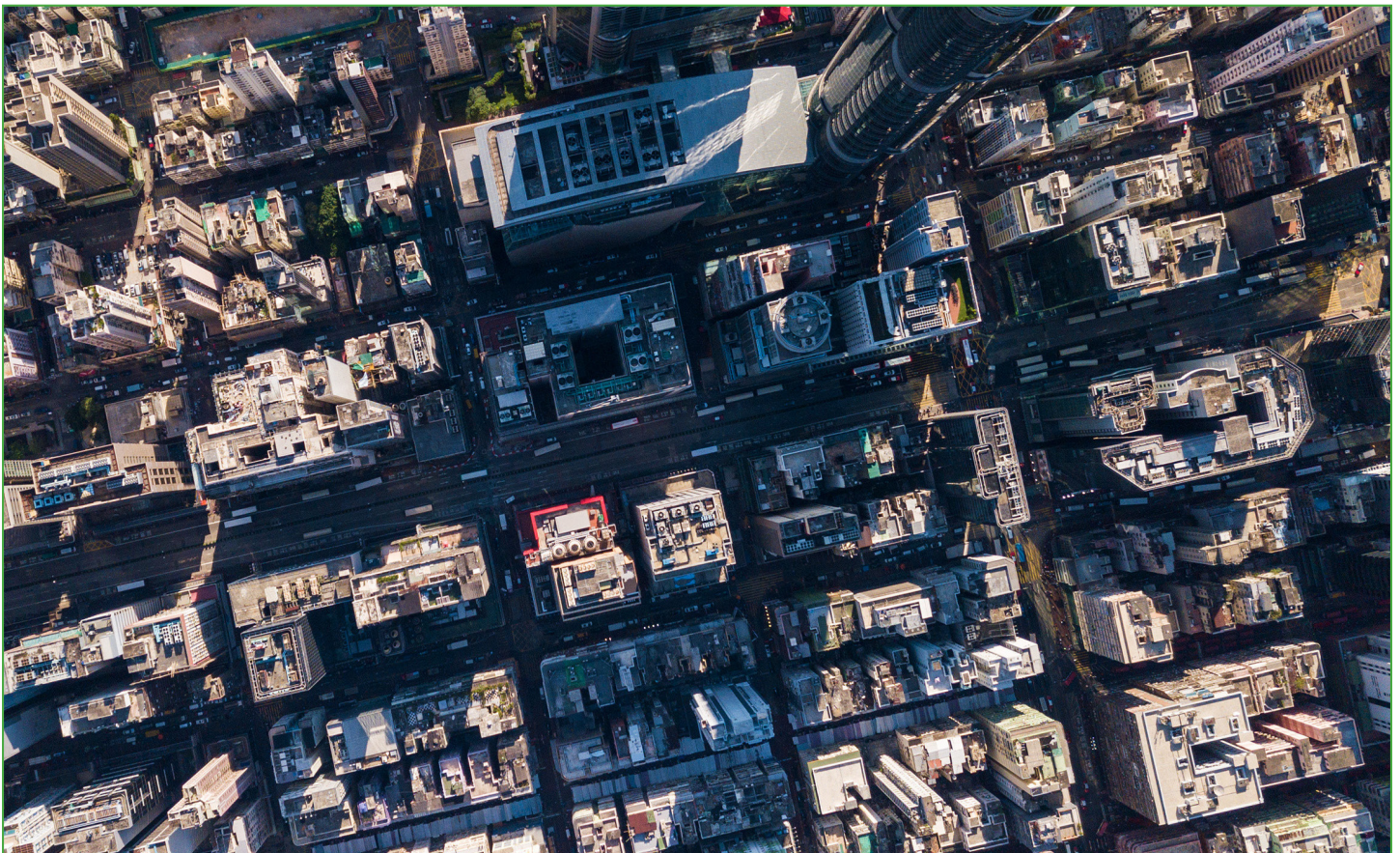# DAY ONE GREEN: CLOUD METRO ARCHITECTURE

Cloud Metro networks allow operators to flexibly deploy next-generation metro edge services while reducing network total cost of ownership, energy consumption, and CO_2 emissions.

