

2020

California State Broadband Cost Model (CBCM)

CBCM Report—December 2020



Authored By:

CostQuest Associates
1430 E. McMillan St.
Cincinnati, OH 45206
U. S.

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EXECUTIVE SUMMARY

INTRODUCTION

Chico State University, on behalf of California Public Utilities Commission (CPUC), engaged CostQuest Associates, Inc. (CQA) to provide a statewide cost model for broadband and voice services using methods consistent with the adopted FCC Connect America Cost Model (CACM) as modified by the approach requested by the CPUC. The CACM is used under multiple FCC funding mechanisms, including the Rural Digital Opportunity Fund (RDOF) program¹. It must be noted here however that the California State Broadband Cost Model (CBCM) is not the CACM. The CBCM has as its purpose the estimation of investment to build broadband network infrastructure to given locations on a one-time capital cost basis.

The cost elements comprising CBCM are based on network design and engineering methods, to model, as closely as possible, estimated network deployment costs of a fiber to the premises network capable of meeting current and future consumer bandwidth demand requirements. The model's inputs are flexible, so that information about cost factors specific to areas of California may be adjusted going forward, at the option of the CPUC.

The purpose of the CBCM is to provide the CPUC and state Policy Makers with cost estimates for broadband across the state. To that end, and to support the various needs the CPUC seeks to address, the CBCM is provided as an iterative process. This model provides Middle Mile and Access Network investment with aggregate build out costs for Fiber to the Premises (FTTP) for the access networks and service tiers as described in the Scope section of this report. FTTP networks are capable of providing services with bandwidth up to 1000 Mbps. Investment is categorized above and below a threshold. The threshold value is intended to help identify areas which may be too costly for economically viable FTTP.

Future iterations of the model may be expanded to include additional network tech types, tiers of service, and geographies. We note, for example, a majority of California housing units are served with broadband services provided by cable companies. At the request of CPUC staff, the model may be adjusted to evaluate areas served by cable companies.

SUMMARY FINDINGS

The cost models provide estimates for a Fiber to the Premises (FTTP) network. The Fiber to the Premises network is constructed for all unserved locations. Unserved locations *over* an investment threshold are served with the same network as those *under* the threshold.

¹ The FCC RDOF Program information is available at: <https://www.fcc.gov/auction/904>. RDOF mapped locations in California are available via CPUC mapping at: <https://www.broadbandmap.ca.gov/federalfunding/>. The CPUC's support mechanisms for in-state RDOF bidders and federal program updates are available at: <https://www.cpuc.ca.gov/broadbandfederalfunding/>.

The estimated investments to provide voice and broadband² were calculated for areas not served by the following speed standards:

1. 25 Mbps download / 3 Mbps upload
2. 100 Mbps download / no specified upload
3. 100 Mbps download / 10Mbps upload

Results are presented in Tables 1-4, below. The access network values allocate 100% of the middle mile structure to the voice and broadband network. Associated state maps for each speed standard table can be found in a separate document; see appendix D for detail.

Table 1: Estimated Investments - Statewide Comparative Summary, by Speed Tier³

Tier 1 (25/3) Total Network Investment	Category	Structure Count (Demand Locations)	Passed Access Investment	Service Turnup Based Investment	Total Investment
	Unserviced Network Subtotal	513,700	\$3,034,255,049	\$350,898,450	\$3,385,153,499
	Statewide Middle Mile Network Subtotal	na	na	na	\$2,167,280,701
See: Table 2	Total Investment	na	na	na	\$5,552,434,200
Tier 2 (100 Down) Total Network Investment	Category	Structure Count (Demand Locations)	Passed Access Investment	Service Turnup Based Investment	Total Investment
	Unserviced Network Subtotal	760,053	\$4,058,476,496	\$507,437,479	\$4,565,913,975
	Statewide Middle Mile Network Subtotal	na	na	na	\$2,167,280,701
See: Table 3	Total Investment	na	na	na	\$6,733,194,676
Tier 3 (100/10) Total Network Investment	Category	Structure Count (Demand Locations)	Passed Access Investment	Service Turnup Based Investment	Total Investment
	Unserviced Network Subtotal	779,065	\$4,114,007,951	\$518,715,826	\$4,632,723,777
	Statewide Middle Mile Network Subtotal	na	na	na	\$2,167,280,701
See: Table 4	Total Investment	na	na	na	\$6,800,004,478

² The Service Turnup investment (ONT and Drop) is not sensitive to the service speed deployed, up to 1 Gb of best-efforts service. The access network investment, while fairly static, is sensitive to the delivered speeds mainly with respect to splitter ratios and core electronics. Those sensitivities will be driven by bandwidth consumption assumptions for the end user, services consumed, and the number of supported end users connected to the network in an area.

³ The Statewide Middle Mile Network Subtotal is based on a full state greenfield analysis.

Table 2: Estimated Investments - Statewide for 25/3 Bandwidth Tier: FTTP to Areas Lacking 25/3 Mbps⁴⁵

Total Network Investment	Category	Structure Count (Demand Locations)	Investment	% of Total Investment	Total Investment
	Unserviced Network Subtotal	513,700	\$3,385,153,499	60.97%	\$5,552,434,200
	Statewide Middle Mile Network Subtotal	na	\$2,167,280,701	39.03%	
Unserviced Network	Category	Structure Count (Demand Locations)	Passed Access Investment	Service Turnup Based Investment	Total Investment
	Brownfield	488,815	\$2,283,772,040	\$334,522,794	\$2,618,294,834
	Over Threshold	36,027	\$933,111,622	\$25,561,272	\$958,672,894
	Under Threshold	452,788	\$1,350,660,418	\$308,961,522	\$1,659,621,940
	Greenfield	24,885	\$750,483,009	\$16,375,656	\$766,858,665
	Over Threshold	12,882	\$684,018,803	\$9,434,506	\$693,453,309
	Under Threshold	12,003	\$66,464,206	\$6,941,150	\$73,405,356
	Subtotal Over Threshold	48,909	\$1,617,130,425	\$34,995,778	\$1,652,126,203
	Subtotal Under Threshold	464,791	\$1,417,124,624	\$315,902,672	\$1,733,027,296
	Total	513,700	\$3,034,255,049	\$350,898,450	\$3,385,153,499
Dark Fiber Middle Mile Network				Middle Mile:	\$2,167,280,701

Threshold = \$9,180 Capex per structure, based on the capital portion of the Extremely High Cost Threshold (EHCT). See: CBCM Report, December 2020.

