ESnet Site User Cost Policy
DOE Office of Science, Office of Advanced Scientific Computing Research
Fiscal Year 2022

Reasons for a Cost Policy

The Energy Sciences Network (ESnet) is the Department of Energy (DOE) Office of Science's (SC) high-performance network user facility, delivering highly-reliable data transport capabilities and services optimized for the requirements of data-intensive science. ESnet is stewarded by SC's Advanced Scientific Computing Research Program (ASCR), and managed and operated by the Scientific Networking Division at Lawrence Berkeley National Laboratory (LBNL).

SC contributes to the broader DOE mission by extending the reach of ESnet services to non-SC partners. ESnet, like many SC User Facilities, has a wide variety of formal user engagements with other institutions, some of which have no affiliation with the SC research enterprise. Unlike most other SC User Facilities, the services that ESnet provides to institutions are typically continuous over many years, with occasional discrete periods of project-like upgrades.

ESnet and ASCR manage user governance of ESnet operations at the site level (not the individual user level), and use the following definitions to differentiate between users:

> **Site User:** An ESnet Site User is an institution with access to the ESnet wide area network (WAN). ESnet Site Users enjoy membership in the ESnet Site Coordinators Committee (ESCC).
> **Endpoint User:** An ESnet Endpoint User is an individual user of ESnet who sends or receives data over ESnet; endpoint users are also dependent on the Local Area Network services. There is no formal agreement between ESnet and an Endpoint User, and ESnet does not track individual Endpoint Users.

This cost policy applies to Site Users; the policy is not relevant to Endpoint Users.

This cost policy provides a holistic framework for determining whether a Site User should pay ESnet User Connection Costs, and for calculating those costs in a transparent way. Together, ASCR and ESnet see the cost policy as a critical platform to promote healthy and durable partnerships between ESnet and its Site Users.

Principles that Frame this Cost Policy

The following principles, which flow from SC user facility policy and ESnet Acceptable Use Policy, inform the cost policy:

As an SC User Facility[1]***, ESnet's science mission comes first. ESnet provides specialized services to enable research and is not just an Internet Service Provider (ISP).***
- ESnet's primary mission is support of scientific data movement and DOE science mission objectives, and ASCR continually directs ESnet to evolve its network architecture and services to meet DOE science mission objectives.
- As an SC User Facility, ESnet focuses on defining the state-of-the-art in high performance network services to accelerate scientific discovery. SC must ensure that ESnet's core scientific mission will not be negatively impacted by non-SC use of ESnet.
- ESnet does not compete with the private sector; ESnet's core program is architected to achieve its core mission objectives.

Based on its longstanding stewardship model for SC User Facilities, SC fully funds the ESnet core program to ensure operational stability.[2]*** Site User partners may be required to cover incremental costs related to their specialized needs/use.***[3]
- SC provides direct support for ESnet core operations from congressional appropriations.
- SC requires that ESnet must not be compromised financially if partners decide to discontinue using ESnet network connections.
- ESnet collects incremental costs from partners in a manner consistent with DOE incremental cost recovery policies.

Site User partners desire cost transparency.
- The cost formulas are designed to treat a wide variety of partners equitably, and to be as simple as possible.

SC and LBNL adhere to DOE pricing policies and federal accounting regulations.
- Non-payment by non-SC partners could result in LBNL unallowable costs, which would violate the terms of the LBNL Management and Operations contract with DOE and the Anti-Deficiency Act.

Value Proposition for Site Users

Site Users leverage the substantial SC investments (tens of millions of dollars per year) in the ESnet core program:

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[1] See Appendix A for information on SC user facilities policies.

[2] The ESnet "core program" spans the operations, maintenance, R&D, and other activities that enable ESnet's core operational and innovation capabilities.

[3] See Appendix B for information on the user facilities provisions in DOE Order 522.1, Pricing of Departmental Materials and Services.

- **Fiber infrastructure:** Procurement of use rights and repair and relocation services for thousands of miles of optical fiber;
- **Capacity growth:** Continual investments to increase the lit capacity of the backbone network;
- **Colocation space:** Annual lease and power payments for dozens of data center (colocation) and hundreds of amplifier spaces across the country that host the backbone network equipment;
- **Network equipment and software:** Annual operations and maintenance costs for hundreds of pieces of optical and routing equipment;
- **Operations hardware and software:** Enterprise computing and storage, including the primary and secondary control data centers, measurement servers, and software to enable network operations;
- **Innovation:** Investments to drive creation of new capabilities and services.