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Day One Green

Cloud Metro Architecture

Abstract

Cloud computing, edge computing, and metro networks are converging as network operators move to 5G networks and evolve to deliver new services. The emergence of disaggregation for the 5G vRAN and separation of the 5G core user and control plane to meet more ambitious service requirements are accelerating this trend. An ACG Research report published in the r st quarter of 2022 dened th e characteristics, services, and requirements of Cloud Metro networks. Juniper Networks is leading this network transformation with a new generation of routing systems designed for modern Cloud Metro networks. Juniper's solution is comprehensive with improvements in router architecture, automation, AIOps, service assurance, and security. The Cloud Metro solution allows operators to flexibly deploy next-generation metro edge services while reducing network total cost of ownership (TCO), energy consumption, and CO_2 emissions, not to mention added longevity of networking equipment and hardware lifespan. This new generation of Cloud Metro networks can help you reach your own carbon abatement targets. Your results may vary but when combined with the other technologies featured in Day One Green papers can provide incremental improvements that ad up over time.

NOTE   This Day One Green paper was originally published as a Juniper Networks blog: The TCO and Environmental Benefits of the Juniper Networks Cloud Metro Network Solutions.

Introduction

This study presents a TCO model of a network of 10,000 Cloud Metro routers and compares the Juniper ACX7509 Cloud Metro router with a similar generation router from two competitors with signicant global deployment. Specially , we compare three routers:

- ACX7509 Cloud Metro router
- Competitor A (this is a current generation router from a leading vendor)
- Competitor B (this is an older generation router from a leading vendor with a large global installed base)

Our results show that the Juniper ACX7509 has a TCO benet of 5 3% over Competitor A and 71% over Competitor B. Much of this benet i s due to reduced power, cooling, and space. The reduced power consumption of the Juniper ACX7509 in a network of 10,000 nodes results in a CO_2 emissions reduction of 69,765 metric tons compared to Competitor A, and 145,063 metric tons of CO_2 emissions compared to Competitor B.

These savings become larger as the metro network grows. The environmental eciency of Juniper's ACX7509 helps reduce both TCO and greenhouse gas emissions. A summary of power and cooling, floorspace, CO_2, and total OpEx savings is presented in Table 1.

Table 1   *Summary of ACX Savings Over Competitor A and Competitor B*

ACX7509 Savings	Competi or A	Competi or B
Power & Cooling	61%	77%
Floorspace	29%	64%
CO_2	61%	77%
Total OpEx Savings (Including Labor)	53%	71%

Juniper's Cloud Metro Value Proposition

Juniper's Cloud Metro networks are designed to scale modern 5G, edge, and multicloud services while providing a high-availability architecture. The key components are:

- Sustainable high-performance metro networking systems
- The ACX7000 family of routers
- Cloud-delivered Automation-as-a-Service (AaaS)
- AI-Ops to improve network operations
- Embedded active service assurance
- Built-in zero-trust security
- Converged IP services fabric

The ACX7000 family routers deliver a variety of L2 and L3 services at the metro edge of the network:

- L3VPN

- L2VPN

- BNG

- MPLS

- Segment Routing

The ACX7000 family routers have leveraged the latest generation chip-sets and system architecture design, resulting in lower power consumption and less rack space. See the Day One Green library for individual papers on these chips sets and thermal advances.

This paper reviews the ACX7509, part of the Juniper ACX7000 family, for its TCO and environmental benet capabilities as shown in Figure 1:

- Centralized architecture with orthogonal design and no backplane

- No fabric cards because FEB cards provide both forwarding and fabric capabilities

- Common ports for 1-50GE (SFP)

- Common ports for 10-400GE (QSFP)

- Embeds Broadcom Jericho2c today, ready for Jericho3 for 800GE and beyond

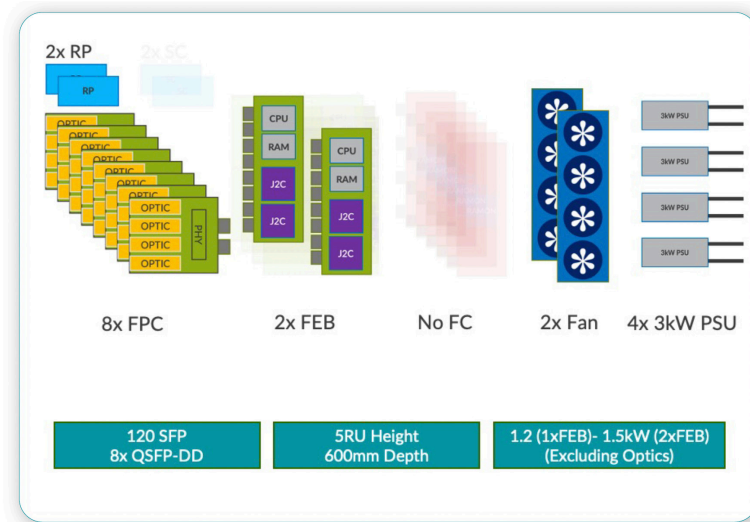- A smaller 5RU chassis reduces the number of fans required