⁴ *ibid*

⁵ Brownfield - assumes the ILEC or cable provider can reuse existing structure. Greenfield – assumes no existing structure.

Table 3: Estimated Investments - Statewide for Bandwidth Tier: FTTP to Areas Lacking 100 Mbps Download⁶⁷

Total Network Investment	Category	Structure Count (Demand Locations)	Investment	% of Total Investment	Total Investment
	Unserviced Network Subtotal	760,053	\$4,565,913,975	67.81%	\$6,733,194,676
	Statewide Middle Mile Network Subtotal	na	\$2,167,280,701	32.19%	
Unserviced Network	Category	Structure Count (Demand Locations)	Passed Access Investment	Service Turnup Based Investment	Total Investment
	Brownfield	705,031	\$3,123,118,595	\$473,092,661	\$3,596,211,256
	Over Threshold	42,879	\$1,062,679,254	\$30,931,798	\$1,093,611,052
	Under Threshold	662,152	\$2,060,439,341	\$442,160,863	\$2,502,600,204
	Greenfield	55,022	\$935,357,901	\$34,344,819	\$969,702,719
	Over Threshold	15,257	\$743,304,844	\$11,260,204	\$754,565,048
	Under Threshold	39,765	\$192,053,057	\$23,084,615	\$215,137,671
	Subtotal Over Threshold	58,136	\$1,805,984,098	\$42,192,002	\$1,848,176,100
	Subtotal Under Threshold	701,917	\$2,252,492,398	\$465,245,477	\$2,717,737,875
	Total	760,053	\$4,058,476,496	\$507,437,479	\$4,565,913,975
Dark Fiber Middle Mile Network				Middle Mile:	\$2,167,280,701

Threshold = \$9,180 Capex per structure, based on the capital portion of the Extremely High Cost Threshold (EHCT). See: CBCM, December 2020.

⁶ *ibid*

⁷ Brownfield - assumes the ILEC or cable provider can reuse existing structure. Greenfield – assumes no existing structure.

middle mile networks. In the context of an FTTP access network, buildings and houses are connected with fiber optics, and data traffic is aggregated to a high-capacity node such as a Central Office or Hub/Headend. The middle mile network connects these high-capacity aggregation points together so data traffic can be exchanged among the points and to the internet.

Estimated investments for the unserved areas are categorized above or below a threshold. The threshold is based on the Extremely High-Cost threshold value established by the FCC, \$198.60 per month.¹⁰ Derivation of the threshold is described in *Threshold Development*, pages 13–16.

Going forward in further iterations of the CBCM, CPUC may consider conducting a cost and/or geospatial analysis of the relationship of middle mile nodes and their proximity to clusters of areas ‘Over Threshold.’ This type of analysis could inform a strategy ensuring middle mile routes and node placement will support areas of California that are most expensive to serve with nodes for eventual backhaul facilities.

MODEL OVERVIEW

CBCM follows the same processing methods used by the FCC Connect America Cost Model.¹¹ The logic for the access and middle mile calculations are derived from CostQuest LandLine (CQLL) and CostQuest Middle Mile (CQMM) models. Both models were developed to reflect a realistic, engineering-based understanding of what drives (i.e., causes) investments. Both CQLL and CQMM are forward-looking models. They take as given the locations of service demand and an aggregation point (Central Office, Node0, Hub). The access network necessary to connect demand along roads to the Central Office is then modeled with CQLL. CQMM models the middle mile network.

Both models function like an engineer in developing a cost estimate for serving an area. The models work to survey a serving area for demand locations and network termination. Demand areas are connected with one another and aggregation points. Service demand is measured along the network to ensure that adequately sized materials and electronics are placed. Quantities of fiber cable, labor hours, and supporting structure are developed and tallied. This generates a bill of materials. This bill of materials is costed using the appropriate sizes, quantities, and prices.

The list below summarizes the basic assets captured.

- Optical Network Terminals (ONT)

¹⁰ The CAFII Final Adopted Offer of Support was released in April 2015. The illustrative results describe the cost benchmark and extremely high-cost threshold. The illustrative report is available at https://www.fcc.gov/wcb/CAM_4.3_Results_Final_042915.xlsx

¹¹ The model methodology can be found at, <https://www.fcc.gov/wcb/CAM%20v.4.2%20Methodology.pdf>.

- Fiber Drop
- Fiber Service Terminals
- Fiber Splitters
- Aerial Structure: Poles, Anchors, Guy
- Underground Structure: Conduit, Duct, Manhole
- Aerial, Buried, Underground Fiber Optic Cable
- Optical Line Terminal (OLT)
- Routers, eSwitches, and Regeneration Equipment
- Central Office Land and Building (as capital investments)
- Miscellaneous Material
- Capitalized Labor for engineering, splicing/placing, and configuring for service. Labor rates used are based on a survey of market rates with adjustments to local labor conditions via RSMeans city indices¹².

The access network follows a PON (Passive Optical Network) design. Power for the optical network at the Central Office / Hub location is provided using commercial power and generator power for backup. The passive optical network terminates at the demand location on an ONT. The ONT provides backup power via battery for up to eight hours.

All broadband and voice traffic are handled on IP networks. Middle mile networks connect Node0 (Central Office, Hub Headend) locations. Traffic moves among the Node0 locations on a high-capacity IP network. Diagrams simplifying each network topology are shown below.

¹² The RS Means adjustment provides a Zip3 specific adjustment, to CACM adopted labor costs. While it is likely reflective of major Telecom providers, it may not reflect the specific values in prevailing wage sources.