In addition, SC bears full responsibility for the costs of periodic major upgrades to ESnet; the ESnet6 upgrade, for example, constitutes a $150M investment by SC to renew the core network infrastructure and capabilities.

This relationship of SC and ESnet to the ESnet Site Users is in keeping with the Cooperative Stewardship model, a core management philosophy for stable stewardship of major scientific user facilities.[4] The Cooperative Stewardship model holds that a sole programmatic owner/steward provides funds to support the core operations of the facility, and partner users may support specialized capabilities that leverage the core.[5] In the case of ESnet, each Site User leverages SC's investments in the construction and core operations of the ESnet wide area network.

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[4] *Cooperative Stewardship: Managing the Nation's Multidisciplinary User Facilities for Research with Synchrotron Radiation, Neutrons, and High Magnetic Fields (1999).* The National Academies **https://doi.org/10.17226/9705**

[5] A useful analogy for the relationship between ESnet and its Site Users is the relationship between a DOE x-ray light source and the partners that build "end station" laboratories. In the case of the light source, the Office of Science provides full support for the core systems that create the high intensity x-ray source, and other institutions may partner with the light source to build specialized experimental end stations that use the x-rays. The end station partner leverages SC's investments in the construction and core operations of the light source user facility.

Cost Policy Framework

The cost policy is framed in a 2x2 decision matrix differentiated by the Type of User and the Type of Work.

Type of User: The cost policy differentiates between **SC Site Users** and **non-SC Site Users**:
- An **SC Site User** is an SC national laboratory, an SC User Facility, or any other site formally designated as such by the Office of Science.
- A **Non-SC Site User** is any Site User that is not an SC Site User. Designation of a Non-SC Site User requires written approval from the Office of Advanced Scientific Computing Research.

Type of Work: The cost policy differentiates between **Builds** and **Ongoing Operations**:
- A **Build** is the creation or upgrade of a Site User connection.
- **Ongoing Operations** is maintenance and enhancement of ongoing ESnet connectivity services to a Site User.

The cost policy has four distinct cases summarized as follows:

	SC Site User	Non-SC Site User
Builds	The Site User pays up to the whole amount of the costs associated with the build.	The Site User pays the whole amount of the costs associated with the build.
Ongoing Operations	The Site User pays limited or no costs associated with ongoing operations.	The Site User pays costs associated with ongoing operations.

Appendix C provides additional discussion and examples for each case for reference.

There are occasions when an SC Site User seeks to augment its ESnet partnership for non-SC mission purposes; in these circumstances ASCR determines whether ESnet should recover costs from the SC Site User.

The cost elements that may contribute to the total cost for a Site User are illustrated in the figure below:
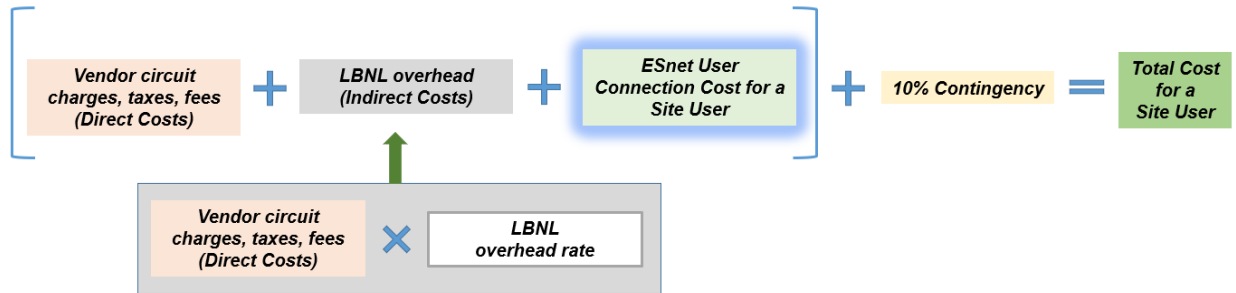

The cost elements are explained below. Note that each Site User may have a different portfolio of cost elements (i.e., every element does not apply to every Site User). Contingency is applied for every Site User.

