," and "edge." Intelligent equipment includes remotely controllable electric shovels, mine trucks, and electric drills, as well as autonomously driven mine trucks. The 5G private network provides a basic communication network for unmanned mining sites, meeting the requirements of high upstream transmission, low latency, high reliability, and security in mining scenarios. The edge data center integrates mining-edge containerized equipment rooms, network/computing resources, and various unmanned mining applications. It centrally stores mining production data, enabling simplified deployment and operation.

Through the application of ICT technology, the mining industry has achieved significant carbon emissions reductions. By calculating the carbon reduction factor:

- Estimated 642 tons annual reduction in carbon dioxide emissions

- Approximately 8.4-fold increase in the Vertical Enablement Index (VEI) which is a significant increase in our carbon handprint.

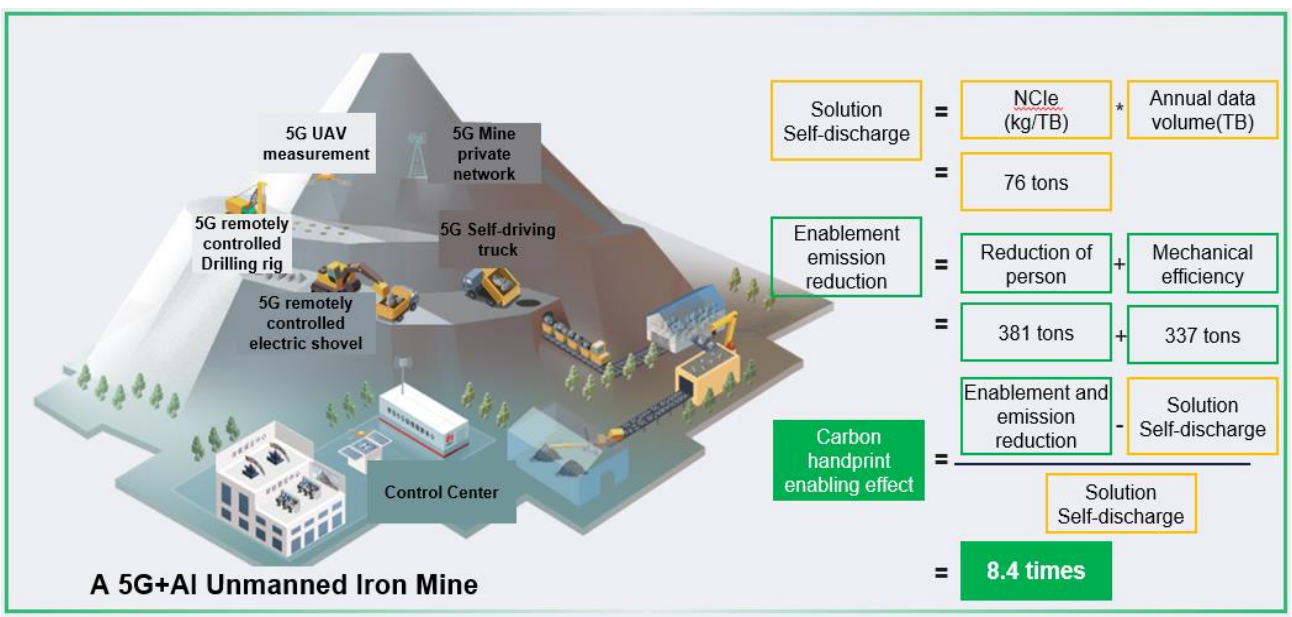


Figure 14: A trial intelligent mining site as example of vertical enablement by ICT

2.3.4 Green Full-service Area

In the past, Telco Central Offices (COs) were strategically located near users to provide traditional telephony services like Plain Old Telephone Service (POTS). However, with advancements in telephony and data transmission technologies, many COs have undergone upgrades or re-architecting, transforming into FTTH, Data Centers, telco edges or wireless backhaul infrastructure (Microwave/Millimetre-Wave) solutions.

Moving forward, it becomes imperative to prioritize environmentally sustainable practices. This involves adopting renewable energy sources, maximizing energy efficiency, and leveraging the potential of telco edges to provide ICT services to the region while empowering communities with ICT and digital solutions. Embracing these initiatives presents an exceptional opportunity to make a positive carbon handprint within the community. By harnessing renewable energy sources such as solar or wind power, Telco edges can significantly reduce their carbon footprint and contribute to a greener future. Additionally, optimizing energy efficiency within these facilities not only minimizes environmental impact but also enhances cost-effectiveness and operational sustainability.

The role of the Full-service Area extends beyond providing traditional telecommunication services. It serves as a catalyst for digital transformation within the community, enabling access to ICT solutions and empowering individuals and businesses. This integration of ICT and digital solutions has the potential to enhance various aspects of daily life, including education, healthcare, transportation, and more.

As the Full-service Area has developed in multi-services vigorously, it become necessary to effectively measure their maturity, to safe guard the effective investment and high-quality services. Here are some dimensions to consider:

- Giga-coverage Rate: Rate of Gigabit services
- Resilience: Level of service resilience
- Hard Pipe Capability: Ability to deploy network slicing
- Network Modernization: Modernization of fixed and mobile networks
- Network Energy Efficiency: Energy Efficiency on network level
- Average PUE: The average of PUE of
- Point of Interest(POI) Distance: Distance from Fiber Access Terminal(FAT) to user
- Fiber Distribution Terminal(FDT) Density: Number of FDT per square kilometer

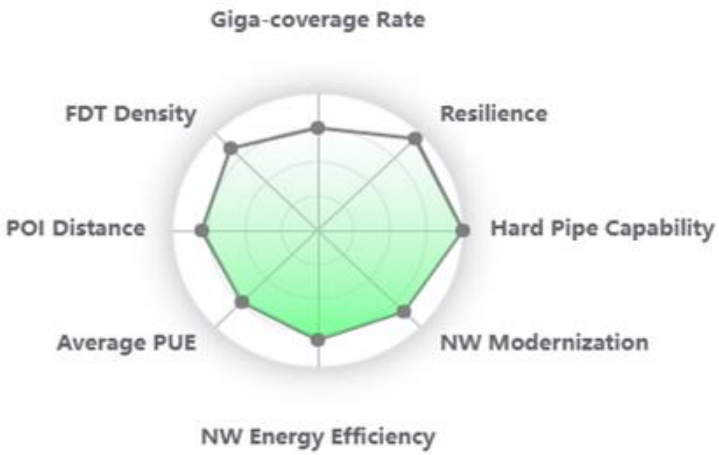


Figure 15: A Multi-Dimension Model to Evaluate Maturity of Full-service Areas

3. Conclusion

This white paper is an important step towards promoting green development in the ICT industry, as we work together to standardize Green Management. By establishing a systematic framework, we hope to facilitate the reduction of carbon emissions and promote greater sustainability across various sectors.

The proposed framework in the white paper serves as a pivotal idea that empowers ICT organizations to effectively govern, plan, and execute their green commitments and initiatives. With further standardization on practices and guidelines, the industry can harmonize efforts, share best practices, and drive meaningful change in the environmental impact.

We call upon all stakeholders, industry development organizations, standards organizations and academia to actively participate in this standardization initiative. Together, we can shape a greener and more sustainable future, leveraging the transformative power of ICT to address environmental challenges and achieve a low-carbon economy.

Through this collaborative endeavor, we envision a future where Green Management becomes a fundamental component of ICT operations. The time for action is now. Let us unite in our commitment to develop a common language on green management and pave the way for a more environmentally conscious and resilient world. Together, we can drive innovation, foster collaboration, and create a lasting positive impact on our planet.

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