Driving Energy Efficiency and Sustainability

Classification: Technical Outlook
Confidentiality: PUBLIC
Version 1
April 2025
[Driving EES]

Legal

Contents

List of Figures

List of Tables

Executive Summary

As the world rapidly evolves and AI continues to reshape societies and economies, the limitations of current digital infrastructure are becoming increasingly evident. Escalating demand, mounting environmental challenges, and uncertainties in global energy supply have rendered incremental upgrades to existing systems inadequate.

By 2030, the Innovative Optical Wireless Network Global Forum (IOWN Global Forum) envisions a more sustainable, energy-efficient, and data-centric infrastructure that minimizes environmental impact while maximizing reliability and performance. As a key activity to achieve this vision, IOWN Global Forum is spearheading the development of industry-wide metrics to evaluate and benchmark the energy efficiency of communication and computing infrastructures. These metrics will also enable the quantification of the impact of innovative solutions developed by forum members. By integrating photonics-based technologies and energy-saving strategies such as resource allocation, the Forum is paving the way for a sustainable, interconnected world.

In response to these challenges and in pursuit of its 2030 vision, the Forum is spearheading the shift from electronics-based to photonics-based systems by redesigning global infrastructure with a focus on energy-efficient systems that minimize the power consumption of computing and networking operations. The IOWN Global Forum is at the forefront of this transformation, driving the transition from electronics-based systems to photonics-based systems. Breakthrough innovations such as all-photonics networks and optical disaggregated computing, powered by Photonics-Electronics Convergence hardware, promise major advances to revolutionize data centers, delivering substantial advancements in both energy efficiency and overall performance.

1. Introduction

Increasing demand for high-performance communication networks highlights the need to address energy consumption efficiency and sustainability in a holistic manner. Although metrics exist for individual network components, a comprehensive and standardized metric that spans multiple layers—such as compute, packet, and optical layers—is currently lacking. This initiative seeks to close this gap by developing a unified metric that facilitates quantifiable and measurable improvements in energy efficiency across the IOWN Global Forum ecosystem.

The document outlines the current strategies that leverage Data-Centric Infrastructure and Open All-Photonics Network for energy efficiency and sustainability projects, as well as the initiatives within the IOWN Global Forum. It highlights the challenges in these areas and presents approaches aimed at addressing them effectively.

1.1. Purpose

The purpose of this document is to introduce the Energy Efficiency and Sustainability project in the IOWN Global Forum. This project will undertake various activities, including studying and documenting the Standards Development Organizations (SDOs) for metrics, defining and documenting Proof of Concepts (POCs), and establishing a framework for energy efficiency and sustainability metrics across the IOWN Global Forum ecosystem.

1.2. Scope of Work

Technological advancements and their associated environmental impacts necessitate innovative solutions for sustainable growth. To evaluate the progress and impact of infrastructure technologies through Proof of Concepts, this initiative seeks to quantify energy efficiency in both the compute and network layers while fostering integration across traditionally siloed layers. Energy efficiency and sustainability efforts of member companies of the IOWN Global Forum cover the entire lifecycle of the infrastructure from resource consumption during production and deployment, through resource and energy consumption as well as emissions during operation, to repair, reuse, and recycling at the end of its life span. While all these factors significantly impact the cost and environmental footprint of Forum members, this initial effort focuses on energy efficiency and emissions during the operation of infrastructures. Although this phase does not include a life cycle analysis of products, such an analysis may be explored in future phases.

The scope of this initiative focuses on creating a holistic framework to measure and enhance energy efficiency across compute and network layers, ensuring sustainable progress.

- Developing methods to quantify energy efficiency for the IOWN Global Forum for compute and network layers.
- Investigating the complexities of optimizing energy consumption across the entire communication system in a holistic manner.
- Driving progress in energy efficiency and sustainability by establishing clear metrics for compute and network layers.

1.3. Objectives

The objectives of this initiative are focused on defining and implementing strategies to measure, evaluate, and improve energy efficiency and sustainability within the IOWN Global Forum ecosystem through collaboration with Standards Development Organizations (SDOs) and other relevant fora.