Cost Element	Description
Vendor circuit charges (direct cost)	The pass-through cost of the 12-month direct circuit service subcontract, which comes directly as a quote from the circuit vendor.
Vendor taxes and fees (direct cost)	The pass-through cost of taxes and fees associated with the circuit service subcontract, which comes from the circuit vendor's quote. Note that these costs are estimated taxes and fees that are subject to change by the FCC and circuit vendor on a quarterly basis.
LBNL overhead (indirect cost)	The cost associated with application of the LBNL overhead rate, which is determined annually by the LBNL Office of the Chief Financial Officer, in accordance with the terms of the Laboratory's M&O Contract with DOE; this indirect cost is applied to every project undertaken by the Laboratory.
ESnet User Connection Cost (calculated)	The incremental cost for ESnet to manage the Site User's circuit(s) and connection(s) to ESnet. This element is the primary focus of this Cost Policy.
Contingency	ESnet includes a contingency of 10% of the total estimated costs to account for changes to vendor taxes and fees.

Calculation of the ESnet User Connection Cost

This section explains the cost basis and formula that ESnet uses to calculate the ESnet User Connection Cost for a Site User.

The ESnet User Connection Cost formula is rooted in the longstanding cost recovery principles for DOE user facilities. All SC User Facilities take the same basic approach: users may be charged for incremental costs incurred over and above normal use of the facility. For ESnet, the calculation of incremental costs for Site Users can be represented by the following illustration:
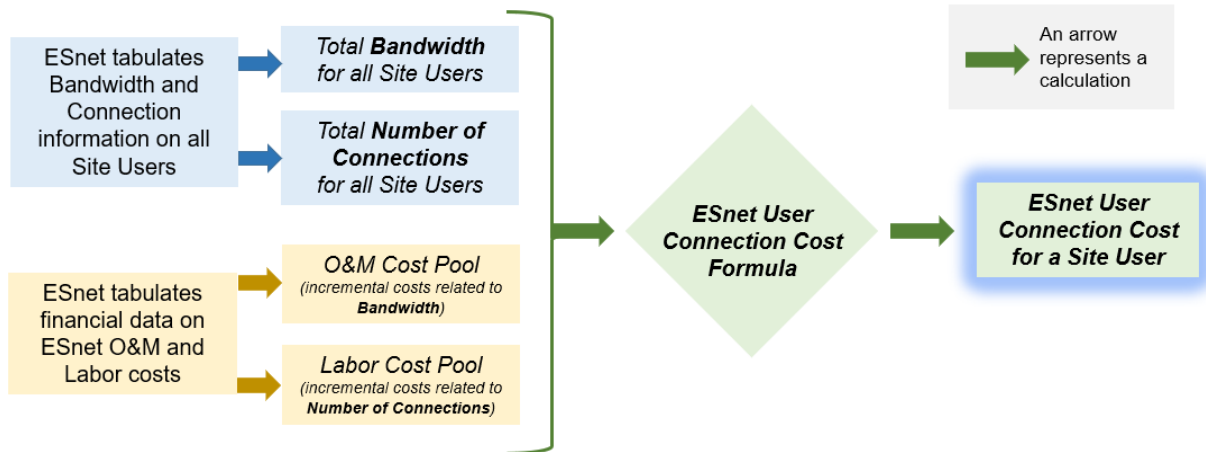
ESnet's User Connection Cost Formula

ESnet's annual calculation of the incremental cost charge for a Site User scales with the **Bandwidth** and **Number of Connections** for that Site User. **Bandwidth** is defined as the aggregate bandwidth capacity of ESnet network connections directly serving the Site User; the **Number of Connections** is the number of circuits or optical waves connecting a Site User to the ESnet network.

ESnet's annual calculation of the incremental cost charge for a Site User is based on four key pieces of information:
- The tabulated **Total Bandwidth for all Site Users**
- The tabulated **Total Number of Connections for all Site Users**
- The **Operations and Maintenance (O&M) Cost Pool**, which is the aggregate incremental costs to support the **Total Bandwidth for all Site Users**
- The **Labor Cost Pool**, which is the aggregate incremental cost to support the **Total Number of Connections for all Site Users**

Each of these four key pieces of the incremental cost calculation are explained in detail below.

