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International Society of Broadband Experts

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From the Editors

We are excited to present the second 2020 issue of the SCTE•ISBE Journal of Energy Management. Our Journal is intended to spur creative thinking, drive new standards and, encourage participation in discussions to optimize our energy portfolio in the cable industry.

In this edition we present three articles. The first examines precision air vs. comfort cooling as it relates to critical facilities. Interestingly, heat management represents on average 30% of the total costs of critical facility operations. Next, we present a method for approaching how cable operators can move forward with fleet electrification. Electrification of vehicles (EVs) is an important strategic discussion that should be had, as vehicle manufacturers continue to transition to more and more EV products. The third paper examines a total cost of ownership (TCO) framework for determining the best method for delivering the 10G networks. Financial implications are a major consideration when reviewing strategic major topics like network upgrades/evolution. Finally, in a letter to the editors, the importance of managing company diesel fuel supply chain as it relates to our targeted maximum availability of service is discussed.

We are thankful for the individuals who contributed to the Journal of Energy Management. We hope to spark some new ideas during your enjoyable read. If you have feedback on this issue, have a new idea, or would like to share a success story please let us know at journals@scte.org.

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Precision vs. Comfort Cooling & The Beneficial Use of Intelligent Free Cooling

A Technical Paper prepared for SCTE•ISBE
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1. Introduction

Precision air conditioners are air conditioners designed for special rooms that require constant temperature, humidity, and cleanliness. Understanding the difference between comfort cooling and precision cooling can be a major factor in reducing energy consumption in data centers and other precision environments.

Typical applicable locations are the following:

- Data Centers
- Computer Rooms
- Telecom Equipment Rooms and Shelters
- Centralized Monitoring Rooms
- Healthcare Equipment Rooms
- Manufacturing Facilities - Precision Environments
- Test Labs

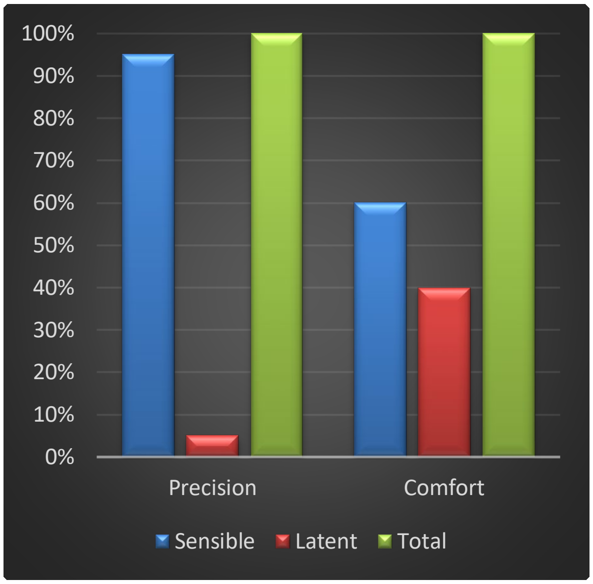

Figure 1 - Percision vs. Comfort Cooling

Precision Cooling Equipment

- High sensible heat ratio
- 95% of work = cooling air temperature
- 5% of work = removing humidity

Comfort Cooling Equipment

- Lower sensible heat ratio
- 60% of work = cooling air temperature
- 40% of work = removing humidity

2. Why Do I need a Precision Air Conditioner?

Data centers (also referred to as server rooms or IT rooms) are the backbone of any business' organization, providing capabilities of centralized storage, backups, management, networking and the dissemination of data.

Most contemporary data centers contain equipment racks that secure servers, storage devices, network cabling and other IT equipment. Data center design is primarily comprised of the utility infrastructure like power supplies, fire suppression and other security devices.

Data center equipment generates a considerable amount of heat in a relatively small area. This is because every watt of power used by a system is dissipated into the air as heat. Unless the heat is removed, the ambient temperature will rise, eventually beyond design specifications resulting in electronic equipment failure.

Traditional comfort air conditioners are not designed to handle the heat load concentration and heat load composition of the data room, nor to provide the precise temperature and humidity conditions for the electrical equipment of data center. Precision air conditioners are designed for precise temperature and humidity control, with high reliability to ensure the continuous operation of data centers throughout the year.

Precision air conditioners in data centers can control the temperature and relative humidity in ± 34ºF, ± 5%, greatly improving the service life and reliability of the equipment.

2.1. Temperature and Humidity Requirements of Data Centers

Maintaining temperature and humidity design conditions is critical to the smooth operation of data rooms. The design conditions should be between 72 °F to 75 °F and a relative humidity (R.H.) of 35% to 50%. Just as environmental conditions may cause damage, rapid temperature fluctuations may also have a negative impact on hardware operation, which is one reason to keep the hardware running even when the hardware is not processing data.

In contrast, the comfort air-conditioning system is designed to keep the indoor temperature and humidity at 80 °F and 50% R.H when the outdoor temperature and humidity at 95 °F and 48% R.H in the summer. Comfort air conditioners on the other hand do not have dedicated humidification and control systems. A simple controller cannot maintain the set point 23 ± 68 °F required for the temperature. Therefore, high temperature and humidity may cause high ambient temperature and humidity range fluctuations.

2.2. Problems Caused by the Wrong Enviornment

2.2.1. High & Low Temperature

A high or low ambient temperature, or rapid temperature swings, can corrupt data processing and shut down an entire system. Temperature variations can alter the electrical and physical characteristics of electronic chips and other board components, causing faulty operation or failure. These problems may be transient or may last for days. Even transient problems can be very difficult to diagnose and repair.

2.2.2. High Humidity

High humidity can result in tape and surface deterioration, head crashes, condensation, corrosion, paper handling problems, and gold and silver migration leading to component and board failures.

2.2.3. Low Humidity

Low humidity greatly increases the possibility of static electric discharges. Such static discharges can corrupt data and damage hardware.

2.3. The Difference Between Precision and Comfort Cooling

In order to provide a stable and reliable working environment for IT devices, the temperature and humidity of the room must be strictly controlled within a range. Therefore, the design of precision air conditioners is very different from traditional comfort air conditioners in the following aspects:

2.3.1. High Sensible Heat Ratio and Small Enthalpy Difference

A heat load has two separate components: sensible heat and latent heat. Sensible heat is the increase or decrease in air-dry bulb temperature. Latent heat is the increase or decrease in the moisture content of the air. The total cooling capacity of an air conditioner is the sum of the sensible heat removed and the latent heat removed.

Total Cooling Capacity = Sensible Cooling + Latent Cooling

The Sensible Heat Ratio is the percentage of the total cooling that is sensible.

Sensible Heat Ratio (SHR) = Sensible Cooling

In a datacenter, the cooling load is made up almost entirely of sensible heat coming from IT hardware, lights, support equipment, and motors. There are very little latent loads since there are fewer people, limited outside air, and usually a vapor barrier to add further moisture protection. The required SHR of an air conditioner to match this heat load profile is very high, 0.95-0.99. Precision air conditioning is designed to meet these very high sensible heat ratios.

In contrast, a comfort air conditioner typically has a SHR of 0.65-0.70 and provides too little sensible cooling and too much latent cooling. The excess latent cooling means that too much moisture is continually being removed from the air and a high energy use humidifier is required to replace moisture.

Traditional comfort air conditioners are mainly designed for human comfort, with smaller amounts of supply air cfm per square foot than sensible cooling found in most precision environments. The sensible heat in equipment rooms accounts for more than 90% of the total heat. Heat loads from lighting, heat conduction through walls, ceilings, windows, floors, and solar radiation heat, seepage wind and fresh air heat through gaps, etc. The amount of moisture generated by the heat gain is very small, so the use of comfort air conditioners will inevitably cause the relative humidity in the equipment room to be too low. The surface of the internal circuit components of the device will accumulate static electricity, which will cause damage to the device and interfere with data transmission and storage. At the same time, as the cooling capacity (40% to 60%) is consumed in dehumidification, the actual cooling capacity of the cooling equipment is reduced, which greatly increases the energy consumption.

A precision air conditioner is designed to strictly control the evaporation pressure in the evaporator and increase the amount of supply air. The goal is to have the surface temperature of the evaporator higher than the dew point temperature of the air without the need for dehumidification. Thus, the cooling capacity is used to cool by reducing cooling loss during dehumidification (large air volume, small air enthalpy difference).

