

Silicon, Systems, and Operations: **A practical framework for sustainable** **technology adoption in telecoms**



This brief presents a framework to help operators drive tangible sustainability outcomes in their next phase of networking



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Industry context

- Sustainability has become a strategic theme for the telecoms industry, with approximately 73% of Tier-1 and Tier-2 operators having committed to net zero between 2040 and 2050.¹
- As operators progress to the next-phase of networking, systematically integrating sustainability into network operations is necessary, especially as the simpler, “low-hanging fruit” initiatives have been implemented.
- At the same time, regulatory bodies are intensifying their scrutiny of net-zero efforts, tightening legislation, and refining definitions of what true net-zero involves.
- To maximize the impact of both current and future initiatives, operators need a holistic approach that fully integrates sustainability across network architecture, design and operations.
- Achieving this requires an end-to-end framework that embeds sustainability throughout all aspects of networking, supporting incremental gains and lasting improvements.
- Therefore, the question facing the industry:

How can operators adopt a comprehensive approach to network sustainability today, that incorporates meaningful initiatives which will set them up for success in the next phase of networking?

Document scope

This brief guides telecom operators in adopting a comprehensive sustainability approach in their networking journey

- Juniper Network’s end-to-end framework extends sustainability through integrated innovations, enabling meaningful and lasting impact beyond combined isolated efforts.
- This framework identifies actionable sustainability initiatives to implement across three key networking elements: Silicon, Systems, and Operations.
- In collaboration with Juniper Networks, we have evaluated how Juniper’s solutions map to this framework and provided insights into how network operators can benefit from these sustainability initiatives.

This brief is supported by primary and secondary research insights, including interviews with telecoms operators and technology experts.



Telecoms operators



Technology experts

To reach net zero, operators must adopt a comprehensive sustainability approach to networking