- Establish Unified Metrics: Develop standardized and comprehensive metrics to consistently measure energy efficiency across the compute, packet, and optical layers of network application in all Proof of Concepts (POCs).

- System-Wide Optimization: Drive quantifiable and measurable progress in energy efficiency by fostering integration and collaboration across traditionally siloed layers, including compute and network systems, including point to multi-point/point-to-point reconfigurations, hibernation approaches, study of protocol efficiencies.
- Holistic Optimization Approach: Advocate for an academically grounded and integrated approach to energy efficiency by ensuring that interventions in one area of the network do not inadvertently offset gains by increasing energy consumption elsewhere. This approach reflects a systems-thinking methodology encouraging a net-positive outcome that accounts for the interdependencies between traditionally siloed layers, such as compute and network systems.
- Actionable Insights and Practices: Utilize data-driven insights and implement sustainable practices to enhance energy efficiency and drive impactful improvements across the IOWN Global Forum ecosystem based on the documented PoC results and reports.

1.3.1. Upcoming Deliverables

- **Metric Framework document:** A detailed, comprehensive framework for measuring energy efficiency across all layers of the IOWN Global Forum ecosystem, based on an in-depth analysis of various pertinent SDO and for available documents.
- **Implementation Guidelines:** Recommendations and methodologies for applying the metric consistently in all Forum Recognized POCs.
- **Energy Efficiency Assessment Reports:** Consolidated findings and evaluations for each POC, demonstrating measurable progress in energy efficiency.
- **Integration Methodologies:** Tools and best practices for fostering cross-layer collaboration and improving system-wide energy consumption.

1.4. Service Provider's statements

The International Energy Agency (IEA) predicts that data centers' total electricity consumption could reach 1,000 TWh by 2026. Most data centers are typically located near urban areas and require large physical sites to house thousands of servers. These centers play a crucial role in handling massive data loads and providing high-performance computing services. However, they also present significant challenges regarding energy consumption and carbon emissions. The following statements are listed from service providers in alphabetical order.

BT Group [1, 2]
BT Group consumes nearly 1% of the UK's electricity, making energy efficiency a critical priority. As a leader in climate action for over 30 years, BT launched the BT Group Manifesto in December 2021 to promote responsible and sustainable growth. The company has already transitioned to 100% renewable electricity worldwide and is working to electrify its fleet by 2030. BT is also

innovating with digital twin technology and exploring new materials to enhance energy efficiency, reduce heat generation, and support the circular economy.

Chunghwa Telecom [3]
Chunghwa Telecom (CHT) is committed to global ESG(Environment, Social, Governance) practices and aims to achieve net-zero carbon emissions by 2045. By adopting the IOWN All-Photonics Network and data-centric infrastructure, CHT plan to support the use of distributed data centers. These smaller, localized centers maximize the use of green energy sources, reducing strain on the electricity grid and minimizing carbon emissions.

Google Cloud [4]
Google's 2023 Environmental Report emphasizes sustainability as a core pillar of its cloud infrastructure strategy [4].

IBM Cloud [5]
Read about IBM's commitment to environmental, social, and governance in their 2023 ESG Report "IBM Impact" [5].

KDDI [6]
KDDI is currently promoting its environmental conservation plan, the KDDI GREEN PLAN [6]. Toward decarbonized society, KDDI group has committed to achieve net zero emissions (Greenhouse Gas protocol's scope 1, 2, and 3) by the end of fiscal 2040. In the short term, KDDI achieves 100% of the effective renewable energy ratio for electricity used in KDDI data centers around the world by fiscal 2025.

Microsoft Azure [7]
Learn about Microsoft's "GREEN PLAN" and their commitment to achieving net-zero emissions by 2040 [7].

NTT [8]
In 2021, NTT unveiled its environmental and energy vision, "NTT Green Innovation toward 2040," to achieve carbon neutrality by 2040 [8]. The company plans to reduce greenhouse gas emissions to virtually zero, with 45% of the reduction achieved through IOWN technologies. This initiative highlights NTT's commitment to environmental sustainability both in Japan and globally.