2.3.2. Large Air Volume

In order to dissipate the high heat loads of data centers, the cooling systems must circulate enormous velocities of air. Comfort air conditioners operate at very low CFM velocities and at slower rates of speed than precision air conditioners. They can only partially circulate airflow in short distances in the supply air direction, instead of generating an overall airflow circulation in the data center. This may result in localized temperature differences, low temperatures near the supply air direction, and high temperatures in other areas. All of these factors can result in local heat buildup, which can damage the IT device due to overheating.

Precision air conditioners produce high CFM levels, high air changes per hour rates that can potentially reaching 30~60 times per hour. This high amount of CFM moves more air through the space improving air distribution and reducing the chance of localized hot spots.

2.3.3. Air Cleanliness

Air quality is equally important for electronic circuitry. Dust is certainly one of the worst enemies and can adversely affect the operation and reliability of data processing equipment due to stray currents.

For traditional comfort air conditioners, due to the small air volume and the low ventilation rate, the air in data centers cannot guarantee a sufficiently high speed to bring the dust back to the filter. Thus, the dust is deposited inside of the electrical equipment, which has detrimental effects on the electrical equipment. At the same time, the air filter is not intended for clean applications.

Precision air conditioners produce large volumes of supply air and high ventilation rates. They require high efficiency air filtration to filter out dust to preserve the overall cleanliness of data centers.

2.3.4. Reliability

The 24-Hour operation of precision air conditioners are designed and built to run non-stop 8760 hours a year. These systems are designed with components selected and redundancy incorporated to ensure zero downtime. System controls maintain room conditions for the full range of outside ambient conditions, summer or winter. Comfort air conditioners are designed to run during summer days, up to an expected maximum of 1200 hours per year. These systems are not designed or expected to operate non-stop, or 8760 hours a year. Neither the controls nor the refrigeration systems are designed for zero downtime or winter operation.

2.3.5. Humidity Control

Precision air conditioners are generally equipped with a humidity control system, which consists of a high-efficiency humidification system, dehumidification and electric heating compensation systems. Through the microprocessor, precision air conditioners can accurately control the temperatures and humidity in data centers based on the data from each sensor. The comfort air conditioner is generally not equipped with a humidification system. Comfort air conditioner systems tend to control the temperature inaccurately and cannot control the humidity, so these systems cannot meet the heating and cooling load needs of most data centers.

2.3.6. Control Accuracy

Precision air conditioning systems usually consist of a cooling system, an electrical heating compensation system, a humidification system and a de-humification system. These are all critical, so that the unit can quickly respond to environmental changes through the microprocessor-based controller and ensure the environment can be accurately maintained with a very small temperature set point range.

Comfort air conditioning systems usually do not produce heat, humidification and dehumidification systems, but these are essential for a stable indoor environment. Comfort air conditioner systems have limited controls that are unable to react quickly or provide rapid control.

2.3.7. Air Distribution Method

The air supply schemes of air-conditioned rooms depend on the heat source and distribution in the room. In view of equipment arrangement and the wiring method in data centers, two design configurations are common: 1) a raised floor system, and 2) overhead air distribution.

Precision air conditioners usually do not use air ducts for supply air and return air but use the space under the raised floor or upper the ceiling as the static pressure box. This space acts as a plenum chamber for supply air and return, so that the static pressure is uniform throughout the entire data center.

2.4. Sensible Cooling vs. Latent Cooling

Sensible cooling is used to remove heat, while latent cooling is used to remove moisture. Spaces with high density heat loads and little need for dehumidification require high sensible cooling capability and low latent cooling capability. This would generally be a 0.8 to 1.0 sensible heat ratio (SHR) where the ratio is represented as sensible cooling over total cooling. Spaces like these require precision cooling.

In data room applications where there are rapid temperature swings, high or low humidity can have negative effects on the room’s electronics. High, low, or fluctuating temperatures are capable of corrupting and even shutting down entire data systems. For precision air systems with lower than 1 SHR, a humidifier is often included to put moisture back into the room.

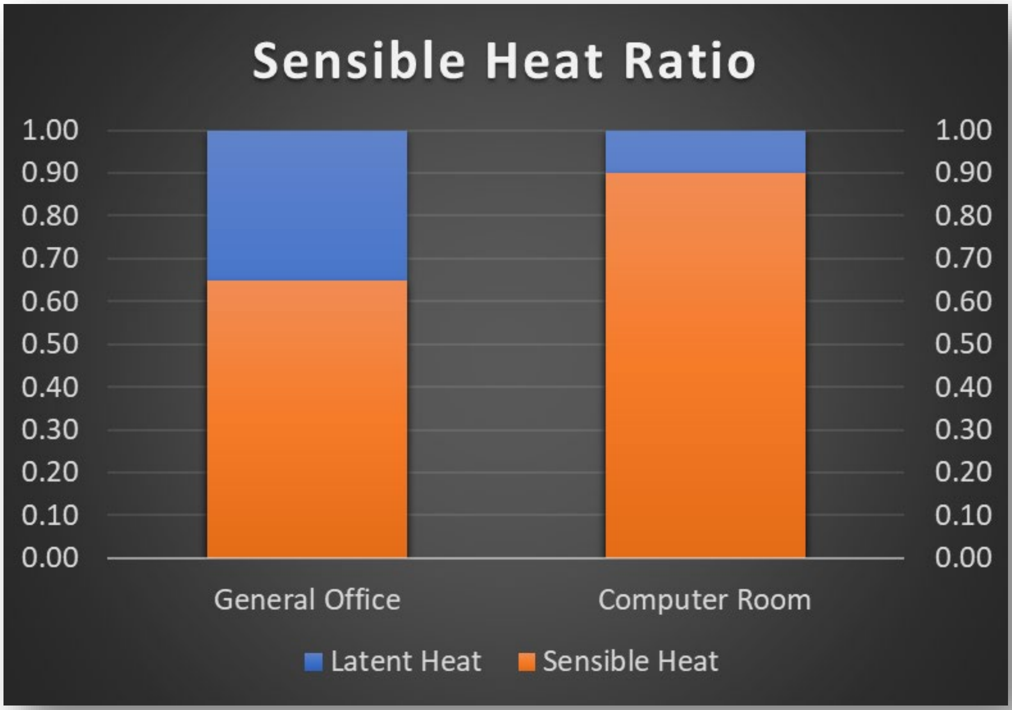

Figure 2 - Sensible Heat Ratio

2.5. Beneficial Use of Intelligent Free Cooling

2.5.1. Intelligent Free Cooling

Intelligent Free cooling is an energy efficient process incorporated within contemporary HVAC systems that uses low external air temperatures to assist in lowering the internal air temperature in a building, or data center, by using naturally cool air or water instead of a mechanical cooling process.

While intelligent free cooling with direct outside air is extremely efficient for cooling remote cell sites and small equipment rooms, care must be taken in locations where air contamination is an issue.

2.5.2. Air Filter Protection Device (AFPD)

The patented AIRSYS AFPD (Air Filter Protection Device) is field proven and engineered to protect air filters from dust and debris. In many locations, the AFPD will optimize free cooling during periods when the air is clean, thereby extending the life of the primary air filter.

2.6. Why Do I Need Intelligent Free Cooling and an Air Filter Protection Device?

Due to the risk of clogged filters causing diminished cooling capacity and high temperature alarms, free cooling is often manually disabled for these locations by technicians to reduce costly service calls. On an

average telecom shelter site or small data center with a 10kW load, approximately $2,000/yr. on an average is lost when relying solely on compressors for cooling. Not to mention the wear and tear that occurs by the overuse of compressors causing more service calls.
This issue can be resolved by setting up Intelligent Free Cooling (IFC), a 2-layer approach to maximize energy saving while protecting the building from air contaminates.

:

Air Filter Protection Device (AFPD)

This AIRSYS patented AFPD device is field installed and communicates airborne contaminate density to the AIRSYS Lead/Lag controller. The controller immediately shuts the outdoor air damper when the contaminate density exceeds the predefined threshold.

Air Pressure Switch

An air pressure switch comes standard on all AIRSYS units and allows the user to set maximum primary air filter dirtiness. If this threshold is exceeded, Free Cooling (FC) is disabled until the filters are replaced. Even in worst-case scenarios, mechanical cooling capacity will be maintained.

Note: Software upgrades to AIRSYS Lead/lag Controller may be required for compatibility. Have your maintenance contractor contact us for more information.

