Rural Electric Cooperative Broadband Benchmarking Report

Results and insights from a comprehensive data gathering exercise

November 10, 2020

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Introduction

Background and Benchmarking Project Goals

Electric co-ops are stepping up to the challenge of bridging the broadband divide while evolving to a smarter grid.

There is now a critical mass of electric cooperatives that have deployed broadband and have operational networks and a track record. **We endeavored to catalog and share their experience and results to help cooperatives that are currently evaluating their own broadband plans.**

"If you've met one electric cooperative … you've met *one* electric cooperative" …

Nowhere is this saying more evident than with broadband. The business needs, competitive environment, financial situation, population density, demographics, and topography of each electric co-op are so different, it requires an individual response. A "one size fits all" approach simply won't work. This dynamic is reflected in the benchmarking results, with a range of strategies, technologies, and metrics.

Cooperative principle #6: Cooperation Among Cooperatives … Thank you to our members

We are grateful to the 36 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 informed decisions.

This report contains benchmarking information in five categories:

Use Cases and Technologies, Deployment Metrics and Cost, Subscribers and Revenue, Operations, and Business Considerations

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.

Survey population and electric cooperative overview

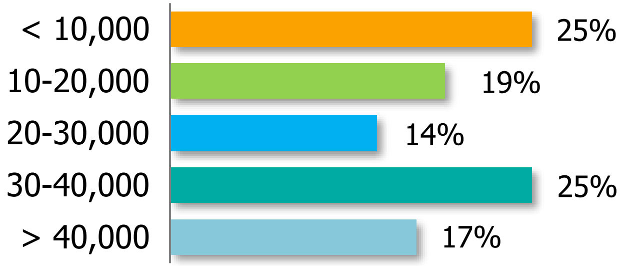
Electric cooperative overview [1]

- Serve over **20 million homes and businesses**
- Own and maintain **2.6 million miles** of distribution lines
- Cover **56% of the nation's landmass**
- **834 distribution co-ops** that deliver electricity and other services to their communities
- **63 generation and transmission** cooperatives that provide wholesale power

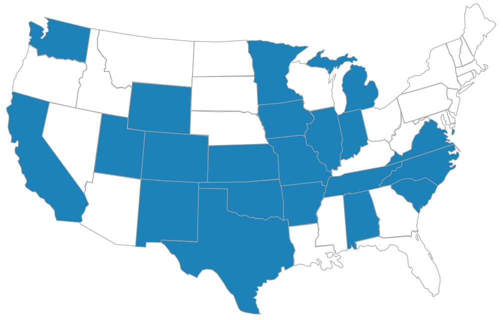
Survey population:

- **36 electric cooperatives** that have deployed broadband and have had **live customers for at least one year**
- Members of **various sizes** (as measured by electric meters), representative of the membership as a whole
- Members from **21 different states** with diverse characteristics
- Have used **various consultants**, contractors, and equipment vendors
  - Specifically, to ensure that the survey population reflects a wide range of experiences, we sought to have a survey population representing roughly **two-thirds non-NRTC-supported projects**; the remainder used other consultants or self-performed

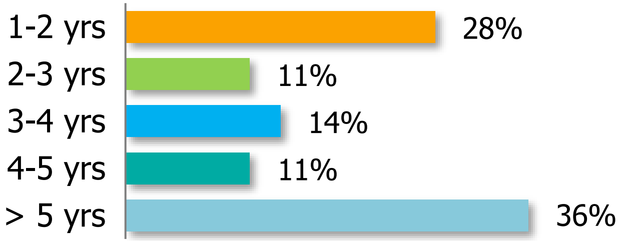
Participants by meter count



Participants by state



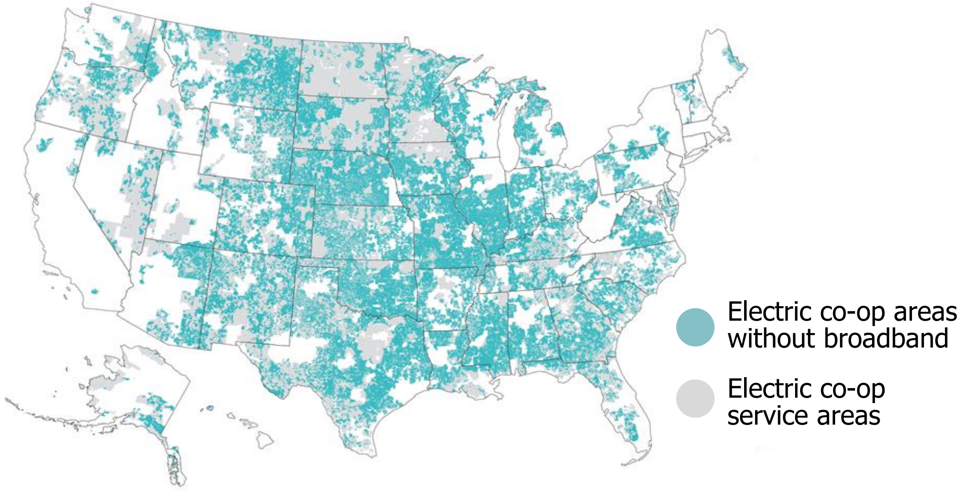
Time since live network



(1) Source: NRECA

Our electric members are deploying broadband to serve community needs, strengthen their local economies, and move to a smarter grid

Electric cooperative service areas are underserved for broadband [1]

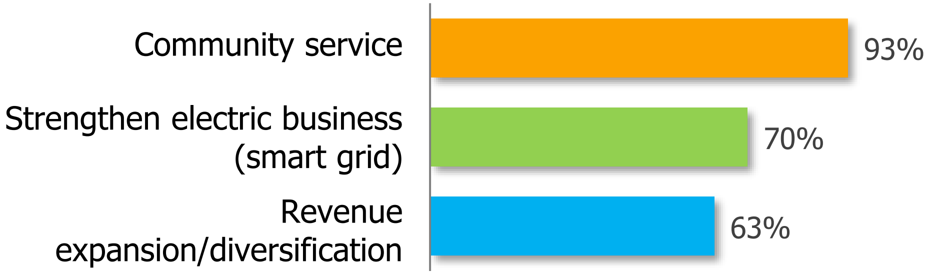


Members are creating smarter grids and smarter communities with an evolving set of technologies

Electrics are positioned to help, as 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 loan capital at attractive rates
- A long-term outlook and appreciate building assets

Respondents' motivations to invest in broadband



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(1) Source: NRECA

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Executive Summary

Key takeaways

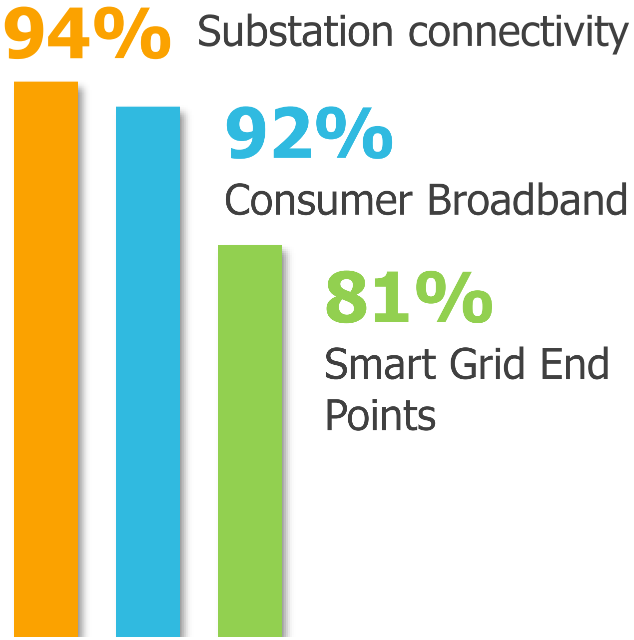
Cooperative builds have been largely **successful**

88%
Take rates greater than expectations

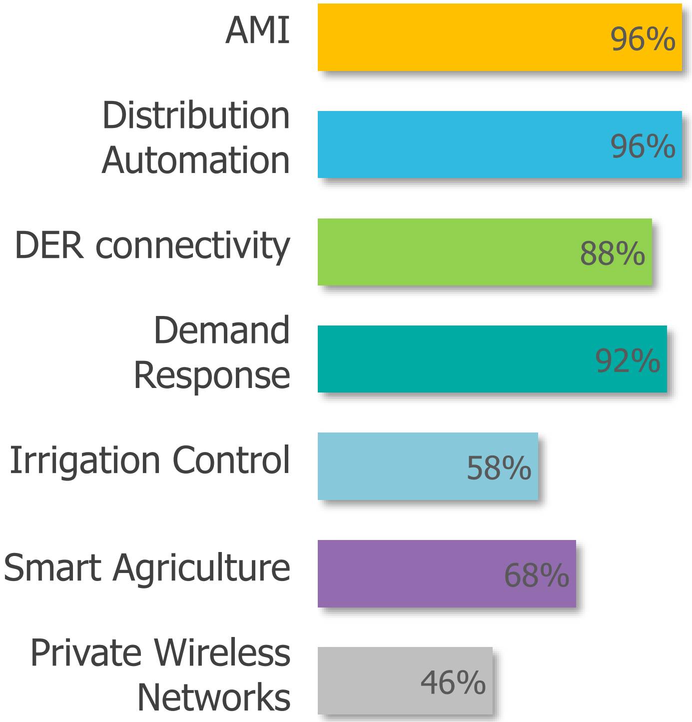
92%
Favorable response in member surveys

10%
Median Internal Rate of Return

Fiber is being leveraged for **Smart Grid** and **Broadband**



Members leveraging investment to serve **future use cases**



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Use cases/technologies: Electrics are incorporating the connectivity needs of their community and their utility operations into holistic plans

Co-ops are using a mix of technologies for various use cases

- Fiber most often used for broadband and substation connectivity
- Wireless used for smart grid and for all use cases where fiber is not feasible
- Considering several advanced smart grid and smart community solutions

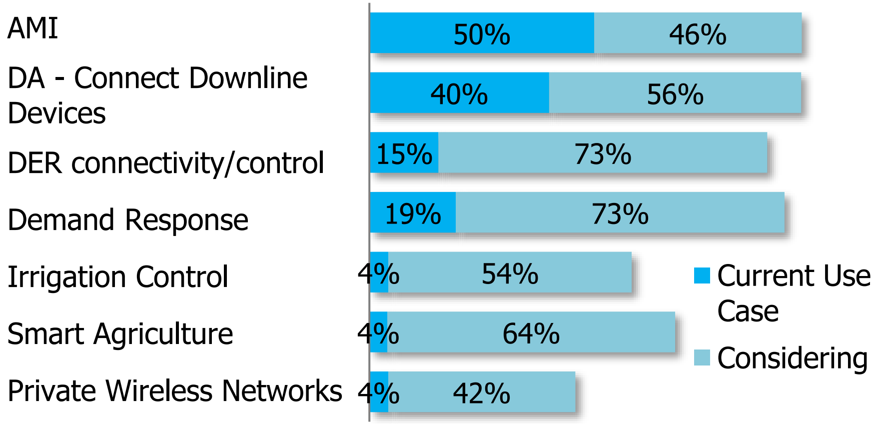
These members have taken a long-term view to inform their choices