Figure 1   ACX7509 System Architecture

These features lower TCO for the following reasons:

- ACX7509 supports future generation chipsets, which extend system lifetime from 3−5 years to 7−12 years. Extended system lifetime reduces the TCO because forklift upgrades are not required to upgrade router capacity and features with the next-generation chipsets

- Eliminating fabric cards reduces both power and space

- Getting rid of fabric cards also improves life-cycle management because FEB cards can be upgraded without also needing to upgrade fabrics or forklift chassis

- Eliminating fabric cards decreases the number of components that can fail and therefore improves MTBF and increases service availability

- Common ports for both 1-50GE and 10-400GE allow service instantiation and changes to be done remotely, reducing truck rolls and manually changing hardware

- Lower power and smaller chassis cut down power, cooling, and oor space expenses

- High-density interfaces and lower cost per port reduces TCO

Paragon Automation as a Service

The goal of Paragon Automation as a Service is to provide a cloud-based service to operators providing network automation. Automation as a Service is a consumption-based SaaS service. Today, most operators are implementing multiple types of network automation, but there are challenges:

- CSPs must create and maintain scripts (Ansible, etc.)

- Automation requires knowledgeable sta to implement and maintain automation software and systems

- There is a gap in the marketplace for skilled network/automation sta; this was further increased by the great resignation

Juniper's cloud-delivered Paragon Automation as a Service provides:

- On-boarding new equipment

- Testing new equipment

- Service activation

- Ensuring security

Device onboarding is typically performed semi-automatically with few security and assurance checks. It is a time consuming and error-prone process that requires signicant manual eort. In many cases eld technicians must have CLI knowledge, technical documentation, and experience testing network connectivity. The lack of automated

oversight translates into costly errors and unacceptable times to market. To ensure secure, fast, error-free deployment at scale, communication service providers need to reimagine their device on-boarding process with automation.

Paragon Automation as a Service allows eld engineering to perform on-boarding quickly, easily, and accurately through its mobile devices. In minutes hardware and software authenticity is validated, latest software is imaged, secure zero-touch congura tion and provisioning is completed, additional device health checks and network performance tests are done before the inventory is updated, resulting in devices that are fully ready for service. This is more than ZTP. Traditional ZTP implementations are limited to automatic congura tion while Paragon Automation as a Service provides secure ZTP, device trust validation, device health checks, and network connectivity and performance testing. These features are automated and do not require manual intervention.

The key benets of Paragon Automation as a Service are:

- Accelerate time to revenue at global enterprise and CSP scale with instant device onboarding

- Ensure network trust with device integrity, compliance, and health checks

- Guarantee device performance and service quality

- Provide error-free deployment, avoiding costly mistakes by getting it right the r st time

- Reduce the skill-sets required by technicians

- Decrease the labor expense required to install network devices

Given that there are tens of thousands of routers in a metro network these savings are signicant.

AIOps

One of the main benets of a SaaS based AIOps solution is that we can better train algorithms by using anonymized data from multiple situations. The benet is a better AIOps solution for all.

Predictive maintenance is another benet of AIOps. Predictive maintenance is a technique that uses data analysis tools and techniques to detect anomalies in operations and defects in equipment and processes so they can be x ed before they result in failure. Ideally, predictive maintenance allows the maintenance frequency to be as low as possible to prevent unplanned reactive maintenance without incurring costs associated with doing too much preventive maintenance.

The Juniper Paragon Automation AIOps solution is based on both device telemetry and active service assurance. Service assurance and customers' experiences are optimized by actively monitoring quality, not only focusing on device telemetry like most other solutions in the market today.