Operations and Maintenance Cost Pool Component

The **Operations and Maintenance (O&M) Cost Pool** is calculated from the following ESnet cost elements:

1. **Network: Backbone Equipment Maintenance:** This element relates to maintenance and support for the specific backbone network equipment that enables capacity growth.

2. **Network: Peering and Cross Connects:** This element includes two functional costs: 1) circuits that provide connection to the Internet and/or cloud computing entities for ESnet users and 2) cross-connects that serve a variety of connections (not limited to connecting the internet/cloud providers):

3. **Network: Software:** This element includes costs to maintain software tools used to design and support the network.

4. **Network: Low Value:** This element includes low monetary value components, goods, and services that are necessary to install, connect, operate, and maintain the ESnet networking equipment and related network services.

5. **Infrastructure: Operations Maintenance:** This element comprises the maintenance and support costs for the computer and storage equipment assets directly related to control and monitoring.

6. **Security: Security Operations:** This element includes support costs for WAN security appliances, Splunk maintenance, vulnerability scanning services, and other operational security related services and support.

7. **Network Operations Center (NOC):** This element comprises the cost of an external NOC provider to monitor ESnet's layer 1 optical network and coordinate repairs with ESnet's optical hardware vendors and dark fiber providers. The contribution of this cost element to the *O&M Cost Pool* is scaled by a factor of 20% for the following reason: ESnet's physical presence consists of Hub colocation sites (52 locations) and amplifier locations, called Inline Amplified (ILA) sites, along the fiber route (257 locations). The Hub sites provide space for network equipment for ESnet backbone connections and Site User Connections, while the ILA amplifier sites do not house any equipment specific to Site User Connections. The Hub sites account for 20% of the total number of locations, thus, a 20% scaling factor for NOC costs to the *O&M Cost Pool*.

ESnet calculates the **O&M Cost Pool** as follows:

$$[O\&M\ Cost\ Pool] = [100\%] \times [Network] +$$
$$[100\%] \times [Infrastructure\ Operations\ Maintenance] +$$
$$[100\%] \times [Security\ Operations] +$$
$$[20\%] \times [NOC]$$

Appendix D lists the operational cost elements that are excluded from the *O&M Cost Pool*. These 100% SC-supported operational cost elements relate to core operations expenditures that are aligned with our core principles stated above, or either scale shallowly, or not at all, with Bandwidth or Number of Connections.

Labor Cost Pool Component

The *Labor Cost Pool* is calculated from the following ESnet cost elements, which relate to staff roles that support Site User connections. Each element is multiplied by a scaling factor that accounts for the strength of the scaling with the Number of Connections.

ESnet Staff Type	Role/Activity	Scaling factor	Scaling rationale
Network Operations Center (NOC)	24x7 operations monitoring and Level 1 support; change management; site communication	100%	The cost of people to monitor and maintain the network is directly proportional to the Number of Connections, hence the scaling factor is 100%.
Network Engineering	Level 2-4 operations support; capacity planning	5%	The fraction of time spent to configure, update, monitor, and maintain the Site User connections and their traffic across the ESnet backbone network.
Network Security	Wide Area Network security impacting sites	5%	The fraction of time spent to configure, update, monitor, and maintain the Site User connections and their traffic across the ESnet backbone network.
Systems and Software	Operational support of performance test servers and assistance in running performance reports from the ESnet portal	5%	The fraction of time spent for support of network management, performance, network measurement, data analytics, automation of the network and related hardware in support of user services and troubleshooting capabilities.
Management	Cost calculations and assurance; financial management; communications	1%	The fraction of time spent for oversight of the projects, managing diverse relationships and dealing with policy-related issues.

