Rural Electric Cooperative Broadband Benchmarking Report

2022 Refresh

Results and insights from a comprehensive data gathering exercise

October 2022

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Introduction

Background and benchmarking project goals

Since NRTC published its first REC broadband benchmarking report in 2020, the number of electric co-ops stepping up to bridge the broadband divide has continued to grow. Now, more than 200 of our electric members have either deployed or are deploying broadband to help meet a critical need for their communities, while leveraging these technologies for a smarter grid.

Rural Electric Broadband Benchmarking Report Refresh

For this report, NRTC and NRECA collaborated to expand the scope of this data, **now including 88 members**, and the topics covered. The reports' goal continues to be to **catalog our members' results to help cooperatives that are evaluating broadband**.

Also, due to the larger sample size we can use correlations in the data to draw insights and highlight **key technology and business trends**.

This report consists of six main sections:

1. Executive summary
2. Use cases and technologies
3. Deployment statistics
4. Subscribers and revenues
5. Business considerations
6. Operations

Cooperative Principle #6: Cooperation among cooperatives … thank you to our members

We are grateful to the co-ops that shared details of their broadband journey with us. Their participation and hard-won experience will benefit the next wave of electric co-ops considering broadband, helping them make fully informed decisions.

Survey population and electric cooperative overview

Electric cooperative overview

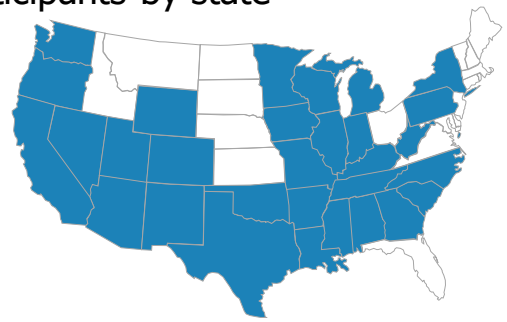
- Serve over **21 million homes and businesses**
- Own and maintain **2.7 million miles** of distribution lines
- Cover **56% of the nation's landmass**
- **831 distribution co-ops** that deliver electricity and other services to their communities
- **63 generation and transmission** cooperatives that provide wholesale power

Survey participants:

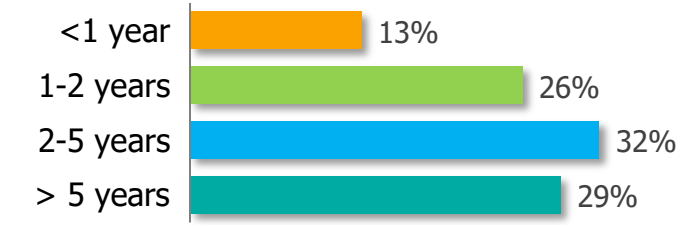
- **88 electric cooperatives** that have deployed broadband
- Members of **various sizes** (as measured by electric meters), representative of the membership as a whole
- Members from **29 states** with diverse characteristics

Participants by meter count

Participants by state



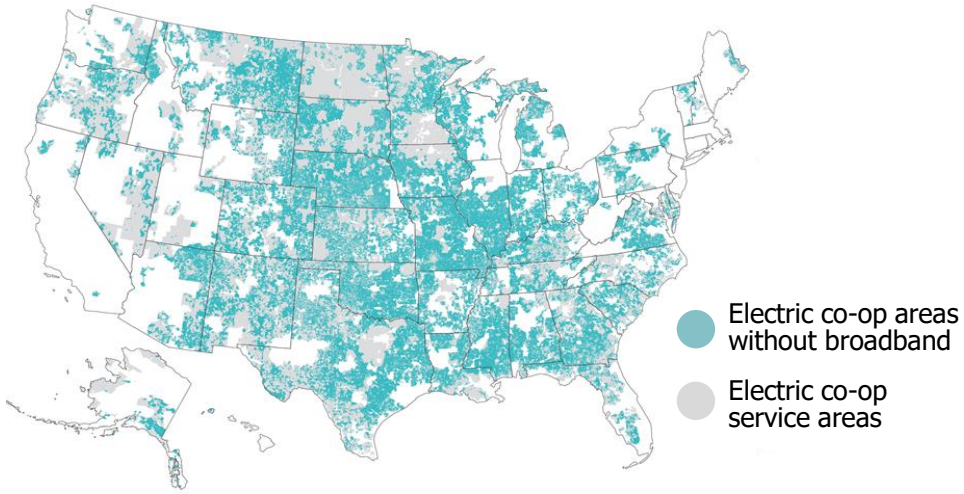
Time since live network



(1) Source: NRECA

Our members are deploying broadband to strengthen their local economies and move to a smarter grid

Electric cooperative service areas are underserved for broadband

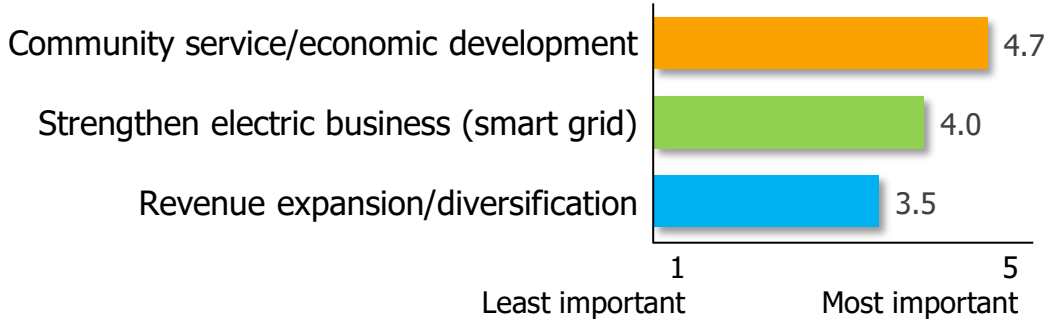


Members are creating smarter grids and smarter communities with an evolving set of technologies

Electric co-ops are positioned to help, they have:

- Poles and other vertical assets, rights of way
- Presence in rural America and member relationships
- A need for broadband for smart grid connectivity
- The ability to finance at attractive rates
- A long-term outlook and understanding of how to build assets

Respondents' motivations to invest in broadband



(1) An electric co-op's ability to engage in the retail broadband business may be impacted by state law and other factors

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Executive summary

We are seeing continued momentum for the trends identified in our first report

Cooperative builds are strengthening **rural economies**

#1 reason
Economic development the primary motivation for broadband

80%
Seeing an increase in population, businesses, or jobs

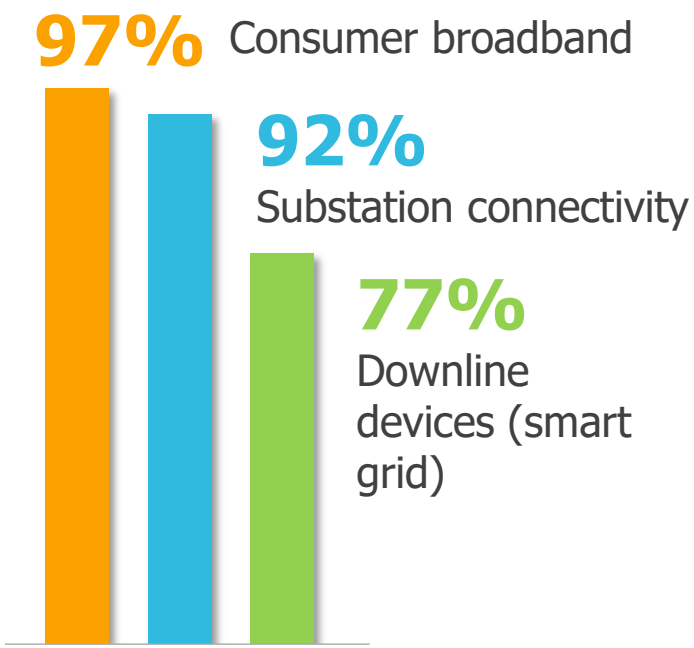
Cooperative builds have been **successful**

75%
Take rates greater than expectations

77%
Favorable response in member surveys

9%
Median internal rate of return

Cooperatives leverage **fiber** for **smart grid** and **broadband**



We are also seeing some clear trends

Technologies

Technologies are evolving

- More use of advanced optical technologies such as XGS-PON
- Momentum for advanced distributed split architectures
- Placement technologies based on plant conditions; ADSS use growing
- Many using full-featured fiber designs to enable efficient network construction and maintenance

Members are building faster, more reliable networks

- Majority of investment is in fiber
- Fiber increasingly leveraged for both consumer broadband and smart grid
- More deploying redundant head ends

Deployment statistics

Costs are rising

- Price pressure on materials and labor leads to a 29% increase in cost per aerial mile for recent projects compared to earlier projects

Economics are positive

- 8% or greater median IRR in all density and tenure cohorts

Business considerations

Cooperative lenders, grants, and partnerships remain key

- 90% borrowed from co-op lenders
- 92% of respondents received at least one grant; 63% received two or more
- 36% of respondents have a partnership in place

Subscribers and revenue

Take rates exceptional for mature networks

- 50% and above seen for those in service for more than two years

Higher data speeds

- Most offering at least 1 Gbps
- Most data plans are symmetrical, highlighting an advantage of fiber

Operations

Members using a mix of staffing models

- Staffing levels vary with network size
- Many look to outsource functions such as help desk & NOC monitoring
- Members say the most difficult issues are reporting/compliance, materials procurement, and hiring

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Use cases and technologies

Definitions

Correlations and trends by tenure and density groupings

In this report, we use correlations in the data to draw insights and highlight key technology and business trends.

Two types of groupings draw out these trends:

- Groupings by "tenure", defined as the time since having a live network with customers
- Groupings by density, defined as locations passed per mile of fiber

Box and whisker charts display deployment statistics and results

Co-op deployments vary widely in many aspects such as technologies used and household density. Therefore, benchmarking results require looking at more than just averages.