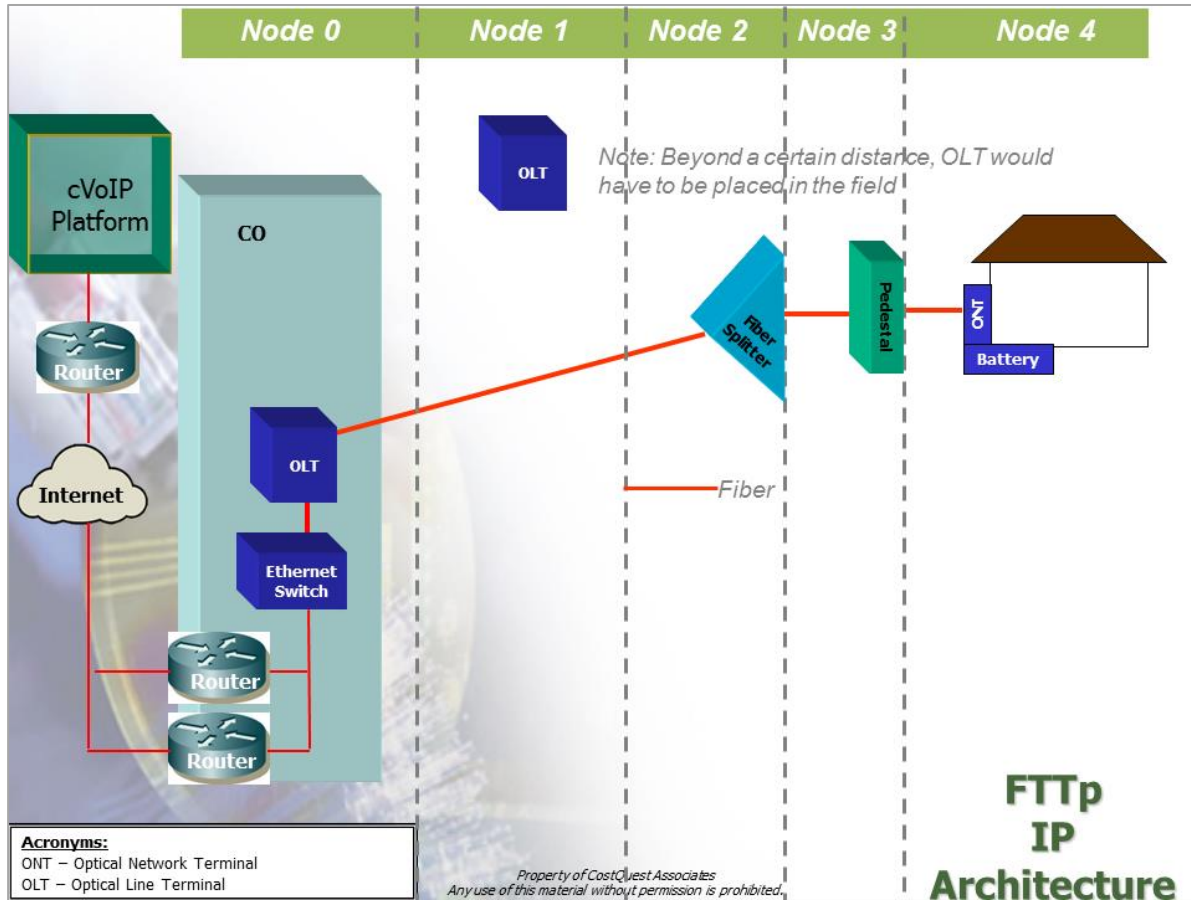


Figure 1: FTTP Passive Optical Network Architecture

The middle mile network extends between the service provider’s point of interconnection with the Internet to the service provider’s point of interconnection (“POI” or CO). A network diagram is shown below.