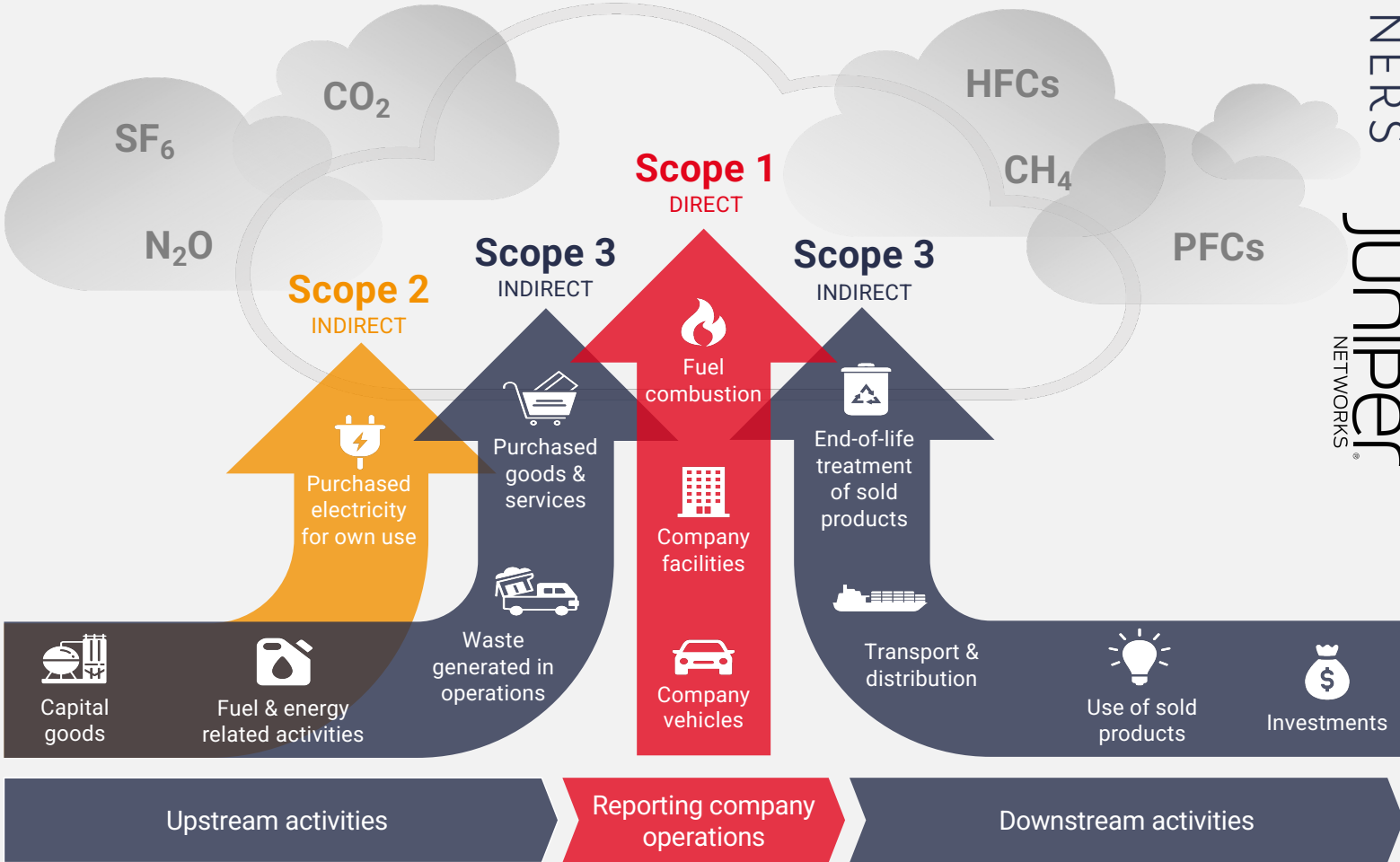
Market insight

The telecom industry faces a dual challenge: managing the explosive growth in data traffic while reducing environmental impact. With annual traffic growth rates ranging between 20% and 40%, driven by increasingly data-intensive applications, operators must grapple with the rising energy demands required to sustain this expansion. Without intervention, the energy required to power telecom networks risks undermining global net-zero goals.

Progress is being made. Between 2019 and 2022, the [GSMA](#) reported that global internet traffic more than doubled, yet the telecom industry achieved a 6% reduction in Scope 1 and 2 operational emissions, owing to initial sustainability quick wins like legacy network upgrades, simple energy-saving optimizations, and greater use of renewable energy.

However, these steps are only the beginning. Meeting the industry's ambitious net-zero targets will require a significant shift from incremental improvements to a comprehensive, holistic sustainability approach that ensures emissions do not scale with traffic growth. Operators must seek to implement advanced, integrated initiatives that address all facets of their networks simultaneously.

Figure 1: Classification of greenhouse gas emissions



Operators must adopt an end-to-end framework to embed sustainability holistically across key networking elements

To adopt a comprehensive, end-to-end approach, operators must evaluate their sustainability efforts across three key networking elements: Silicon, Systems, and Operations.



SILICON

Prioritizing sustainability in foundational components like next-generation silicon chipsets and optics enables:

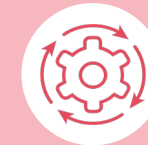
- **More capabilities, more efficiently:** Network efficiency improvements must outpace network capacity demands to drive reductions in Scope 3
- **Optimized energy consumption:** Purpose-built silicon optimises performance and power use to reduce Scope 2 emissions
- **Minimized physical footprint:** Greater space efficiency cuts maintenance costs (Scope 1 and 2) by reducing the number of components needing upkeep, while lowering the need for supporting infrastructure e.g., cooling systems



SYSTEMS

Embedding sustainability in network architecture and design (e.g. through convergence or modular design) offers:

- **Align capacity with demand for greater efficiency:** Enabling operators to dynamically power devices on or off based on demand, reducing Scope 2
- **Greater resource efficiency:** Streamlined system design reduces resource duplications, reducing Scope 2 emissions
- **Thermal optimized designs:** innovative system design, IC placement, power supply efficiency, & fan use provides power savings, reducing Scope 1 & Scope 3



OPERATIONS

Optimizing live network operations through software and platforms drives:

- **Improved power efficiency:** Dynamic, automated energy management lowers energy consumption, minimizing Scope 2 emissions
- **Minimized field intervention:** Proactive and centralized network operations reduces the need for repair call-outs, minimizing Scope 1 emissions
- **Extended network lifecycles:** modular systems designed for extended life spans reduces upgrade cycles (thus Scope 3)

Embedding sustainability across Silicon, Systems, and Operations allows operators to take a comprehensive approach to telecom networking. This integrated framework moves them beyond isolated efforts, enabling meaningful and lasting sustainability impact.



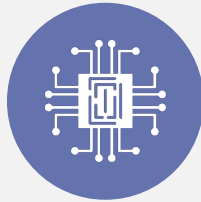
Built-for-purpose silicon and optical technologies offer significant sustainability advantages for networks

As telecom networks evolve to handle growing demands, advancing sustainability at the hardware level becomes crucial.

Purpose-built silicon, designed specifically for network platforms and use cases, offers significant efficiency advantages over general-purposes processors. Network Application Specific Integrated Circuit (ASICs) deliver optimized performance and power efficiency, enabling greater utilization for demanding workloads.

By prioritizing sustainable advancements in silicon components and optical solutions, operators can reduce energy consumption and lower emissions while delivering a scalable, future-ready network architecture.

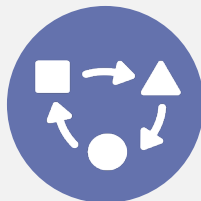
Key sustainability initiatives in advanced silicon and optics include:



Next-generation silicon chipsets: 7nm technology network processors deliver better power efficiency, faster switching performance, and higher density. Enabling the delivery of higher throughput machines with greater power and space efficiency, reducing Scope 2 & 3 emissions.



Upgrading optics: New coherent optics enable IPoDWDM architectures, the convergence of optical transport with routing, dramatically reducing the power, space, and carbon footprint of legacy architectures. The modularity of pluggables means that equipment life can be extended thereby reducing Scope 3 emissions.



Adaptive component design: Advanced chipsets use modular functionality to optimize energy consumption. While multiple functions are integrated onto a single system-on-a-chip (SoC), unused components can be put into sleep mode, reducing energy consumption (Scope 2 emissions) without shutting down the entire chip.



By consolidating systems, we're able to meet new demands without having to build out expensive new facilities with high footprint.

Technology Centre – Senior Solution Architect, Tier 1 EMEA operator

Operators must fully understand and test if their silicon achieves targeted efficiency and performance. With the rise of workload-specific chipsets, operators must evaluate their silicon selection according to the need at hand. These must strike the balance between flexibility (e.g., running cloud-native applications which provides flexibility and scalability into the future) and specificity (e.g. data plane functions). Only testing will prove this out.



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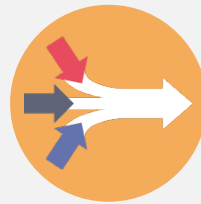
Sustainable-by-design systems can empower efficient deployment, maintenance and upgrade, improving lifecycle sustainability

Building sustainability by design within network systems, architectures and infrastructure is essential for a future-proof and resilient network.

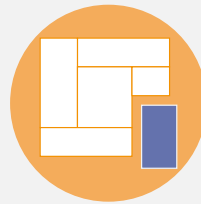
"Systems" encompasses the architectural and design components of network resources, such as power supplies, chassis, and shelving across mobile, fixed, and enterprise networks.

More modern and sustainable system design improves flexibility and scalability, simplifying operations to meet evolving demands efficiently, whilst also facilitating easy recycling or reuse of components to reduce environmental impact.