- Foundational investments in long-term assets are being leveraged to benefit multiple stakeholders in rural communities
  - Fiber backbones are a must-have for utility operations and co-ops are extending their backbones to serve additional use cases
  - Wireless towers and poles can be leveraged for intelligence and control of critical assets and solutions such as Smart Agriculture and Private Networks
- Technology evolution will enable network convergence
  - Evolving tech will simplify networks, providing cost & maintenance efficiencies
  - Members are evaluating evolving technologies such as Private LTE / IoT for both smart grid and consumer broadband

Technologies used per use case

	Technology Category		# of Technologies	
	Fiber	Wireless	Avg	Max
Substation Connectivity	94%	25%	1.5	3
Smart Grid	81%	42%	1.5	5
Land Mobile Radio	0%	47%	0.9	5
Consumer Broadband	92%	42%	1.6	5
Business Broadband	94%	33%	1.5	5

Additional current and future use cases



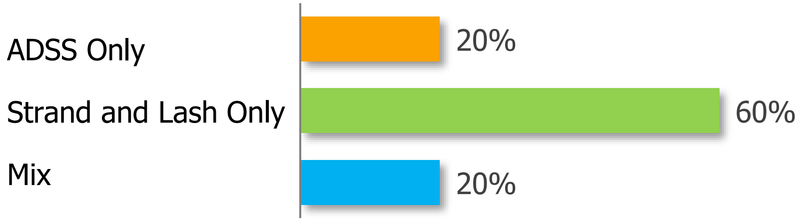
Network Design: Technology choices and deployment methods should result from a cooperative's unique situation and goals

This report shows the range of choices that co-ops typically make – and it shows that one size does not fit all

- Choices reflect different situations and balance multiple goals such as cost, ease of deployment and maintenance, and future flexibility
- During deployment planning, make sure to make these choices deliberately
  - Architecture and network design (i.e. centralized vs. distributed split, strand count) should reflect the density of the area and future capacity needs
  - Aerial placement technologies should balance Make Ready requirements and ease of deployment and maintenance with cost
  - Spectrum bands used should reflect the topography of your area and the use cases desired (i.e. smart grid vs. consumer broadband)
  - There are several equipment vendors; selection should reflect criteria developed for a member's specific situation as well

Distribution architectures

Aerial placement technologies



Wireless spectrum bands

	5GHz	Legacy 3.5 GHz	CBRS (Planned)	900 MHz
Substation Connectivity	78%	22%	44%	44%
Smart Grid Endpoints	25%	0%	17%	83%
Consumer Broadband	79%	36%	50%	50%

Results: This report shows that cost and revenue metrics vary, but also shows central tendencies useful for planning

Data shows very strong interest in cooperative broadband

- 25-75th percentile take rate within a tight range of 43-52%
  - For projects with over two years since launch, range is 44-64%
- 88% reported having take rates greater than their feasibility forecast
- 92% favorable response in member surveys

Cost metrics varied depending on individual situations

- Cost per mile generally $20-30K; variability driven by factors such as the percent of aerial vs. underground miles and make ready requirements
- 76% had greater than expected capex; reasons varied from permitting, make ready, terrain issues, changes to the plan, and greater than expected take rates

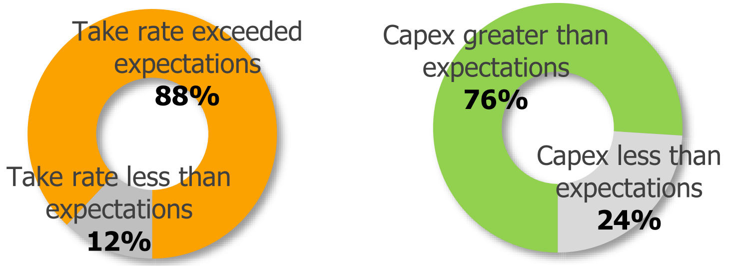
Return on investment attractive

- Median IRR of respondents is 10%, exceeding the low cost of capital that most cooperatives can access

Deployment statistics and cost/revenue metrics

	Miles	Sites	Homes	Take Rate	ARPU (2)
Min	50	6	3K	11%	$45
25th % (1)	1,100	25	12K	43%	$60
50th %	2,000	50	23K	46%	$74
75th %	3,050	74	32K	52%	$92
Max	14,000	825	285K	80%	$130

	Capex per mile					
	Aerial	Make Ready	Under-ground	Capex/ Drop	Total Capex	IRR
Min	$13K	$0.6K	$24K	$400	$5M	1%
25th %	$17K	$1.4K	$36K	$834	$29M	8%
50th %	$20K	$2.5K	$49K	$1,385	$65M	10%
75th %	$26K	$3.8K	$59K	$2,051	$84M	13%
Max	$33K	$12.0K	$120K	$3,200	$176M	14%



(1) Represents the 25th percentile; (2) Residential ARPU

Operations and Business Considerations: Operating a broadband business is new for electrics; Members use a mix of internal resources and outsourced partners

Composition of members' internal teams vary

- Members typically hire a Broadband Manager; beyond this, the approach varies
- Many members share resources and allocate across their electric and broadband businesses for functions such as finance, warehousing, purchasing, and admin
- Most variability in the approach for resource-intensive functions such as Customer Service, Help Desk, and Installation

Members are leveraging the manpower and expertise of partners and are bringing these functions in-house when appropriate

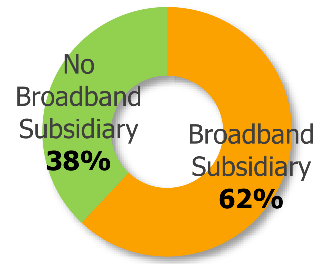
- Building a broadband business quickly is difficult; Some functions are different than the electric business and expertise is often scarce; Conversely, members want to promote local jobs – this approach can meet both of these challenges

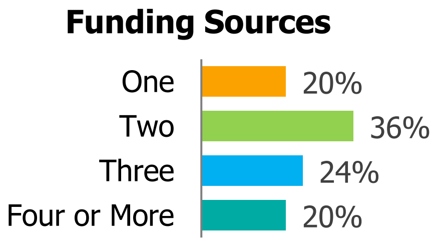
There are also several business considerations to work through

- 62% of members create a broadband subsidiary
- Most members secure more than one source of funding
- Members also engaged in various partnerships to for services such as video and cost sharing such as construction

Employee count	Min	Median	Max
Management/Finance/Marketing	1.0	3.5	29
Engineering/OSP/Construction	0.6	4.0	15
Customer Service Reps	0.2	2.8	20
Maintenance Techs	0.0	3.0	12
Installation Techs	1.0	3.0	40
Total (not additive)	3.5	16.1	74

In-source vs. outsource	In-source	Out-source	Both
Marketing	85%	0%	15%
IT / Network Engineering	63%	0%	37%
Help Desk	23%	15%	62%
Network (NOC) Monitoring	69%	12%	19%
Installation	37%	15%	48%





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Use Cases and Technologies

Electrics have deployed a mix of wired and wireless technologies for smart grid communications & consumer broadband; Fiber the overwhelming choice among respondents

Members report using up to five different access technologies for most applications

- The overwhelming majority of respondents have built a fiber backbone to their substations and other critical assets; some use wireless for more remote or hard-to-reach substations
- While members historically have used wireless to connect smart grid endpoints, most report extending fiber to connect some end points
- Majority using Public Wireless, the large wireless operators, for workforce/vehicle management solutions
- For Land/Mobile Radio, however, co-ops more likely to build their own network using fixed wireless
- While most respondents have fiber in some portion of their networks, almost half use wireless as part of hybrid fiber/wireless networks

Use Cases and Technologies Employed / **# of Technologies**

% using respective technology	Fiber	Leased Lines	P2P Ethernet	Copper/ DSL	Fixed Wireless	Public Wireless	Satellite	Average	Max
Substation Connectivity	94%	8%	6%	0%	25%	8%	3%	1.5	3
Smart Grid Endpoints	81%	6%	6%	6%	42%	8%	0%	1.7	5
Workforce / Vehicle Management	6%	0%	3%	0%	6%	58%	3%	1.0	1
Land Mobile Radio	0%	3%	6%	0%	47%	11%	3%	1.3	5
Consumer Broadband	92%	6%	6%	3%	42%	0%	8%	1.6	5
Business Broadband	94%	6%	8%	3%	33%	0%	0%	1.5	5

Definitions: Fiber: Fiber deployed by the co-op   Leased lines: Typically owned by a landline telecom operator   P2P: Point to Point   Fixed Wireless: Point to Point or Point to Multi-Point Wireless   Public Wireless: Typically national wireless carriers

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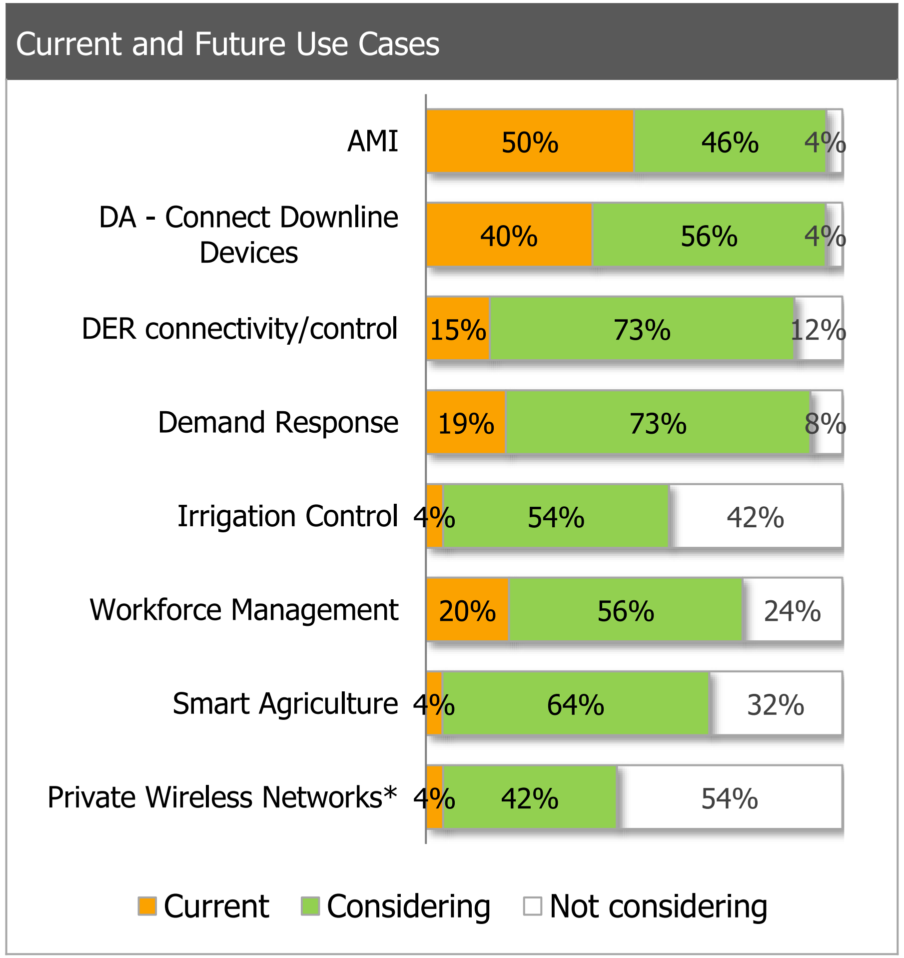
Looking forward, members are considering how they can leverage their communications assets for more advanced smart grid solutions and applications such as Smart Agriculture