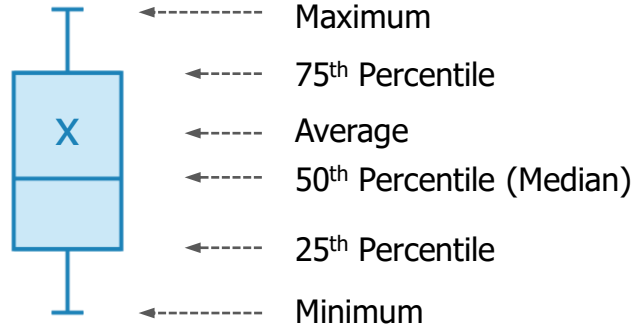
To display and explain results, we use "box and whisker" charts that allow us to:

- Show the range of results from minimum to maximum
- Show both the median and average results
- Show the most common results, defined as the 25th to the 75th percentile range

Respondents by tenure (time since live network)

Respondents by density (locations per mile of fiber)

Box and whisker chart definition



Among respondents, fiber is the overwhelming choice for broadband and smart grid, especially co-ops with recent deployments

Fiber is used both for broadband and smart grid

- Most respondents have a **fiber backbone to their substations**; some use wireless for more remote substations
- Most also use **fiber to connect downline assets** such as automated capacitors, switches, voltage regulators, and reclosers
- Some report using fiber for metering; the most common current use case is backhaul to access points, but WiFi meters and other solutions closer to the consumer location are emerging
- Majority using public wireless (the service of large wireless operators) for workforce/vehicle management solutions
- Co-ops are more likely to build their own land mobile radio networks using private wireless

Use cases and technologies employed (1)

% using each technology	Fiber	Private Wireless	AMI Network	Public Wireless
Consumer broadband	97%	18%	0%	5%
Substation connectivity	92%	17%	0%	8%
Downline assets	77%	18%	18%	9%
Metering	36%	10%	83%	5%
Workforce comms	0%	24%	3%	55%
Land mobile radio	0%	61%	0%	11%

Key trends

Fiber is being pushed deeper into broadband and smart grid networks

- Most respondents that have deployed broadband in the last two years have used **only fiber for both broadband and smart grid**

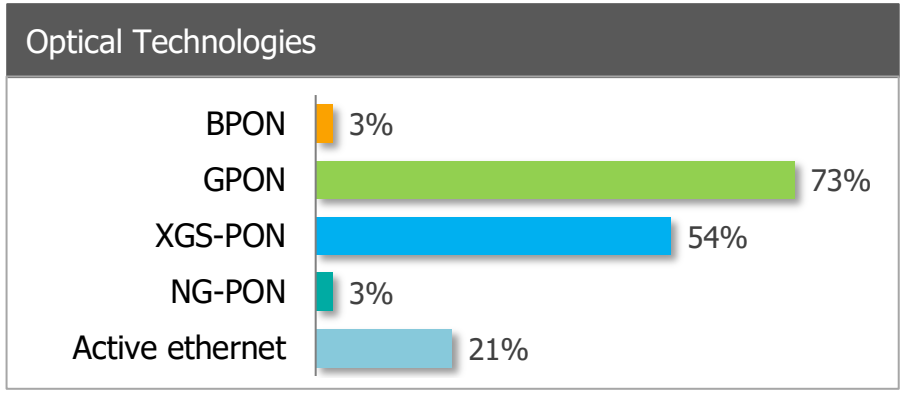
Fiber Only	<2 years	2-5 years	5+ Years
Broadband	94%	70%	75%
Downline	70%	55%	45%

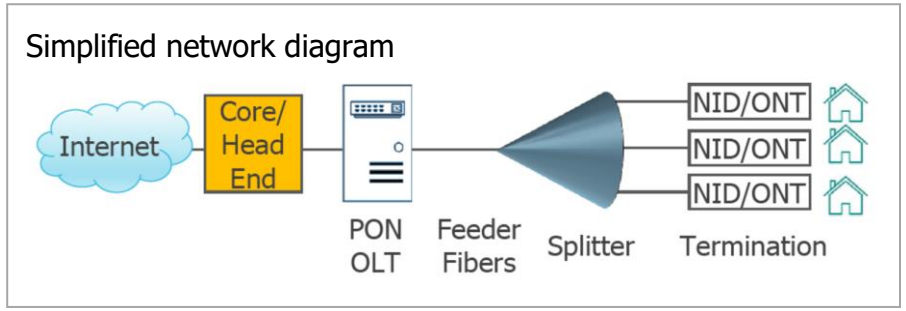
(1) Total can be greater than 100% as more than one technology can be used

Optical access networking technologies

Optical technology has evolved to meet increasing bandwidth demands

- **Passive optical networks (PON)** provide access using centralized electronics and passive splitters in the field; can be upgraded over time to meet 20-30% yearly bandwidth growth and provide higher throughput
- **GPON (Gigabit PON):** Currently the most widely used technology; operating at 2.5 Gbps downstream and 1.2 Gbps upstream; can support 1 Gbps service
- **XGS-PON:** Next-generation PON; more costly but delivers higher symmetrical throughput (10 Gbps down and up); can support more 1+ Gbps services per port, enabling a more efficient architecture for high-throughput services; can be overlayed on a GPON network for easy upgrade and migration
- **NGPON2:** Even more speed (40 Gbps), multiple wavelengths but very expensive
- **Active ethernet:** Provides each subscriber with their own fiber link; usually an option for business customers used along with a PON technology





Key trends

XGS-PON more common in recent deployments, while mature networks are upgrading

- **XGS-PON used by 68%** of newer deployments
- In fact, for those with live customers for <1 year, **89% used XGS-PON**
- Mature networks are **upgrading their electronics**, confirming the expectation of a 5-7 year upgrade timeframe

Tenure	<2 years	2-5 years	5+ Years
GPON	57%	91%	87%
XGS-PON	68%	39%	57%

Distribution architecture

There are three primary distribution architectures

Centralized split

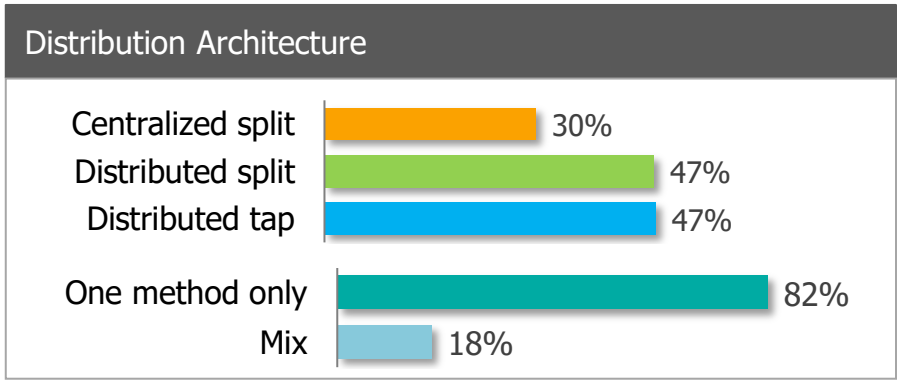
- Architecture historically used by incumbent telcos; still useful in highly dense areas; usually requires larger count cables, driving greater costs

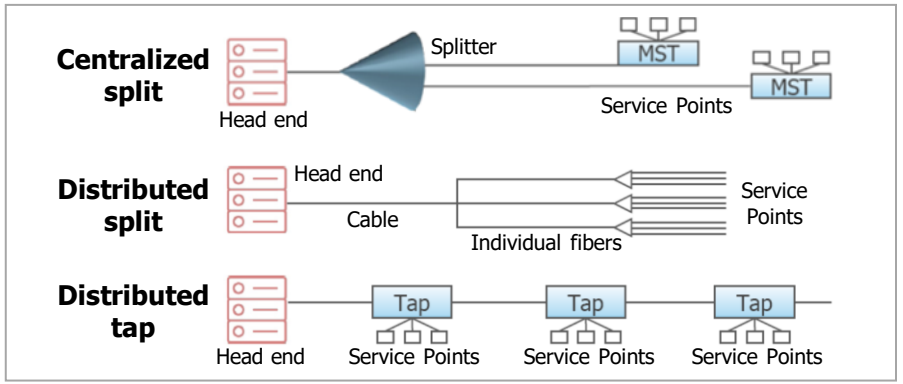
Distributed split

- Latest-generation architecture, cost effective in both dense and rural areas
- Smaller fibers go deeper into the network before being split
- Since splitting is closer to the customer, more capacity is available for the future
- Along with centralized split, has a wide ecosystem due to use by national operators; this ensures compatibility of devices and tools and future support

Distributed tap

- 2nd generation option in less dense areas; taps divert optical signals to subscribers
- Can lead to lower up-front costs by using fewer fiber strands; however, has a smaller ecosystem and significantly reduces flexibility and growth options.





Key trends

Distributed split used most in recent deployments, choice varies by density

- Distributed **split most common** in recent deployments
- **Distributed split and tap** most common in **lower-density** areas
- **Centralized split** used more often in **higher-density** areas

	Tenure			Density		
Architecture	<2 yrs	2-5 yrs	5+ yrs	Low	Mid	High
Cent. Split	21%	32%	23%	8%	23%	33%
Distr. Split	45%	32%	37%	42%	42%	33%
Distr. Tap	34%	36%	40%	50%	35%	33%

Aerial placement technologies

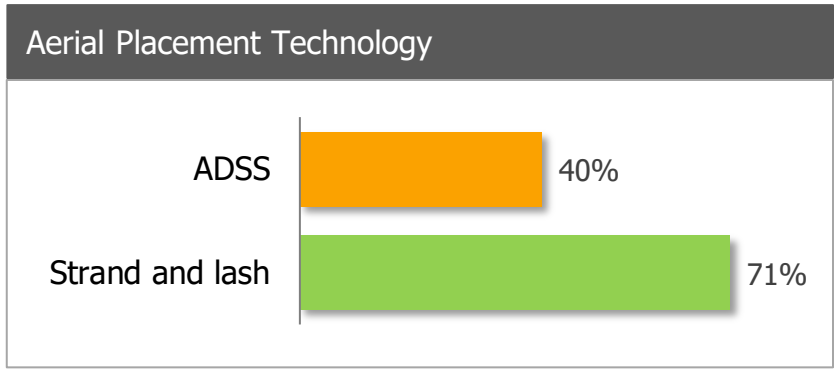
Technologies

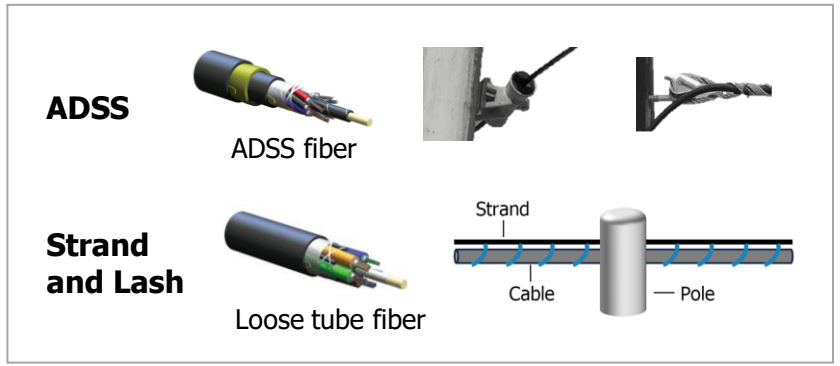
All-dielectric self-supporting (ADSS) cable supports itself between poles without conductive metals; cable runs through a trunnion and is secured with a grommet