The key benets of the Juniper Paragon Automation AIOps solution are:

- Change network management from reactive ops to proactive ops
- Reduce the required skill levels of engineers and technicians managing the network
- Shorten training times
- Decrease mean time to repair problems
- Improve network availability and performance
- Maintain customer service level agreements

Reducing labor expense while improving network availability and performance is the main TCO benet of the Juniper Paragon Automation AIOps solution.

Embedded Active Service Assurance

High-quality service assurance is a key success factor in every network. Although eectiv e service assurance depends on eectiv e fault management and AIOps, it is also important to actively monitor network performance to nd problems before users or systems can detect them. Most service assurance monitoring uses either:

Passive Traffic Monitoring

Active probes inserted in the network to generate and monitor trac and detect performance problems

Juniper's Paragon Active Assurance is embedded in the ACX7000 routers; an active probe is not required. It is a programmable, active test and monitoring solution for physical, hybrid, and virtual networks. Unlike passive monitoring approaches, it uses active, synthetic trac to verify application and service performance. Service monitoring is delivered throughout the life of the service. Active Layer 2–7 service testing veries that services are congur ed correctly the r st time and ensures that service changes do not impact service quality. It provides detailed reports and alarms to alert operations of network performance problems. Because Paragon Active Assurance is embedded in the ACX7000 routers, there is no need for additional servers, probes or virtual machines (VMs) to install test agents. Where Juniper ACX7000 routers are not present, software test agents can still be deployed as VMs or as container applications or on bare-metal x86 hardware to meet multivendor testing needs. This reduces CapEx and cuts the cost of integrating and deploying agents. High- quality service assurance is critical because it improves customers' satisfaction and reduces churn.

Built-In Zero-Trust Security

Cloud Metro networks can have tens of thousands of routers deployed. There is a high risk of routers being compromised and the results can be catastrophic. The consequences

of security breaches are high. Zero trust, the security principle of "never trust by default, always verify" has become a best practice across industries.

A recent report from Microsoft, 2 https://www.microsoft.com/security/blog/2022/01/12/microsoft-zero-trust-solutions-deliver-92-percent-return-on-investment-says-new-forrester- study/, has quantied the economic impact of zero-trust solution. Highlights from the report include:

- Three-year 92% return on investment with a payback period of fewer than six months

- 50% lower chance of a data breach

- Numerous eciency   gains of 50% or higher across security processes

The cost of security breaches is signicant   and implementing zero-trust security is critical to reducing the risk of network security breaches. All Juniper ACX7000 routers have built-in zero-trust security. DevID with TPM 2.0 hardware and software attestation validates the identity, authenticity, and integrity of each device. This is especially important in a Cloud Metro network that can have tens of thousands of devices deployed in unsafe locations such as street cabinets. It reduces the risk of counterfeit products or routers without proper software releases being deployed. In contrast, without these security capabilities, routers can be compromised and used to launch DDoS attacks as botnets. In addition to device security, it is also important to ensure data security, for example, protecting data-at-rest with native le encryption and data-in-transit with MACsec.

Converged IP Services Fabric

Cloud Metro reimagines today's siloed, point-to-point metro networks as a versatile IP services fabric that enables "Any Service, Any Place, Any Device" connectivity for distributed edge clouds and applications. It oer s the ability to intelligently steer trac   not just to central data centers, but across multiple hubs (Edge Cloud), vaults and caches within the metro domain. These capabilities enable a more intelligent and future-ready metro with improved latency and bandwidth eciency   .

TCO Model Framework and Assumptions

The focus of this TCO model is on the OpEx benets of the ACX7509 router. The objectives of the OpEx model:

- Compare power and space expense of the ACX7509 with two other industry-leading routers and show the OpEx benets   in a large Cloud Metro network

■ In the same network show the OpEx benets of AIOps as compared to a similar network without AIOps

In this model three routers are compared:

■ ACX7509

■ Competitor A: this is a current generation router similar to the ACX7509 from a leading vendor;

■ Competitor B: this is an older generation router from a leading vendor with a large global installed base.