Oracle Cloud Infrastructure [9, 10, 11]
Beyond its inherent business benefits, the cloud offers a more sustainable alternative for companies looking to minimize their environmental impact [9]. Oracle manages and maintains a very dense computing environment, attaining much higher utilization rates than an organization can achieve with an on-premises system. OCI provides an elastic computing platform that can grow dynamically with an organization as needed, eliminating excess capacity builds to meet future demand. Oracle Cloud further reduces its environmental footprint by leveraging state-of-the-art cooling and energy efficiency technologies at our green data centers. For example, in

Europe, Oracle Cloud data centers are powered using 100% renewable energy [11]. Our goal is to achieve 100% renewable energy use in all our OCI data centers by 2025.

Orange Group [12]
Orange Group, which operates networks in 26 countries across Europe, the Middle East, and Africa, has committed to achieving net-zero carbon emissions by 2040 [12]. This ambitious goal includes reducing greenhouse gas emissions (Scope 1, 2, and 3, as defined by the Greenhouse Gas Protocol). By leveraging innovative technologies and sustainable practices, Orange is driving significant environmental progress.

2. Ongoing Related Work in the Forum

Member companies of the IOWN Global Forum are already working on the following topics that aim at improving energy efficiency and sustainability.

- Co-Package Optics device hardware implementation.
- Photonics-Electric Convergence hardware implementation.
- All-Photonics Network deployment eliminating many electric devices.
- Elastic Load Balancing (ELB) to optimize resource allocation in Fronthaul (FH) and Radio Access Networks (RAN) and enhance power saving operation.
- Impact study of Hollow Core Fiber.
- Energy consumption Efficiency aware network path optimization in all-photonics network paths.
- Reconfigurable PtP/PtMP optical network access.
- Hibernation of network element equipment in Packet and All-Photonics Network layer.
- Energy consumption Efficiency aware data-centric infrastructure selection to deploy cloud native applications including Packet and All-Photonics Network layer.
- Hibernation of CPU related states based on the CPU load in statistical bare metal compute nodes.
- Dynamic composability of CPU host and PCIe devices (GPU/DPU/IPU/NVMe/CXLmem/etc) in a timely manner to avoid over-provisioning of compute and device resources by Composable Disaggregated Infrastructure technology.
- Remote GPU Service for AI inference over light speed RDMA for Sensor Data Aggregation and Ingestion in CPS use cases.
- Green Computing with Remote GPU Service for Generative AI / LLM.

3. Gap analysis

The IOWN Global Forum has identified several critical gaps in current energy management and optimization practices within network infrastructures. Existing energy consumption evaluation methodologies suffer from a critical limitation: the lack of a unified metric spanning the compute, packet, and photonics network layers. Each layer has its own energy consumption indicators, but there is no comprehensive end-to-end metric integrating these layers. As shown in the following figure, the core challenge lies in the lack of a unified energy efficiency metric encompassing the compute, packet, and all-photonics network layers. Current methodologies remain siloed, focusing on individual layers, which results in fragmented assessments and hinders holistic energy optimization across the communication system. For instance, in the 5G/6G era, GPUaaS for RAN and AI can be implemented as a feature of Data-Centric Infrastructure as a Service and is capable of monitoring the CPU and GPU power usage of container workloads, but there is no solution to monitor the power usage of networks connecting workloads, such as Mobile Front haul.