Pros	▪ Much less make ready: self-supporting, no messenger required; no bonding/grounding ▪ Less surface area, less wind effect, and ice loading; less long-term maintenance ▪ Can be installed in a single pass operation – decreases build time
Cons	▪ Located in the power space which requires "line-qualified" workers to install ▪ Fiber cables generally cost more than non-ADSS cables of the same size

Strand and lash: Steel support strand placed on pole line and fixed in place with mounting bracket; cable attached to support strand with a lashing wire

Pros	▪ Not located in the power space, fewer worker qualifications required to install ▪ Less costly than ADSS and available in much higher fiber counts ▪ Can be over-lashed to existing cables and over-lashed with additional fibers
Cons	▪ Lower position on the pole; more exposed to risk; conflicts with other telco attachments ▪ Often requires extensive make ready which can lengthen construction timelines ▪ Cannot be installed in a single pass; must be grounded/bonded





Key trends

Recent deployments show uptick in use of ADSS

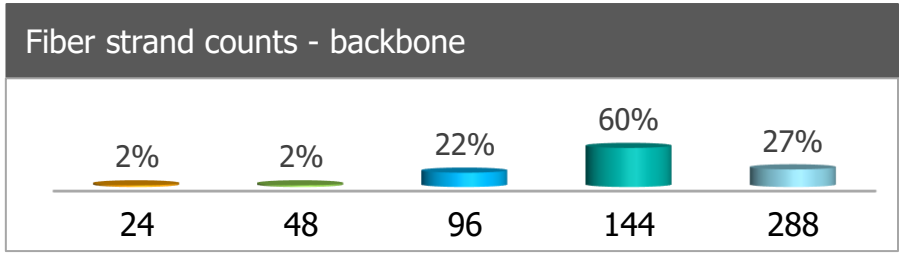
- The recent growth of ADSS likely due to increased availability and awareness of its support and benefits
- Earlier deployments used strand and lash because of its initial use by incumbent telcos with copper networks in urban areas

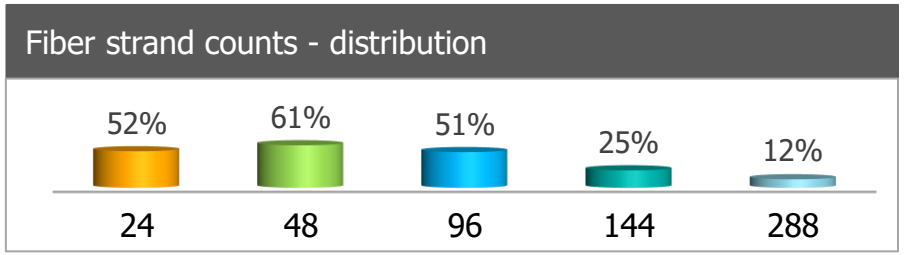
Tenure	<2 years	2-5 years	5+ Years
ADSS	47%	29%	38%
Strand & lash	63%	79%	79%

Fiber strand counts

Members are planning for future demand in their network design

- Strand count is the number of optical fiber strands in a cable
- Higher strand counts carry greater capacity but are more costly
- Backbone networks often have higher strand counts in more densely populated areas and areas where growth is expected over time
- Internet providers use smaller strand counts for distribution to end consumers and in low population areas
- It is important to plan for future demand and use cases including the ability to lease fiber, when allocating strand counts





Key trends

Strand counts vary by density

- Distribution strand counts average **41 in lower densities** and **increase** for dense networks
- Backbone strand counts vary less, but are still lower in lower densities

Average of strand counts

Density	Low	Mid	High
Backbone	124	178	148
Distribution	41	73	91

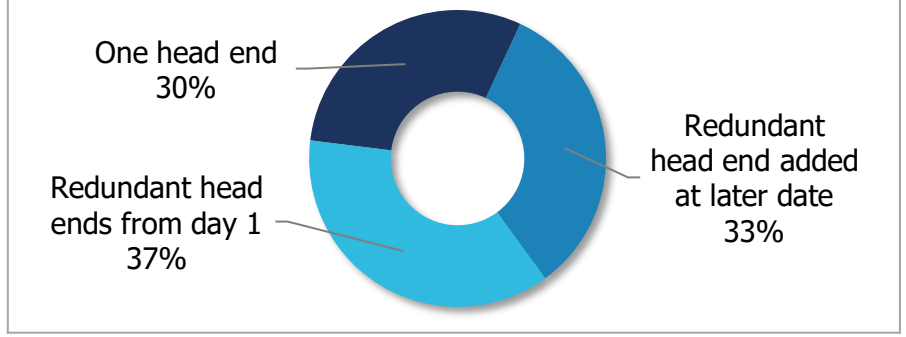
Core network

Technologies

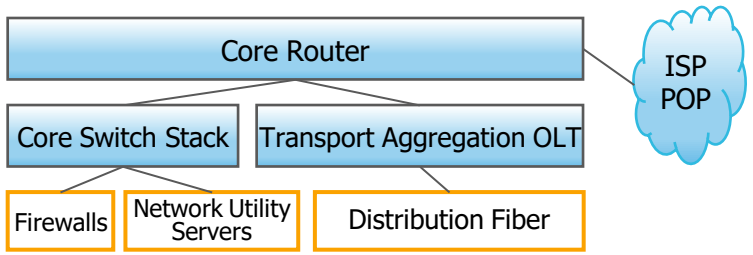
Data traffic from the access network is transported to the head end to reach the layer 3 core router and internet access

- Core switches provide connect servers and firewalls to the network
- Core routers are the gateway to a wide area network (WAN) or the internet, providing IP address routing internally and externally
- Members also face the choice of deploying one head end or redundant head ends
- Transport network nodes at the head ends aggregate traffic and hand up to the core network
- Transport network technologies are beginning to evolve from layer 2-based optical ethernet ring technologies to IP-based and MPLS-based technologies
- Redundant head ends ensure service reliability, especially in a disaster situation; however, redundancy entails more cost

One or two head ends



Simplified network diagram



Key trends

Redundant head ends used most often in recent deployments and dense networks

- **Older builds tend to have one head end**; this may be partially due to the cost of video head ends, which few recent networks support
- **Density is also a factor**, as higher subscriber counts more easily cover the additional cost; note older builds also have lower density

	Tenure			Density		
Head ends	<2 yrs	2-5 yrs	5+ yrs	Low	Mid	High
One	19%	23%	59%	54%	29%	26%
Two	81%	77%	41%	46%	71%	74%

Fiber design

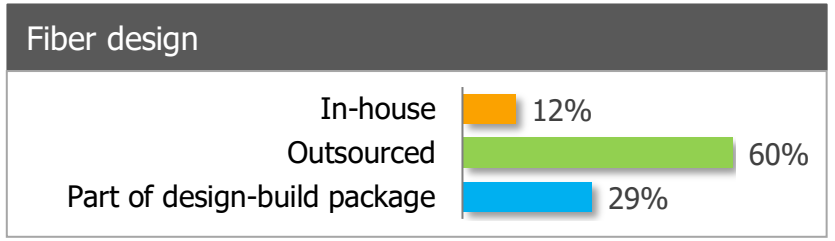
Fully-featured, end-to-end fiber designs include eight main deliverables:

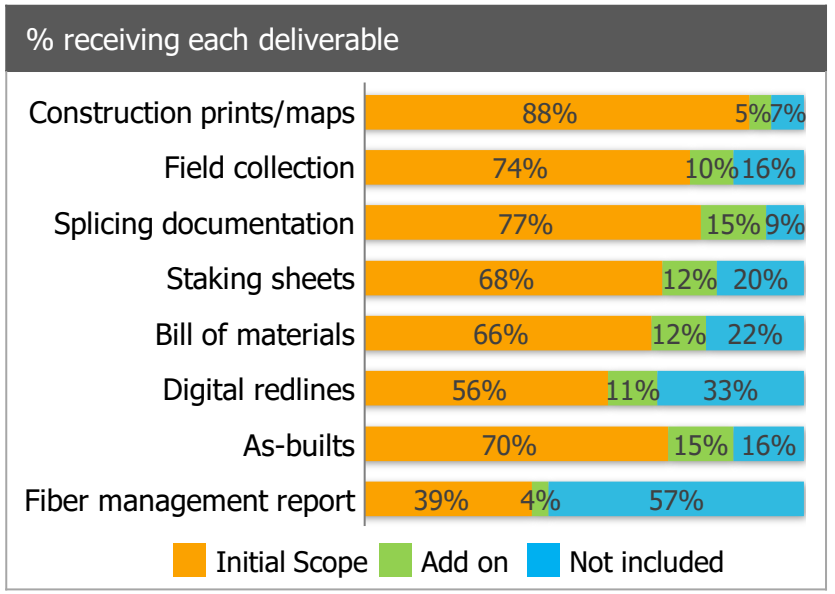
- **Construction prints/maps** are a geographic view of the network; started as CAD prints and have evolved to GIS-based maps
- **Field collection** assesses the existing plant using in-field GIS applications
- **Splicing documentation** lists the required fiber-to-fiber splicing that must take place
- **Staking sheets** detail the required RUS units to construct the FTTH network
- **Bill of materials** lists the materials and RUS units required for construction
- **Redlines** record and validate the plant and equipment, controlling change during construction using a near real time GIS redline process
- **As-builts:** Post-construction geodatabase that feeds a GIS asset management system
- **Fiber management system reports** detail fiber assignments from the central office to the customer, facilitating accurate operations and provisioning

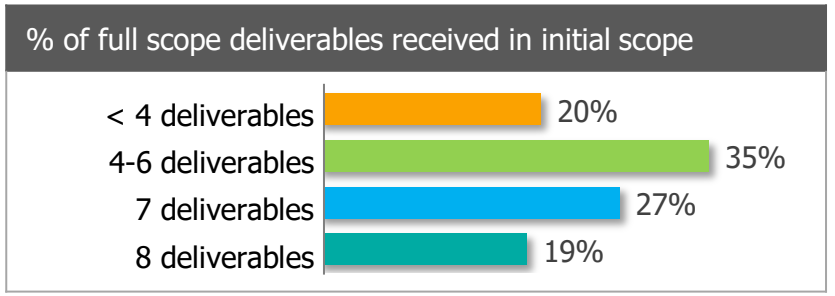
Advanced GIS-based designs seamlessly capture and integrate data from each of these, creating efficiency in network construction and maintenance

Members receive many of these deliverables; however, most do not receive them all in the initial scope provided by their design firms

- Most members receive the main deliverables in the initial scope or as an add-on service
- However, only 19% of respondents received all deliverables in the initial scope







