

# Cost of FTTH Powering

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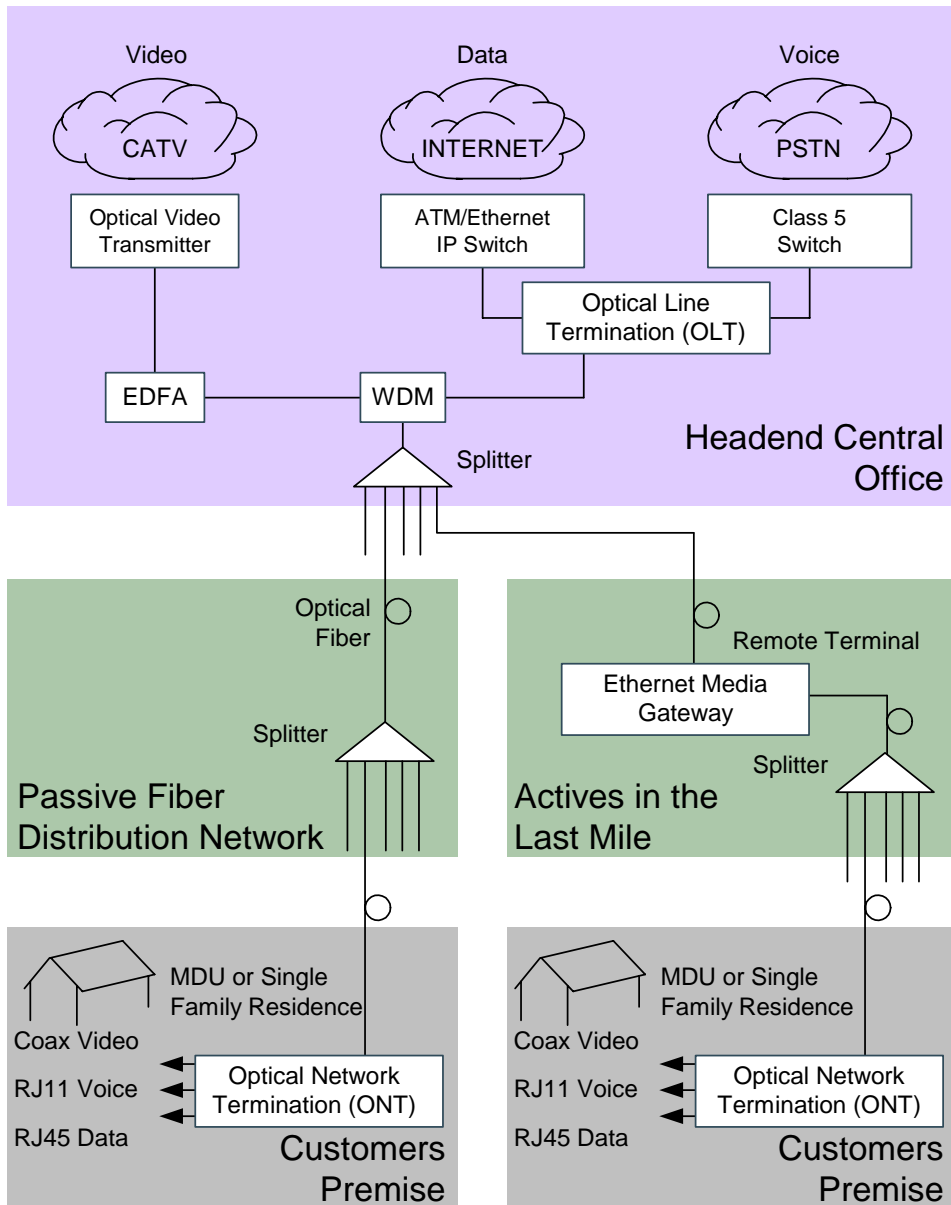
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### **Cost of FTTH Powering**

Within the last few years FTTH networks have moved from field trial status with early adopters in forward looking communities to deployments at large utilities and now a strong interest by Regional Bell Operating Companies (RBOC) and other service providers. FTTH networks are the next generation broadband access network and today's most viable means to compete with Cable TV (CATV) operators with bundled voice, video, and data services to the home. The Fiber-to-the-Home Council is currently projecting 128 communities in 32 states that are implementing FTTH builds. Initial FTTH deployments in smaller communities have represented a means to become independent of their local phone or CATV providers, that have not reinvested in the infrastructure needed to support the same level of service offered in larger metropolitan markets. With RBOCs recognizing that their twisted pair infrastructure and aging copper will not support more than limited DSL services, large scale deployments of FTTH networks are just beginning. Early FTTH network architectures have varied greatly due to the markets, business plans, and the architecture driven by the equipment supplier selected primarily based on up front costs. Often the true cost of the powering architecture from the headend, active in the last mile and the optical network termination (ONT) at the premise, has been overlooked. With only brief overview of the actual FTTH network, this paper will explore powering solutions including enclosure systems, power supplies, and standby batteries that have gained acceptance in today's rapidly maturing FTTH market as well as explore related capital and reoccurring costs.