Figure 3 - Intelligent Free Cooling and AFPD, a Two-Layer Approach

3. Benefits of Intelligent Free Cooling

3.1. Unlocking Energy Savings

Compared to relying solely on compressors for cooling, enabling IFC can easily save $1,000-$2,000/yr. for each medium sized (10kW) site. The ROI is less than 6 months from utility cost savings alone.

3.2. Reducing Long Term Operational Expenditures (OPEX)

Depending on the climate, IFC can offset compressor run times and turn-ons by 40-90% throughout the year. This eases the wear and tear on the compressor and related components such as switches, contactors, and condenser fan motors. This significantly extends the life expectancy of the system and reduces overall maintenance costs.

3.3. Added Cooling Redundancy

Having another form of cooling provides a safety layer in temperature control on remote sites. IFC can help offset the entire heat load during colder months and cooler nights while providing emergency ventilation during the hotter times of the year.

4. Conclusions

The added two-layer approach of both IFC and AFPD will provide added reliability for HVAC equipment in the harshest environmental conditions. Our AIRSYS UNICOOL system incorporates both technologies in unison to enhance energy efficiency as well even in the most challenging outdoor environments across the globe.

Appendix

Figure 4 - Comparison – Precision Air Conditioners vs. Comfort Air Conditioners

No.	Items	Precision air conditioner (CRAC)	Comfort air conditioner
1	Design motivation	Designed to dissipate high heat loads. Ensure the temperature, humidity and cleanliness of the equipment room.	Designed for human comfort perceived as pleasant by people.
2	Application	Data Centers Computer rooms Telecom equipment room and shelters, Centralized monitoring rooms Healthcare Equipment Rooms Manufacturing facilities requiring precise environments Precision operating rooms	Offices, hotels, supermarkets, Movie theaters.

No.	Items	Precision air conditioner (CRAC)	Comfort air conditioner
3	Operating time	Server rooms operate 24 hours a day, seven days a week, 365 days a year. CRAC units are designed to operate continuously, non-stop on an annual basis.	Intermittent and cyclic operation only when people are working or occupying the area. 10~12 hours per day at 100~150 days per year.
4	Air volume	Operate at a high air flow rate, the high ventilation rate is necessary to remove hot spots, 30-50 times per hour.	Operate at a much lower airflow, ventilation rate is less than 5 times per hour, high enthalpy difference.
5	Proportion of capacity or sensible heat ratio (SHR)	Provide very high sensible heat ratio (SHR) - 0.85 to 0.95.	Typically has a SHR of 0.60 to 0.70, thereby providing little sensible cooling and too much latent cooling. This means that more capacity is needed to do the same job as a precision air conditioning system.
6	Supply air temperature	Higher than dew point temperature.	Lower than dew point temperature.
7	Air cleanliness	CRAC Units clean the air continuously through the high-efficiency air filters and the system design of the blower operating all of the time.	Use disposable or washable filters of undetermined efficiency. Not intended for clean applications.
8	Humidity regulation	Have the ability to control the humidity levels to the space. The units can add humidity with a humidifier that is built into the unit.	Achieve unregulated dehumidification suitable for comfort cooling.
9	Environment adaptability	Outdoor temperature -86°F~+113F.	Outdoor temperature - 41°F~+104°F.
10	Control accuracy	Regulate temperatures and humidity within tight limits; ±1 °F and humidity at ±5 %.	Can't regulate humidity and temperature within precise margins.
11	Control system	Equipped with microprocessor-based controls, which are sensitive and respond quickly to environment conditions.	Generally, have basic, limited controls, unable to react or provide rapid control
12	Remote control	Easy integration to BMS using standard protocols, remotely monitor the units, collect and store data.	Unable to remotely control the unit.
13	Alarm	Automatically shows the fault and alarm on time on the interface.	Unable to show alarms.

No.	Items	Precision air conditioner (CRAC)	Comfort air conditioner
14	Diversity of options	Very large due to individual production.	Lower, due to mass production.
15	Air distribution method	Diversity of schemes, top throw, down throw, up-front throw, displacement, ducted, etc.	Up-front air supply in a short distance, resulting in localized hot spots.
16	Reliability	Be designed to accommodate continuous heat extraction and consider redundancy into the design to continue the facility’s operation during a failure event.	Designed with standard components, inability to switch to another unit during failure event.

Drive to Sustainability

Electric Fleets Contribution Toward Zero-Emission Goals and Operational Savings

A Technical Paper prepared for SCTE•ISBE by Black & Veatch

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1. Introduction

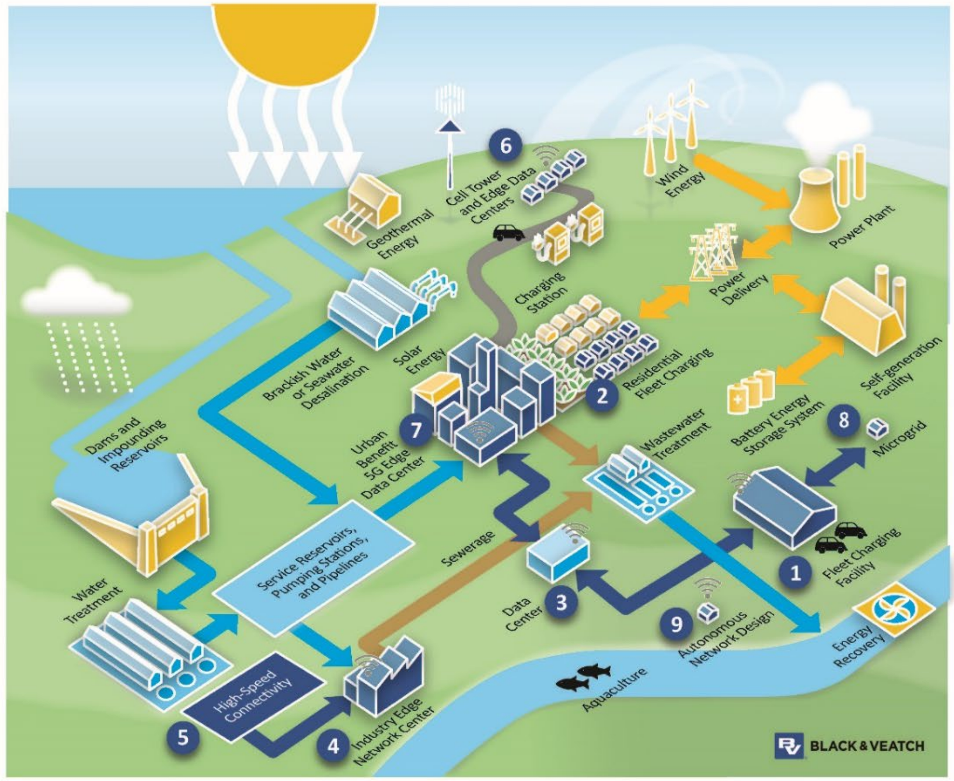
Among the top energy users, the communications industry is turning a corner on sustainability with commitments to incorporate renewable energy to reduce carbon footprints. The top two energy consumers, AT&T and Verizon, each increased their sustainability stakes. AT&T set a goal to achieve carbon savings 10 times the footprint of their operations by 2025. [1] Verizon expects to be carbon neutral by 2035.[2] Comcast also set aspirational, long-term goals to reach zero-emissions, zero waste, and 100% renewable energy.[3]

As all types of commercial and industrial organizations design sustainability plans, yet require significant energy to power their operations, the big picture is a complex ecosystem of renewable resources and onsite generation that also likely mixes electricity provided by local utilities. A zero-emission, zero-waste operation is possible through careful consideration of available natural resources, from water reservoirs to wind energy and solar power and geothermal energy. While ideal toward our clean energy future, these complex systems will likely be integrated in phases, and depending on your business goals and needs, it makes sense to prioritize some implementations. (Figure 1)

With companies like AT&T, Verizon and Comcast making up some of the largest private fleet owners, the industry could make considerable gains toward their sustainability goals by starting with electrifying corporate fleet vehicles. In this paper steps to deepening electrification of fleets is outlined.

Encouraged by advances in electric trucks, vans and buses, fleet and sustainability managers are turning away from the combustion engine, enticed by the promise of zero emissions, cost savings on maintenance and fuel, and improved driver safety. These benefits, paired with the decreasing cost of battery storage and improved battery performance, are driving the electrification fleet vehicles.