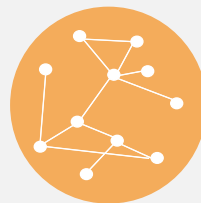
Key sustainability initiatives in systems include:



Converged architectures: Network and service convergence unlocks greater resource sharing. Shared infrastructures reduces the need to maintain separate networks, reducing Scope 1 emissions. Additionally, consolidating network traffic and devices lowers Scope 2 and 3 emissions, respectively.



Fixed and modular designs: A portfolio of fixed and modular platform solutions provide greater versatility for scale-up and scale-out architectures, which benefit sustainability initiatives. Modular platform design for both options enables component-level replacements for greater longevity & fewer renewals to reduce embedded carbon and Scope 3 emissions.



Metro fabric architectures: The extent to which traffic from client to service is generated at the network edge directly correlates with network emissions. Edge deployments enables more local workload processing, reducing the energy and resources (e.g. in cooling) associated with sending traffic to the core.



Modular chassis with more capacity to expand by adding individual line cards is helpful. This provides cost, space and energy efficiency.

Associate Fellow, Tier-1 operator, NAM



While network convergence was not driven by sustainability, we have seen benefits. Our preference is to continue – fewer layers, less complexity and number of devices so lower consumption and embedded carbon.

SVP, Head of Network Architecture, Tier-1 EMEA operator



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Operators can optimise and automate network operations to simplify resource management and reduce energy consumption

Optimizing network operations enables operators to dynamically reduce energy consumption and minimize the need for field interventions.

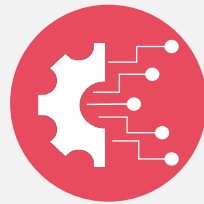
While silicon and systems drive foundational efficiencies, operators must also focus on optimizing in-life network operations to maximize overall sustainability gains at scale.

By adopting software and platforms that leverage A3 (automation, analytics and AI), operators can achieve direct real-time sustainability impact from adaptive resource management and optimized network management.

Key sustainability initiatives in operations include:



A3* energy reporting & optimization tools: A3 can enable intelligent energy saving by analyzing traffic patterns to inform or trigger sustainable actions. For example, device modules (e.g. ports, packet forwarding engines, silicon components) can be dynamically placed in energy saving mode, reducing Scope 2 emissions.



Predictive maintenance: Analytics tools enable proactive network management, by predicting faults before they occur, allowing for preventative action and reducing the need for extensive mitigation. They also enables more centralized maintenance, minimizing field interventions thus reducing Scope 1 emissions.



Energy-optimized routing: Operators can automate routing to prioritize the most sustainable path (e.g. with lower power devices and/or lower emissions energy supply) and redirect live traffic during network operations. This reduces Scope 2 emissions.



AI energy management systems pull data from the network to create closed-loop automation based on historical analytics, optimising thermal performance and reducing power consumption.

Senior Solution Architect, Tier-1 MENA operator



Any automation for remote troubleshooting is important for saving both costs and emissions, always trying to minimize dispatch vehicles.

- Associate Fellow, Tier-1 operator, NAM
























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JUNIPER
NETWORKS

STL has mapped Juniper Networks technology to the Silicon, Systems, and Operations (SSO) framework

Juniper has requested that STL Partners map some of its sustainable technology solutions to the framework, indicating the specific framework domains and each emission scopes each product addresses.

Juniper technology	 Silicon	 Systems	 Operations	Emission scope mitigated
Platforms	✓	✓	✓	 1  2  3
Juniper Paragon Automation	✓	✓	✓	 1  2  3
Juniper RAN Intelligent Controller (RIC)		✓	✓	 1  2  3
Juniper Energy Intelligence	✓	✓	✓	 1  2  3
Liquid Cooling	✓	✓		 1  2  3
Juniper Mist		✓	✓	 1  2  3



Juniper Networks® EX Series, MX Series, PTX Series, ACX Series and QFX Series



Solution overview

Juniper platforms include network switches and routers designed to provide high-capacity and service density across the access, metro, edge, core & data center with industry leading energy-efficiency.