Although not mandated, providing a minimum of eight hours of emergency backup power represents the minimum accepted standby time needed to offer [1] Telephony primary line voice service or "lifeline service" including emergency 911 calls.

*Simplified FTTH Network Diagram*



FTTH networks can be divided into four sections; the headend or central office (HE/CO), the passive optical fiber distribution network, actives in the last mile and the ONT at the customers premise. Other than the passive optical fiber network, each section of the network has unique powering requirements and associated costs. A brief overview of the FTTH network from the headend to the home is necessary to visualize the physical properties of each section.

At the HE/CO the optoelectronics equipment is interfaced into the public switched telephone network or PSTN using T-1 phone connection supporting data rates of 1.544Mbits and is connected to ATM or Ethernet interfaces. Broadband video services enter the FTTH system from the cable television (CATV) headend or from a satellite feed. The HE/CO has both AC and DC standby power using large capacity stationary battery banks augmented with standby AC generator systems. The passive fiber optic section of the network includes optical fiber, combiners/splitters and wave division multiplexing (WDM) modules that multiplex and demultiplex upstream and downstream optical signals. Some FTTH network architectures include Ethernet switches or media gateways within the last mile of the network which can be deployed in environmentally controlled Remote Terminal (RT) enclosures with the power supply, standby batteries and ancillary rack mount equipment. At the home or multiple dwelling unit (MDU) the optical network termination equipment (ONT) serves as the optical to electrical media converter (OEC), providing the user interfaces at the home including RJ11 jacks for telephony, RJ45 for data and 75ohm coax for video. New options in powering the ONT at the home offers the operator low initial cost, ease of deployment and low cost of ownership with greater reliability than first generation DC uninterruptible power supplies (UPS) located in the home.

## **Headend and Central Office**

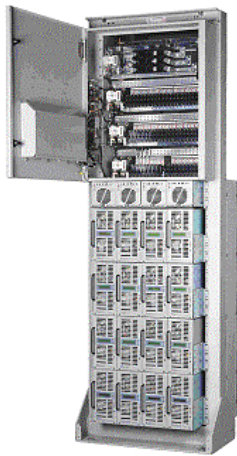
Headends and central offices can be powered by traditional AC UPS, -48V DC UPS plants or a hybrid of both and often include a standby generator system. Most soft switch and high speed data equipment are -48V powered while most video gear is AC powered. AC UPS plants are typically used for 15 minutes to 1 hour runtimes and most often used to provide ride through power until the AC standby generator is brought on line. AC UPS plants with greater runtimes than one hour are not cost and floor space effective compared with DC UPS options. DC power plants providing eight hours of runtime can be configured with or without standby AC generators fueled by diesel or natural gas.

DC plants supporting HE/CO FTTH networks are scalable from 10 Amps to 10,000 Amps. Power N+1 design is the most reliable form of HE/CO power. Large AC UPS' have multiple points of failure.

AC UPS systems are either single-phase or three-phase. Three-phase plants are capable of providing 20kVA to 150kVA of power and can support the entire load of the HE/CO. Single-phase AC UPS plants provide from 600VA to 18kVA of power, and usually power individual AC loads or are used in remote hub sites.

For greatest reliability and cleanest power, the HE/CO should be -48V powered [2] with the ancillary AC equipment powered via an inverter that converts direct current (DC) into alternating current (AC) or by using a standalone AC UPS. The inverter solution is the most cost-effective, with full N+1 redundancy capability and one battery bank to purchase and maintain. N+1 redundancy extends the MTBF (Mean Time Between Failure) of the system and is accomplished by installing a surplus of power modules that are available to take over the load of any failed module.

The following costs are provided for comparison purposes of HE/CO powering options and are generally stated at the end user level. A 100 Amp DC UPS can cost in the \$3,000 range while a 1,200 Amp DC UPS can cost up to \$18,000. A single phase AC UPS providing 600VA of power costs \$1,800 while a 18kVA AC UPS costs nearly \$16000. A 25kVA three phase AC UPS costs in the \$30,000 range and a 150kVA costs up to \$53,000.