Respondents currently are leveraging broadband for connectivity to the most critical smart grid assets (sub stations, meters, downline devices)

Most respondents are considering a wide range of use cases to serve their own electric grid and their community connectivity needs

- Consumer demand for Distributed Energy Resources (e.g., solar, storage, EVs, etc.) is increasing while the prices for these technologies continue to fall. The ability to monitor the load impact and remotely manage these assets will be a critical tool for shaping load profiles and reducing wholesale costs for cooperatives.
- Cooperatives are investigating new ways to save energy during peak demand periods with Demand Response solutions. Broadband better enables two-way communications to utility assets and "behind the meter" assets such as thermostats, water heaters, and generators
- Some members are considering emerging applications such as Smart Agriculture and Private Wireless Networks to serve the needs of farms, businesses, and institutions such as hospitals, campuses and military bases



* For C&I, or campuses / military bases

Optical Access Networking Technologies

Most networks using GPON, with some starting to deploy next-gen PON

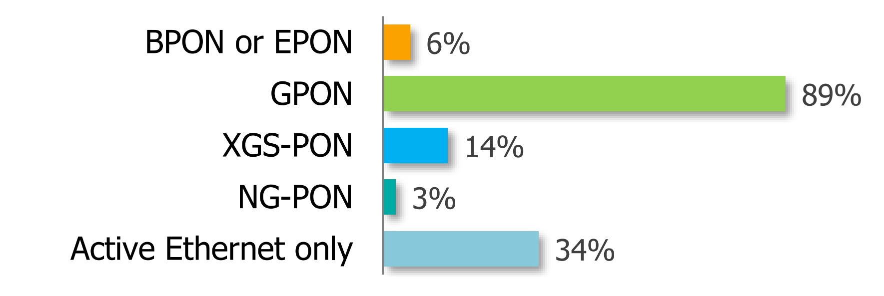
Passive Optical Networks (PON) provide fiber access to customers using limited electronics in the field. Passive splitters are used to service multiple customers from one PON port; optical technologies have evolved over time:

- **BPON (Broadband PON):** First, legacy generation – only 3% of respondents reported having some BPON in their networks
- **EPON (Ethernet PON):** Deployed in Asia and some cable companies – no respondents reported using this technology
- **GPON (Gigabit PON):** Currently the most widely used technology; operating at 2.5 Gbps downstream and 1.2 Gbps upstream; capable of supporting 1 Gig service for customers; most respondents are using this technology
- **XGS-PON:** Next generation PON; more costly but delivers higher symmetrical throughput (10 Gbps downstream and upstream); capable of supporting more 1Gig services; some respondents are beginning to use this technology
- **NGPON2:** Even more speed (40 Gbps), multiple wavelengths but very expensive
- **Active Ethernet:** Provides each subscriber with their own fiber link from the OLT; 35% of respondents reported using this technology

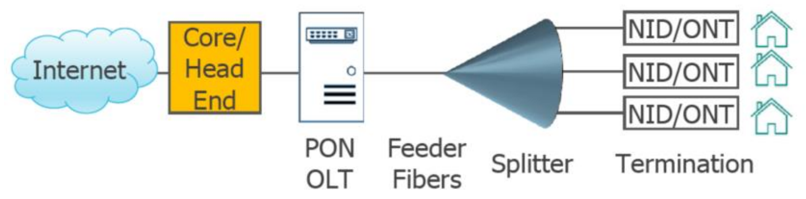
Calix and ADTRAN the most used optical networking vendors

- 83% of members report using Calix or ADTRAN
- Five other vendors were represented in 26% of respondent networks
- 89% have one electronics vendor and 11% have two vendors

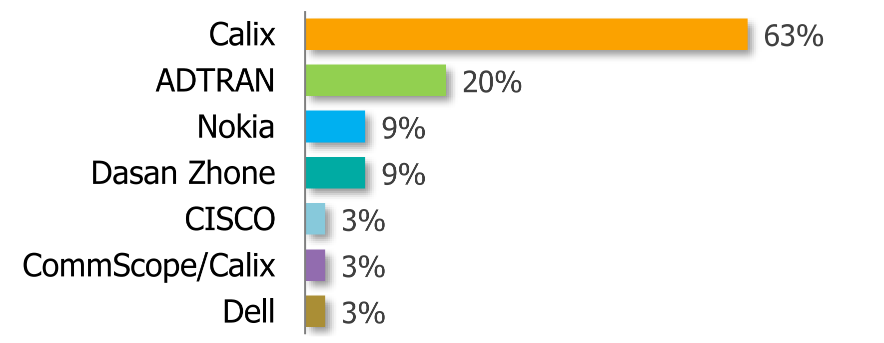
Optical Technologies



Simplified network diagram



Optical Networking Vendors (% using each vendor)



Distribution Architecture

The majority of members have deployed a Split architecture

Centralized Split

- Intended for use in a dense areas; The cabinet is usually in the center of a serving area to decrease distances to customers; Generally requires larger cables
- Has a wide ecosystem for connecting devices as this is a frequent choice by national operators: Ensures compatibility of devices and tools and future support
- Other advantages include ease of maintenance due to a single point of access and OLT utilization efficiency as splitters can be added as an area grows

Distributed Split

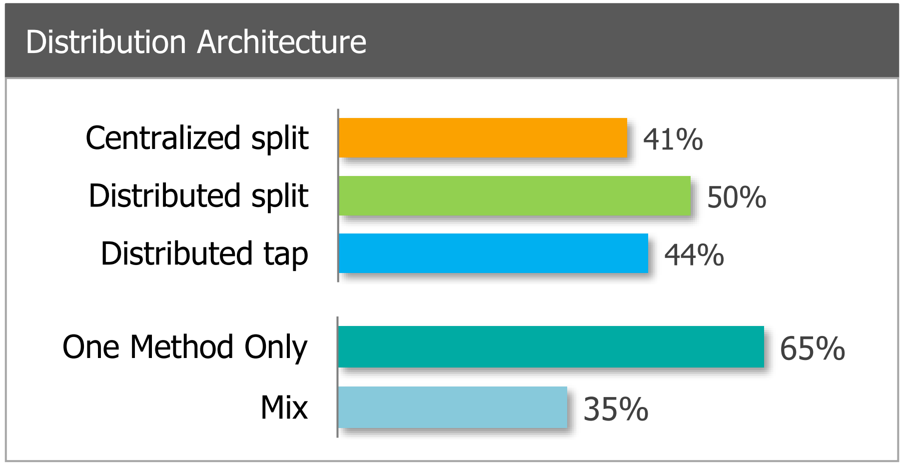
- Can be used in both dense and rural service areas
- Smaller fibers can be pushed deeper into the network before being split; This maximizes fiber reach before the splitter ratio needs to be changed; Since splitting is closer to the customer, more capacity is available for future needs
- Similar to Centralized Split, has a large ecosystem

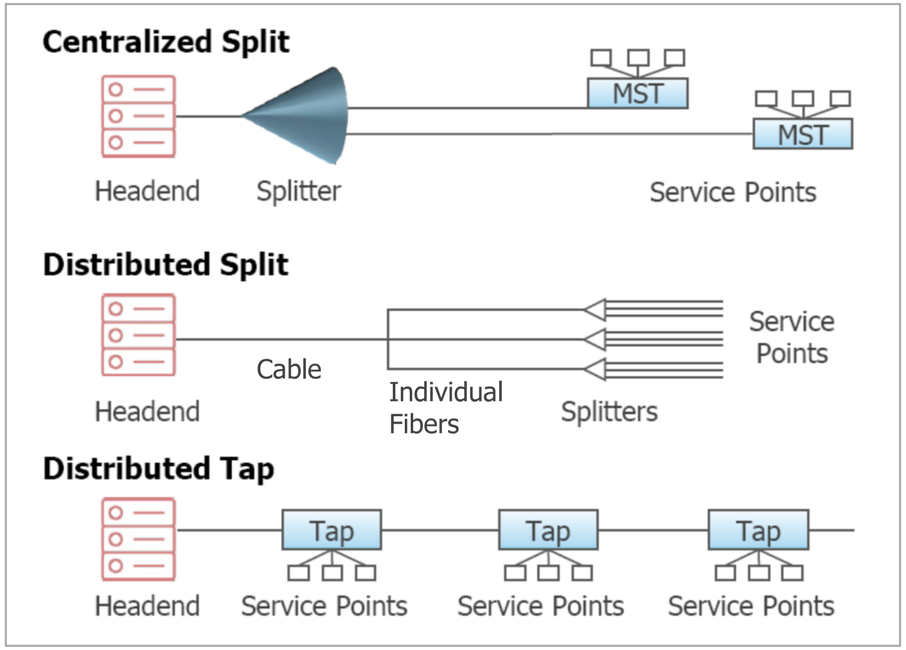
Distributed Tap

- Another option in less dense areas, taps divert optical signals to subscribers
- Legacy option that can lead to lower up-front costs as it can use less fiber strands, however, now has a smaller ecosystem

Members use a mix of architectures most often based on density

Centralized split most often used in more dense areas of member territories and distributed split for the more remote areas. Those using distributed tap are most likely to use it as a single solution, although many still use a mix of solutions.