How the solution maps to the presented SSO framework



Silicon

Silicon: Juniper silicon is built for purpose, as compared to x86, enabling it to provide industry leading capacity and efficiency. Trio 6, as an example provides up to 70% power efficiency savings.¹



Systems

Systems: PTX Series routers provide ultra-efficient 461Tbs of capacity. Juniper's IPoDWM solution converges L1-L3, optical-packet, with a plug & play form factor, enabling future-proofed upgrades.



Operations

Operations: All routers provide visibility into power consumption & the ability to dynamically optimize for greater efficiency at the component level.



Solution maturity as of 2025

No telco service yet	Telco/POC trial	Commercial solution	Scaled solution
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How the solution works

- Juniper platforms support diverse use cases, from hyperscaler data centers to telco edge and metro networks. Fixed systems optimize capacity and efficiency in a specific form factor, while modular systems provide greater versatility with the potential for higher capacity across a broad range of metro, edge, core and DC use cases.

Deep dive on PTX Series:

- Initially designed as large modular systems, the PTX platform has evolved into compact, fixed form factors, including a single RU model tailored for modern data centers.
- Independent power zones within the chips manage components like memory and packet forwarding engines, powering them based on demand to minimize idle energy use.
- Optical components, such as amplifiers and DSPs, are integrated into pluggable optics, enabling seamless optical and routing operations in a single device.
- Machine learning models leverage telemetry from PTX systems to predict power trends and optimize resource allocation across network infrastructure.



Key sustainability impacts of solution

Reduces scope



Scope 1: Independent power zones reduce heat generation, lowering cooling-related on-site emissions.

Scope 2: Optimised energy efficiency in fixed systems cuts electricity consumption.

Scope 3: Integrate pluggable optics and durable designs minimise infrastructure upgrades, reducing supply chain emissions.

- Juniper's Express 5 chipset, powering the PTX routers, delivers heightened energy efficiency with a performance of **0.05 Watts per Gbps**.²

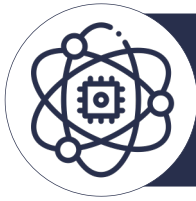


LIBERTY GLOBAL®

"The sustainability of Juniper Networks PTX Series Routers provides the best five-year TCO, which has also enabled us to really plan for the future and manage costs in direct ratio to ongoing growth..."

¹ [Juniper Introduces New Trio 6-based MX Portfolio](#), January 2022

² [Juniper Corporate Social Responsibility Report](#), 2024



Juniper® Paragon Automation – Energy Efficient Automation



Solution overview

Juniper Paragon Automation provides device-level power observability, scanning and optimization capabilities for the WAN as part of the wider device management, network compliance, intent-based service orchestration and other WAN automation use case portfolio.



How the solutions map to the presented SSO framework



Silicon



Systems



Operations

Silicon: Real-time telemetry provides insights into capacity utilization and power consumption, which operators can use to track/optimize energy efficiency.

Systems: Analyzes configurations across thousands of routers to identify unused components, which can be turned off to minimize wasted power

Operations: Real-time monitoring & active assurance optimises service delivery and troubleshooting.



Solution maturity as of 2025

No telco service yet	Telco/POC trial	Commercial solution	Scaled solution
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How the solution works

- Juniper Paragon Automation automates network device lifecycle management from Day 0 to Day 2, reducing device onboarding from hours to minutes
- Embedded active assurance uses built-in data test agents across thousands of routers to measure service quality, enabling consistent service delivery. It verifies service connections and configurations against predefined models, maintaining performance.
- Juniper Paragon Automation’s central servers provide real-time dashboards for monitoring network performance, security, and compliance, with instant assessments of trust levels and vulnerabilities.
- Device power consumption is optimized by adjusting device configurations based on component utilization.
- Power efficient automation leverages power observability to create recommendations to adjust device configurations.