ESnet calculates the *Labor Cost Pool* as follows:

$$
\begin{aligned}
[Labor\ Cost\ Pool]\ =\ &[100\%] \times [NOC\ Labor]\ + \\
&[5\%] \times [Network\ Engineering\ Labor]\ + \\
&[5\%] \times [Network\ Security\ Labor]\ + \\
&[5\%] \times [Systems\ and\ Software\ Labor]\ + \\
&[1\%] \times [Management\ Labor]
\end{aligned}
$$

Tabulation of the Total Site User Bandwidth and Number of Connections

Each year, typically in the late spring, ESnet tabulates data on the Site User Bandwidth and number of Site User Connections, defined as follows:

- **Site User Bandwidth** is defined as the aggregate bandwidth capacity of ESnet network connections serving the Site User. For example, if a Site User has one 100G and two 10G connections to ESnet, the value of *Site User Bandwidth* is 120G (100G + 10G + 10G) for that Site User.
- **Site User Connections** is defined as the total number of circuits or optical waves connecting a Site User to the ESnet network. For example, if a Site User has one 100G and two 10G connections, the value of *Site User Connections* is 3 for that Site User.

ESnet aggregates this data to calculate:

- **Total Number of ESnet Site Connections** is the total number of *Site User Connections* into the ESnet backbone network, or more specifically, the total number of connections that are purpose-built or leased to connect Site Users to the ESnet network.
- **Total ESnet Site User Bandwidth** is the aggregate bandwidth of all Site User Connections network-wide, i.e., the total bandwidth of all the ESnet edge interfaces toward Site Users.

ESnet User Connection Cost Formula

The ESnet User Connection Cost is calculated using this formula:

$$
\begin{aligned}
ESnet\ User\ Connection\ Cost = &\frac{Site\ User\ Bandwidth}{Total\ ESnet\ Site\ User\ Bandwidth} \times [O\&M\ Cost\ Pool] \\
\\
+ &\frac{Site\ User\ Connections}{Total\ Number\ of\ ESnet\ Site\ Connections} \times [Labor\ Cost\ Pool]
\end{aligned}
$$

Example calculation: A Site User with one 10G connection and two 100G connections has three Connections and an aggregate Bandwidth of 210G. These values are inserted into the formula to determine the ESnet User Connection Cost for the Site User:

$$ESnet\ User\ Connection\ Cost = \frac{210\ G}{Total\ ESnet\ Site\ User\ Bandwidth} \times [O\&M\ Cost\ Pool]$$
$$+ \frac{3\ Connections}{Total\ Number\ of\ ESnet\ Site\ Connections} \times [Labor\ Cost\ Pool]$$

See Appendix E for additional discussion of the cost formula.

Important notes about the ESnet User Connection Cost

In order to incentivize Site User upgrades, ESnet and ASCR do not invoke mid-year increases to the ESnet User Connection Cost. When a Site User adds connections or bandwidth the ESnet User Connection Cost will not change to reflect these additions until the following fiscal year. For example, if a Site User adds a connection in February, the ESnet User Connection Cost calculation will incorporate that additional connection in the fiscal year beginning October 1 of that year. Any direct costs (e.g., circuit costs) associated with the upgrade will still be charged to the Site User mid-year.

ESnet's Issuance of its Annual Budget Request to a Site User

Each year, in the summer timeframe, ESnet issues an Annual Budget Request to each Site User for the upcoming fiscal year.

Implementation of Billing, Contingency, and Reconciliation

ESnet implements the analytic and financial processes for this cost policy on an annual basis.

Annual Cost Analysis

Each fiscal year, ESnet conducts a formal analysis to update estimated costs (direct and indirect) and evaluate Site Users for their estimated Number of Connections and Bandwidth. These estimates are used as the basis for the cost pools and fees charged as described above.

Contingency and Reconciliation

To minimize the risk of unallowable costs (Anti-Deficiency Act violations), ESnet includes a contingency of 10% of estimated costs in the fee charged to each Non-SC Site User. ESnet reconciles the estimates against year-end actuals to ensure that the proposed contingency is maintained, and if used, the site is charged only the delta needed to refresh the contingency back to the 10% level.

Upgrades

When a site requests an upgrade during the year (either a new connection or additional bandwidth), this request will be treated as a project, and will include all costs for equipment and labor associated with the upgrade. Upgrades that occur after the annual snapshot of connections and bandwidth will be incorporated into the following fiscal year. A specific budget summary will be created for the upgrade project and provided to the Site User. Any direct costs (e.g. circuit costs) associated with the upgrade will be charged as they occur throughout the year.