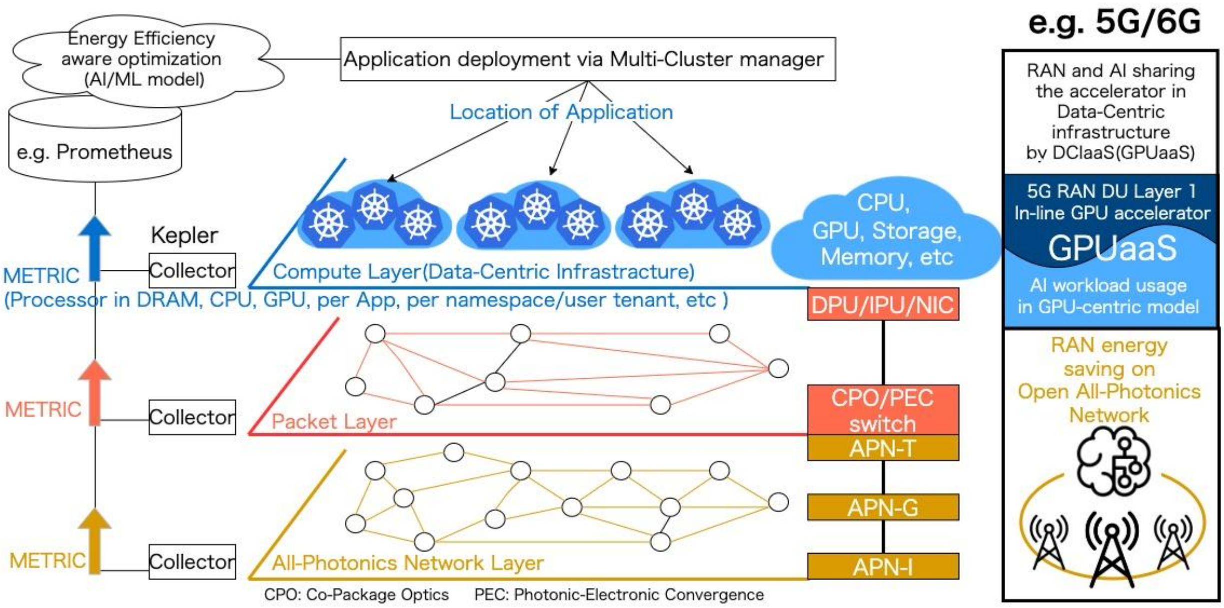

Figure 1: Real-time multi-layer metric reporting

This fragmentation obstructs efforts to accurately quantify and optimize the overall energy consumption efficiency of data center and network operations, as seen in the following examples:

- **Cloud-native computing environments, such as Data-Centric Infrastructure:** Kepler (Kubernetes-based Efficient Power Level Exporter) [13] has been listed in the Cloud Native Sustainability Landscape [14] for power monitoring in cloud-native environments. Before Kepler, data centers monitored energy consumption using utility power meters, smart PDUs, and UPS systems. Server-level energy usage was tracked via IPMI, Intel RAPL, and virtualization tools like VMware vSphere. Software tools such as Linux's powertop and turbostat provided per-server insights, while metrics like PUE, CLF, and WUE measured efficiency. However, traditional methods struggled to effectively monitor energy consumption in containerized workloads, making energy tracking complex and inefficient. Kepler addressed this challenge by using eBPF tracing and machine learning to estimate power consumption at the workload level, integrating with Prometheus and OpenTelemetry for real-time monitoring. By attributing power consumption to individual services, Kepler improves the efficiency of cloud-native application deployments in green data centers. This has streamlined power management in Kubernetes environments, improving data center efficiency. However, Kepler currently focuses only on the physical compute layer, overlooking the energy impact of network infrastructure and non-software-defined storage components, such as high-efficiency packet processing, photonics network, and SANs. These elements are critical for service delivery and significantly influence overall energy efficiency.

- **Packet networks:** Energy consumption increases with traffic volume, as the number of packets received and routed grows. Consequently, the power required to operate these switches increases significantly. Packet-based networks provide energy consumption data to Network Management Systems (NMS) using hardware telemetry, SNMP, NETCONF/YANG, and AI-driven analytics. Devices like smart routers, PoE switches, and NICs report real-time power usage, while SNMP MIBs (e.g., ENTITY-SENSOR-MIB) and Cisco EnergyWise enable monitoring. IEEE 802.3az (Energy-Efficient Ethernet) and Green Ethernet optimize power during low traffic. sFlow and IPFIX analyze network traffic for energy efficiency insights. AI-driven cloud-based NMS solutions (e.g., Cisco DNA Center) further optimize power use, helping reduce costs and improve sustainability in modern networks by dynamically adjusting energy consumption based on real-time traffic patterns. Packet-based network energy monitoring faces several challenges. Limited accuracy in SNMP and telemetry makes precise tracking difficult. Device incompatibility arises as older hardware lacks power monitoring, and proprietary protocols hinder interoperability. High overhead due to frequent polling, increasing CPU and bandwidth load occurs. Lack of predictive control means most systems react to inefficiencies rather than prevent them, as AI-driven optimizations require significant data processing, which not all networks can support efficiently.
- **Optical networks, such as All-Photonics Network:** Energy consumption is typically measured by the energy required to transmit a single bit. While this metric is useful for comparing optical transmission systems, it often fails to account for the actual power consumed in delivering services. Optical transceivers generally operate at full data rates regardless of the actual throughput, making energy consumption more dependent on network design rather than service-specific requirements.

