Green Network Evolution with Digital-twins Platform （GNED） Whitepaper

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Executive Summary

This white paper offers a proposal to introduce a systematic approach to enable ICT (Information and Communication Technologies) to achieve net Carbon Zero operations. Huawei Technologies GNED (Green Network Evolution with Digital-twins platform) can help network operators measure their energy efficiency, adopt green metrics to quantify their energy usage, and design their networks to achieve Carbon Zero.

Global Warming is now of major international concern and many countries have pledged to attain Carbon Zero at specific future dates. By 2022, 148 countries had committed to Carbon Neutrality, Net Zero or Climate Neutrality. Consequently, network operators must also show tangible results in a move towards Carbon Zero.

Furthermore, with energy costs continuing to rise, network operators are spending an increasing portion of their OPEX on electricity, including batteries and diesel generators to support stable and reliable services. Thus, there is also a pressing economic argument for network operators to improve their energy efficiency.

One missing aspect is an operation framework; many network operators have well developed systems to monitor network quality but they lack tools to monitor energy efficiency and energy saving. For example, Autonomous Network capabilities are focused on improving network planning and network operations but tend not to focus so much on energy usage. Therefore, it is necessary to address this gap by building energy management into network planning and network operations in order to successfully meet the need for improved energy efficiency and carbon reduction.

Huawei GNED is a platform specifically designed to help network operators monitor their energy usage and provide recommendations for improvement. GNED is based on an Open Architecture and Agile Methodology to allow network operators to flexibly connect to existing systems, while offering scalability and faster time to market.

In summary, this white paper serves as a call for action. Let us systematically address the energy efficiency of ICT network and operations so that our industry can become a leader in the quest for Carbon Zero.

1. The Missing Piece in Network Services – Energy Management Using GNED

In 2022, China Mobile committed 30-60 Decarbonization Goals to reach CO_2 emissions peak before 2030 and achieve carbon neutrality by 2060[1]. Huawei as the long-term partner, has been collaborating with China Mobile to explore best solutions and practices to achieve the 30-60 goals. Huawei GNED was developed for Energy Saving and Management while maintaining top standard network performance and customer experiences. After several use cases succeeded in different regions, the deployment of GNED has been a resounding success, offering more benefits on renewable energy integrations, network modernization solutions, energy saving features, vertical industry enablement, etc.

With the experience with China Mobile, Huawei sees the need for network operators to have a system to measure and control its energy usage. Also, reduce energy wastage and to improve energy efficiency has become a big topic. It is not just for reducing OPEX spending but also in compliance to government initiatives in reducing CO_2 emission.

In order to achieve that, network operators need seriously look into its present energy consumption and not just work on network operation team but to start from network planning. A holistic approach is required to examine all its facilities on energy efficiency. Then, select all those facilities with very low energy efficiency and evaluate the methods to replace it. In order to do so, systematic process to do energy management at network planning and network operations are necessary to be added into their existing processes. Also, network operators need to establish or adopt energy metrics to quantify energy management. Finally, a tool like GNED is needed to do the actual monitoring.

For the energy management processes, Huawei adopts eTOM (enhanced Telecom Operation Map) [2] model and suggested new blocks to add to network planning and network operations. In addition, it is also necessary to add in new metrics into the "Enterprise Performance Management" for network operators to evaluate its performance and indicate their achievements at their "Environmental, Social and Governance" (ESG) annual report.