Aerial Placement Technologies

Technologies

ADSS: Cable supports itself between poles without using any conductive metal elements; cable runs through a trunnion and is secured with a grommet

Pros	▪ Less make ready: Self-supporting, no messenger required; no bonding/grounding ▪ Fewer anchors and guys required when placed next to power ▪ Less surface area, less wind effect, and ice loading; less long-term maintenance ▪ Can be installed in a single pass operation
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

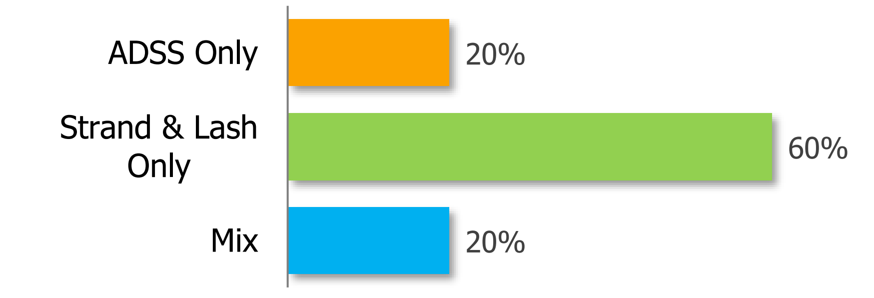
Strand and Lash: Steel support strand placed on pole line and fixed in place with mounting bracket; Cable attached to support strand with a lashing wire

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; can be over-lashed with additional fibers
Cons	▪ Lower position on the pole, more exposed to risk ▪ Additional exposure to ice and wind loading and more maintenance post install ▪ Must be grounded/bonded; more make ready; cannot be installed in a single pass

Strand and Lash the most popular, but 40% either used ADSS or a mix

64% of respondents reported using Strand and Lash, 30% reported using ADSS, and 7% used some OGPW (Optical Ground Wire); most chose a single solution rather than a mix of methods

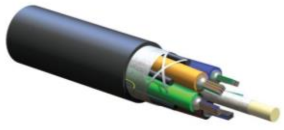
Aerial Placement Technology



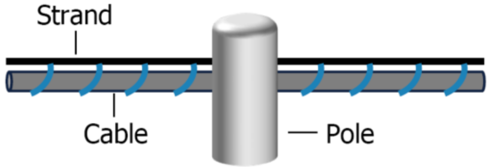
ADSS

ADSS fiber

Strand and Lash



Loose tube fiber



Underground methods

Methods

Trenching

- Creates an open trench in the ground; fiber cable is placed in the trench and back-filled with dirt
- Best for open areas, fields, and along roads where ground disturbance is less of a concern; It's effective in all soil types and often only used for short runs due to cost and restoral

Boring

- Often called Directional Boring, this method uses rigs to drill tunnels; the cable is then pulled through the tunnel
- More expensive method, used when ground disturbance is a concern

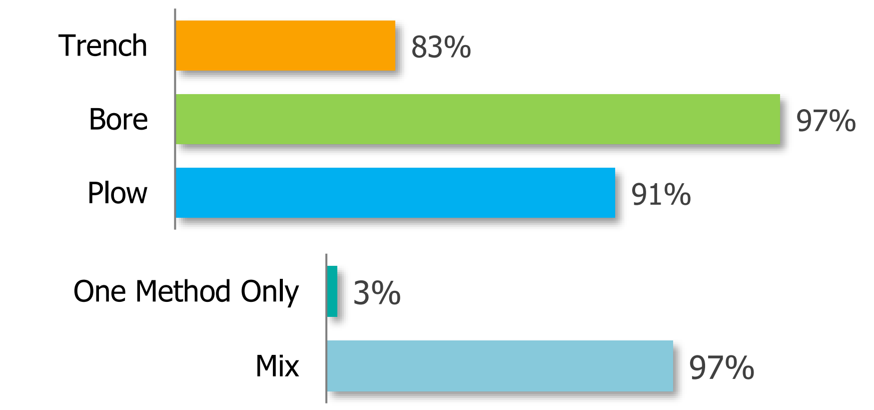
Plowing

- Uses a plow to cut a narrow slit in the ground to place the fiber cable
- Best in open areas and where shallow placement and smaller trench width is acceptable; less ground disturbance and restoration than trenching and most cost-effective method of underground placement

Respondents used the methods evenly and rarely only used one method

Only 3% used one method only. In fact, 74% reported using all three techniques. Respondents split almost evenly between the three methods.

Underground Methods (1)



Underground Methods

Trenching Boring Plowing

(1) Represents the amount of respondents who report using each technology

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Fiber strand counts

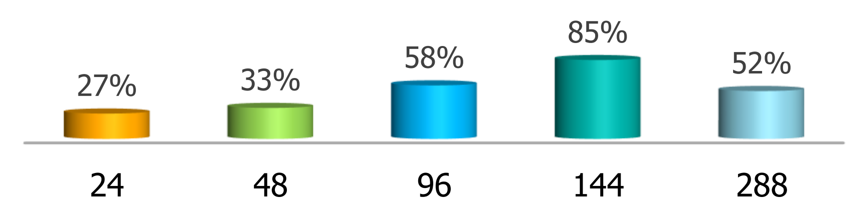
Members are planning for future demand when designing their networks

- Strand count is the number of optical fiber strands in a cable
- Higher strand counts carry greater capacity but are more costly
- The typical strand count range is between 24 and 288
- Higher strand counts are often used for the backbone, more densely populated areas, and areas where growth is expected over time
- Smaller strand counts are used more often for distribution to the end consumer and in less dense areas
- Planning for future demand, including the ability to lease fiber, is important; Deploying a robust network from the outset is more cost effective than going back and over-lashing at a later time

Members reported using higher strand counts in the backbone portion of their networks and a mix, albeit lower, in the distribution portion

- Respondents used a mix strand counts in their networks
- For backbone, 33% reported using one strand count type (between 96 and 288); for distribution 91% used multiple strand count types

Fiber Strand Counts - Backbone (1)



Fiber Strand Counts - Distribution (1)

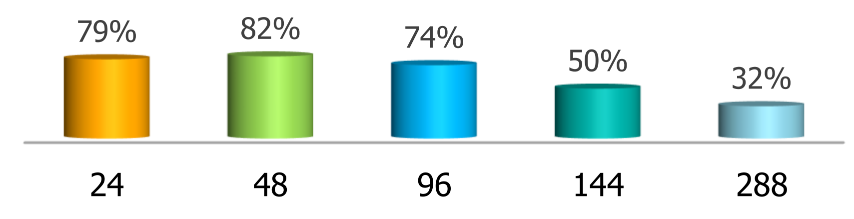


Figure x: Fiber strands

(1) Represents some amount of these strand counts in backbone and distribution

Core Network

Technologies

Data traffic from the access network is transported to the headend to reach the Layer 3 core router network and internet access

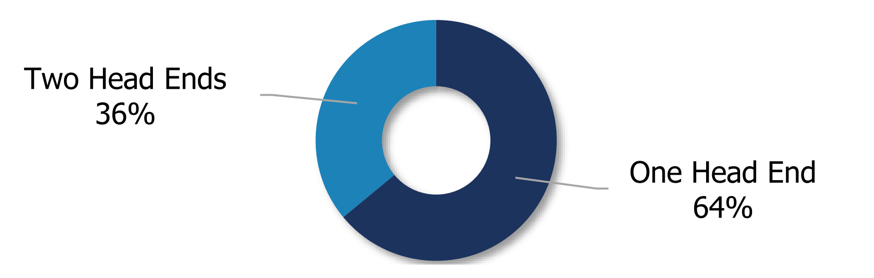
- Transport network nodes at the head ends aggregate traffic and hand up to the core network
- Core switches provide the final aggregation point for the network and connect servers and firewalls to the network
- Core routers are the gateway to a wide area network (WAN) or the Internet, providing IP address routing internally and externally
- Members also face the choice of deploying one head end or redundant head ends
- Redundant head ends ensure service reliability, especially in a disaster situation; however, redundancy entails more cost
- 76% of respondents have started with one head end, while 24% have built redundancy

Juniper and Cisco the most used core networking vendors

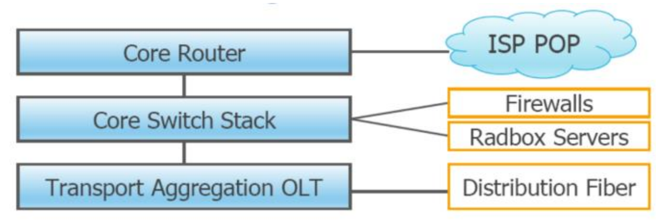
Several vendors provide optical networking equipment; Benchmarking results:

- 97% of members report using Juniper and Cisco
- Three other vendors were represented in 14% of respondent networks
- 89% have one core vendor and 11% have two vendors

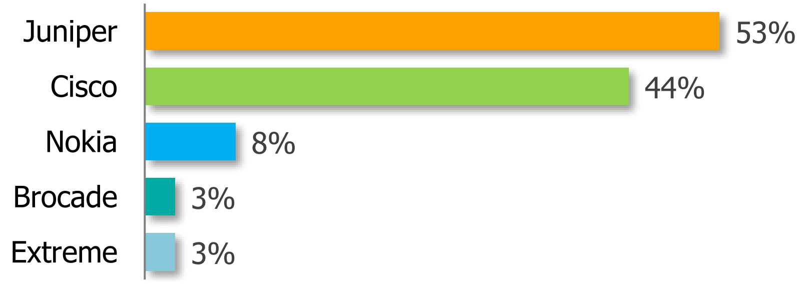
One or two Head Ends



Simplified network diagram



Core Networking Vendors (% using each vendor)



Wireless Spectrum Bands

Spectrum bands vary in frequency and licensing

- **Lower bands:** Allow signals to travel further and travel through obstacles
- **Higher bands:** More available spectrum, larger channel sizes, greater throughput
- **Licensed** spectrum ensures availability for services requiring more reliability but often has less availability than unlicensed and requires investment

42% used wireless for broadband with offers up to and exceeding 100 Mbps

- Mid and high bands used for use cases greater throughput (backbone, broadband)
- Lower bands used for applications requiring ubiquitous coverage and lower throughput (Smart Grid, Workforce Management, Land-Mobile Radio)
- Members planning to use emerging bands such as CBRS in combination with LTE

Wireless Spectrum Fundamentals

Band Type	Throughput	Channel Size	Propagation
High 28-300GHz	**Most:** Up to 1 Gbps	0.4-2 GHz	**Short**: Feet (~1,000)
Mid 2.5-5.0GHz	**Mid:** 100 Mbps+	20-100 MHz	**Mid**: KMs (2-10)
Low 0.6-2.5GHz	**Lower:** Up to 25 Mbps	20 MHz Max	**Long**: Miles (6-10)

Wireless Spectrum Bands / **# of Bands**

% using respective bands (1)	5GHz	Legacy 3.5 GHz	CBRS (Planned)	2.5 GHz	900 MHz Licensed	900 MHz Un-Licensed	mmWave	Average	Max
Substation Interconnection	78%	22%	44%	11%	0%	44%	11%	2.1	3
Smart Grid Endpoints	25%	0%	17%	0%	42%	42%	0%	1.3	3
Workforce/Vehicle Management	20%	0%	10%	10%	50%	50%	0%	1.4	4
Land Mobile Radio	0%	0%	0%	0%	100%	0%	0%	1.0	1
Consumer Broadband	79%	36%	50%	21%	7%	43%	7%	2.4	5
Business Broadband	100%	38%	50%	38%	13%	38%	13%	2.9	5

(1) Percentages only reflect the respondents using wireless for each use case

Legacy 3.5GHz: Used the 3.5GHz band that is being transitioned to CBRS   CBRS: Shared use or licensed spectrum in the 3.5 GHz range; mmWave: Millimeter Wave

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There are several providers of wireless equipment, many of which focus on certain bands or use cases; Likewise, respondents are using a mix of vendors

- For backbone connectivity, respondents using a range of vendors, on average close to two
- Respondents mostly using Advance Metering Infrastructure (AMI) vendors to connect their smart grid end points; These vendors provide proprietary smart grid networks using low band licensed or unlicensed spectrum
- All respondents who deployed a Land Mobile Radio network used Motorola's LMR solution
- For consumer broadband, Cambium, Radwin, and Ubiquity most often used by respondents; These vendors provide point-to-point and point-to-multipoint solutions in a number of bands
- Limited use to date of Ericsson, Nokia, and Samsung equipment; However, these vendors generally provide standards-based LTE solutions that are positioned to serve many of these use cases in the future

Wireless Vendors

% using respective Vendors	AMI Vendor	Cambium	DragonWave	Motorola	Mimosa	Radwin	Siklu	Ubiquity	Average	Max
Substation Interconnection	25%	50%	25%	8%	17%	8%	0%	25%	1.8	3
Smart Grid Endpoints	87%	7%	0%	0%	7%	0%	0%	7%	1.1	2
Workforce/Vehicle Management	67%	33%	0%	0%	0%	0%	0%	33%	1.3	2
Land Mobile Radio	0%	0%	0%	100%	0%	0%	0%	0%	1.0	1
Consumer / Business Broadband	0%	57%	0%	0%	14%	21%	7%	50%	1.6	3

Note: Results for Ericsson, Nokia, and Samsung excluded as they show limited use
Definitions: For percentages, only counts respondents using wireless for each use case
AMI Vendor: Provider of proprietary Advanced Metering network

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Member driven. Technology focused.