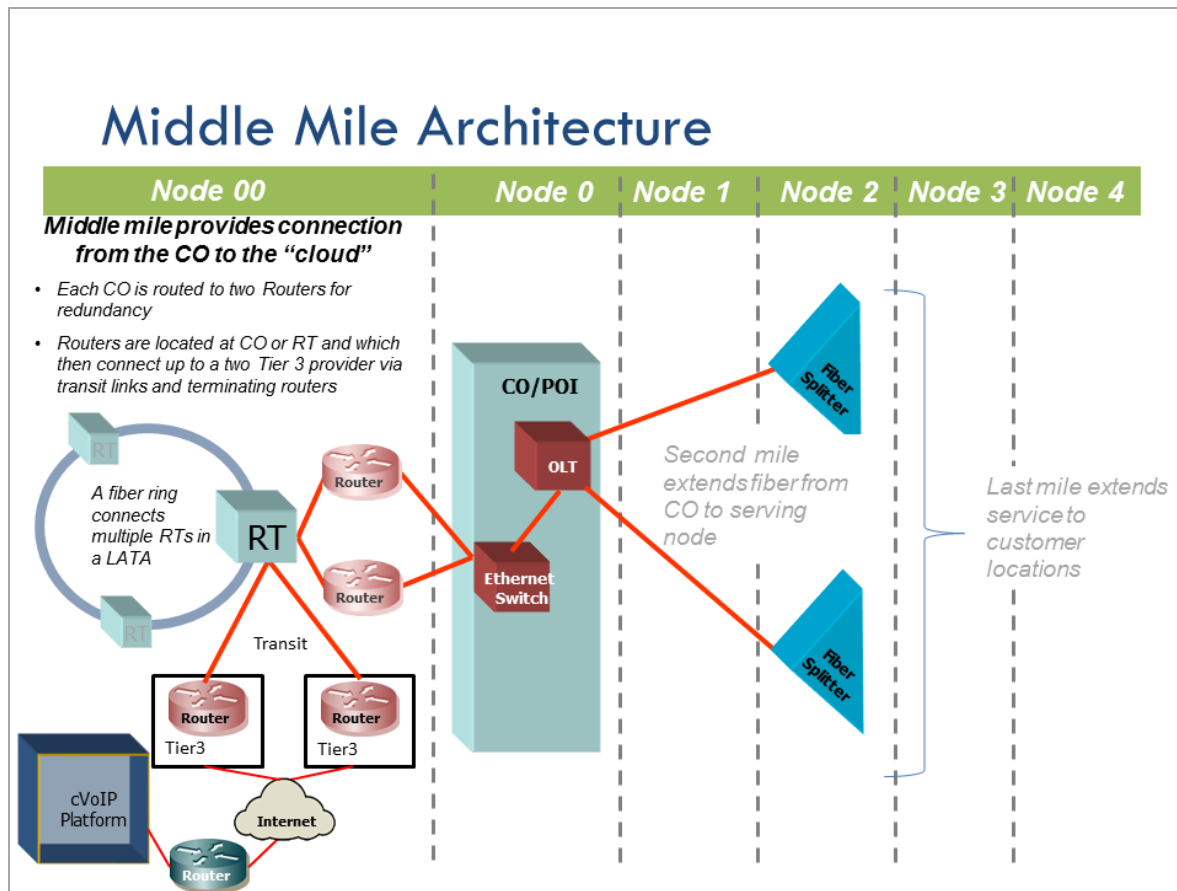


Figure 2: Middle Mile Architecture

THRESHOLD DEVELOPMENT

Investment in communication networks follows what has been described as a hockey stick shape. As shown on the blue line in the figure below, per-unit network investment follows a low rate of change until a certain point. After that inflection point, investment per unit changes dramatically.

The figure below was derived from the California State Broadband Cost Model. It shows the changes in unit investment to provide FTTP across all Census Blocks (Blocks) in California-served and unserved areas. Because all areas of the State are considered, the particular service tier is not considered.

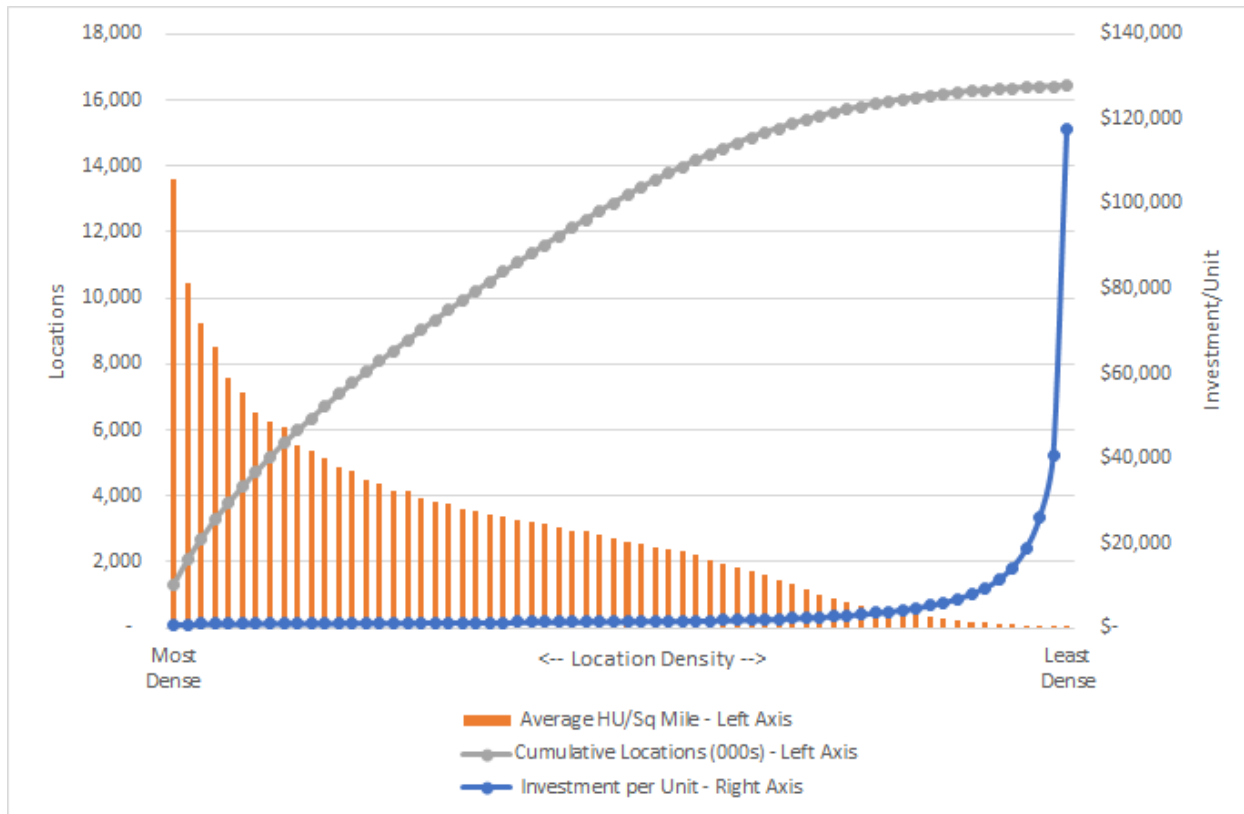


Figure 3: Hockey-stick Function Example

The figure is composed of three curves. Each curve was developed by examining all Census Blocks in the State of California. Blocks were characterized as to the number of locations (gray curve), the density in locations per square mile (orange curve), and the investment to provide broadband per location (blue curve). Blocks were rank ordered from the lowest investment per unit to highest. Each curve represents the trends from the lowest investment per unit to the highest and from most dense to the least.

Examining all curves together allows a person to see important properties of network investment. First, as density falls, the number of locations grows at a relatively constant rate. As the cumulative location count flattens, the addition of locations begins to grow very slowly. In other words, most locations are in dense areas. As we move out of dense areas we gain fewer and fewer locations.

Second, the most dense blocks have the lowest investment per location served. Investment rises at a slow but consistent rate as density falls. At some point the gray and orange curves start to flatten. As a result, investment per unit increases significantly. The flat investment curve shifting to a high growth rate is what gives the blue line, the hockey stick shape.