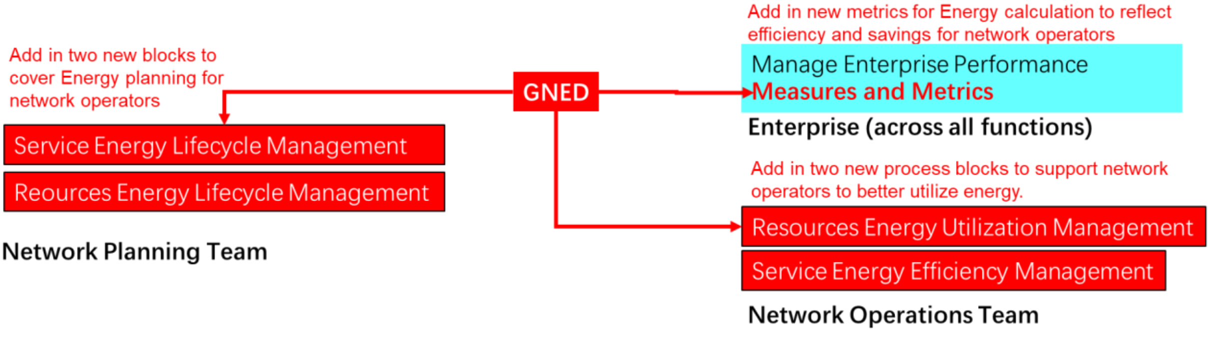


Figure 1. New process blocks on Energy Mgt for Network Planning and Network Operations

For the Network Planning stage (eTOM: “Business Value Development” and “Operation Readiness and Support”), two new processes are suggested for energy planning, including “Service Energy Lifecycle Management” and “Resources Energy Lifecycle Management”.

Service Energy Lifecycle Management: Focuses on managing the energy consumption and efficiency of network services throughout their lifecycle. It involves assessing the

energy requirements of each service, optimizing energy usage during service design and deployment, and continuously optimizing energy consumption during operation. The management ensures that energy efficiency considerations are integrated into the planning and management of network services, enabling the identification and implementation of energy-saving measures.

Resources Energy Lifecycle Management: Encompasses the management of energy consumption and efficiency for network resources. It involves evaluating the energy requirements of various network resources, such as servers, routers, and switches, and implementing energy-efficient technologies and practices during resource planning, deployment, and operation. Resources Energy Lifecycle Management focuses on optimizing resource energy usage, reducing energy waste, and promoting energy-saving initiatives within the network infrastructure.

With these two new processes, network operators can effectively manage and optimize energy consumption in network planning, ensuring that energy efficiency considerations are integrated throughout the lifecycle of services and resources. This additionally enables proactively identification of energy-saving strategies, leading to reduced energy costs, enhanced sustainability, and improved environmental performance.

For the “Operations” stage, two new processes are suggested, including “Resources Energy Utilization Management” and “Service Energy Efficiency Management”.

Resources Energy Utilization Management: Focuses on actively managing the energy utilization of network resources during operations. It involves monitoring and optimizing the energy consumption of various network components, such as servers, data centers, and network devices. This element aims to identify energy-intensive areas, implement energy-saving practices, and ensure optimal energy utilization across the network infrastructure. By actively managing resource energy utilization, organizations can reduce energy waste, improve operational efficiency, and achieve cost savings.

Service Energy Efficiency Management: Addresses the management of energy efficiency for network services during operations. It involves monitoring and optimizing the energy consumption of services, ensuring that energy-efficient practices and technologies are utilized. This element focuses on identifying opportunities to improve energy efficiency within service operations, such as optimizing virtualization, workload management, and power management strategies. By prioritizing energy efficiency in service operations, organizations can reduce energy consumption, lower operational costs, and contribute to sustainability goals.

In relation to “Manage Enterprise Performance”, energy metrics are being established and being collected to evaluate the effectiveness of the planning stage and the actual outcome in the operations stage. Chapter 2 will introduce these metrics.

GNED provides a comprehensive solution for managing energy challenges and optimizing energy management. By implementing the platform, network operators can monitor energy consumption in real-time, identify opportunities for energy savings, and make informed decisions to improve energy efficiency. This integration enables network operators to address environmental concerns, drive sustainability initiatives, and achieve enhanced business performance.

1.1 GNED Reference Architecture

GNED is a versatile platform with multiple functions. It will first collect energy consumption data from the physical and data layer through an Open API gateway. By harnessing the capabilities of the NetLIVE, GNED facilitates comprehensive evaluation and design of microservices & service-oriented architecture to achieve simulation and optimization. GNED ultimately aims to offer various features and benefits, including energy efficiency analysis, monitoring of low carbon initiatives, implementation of low carbon algorithms, and digitalization of network operations. A simplified GNED reference architecture is shown below:

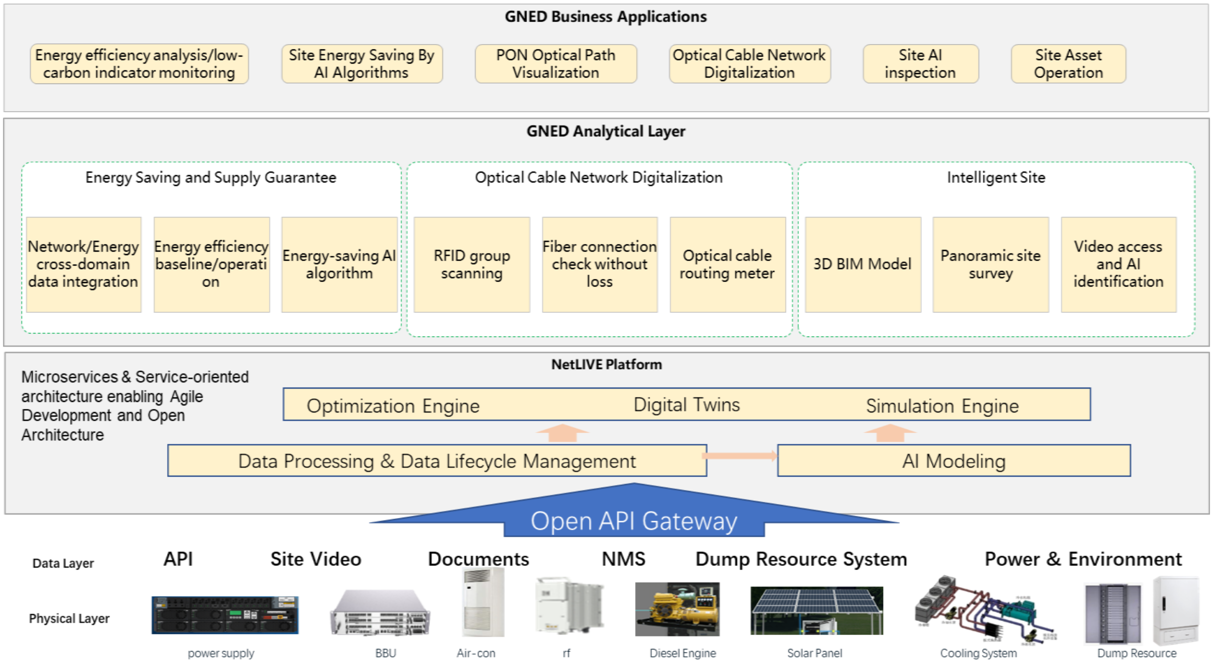


Figure 2. GNED Architecture

1.1.1 Physical and Data layer

At the physical layer, GNED encompasses multiple channels of energy usage, such as Baseband Units (BBU), diesel engines, solar panels, and more. These channels represent the diverse sources and mechanisms through which energy is consumed within the network infrastructure.

Moving to the data layer, the energy usage channels are categorized into specific types, including Application Programming Interfaces (APIs), site videos, documents, and power and environmental data. Each of these types represents a distinct aspect of energy usage and provides valuable insights into the energy consumption patterns within the network.

1.1.2 NetLIVE

The GNED, with its core being the NetLIVE, facilitates the integration of the physical layer and data layer through an open API gateway. NetLIVE operates on a microservices and service-oriented architecture, designed to support agile development and an open architecture approach. By leveraging these principles, NetLIVE enables seamless communication between the physical infrastructure components and the data layer, allowing for efficient data exchange and evaluation. This flexible architecture empowers organizations to adapt quickly, promote collaboration, and achieve optimal GNED outcomes.

Digital-twins technology plays a crucial role and consists of two key components: the optimization engine and the simulation engine. Through the open API gateway, data collected from the physical and data layers is transmitted to the data processing and data lifecycle management modules, which then feed the data into these two engines for analysis.

The optimization engine utilizes the collected data to provide continuous recommendations to operators. These recommendations aim to help operators achieve maximum energy efficiency from strategies based on the insights gathered. By leveraging real-time and historical data, the optimization engine assists operators in making informed decisions to optimize energy consumption and improve overall network efficiency. Simultaneously, the simulation engine employs AI modeling techniques to simulate various energy situations. By creating virtual scenarios, the simulation engine evaluates different energy usage patterns and assesses whether energy consumption exceeds the maximum desired level. This enables operators to test different scenarios and identify potential energy-saving opportunities.

1.1.3 GNED's Analytical Layer

The analytical layer, which is placed above the NetLIVE, offers three key functions to enhance performance.