Deployment Statistics and Costs

Box and whisker explanation

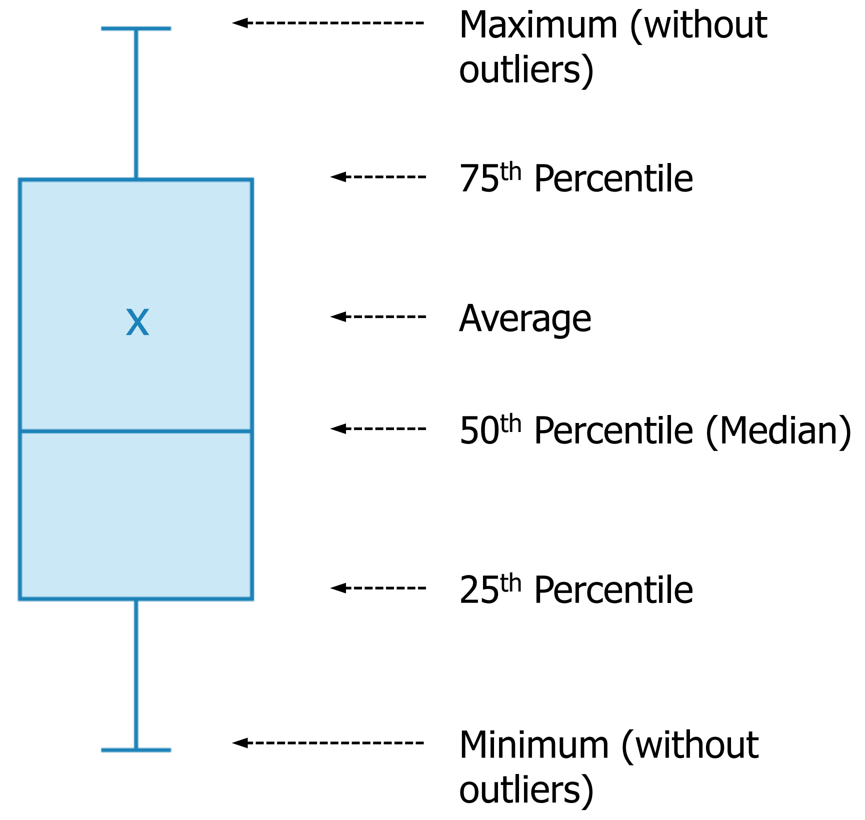
Co-op deployments vary widely in many aspects such as technologies used and household density. Therefore, benchmarking results cannot be understood by only looking at averages.

To display and explain results, we have used "box and whisker" charts. These allow us to:

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

Note that we have excluded outlier results to make the charts easier to read.

Chart definition



Deployment Statistics

The reported characteristics of cooperative deployments vary widely:

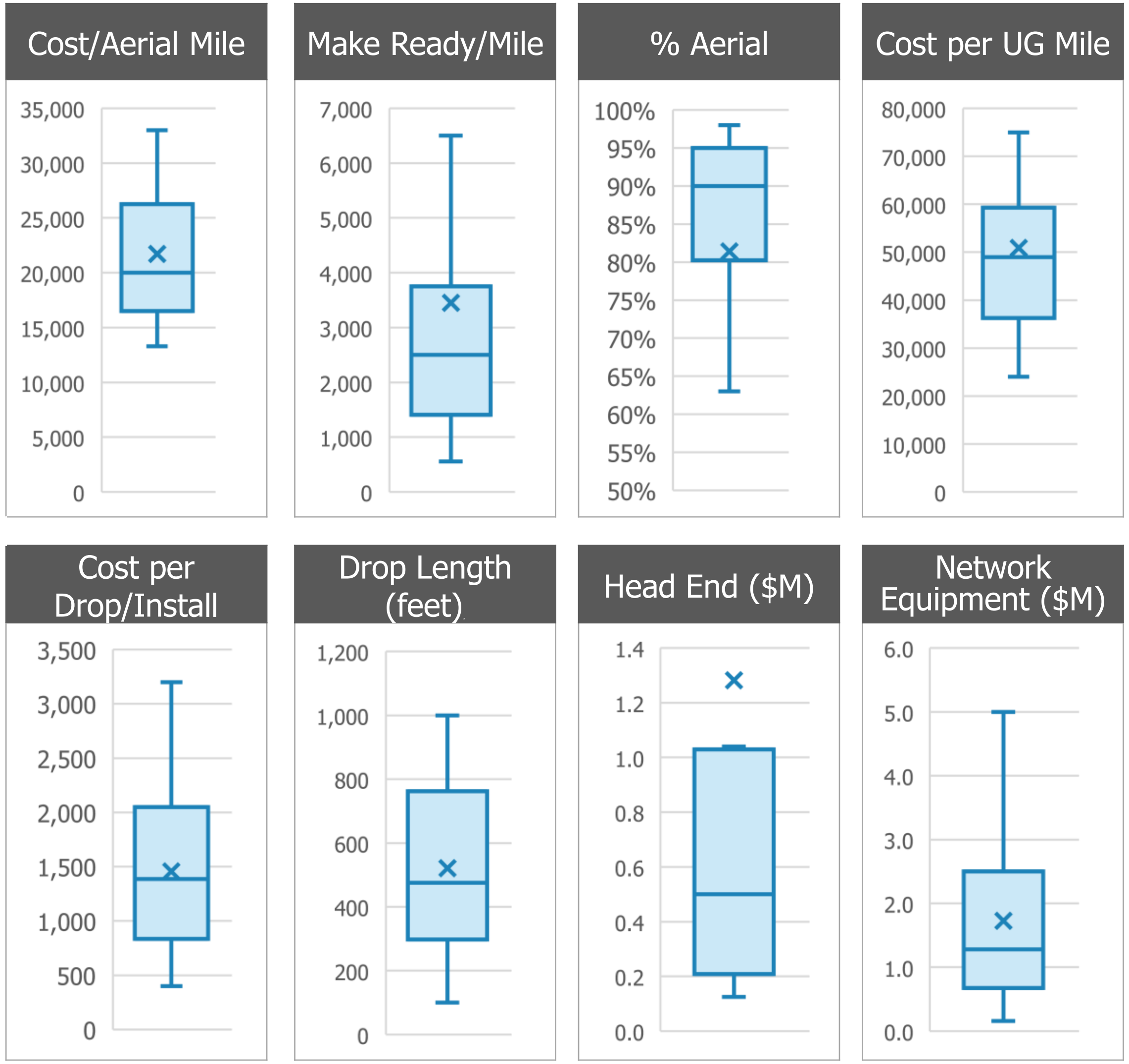
- **Deployment timelines** generally between 4 - 6 years with a median of 5 years; Average years of deployment to date: 3.3 years
- **Fiber miles** generally between 1,000 - 3,000 miles with some larger projects; Average miles deployed to date: 1,200
- **Wireless sites** generally between 25 - 75 sites with some larger projects; Average sites deployed to date: 92 (median 44)
- **Homes passed** generally between 12,000 - 32,000 homes with some larger projects; Average homes passed to date: 17,000 (median 12,500)
- **Businesses passed** generally between 500 - 2,500; Average businesses passed to date: 1,200 (median 700)

Data represents the total project, not construction to date

Deployment Costs

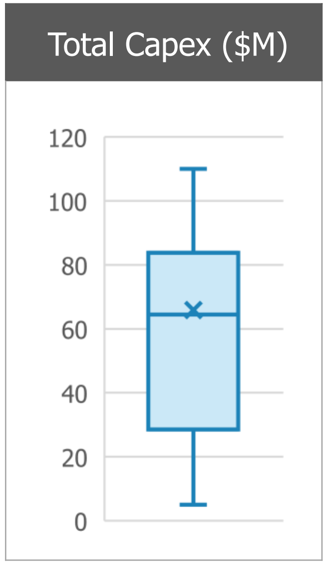
The costs of cooperative deployments vary; however, metrics converge around averages that can be used for planning purposes:

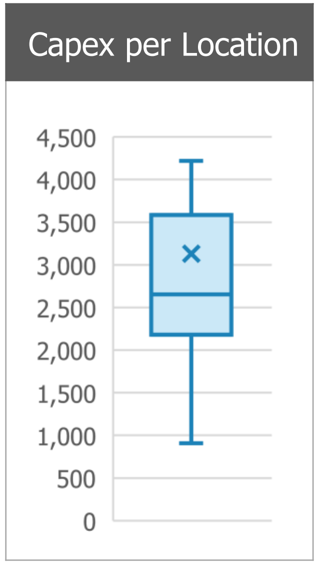
- **Cost per aerial mile** generally between $16,500 - 26,250 with an average of $21,700
- **Make ready cost per mile** generally between $1,400-3,750 with an average of $3,450; Median was lower ($2,500) as a few projects with higher Make Ready increased the average; Plant age, pole condition, terrain challenges and other factors causes these costs to vary
- **Percent aerial** generally between 80-95% with a median of 90% This is driven by the characteristics of the existing electric plant as the fiber miles tend to follow the electric
- **Cost per underground mile** generally between $36,000 - 59,000 with an average of $51,000
- **Cost per service drop, including installation** generally between $800 - 2,000 with an average of $1,450; This includes the fiber drop to the premises, installation, and subscriber equipment
- **Average drop length** generally between 300 - 760 feet with an average of 520; There was a correlation between drop length and cost per drop: Cost per foot averaged $3
- **Head end** median cost was $500,000 but varied greatly depending on the size of the network and the services offered; Higher costs seen for larger projects with video head ends and redundancy