Payments to ESnet

ESnet relies on Site Users to pay assessed costs promptly because any delay places an administrative burden on ESnet that interferes with core mission activities.

In a scenario where a non-SC Site User does not remit funds at the appropriate time, contingency funds provided by that Site User may be used to cover ESnet costs during that time frame. If there are no contingency funds available for that Site User, ESnet will escalate the issue to ASCR and the cognizant DOE headquarters Program Office for resolution. As network connectivity is important to the connected site, ASCR may agree to temporarily cover the incremental cost of supporting the site with ESnet allocated SC funds while resolution is in progress. In extreme circumstances, with ASCR's concurrence, ESnet may cease network services provided to the site after due notice.

Revision of this Policy

This policy is a living document; it may be subject to review and revision by ASCR and ESnet. ASCR holds the authority to reissue future revisions of the policy. ESnet will notify Site Users in a timely fashion of any ASCR reissuance of the policy.

Appendix A: Office of Science Definition of a User Facility

The Office of Science definition of a user facility is as follows:

A user facility is a federally sponsored research facility available for external use to advance scientific or technical knowledge under the following conditions:
- The facility is open to all interested potential users without regard to nationality or institutional affiliation.
- Allocation of facility resources is determined by merit review of the proposed work.
- User fees are not charged for non-proprietary work if the user intends to publish the research results in the open literature. Full cost recovery is required for proprietary work.
- The facility provides resources sufficient for users to conduct work safely and efficiently.
- The facility supports a formal user organization to represent the users and facilitate sharing of information, forming collaborations, and organizing research efforts among users.
- The facility capability does not compete with an available private sector capability.

The Office of Science website[6] contains a rich set of information resources that describe the SC User Facilities enterprise, policies, and user projects.

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[6] https://science.osti.gov/User-Facilities

Appendix B: DOE Order 522.1A: Pricing of Departmental Materials and Services

DOE Order 522.1A contains these special provisions related to User Facilities:

6. ACTIVITIES REQUIRING SPECIAL PRICING CONSIDERATION
   f. Departmental User Facilities.
   (1) Designation of User Facilities that Warrant Special Pricing Consideration. User facilities are those facilities managed and funded by a DOE Program and operated with the express purpose of being available for research by a broad community of qualified users on the basis of programmatic interest, scientific merit of research proposals, technical feasibility, capability of the experimental group, and availability of the resources required. The term user facility includes, but is not limited to: (1) a user facility as described in 42 U.S.C. §13503(a)(2); (2) a National Nuclear Security Administration Defense Programs Technology Deployment Center/User Facility; and (3) any other Departmental facility designated by the Department as a user facility. Examples of Departmental user facilities include accelerators, supercomputers, and x-ray light sources. User facilities are not restricted to a particular type, technical discipline, or size. User facilities not specifically designated by statute must meet the following criteria to be eligible for special pricing consideration (see paragraphs 2 and 3 of this section):
   (a) Designation of a Departmental facility as a user facility has been approved by the cognizant Under Secretary;
   (b) Full-cost recovery from non-DOE users is not required to pay the full cost of operating the facility;
   (c) The designation of the user facility and its availability for research is publicly disclosed to the research community;
   (d) Arrangements for managing intellectual property generated through use of the facility have been approved by the DOE General Counsel and have been disclosed to potential users.
   (2) Pricing for Non-Proprietary Research. Access to user facilities will be authorized at no charge for non-proprietary research that is approved by laboratory management, usually with the advice of a technical advisory committee. The facility manager will determine which requests meet those criteria and report periodically to the cognizant DOE Program Office. Classified research that can be shared in classified journals or classified publications is considered to be non-proprietary for the purposes of this policy. Non-proprietary users may be charged for incremental costs incurred over and above normal use of the facility at the discretion of the facility manager. Such costs may include operating a facility outside of the normal operating mode or schedule; unusual security, safety, or technical arrangements; and consumables.

Appendix C: Cost Policy Decision Matrix Examples

This section provides a short discussion of each scenario in the 2x2 cost policy decision matrix.

