Barry Electric Cooperative Description of Technology and System Design

System Design

The current Barry Electric Fiber to the Home (FTTH) network will be expanded to reach all the locations awarded to Barry Electric during the 903 auction. The construction of the FTTH network began February 2016 and is scheduled to be completed in 2019. The FTTH network was designed to serve all customers in Barry Electric's current electric service territory.

Barry Electric contracted with Finley Engineering to design the FTTH network. The FTTH design has been successfully implemented by Finley Engineering in traditional telephone company networks as well as competitive FTTH network builds. An estimate of costs for the FTTH network were compiled from similar projects designed and completed by Finley Engineering, make ready consideration and associated make ready costs for Barry Electric's distribution system were compiled from previous make ready costs of like electric distribution systems. The design and cost estimate are the basis for decision making regarding financial requirements for the build out and operation of the FTTH network.

The 2,308 locations awarded Barry Electric at the conclusion of the 903 auction; 99.8% of the locations are within Barry Electric's current electric service territory, with the remaining .2% outside of Barry Electric's current electric service territory. An estimate of costs and proposed network expansion were compiled from similar projects designed and completed by Finley Engineering for the .2% of locations outside of Barry Electric's current electric service territory. Listed below are the specific design criteria utilized for the FTTH network.

- Aerial mainline fiber installation, service drops will be a mix of aerial and buried within Barry Electric's current electric service territory.
- Buried mainline fiber installation, service drops will be buried outside of Barry Electric's current electric service territory.
- Initial NESC loading and clearance considerations from a sample walkout for aerial fiber installations were made. Final make ready requirements were determined at the time of staking.
- Fiber and optical redundancy for remote electronic equipment locations were established.
- FSAN standard 2.4 GPON B+ and C+ distance and loss limits.
- 40km 10GigE transport facilities between the POP and remote equipment locations.
- Final design loading was 1.3 to 1.5 allowing for some subscriber growth.
- Subscriber count per line which limits fiber cable size to a maximum of 288 fiber cable for long span aerial fiber installations.

- Fiber count limits per splitter cabinet installation to accommodate the use of (3) standard splitter cabinet sizes.
- Splitter cabinet sizing which accommodates 1X32 splitters for the respective 2.4 GPON B+ and C+ standards.
- SIP (IP based) protocol for voice services.

The network will employ a protected fiber ring containing (7) remote node locations and also a centralized POP location which serves as the network interface for voice, video and data services.

The location of the (7) equipment sites and centralized splitter cabinets are situated strategically at the intersection of Barry Electric's distribution lines, allowing for efficient network segmentation per the design criteria. The POP location is an existing location utilized by Barry Electric for current broadband interconnection and internal operations.

The (7) remote note locations utilize additional remote splitter cabinets to allow for a maximum cable size of 288 fibers, this design criterion helps reduce the impact larger fiber cable would have when determining make ready requirements to comply with NESC loading and clearance requirements. Feeder fiber to splitter cabinet locations are sized to allow for future growth of subscribers in the network. The design also allows for additional dedicated fiber between the remote equipment node locations and the associated splitter cabinets, these additional fiber facilities allow for dedicated 1 GigE Active Ethernet or fiber transport services. As a part of the overall fiber design for subscriber services; fiber facilities have been designed for future SCADA, AMI and MDM purposes for Barry Electric operations.

Subscriber services will be deployed to meet ETC requirements. Voice services will be deployed from an existing ETC designated voice switch, broadband operations will be conducted according to the current ISP operations of Barry Electric.

Description of Technology

The existing and proposed Barry Electric network is designed and engineered to be a Gigabit network; a 2.5 GPON Calix network delivered over a FTTH architecture utilizing a 1X32 passive split is fully capable of meeting the speed, performance and latency tier, and can also deliver high quality voice service. The voice service offered by Barry Electric is a high quality SIP based voice service. The same vendor platform delivering SIP service to Barry Electric is also used by existing telecom providers for provision of their ETC voice services.