*DC UPS options: Medium DC Kit (100 – 1,200 Amp) to  
Single Phase 500 to 25kVA*



*AC UPS options: Single Phase AC UPS 600VA – 18kVA to  
Three Phase AC UPS 15kVA – 150kVA*

## **Actives in the Last Mile**

Optical signal processors or media gateways deployed in the last mile of the FTTH network typically serve less than 100 homes each and are placed in cost-effective curbside ground mount or pole mount (environmentally controlled enclosure systems), which are located throughout the residential community. Enclosures systems are optimized to support physical and environmental requirements of the media gateways used. These enclosures include equipment rack mount space for the electro-optics, fiber management, power supply, standby batteries, AC service entrance, AC power distribution, and surge protection. The enclosure's placement in the network, type of AC service and degree of environmental protection needed for the gateway, has a direct relationship on capital and reoccurring costs. Cost is primarily driven by the environmental ratings of the optoelectronics equipment selected, placement and the AC service dictated by the local jurisdiction having responsibility for permitting.

### **Physical Placement**

Placement of these enclosures in the network follow the same rules and constraints as CATV operators have faced with their network power supplies over the last 25 years. Deployments of gateway enclosures are not likely to encounter community or regulatory roadblocks due to their similar size, and lower power ratings. Both ground and pole mount enclosure systems are required, with ground mount enclosures representing a 25% higher cost due to the greater degree of planning, permitting, trenching, disruptive groundwork, and the concrete pad needed for mounting the enclosure.

## AC Service

Interfacing the gateway enclosure to the local utility for AC power has a direct up front and long term cost impact. Enclosure manufacturers need to offer configurable AC service and distribution options in order to comply with the requirements of the local authority having jurisdiction. These requirements vary throughout the country. In the Western United States the Electric Utility Service Equipment Requirements Committee or EUSERC has established generally accepted compliance guidelines for outdoor enclosure systems. The most basic and lowest cost service entrance acceptable in most jurisdictions, is a 70A rainproof NEMA 3R load center with dual duplex outlets capable of supporting AC distribution, transient surge protection, and the DC UPS power supply. This form of AC service on a gateway enclosure can cost less than \$150 while an enclosure configured with a meter can cost \$250 or more. The cost of AC power can vary depending on the method of payment contracted. AC power can be purchased from the local utility as metered service similar to a single-family residence. Power consumption is recorded and billed on a regular basis or on a negotiated flat rate basis often tied to the rating of the main breaker or calculated average power consumption. Early discussions with the local utility can minimize initial costs and reoccurring utility expenses as well and define the correct service entrance needed for the project.



***Power supply systems in the last mile (environmentally controlled and convection cooled pole mount)***

## **Environmental Considerations for Hardened Actives**

Enclosures supporting gateways in the last mile of the FTTH network can vary in cost depending on the degree to which the gateway is environmentally hardened. Convection cooled enclosure systems can support environmentally hardened gateways that are specified to operate from -40°C to +60°C and 95% humidity. They offer an inexpensive cost model, as they do not require costly active thermal management systems. These enclosures should be designed and qualified as a system considering convection cooling airflow, component placement and ventilation while also restricting water, snow, and dust ingress. Passive thermal management must address the total thermal load of the optics and power supply under full load conditions and variation in battery temperatures. A properly engineered enclosure system should be capable of operating at maximum power dissipation conditions, with less than a 20°C internal temperature rise when subjected to a thermal load test including solar loading. A thermal load test that simulates typical summer conditions in North America can be performed in a thermal chamber with 40°C uncirculated ambient air temperature and 40 Watts of solar loading per square foot placed on three adjacent sides of the enclosure. The temperature variation between batteries is critical and should be less than 5°C to assure proper temperature charge compensation is applied to the battery string. Battery life and associated standby capacity and system reliability can be significantly reduced with improperly charged batteries. FTTH sites that experience prolonged temperatures above 40°C should be equipped with an optional thermostatically controlled fan.



*Pole mount convection cooled enclosure system supporting actives in the last mile*



## Additional Considerations

Other considerations include power supply and status monitoring, batteries, regulatory compliance, grounding, surge protection and the materials selected should support a long service life.

## Power Supply

An FTTH gateway typically consumes less than 250Watts of -48VDC power and can be efficiently powered with 300 Watt power supply specified to operate over the same -40°C to +60°C conditions and should include a temperature compensated charger appropriate to the batteries used.