Energy Saving and Supply Guarantee: This function encompasses three capabilities that drive efficient energy management and ensure a reliable energy supply. The first capability is Network/Energy Cross-domain Data Integration which enables the seamless integration and analysis of data from both network and energy domains. The second, Energy efficiency baseline/operation, establishes energy efficiency baselines and facilitates ongoing monitoring and operation of energy consumption. The third, Energy-saving AI algorithm, leverages artificial intelligence to develop advanced algorithms that identify energy-saving opportunities and optimize energy consumption. empowers organizations to make data-driven decisions, optimize energy usage.

Optical Cable Network Digitalization: This function enables the efficient management and digitalization of optical cable networks and enhances network performance and streamline operations. There are three capabilities. The first, RFID Group Scanning, leverages RFID technology to facilitate the rapid and accurate scanning of optical cable groups. Second, Fiber Connection Check Without Loss, empowers network operators to perform connection checks on optical fibers without incurring signal loss. Third, Optical Cable Routing Meter, provides precise measurements of optical cable routing, offering valuable insights into cable lengths, routing paths, and physical network layout.

Intelligent Site: This function brings forth a suite of capabilities that revolutionize site management and optimization. It empowers organizations to harness advanced technologies and data-driven insights for efficient site operations. The first capability, "3D BIM Model," leverages Building Information Modeling (BIM) technology to create comprehensive and interactive 3D models of site infrastructure. Second, Panoramic Site Survey, facilitates the collection of detailed site information through panoramic imaging and surveying techniques. Third, Video access and AI identification, integrates video surveillance systems with artificial intelligence algorithms to enable real-time monitoring and identification of site activities.

1.1.4 GNED's Business Application Layer

The Business Application layer at the top of GNED provides a range of powerful tools and functionalities that enables businesses to enhance their operational efficiency, reduce costs and achieve sustainability goals.

Energy Efficiency Analysis/Low-carbon Indicator Monitoring: This function empowers organizations to assess and optimize their energy efficiency while monitoring low-carbon indicators. It combines advanced analytics and monitoring capabilities to provide valuable insights into energy consumption patterns, identify areas for improvement, and track progress towards low-carbon goals.

Site Energy Saving By AI Algorithms: By analyzing data from various sources, such as energy consumption patterns, weather conditions, and occupancy rates, these algorithms identify opportunities for energy optimization and provide recommendations for site-specific energy-saving measures. This function empowers organizations to automate energy management processes, reduce energy waste, and achieve substantial energy saving.

PON Optical Path Visualization: This function offers organizations a comprehensive and visual representation of Passive Optical Network (PON) optical paths. This function leverages advanced visualization techniques to provide a clear and intuitive view of the optical network infrastructure, including optical splitters, connections, and signal paths.

Optical Cable Network Digitalization: This function leverages advanced technologies to facilitate efficient management of optical cables, including capabilities such as RFID group scanning, fiber connection check without loss, and accurate measurement of optical cable routing. By digitizing the optical cable network, organizations can improve inventory management, enhance maintenance efficiency, and optimize resource allocation.

Leveraging the above functions, including advanced analytics, AI algorithms, and visualization capabilities, operators can gain valuable insights, optimize energy usage, streamline network infrastructure and improve decision-making, ultimately driving sustainability growth and competitive advantage.

GNED is a transformative tool developed with multiple layers from physical, data, digital-twin, analytical and business application to accelerate the ICTs' journey towards Carbon Zero.

2. Establish Metrics to Measures

Network operators with their special environment would also benefit from having a set of metrics to measure energy efficiencies. With this in mind, Huawei has developed the following metrics on energy efficiency, which have been validated by a number of network operators:

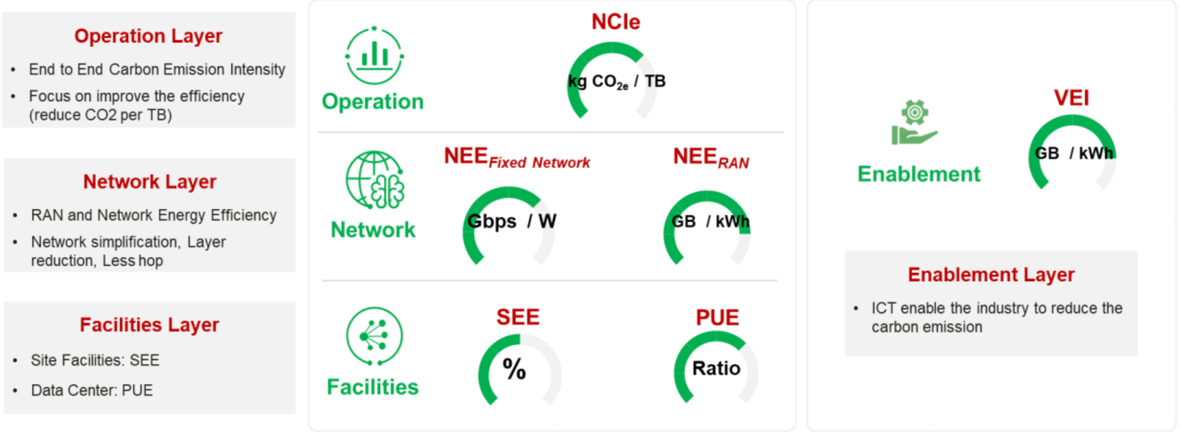


Figure 3. Energy Metrics on Green Management

Apart from the most common index absolute GHG Emission used to measure the environmental impact of network operators, Huawei has adopted multiple metrics to provide a comprehensive and holistic view for energy and sustainability management.

Facilities Layer: Site Energy Efficiency (SEE from ITU-T L.1350) and Power Usage Efficiency (PUE) are both consolidated index which captures multiple parameters available in network sites and data centers to measure the overall energy efficiency. This index indicates what proportion of total consumed energy is used for actual telecommunication equipment.

Network Layer: Network Energy Efficiency (NEE) for Fixed Network or Radio Access Network (RAN) measures the overall energy efficiency of the entire network. This index is incorporated with the data traffic volume, and also considers the network coverage and user experience. It is a sophisticated model designed to jointly optimize energy efficiency and network performance. It is now under development by ITU to finalize it as a standard.

Operation Layer: Network Carbon Intensity Energy (NCIe from ITU-T L.1333) is a new standard for measuring the environmental impact of ICT networks. NCIe is calculated as the amount of carbon dioxide emitted per unit of data traffic. It can be used to benchmark the environmental impact of ICT networks with network performance.

Environment Layer: Vertical Enablement Index (VEI, referencing the methodology from ITU-T L.1480) 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.

These metrics are embedded in the GNED, and it is introduced in detail in the whitepaper - Green Management, joint released by China Mobile and Huawei in Sep-2023[3].

3. Usage of GNED in Live Network Planning and Operations

GNED has been successfully deployed in actual environment to support energy management. Two use cases, one for Network Planning and one for Network Operations are provided below:

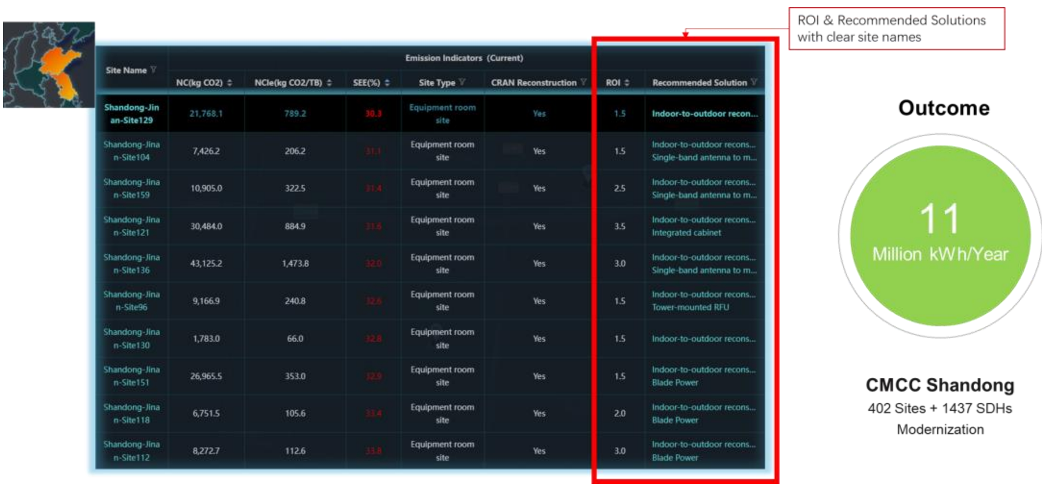
3.1 Network Planning Use Case

In the Operation S use case study, the application of GNED revealed a low level of energy efficiency due to the absence of renewable energy sources currently utilized in the region. The analysis indicated that the energy efficiency, measured by the SEE%, was below 40%. This highlighted the urgent need for modernization efforts in Operator S energy infrastructure.