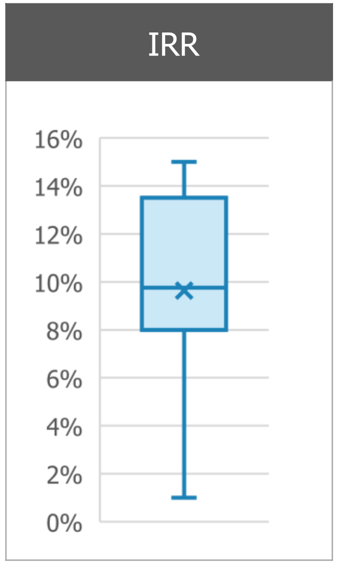


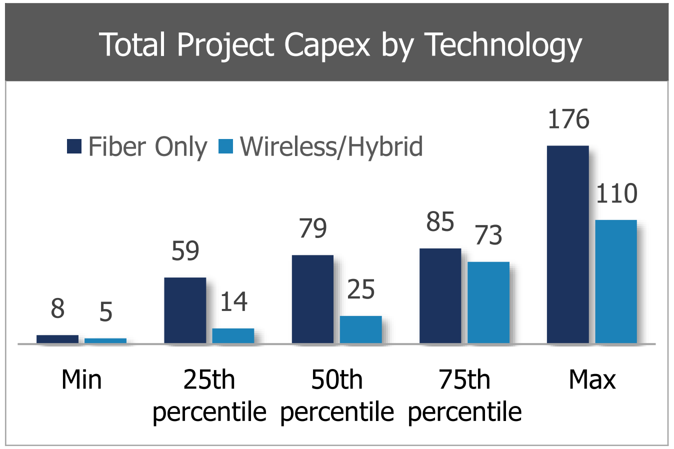
Deployment Costs and Return

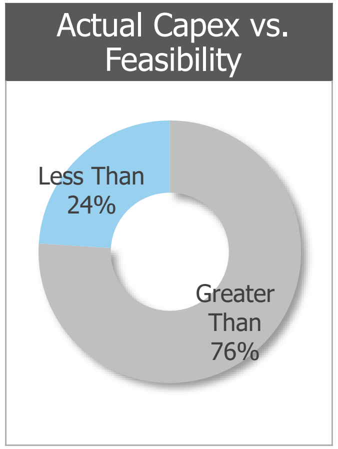
- **Total Project Capex** varied widely as the projects had varying number of miles and used different technologies; The 25-75th percentile was $28-$84M with average and median of ~$65M
- Total **Capex per location** covered (homes and businesses) averaged $3,100 with a median of $2,650
- Lower project capex reported for wireless and hybrid fiber/wireless projects, partly because they had lower average project size (covered fewer homes) along with lower cost per location
- Average **Internal Rate of Return (IRR)** was 10% and most spanned between 8% and 13%
- 76% of respondents said the actual capex was greater than their feasibility forecast; The reasons cited for this varied greatly:
  - Permitting costs
  - More rock than expected for underground boring
  - Greater take rate (causes more drop costs)
  - More make ready than expected due to pole change outs
  - Drop costs
  - More wireless sites than expected due to line of sight issues
  - Change in technology (fiber vs. wireless)
  - Change in design (number of miles, strand counts, etc. – some greater, some less)
  - Equipment cost differences (some greater and some less than planned)
  - Faster deployment timeline than plan







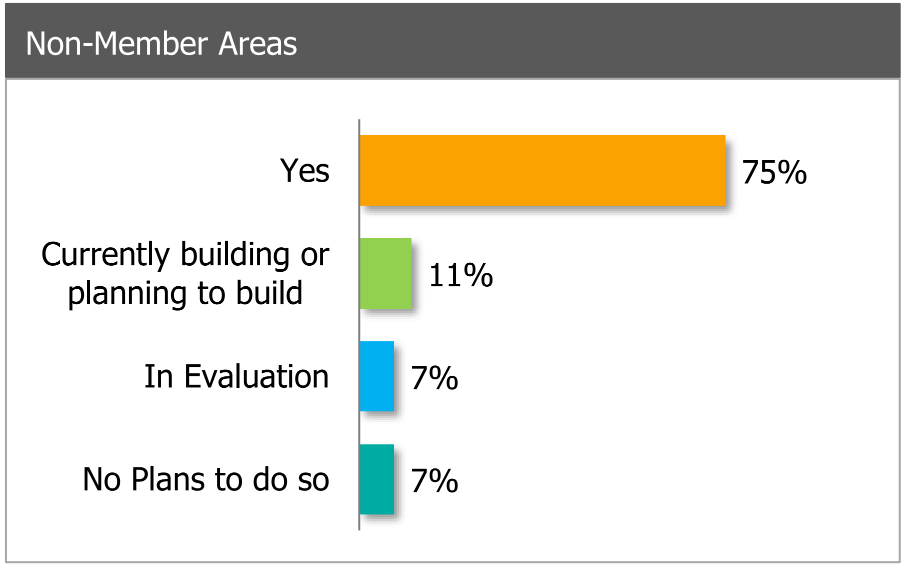




Non-member Areas

Cooperative broadband projects always 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 than otherwise available but provides better scale and economics to the overall network.

- 75% of respondents said that they have built to “non-member” areas
- Only 7% said that they have no plans for these areas



Member Surveys

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

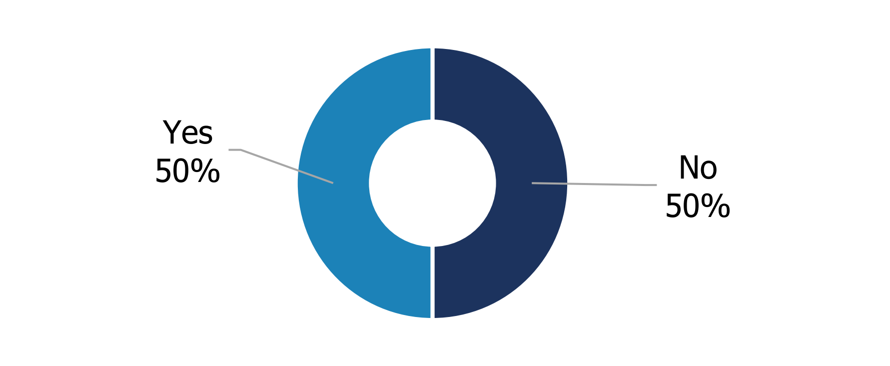
Member surveys help gauge member interest in the topic of broadband, better evaluate the competitive landscape a cooperative might face in deploying a new broadband service and help confirm potential project "take- rates".

Surveys can take many forms (telephone, mail, email, hybrid) and ideally are constructed in a manner that makes them statistically valid. In other words, in a manner that makes their results useful for projection because the data collected conforms to modern research standards and allows for the calculation of a confidence level and margin of error.

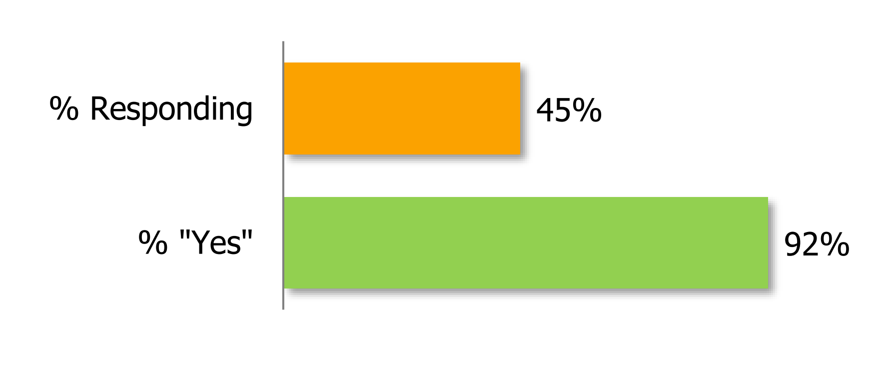
Respondent results

- 50% of respondents said that they conducted a member survey
- Of those conducting a member survey, average response rates (members willing to participate in their cooperatives broadband survey) averaged 45%
- For the individual cooperative members responding to these surveys, 92% gave a "yes" vote in favor of their cooperative providing broadband service.

Completion of Member Survey



Median Survey Results



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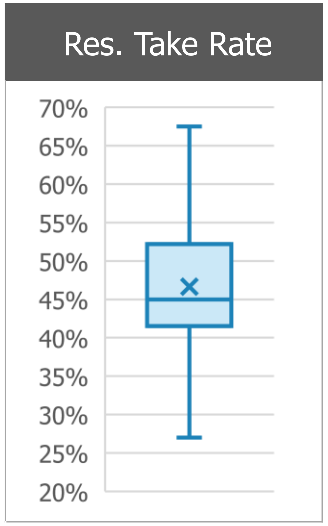
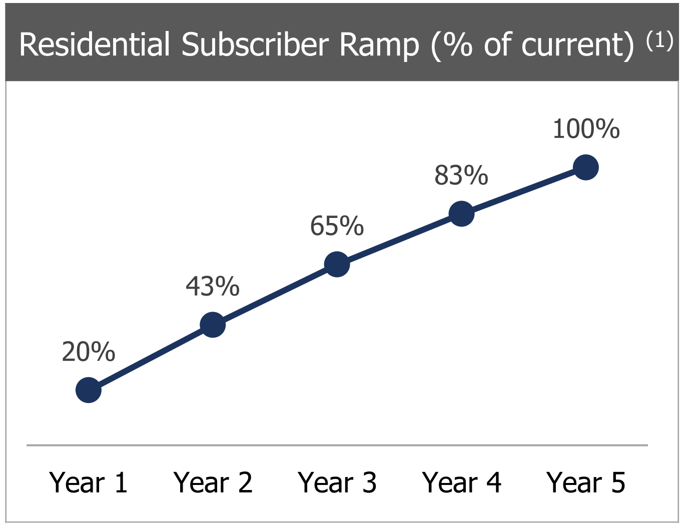
Subscribers and Revenue

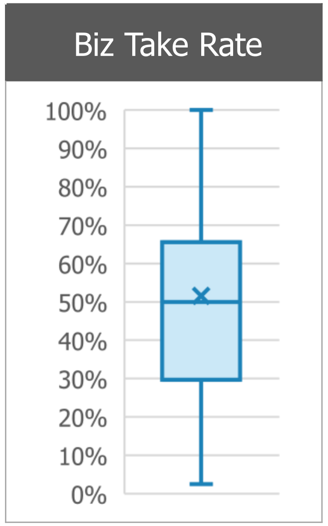
Take Rates

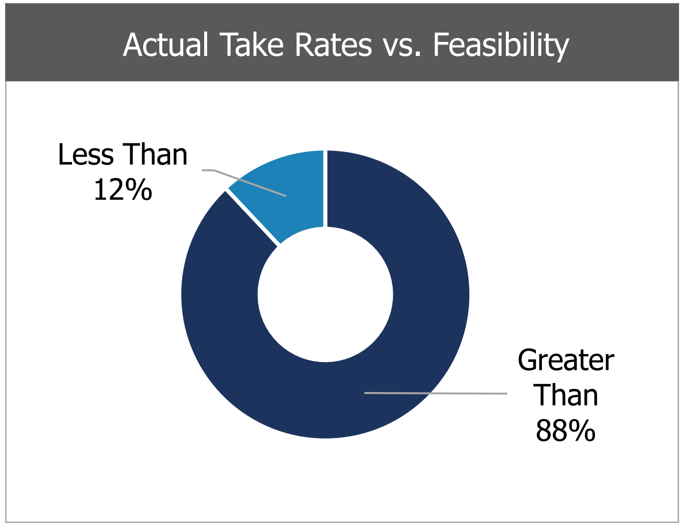
Take rate is the percentage of covered homes and businesses that become subscribers