## Status Monitoring

Power supply status monitoring and control complying with PacketCable™ UPS specifications provides adequate information on the status of the power supply and standby batteries. These requirements have been developed as a cooperative effort undertaken at the direction of Cable Television Laboratories, Inc. (CableLabs®) for embedded multimedia terminal adapter (MTA) primary line support per PKT-SP-EMTA-Primary-101-001128. Local status is provided by light emitting diodes or LED's on the power supply and report output okay (green), standby operation (green blinking), low or missing battery (red blinking), and replace battery (red). The alarm indicators are connected to the gateway and communicate AC failure (TELM 1), replace battery (TELM 2), battery missing (TELM 3) and battery low voltage (TELM 4).



*Gelled 50Ah maintenance free sealed valve regulated lead acid battery and 300 Watt UPS used to power actives in the last mile*

## **Batteries**

One 48VDC string of 50Ah VRLA gelcell batteries provide eight hours of standby runtime at 25°C with a 250 watt load. Proper selection of these batteries must take into consideration that up to 100 customers can receive lifeline services from one gateway system enclosure, so the batteries selected must be designed for thermally demanding float service outdoor applications, and have a high temperature at or above 60°C. Although lead acid batteries have been in existence for over a hundred years, today's gelled electrolyte valve regulated lead acid (VRLA) batteries represent significant improvements over earlier flooded and absorbed glass mat (AGM) technologies. Gelled batteries more effectively dissipate internally generated heat than earlier AGM batteries resulting in a lower float current, thereby increasing battery float life and lower overall power consumption. The use of lower cost flooded VRLA batteries should be avoided as they vent higher levels of hydrogen and require higher levels of maintenance to prevent dry-out, that can lead to an explosive condition. AGM batteries are less efficient than gel batteries in dissipating internal heat to the case and run the risk of thermal runaway. Gelled batteries have been standardized for use in outdoor power supply enclosures by most CATV MSOs. Float service batteries have thicker lead grid structures with less surface area in contact with the electrolyte resulting in longer service life than starting and deep cycle batteries that have a greater number of thinner grids and larger area in contact with the electrolyte.

## **Regulatory Considerations**

Enclosures should be evaluated and certified to known safety standards by a NRTL (UL, CSA, ITS, etc.) and marked with the independent Laboratory's NRTL mark. Without a safety mark, local authorities having jurisdiction (AHJ's) may refuse to allow connection to the utility service. This may cause significant construction delays and additional costs if a laboratory inspector is required to travel to the site to field certify the system.

Regulatory compliance evaluations for enclosures should be performed following requirements of CSA C22.2 No. 94 and/or UL 50, to demonstrate compliance with the US National Electric Code (NEC) and the Canadian Electrical Code (CEC). Enclosure standards apply to both indoor and outdoor enclosures and covers safety requirements for environmental, mechanical, chemical and safety hazards, and general workmanship requirements. Hazards for an integrated

UPS, including electrical shock hazards, are evaluated to product specific standards such as CSA C22.2 No. 107.3 and UL 1778 (the Bi-National Standard for UPS equipment). Additionally, this standard includes as a 'reference document', the general requirements of CSA C22.2 No. 60950 and UL 60950. CSA Standards are published as Canadian National Standards and UL Standards are published as ANSI Standards.

The cost figures presented below are intended to provide a general understanding of the cost related to the purchase, installation and maintenance of a power supply enclosure system supporting environmentally hardened gateways. End user pricing for a CSA/UL marked pole mount enclosure system including 14 rack mounting spaces, a 300Watt power supply, 48VDC string gelled batteries with up to five years of service life, AC service entrance, AC distribution, and AC surge protection can range from \$1,500 to \$1,800. A ground mount enclosure similarly equipped would cost 10% more due to its heavier and more tamper resistant construction. Installation, electrical hookup, turn-up test, and permitting fees can range from \$400 to \$800 per site for a pole mount system. Excluding trenching up to the enclosure, additional costs related to installing a ground mount system can range from \$1,000 to \$1,500 due the cost of the site excavation, grounding, fill material and the concrete pad. Reoccurring operational costs include battery and system maintenance, utility fees, and pole attachment fees and may range from \$100 to \$300 per year.