Table 2   Power and Space Requirements for Each Router

Router	KWatt	RU	Monthly Power Expense	Monthly Cooling Expense	Monthly Space Expense
ACX 7509	1,167	5	118	47	90
Competitor A	3,008	7	303	121	126
Competitor B	4,995	14	503	201	252
ACX Savings vs Competitor A	61%	29%	61%	61%	29%
ACX Savings vs Competitor B	77%	64%	77%	77%	64%

ACG Research used its Business Analytics Engine (BAE)(https://www.acgbae.com/) to model and compare the OpEx of the ACX7509 with Competitor A and Competitor B routers. The BAE is a visual, cloud-based economic simulation engine that calculates TCO and return on investment for many IT and network use cases. Figure 2 presents the high-level input to the BAE. In this analysis we assume a large Cloud Metro network that starts with 2,000 edge service routers and grows to 10,000 routers over v e years. We also consider the following categories of labor:

■ Change management

■ Hardware replacement

■ Help desk

■ Fault management

■ Performance management

■ Software upgrades

Table 3 lists these categories of labor and the savings. Most of the savings are due to AIOps network management automation; however, the hardware replacement savings are due to the ACX7509 architecture that has fewer physical components (no fabric cards) and e xible ports that can be congur ed by software. This leads to reduced truck rolls and hardware replacement costs.

Table 3   Categories of Labor and ACX 7509 Labor Savings

FTE Name	ACX 7509 Savings	Notes
Change Management with AIOps	10%	Due to AIOps
Hardware Replacement with AIOps	20%	Due to reduced truck rolls result of HW architecture
Help Desk Trouble Tickets with AIOps	60%	Due to AIOps
NOC Fault Management with AIOps	70%	Due to AIOps
Performance Management with AIOps	70%	
Software Upgrades with AIOps	10%	

Figure 2   BAE Input Assumptions and Cloud-Based Economic Simulation
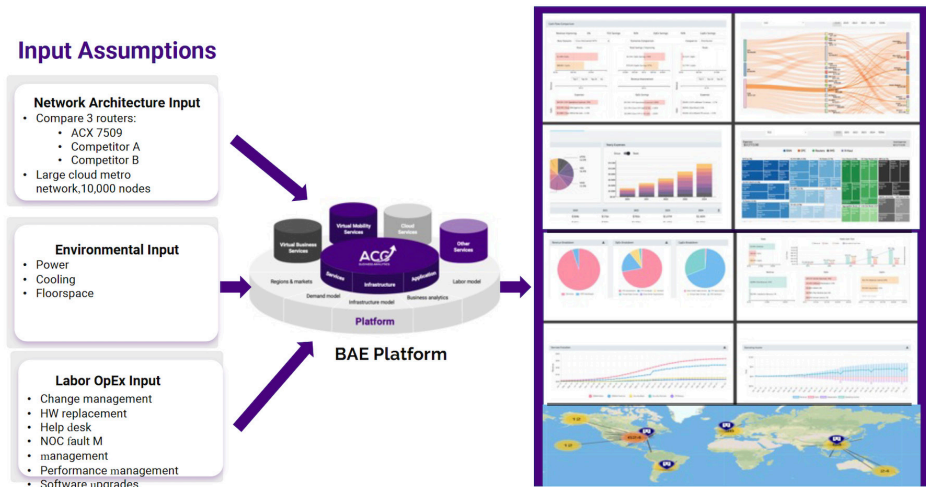
TCO Results

In this TCO analysis we considered OpEx for power, cooling, oor space, and network management labor expenses. We also examined the environmental benefits of lowering power consumption to reduce CO_2 emissions. The results show that the ACX7509 significantly reduces both OpEx and CO_2 emissions compared to the competitive products. In a large metro network, the reduction in environmental expenses associated with power, cooling, and oor space are signicant. T able 4 presents the cumulative v e-year environmental OpEx for each alternative and shows the ACX7509 environmental expense savings.

Table 4:   *Five-Year Cumulative Environmental OpEx with ACX Savings*

Five-Year Cumulati e Environmental OpEx		ACX 7509 Savings
ACX7509	$90.9M	N/A
Competitor A	$196M	54%
Competitor B	$341M	73%

In addition to the reduction in power, cooling, and oor space expenses, AIOps reduces network operations labor expenses. Table 5 shows the v e-year cumulative OpEx and the ACX 7509 savings. The savings are 53% when compared to a current generation router from a leading vendor and 71% when compared to a legacy platform from a leading vendor with a very large installed base. The benets of the ACX 7509 architecture with reduced power consumption and lower footprint combined with the AIOps benets are the drivers of these OpEx savings.