[1] AT&T, Social Responsibility. 2020. Retrieved from https://about.att.com/csr/home/environment/reducing- emissions.html
[2] Verizon, Sustainability Efforts.2020. Retrieved from https://www.verizon.com/about/responsibility/sustainability
[3] Comcast, Sustainability Report. 2019. Retrieved from https://corporate.comcast.com/values/report/2019/sustainability



Information and Communications Technology (ICT) service providers play an essential role in a sustainable community by supporting the following areas.

1. Charging fleets of electric cars, buses, truck, etc. to eliminate emissions.
2. Residential charging can supplement a centralized charging and parking facility and provide flexible charging capacity.
3. Deploying fiber optic technology for secure high bandwidth connectivity.
4. Supporting connectivity, security and power to industries at the edge of the network.
5. Ensuring that data centers remain operational 24/7 and have sufficient capacity to meet demand.
6. Deploying and maintaining wireless network infrastructure to ensure we are always connected.
7. Enhancing safety and increasing efficiency through Smart Communities and new 5G capabilities.
8. Microgrids may support the substantial energy increase needed for fleet charging loads.
9. Supporting the connectivity to deliver V2X (vehicle-to-everything) capabilities that autonomous vehicles require.

Figure 1 - Renewable Energy Ecosystem Design

2. Why Electric Fleets

Coast to coast, fleet and sustainability managers are planning and launching electric fleet programs. Doing so will achieve several critical measures:

Adhere to strict emissions standards
According to estimates, the U.S. e-commerce and delivery sector consumes 5.4 million gallons of diesel per day, outputting 55,000 metric tons of carbon emissions.[4] To address this, regulators are passing stringent regulations on fuel economy and emissions, driving transit agencies, school districts and e-commerce and delivery companies like Amazon, FedEx and UPS to deploy cleaner, quieter fleets.

Lower operating and maintenance costs
The fuel economy of electric fleets is far better than their diesel counterparts – electric buses get 5x more fuel economy than diesel buses operating on the same route and due to the magic of the motor's recovery of energy while breaking will rarely need break service and will never require emissions systems maintenance. When looking at the total cost of ownership, one electric school bus is $31,000 cheaper than diesel, and one electric transit bus is $81,000 cheaper, according to WISPIRG.[6] Plus, advancements in vehicle-to-grid (V2G) capabilities will help enable peak shaving, demand charge management and revenue streams as two-way power flow and utility digitization advances – pilot programs show that one V2G eBus can generate $6,100 annually.

Improve safety and working conditions
Electric drivetrains are quiet and fumeless, and without a loud, vibrating engine to distract the driver, provide several safety and operational benefits. By improving the driver experience and reducing driver fatigue, eFleets can help improve driver retention. In addition, on-board telematics can monitor and collect speed data, enabling managers to encourage safe driving habits.

Need for connectivity and resilient communications
As the electric and automation revolution takes hold, the importance of communications will increase exponentially. Communications providers that take the initiative with their own fleets will be well positioned to serve their customers and their bandwidth requirements. With autonomous transport looming, combining an electric-vehicle approach positions communication companies in a unique way to not only adopt this powerful combination but also to explore business opportunities developing out of the dependency of high-bandwidth low-latency communication networks. A perfect scenario may be right on our technology transportation horizon combining electric vehicles, low-latency high speed data networks and artificial intelligence that many of the cable operators are developing. Section three outlines steps to consider in broadening adoption of electrified fleet.

3. Builing the Capacity to Charge Your Electric Fleet

Fleet and sustainability managers are navigating a new maze of technologies, infrastructure choices, and supply chains as electricity becomes their new fuel. The transition to eFleets is different for each organization. Some leaders electrify major portions of their fleets, while others begin with a smaller trial project to help with proof-of-concept. Regardless of the undertaking, these 8 Steps guide the process, inform scheduling, and help managers cost-effectively plan optimal high-power charging facilities.

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[4] Bloomberg. 2019. Etsy Wants to Make Your Home Delivery Carbon Free. Retrieved from https://www.bloomberg.com/news/articles/2019-02-27/etsy-wants-to-clean-up-e-commerce-s-act-with-carbon-offsets

Step 1 Define Drive Cycles, Duty Cycles, & Operational Considerations

This information helps determine the Total Cost of Ownership (TOC), optimize battery sizes, and translate route data into cost savings. Managers will decide how many vehicles they will electrify, as well as when and where vehicles will charge based on duty cycles and routes. Options include depot charging, on-route, shared, and destination/endpoint charging — either alone or in combination — to meet capacity and resilience requirements over time. Innovative clean transit (ICT) provider's operations often include personnel taking vehicles home overnight. Charging at home or in their neighborhood will open up more opportunities to distribute the load while providing beneficial grid services in the form of Smart Charging or Vehicle to Grid (V2G). Based on service panel capacity, adding charging stations in a residential setting is typically not too difficult. Coordinating hundreds or thousands of installations and addressing billing systems will take a concerted effort. Developing a fleet-wide view of this information helps a technology integrator, like Black & Veatch, develop an infrastructure plan to meet current and future capacity needs of the fleet.

Step 2. Review and Select Technologies

Fleet and sustainability managers will need to consider types of trucks and buses, as well as charging connectors, charging speeds, and networking capabilities. These selections help managers build the ideal system and delineate all-in deployment costs. Technology continues to rapidly advance. Managers will benefit from insight around vendors and their equipment to ensure interoperability so that separate technologies form a cohesive network.

For commercial fleets, Level 2 and DC Fast Charging technologies are most appropriate. Medium-duty vehicles may only need Level 2 technology if they have ample time to charge, but trucks with large batteries and less downtime will require high AC and DC fast charging. In addition to hardware, it's important to consider software / network solutions. These solutions not only provide maintenance and monitoring for up time they enable data analytics functions to optimize charging, cost of energy, and potential revenue streams, and integrate on-site facilities and the distributed energy resources (DERs) grid. A networked system is especially valuable as the size of fleets and battery capacities grow exponentially.

Step 3. Understand Charging Loads & Power Delivery

It is essential to determine daily power requirements of charging. In transit, multimegawatt sites are common, which generates big energy demand. As a point of reference, a fleet of 56 buses would require roughly around 11 MWh/day; a fleet of 542 could demand around 109 MWh/day. The requirement to substantially increase energy at the site presents an opportunity to deploy microgrid technology approach. Microgrids integrate clean, resilient, efficient, and secure on-site power generation and energy storage, which helps offset energy costs and contributes to corporate sustainability goals.

The addition of high-power charging load and DERs will typically require equipment upgrades to grid elements and building facilities. Building retrofits require electrical and utility interface planning, cooling design, and space for equipment. Distribution grid upgrades vary greatly, but Step 7 outlines upgrades that Black & Veatch most commonly sees during charging facility planning.

Step 4. Implement Site Design and Planning

In most cases, managers will retrofit charging facilities at their existing properties; careful consideration of physical space and power supply is critical. If new sites are needed, then thoughtful and informed site selection will minimize project cost and time to orient charging facility layout and bring adequate power to the site. Regardless of whether sites are existing or new, several factors can dramatically affect schedule and cost, like distance from the site to a substation and whether additional upgrades are needed along the distribution circuit resulting from competing site developments and charging load.

Depending on the site, one or more upstream power delivery and /or distribution grid upgrades may be required including: reconductoring/upgrading the conductors on the circuit supplying the site, adding one or more conductors to the existing feeder pathway from the substation, installing a new feeder, substation upgrades and building a new substation. Although electrification can be a "one-day" idea, it's important to start the planning process now, even if plans are several years away, to factor in whether the power supply will be ready when the organization is ready to electrify.

Table 1 - Expected Time Ranges for Medium- and Heavy-Duty EV Infrastructure Deployment (No Distribution Upgrades)*

Project Phase	Typical Ranges (Months)	
Engineering / Design	0.50	2.00
Permitting / Land Use	0.50	3.00
Construction	1.75	2.50
Commissioning	0.25	0.50
Total Project Schedule	3.00	8.00

* Assumes 1-2 megawatt load, power is available on site, new utility service and transformer, 480v supply, existing utility right-of-way, limited to no building integration. May include service extension.

Table 2 - Expected Time Ranges for Medium- and Heavy-Duty EV Infrastructure Power Delivery Upgrades *

Potential Power Delivery Upgrades	Typical Ranges (Months)	
Supply Conductor (Service Extension)	0	2
Medium Voltage (Service Provisioning)	0	5
Feeder Re-Conductor	6	36
Feeder Additional Conductor	6	36
New Feeder	9	48
Substation Upgrade Required	18	36
New Substation Required	24	48

* Example ranges – all power delivery scenarios re specific to a location, feeder access, existing, in-queue projects and utility operating/power provisioning standards.