## Environmental Considerations for Sensitive Actives



*Controlled environment Remote Terminal with EUSERC AC service and DC air conditioner*

## **Thermal Management**

Environmentally controlled Remote Terminal (RTs) enclosures are needed to support nonhardened gateways in the last mile. These RTs are equipped with either a heat exchanger or an air conditioner representing a higher capital and reoccurring cost but offer additional rack mount space for future expansion and provide a reliable environment for sensitive electronics. Selection of the proper thermal management solution is the key to long term reliability of the network and lower operational costs. Options include AC or DC powered air conditioners and AC or DC powered heat exchangers. AC and DC heaters are also used in lightly loaded colder climates. Enclosures equipped with air conditioners and heaters provide stable internal operating temperatures while seasonable temperatures can vary from  $-40^{\circ}\text{C}$  to  $+55^{\circ}\text{C}$ .

Generally RT enclosures are larger than convection cooled enclosures and are usually located on the ground in easements or right-of-ways and most likely have a metered AC service due to its greater powering requirements. Regulatory compliance testing and thermal testing with solar loading is performed in a similar manner as the smaller convection cooled enclosures described above.

Alternating current or AC powered air conditioners are the most common systems used today with costs benefiting from the use of high volume residential and commercial compressors and controllers. The downside of using AC powered air conditioners is that if used without an expensive automatic transfer switch and an AC standby generator, cooling of the electronics will stop during critical AC outages. The standby batteries in the RT will continue to support the FTTH network equipment, dissipating the entire thermal load into the insulated enclosure, which can quickly send the sensitive electronics past their thermal limits.

DC powered air conditioners are now available and are recommended for use in FTTH applications. These systems use a variable speed 48VDC brushless motor compressor resulting in reduced power consumption by providing the correct level of cooling for the thermal load and external ambient conditions. DC air conditioners seamlessly continue to perform during AC power outages. Coupling a natural gas or propane fueled DC generator system with standby

batteries can provide an indefinite runtime without the need of an expensive automatic transfer switch.

Heat exchangers are about half the cost of an air conditioner but have limitations that restrict their use. Heat exchangers transfer heat from an area of higher temperature (inside the enclosure), to one of lower temperature (external ambient), allowing the internal temperature of the enclosure to track the external ambient temperatures. With a typical 500 Watt thermal load the temperature inside a heat exchanger equipped enclosure will be approximately 10°C above the external ambient temperature. Many locations in the United States frequently experience temperatures of 35°C. Add the 10°C temperature rise as outlined above and that puts the internal operating temperature rise to 45°C, which is unacceptable for non-hardened electronics. Unlike air conditioner systems, heat exchangers do not dehumidify and remove moisture that may have entered the RT during a service interval on a humid or rainy day which leads to corrosion concerns.



*Rectifier kit with stand-alone fuse panel in a controlled environment Remote Terminal*

## **Power Supply**

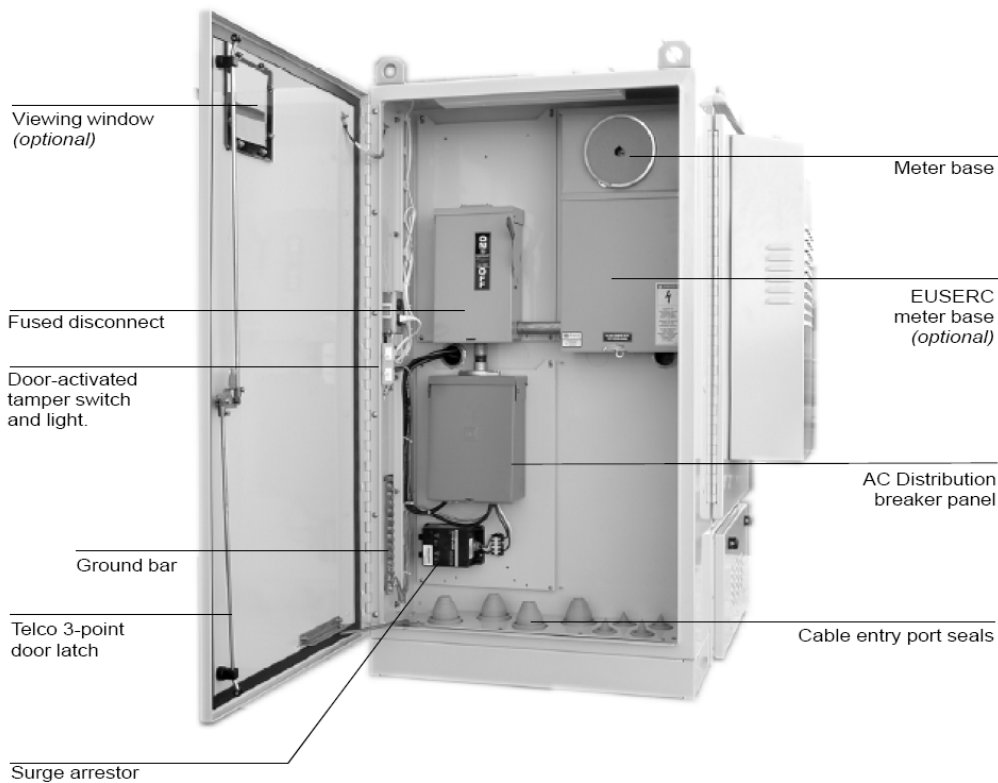
DC Power is provided by a rectifier that converts alternating current to DC the current needed to power the equipment and to charge batteries. Rectifiers with hot swappable modules can provide cost-effective scalable N+1 redundancy and include alarm and supervisory capability. DC distribution to the heater, air conditioner and electronics can be in the form of GMT fuses or