Key sustainability impacts of solution

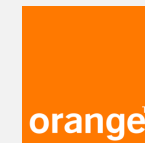
Reduces scope



Scope 2: Lowered through the optimisation of network resource allocation, automating device management and energy-saving measures.

Scope 3: Decreased by extending equipment lifespans with predictive maintenance, reducing the frequency of replacements and need for truck rolls.

- Juniper Paragon Automation supports higher traffic loads on existing routing infrastructure, reducing TCO by up to 27% compared to without automation technology.¹



By using Juniper Paragon Automation, Orange Egypt accelerated service deployment from days to minutes, minimising downtime and reducing truck rolls



Juniper’s Power Steering innovation was recently recognised with a Green Future Best Practice Award from Deutsche Telekom

¹ [ACG's The Economic Benefits of Automating Capacity Optimisation in IP Networks](#), 2022



Juniper® RAN Intelligent Controller (RIC)



Solution overview

Juniper RAN Intelligent Controller (RIC) is a software-defined component of the Open RAN architecture. It provides a unified interface for third-party applications, enabling enhanced energy efficiency, cost reduction, and new business models for telecom operators.



How the solution maps to the presented SSO framework



Silicon



Systems



Operations

Systems: Adopts a disaggregated, neutral platform architecture, enabling RAN optimization by ISVs and CSPs themselves, independently of RAN suppliers.

Operations: Dynamically monitors and manages traffic flows, deactivating underutilized infrastructure.



Solution maturity as of 2025

No telco service yet

Telco/POC trial

Commercial solution

Scaled solution



How the solution works

- Juniper RIC provides standardized interfaces and hardware interoperability across multiple vendors, facilitating integration of third-party rApps and xApps.
- The energy-saving rApp analyses traffic patterns in real-time, deactivating capacity booster cells during low-traffic periods. These deactivated cells are excluded from the decision-making and negotiation process when determining which cell a device connects to within a multi-cell range.
- In advanced scenarios, underutilized portions of MIMO antennas are dynamically turned off, conserving energy while maintaining accessibility and connectivity.
- This resource management is through AI-driven adjustments that optimize beamforming and resource allocation to meet network demand.
- Juniper's contributions to the E2 Service Model (E2SM) in Cell Configuration and Control, enable granular energy-saving actions like advanced antenna sleep modes, enhancing sustainability.
- The RIC also triggers power-saving modes for base station servers, reducing energy consumption across the network.



Key sustainability impacts of solution

Reduces scope



Scope 2: Reduces energy consumed by base station infrastructure, lowering electricity and power needed to operate the network.

Scope 3: Mitigates the degradation on hardware by optimising traffic usage, delaying the need for hardware upgrades and reducing upstream emissions.

- Trials with operators showcased how deactivating cells as part of dynamic resource management could yield up to 25% energy efficiency improvements while maintaining accessibility and coverage.¹



In trials with Vodafone, Juniper RIC demonstrated significant energy savings by processing real-world traffic data from over 700 sites.

¹ [Juniper's Enabling Multi-Vendor O-RAN RIC xApps/rApps Coordination with Juniper RAN Intelligent Controller \(RIC\)](#), 2024



Juniper® Energy Intelligence



Solution overview

Juniper Energy Intelligence is an observability dashboard that provides visibility into energy usage across network segments. It tracks power consumption, temperature, and carbon emissions at the device, system, and component level to enable precise, data-driven optimization.



How the solution maps to the presented SSO framework



Silicon



Systems



Operations

Silicon: Juniper Energy Intelligence provides power consumption insights down to the component level.

Systems: Taps in on data flows from sensors across all network elements including non-Juniper devices

Operations: Provides analytics based on traffic patterns to help optimize networks. Informs the powering down of network routers, switches, and server components when demand is low.