The following table summarizes the identified gaps, their implications, and proposed solutions.

Table 1: Identified Gaps

Item	Description
Standards Development Organizations (SDO) aspects	There is currently a lack of support for energy usage reporting in virtualization environments, inaccurate energy measurement capabilities, and inconsistent reporting standards across regions and organizations. To address these issues, enabling communication service providers (CSPs) to report energy usage per tenant, breaking down energy consumption data to equivalent CO_2 (eCO_2) levels per region/geography, and standardizing reporting metrics are essential steps. A dedicated study is proposed as a proof of concept (POC) to explore these solutions. A dedicated study is proposed by the member companies where the available standards and relevant materials from various fora will be assessed and tested with the challenges listed above.
Monitoring aspects	Current energy measurements are rough and lack precision, as well as support for virtualized environments, limiting the ability to make accurate, data-driven decisions. While the computing layer has a solution, the absence of real-time data collection at the network layers further exacerbates this issue. Enhancing the accuracy and granularity of energy measurements, enabling real-time monitoring capabilities, and supporting better decision-making with detailed insights are key priorities. This will also be explored through fiber sensing laboratory initiatives.
Multi-layered aspects	The existing network communication forwarding approach typically relies on hop-by-hop forwarding, and the analysis lacks integrated energy calculations for entire paths. Consequently, there is limited control over energy consumption across layers. By allowing operators to manage the network layers and computing layers more effectively, enabling energy-efficient routing, and improving overall path optimization, energy consumption can be minimized, thereby enhancing network energy efficiency as well as the computing environment, such as data centers. A modeling study has been proposed to validate these improvements.

Item	Description
Reporting aspects	There is no unified reporting method for energy consumption data, a lack of historical data comparison capabilities, and inconsistent units of measurement across different network layers and systems. Establishing a unified method to represent energy consumption parameters and standardizing units of measurement are critical steps toward improving reporting transparency and consistency, as well as enabling historical comparisons. This is a multi-layered issue. Unless the multiple layers are addressed, the problem cannot be resolved.
Hibernation aspects	There is a lack of capability to implement energy-saving hibernation techniques and insufficient data to make energy-saving decisions leading to high energy consumption even during idle states. Introducing methods to save energy based on elastic networking principles, reducing idle period energy usage, and automating the hibernation process are proposed solutions. These are being investigated through modeling studies. The hardware cannot transition into a lower power-consuming state; instead, it must be completely switched off. Additionally, in composable disaggregated infrastructure, such as a data-centric infrastructure subsystem, it must release compute resources. Furthermore, greater composability at the computing layer is also needed. This necessitates a dynamic and elastic load-balancing approach, where the network intelligently redirects traffic to active resources while others remain powered down.
Point-to-Multipoint aspects	Current optical transport system infrastructures lack an agile, dynamic setup of Point-to-Point (PtP) / Point-to-MultiPoints (PtMP) reconfiguration capabilities for energy management. This gap is being explored through modeling and laboratory studies. An example of an expected optical transport system is PtP / PtMP reconfigurable system which can change its mode from PtP to PtMP according to the traffic requirement. The system not only can reduce power consumption by changing the mode but also can reduce the number of APN-Ts by the sharing of data center side APN-Ts which lead to the power and cost reduction.

Addressing these gaps will enable and improve energy management practices, improve transparency, and drive greater energy efficiency across network infrastructures, ultimately contributing to a more sustainable industry.

4. Approach

To address the identified gaps related to energy consumption efficiency within network infrastructures, the IOWN Global Forum proposes a holistic and innovative approach. This approach focuses on dynamic resource control, improved observability, and energy efficiency-aware optimization strategies tailored to the unique demands of modern network and computing environments.