circuit breakers. Rectifier features include temperature compensation for battery charging, system over voltage protection alarm, system high voltage alarm, low voltage alarm, low voltage disconnect alarm, fuse / circuit breaker fail alarm, AC mains fail alarm and rectifier minor alarm.

### Standby Batteries

The RT has battery storage locations that are isolated from the equipment section and is capable of housing up to four 105Ah front terminal batteries supporting a 12.5 Amps load for approximately eight hours. Battery strings can be added for additional capacity or redundancy.

AC service and distribution should be configured as necessary to comply with the local authority having jurisdiction.



*EUSERC compliant enclosed AC with meter reader window.*

Generally end user pricing for a CSA/UL marked RT system including up to 40 rack mounting spaces, rectifier with N+1 redundancy, 3,000 BTU DC air conditioner, DC heater, batteries,

metered AC service entrance and AC distribution with surge protection can range from \$9,000 to \$12,000. Additional capital expenditures include permitting fees, site preparation, trenching, installation, electrical hookup and turn-up and test and may cost as much as \$4,500 to \$8,000 depending on the site. Reoccurring operational costs including battery and system maintenance, utility fees, and right of way fees can range from \$1,000 to \$2,500 per year.

## Customer Premise



*MDU 100 Watt eight output UPS*

Most multiple dwelling units (MDUs) powering requirements can be satisfied with a single versatile wall or pole mount indoor or outdoor rated power supply. Standby power for the MDU power is supplied by a single 50Ah sealed lead acid gelcell battery providing four hours of runtime for a 100 Watt load at 25°C. Temperature compensation assures proper charging over an operating temperature of -40°C to +55°C. The vented convection cooled enclosure is constructed of rugged powder coated aluminum and includes knockouts for routing a dedicated AC service connection to the input terminal block. The output terminal block provides up to eight isolated polyswitch protected outputs to the optical network termination located in the MDU. If any one of the eight output power lines is shorted the corresponding poly switch opens without affecting adjacent outputs. When the short is removed the polyswitch cools and recovers reestablishing the connection.

An outdoor rated, 100 Watt MDU power supply with eight protected outputs, and a 50Ah battery can range between \$400 and \$450.

New options in powering the ONT at the home addresses reliability, battery access, and maintenance issues associated with first generation ONT power supplies and provides the FTTH operator installation options, low initial costs, and low cost of ownership.



*Early generation indoor premise ONT power supply typically installed indoors*

Early generation ONT power supplies have been located inside the users residence, most likely in their garage or basement and plugged into the closest ground fault interrupted circuit. Placement of the power supply and battery in the home has presented several obstacles. The 7Ah sealed lead acid battery is currently the accepted standard for the home UPS, and has a usable life expectancy of two to three years. (Longer life 7.2Ah batteries are available for a premium price.) Gaining access to the power supply in order to replace the battery requires the network operator to call the customer and schedule a time during the week that the resident can be at home. The magnitude of this problem is exposed when you consider the logistics of coordinating this seemingly simple task and then multiplying it by the number of subscribers served. In addition, all of the batteries should reach their end of life in year three. Shifting battery replacement responsibility to the resident, or renter invites liability issues as many residents are not motivated and are not likely to replace batteries. This architecture uses a single enclosure with battery included, providing the lowest upfront cost.



Having the power supply plugged into a shared AC outlet in the garage or basement is an invitation to have the resident unplug the power supply to plug in a power tool and forget to replug the power supply back in. A VRLA battery left discharged for prolonged periods will cause irreversible battery damage. Placing the battery inside the home represents significant operational, liability and system reliability costs.