Case 1: SC Site User Builds

This case presents when an existing or prospective SC Site User expresses interest in creating a new site connection to ESnet or upgrading an existing site connection to ESnet.

Upon receipt of a formal request in writing from the Site Coordinator, ESnet begins a process of discovery and analysis to validate the request and propose one or more potential solutions that are aligned with ESnet's standard connection models. Based on this analysis, ESnet develops an action recommendation for ASCR's consideration. When ESnet and ASCR agree on a response, ESnet provides the response to the requestor. In cases that are costly and/or complex, ASCR generally makes the final determination, usually in consultation with the sponsor SC program (i.e., BES, BER, FES, HEP, NP).

SC Site Users pay up to partial or whole costs associated with the build based on the principle that ESnet and ASCR should weigh the value proposition of the cost of the request against the benefit of ongoing SC support for ESnet's core network and science services. The division of costs between the Site User and ESnet for SC Site User builds are determined on a case-by-case basis by ASCR and ESnet.

ASCR strongly recommends that major projects requiring network builds budget for those builds "on project." Historically it is typical for the sponsor SC Program to cover the lion's share of costs for such builds. Budgeting for network builds within the project's baseline helps ensure that cost and schedule risks are well managed.

Three hypothetical scenarios are presented in the table below to provide rough illustrations of ASCR's approach to cost determinations.

Example scenario	Description	Addition/build/request	Billing scenario
1	SC Lab X learns of a telecom vendor's new fiber build in their area that could provide additional resiliency for the Lab.	SC Lab X requests acquisition of a dark fiber pair on the new fiber route between SC Lab X location and the ESnet backbone. A 2 km build is required to connect SC Lab X fiber to the vendor's new fiber handhole.	ESnet, ASCR, and SC Lab X will negotiate a consensus cost arrangement. Due to the general benefit to the SC mission of increased resiliency for SC Site Users, bias will be towards ASCR contributions.
2	SC Program Office Y requests ESnet connectivity to a new User Facility or scientific instrument in a remote region, far from ESnet's existing footprint.	SC Program Office Y requests that ESnet acquire connectivity (dark fiber, fiber spectrum, or leased services) to the remote location and extend the ESnet network to the new site border.	ESnet, ASCR, and SC Program Office Y will negotiate a consensus cost arrangement. Due to the large anticipated costs, SC Program Office Y may be expected to contribute a significant portion, perhaps even the whole costs.
3	SC National Laboratory Z is planning to open an additional office in the Washington DC metro area.	SC National Laboratory Z requests a 10G circuit for the new DC office location into the ESnet network backbone.	SC National Laboratory Z is likely expected to cover the entirety of build costs due to the parochial nature of the circuit (lab business operations).

Case 2: SC Site User Ongoing Operations

An SC Site User pays limited or no costs associated with ongoing operations of its site connections. An example of when limited costs may be incurred by an SC Site User would be a Site User-requested connection to a separate location for collaboration or work that is not SC motivated. Such requests will be evaluated on a case by case basis to determine the cost obligation.

Case 3: Non-SC Site User Builds

This case presents when an existing or prospective Non-SC Site User expresses interest in creating a new site connection to ESnet or upgrading an existing site connection to ESnet.

Upon receipt of a formal request in writing from the Site User, ESnet begins a process of discovery and analysis to validate the request and propose one or more potential solutions. Based on this analysis, ESnet develops an action recommendation, including a multi-year cost projection for the Non-SC Site User, for ASCR's consideration. When ESnet and ASCR agree on a response, ESnet provides the response to the requestor.

In general, Non-SC Site Users pay the whole cost associated with the build based on the principle that SC appropriations may not subsidize non-SC activities.

Case 4: Non-SC Site User Ongoing Operations

Each Non-SC Site User pays an annual fee to ESnet (LBNL) based on the incremental cost borne by ESnet to operate and manage the Site User's site connection(s).

On an annual basis, ESnet calculates the Non-SC Site User Cost Pool based on estimated incremental costs to network operations due to the additional aggregate Bandwidth and Number of Connections for Non-SC Site Users.

The individual charges to a Non-SC Site User scale proportionately with the user's link Bandwidth and Number of Connections.