To address this issue, GNED proposed solutions for modernization and predicted the return on investment (ROI). Digital Twins technology played a pivotal role in implementing these solutions, leveraging the power of two engines. The first engine focused on integrating renewable energy sources into the energy mix, allowing Operator S to harness clean and sustainable energy. The second engine focused on modernizing the existing digital equipment to improve energy efficiency and overall performance.

The main positive results of implementing GNED are twofold. Firstly, the modernization efforts facilitated by the system resulted in the deployment of advanced digital equipment, enhancing energy efficiency and overall system performance. This led to optimized resource utilization and improved operational effectiveness for Operator S. Another significant impact was the improvement in ROI. By deploying advanced digital equipment and optimizing resource utilization, Operator S was able to reduce electricity costs and enhance operational efficiency. These positive outcomes provided a solid foundation for creating a sound business case to demonstrate to management the financial benefits of the modernization initiative. The improved ROI showcased the value and potential profitability of investing in renewable energy sources, energy efficiency measures, and digital transformation, further reinforcing the importance of prioritizing modernization efforts in Operator S's energy sector.

As result, Operator S achieved a saving of 11 Million kWh/year after modernization of 402 mobile sites and 1437 SDH backhaul links recommended by the GNED.



Site Name	Emission Indicators (Current)						
	NC(kg CO2)	NCIe(kg CO2/TB)	SEE(%)	Site Type	CRAN Reconstruction	ROI	Recommended Solution
Shandong-Jinan-Site129	21,768.1	789.2	30.3	Equipment room site	Yes	1.5	Indoor-to-outdoor recon...
Shandong-Jinan-Site104	7,426.2	206.2	31.1	Equipment room site	Yes	1.5	Indoor-to-outdoor recons... Single-band antenna to m...
Shandong-Jinan-Site159	10,905.0	322.5	31.4	Equipment room site	Yes	2.5	Indoor-to-outdoor recons... Single-band antenna to m...
Shandong-Jinan-Site121	30,484.0	884.9	31.6	Equipment room site	Yes	3.5	Indoor-to-outdoor recons... Integrated cabinet
Shandong-Jinan-Site136	43,125.2	1,473.8	32.0	Equipment room site	Yes	3.0	Indoor-to-outdoor recons... Single-band antenna to m...
Shandong-Jinan-Site96	9,166.9	240.8	32.6	Equipment room site	Yes	1.5	Indoor-to-outdoor recons... Tower-mounted RFU
Shandong-Jinan-Site130	1,783.0	66.0	32.8	Equipment room site	Yes	1.5	Indoor-to-outdoor recons...
Shandong-Jinan-Site151	26,965.5	353.0	32.9	Equipment room site	Yes	1.5	Indoor-to-outdoor recons... Blade Power
Shandong-Jinan-Site118	6,751.5	105.6	33.4	Equipment room site	Yes	2.0	Indoor-to-outdoor recons... Blade Power
Shandong-Jinan-Site112	8,272.7	112.6	33.8	Equipment room site	Yes	3.0	Indoor-to-outdoor recons... Blade Power

Figure 4. Recommendations of Modernization Solution with ROI by GNED

3.2 Network Operations Use Case

Another use case in China for Operator C, GNED identified a situation where 5G stations experienced lower traffic during late-night hours, indicating reduced data usage and online activities by citizens. Despite this reduced demand, the stations continued to operate at a high-performing standard, resulting in energy wastage. This highlighted the need for urgent modernization efforts to address this energy inefficiency.

To tackle this issue, GNED proposed solutions that focused on energy-saving features and predicted the potential energy-saving outcomes. Digital Twins involved the installation of sensors to detect equipment usage and traffic at the 5G stations based on algorithms. If the traffic remained below a certain level, the sensors would automatically disable non-essential functions while keeping the core functions operational, thereby conserving energy usage.