Operational costs and reliability issues have been addressed by separating the AC to DC power converter element from the charger and battery elements allowing the battery to be located on the exterior of the home adjacent to the ONT providing the network operator 24/7 access.



*AC to DC power converter installed in a socketed meter collar and an 18 Watt battery module supporting the ONT at the home*

With the AC to DC power converter element being environmentally hardened to perform over a -40°C to +65°C temperature range and capable of supplying either 18 Watts or 30 Watts at 12VDC it can be located in several locations depending on the situation and the ONT used. Many utility companies deploying FTTH networks have preferred using a meter collar system eliminating the reliability issue related to plugging the power supply into a shared AC outlet. The Power-Ring/Home Converter plugs into a socketed meter collar that can be placed between the meter head and the utility service panel. Jaws in the meter collar can be configured at installation to tap AC power before or after the single phase 200A, 240VAC service depending on who will be responsible for paying for the power consumed.

The Home Converter can be mounted in the home and can be powered from 240VAC or 120VAC with the DC output cable routed through the wall directly to the ONT or to the battery box.

**18 Watt 7.2Ah Battery Module**

Load (W)	Runtime @ -40°C -40°F	Runtime @ -20°C -4°F	Runtime @ 25°C 77°F
4	15.0	18.0	20.0
7	8.9	10.1	12.7
10	5.6	6.4	8.0
15	2.8	3.3	5.0
18	2.2	2.6	4.0

**30 Watt 17Ah Battery Module**

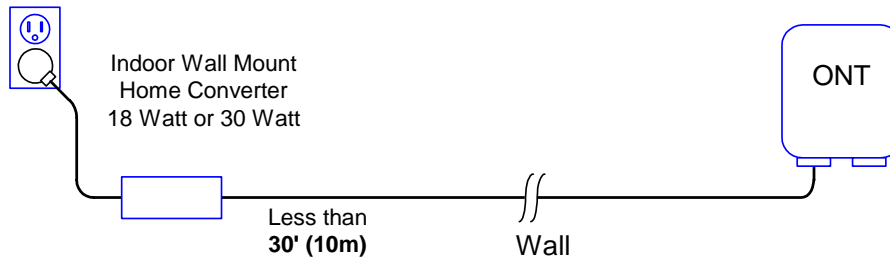
Load (W)	Runtime @ -40°C -40°F	Runtime @ -20°C -4°F	Runtime @ 25°C 77°F
5	16.0	21.3	26.7
10	12.4	16.5	20.7
15	8.4	10.7	15.3
20	6.2	7.9	11.3
25	3.1	4.3	7.3
30	2.8	3.9	6.7

*Standby runtimes in hours for the ONT power supplies over temperature*

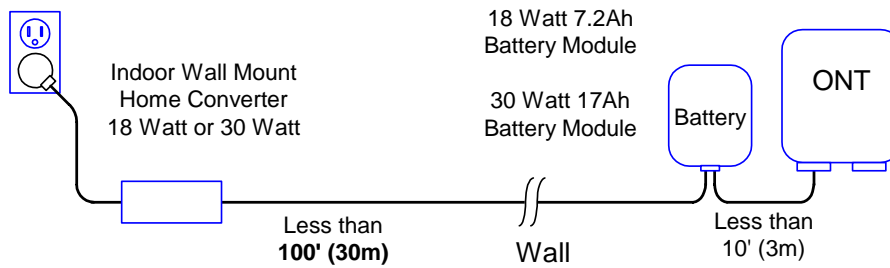
Separating the battery from the power converter and placing it in the exterior of the home requires charge control and thermal management capabilities that early generation power supplies did not address; including insulation, and microprocessor controlled heating, and charge monitoring. These enhancements provide extended battery life and predictable standby runtimes regardless of the temperature in the garage.

The cable length between the battery module and Power-Ring/Home Converter must be 100 feet or less. The cable length between Battery Module and ONT should be less than 10 feet.