- Primary factors influencing take rate are:
  - Degree of competition in an area
  - The service plans being offered (speed, services, etc.)
  - Price
- **Residential take rates:** Average 47% with a median of 45% and business take rates average 52% with a median of 50%
  - For co-ops with networks in service for more than two years, the average residential take rate is 52% and the median is 47%
  - Take rates achieved by cooperatives' focus on quality and their intimate knowledge and relationships with their members
- **Take rates vs. the feasibility forecast:** 88% of respondents said the actual take rate was greater than their feasibility forecast; The reasons cited for this were:
  - Conservative feasibility assumptions
  - Lack of competition
  - Consumer dissatisfaction for cable providers









(1) Graph reflects only projects with five years since deployment

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ARPU

Average Revenue per User (ARPU) results:

- **Residential:**
  - Average for respondents was $79 per user per month
  - In general, ARPU's ranged from $60-92 depending on circumstance and area of the country
  - Cooperatives offering more services (such as voice and video) naturally had higher average revenues due to more service offerings
- **Business:** Averaged $161 per user per month, with a general range between $95-203
- **Stand-alone internet**: Averaged $63 with a general range between $56-$71
- **Voice**: $35, with a 15% take rate
- **Video**: $92, with a 26% take rate

(1) Take rate for those offering the respective service

Price Plans

Pricing plans vary greatly by location and specific circumstances

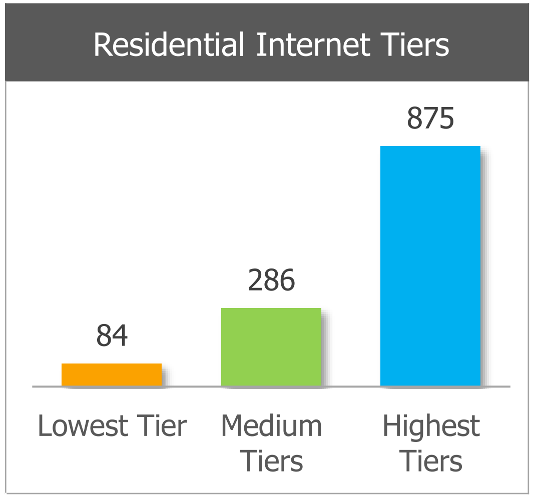
Cooperatives price based on meeting the challenges of their unique competitive situation as well as their cost to provide service

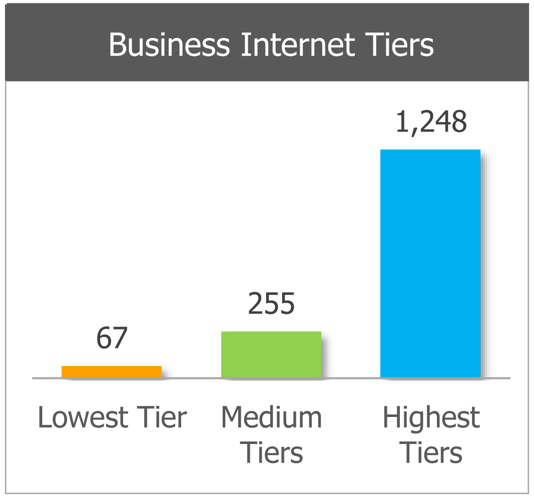
Residential internet speed tiers:

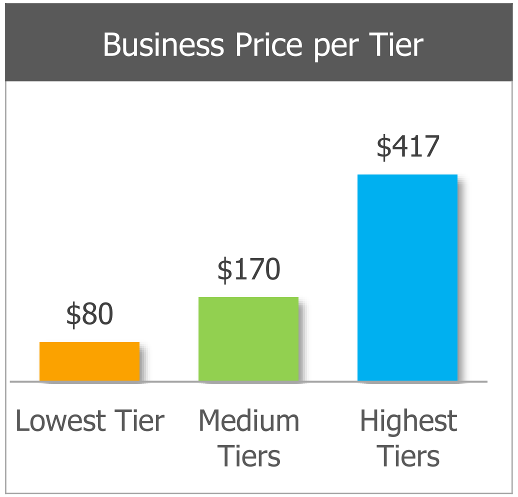
- **Lowest tiers:** Ranged from 5 Mbps to 300 Mbps with an average of 84 Mbps at an average cost of $53 per month
- **Medium tiers:** Ranged from 50 Mbps to 625 Mbps with an average of 286 Mbps at an average cost of $80 per month
- **Highest tiers:** Ranged from 100 Mbps to 2Gbps with an average of 875 Mbps at an average cost of $113 per month

Business internet speed tiers:

- **Lowest tiers:** Average speed of 67Mbps at an average cost of $80 per month
- **Medium tiers:** Average speed of 255Mbps at an average cost of $170 per month
- **Highest tiers:** Average speed of 1.2 Gbps at an average cost of $417 per month







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

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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 the staffing models that are chosen

- There is a strong correlation between subscriber count and staff count for projects with less 10,000 subscribers; Above this count, results vary with outsource mix

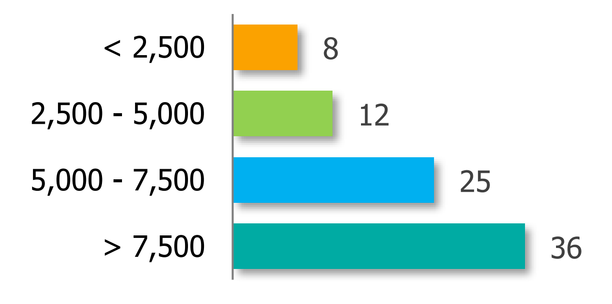
As can be seen in the survey results, co-ops build dedicated broadband teams, but often use shared resources from their electric operations. They also often choose to outsource functions such as Help Desk and installation.

- The median staffing model from respondents included:
  - Broadband Manager
  - Outside Plant Manager, Construction Manager, and Mapping/Staking Tech
  - Marketing
  - Customer Service Reps (3), Maintenance Techs (3), and Install Techs (3)
  - Median team size was 16 and ranged from two to 74

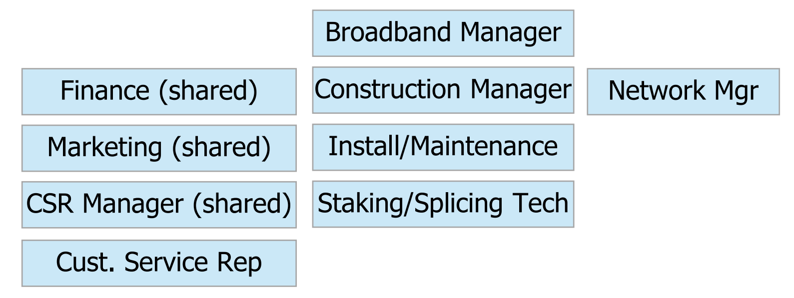
Functional staffing results

Function	Median	Min	Max
Broadband Manager	1.0	0.0	1.8
Admin Assistant	0.2	0.0	1.0
Outside Plant Manager	1.0	0.2	1.0
Construction Manager	1.0	0.2	2.0
Administration	0.5	0.1	8.0
Marketing	1.0	0.1	12.0
Mapping / Staking Tech	1.0	0.0	3.0
IT / Network Engineering	2.0	0.1	11.0
Warehouse	0.5	0.0	3.0
Purchasing	0.4	0.0	1.0
Finance/ Accounting	0.5	0.3	5.0
Customer Service Reps	2.8	0.2	20.0
Maintenance Techs	3.0	0.0	12.0
Installation Techs	3.0	1.0	40.0
Total (not additive)	**16.1**	**2.2**	**73.8**

Internal staff size by subscriber count



Typical Org Chart



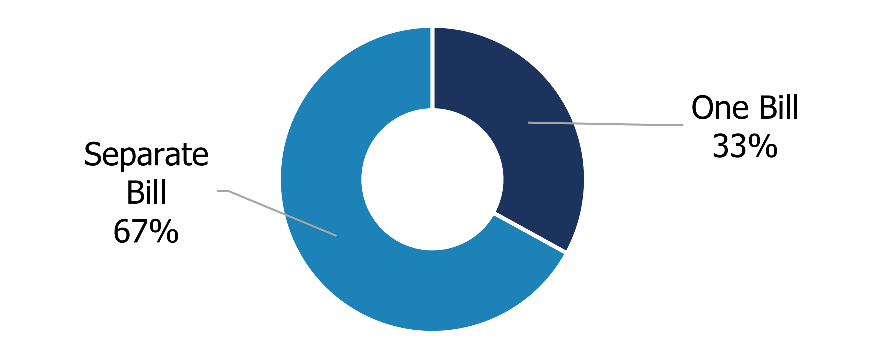
Function	In-source	Out-Source	Both
Marketing	85%	0%	15%
IT / Network Engineering	63%	0%	37%
Purchasing	85%	7%	7%
Customer Service	70%	0%	30%
Help Desk	23%	15%	62%
Network (NOC) Monitoring	69%	12%	19%
Installation	37%	15%	48%

Billing

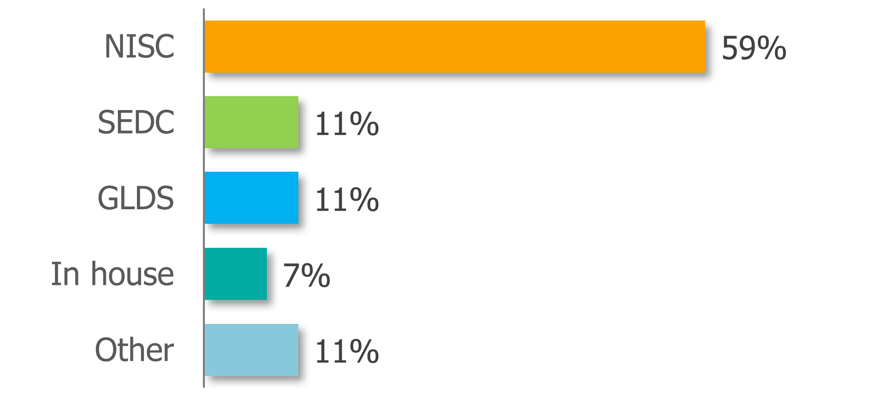
There are several steps beyond construction to prepare to run a broadband business such as changes to billing processes

- Members either combine broadband billing with electric billing or provide separate bills; 67% of respondents provide separate broadband and electric bills and 33% have combined billing
  - Typically, if members use their existing electric billing platform for broadband, they need to upgrade to their telecom module to support broadband and voice fees, taxes and call detail records
- Systems also typically can integrate with FTTH/FWA provisioning system as well as with VoIP and other ancillary services
- There are many billing vendors; 59% of members use NISC's platforms and the remaining members are fairly evenly spread across SEDC, GLDS, in-house and other platforms

Billing approach



Billing Vendor(s)