Step 5. Conduct Utility Coordination, Engineering & Design

Fleet and sustainability managers benefit from starting utility engagement as early as possible in the design process. Utility coordination is facilitated by strong existing relationships and knowledge of utility engineering and business practices. Managers that work with a technology integrator with these attributes can often accelerate utility design and service delivery for high-power charging. During this phase, managers and their technology integrators will work with host utilities to develop power delivery roadmaps that leverage utility programs and charging rates. Calculated savings based on future charging loads will be incorporated into the planning process. To future-proof design, it's important to consider growth over 5-10 years (and longer) to anticipate power capacity for a facility. While charging technology will continue to advance, it is most cost-effective to plan for and install anticipated on-site infrastructure (like conduit and switch gear) and make room for transformers, energy storage, and utility interconnections during initial construction versus down the road, which requires costly rework construction.

Step 6. Apply for Permit and Approvals

Land use, right-of-way, and permitting requirements become more complex with increased power levels. This is driven by space requirements for charging equipment, as well as the required permits and permissions that the utility will need to cross multiple parcels belonging to multiple land owners as part of power delivery. Frequently, completing permitting and utility applications with new products and technologies can be challenging because specifications and certifications are still being finalized. But, states are working hard to make permitting easier. Many states and utilities have checklists and guides that help managers submit correct and complete compliance documentation, as well as expedited permitting that streamlines the permit, installation, and inspection process.

Beyond permits, required paperwork can include interagency agreements and approvals, state environmental impact filings, and applicable terms and conditions of equipment, including differences of vehicles, infrastructure, lease holder agreements, and deployment services. The bottom line: Start early to finish on time.

Step 7. Distribution Grid Upgrades

Fleet managers taking the long view approach should begin strategic discussions with their local utility providers to create the necessary relationships to address these more complex needs. Beyond building upgrades, new charging loads may require upgraded or new utility feeders, substation modernization, and even new substations. Engineering, design, and construction scopes become more substantial with increasingly complex upgrades, which affects deployment cost and schedule. In general, a power delivery schedule without grid upgrades is about 8 months. A schedule with grid upgrades can run 48 months or longer depending on complexity of the upgrade, with a new substation serviced by new transmission lines being the most complex.

Table 3 - Potential Grid Upgrades and Associated Charging Power Needs

Potential Power Delivery Upgrade	MW
Supply Conductor (Service Extension)	0 – 1
Medium Voltage (Service Provisioning)	3 – 5
Feeder Re-Conductor	1 – 5
Feeder Additional Conductor	3 – 5
New Feeder	5 – 10
Substation Upgrade Required	5 – 10
New Substation Required	10 – 20

* Example ranges – all power delivery scenarios re specific to a location, feeder access, existing, in-queue projects and utility operating/power provisioning standards.

Step 8. Obtain Equipment, Construct and Commission
Once a manager obtains all permits and approvals, site construction using UL and field certified equipment can begin. Equipment usually includes chargers, switchgear, transformers, panelboards, cable, and connectors; storage will be necessary to protect equipment during installation. Construction usually involves exterior building work, which may include boring, trenching, paving, and landscaping, as well as internal building work, which may include drywall, painting, and ceiling repair. Traffic control is often required. Site safety plans are managed by the construction companies. Typically, additional commissioning and testing are conducted once full power has been delivered to the site, which needs to be reflected in the project schedule.

4. Conclusions

Electrifying fleets provides high impact toward meeting sustainability goals, and in turn, with proper planning could also provide lower TCO. Massive industry investment and advances in vehicles, power electronics, battery prices, and battery performance are generating technology confidence and motivating fleet and sustainability managers to begin fleet electrification. But, an eFleet is a non-starter without well designed power delivery and charging facilities. As long-term investments, charging facilities are intended to be enduring networks that support fleet owners and their unique transportation mission well into the future. Insightful planning is critical because present-day design decisions impact longevity, scalability for future growth, and bottom line TCO.

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Capital and Operational Spend Aspects in Cable Operator 10G evolution

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1. Abstract

Cable operators are heading to 10G crossroads with different options such as Extended Spectrum DOCSIS, Fiber Deep, and targeted Fiber To The Home. These are multi-billion-dollar strategic investments, both from initial capital overlay (CapEx) and long tail operational overlay (OpEx) points of view. Although making these investments typically depends on where you are with your current state of the network, one wrong move will result in significant regrettable investments over the lifetime of the network.

In the previous papers, presented in 4Q 2019 and 1Q 2020, we explained evaluating different 10G network upgrade options from operational centric point of view. In this paper we look at these end-to-end costs from both the capital and the operational spend perspective. This total cost of ownership (TCO) approach will reveal very interesting choices that a cable leader will have to make to deploy a sustainable network with the least regrettable investments. We extend the DTS OpEx framework to include the capital spend to create a comprehensive TCO framework. We evaluate different 10G evolution option's challenges and opportunities using this framework. In the process we will define different TCO metrics that an operator may consider in making such decisions. This paper will make certain recommendations based on the current state of the operator's access network. As an example, the TCO economics of deployment of microgrids and non-traditional energy sources in the outside plant to complement the expansion of the systems will be examined.

What is the problem?

Cable operators are racing towards 10G capable access networks. There are multiple paths to reach the end goal, each posing different challenges. How to evaluate what is right for the operator?

Key words: CapEx, OpEx, TCO

Key Takeaways

Operators need to use a framework that encompasses technological, operational, and financial analysis over a long period, such as the one proposed in this paper. We specifically addressed Total Cost of Ownership based framework in this paper. We recommend operators to develop -

- Long-term strategic plans
- Different financial metrics as proposed
- OpEx versus CapEx implications
- Short-term decision criteria (such as powering) based on long term plans

2. 10G access evolution background

Cable operator's access network is constantly evolving. As shown in Figure 1, with the recent initiative to offer 10G capabilities [1] cable operators are investing into reliable, secure, higher speed and lower latency access networks. This future access network is not a single technology, but a conglomeration of access and in-home technologies. For example, the technologies being evaluated are DOCSIS 3.1, DOCSIS 4.0, Low Latency DOCSIS, PON, Coherent Optics (for improved access optical network), and next generation WiFi (refer to [1] for details).

Figure 1 - Cable Operators multi-faceted 10G initiative

Such evolution will fuel innovation for future application capabilities. But the transformation of access networks must be performed carefully with architectural, financial, and operational considerations. In this paper we evaluate the financial aspects in detail.

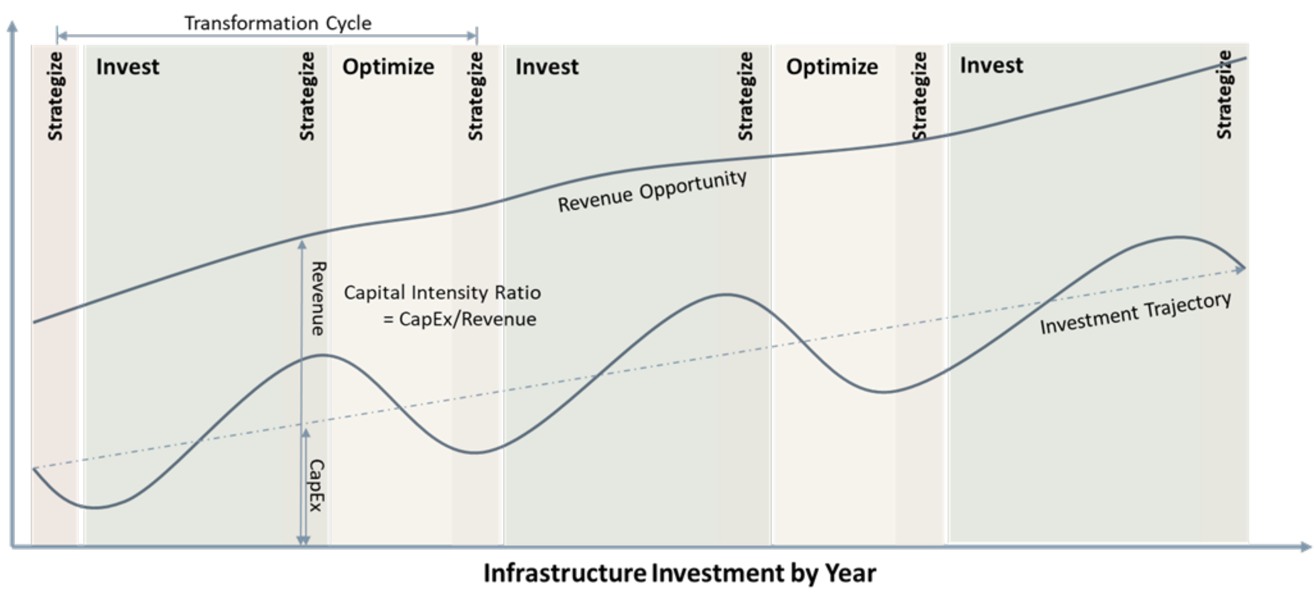

Figure 2 - A Telecommunication operator's transformation is cyclical with an average CIR of 20%