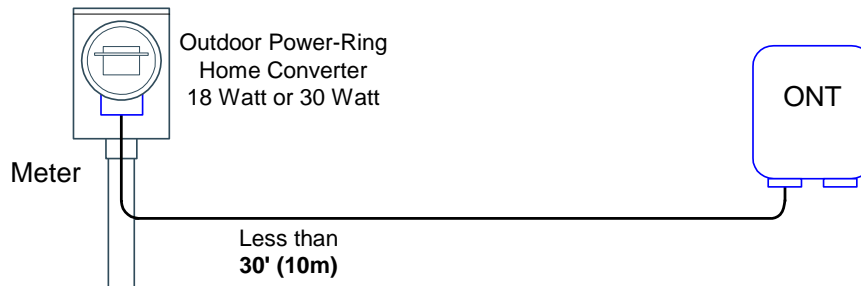
**Indoor to Outdoor Powering**



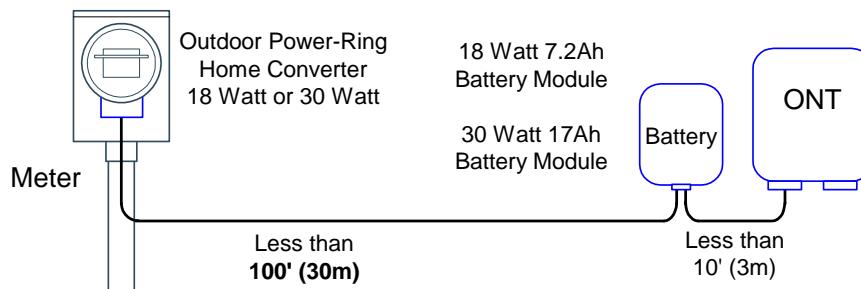
**Indoor to Outdoor Powering UPS**



**Outdoor Powering**



**Outdoor Powering UPS**



*ONT powering options with and without UPS with -40°C to +60°C components*

The cable used to connect the Power-Ring/Home Converter to the Battery Module requires a three conductor, multi-strand cable. The cable connecting the Battery Module and the ONT can require a four to seven wire, multi-strand cable depending on the ONT. The wire gage size should be selected based on the distance between the Power-Ring Converter, collocated Battery Module and ONT. Installers should only use outdoor rated cable for outdoor environment and use the next largest wire size as a good practice.

The following costs are rough end user pricing levels for the ONT powering options diagrammed above for both 18 Watt and 30 Watt systems. Indoor to outdoor, \$45 to \$50. Indoor to outdoor powering with a UPS, \$100 to \$140. Outdoor powering, \$80 to \$85. Outdoor powering with UPS, \$135 to \$180. Early generation 18 Watt indoor premise ONT power supply has an initial cost of \$35 to \$50 but higher maintenance cost due to access and battery replacement.

Future cost savings associated with powering the ONT at the premise will likely be facilitated by establishing interoperability standards allowing for the battery and battery charger to be embedded in the ONT. Savings would be realized by reducing the number of items needed to be purchased, staged for field deployment, and installed. Integrating the battery and charger in the ONT also reduces the clutter on the side of the home. Locating the power converter at the home will be application specific and require a number of placement solutions.

## **Conclusion**

Powering solutions supporting FTTH networks and architectures need to be varied to address the unique needs of each application. Selecting the best value powering solution for the HE/CO, actives in the last mile or at the customers premises, must balance attractive upfront costs offered by some architectural solutions with lower long term operational costs and reliability offered by other architectures. Headends and central offices can be powered by traditional AC UPS, -48V DC UPS plants or a hybrid of both and often include a standby generator system. For greatest reliability and cleanest power, the HE/CO should be -48V powered with the ancillary AC equipment powered via an inverter. Actives located in the last mile of the network are housed in outdoor, pole or curbside enclosures. Initial costs and reoccurring costs are directly related to the environmental rating of the FTTH actives used, pole or ground placement, and type

of AC service entrance. Convection cooled enclosures should be used if at all possible as they represent a lower upfront cost, low maintenance and greater reliability. If active thermal management is required, a DC cooling solution should be selected as they continue to perform during AC outages. Only enclosure systems designed as an integrated system, qualified to perform over all operating conditions and marked with independent Laboratory's NRTL mark should be considered to minimize delays. New options in powering the ONT at the customers premise overcome battery replacement and reliability issues. Separating the AC to DC power converter from battery module and placing the battery on the outside of the home with the ONT allows 24/7 battery replacement and service access. Placing the AC to DC power converter in the utility meter provides a reliable, dedicated AC connection as opposed to a shared outlet in a garage or basement.

References:

[1] Network Reliability and Interoperability Council, best practices number 6-6-5206.

[2] Powering the Internet, Datacom Equipment in Telecom Facilities: The Need for a DC Powering Option (by the Technical Subgroup on Telecommunications Energy Systems of the Power Electronics Society of the Institute of Electrical and Electronics Engineers, Inc.)