Different network technologies will demonstrate similar sensitivities. Each technology may show inflection points differently, but with communication networks there remains an inverse relationship between location density and investment to serve.

INVESTMENT CATEGORIZATION

Understanding the hockey stick shaped pattern of network investment provides policy makers with a method to categorize investment. For example, support policy could be formed around a simple rank ordering of investment. This would allow funding the lowest cost or highest cost areas until some budget threshold was reached.

In other cases, policy could be developed that categorizes investment above and below the network investment curve's inflection point. The FCC may have used such a method in setting the Extremely High-Cost Threshold (EHCT) in development of CAFII.

Figure 4 is an adaption of the previous figure. It was modified to show the investment driven portion of the Extremely High-Cost Threshold (black line). This level of investment nearly intersects the inflection point of the network investment curve.

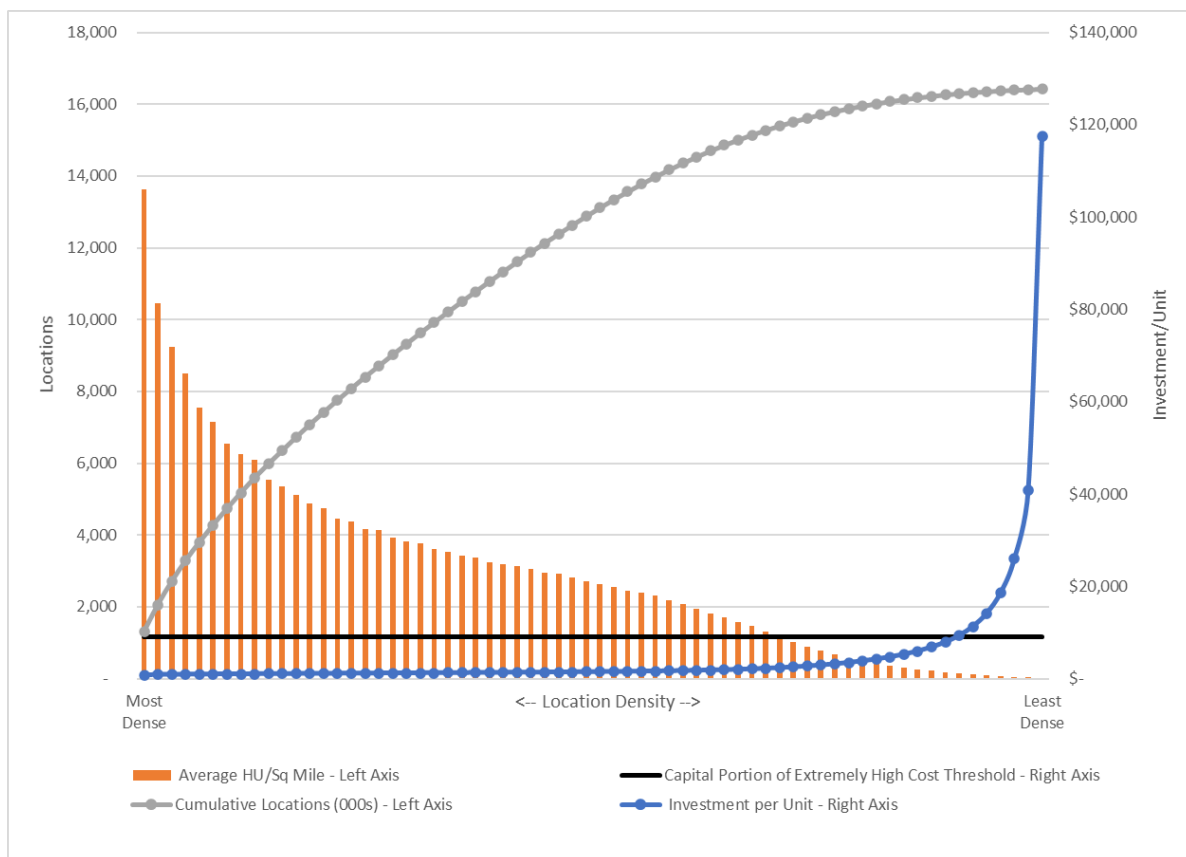


Figure 4: California Cost Curve Unit Investment with EHCT

The EHCT was used to develop the Connect America Fund offers of support to price cap carriers. Where the modeled forward-looking monthly cost was below this threshold, unserved blocks could be funded by through the FCC’s offer of support to carriers. If the cost per month exceeded the EHCT, the unserved block would be funded through a different mechanism. Implementing this EHCT allowed the FCC to pursue different policy tools and objectives in blocks that exhibited different economics¹³.

The FCC’s EHCT, \$198.60 per month, contains capital and operational expense components. The capital expense portion (\$91.80) was estimated based on the ratio of total monthly capital cost to total monthly cost. The \$91.80 was converted into \$9,180 in investment based on the ratio of total capital expense to total investment (0.01).

STRUCTURE LOCATION ANALYSIS

In this analysis, structures are buildings likely requiring broadband services. A structure can contain a housing unit (occupied or unoccupied) a commercial or community enterprise (collectively a business) or some combination of each. The table below provides summary statistics on the breakdown of structures (demand locations) analyzed.¹⁴

Table 5: Brownfield and Greenfield Analyzed Structure Summary 25/3

Structure Count (Demand Locations)	Column Labels		
Row Labels	Brownfield	Greenfield	Grand Total
<input type="checkbox"/> Unserved – No Service	3.32%	22.92%	3.45%
Over Threshold	0.29%	14.08%	0.39%
Under Threshold	3.03%	8.84%	3.07%
<input type="checkbox"/> Unserved – Slow Service	1.35%	10.92%	1.41%
Over Threshold	0.05%	3.44%	0.08%
Under Threshold	1.29%	7.48%	1.34%
<input type="checkbox"/> Served	95.34%	66.17%	95.13%
Over Threshold	0.09%	4.63%	0.13%
Under Threshold	95.24%	61.53%	95.01%
Grand Total	100.00%	100.00%	100.00%

¹³ See USF/ICC Transformation Order, <https://docs.fcc.gov/public/attachments/FCC-11-161A1.pdf>, at paragraph 167. “Specifically, we will use the model to identify those census blocks where the cost of service is likely to be higher than can be supported through reasonable end-user rates alone, and, therefore, should be eligible for CAF support. We will also use the model to identify, from among these, a small number of extremely high-cost census blocks that should receive funding specifically set aside for remote and extremely high-cost areas...”