Appendix D: ESnet cost elements not included in the O&M Cost Pool

1. **Network: Circuits:** This element comprises purchased circuits that provide connection for some SC Site Users to the ESnet backbone for sites not served by the ESnet fiber infrastructure.

2. **Network: Colocation:** This element relates to provision of the colocation space and power for all ESnet backbone locations. These colocation costs are essential for all connected users as they are an integral building block of the ESnet backbone, as well as the point where sites connect to the ESnet backbone.

3. **Network: Transatlantic:** This element comprises the transatlantic connectivity via purchased circuits, which primarily benefits SC mission stakeholders.

4. **Network: Network Equipment:** This element covers the routine refresh of existing ESnet network hardware to support the backbone and Site User connections, as well as the incremental addition of new network hardware to increase network capacity on the ESnet backbone.

5. **Network: Network Capacity Growth**: This element covers additional bandwidth capacity added to the ESnet network backbone to address the growth in data coming from or to the connected sites. ESnet executes a capacity planning process that looks at all network interfaces each quarter, and determines upgrades based on analysis of the capacity planning data.

6. **Network: Production Network**: This element spans activities necessary for the support of ESnet's backbone fiber infrastructure, including:
    ● Fiber Indefeasible Right of Use (IRU)[7] for the United States ESnet backbone.
    ● Fiber IRU for the BayExpress and ChiExpress Metro Area Networks.
    ● Fiber IRU for the Long Island MAN (LIMAN).
    ● Ad hoc fiber repairs and fiber relocations as required under the fiber IRUs.
    ● O&M funding to Internet2 for ESnet's portion of the shared Internet2/ESnet optical infrastructure (ESnet5), including fiber and optical node monitoring.

7. **Infrastructure: Software Support**: This element covers the procurement, licensing, and support for enterprise software used at ESnet, including:
    ● Productivity tools for ESnet staff: Slack, Evernote, Zoom, etc.
    ● Productivity tools and cloud hosting for ESnet's software engineering group: JIRA, Standuply, Google Cloud, etc.

8. **Infrastructure: Operations Equipment:** This element covers provisioning of enterprise computing equipment and storage for ESnet's primary (LBNL) and secondary (BNL)

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[7] An IRU is the legal agreement to access and use optical fiber; in general, data service providers do not own optical fiber.

data centers, and network services measurement servers that are installed at ESnet Hub sites.

9. **Infrastructure: CRT Related Costs**: This element covers the space charges for ESnet's footprint on the computing room floor in LBNL Building 59, as well as any improvements made to that area for ESnet equipment.

Appendix E: Additional discussion of the ESnet User Connection Cost Formula

In the example provided of a Site User with one 10G connection and two 100G connections, we saw that the ESner User Connection Cost formula calculation was:

$$ESnet\ User\ Connection\ Cost = \frac{210\ G}{Total\ ESnet\ Site\ User\ Bandwidth} \times [O\&M\ Cost\ Pool]$$
$$+ \frac{3\ Connections}{Total\ Number\ of\ ESnet\ Site\ Connections} \times [Labor\ Cost\ Pool]$$

Another way of thinking about the ESnet User Connection Cost is a sum of calculated values for the different connection types, e.g., a 1G connection, a 10G connection, a 100G connection, etc.:

$$10G\ Connection\ Cost = \frac{10G}{Total\ ESnet\ Site\ User\ Bandwidth} \times [O\&M\ Cost\ Pool]$$
$$+ \frac{1\ Connection}{Total\ Number\ of\ ESnet\ Site\ Connections} \times [Labor\ Cost\ Pool]$$

$$100G\ Connection\ Cost = \frac{100G}{Total\ ESnet\ Site\ User\ Bandwidth} \times [O\&M\ Cost\ Pool]$$
$$+ \frac{1\ Connection}{Total\ Number\ of\ ESnet\ Site\ Connections} \times [Labor\ Cost\ Pool]$$

Our example Site User calculation could therefore also be expressed as:

$$ESnet\ User\ Connection\ Cost = 1 \times [10G\ Connection\ Cost] + 2 \times [100G\ Connection\ Cost]$$

A Site User considering future upgrades can use the cost formula in this way to get a rough sense of the change to its ESnet User Connection Cost, notwithstanding the annual changes to the other elements in the cost formula.