4.1. Enhanced Observability and Real-time Monitoring

The proposed approach includes leveraging robust observability tools that provide real-time insights into power consumption and energy efficiency metrics, because optimizing power consumption requires a comprehensive view of energy usage across computing and all-photonics network infrastructures.

- Observability Tools for All-Photonics Networks: These tools enable detailed monitoring of energy consumption within all-photonics network environments, offering operators actionable insights to make data-driven optimizations. This includes visualizing power usage patterns, detecting inefficiencies, and recommending adjustments based on predictive analytics.
- Observability Tools for cloud-native computing in data-centric infrastructure: Existing de-facto power consumption monitoring tools for user tenants and container applications in computing environments, such as Kepler, should be adapted to maintain a broad ecosystem within the open-source user space.
- Integrated Data Collection and Analysis: By integrating data collection across multiple layers, from computer to network, the approach allows for holistic energy efficiency assessments. This integrated view ensures that all components of the network ecosystem are considered in energy usage optimization strategies.

4.2. Energy-Efficiency-Aware Computing and Network Systems

Achieving energy efficiency across compute and network systems requires an end-to-end optimization framework that dynamically adapts automation based on energy consumption patterns. This approach integrates advanced techniques such as dynamic compute resource allocation, network path reconfiguration, and the deployment of low-energy hardware:

- **Adoption of All-Photonics Network system**
  Integrating photonics-based systems into network infrastructures significantly improves energy efficiency and data transmission speed. The Forum will evaluate and document optimized configurations of all-photonics environments to maximize their sustainability impact, highlighting their potential to reduce overall energy usage.

- **Adoption of Dynamic Resource Control for Energy Optimization**
  Traditional compute and network systems based on Commercial Off-The-Shelf (COTS) hardware and electric device-oriented wide-area networks (WANs) are typically designed to handle aggregated peak load demands. This approach often results in over-provisioning, leading to excessive power consumption during periods of lower demand. To overcome this inefficiency, member companies of the Forum conduct research to identify dynamic resource control mechanisms that optimize energy consumption based on real-time workload and traffic conditions. This approach involves dynamic compute resource allocation leveraging an optical disaggregated architecture, APN-C (SDN controller), a multi-cluster manager, and Kubernetes controllers developed under the Cloud Native Computing Foundation (CNCF). Furthermore, energy-efficiency-aware dynamic resource allocation is implemented within data-centric infrastructures, including energy-efficient path selection. This ensures that computing resources are provisioned and utilized based on actual demand, while connectivity over the APN is dynamically adjusted to minimize energy consumption and improve overall operational efficiency.
- **Research on Predictive AI and Deterministic Networking**
  Combining predictive analytics with deterministic networking enables precise energy optimization across compute and network resources. This unified approach ensures that improvements in energy efficiency are achieved without compromising performance, paving the way for smarter and more sustainable operations. However, further research is needed.

4.3. Collaborative Development and Standardization

To ensure widespread adoption and effective implementation, the proposed solutions will involve collaboration with industry stakeholders, including standards development organizations (SDOs), network operators, and technology providers. This collaboration aims to standardize energy efficiency metrics, develop well-supported methodologies, and foster the adoption of best practices.

By integrating these innovative strategies, the IOWN Global Forum seeks to create a more sustainable, energy-efficient network and computing infrastructure that minimizes environmental impact while meeting the performance demands of modern digital services. This approach addresses the limitations of traditional systems, leverages advanced photonics technologies, and empowers network operators to optimize energy consumption on an end-to-end basis.

5. Value Proposition

The value proposition of the IOWN Global Forum, listed in Table 2, centers on transforming network infrastructures to achieve unparalleled energy efficiency, sustainability, and operational optimization. By addressing critical gaps and adapting advanced energy management solutions, the approach delivers value not only for operators, but also for tech providers and industry stakeholders, giving all involved parties a motivation to drive its implementation forward. The forum's initiatives enable actionable insights, dynamic resource control mechanisms, and real-time energy observability to reduce energy consumption, lower carbon footprints, and meet evolving regulatory and environmental standards.