The FTTH access network deployed by Barry Electric utilizes from Calix the E7-20 and E7-2 equipment platform which is compliant with the ITU-T G.984 GPON standard. The physical fiber network engineered and deployed at Barry Electric also is based on the optical requirements to effectively implement the G.984 GPON network, utilizing 1X32 optical splitters

deployed in office location as well as remote equipment sites. The network placed in service by Barry Electric is capable of supporting 1GigE connections to all customers.

Backhaul in the Barry Electric network is accomplished by industry standard equipment from Cisco Networks capable of providing 10GigE ring protected connectivity to all remote equipment nodes via standards based on Metro Ethernet Forum (MEF) or Multiprotocol Label Switching (MPLS). The physical network is further designed to support the addition of Dense Wave Division Multiplexing (DWDM) as bandwidth needs in the backhaul network increases.

Backbone connectivity in the Barry Electric core network is accomplished with redundant routing engines from Juniper Networks utilizing standard Ethernet routing protocols and (3) internet backbone broadband applications. Backbone bandwidth is dynamic and based on usage. The existing routing devices can be augmented to support additional bandwidth requirements as it becomes needed.

Broadband internet services are offered from the FTTH network via a Calix Optical Network Unit (ONU) with either a Cat 5e or WiFi technology connecting customer devises. Service plans of up to 1GigE are currently offered by Barry Electric and the same service plans will be offered in the areas Barry Electric was awarded during the CAF II auction. Backhaul and backbone connections are redundant 10 GigE connections with backbone bandwidth available to support growth in the network capacity from the proposed network.

The Calix equipment used in the FTTH network leverages industry standard testing based on RFC2544 to measure throughput and latency across the GPON equipment. Due to the asymmetric nature of GPON (2.5 Gbps downstream/1.25 Gbps upstream), there is an increased latency in the upstream direction versus the downstream direction. The equipment solutions typically maintain a latency of -26 microseconds in the downstream direction and 750 microseconds in the upstream direction while supporting 1Gbps services in a PON with 64 subscribers.

Voice services on the Barry Electric network are currently provided on a retail basis utilizing wholesale SIP based VoIP. The SIP VoIP service solution is delivered from an industry recognized Class 5 end office switch. The VoIP solution offered meets all requirements for Eligible Telecommunications Carrier (ETC) status; including 911 and CALEA requirements. As Barry Electric utilizes redundant ISP backbone connections the availability of voice services would not be affected by congestion in a single network link or loss of connection of one backbone link. The existing Barry Electric backhaul and core routing networks are redundant in nature to ensure no single point of failure exists for services offered in the network.

The specific fiber network and electronic equipment technology utilized for the Barry Electric network are as follows:

- FSAN B+ and C+ physical design standard
- FSAN 2.4 GPON: B+ and C+ optics
- FSAN 1X32 optical splitters
- 1 GigE Active Ethernet or dedicated fiber services to select subscribers
- 1 GigE or 10 GigE (lag capable) transport services between nodes
- 1 GigE or 10 GigE (lag capable) uplink for voice and broadband services
- Fiber facility and equipment based redundancy
- SIP voice service
- Future TR-69 network administration capabilities

Project Plan

Barry Electric began the process of building a FTTH network for their electric service territory in 2014. Barry Electric contracted with Finley Engineering to design and provide a cost estimate for the FTTH network in 2015. The FTTH network has 8 electronic equipment areas; Central Office and 7 Remotes. The construction of the FTTH network was scheduled into 8 phases. The phases are listed below:

Phase/Remote

PHASE 1 – CO and Middle Mile

PHASE 2 – REMOTE 3

PHASE 3 – REMOTE 6

PHASE 4 – REMOTE 5

PHASE 5 – REMOTE 4

PHASE 6 – REMOTE 1

PHASE 7 – REMOTE 2

PHASE 8 – REMOTE 7

Construction of phase 1 and Middle Mile to Level 3 and KAMO began in February of 2016 and was completed February of 2017. Construction of phase 2 began in August of 2016 and was completed July of 2017. Construction of phase 3 began in March of 2017 and was completed January of 2018. Construction of phase 4 began in January of 2018 and was completed June of 2018. Construction of phase 5 began May of 2018 and will be completed November of 2018. Construction of phase 6 began August of 2018 scheduled to be completed December of 2019.