Solution maturity as of 2025

No telco service yet	Telco/POC trial	Commercial solution	Scaled solution
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How the solution works

- Network switches and routers are equipped with hundreds of thermal and power sensors, which continuously generate data.
- The Juniper Energy Intelligence dashboard analyses this data to deliver real-time energy insights across network environments, including data centers, transport networks, and enterprise campuses.
- Using AI-driven analytics and anomaly detection, the dashboard offers operators actionable insights to diagnose power usage and temperature issues.
- The solution provides network operators with the insights needed to deactivate underused network components, leveraging available power saving features during off-peak hours to optimize energy efficiency.
- Designed to work with both Juniper and non-Juniper devices, it supports multi-tenant setups, enabling service providers to extend energy management services to their customers.
- By minimizing the need for manual monitoring, the Energy Intelligence solution helps operators reduce OPEX while providing a comprehensive view of the network's energy footprint and efficiency metrics.



Key sustainability impacts of solution

Reduces scope



Scope 2: Reduced by minimising direct power usage and carbon emissions.

Scope 3: Reduced through predictive maintenance and efficient power management extending the lifespan of network components, reducing the need for hardware replacements.

- By deactivating unused Packet Forwarding Engines (PFEs), the product saves approximately 200-300 watts per component, achieving substantial reductions in energy consumption.
- The dashboard includes tools to optimise Power Usage Effectiveness (PUE) in data centres and Energy Efficient Ratios (EER) in transport networks, promoting sustainable operations.
- Juniper claims that its solution reduces energy consumption by approximately 25% during off-peak hours.



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Liquid Cooling



Solution overview

Juniper's liquid cooling supplements traditional air-cooling methods for high-heat density components in networking systems.



Silicon



Systems

Silicon: Liquid cooling provides improved heat dissipation for silicon

Systems: Integrates with DC infrastructure to enhance efficiency

No telco service yet

Telco/POC trial

Commercial solution

Scaled solution



How the solution works

- Juniper's liquid-cooled platform will use cold-plate cooling technology, targeting only the hottest components, such as ASICs or chips, with liquid circulated through a closed-loop system.
- It works in tandem with air cooling (fans) for less heat intensive components, enabling hybrid cooling. This approach enables data centers to achieve greater energy efficiency and sustainability while maintaining flexibility.



Key sustainability impacts of solution

- 2** **Scope 2:** Air cooling fans can operate at lower speeds, lowering electricity consumption
- 3** **Scope 3:** Facilitates waste heat capture for reuse, reducing indirect emissions



BT trialled Juniper's switch with Iceotope's Liquid Cooling, highlighting its potential to boost energy efficiency and support broader sustainability goals



Juniper Mist™



Solution overview

Juniper Mist leverages AI-Native Networking and cloud-based management to boost user experience and automate troubleshooting across wired + wireless networks.



Systems



Operations

Systems: Cloud-native reduces physical infrastructure

Operations: Visibility drives informed network decisions

No telco service yet

Telco/POC trial

Commercial solution

Scaled solution



How the solution works

- Juniper Mist leverages an AI engine, cloud-native architecture, and dynamic APIs to simplify network configuration, automate issue resolution, and deliver real-time insights on network performance.
- Key benefits include AI-powered remote troubleshooting, deployment templates for rapid implementation, integration with IoT systems, and microservices that enhance the user experience while minimising network downtime to zero.