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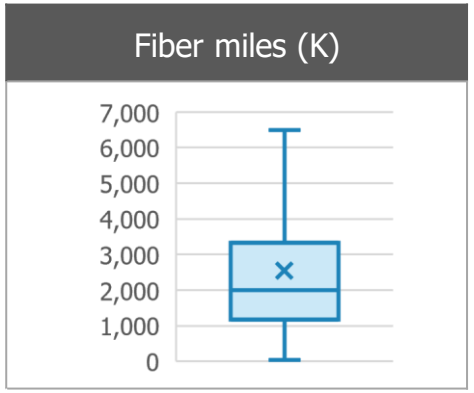
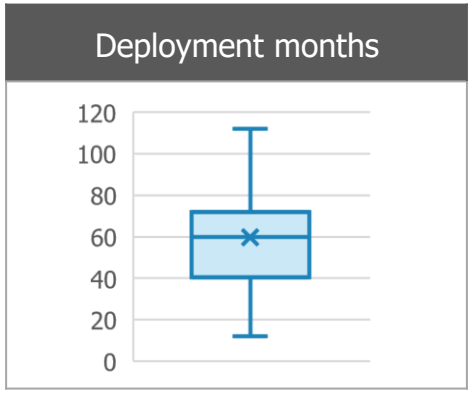
Deployment statistics

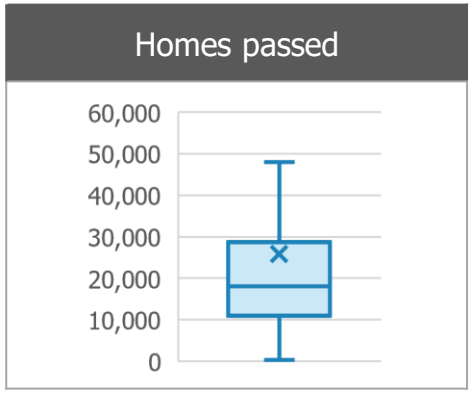
Deployment statistics

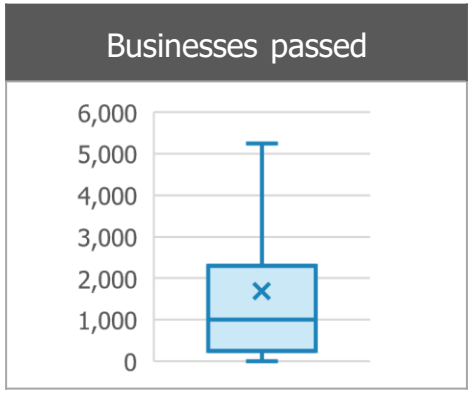
The characteristics of cooperative deployments vary widely:

- Median **deployment timeline** of 5 years
- On average, respondents were 3 years into the 5-year total build; however even after the main build is completed, edge outs continue
- The **median total project was**:
  - 1,990 fiber miles
  - 18,000 homes passed
  - 1,000 businesses passed









Key trends

Project density varies significantly

- Median fiber miles have remained consistent over time, however, earlier projects had fewer locations per mile
- The high-density group had 3x the locations per mile as the low-density group

Tenure	Fiber miles	Locations	Loc./Mi(2)
<2 yrs	2.0K	21K	12.5
2-5 yrs	1.8K	19K	13.0
5+ yrs	2.0K	15K	8.7

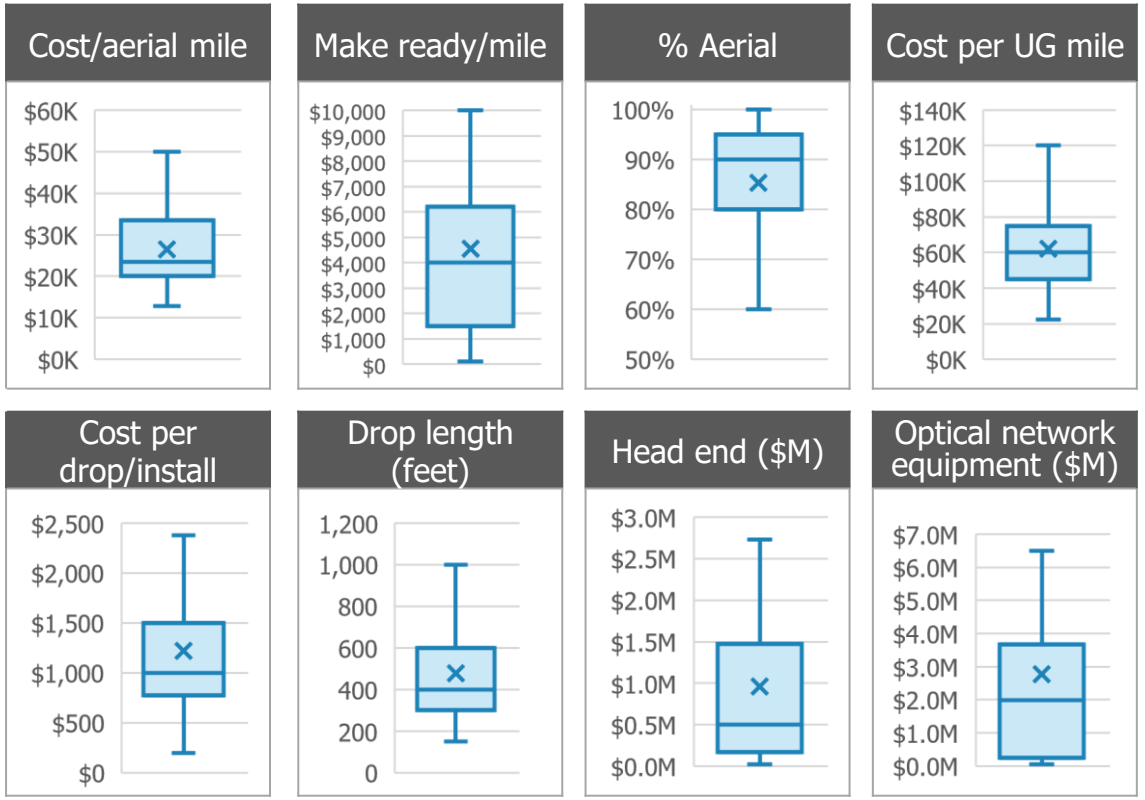
Density	Miles	Locations	Loc./Mi(2)
Low	2.0K	10K	5.1
Mid	2.0K	20K	9.9
High	1.4K	27K	16.4

(1) Data represents the total project, not construction to date
(2) Represents median locations per mile for individual members, not based on median miles and locations for each cohort

Deployment costs

The costs of cooperative deployments vary; however, metrics converge around averages that can be used for planning:

- Median **cost per aerial mile** of $23,375; variation caused by the amount of make ready, placement, and strand counts
- Median **make ready cost per mile** $4,000; variation caused by plant age, pole condition, and terrain challenges
- Median **percent aerial** of 90%, driven by the characteristics of the existing electric plant
- Median **cost per underground mile** of $60,000 driven by terrain and strand counts
- Median **cost per service drop, including installation** of $1,000; variation due to drop length and drop type (overhead, underground)
- Median **head end** median cost was $500,000; variation caused by network size, redundancy, and services offered such as video



Key trends

Costs are going up

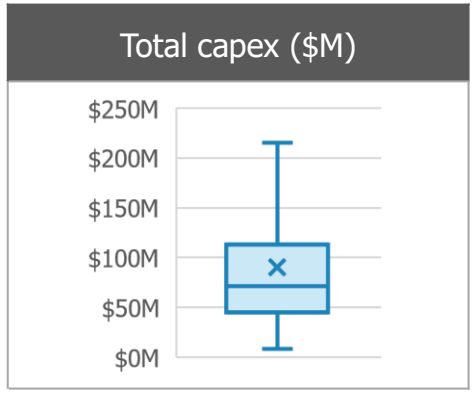
- Cost per aerial and underground mile are highest in the most recent deployments
- This is due to **price pressures on materials and labor**

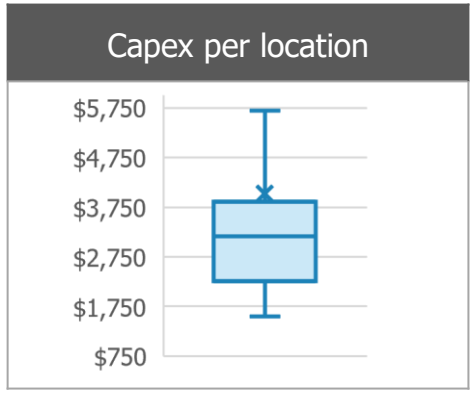
Tenure	$/aerial mile	$/UG mile
<2 yrs	$28K	$79K
2-5 yrs	$24K	$51K
5+ yrs	$22K	$57K

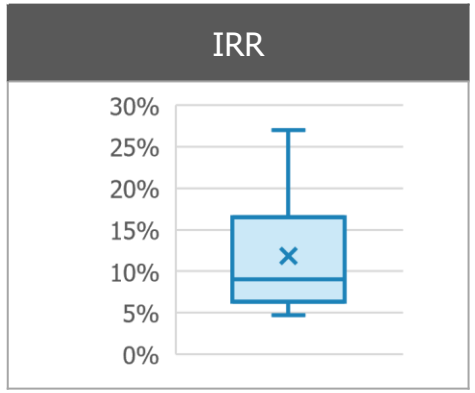
Density	Drop $	Drop feet
Low	$1,047	400
Mid	$1,200	513
High	$825	307

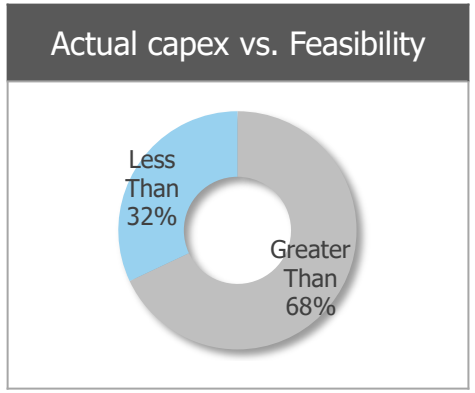
Deployment costs and return

- Median **project capex** of $72 million, with a large range of project sizes
- Median **internal rate of return (IRR)** of 9%
  - Given the ability to access capital at favorable rates through cooperative lenders, this generally indicates positive economics of the broadband business
- 68% of respondents said the actual capex was greater than their feasibility forecast; reasons for this are generally:
  - Greater take rate (causes more drop costs)
  - Change in scope (miles, homes covered, etc.)
  - Greater costs than expected for equipment, make ready, and labor









Key trends

Members reported positive economics

- Project cost has increased since the earlier deployments
- Cost per passing correlates with density
- **>8% median IRRs in all tenures and densities;** many variables contributing including grants, costs, and take rates