¹⁴ Numbers may not sum to 100% due to formatting.

Table 6: Brownfield and Greenfield Analyzed Structure Summary 100/x

Structure Count (Demand Locations)		Column Labels		
Row Labels		Brownfield	Greenfield	Grand Total
<input type="checkbox"/> Unserved – No Service		3.32%	22.92%	3.45%
Over Threshold		0.29%	14.08%	0.39%
Under Threshold		3.03%	8.84%	3.07%
<input type="checkbox"/> Unserved – Slow Service		3.41%	51.89%	3.75%
Over Threshold		0.12%	6.67%	0.17%
Under Threshold		3.29%	45.23%	3.58%
<input type="checkbox"/> Served		93.28%	25.19%	92.80%
Over Threshold		0.03%	1.41%	0.04%
Under Threshold		93.25%	23.79%	92.76%
Grand Total		100.00%	100.00%	100.00%

Table 7: Brownfield and Greenfield Analyzed Structure Summary 100/10

Structure Count (Demand Locations)		Column Labels		
Row Labels		Brownfield	Greenfield	Grand Total
<input type="checkbox"/> Unserved – No Service		3.32%	22.92%	3.45%
Over Threshold		0.29%	14.08%	0.39%
Under Threshold		3.03%	8.84%	3.07%
<input type="checkbox"/> Unserved – Slow Service		3.59%	52.17%	3.93%
Over Threshold		0.12%	6.77%	0.17%
Under Threshold		3.47%	45.40%	3.76%
<input type="checkbox"/> Served		93.10%	24.91%	92.62%
Over Threshold		0.03%	1.30%	0.04%
Under Threshold		93.07%	23.61%	92.58%
Grand Total		100.00%	100.00%	100.00%

DATA SOURCES

The CBCM V2model uses geographic and financial data sources. These inputs are listed below

- Geographic
 - Three largest Incumbent LEC boundaries by Census Block; CPUC / Chico (8/2020)
 - Data file: FCC_Study_Areas_by_Block
 - Four largest Cable Provider boundaries by Census Block; CPUC / Chico (8/2020)
 - Data File: Video_Franchise_Territories_by_Block
 - Roads, US Census TIGER 2010 vintage
 - Demographic demand, CQA Demand Source - CQA estimates 2020 v1
 - Service Area Boundaries, GeoResults 2018 Q3
 - Broadband Service Standards (25/3,100/x, 100/10);
CA_BB_Served_Tiers_by_Block_Dec2019; CPUC/Chico (11/2020)
- Financial
 - FCC Connect America Input Collection ¹⁵(4/2014)
 - Modified FCC Connect America Input Collection to reflect all middle mile cost apportioned to broadband, voice network.
 - Modified FCC Connect America Input Collect to reflect brownfield and greenfield scenario
 - Brownfield scenario removes pole and conduit investment (structure and labor).
 - Brownfield scenario adjusts placing value for conduit and aerial cable rework.
 - Greenfield scenario adjusts placing costs based on review of current costs.

¹⁵ FCC Default inputs are available for public download.

https://www.fcc.gov/bureaus/wcb/Connect_America_Cost_Model_v4.1.1Default%20Inputs.zip

COST MODEL DATA FIELDS

The Data Dictionary is below.

Table 8: Cost Model Field Definitions

Field	Definition
Category	Geographies Modeled: Brownfield and Greenfield In Brownfield areas structure investment is not retained. Brownfield areas are areas within the top 3 ILEC and top 4 Cable providers. Greenfield areas are not Brownfield. In Greenfield areas structure investment is retained.
Threshold	A distinction to define areas above or below a per unit investment value.
Total Investment	For areas considered, Total Investment and Capitalized Labor.
Passed Investment	Investment and Capitalized labor for network to pass locations. (breakout of Total Investment)
Service Turnup Investment	Investment and Capitalized labor for network to connect to locations. (Drop and Optical Network Terminal) (breakout of Total Investment)
Middle Mile Investment	The estimated investment for a dark-fiber, full state middle mile network including fiber, structure, capitalized labor and regeneration electronics.
Structure Count (Demand Locations)	Count of structures. Housing Units, occupied or unoccupied, and businesses are contained within structures.

APPENDIX A—MODEL PARAMETERS

Item	Value
Block Level	Census Block - using Tiger 2010
Delivery type	Fiber to the prem (FTTP)
Network Type	Greenfield and Brownfield
	<i>Brownfield - assumes the ILEC or cable provider can reuse existing structure (telephone poles, duct, conduit, and manholes).</i>
	<i>Greenfield - assumes the builder of the broadband network must purchase and install poles, duct, conduit, and manholes.</i>
Costs / Investments	Where possible we are using the modeling, approach used for FCC costs
Middle Mile Funding Allocations	Aggregate buildout costs for access networks and middle mile networks expressed as a single figure for full state
Service Tiers - separate numbers for each tier	Unserved - All California locations not meeting 25/3 standards (defined by CA_BB_Served_Tiers_by_Block_Dec2019_20201111.csv)
	Unserved - All California locations not meeting 100/x standards (defined by CA_BB_Served_Tiers_by_Block_Dec2019_20201111.csv)
	Unserved - All California locations not meeting 100/10 standards (defined by CA_BB_Served_Tiers_by_Block_Dec2019_20201111.csv)
	Unserved - All California locations not meeting 25/3 standards (defined by CPUC Chico Data - FCC_Study_Area_byBlock.zip)
	Unserved Cutoff: investments for those areas below and above FCC Extremely High-Cost Threshold
	Unserved only for each service tier (under 25/3; 100/x; 100/10; threshold)
	Served or Unserved
Demand Locations	CQA estimates 2020 v1 - no breakout by residential/business
Network Buildout Types/Geographies	Brownfield
	ILEC areas (the 3 price cap providers)
	Top 4 cable franchise areas
	Greenfield
	Areas outside of the ILEC (3 carriers) / CableCo (4 carrier) boundaries
	As identified in CA data file

Item	Value
Debt/Equity ratio	Consistent with FCC inputs, 55%/45%
Discount Rate	Consistent with FCC inputs, 8.50%
Poles	Pole space can be purchased/leased. FCC pole investments are used.