A typical investment in the telecommunication industry is cyclical in nature (refer to [2] for a detailed discussion). Best place to observe this cyclical nature would be to refer to one of the Cable operator's 10Ks over the last 10 years. This cyclical investment has three phases, as shown in Figure 2, that **strategizes** the investment both for short term (more for tactical reasons) and long term (more for transformational reasons), **invests** in the transformational core assets (network infrastructure) at appropriate rate, and **optimizes** the CapEx investment and other aspects, such as operational spend, to reap the benefits of the investment. On an average, the CapEx investment will trend up in any growing telecom company. The revenue trajectory should at a minimum be parallel with the investment trajectory for a healthy company. There are many factors that impact the revenue growth – poor transformation investment that does not meet growing customer demands, competition from new entrants and incumbents, and of course the changing habits of the customers. A healthy telecom company invests (plows back) on an average approximately 20% of the revenue in their network, i.e., a Capital Intensity Ratio (CapEx/Revenue) of 20%. Out of this 20% of the investment approximately 90% of the CapEx is invested in access. So, the right access investment strategy needs to be idealized.

CapEx only provides insights into onetime investment into network actions (greenfield deployments, brownfield upgrades, customer installations etc.). Operational spend, on the other hand, provides the upkeep of the network (and the customers) such as maintenance, powering, troubleshooting etc. Refer to the insert "CapEx versus OpEx Components" for a bit more details on the differences. Note that the OpEx considered in this paper are only related to the upkeep of the access network. This does not include the operational overhead, operational in efficiencies in an organization or the operational spend due to non-access network elements.

Insert: CapEx versus OpEx Components

Access CapEx Components: *This typically includes - facility installations (CMTS, Optics, CIN etc.), OSP equipment (nodes, cabinets, OLTs, amps etc.), OSP construction (node splits, plant extensions, drops etc.), and in home deployments (installs, CPEs, STBs, pre/post wiring etc.)*

Access OpEx Components: *This typically includes – powering solutions (facility and OSP), cooling (facility), maintenance (across access), trouble calls (facility, OSP and in home), and truck rolls (facility, OSP and in home)*

It is a common practice to perform a combined CapEx and OpEx, also known as Total Cost of Ownership (TCO), financial analysis to gain cohesive investment insights. Such TCO analysis is typically performed over multiple deployment years. We have seen customers using a four or six quarter planning for tactical deployments, three or five-year plan for a short-term strategic planning and a ten-year planning for a long-term strategic view. When such longer-term planning is being performed both the total aggregated cost and the net present value (NPV) will give different perspective of costs. An aggregate cost obviously gives the total investment profile, whereas the NPV provides information on the investment overlay with more emphasis to the nearer years.

When an operator compares different long-term access deployment strategies, from cost only point of view (note that we are not making any assumptions on the revenue aspects here), a regrettable investment can be defined as the TCO difference between the scenarios. Note both the aggregate TCO and TCO NPV need to be considered to gain comprehensive insights.

In our previous SCTE Journal of Energy Management contributions we have highlighted end to end operational impact analysis and made important recommendations. These recommendations are summarized in the insert "End to End Operational Impact Analysis Recommendations". As we have started discussing, the operational analysis gives only part of the solution. In this paper we extend our analysis to TCO. Also note that TCO analysis provides only the financial view of the access strategy. This along with the operational and technological feasibility need to be evaluated before adopting to the strategy. In an upcoming paper we look at the operational and technological feasibility (in the context of product requirements) along with TCO.

Insert: End to End Operational Impact Analysis Recommendations

In our previous work at SCTE we proposed a detailed access network operational framework ([3], [4]). Here is a quick summary of the recommendations provided:

- *Align your operational strategy with company's access strategy*
- *Energy consumption is not the only ops metric to be optimized*
- *Include end-to-end operational factors such as space and cooling*
- *Plan long-term solutions before making the short-term next steps*
- *Note that the ISP and the OSP incentives can be different*

Architecture	ISP Options	OSP Options
CAA	I-CCAP (D3.1) + Optical Aggregation	Node Split, Mid-split
DAA	CCAP Core + CIN V-CCAP + CIN	All of the above +N+0, Full Duplex, 1.2/High-split, 1.8/High-split
	Optical Aggregation	Fiber To The Home

Figure 3 - Different inside plant and outside plant options to reach 10G capabilities

3. TCO scenarios

Cable operators have many access levers to reach 10G capabilities as summarized in Figure 3. This paper is not intended to be a primer on access technologies. If you need additional information on the basics of access, brownfield and greenfield upgrade strategies in detail we recommend you to refer to the white papers [5], [6], [7] respectively. For more discussion on the interaction between the access architectures and their interaction with the ISP and OSP options, as shown in Figure 3, refer to our previous paper [4]. In this paper we added the Fiber-To-The-Home (FTTH) option as an additional access option to be evaluated under DAA architecture, as this is one of the options that Cable operators are using to reach 10G capabilities.

Figure 4 gives the three end-to-end access scenarios that are being prominently evaluated by cable operators. These scenarios are compared throughout the rest of the paper. In the following analysis we also evaluate different OSP powering options to show case how such framework can be used from end to end long-term perspective and at the same time can zoom into the detailed deployment related decision making.

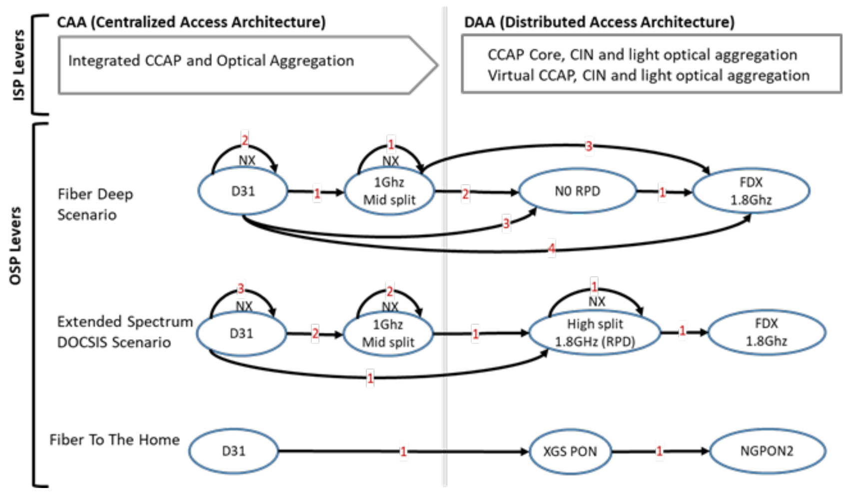

Figure 4 - Three brownfield upgrade scenarios used to demonstrate TCO analysis

In this analysis we consider a fictitious network of ~2K nodes with 1 million homes passed in three markets in North Carolina. At the start of the analysis all nodes and customers are DOCSIS 3.1. The three evaluated upgrade scenarios are as follows, as shown in Figure 4.

- Fiber Deep: This strategy manages the demand growth by mainly reducing the number of active subs in a service group. A network element is upgraded to support mid split if the evolution is upstream related otherwise will be upgraded to a two-way node split. If the DAA architecture and N0 is available, we assume the operator transition to N+0 RPD state. If the need arises the operator will migrate the N+0 nodes to full duplex (FDX) state. We assume in FDX state they will be in 1.8GHz plant state.
- Extended Spectrum DOCSIS (ESD): This strategy mainly enhances the spectrum capabilities to manage the demand growth. A network is upgraded in the upstream to high split and overall to 1.8GHz as soon as needed and the devices are available. Regular node splits are used as additional levers. The network eventually reaches 1.8GHz based FDX as in the previous upgrade path. The FDX state is possible only when the network reaches N+0 state.
- Fiber-To-The-Home (FTTH): The strategy here is to aggressively move to FTTH state as soon as possible. Here we assume hardened OLTs are deployed in the outside plant. Although there are EPON (1G/1G and 10/10G) and GPON technologies available, we assume the operator can deploy XGSPON now and when needed, upgrade to NGPON2.