Table 5   *Five-Year Cumulative OpEx and ACX 7509 Savings*

Five-Year Cumulati e OpEx		ACX 7509 Savings
ACX7509	$107M	N/A
Competi or A	$229M	53%
Competi or B	$347M	71%

We compared the v e-year annual OpEx spend for the ACX 7509, Competitor A, and Competitor B (Figure 3). The OpEx grows as the network increases from 2,000 routers to 10,000 routers. The key point is that as the network expands, the dier ence in OpEx expenses between the ACX7509 and the competitors becomes greater.
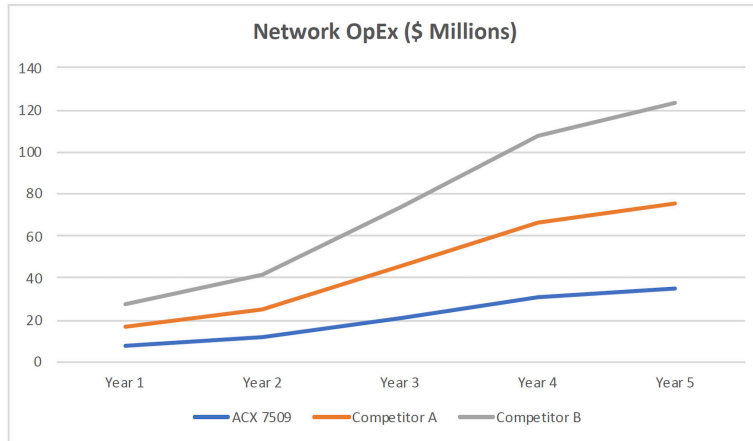
Figure 3   *Five-Year Annual OpEx Spend for Each Alternative*

Next, Figure 4 shows the v e-year cumulative OpEx savings comparing the ACX7509 with Competitor A, and a similar OpEx breakdown for Competitor B is presented in Figure 5. The diagrams show the savings both in absolute dollars and as a percentage. In both cases power, cooling, and oor space account for most of the savings because we considered a large and growing metro network where environmental expenses are signicant.
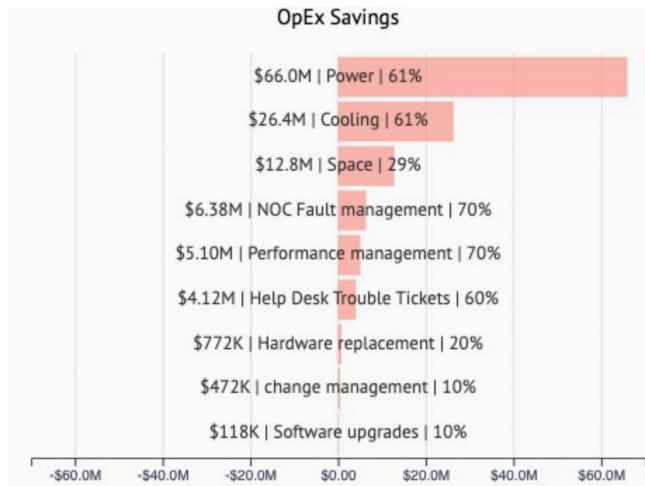

Figure 4   *Five-Year Cumulative Breakdown of OpEx for Competitor A and ACX 7509*
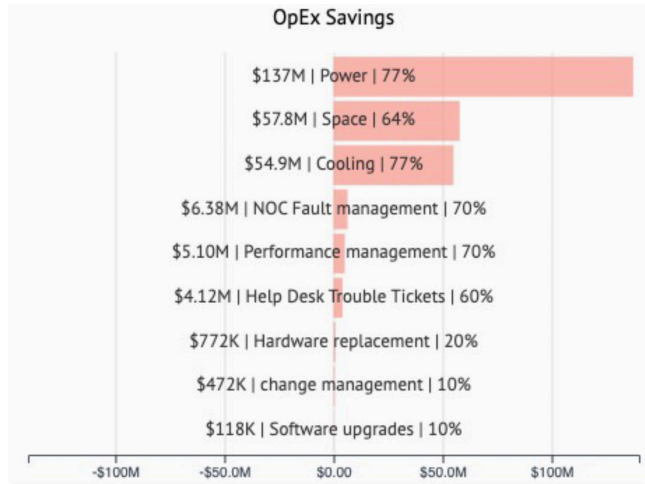
Figure 5   *Five-Year Cumulative Breakdown of OpEx for Competitor B and ACX 7509*

In addition to reducing OpEx, the decreased power consumption of the ACX7509 lowers CO_2 emissions. Table 6 shows the total power consumption, CO_2 emissions, and CO_2 savings and the CO_2 savings compared to Competitor A and Competitor B. These savings become greater as the metro network grows.