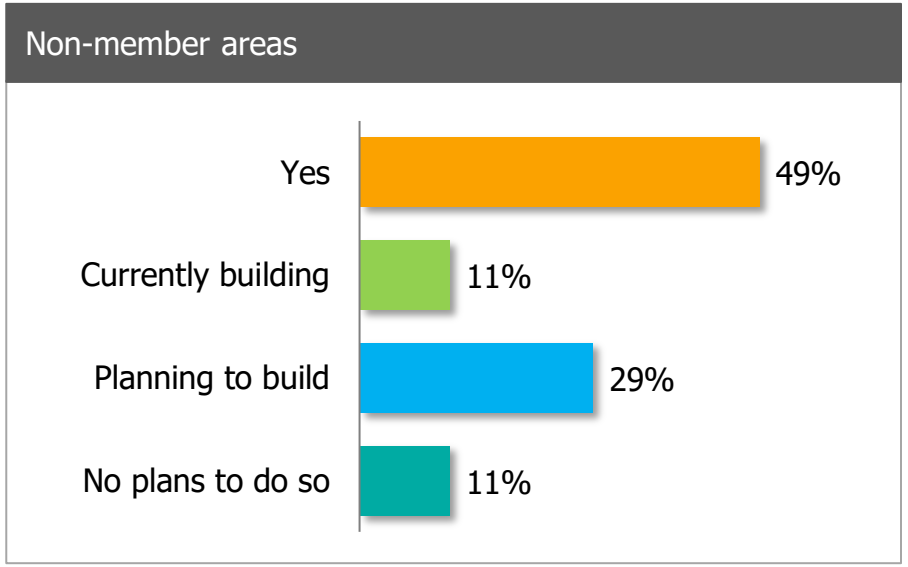
Tenure	Capex	Per Passing (1)	IRR
<2 yrs	$75M	$3.3K	9%
2-5 yrs	$79M	$2.7K	15%
5+ yrs	$48M	$3.6K	10%

Density	Capex	Per Passing (1)	IRR
Low	$60M	$7.3K	13%
Mid	$79M	$3.5K	9%
High	$62M	$2.1K	8%

(1) Represents median locations per mile for individual members, not based on median miles and locations for each cohort

Non-member areas

- Cooperative broadband projects generally start with a focus on the connectivity needs of the membership
- When members begin evaluating the needs of their area, however, many find that they can help communities outside of their service territory
- Doing so not only provides a service to unserved areas, but provides better scale and economics to the overall network
- 60% of respondents have built or are building "non-member" areas
- Only 11% said that they have no plans for these areas



Key trends

Regardless of tenure, most members plan to serve non-member areas

- Most members with customers for over two years have built to non-members
- Fewer new projects have built to non-members, but many are planning to do so in the future

Tenure	Yes/building	Planning to	No
<2 years	33%	56%	11%
2-5 years	78%	11%	11%
5+ years	68%	21%	11%

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Subscribers and revenue

Take rates

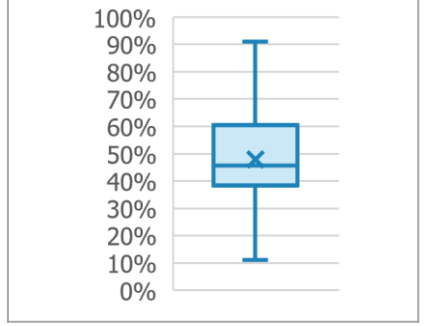
Take rate is the percentage of covered homes and businesses that become subscribers; primary factors influencing take rate are:

- Degree of competition in an area
- The service plans being offered (speed, services, etc.)
- Price

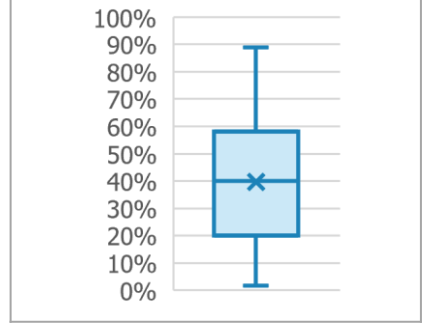
Cooperatives have been able to achieve attractive take rates due to their focus on quality and their relationships with their members

- Median **residential take rate** of 46%
- Median **business take rate** of 40%
- **Take rates vs. the feasibility forecast:** 75% of respondents said the actual take rate was greater than their feasibility forecast

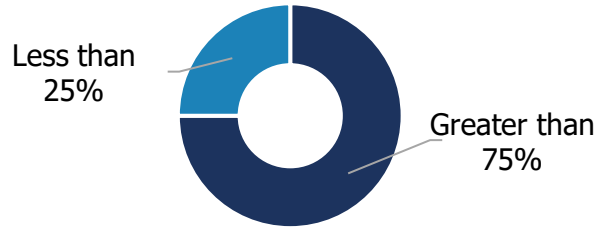
Current res. take rate



Current business take rate



Actual take rates vs. Feasibility



Key trends

Take rates for mature networks and low-density projects exceed 50%

- Members **quickly ramp their take rates**, with projects reaching more than 50% in 2-5 years
- Low density areas have higher take rates, presumably due to **less competition**

Residential take rate – To date and total project (1)

Tenure	To date	Total project
<2 yrs	34%	45%
2-5 yrs	53%	54%
5+ yrs	50%	50%

Density	To date	Total project
Low	49%	53%
Mid	46%	52%
High	43%	45%

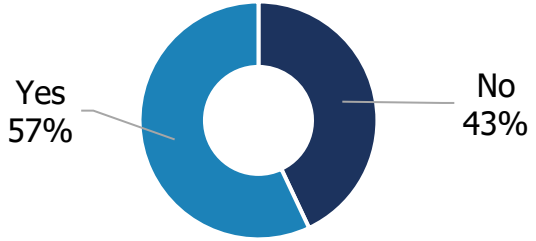
(1) "To date" represents the current take rate of current locations passed; "Total Project" represents the total anticipated take rate from the total locations passed once the project is complete

Member surveys

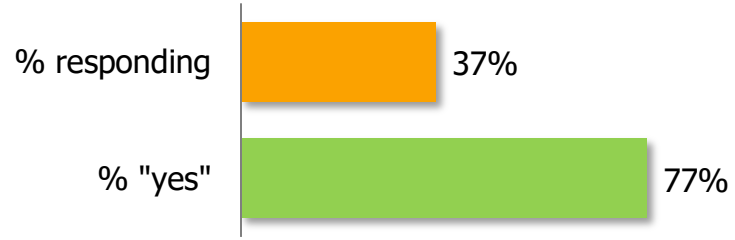
Prior to deciding to deploy broadband, many co-ops conduct a member survey

- Member surveys help **gauge member interest** in broadband and help **confirm potential project take rates**
- Surveys can **take many forms (telephone, mail, email, hybrid)** and ideally conform to research standards, allowing for a confidence level and margin of error
- Many members use **tools such as CrowdFiber** to visualize a territory, gauge availability of existing broadband options, use speed test data to assess potential competitors, and interactively communicate with members to measure their interest in broadband service

Completion of member survey



Median survey results



Key trends

Most recent projects conducted a member survey

- Awareness of the benefits of member surveys has increased their use among cooperatives

Tenure	<2 years	2-5 years	5+ Years
Survey	81%	47%	44%

Competition

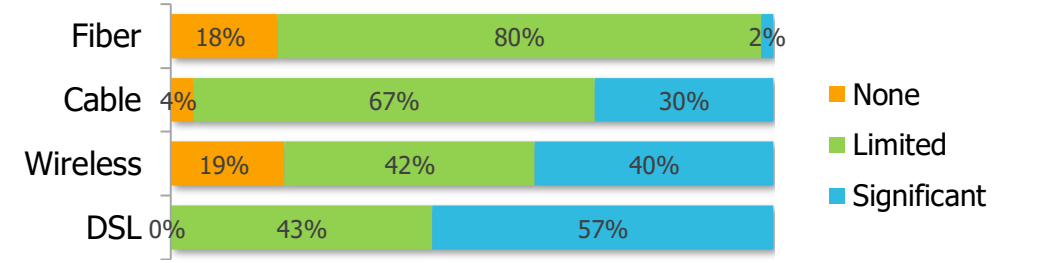
Members see limited competition from fiber and cable

- This result is intuitive as the impetus for these projects is to meet community needs where broadband options are lacking
- Additionally, most respondents received grants for areas that lack robust broadband options

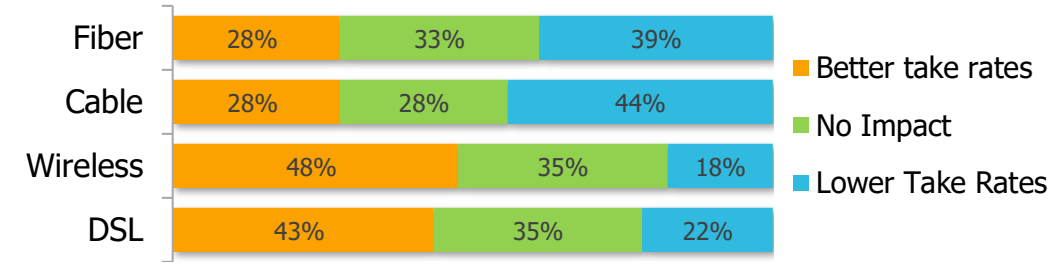
Members are competitive with incumbents even where competition exists

- Most members experienced a low impact on their take rates where fixed wireless or DSL competition exists
- 56% of members also experienced a low impact to take rates even where fiber and cable competition exists

Competitive broadband options – coverage by technology



Take rate impact due to competition – by technology



Key trends

Competition concentrated mainly in the higher densities; newer projects seeing more competition

- Isolating cable competition, most often seen in these areas, significant competition only seen in **higher densities**
- Significant competition mostly seen in **newer projects**