Table 2: Value Proposition

Vector	Value
SDO	• CSP to be able to report energy usage per tenant • Break down to eCO2 level per region/geography • Standardize reporting metrics
PtP/PtMP	• Manner to dynamically optimize path usage (In PtP/PtMP, path correspond to mode and speed) • Improvement of network resource utilization ratio • Optimal latency for data transmission
Multi-layered hibernation	• Simple manner to save energy based on elastic networking principle • Reduce energy usage during idle times (C/P state, etc.) • Automate hibernation process
Multi-layered optimization	• Allow choice to manage layers effectively • Enable energy-efficient routing • Improve overall path optimization
Real-time reporting of multi-layer metrics	• Unified method to represent energy consumption parameters • Improve accuracy and granularity of measurements • Standardize units of measurement
Compute host composability	• Data-Centric Infrastructure supports the composable disaggregated infrastructure function to increase high energy efficiency operation.
Monitoring and visualization	• Monitoring of environment with fiber sensing technology for DC facility management • Allow comparisons over time of measurements of data center • Support better decision-making with detailed insights

The EES initiative recognizes the accelerating energy demands driven by the rapid growth of hyper-scalers and cloud providers, spurred by global AI consumption. While the initiative acknowledges that drastic net reductions in compute infrastructure energy consumption are unlikely in the near term, it will focus on strategies to significantly reduce the rate of energy growth. Through architectural optimization and informed equipment choices, the forum aims to achieve measurable efficiency gains. However, it is also recognized that efficiency alone is not sufficient—this effort will be coupled with clear accountability mechanisms to ensure that improvements are both transparent and impactful.

6. Conclusion

The IOWN Global Forum's Energy Efficiency and Sustainability (EES) initiative focuses on addressing specific challenges in optimizing energy consumption across telecommunications networks. The EES initiative recognizes the accelerating energy demand driven by the rapid growth of hyper-scalers and cloud providers. While net reductions in compute infrastructure energy consumption may not be feasible in the near term, the initiative is focused on strategies to significantly reduce the rate of energy growth.

By developing unified metrics that span compute, packet, and optical layers, the initiative aims to provide network operators with practical tools to measure and reduce energy usage. These efforts are supported by targeted strategies such as dynamic resource allocation, energy-aware optimization frameworks, and enhanced observability tools.

A key component of the EES initiative is collaboration with Standards Development Organizations (SDOs) and industry stakeholders to ensure consistent methodologies and best practices. This includes establishing standardized reporting metrics, integrating real-time monitoring systems, and promoting energy-efficient technologies like all-photonics networks. The initiative also explores practical applications, such as network element hibernation and dynamic routing, to minimize energy consumption without compromising performance.

Through these focused activities, the IOWN Global Forum is building a framework that directly addresses the operational and environmental challenges faced by network operators. By prioritizing measurable outcomes, cross-layer coordination, and real-world applicability, the EES initiative supports the transition toward more energy-efficient, sustainable telecommunications infrastructures.

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Abbreviations and acronyms

AI	Artificial Intelligence
CLF	Cooling Load Rate
CPS	Cyber-Physical System
CXL	Compute Express Link
CUE	Carbon Usage Effectiveness
DPU	Data Processing Unit
eBPF	extended Berkeley Packet Filter
GPU	Graphics Processing Unit
IPMI	Intelligent Platform Management Interface
IPU	Infrastructure Processing Unit
Kepler	Kubernetes-based Efficient Power Level Exporter (a Prometheus exporter)
LLM	Large language Models
MIB	Management Information Base
NIC	Network Interface Card
NVMe	Non-Volatile Memory Express
NETCONF	Network Configuration Protocol
PDU	Power Distribution Unit
PtP	Point to Point
PtMP	Point to MultiPoint
PUE	Power Usage Effectiveness
RAPL	Running Average Power Limit
SAN	Storage Area Network
SNMP	Simple Network Management Protocol
YANG	Yet Another Next Generation
UPS	Uninterruptible Power Supply
WUE	Water Usage Effectiveness

Acknowledgments

This Reference Document was jointly prepared by the Technical and Use Case working group on the IOWN Global Forum under the direction of Masahisa Kawashima (Technical WG Chair) and Katsutoshi Ito (Use Case WG Chair).

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History

Revision	Release Date	Summary of Changes
1	April 2025	Initial Release