Table 6   *KWatts and CO_2 Emissions*

Router	Annual KWatts/ ours	CO_2 Emissions Metric Tons	CO_2 Savings Metric Tons
ACX 7509	102,229,299	44,224	N/A
Competitor A	263,500,800	113,989	10.7
Competitor B	437,562,000	189,287	22.2
ACX Savings vs Competitor A	61%	61%	N/A
ACX Savings vs Competitor B	77%	77%	

The results of the TCO model show that the ACX7509 has significant OpEx benefits and CO_2 emissions savings over competitive platforms. The dollar value of these benefits becomes larger as the edge network grows. The environmental benefits also increase with the size of the network.

One calculating factor not considered is to take the amount of savings in Table 6 and apply it towards renewable sources of power such as solar, wind, or other. At some point the renewable power can both help pay for existing power OpEx while lowering the need to purchase additional carbon credits.

Conclusion

This paper has provided an overview of Juniper's Cloud Metro solution and its value proposition. Juniper's Cloud Metro is a holistic solution providing:

- Sustainable high-performance systems

- Cloud delivered Automation-as-a-Service

- AIOps to improve network operations

- Embedded active service assurance

- Zero-trust security

- Converged IP service fabric

The ACX 7409 provides a pathway to energy sustainability via its high-performance, long-lived network infrastructure. This longevity on the job, monitored by AIOps, has the ability to outlast the elements and provide a return on the investment by lowering greenhouse gas emissions.".

ACG Research developed a TCO model that showed signicant $T_{}CO$ savings when compared with two competitive metro routers. The model showed significant reductions in CO_2 emissions because of power decreases in the network. As edge computing and Cloud Metro networks continue to increase, minimizing both TCO and CO_2 emissions is necessary to improving service protability a nd decreasing the environmental impact of networks. This benets p eople and the planet while providing connectivity in the decades ahead.

Speak to your Juniper Networks' account manager or Professional Services rep about the new generation of routing systems designed for modern Cloud Metro networks.

Cloud Metro Resources

Here are some Juniper Cloud Metro resources with up-to-date specica tions and information:

- Cloud Metro landing page: https://www.juniper.net/us/en/solutions/ip-transport-solution/metro.html

- ACX7509 Cloud Metro Router : https://www.juniper.net/us/en/products/routers/acx-series/acx7509-cloud-metro-router.html

- ACX7509 Cloud Metro Router Datasheet: https://www.juniper.net/us/en/products/routers/acx-series/acx7509-cloud-metro-router-datasheet.html

- Paragon Automation as a Service: Cloud-Delivered Network Automation: https://www.juniper.net/us/en/the-feed/topics/network-automation/paragon-automation-as-a-service-cloud-delivered-network-automation.html

- Making the Case for Cloud Metro: https://www.juniper.net/us/en/the-feed/topics/metro/juniper-ceo-rami-rahim-makes-the-case-for-cloud-metro.html

- ACX7000 Family Datasheet: https://www.juniper.net/us/en/products/routers/acx-series/acx7000-family-of-cloud-metro-routers-datasheet.html

- Introducing Juniper's Expanded Cloud Metro solutions https://youtu.be/HpKH-iqEIXXo

- Cloud Metro: Reimagining Metro Networks for Sustainable Business Growth: https://blogs.juniper.net/en-us/service-provider-transformation/cloud-metro-reimagining-metro-networks-for-sustainable-business-growth

- Balancing Design Choices for Sustainable Growth: Juniper ACX7000 Family: https://blogs.juniper.net/en-us/service-provider-transformation/balancing-design-choices-for-sustainable-growth-juniper-acx7000-family

- Heavy Networking 639: Juniper Cloud Metro Boosts Metro Performance, Eciency And Sustainability: https://packetpushers.net/podcast/heavy-networking-639-juniper-cloud-metro-boosts-metro-performance-efficiency-and-sustainability-sponsored