Presence of cable competition

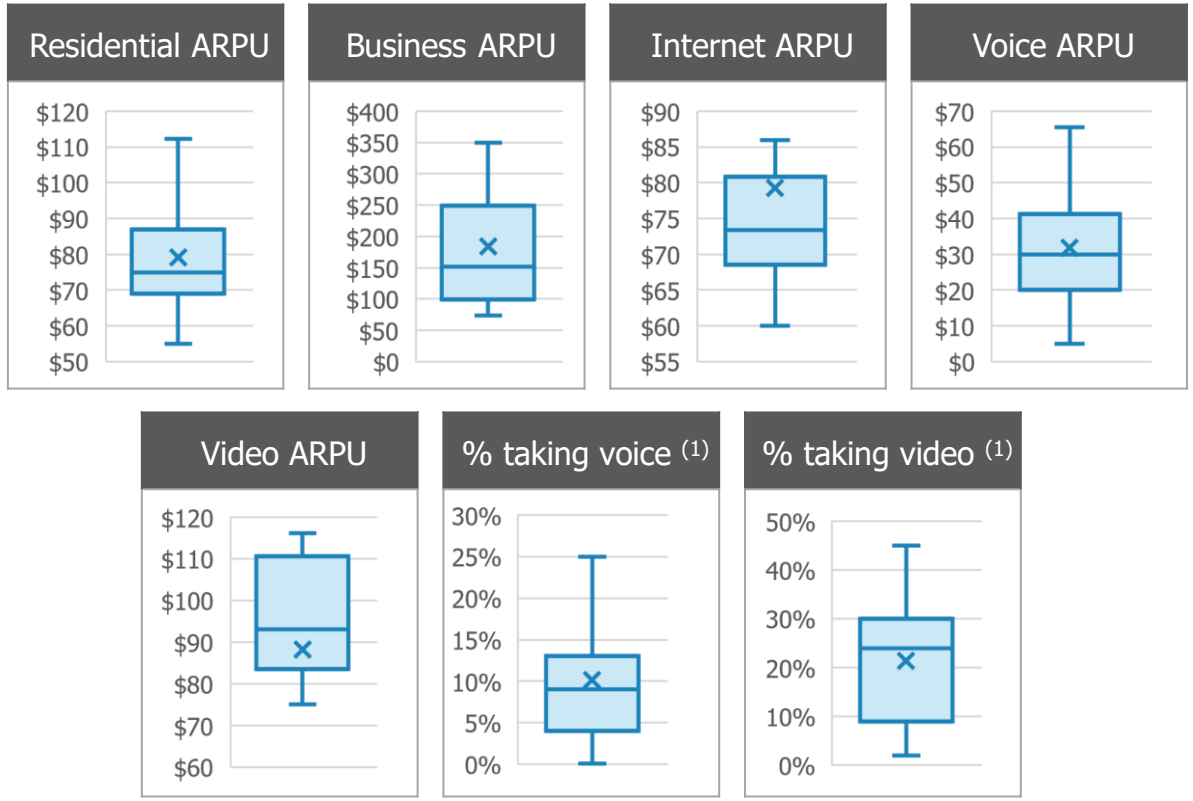
Tenure	None/limited	Signif.
<2 yrs	58%	42%
2-5 yrs	71%	29%
5+ yrs	83%	17%

Density	None/limited	Signif.
Low	92%	8%
Mid	83%	17%
High	44%	56%

ARPU

Median average revenue per user per month (ARPU) results:

- **Residential**: $75
  - Cooperatives offering more services (such as voice and video) have higher average revenues due to more service offerings
- **Business**: $151
- **Internet**: $73
- **Voice**: $30 with 9% of customers taking this service
- **Video**: $93 with 24% of customers taking this service



Key trends

ARPU is lower in more recent projects and in higher densities

- Recent projects report $17 lower ARPU than earlier ones
- This is due to **fewer video offerings among recent projects** and likely **more competition** in these areas
- Higher densities see lower ARPU due to greater competition

Tenure	Res. ARPU	% offering video
<2 years	$74	8%
2-5 years	$75	22%
5+ years	$91	42%

Density	Res. ARPU
Low	$87
Mid	$77
High	$74

(1) Take rate for those offering the respective service

Price plans

Most members offering high-speed, symmetrical rate plans

- A benefit of fiber is the ability to efficiently offer symmetrical speeds
- Almost all respondents reported offering symmetrical speeds

End customers choose plans based on their needs and ability to spend

- Most consumers choosing low and mid tiers
- Consumers choose high tiers if their use cases (high video and gaming use) justify the spend

Avg residential rate plans	Speed (Mbps)	Monthly price	Customer mix
Low tier	100	$55	55%
Mid tiers	375	$72	29%
High tier	1000	$95	15%
Income qualified tier	88	$30	1%

Avg business rate plans	Speed (Mbps)	Monthly price	Customer mix
Low tier	100	$80	61%
Mid tiers	500	$177	31%
High tier	1000	$408	9%

Graphs represent the median speed and price per tier; Low and high tiers as reported by members, "Medium Tiers" represents the average of tiers between low and high

Key trends

Members offer robust speeds regardless of density

- Low density areas have only slightly lower average speeds

Residential download speed by density

Density	Low tier	Mid tier	High tier
Low	60	276	886
Mid	122	517	1,136
High	105	360	1,004

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Business considerations

Funding sources - loans

Multiple sources are available for loans to rural cooperatives

CFC and CoBank are the most popular lenders to electric cooperatives

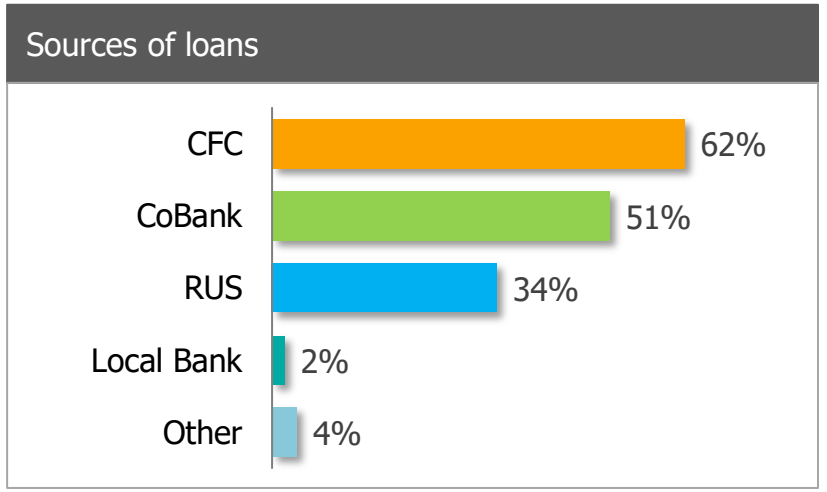
- Both lend to cooperatives based on their total business rather than the specific broadband project
- This allows them to lend at very favorable rates due to the electric cooperatives' strong balance sheets and long positive history of operations
- CFC and CoBank's aggregate loan commitments to electric distribution cooperatives related to broadband projects as of September 30, 2022 exceeds $4.5 billion

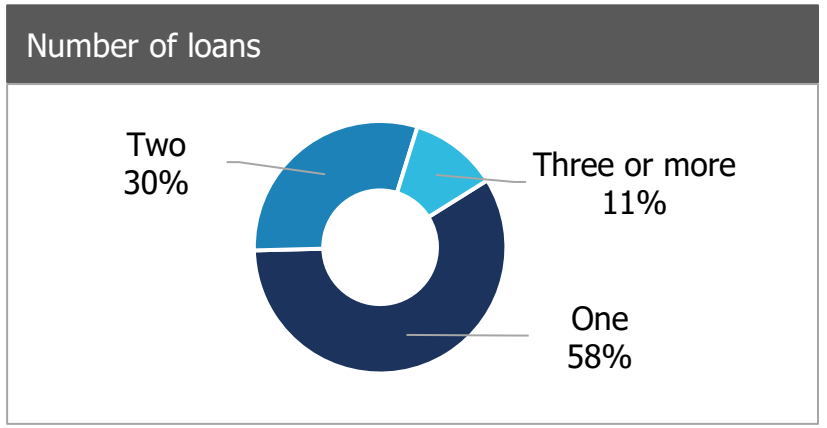
USDA's Rural Utilities Service (RUS) administers several loan and grant programs that apply to telecommunications services

- RUS provides loans and loan guarantees for rural broadband deployments and smart grid initiatives that can can aid in the support and deployment of broadband

Members take advantage of several sources of loans

- 42% of respondents use more than one lender
- 90% received a loan from a cooperative lender - CFC, CoBank or both





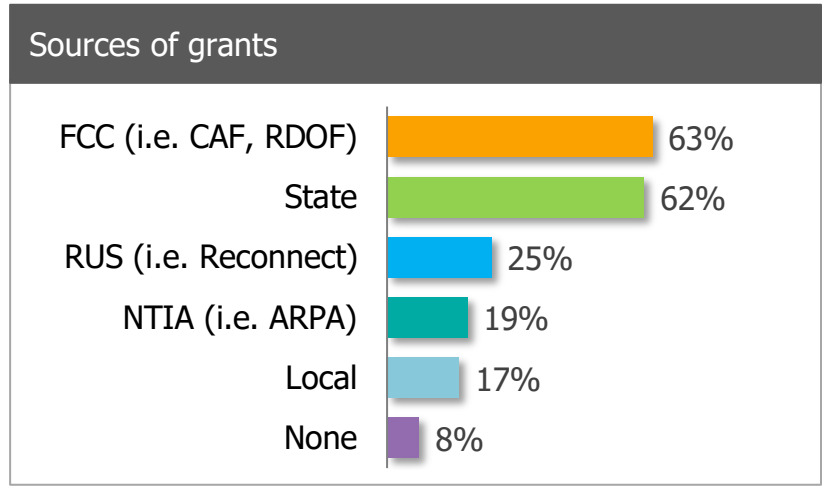
Funding sources - grants

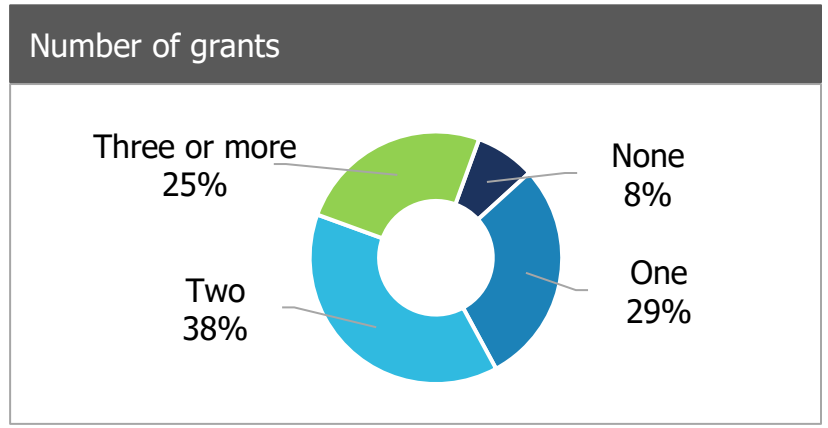
Among many government programs available to rural cooperatives are:

- The **FCC** in recent years held reverse auctions for support
  - The **Connect America Fund (CAF)** II auction took place in 2018 and the **Rural Digital Opportunity Fund (RDOF)** took place in 2020
- **State and Local**
  - **Broadband Equity, Access, and Deployment (BEAD):** $42.5 billion federal grant program allocated to the states to manage – to be distributed in 2023-2024
  - States have also managed grants funded by the **American Rescue Plan (ARPA)** and from their own general revenue – to be distributed in 2023
  - States will also be allocated $2.75 billion from the **Digital Equity Act** directed at broadband adoption and affordability
- **RUS** administers the **ReConnect loan and grant program**; there have been several rounds of this program – rounds 3 and 4 took place in 2022
- **NTIA** manages several broadband programs, including BEAD, **Tribal Connectivity, Connecting Minority Communities, and Middle Mile grant programs**

Members take advantage of several grant programs

- 92% of respondents received at least one grant, 63% received two or more





Business structure and allocations

Basic business/tax structures

Multi-divisional cooperative

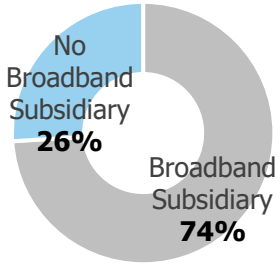
- Electric and broadband are divisions; gains/losses are on a divisional basis
- Management services, cost sharing, leases, loans, between divisions and are eliminated from the 85-15 test to determine tax exempt status

Wholly-owned subsidiary

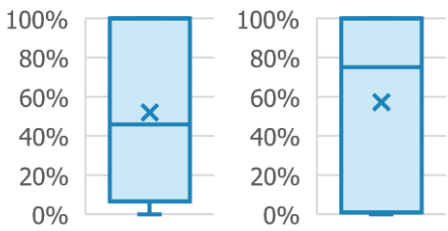
- A new broadband subsidiary is set up and capitalized
- Management services, fiber lease, and related agreements executed
- Record equity method earnings; dividends paid result in non-member income in the 85-15 test

The most common reasons to create a subsidiary cited by respondents are to separate regulated businesses and to comply with state requirements

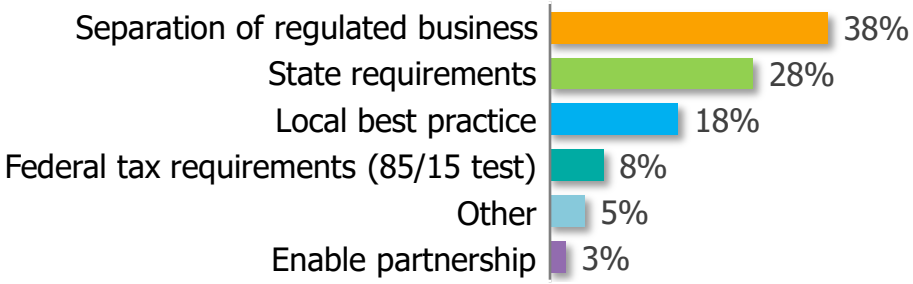
Business structure



% Allocated to electric business



Reasons for creating a subsidiary



Key trends

More members are creating subsidiaries

- This may be due to subsidiary requirements in states such as Mississippi and Tennessee that have a lot of recent deployments

Tenure	<2 years	2-5 years	5+ Years
Subsidiary	89%	67%	63%

(1) Information on basic business/tax structures is a summary by NRTC of the memo entitled *"Tax Issues Related to the Provision of Broadband Services by Tax-Exempt Electric Cooperatives',* dated July 10, 2017 from Bolinger, Segars, Gilbert & Moss, LLP to NRECA (available to NRECA voting members)

Partnerships

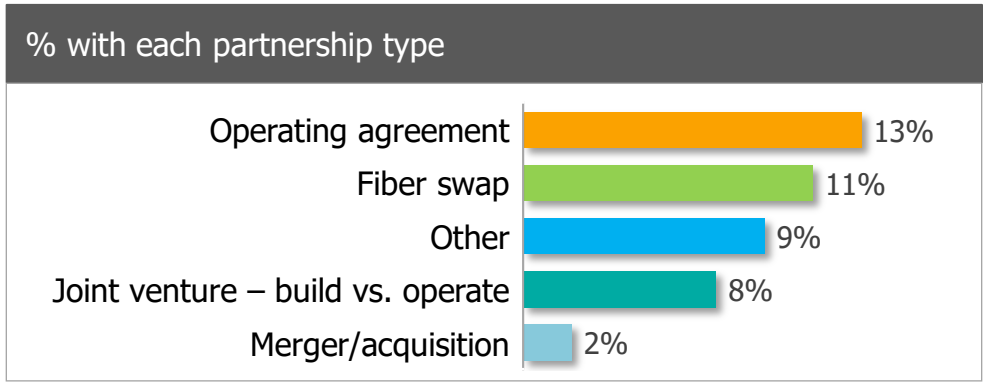
Members report entering various types of partnerships

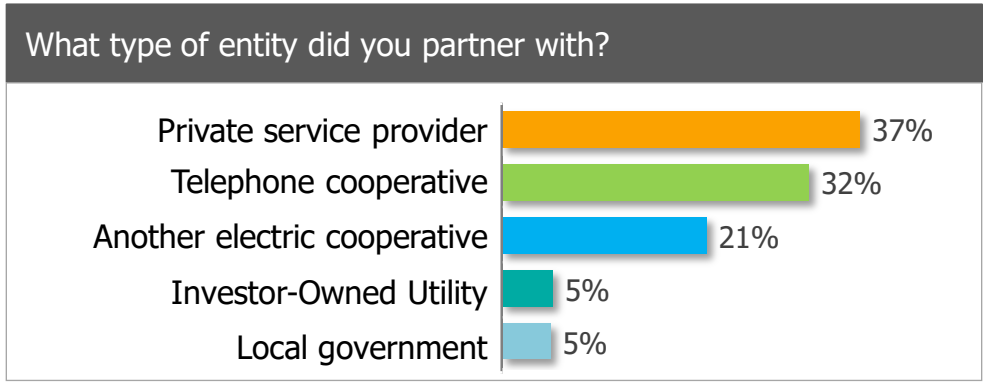
- A typical **operating agreement** is when an electric builds and maintains the network and partners with an ISP that handles customer operations
- **Fiber swaps** to augment each partner's network
- **Joint venture** to build and operate a broadband business
- **Merger/acquisition** to form a unified company

In addition, members note that they have entered partnerships for telephony, leased fiber, and provision of video services

Types of entities

- The most common partners among respondents are service providers, both private providers and telephone cooperatives
- Some also cite partnering with other electric co-ops, IOUs and municipals





Key trends

Partnerships are more frequent in denser areas

- This is likely due to the greater presence of existing service providers in these areas or adjacent to them

Density	Low	Mid	High
Partnerships	27%	33%	44%

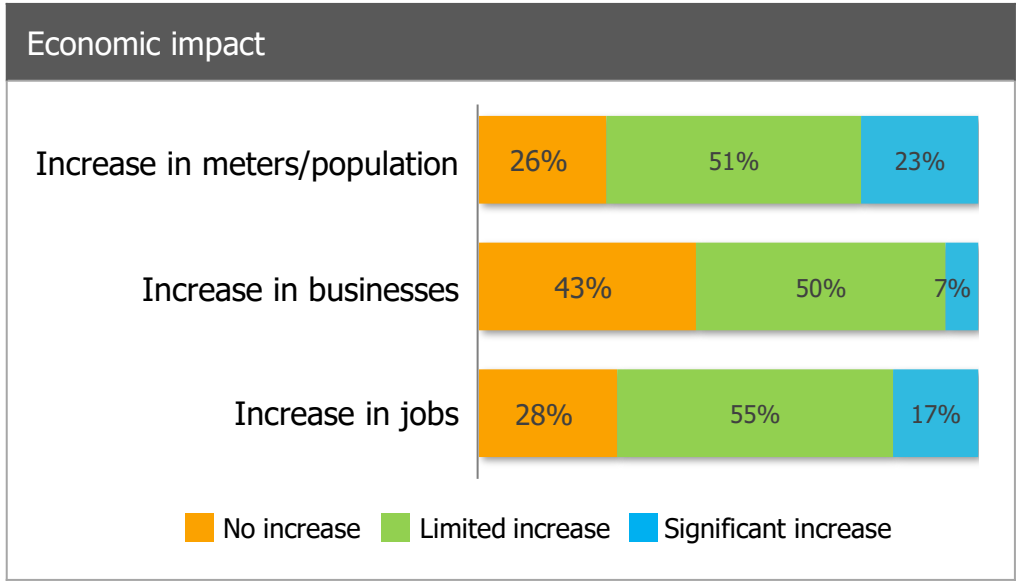
Economic impact

Broadband services have positive effects on local economies

Most respondents do not report quantified results, but share evidence of positive economic impacts such as:

- Increase in electric meters and population
- New businesses: Members cited new data centers, crypto mining operations
- Increase in homebuilding, planned communities, and property sales
- Increase in population moving in – and staying longer
- Increase in people working from home

Taken together, 80% of members report seeing an impact to their local economy from deploying broadband



Key trends

Economic gains take time to materialize

- 85% of respondents in operation for more than two years saw an increase in meters/population compared to 54% of newer projects

Increase in meters	Limited Increase	Significant increase
<2 years	46%	8%
2-5 years	63%	25%
5+ years	47%	35%

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Operations

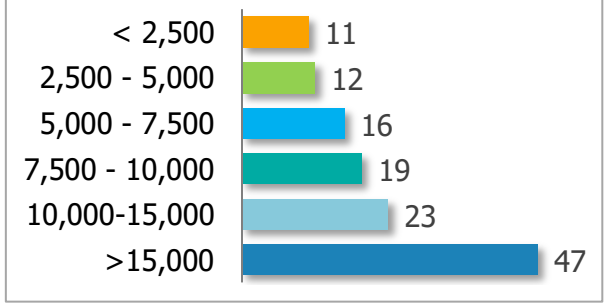
Broadband organization composition

Just as the size of deployments vary, staff composition varies depending on the size of the organization and staffing models

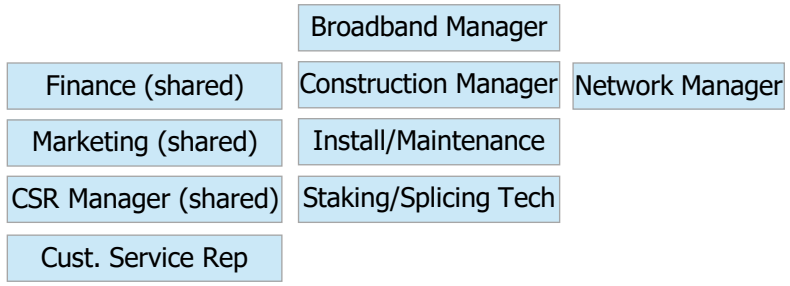
- There is a correlation between subscriber and staff counts
- Co-ops build dedicated teams and use shared resources from electric operations
- Members also often choose to outsource functions such as help desk, installation, and NOC monitoring
- The median staffing model from respondents includes:
  - Broadband Manager, Marketing, and Finance
  - Outside Plant Manager and Mapping/Staking Tech
  - IT/Engineering (2) Customer Service Reps (2), Maintenance Techs (2), and Install Techs (2)