Whenever a node makes a transition, as shown in Figure 4, relevant CapEx spend is made at that point in time. OpEx on the other hand is an ongoing spend, which gets calculated based on the network state. A total cost of ownership (TCO) is the sum of all the spends (in our analysis calculated quarterly).

The following high-level assumptions are made in this analysis:

- Only brownfield analysis is considered: Even though we acknowledge a greenfield deployment will become brownfield as soon as it is turned up, for the sake of simplicity, we did not consider in this analysis.

- CIN and optical costs are part of service group costs: For the sake of simplicity, we considered CIN network costs and end to end optical component costs between facility and the node are included in the service group costs.
- Considered only facility level Virtual CCAP (V-CCAP) costs: We understand that the V-CCAP is distributed in nature with components (CapEx and OpEx related) both in the facility and in the data center. We considered only the facility level impacts in this analysis.
- High level linearly growing costs and power needs are considered: For the sake of simplicity and to show how the framework is used, we considered high level aggregated costs with the linear growth assumptions, as opposed to stepwise upgrade typically needed for inside plant components.
- Upgraded or newly deployed nodes are transitioning to new powering solutions: To evaluate the impact of new powering solutions that reduces or eliminates power OpEx in the outside plant, it is assumed that any node that is transitioned will be migrated to the new powering options

4. TCO metrics discussion

Total Cost of Ownership (TCO) metrics provides financial implications of an access strategy. In addition to the TCO metrics, cable leaders need to consider technological and operational metrics as well (not part of this paper's scope but being planned for a future draft). For example, a product leader may want to offer symmetrical speeds that may restrict the access options, which can be understood only from technological analysis. An operational leader may be concerned about the resource needs and their optimization to meet an access plan, which is feasible only by deriving the long-term resource plans from the access strategy.

To evaluate the TCO impact due to different transformative decision, we propose the following metrics:

- **Long term investment vision**: This metric is a representation of the impact of different transformative decisions and their impact on investment over the long-range planning period. This metric is measured over 5-year or 10-year period.
- **Tactical investment profile**: We recommend using the long-range planning to evaluate short-term tactical plans. That said, there are many decisions (such as the financial, resource and material forecasting, and strategies) depend on the companies immediate (4 - 6 quarter planning) and near term (3 year) planning.
- **Regrettable investments**: One metric that is commonly used by leaders are the regrettable investments. Regrettable not always imply wasted investment. This is typically the investment comparison of two possible deployment scenarios that meets the company's needs, such as product roadmap support etc. This is a very important metric to break the tie between different technological discussions.
- **CapEx to OpEx proportional/relational metrics**: CapEx and OpEx overlay itself will give your different view on the access upgrade strategies. In addition, we recommend using CapEx (one time investments) to OpEx (long tail investments) proportional metrics so that operator have a good understanding of different investment profiles.
- **NPV versus total TCO**: One important factor that a total investment profile does not provide is the metric on how sooner the investment needs to be. This is where the Net Present Value (NPV) of the TCO will play a significant role.
- **Spend profile over time**: Looking at the spend profile graphs over time can give even more insights on the impact of a chosen transformation path. CapEx profile over time will answer if the investment is front loaded or back loaded or evenly distributed. The OpEx profile over time will show the impact of future technology changes on ongoing operational costs.

- **Not considered**: There are many pure financial metrics such as return on investment (ROI), return on invested capital (ROIC), free cashflow, revenue potential etc., as they involve the revenue opportunity assumptions. Such analysis is applicable for the company's business case assessment but not for the TCO analysis.

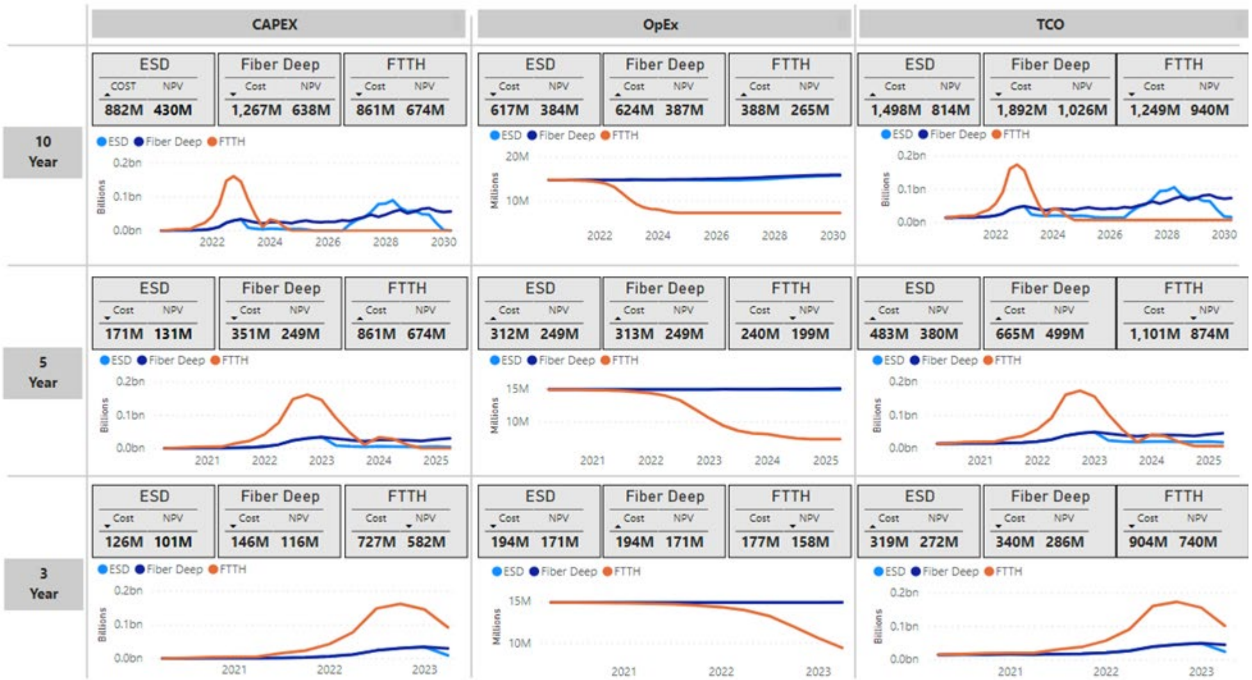

Figure 5 - Comprehensive Total Cost of Ownership comparison view

Figure 5 gives a comprehensive comparison of the three demo scenarios considered in this paper with different proposed TCO metrics. The row (10 year) provides the total long term TCO, with the 3 columns showing the relative impact of CapEx and OpEx for each of the scenarios. The difference between total cost and NPV cost combined with the spend profile in the graphs give clear visual answer to the long-term spend profile related questions. The 5yr. and 3yr. rows help to better understand the short-term and tactical impact of each of these transformation options. The goal of this paper is not to compare different transformation options, but to show how to evaluate them.

In Figure 6, we show the level of impact your long-term access strategy on the CapEx investment. Note that it is essential to focus both on the total and the Net Present Value (NPV) of the CapEx investment. They both provide important financial information. As an example while the FTTH scenario has the overall lowest cost, the fact the NPV and cost are close together is a clear indicator that this scenario requires the majority if investment in the near term where as in contrast the NPV of the ESD scenario is nearly half of the total cost indicating that the majority of investments is at the tail end of the 10-year period. The graph provides a view on the investment profile per quarter over the full 10-year period, clarifying further what could be inferred from the total vs NPV information. A detailed CapEx analysis, as shown in the appendix, can be performed for a tactical activity from budgetary point of view.

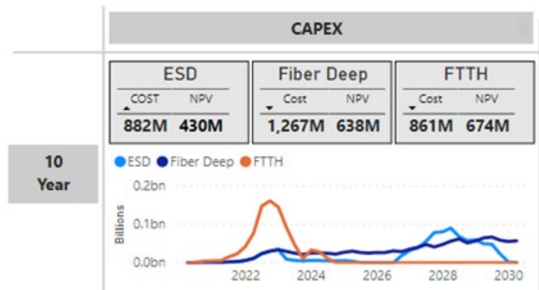

Figure 6 - 10 yr. access strategies CapEx comparison

In Figure 7, we show the impact of different access upgrade strategies on the operational spend. Note that, unlike CapEx, OpEx is a monthly recurring cost. Comparing the numbers, it becomes immediately apparent that the difference in OpEx is driven by technology family rather than deployment architecture. The reason for this can easily be explained by looking at the major contributors to OpEx Cost as shown in Figure 8. While a lot of components contribute to the total OpEx cost the 2 components that outweigh all others by far are truck rolls and trouble tickets. Observation from network deployments have shown that truck rolls and trouble tickets for FTTH network are far lower than for HFC network [13]. Other major contributors to OpEx cost are power and pole rentals.