APPENDIX B—MODEL INPUT REFERENCES

REFERENCE 1—MODEL INPUTS

The FCC adopted platform inputs for the Connect America Cost Model.¹⁶ The inputs which form the basis of an input collection are available as a download from the CACM website.

The inputs are described below. These descriptions are consistent with the CACM document, v4.2

- Annual Charge Factor (ACF)
 - This table captures the Annual Charge Factors that convert Investment into monthly costs. The values loaded into CACM are produced by CostQuest’s CapCost model which is available for download. The basis of the model is the economic determination of the depreciation, cost of money, and income taxes associated with various plant categories. The calculation incorporates industry standard procedures, such as Equal Life Group methods, inclusion of future net salvage, impact of deferred taxes, and mid-year conventions.
 - Key inputs into the derivation are lives of plant, assumed tax lives, survival curve shapes, cost of money, cost of debt, debt/equity split, and future net salvage.
 - Uses depreciation lives consistent with those prescribed by the FCC’s Wireline Competition Bureau’s latest general depreciation in CC Docket No. 92-296.
 - How Used: Converts Investment into monthly values of Depreciation (DEPR), Cost of Money (COM), and Income Taxes (TAX).

- Bandwidth
 - Provides the busy hour bandwidth.
 - Used to size appropriate network components.
 - How Used: Based upon current inputs, Bandwidth is currently not a driver of any capex investment or opex cost.

- Business Take

¹⁶ The input order is available at, <https://www.fcc.gov/document/connect-america-phase-ii-cost-model-order>. The inputs were subsequently released as a Zip archive at, https://www.fcc.gov/bureaus/wcb/Connect_America_Cost_Model_v4.1.1Default%20Inputs.zip

- How Used: Derives the voice and data demand for the business market¹⁷
- Capex
 - Provides the material and installation costs for the plant build
 - Data are applied against the network topology data to derive total build-out investment levels
 - Inputs capture technology, network node, network function, and plant sharing.¹⁸ Within the CBCM, all Material inputs are material only. As an example, the OLT inputs found on the FTTP Material worksheet are material prices only. EF&I is included in the “Total Material Loadings” and “Engineering Rate” on the Labor Rates and Loadings” worksheet. The model always adds in labor costs – either through direct inputs such as the Material Labor worksheet for telco placing and splicing costs and the Structure Labor worksheet for OSP contractor structure placing costs, or through the use of the EF&I factors on the Labor Rates and Loadings worksheet.
 - How Used: Values which derive the total capex.
- COSize Adjustment
 - Provides the user the capability to adjust the assumed purchasing power of small, medium, and large providers.
 - The current inputs assume that all providers can achieve the same purchasing power (either as a result of their size or their ability to buy as a consortium)
 - Adjusts up or down the Capex costs in the model, current inputs are set to 1
 - How Used: In the current release of the model, COSize Adjustment table is used but the value is set to 1.
- OCNCoSize
 - Provides correspondence for OCN, company size category and SAC.
 - How Used: Categorizes the size of each company.

¹⁷ The business and residential take rate inputs can impact CACM in two ways. First, they can impact how components of the modeled network are sized. Second, they can impact how the total investment and resulting costs are unitized.

¹⁸ See Appendix 7, CACM Methodology for additional information on Plant Sharing.

- Opex
 - Provides the estimated operating expenses (Opex) to run and maintain voice and broadband-capable networks.
 - How Used: Values help to develop the operational cost development.

- PlantMix
 - Provides the estimated mix of facilities by type: aerial (cables hung from poles), buried (cable placed directly in a trench), and underground (cables running through conduit and manhole systems).
 - How Used: Determines the mix of facilities required to serve an area.

- PlantMix Buried Conduit
 - Provides values to be used which represent the percentage of buried placements to become buried placement in conduit.
 - How Used: The values in this table indicate the percentage of buried placements to become buried placement in conduit. As an example, if the table value is 1 (100%) for Distribution (Dist) then 100% of the corresponding distribution buried plant placements will be buried in conduit. To preserve backward compatibility with earlier input collections, a non-calculation impacting version of this table is available, PlantMixBuriedConduit NonState. This 'NonState' version has been associated with input collections created before CACM 4.0. If desired, a user can select PlantMixBuriedConduit NonState when creating a CACM 4.0 solution set. A copy of PlantMixBuriedConduit NonState is available for review within the Input Collection published on the CACM website.

- Ptax
 - Sourced from property tax rates in each state compared to a national average.
 - Provides the impact of property tax on the G&A operation costs given the difference of the state rates versus the national average.
 - Captured in the multiplier used for the operational element.

- How Used: Provides an index value to capture the impact of property tax in the operation costs.
- RegionalCostAdjustment
 - Sourced from third party source – RSMeans (2011).
 - Provides the estimated difference in the cost to build and operate in each part of the country.
 - Used to drive differences in Capex and Opex costs due to labor and material cost differences across the country.
 - Applied to All Capex and indirectly to specific Opex components that are derived from Capex.
 - How Used: Captures material and labor costs difference at ZIP3 level.
- StateSpecific Capex
 - Provides an input source for situations in which a state specific CAPEX input is required.
 - How Used: When State Specific Capex toggle is set to “Yes”, CACM reads the values in this table and uses them when processing the States provided in the StateSpecific input workbook. To preserve backward compatibility with earlier input collections, a non-calculation impacting version of this table is available, StateSpecificCapex NonState. This ‘NonState’ version has been associated with input collections created before CACM 4.0. If desired, a user can select StateSpecificCapex NonState when creating a CACM 4.0 solution set. A copy of StateSpecificCapex NonState is available for review within the Input Collection published on the CACM website.
- StateSalesTax
 - Sourced from appropriate sales tax rates for telecommunications plant in each state.
 - How Used: Impacts Capex derivation, applies State Sales Tax.