Construction of phase 7 began August of 2018 scheduled to be completed December of 2019. Construction of phase 8 began July of 2018 scheduled to be completed June of 2019.

Barry Electric was awarded 12 census bidding groups from the Connect America Fund Phase II Auction (Auction 903). The 12 census bidding groups contains 425 eligible census blocks with 2,308 locations to be served by Barry Electric. The number of locations to be served by each remote listed below:

Remote/Number of funded locations

CO – 449

REMOTE 1 – 251

REMOTE 2 – 92

REMOTE 3 – 246

REMOTE 4 – 368

REMOTE 5 – 464

REMOTE 6 – 245

REMOTE 7 – 193

Barry Electric places drops to subscriber's locations as the subscriber contacts Barry Electric requesting service. The current FTTH network design commercially offers service to 99.8% of the eligible locations awarded Barry Electric. Barry Electric will be able to provide service to the eligible locations within 10 business days upon request.

Barry Electric employs network technicians that use Calix equipment to monitor and maintain the FTTH network. Barry Electric has also contracted with Finley Engineering to monitor and maintain the IP network. The backhaul service is monitored and maintained by Level 3.

Construction Schedule

2018

Phase 6

Phase 6 is the construction of Remote 1 service area. The main line mileage for the Remote 1 service area is 142.22. The construction schedule for Remote 1 is 9 miles of main line construction a month. At the end of 2018, 36 miles of the 142.22 miles will be constructed.

Phase 7

Phase 7 is the construction of Remote 2 service area. The main line mileage for the Remote 2 service area is 73.72. The construction schedule for Remote 2 is 5 miles of main line construction a month. At the end of 2018, 20 miles of the 73.72 miles will be constructed.

Phase 8

Phase 8 is the construction of Remote 7 service area. The main line mileage for the Remote 7 service area is 112.07. The construction schedule for Remote 7 is 9.5 miles of main line construction a month. At the end of 2018, 57 miles of the 112.07 miles will be constructed.

Drops

Drops will be placed in remote areas that are completed as the subscriber request service. At the end of 2018 1,772 of the 2,308 CAF II Auction locations will have main line construction to the locations and drops will be placed as the subscriber requests service.

2019

Phase 6

Phase 6 (Remote 1) is scheduled to be completed at the end of 2019. The remaining 106.22 miles of construction will be completed in December with a construction schedule of 9 miles a month.

Phase 7

Phase 7 (Remote 2) is scheduled to be completed at the end of 2019. The remaining 53.72 miles of construction will be completed in November with a construction schedule of 5 miles a month.

Phase 8

Phase 8 (Remote 7) is scheduled to be completed June of 2019. The remaining 55.07 miles of construction will be completed in June with a construction schedule of 9.5 miles a month.

Drops

Drops will be placed in remote areas that are completed as the subscriber request service. At the end of 2019, 2,303 of the 2,308 CAF II Auction locations will have main line construction to the locations and drops will be placed as the subscriber requests service.

2020

CAF II Auction Locations

A design has been finalized to reach the 5 CAF II Auction locations outside of Barry Electric's current FTTH service area. The project will be staked at the end of the spring and ready for construction during the summer. The estimated main line mileage to be constructed is 3.5 miles. The locations are outside of Barry Electric's distribution system, so the main line will be buried do to Barry Electric not owning the poles to the 5 CAF II Auction locations. The construction of the 3.5 miles will be completed at the end of 2020.

Drops

Drops will be placed as the subscriber request service. At the end of 2020, all CAF II Auction locations will have main line construction to the locations and drops will be placed as the subscriber request service.

2021 thru 2029

As subscribers request service, drops will be placed to the locations requesting service.