Functional staffing results	25th percentile	Median	75th percentile
Broadband Manager	1.0	1.0	1.0
Admin Assistant	0.0	0.0	0.5
Outside Plant Manager	0.1	1.0	1.0
Construction Manager	0.0	0.0	0.8
Administration	0.0	0.3	1.0
Marketing	0.0	1.0	1.3
Mapping / Staking Tech	0.1	1.0	1.5
IT / Network Engineering	1.0	2.0	2.0
Warehouse	0.0	0.5	1.0
Purchasing	0.0	0.3	0.5
Finance/ Accounting	0.3	0.5	1.0
Customer Service Reps	1.0	2.0	4.0
Maintenance Techs	1.0	2.0	3.0
Installation Techs	0.0	2.0	4.0
Total	**4.4**	**13.5**	**22.5**

Internal staff size by subscriber count



Typical Org Chart



Function	In-source	Out-Source	Both
Marketing	74%	13%	13%
IT / network engineering	69%	15%	17%
Purchasing	81%	8%	11%
Customer service	74%	7%	19%
Help desk	32%	42%	26%
Network (NOC) monitoring	52%	33%	15%
Installation	35%	31%	33%
Regulatory & compliance	47%	18%	35%
Grant writing	45%	29%	27%

Identifying difficult issues

Members have different experiences with standing up and running a new broadband business

- We asked members to rank 14 issues in terms of difficulty
- Interestingly, every issue ranked "least difficult" by at least one member and every issue ranked "most difficult" by at least one member
- However, by looking at the average response and the mode (most frequent), we can understand which issues members view as more difficult
- Some issues, such as materials procurement and operational readiness, rank as the most difficult for newer projects
- Reporting and compliance are difficult regardless of the maturity of the network

Top 3 issues by tenure

<2 years	2-5 years	5+ years
Materials procurement	Reporting & compliance	Reporting and compliance
Operational readiness	Materials procurement	Securing funding
Reporting & compliance	Marketing and competition	Hiring

Difficulty of issues (1: Least, 14: Most)

Issue	Avg	Min	Max
Reporting and compliance	9.8	1.0	14.0
Materials procurement & logistics	8.9	1.0	14.0
Hiring	8.5	1.0	14.0
Securing funding	8.2	1.0	14.0
Corporate structuring & taxation	8.1	1.0	14.0
Operational readiness	8.1	1.0	14.0
Permitting & rights-of-way	7.3	1.0	14.0
Project management	7.1	1.0	14.0
Network management	6.8	1.0	14.0
Marketing and competition	6.5	1.0	14.0
Make ready	6.5	1.0	14.0
Working with contractors	6.4	1.0	14.0
Call center / help desk	6.3	1.0	14.0
Installations	6.1	1.0	14.0

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Summary results and glossary

Technology choice summary

Technology	Average	Tenure			Density		
		< 2 Years	2-5 Years	5+ Years	Low	Mid	High
Optical networking							
BPON	**3%**	4%	0%	4%	0%	5%	0%
GPON	**73%**	57%	91%	87%	62%	70%	88%
XGS-PON	**54%**	68%	39%	57%	54%	65%	65%
NG-PON2	**3%**	4%	4%	0%	0%	5%	0%
Active ethernet	**21%**	14%	13%	35%	15%	15%	47%
Distribution architecture							
Centralized split	**30%**	21%	32%	23%	8%	23%	33%
Distributed split	**47%**	45%	32%	37%	42%	42%	33%
Distributed tap	**47%**	34%	36%	40%	50%	35%	33%
Aerial placement							
ADSS	**40%**	47%	29%	38%	20%	40%	42%
Strand and Lash	**71%**	63%	79%	79%	80%	60%	58%
Core network							
One head end	**30%**	19%	23%	59%	54%	29%	26%
Redundant from day 1	**37%**	47%	38%	23%	31%	24%	42%
Redundant added later	**33%**	34%	38%	18%	15%	48%	32%

Statistics summary

Metric	Median	Tenure			Density			Average
		< 2 Years	2-5 Years	5+ Years	Low	Mid	Hi	
Fiber Miles	**1,990**	2,020	1,790	2,000	2,000	2,040	1,447	**2,555**
Homes Passed	**18,000**	19,193	18,000	14,500	10,000	19,050	25,000	**25,902**
Businesses Passed	**1,000**	2,000	1,000	540	200	1,050	1,971	**1,689**
Locations	**19,000**	21,193	19,000	15,040	10,200	20,100	26,971	**27,590**
Locations per Mile	**10.7**	12.5	13.0	8.7	5.1	9.9	16.4	**11.6**
% Aerial	**90%**	94%	92%	90%	95%	94%	80%	**85%**
Cost per Aerial Mile	**$23,375**	$28,000	$24,000	$21,720	$22,555	$21,000	$24,375	**$26,505**
Make Ready per Mile	**$4,000**	$4,500	$1,750	$4,600	$5,000	$1,750	$4,000	**$4,549**
Cost per UG Mile	**$60,000**	$78,500	$51,000	$56,720	$67,500	$52,500	$60,000	**$62,159**
Cost per Drop	**$1,000**	$1,000	$1,000	$1,300	$1,047	$1,200	$825	**$1,223**
Drop Feet	**400**	400	455	375	400	513	307	**478**
Head End ($M)	**$0.5**	$0.6	$1.6	$0.4	$0.3	$1.3	$0.3	**$1.0**
Optical Network Equip ($M)	**$2.0**	$2.9	$3.0	$0.6	$1.4	$3.1	$2.0	**$2.9**
Total Capex ($M)	**$71.5**	$75.0	$78.5	$47.6	$60.0	$78.5	$62.0	**$90.1**
Capex per Location	**$3,157**	$3,270	$2,657	$3,623	$7,268	$3,522	$2,068	**$4,019**
IRR	**9%**	9%	15%	10%	13%	9%	8%	**12%**
Res Take Rate (to date)	**46%**	34%	53%	50%	49%	46%	43%	**48%**
Res Take Rate (Total Project)	**50%**	45%	54%	50%	53%	52%	45%	**50%**
Res ARPU	**$75**	$74	$75	$91	$87	$77	$74	**$79**

Glossary

Active Ethernet: Provides each subscriber with a direct point to point connection from the OLT to the subscriber ONT location

All-dielectric self-supporting cable (ADSS): A fiber cable strong enough to support itself without using conductive metal elements

AMI network: Advanced Metering Infrastructure – two-way communications to meters

Average Revenue per Use (ARPU): Expressed per month; Calculated as monthly revenue divided by average subscribers on the network

Backbone (substation connectivity): High-bandwidth, low-latency data connection, enabled by wired or wireless technology, that connects systemically important infrastructure – this is most often substations for electric co-ops

Broadband Passive Optical Network (BPON): First-generation PON capable of 622 Mbps service

Broadband Subsidiary: A Wholly-Owned Subsidiary Corporation, provides broadband services on a non-patronage, taxable income basis

Computer-aided Design (CAD): The use of computers in the design process

Centralized Split: PON splitters located in one closure, typically set in the center of the area it is serving

Distributed Split: No fiber splitters in the central office, fibers pushed deeper into the network before being split

Distributed Tap: A fiber cable is deployed throughout a service area, and fiber-optic taps divert optical signals to subscribers

Glossary

Downline assets: Feeders and equipment between the substation and meters at the member service locations

Ethernet passive optical network (EPON): Deployed in Asia and by some cable companies; same architecture as GPON but with different data protocols

Gigabit-capable passive optical network (GPON): Capable of 2.5 gigabit service; most common PON deployed in North America

Geographical information system (GIS): System for displaying geographical information

Internal rate of return (IRR): Expressed as a percent, used to estimate the profitability of investments; the discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis

Head end (core networking): Gateway to a wide area network (WAN) or the internet; provides the final aggregation point for the network

Land mobile radio: Secure, instant communications systems to field force and vehicles in mission-critical environments such as public safety and utilities; often features one-to-one and one-to-many capabilities and push-to-talk

Make ready: Modification or replacement of a utility pole, or of lines or equipment on the utility pole, to accommodate additional facilities

Next generation passive optical network (XGS-PON): PON capable of 10 Gbps

Next generation passive optical network 2 (NGPON2): PON capable of 40 Gbps

Glossary

Optical line terminal (OLT): Starting point for the optical network, connecting the core switch (head end) to the network

Optical network terminal (ONT): Terminating devices at the end-user location

Optical networking: Communications networking technologies that use signals encoded in light to transmit information

Private wireless network: A dedicated network for use cases such as field area networks (for example smart grid), industrial sites, hospitals, campuses and military bases; ensures dedicated, secure, reliable access to critical applications

Public wireless network: In this context, a network operated by a national wireless company for many customers – as distinct from a private wireless network that is built and operated by one entity for its own purposes

Rural Utilities Service (RUS) units: List of equipment used to develop a bill of materials, as defined by the standards and specifications for RUS-regulated materials, equipment and construction of telecommunication networks

Strand and lash: Steel support strand placed on pole line and fixed in place with mounting bracket; cable attached to support strand with a lashing wire

Substation connectivity: Secure, two-way connectivity to utility substations

Take rate: The percentage of homes and/or businesses passed that subscribe to a service; calculated as subscribers divided by locations passed

Workforce communications/vehicle management: Systems that track and improve efficiency of a field service team or fleet

Acknowledgments

A deep expression of gratitude to the 88 participating electric cooperatives. We asked you to share a lot of detailed information about your broadband technology, business, operations, and results. Your willingness to do so made this report possible. Thank you for your commitment to helping other cooperatives enhance their broadband strategies.

NRTC and NRECA were pleased to collaborate on this effort. Cooperative principles guide everything we do, and this was a wonderful opportunity for us to embody the spirit of Cooperative Principle 6. More importantly, it's what our shared members deserve–their national organizations working together for them. We look forward to more efforts like this, both between our cooperatives and with other like-minded organizations.

NRTC and NRECA look forward to continuing the broadband conversation with our electric cooperative members, helping to evaluate technologies and technology investments that hold promise for you, your members, and the communities you serve.

About NRTC: NRTC is a technology cooperative, owned by the ~1,500 electric and telephone members that we serve. We help our members evaluate, build, and manage broadband, smart grid, and mobile networks.

About NRECA: NRECA is the national trade association representing nearly 900 local electric cooperatives. From growing suburbs to remote farming communities, electric co-ops serve as engines of economic development for 42 million Americans across 56% of the nation's landscape.

Disclaimers:
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