- Residential TakeRate¹⁹
 - How Used: Derives the data and voice demand for the residential market.

REFERENCE 2—SHARING INPUTS

The Plant Sharing inputs as used by the CBCM are below. The inputs differ from default FCC assumptions in that the middle mile route sharing (Percent of Middle Mile Routes Associated with Broadband) has been adjusted to allocate 100% of the middle mile structure investment to the costed service. The default FCC assumption was 50%.

Sharing Assumptions

Green Cells are used in developing the CACM Model Input

Structure sharing

Density	% of Cost Attributed to Studied Carrier			UOM
	Aerial	Buried	Underground	
Rural	48%	96.25%	95.78%	percent
Suburban	48%	80.00%	79.53%	percent
Urban	48%	76.25%	75.78%	percent

Between Distribution and Feeder

Density	% of common route that that shares structure			UOM
	Aerial	Buried	Underground	
Rural	78%	41%	67%	percent
Suburban	78%	41%	67%	percent
Urban	78%	41%	67%	percent

¹⁹ The business and residential take rate inputs can impact CACM in two ways. First, they can impact how components of the modeled network are sized. Second, they can impact how the total investment and resulting costs are unitized. See Appendix 10 CACM Methodology.

Unique IOF/Middle mile

Density	% of route that is dedicated structure			UOM
	Aerial	Buried	Underground	
Rural	37%	71%	26%	percent
Suburban	22%	64%	19%	percent
Urban	14%	56%	11%	percent

Percent of Middle Mile Routes Associated with Broadband

Density	% of route that is attributed to Broadband			UOM
	Aerial	Buried	Underground	
Rural	100%	100%	100%	percent
Suburban	100%	100%	100%	percent
Urban	100%	100%	100%	percent

REFERENCE 3—KEY CALIFORNIA STATE BROADBAND COST MODEL INPUTS

As with any model, output results will be sensitive to the inputs provided.

With the inputs, it is important to consider that most inputs interact with other inputs. Labor rates for example interact with sharing and inputs regarding the amount of time required to complete an activity. Material costs are impacted not just by the vendor pricing but also by the potential utilization of that material. In effect, it is particularly important to look at the results of the collection of inputs not just a single input.

The inputs below are in a rough sequence of priority. Because most discussion to date centers around total investment, capital cost factors and operating expenses are not included.

1. Construction parameters
 - a. Reuse (brownfield / greenfield)
 - b. Topology (fiber to the premise, wireless, coax, copper)
 - c. Incumbent or new entrant (Incumbent or CLEC)
2. Inputs impacting outside plant construction costs
 - a. Excavation cost (cost to trench, bore, etc. under different terrain conditions)

- b. Plant Mix (percent aerial, buried, underground for outside plant)
 - c. Sharing (in projects of this scale, what percent of placing can be shared with other utilities or with other networks like middle mile and access networks)
 - d. Labor rates (for trade construction and engineering)
 - e. Labor productivity (time required to place and put into service equipment or place and splice media)
 - f. Regulatory fees (permitting, restoration)
 - g. Make ready or attachment fees (fees)
- 3. Material costs
 - a. Material investments and capacity
 - b. Power backup requirements
- 4. Miscellaneous costs
 - a. Regulatory / Rights of Way access
 - b. Interest during construction
 - c. Taxes

APPENDIX C—ABOUT COSTQUEST ASSOCIATES

KNOWLEDGE

The CostQuest Associates (CQA) team recently celebrated its 20th year in business, serving a wide range of clientele from small WISPs to Tier 1 providers, state governments, and the FCC at the Federal level. At the core of everything we do is a deep understanding of communications networks and the businesses that own and manage them, with expertise in broadband networks provisioned with Fiber, Fixed Wireless, Mobility, and legacy technologies. Because they are based on CostQuest tools, research, knowledge, broad application, business, and regulatory experience, CostQuest solutions are economic and efficient, so you can count on them to continue to meet the current and future needs of your enterprise.

BUSINESS MANAGEMENT SOLUTIONS

CostQuest has also provided proprietary profitability, cost, telecom engineering, and metrics systems along with demographic data, data analysis, and GIS support to enhance decision making in some of the world's leading companies. In addition, our clients have called on us to prepare economic, cost, and business intelligence papers, presentations, and workshops before legal and regulatory bodies around the world.

EXPERIENCE

Our expertise has been critical in large-scale cost modeling efforts like the Wireline cost model we built for the FCC's Connect America Fund Program and for state-wide broadband mapping efforts like the Broadband Mapping Initiative that established the foundational methodology for our Broadband Serviceable Location Fabric mentioned in the Broadband DATA Act. Other important projects:

- Internationally recognized as leading telecommunication network modeling, costing and profitability experts
- Broadband and USF models: BAM used by FCC for NBP, CACM being used as the FCC's CAF Phase II model, CPM California, CPM Hong Kong, BCPM, NUSC Australia, CostPro-Core New Zealand
- Valuation and Appraisal: Property Tax, M&A and more. AT&T, VZN, Comcast, InSite and others use CQA's Valuation and Appraisal Services
- RCN and Loop models: CQRM in use by carriers with operations in over 40 states, adopted and well received by commissions in all UNE and Tax proceedings
- Wireless Costing: Wireless Models NTIA, CTIA, Wireless Carriers
- Wireless Work: USAC Filings, Audits and Reviews, USAC/USF Workshops, GIS Analysis, Policy Support
- Interconnection model: CostPro-Core in use by the New Zealand Commerce Commission to set rates

APPENDIX D—MAP SETS AND DATA TABLES

Map Sets and Data Tables are available separately, via the CPUC website:

<https://www.cpuc.ca.gov/communications/costmodel/>