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Business Considerations

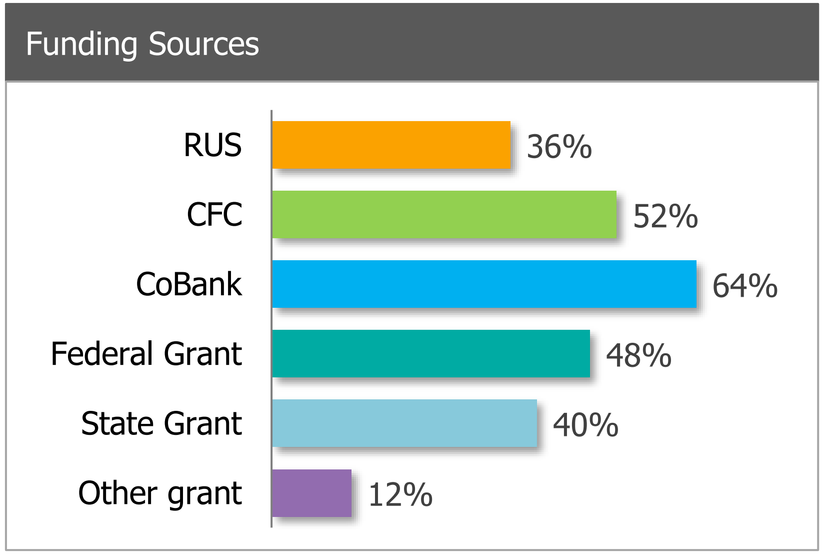
Funding Sources

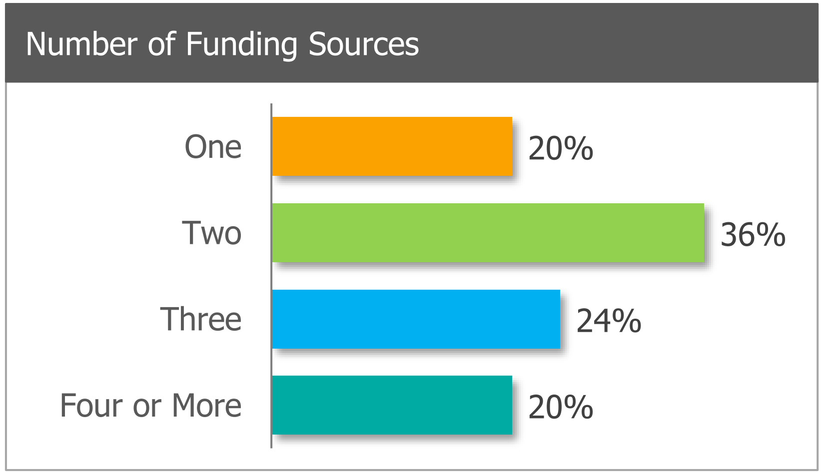
Multiple sources are available for rural broadband funding

- **CFC and CoBank** are the most popular private lenders to electric cooperatives
- **USDA's Rural Utilities Service (RUS)** administers several loan and grant programs that apply to telecommunications services
  - The ReConnect program has awarded ~$800 million in loans and grants in 2019-20; Congress has approved a total of over $2B, or $700M a year
  - The Electric Infrastructure Loan & Loan Guarantee Program encourages rural electrics to build smart grid integrated with broadband connectivity
- **Universal service** is an FCC-administered support program that provides funding to rural "eligible telecommunications carriers" (ETCs)
  - In Phase II of the Connect America Fund (CAF), the FCC allowed rural electrics to become ETCs and compete for funding; CAF-II distributed $1.5B following a 2018 auction
  - The FCC is distributing over $20B through the current Rural Digital Opportunity Fund (RDOF) program; It will auction about $16B in the first phase, beginning October 2020
- **State programs:** Some states have their own universal service programs to augment the federal program; Many also have separate broadband grant programs

Respondent results show that members are taking advantage of these sources to benefit their communities

Results demonstrate that CFC and CoBank loans are the most frequent sources for these projects; However, 80% of respondents use more than one source, including RUS and federal and state grants





Business Structure And Allocations

Basic Business/Tax Structures

Multi-Divisional Cooperative

- Electric and broadband operations are divisions; Gains/losses are on a divisional basis
- Management services, cost sharing, leases, loans, between divisions and eliminated from 85-15 Test

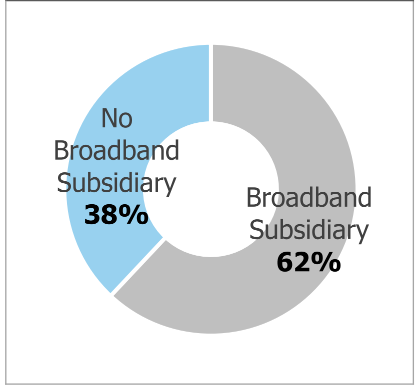
Wholly-Owned Subsidiary Corporation

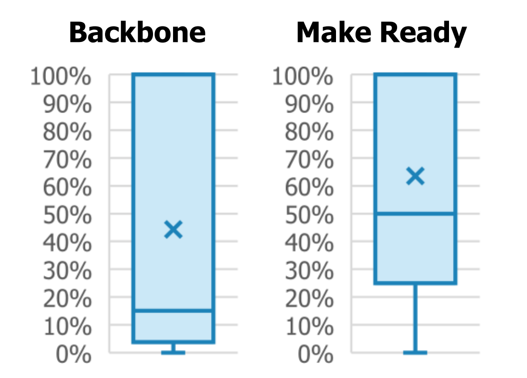
- A new broadband subsidiary is set up and capitalized in exchange for 100% ownership
- Management services, fiber lease, and related agreements executed; 85-15 test and Unrelated Business Income Tax considerations
- Record equity method earnings; Dividends paid result in non-member income in the 85-15 Test

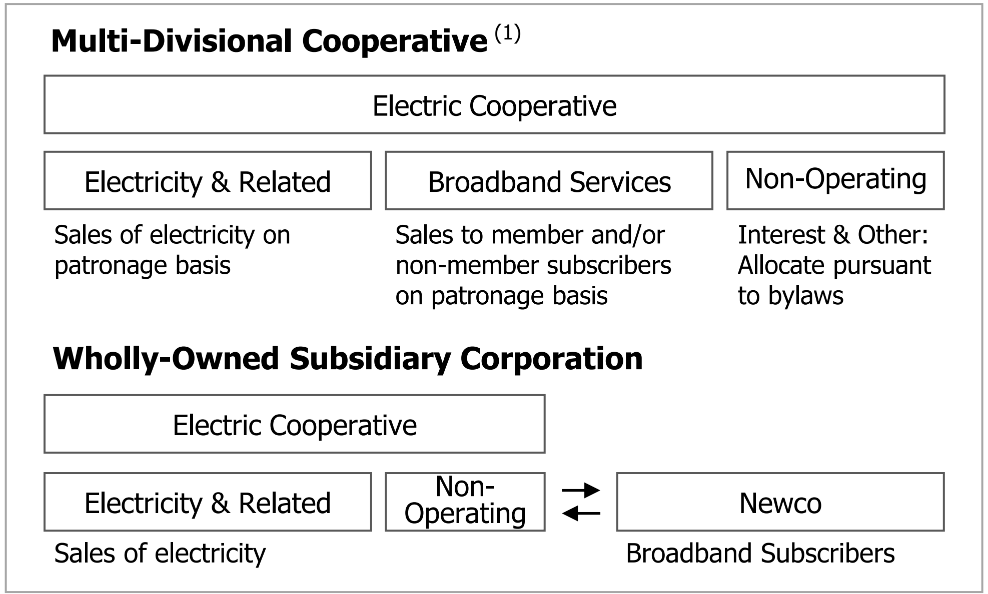
Other structures such as Multi-Divisional Cooperative with Disregarded Entity and Multi-Divisional Cooperative with Non-patronage Services can also be used

Respondent Results

- 62% of respondents set up a broadband subsidiary
- The percent of cost for backbone and make ready allocated to the electric business varied greatly, from 0% to 100%; Most allocated some amount, however, with the 25-75th percentile ranging from 4-100% for backbone and 25-100% for make ready







(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 17, 2017 from Bolinger, Segars, Gilbert & Moss, LLP to NRECA (available to NRECA voting members)

Difficulty of Issues

The benchmarking survey asked members to rank ten issues in terms of difficulty

Interestingly, at least one member ranked every issue as least difficult and nine of the 10 were ranked as the most difficult by at least one member. Just as the characteristics of many deployments are unique, so are the experiences in building and operating the networks.

However, by looking at the average response and the mode (most frequent), we can understand which issues members tend to perceive as more difficult

- Average of 6-7: Project Management, Make Ready, and Systems Integration
- Average of 5-6: Installations, working with contractors, and easements
- Average of <5: Securing funding, marketing, and working with vendors

Difficulty of issues (1: Least, 10: Most)

Issue	Avg	Min	Max	Mode
Project Management	6.9	1.0	10.0	9.0
Make ready	6.2	1.0	10.0	8.0
Systems integration	6.0	1.0	10.0	7.0
Reporting requirements	5.8	1.0	10.0	4.0
Installations	5.7	1.0	10.0	5.0
Working with contractors	5.7	1.0	10.0	7.0
Easements	5.3	1.0	10.0	1.0
Securing funding	4.5	1.0	10.0	1.0
Marketing	4.4	1.0	10.0	2.0
Working with vendors	3.9	1.0	9.0	4.0

Acknowledgements

Thank you for reviewing the *Rural Electric Cooperatives Broadband Benchmarking Report.*

This document covered a wide range of topics, and we hope that you will benefit from the data, experiences and analysis shared. We plan to issue additional reports covering new topics and updated information in the future. Also, as additional members deploy broadband, we hope they'll add their voice to this resource.

A deep expression of gratitude to the 36 cooperatives that have shared their broadband journey with us.

To those considering deploying broadband, thank you for the commitment you're making to evaluate broadband and the role that you might play on behalf of the rural communities and member-consumers you serve.

Vibrant, connected rural communities benefit all of us – creating opportunity and making America stronger and more prosperous.

NRTC is proud to partner with our members in this transformational endeavor.

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.

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Glossary

Glossary: Use Cases

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

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

Business Broadband: Broadband connectivity and associated solutions for Commercial and Industrial members

Consumer Broadband: Broadband connectivity and associated solutions for residential members

Distribution Automation (DA): Monitoring and control of devices on the power grid with two-way communications

DER connectivity/control: Connectivity and control of Distributed Energy Resources such as solar, consumer-sited devices, energy storage, and electric vehicles

Demand Response (DR): Reduction or shifting of customer power consumption, typically during times of peak demand

Irrigation Control: Two-way connectivity and control of irrigation systems

Land Mobile Radio: Secure, instant communications systems to field force and vehicles in mission-critical environments such as Public Safety and Utilities; Has one-to-one and one-to-many capabilities and often push-to-talk

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

Smart Agriculture: The use of sensors, communications, and data analysis to increase the efficiency and yield of farming

Smart Grid Endpoints: Devices on a smart grid network such as meters, reclosers, and sensors

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

Workforce / Vehicle Management: Systems that track and improve efficiency of a field service team or fleet

Glossary: Technologies

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

Boring: Method of underground fiber placement that use rigs to drill a tunnel underneath the ground; The cable is then pulled through the tunnel

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

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

Core Networking: Gateway to a wide area network (WAN) or the internet and provide the final aggregation point for the network

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

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

Glossary: Technologies

Head End: See Core Networking

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

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

Plowing: Method of underground fiber placement that uses a plow machine to cut a narrow slit in the ground and place the fiber cable

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

Trenching: Method of underground fiber placement that creates a trench in the ground; Once the fiber cable is placed, the slit is back-filled with dirt

Wireless Spectrum: Airwaves used for wireless communications technologies to transmit information

Glossary: Business Terms

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

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

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

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