The main positive result was reducing electricity costs. By deploying sensors and enabling energy-saving features, the stations were able to optimize their energy consumption based on the actual traffic demand. This led to significant cost savings by minimizing energy consumption during periods of low data usage.

Operator C achieved an OPEX Saving of 11.2 million RMB on its mobile network, saving approximately 14 million kWh of electricity across the 8,700 5G stations that implemented intelligent power saving in 2023.

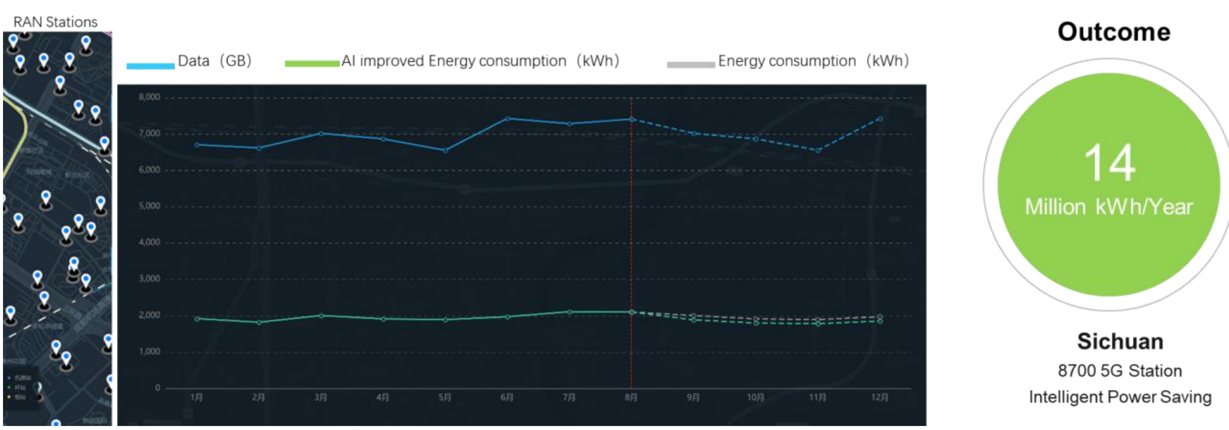


Figure 5. Energy Usage Data Recording by GNED

4. GNED using Open Architecture and Agile Methodology

When it comes to implementing AD (Agile Development) with OA (Open Architecture), there are several options:

- One approach is to use a **microservices architecture**, which is a type of Open Architecture that emphasizes small, independent components that communicate with each other through APIs.
- Another approach is to use a **service-oriented architecture**, which also emphasizes modular components but focuses more on the services that those components provide.

These two approaches can be a combination of microservices and service-oriented architecture. This allows for maximum flexibility and modularity, while also providing a clear delineation of services and components. In addition, GNED uses an API Gateway to connect with data layer. Figure 6 is a simple diagram on API Gateway.

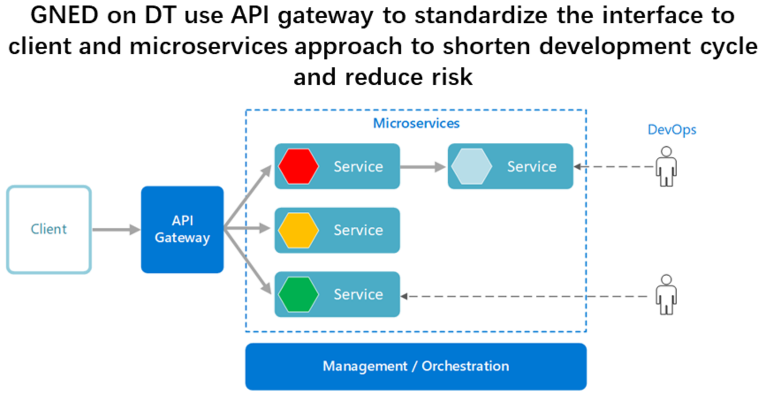


Figure 6. GNED Using API Gateway

Agile development and open architecture can work together to deliver a more efficient and effective development process. Figure 10 is the outcome on best practices for implementing Agile Development with Open Architecture.