Key sustainability impacts of solution

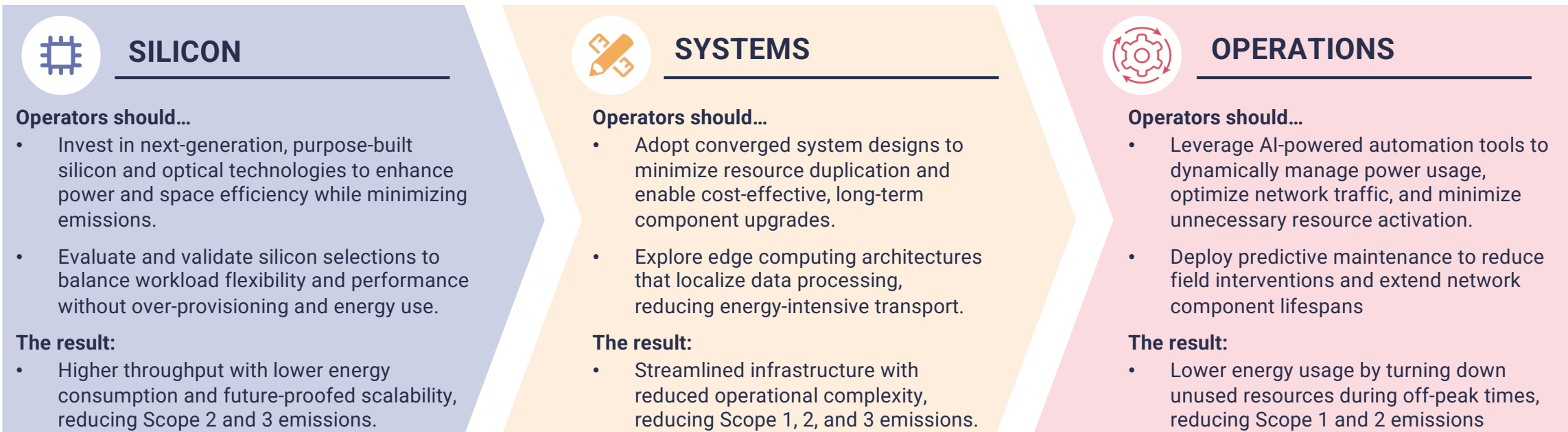
- 2** **Scope 2:** Increased visibility on power consumption, means it can be optimised
- 3** **Scope 3:** Through remote, automated troubleshooting, truck rolls are cut by 85%



VolkerWessels Telecom uses Juniper Mist to optimise UX in campus locations, while streamlining IT operations and speeding troubleshooting

The next phase of networking will belong to operators that embrace a comprehensive and scalable approach

Communications Service Providers must take decisive action to execute on meaningful sustainability initiatives across their entire network. Juniper Networks' focus on delivering sustainable solutions across the Silicon, Systems, and Operations (SSO) framework, provides operators with a comprehensive, scalable approach that drives both business growth and environmental stewardship. CSPs can thereby adopt technology initiatives and solutions aligned to their network sustainability goals.



Across all domains, network operators should conduct a comprehensive sustainability audit within the SSO framework to identify gaps and areas for improvement. This assessment will inform a phased implementation plan that prioritizes "quick wins," such as dynamic energy management tools and modular upgrades. Collaborating with technology vendors such as Juniper to co-create integrated solutions will accelerate the adoption of best practices and ensure transparent progress tracking and reporting.

A message from our research contributors



About STL Partners

STL Partners is an independent consulting and research firm that supports telcos, technology, and digital infrastructure companies to innovate, grow and stay ahead of competition. We provide actionable insights and practical guidance on emerging challenges and opportunities, with a focus on innovation and identifying new sources of growth.

STL covers sustainability through research, consulting, webinars and participating in industry forums. Our [Sustainability Hub](#), brings together insights, learnings and perspectives on sustainability, and sets out the implications for telecoms.

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About Juniper Networks

Juniper Networks believes that connectivity is not the same as experiencing a great connection. Juniper's AI-Native Networking Platform is built from the ground up to leverage AI to deliver exceptional, highly secure, and sustainable user experiences from the edge to the data center and cloud. Additional information can be found at juniper.net or connect with Juniper on [X](#) (formerly Twitter), [LinkedIn](#), and [Facebook](#).

For more information about Juniper's sustainability initiatives and programs, please visit our [sustainability page](#).

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