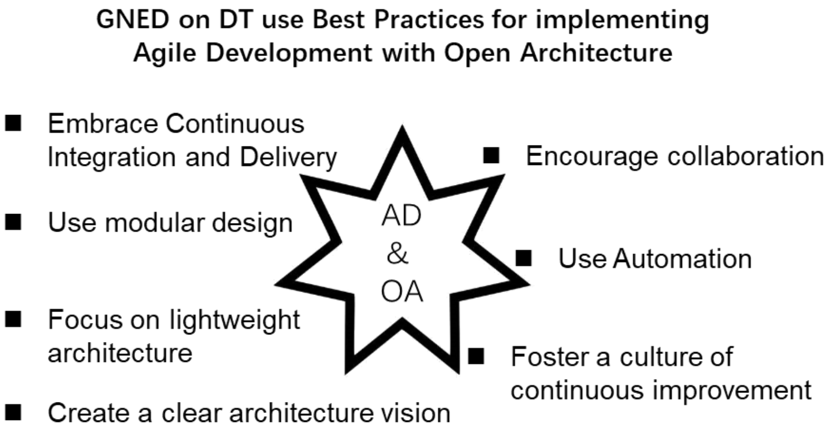


Figure 7. Benefits for GNED by AD & OA

5. GNED References TMF ODA

GNED also references the TM Forum ODA (Open Digital Architecture). For implementation, the GNED used API an open gateway to collect all energy sources. For the information system, GNED references TMF IG1307 and IG1310 Digital Twins for Decision Intelligent reference architecture to establish its core structure. For deployment, GNED references the AIOps TMF IG1190 suite. By using the AIOps operation framework, GNED can continuously develop new features for the Business layer. Figure 11 shows the relationship between GNED and TMF ODA.

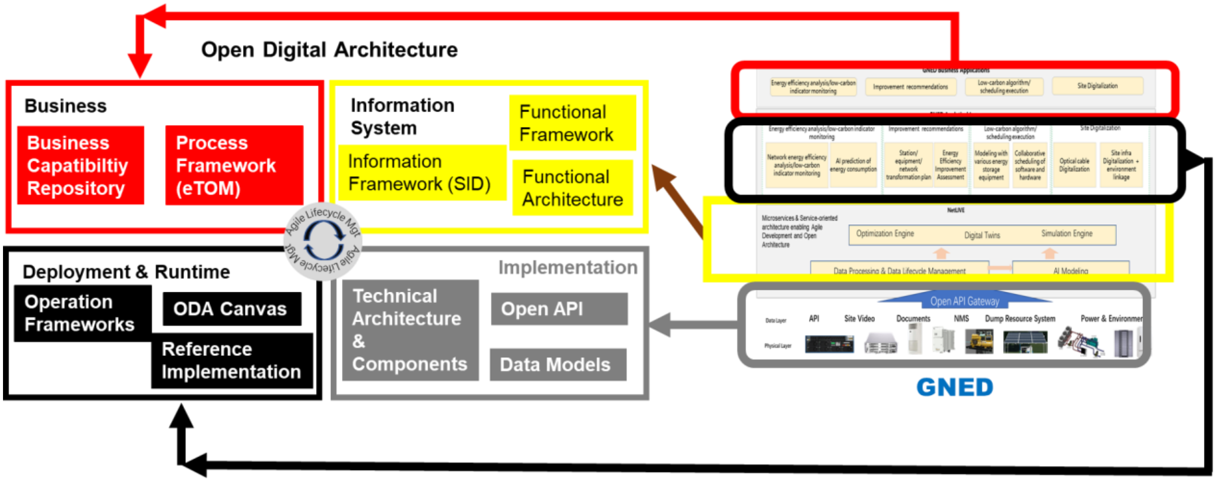


Figure 8. GNED References to TMF ODA Next Steps

6. Next Steps

Future development – GNED is continuing to roll out to network operators around the world, supporting the transition to Carbon Zero. In addition, GNED is already being used in enterprise sectors like mining and is rolling out to transportation and manufacturing.

Huawei is continuing to contribute to Carbon Zero initiatives and will announce future findings at GSMA and TMForum. But we don’t want to work alone. We would like to invite more network operators and enterprises to join us in adopting Carbon Zero projects and making a greener world for our next generation to live in.

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