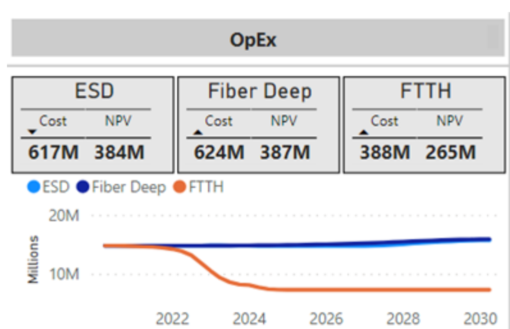

Figure 7 - 10yr. access strategies OpEx comparison

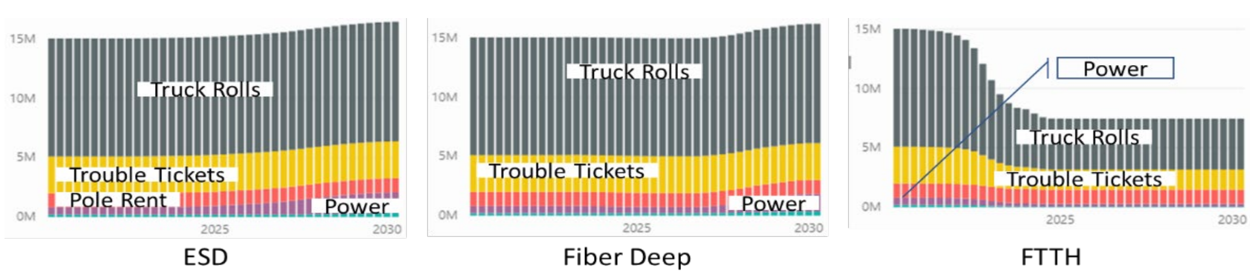

Figure 8 - Major contributors to Operational Expenditure

5. Analyzing the ISP and the OSP powering TCO impacts

Power and power infrastructure maintenance are important contributors for to the total OpEx cost of a network transformation strategy. In addition, power consumption is a very important factor to understand company environmental impacts and sustainability strategy. As an illustration, Figure 9 shows to the long-term power consumption evolution in the access due to different transformational activities for the ESD scenario.

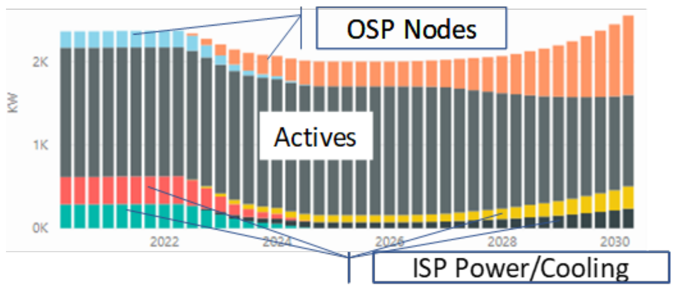

Figure 9 - Power consumption evolution over time for ESD scenario

Although we demonstrate only the power analysis in this paper, similar detailed analysis could be conducted leveraging this framework.

Powering costs are going to skyrocket [12] due to access evolution and its needs. For example, the outside plant powering cost components include –

- CapEx: power supplies, batteries, generators, microgrid etc. during the initial installations
- OpEx: power consumption, replacement, truck rolls, power supply and battery maintenance etc. during the operation of the access power network

Microgrid versus traditional powering options from TCO point of view: microgrid options will have higher initial (CapEx) costs compared to the traditional powering costs. The OpEx costs will be limited (typically limited maintenance) or eliminated (typically for power consumption) for microgrid deployments. These operational costs are a lot higher for traditional grid power only options, as discussed below. Hence understanding the financial impact of a specific microgrid option would require a full TCO comparison against a traditional powering option and is beyond the scope of this particular journal entry. To create some intuition on the financial benefit of deploying a microgrid option, an analysis is presented on the potential OpEx savings for each of the scenarios.

The assumptions include –

- No stepwise upgrades are assumed: We understand the operational spend analysis is not always linear (for example, the ISP powering costs are in the incremental of cabinets, racks and space availability etc.), but for the sake of simplicity we consider linear upgrade.
- CPE powering costs are not included: While CPE power consumption is often analyzed to understand the full environmental impact of a strategy, if does not contribute to OpEx cost (as it is part of the consumer costs) and hence not included in this TCO paper analysis.
- New Microgrid power options are available for only the newer deployments: Existing power deployments are not replaced with the newer powering options. This requires detailed planning.
- No power cost or preventative maintenance cost for the microgrid option.

The power OpEx comparison, without and with transition to a microgrid powering option is shown in Figure 10 for each of the transformation scenarios. The top portion of the graphs represent the power OpEx over time deploying with traditional power infrastructure. The bottom figures show the OpEx evolution when transitioning to a microgrid based network power infrastructure. By comparing the both the figures one can analyze the detailed OpEx benefits of a microgrid powering solution.

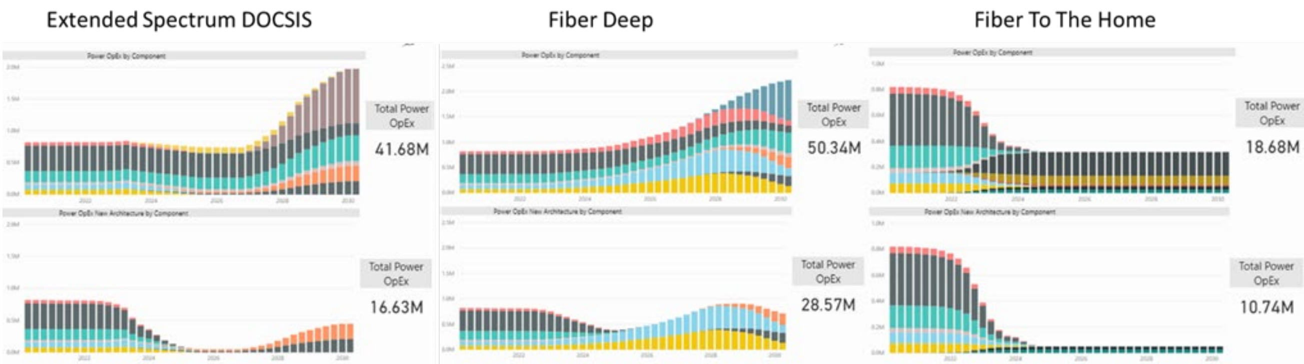

Figure 10 - Powering solutions OpEx comparison

6. Conclusions and recommendations

Access network TCO analysis generates the necessary insights to make sound business decisions on the long-term network transformation strategy and assist in deriving short-term tactical decisions. Multiple viable network transformation strategies can be created considering all operation levers, technology levers and service evolution requirements but the tie breaker insights will come from in-depth analysis of the TCO results as demonstrated in this paper.

With CapEx investments being cyclical in nature, which in some cases peaks, it is easy to get blindsided by the longer-term investment impacts. In addition, not considering the impact of the continuous OpEx component will skew decision making. Looking at TCO over a long transformation cycle gives a clear picture on the relative importance of CapEx vs OpEx and removes the short-term blind spots. A side benefit of evaluating the relative importance allows you to make informed decisions on technology choices that shift costs from OpEx to CapEx as shown in the power impact analysis.

The TCO analysis in this paper concentrates on the access specific costs, it does not reflect the total operational expense of the company. Many factors can drive further optimization of the operational spend such as different organizational structures Center of Excellence vs. distributed, in house labor vs 3rd party labor, and many more.

Finally, going deeper into what drives operational expenses in TCO results can present auxiliary insights into non cost related factors such as sustainability impacts that are becoming a more and more integral part of company’s vision and strategy.

Given a vision on service evolution requirement selecting a sound network investment strategy is all about minimizing regrettable investment. Identifying regrettable investment is only possible by analyzing long term investment and operational costs. That why we recommend that long-term TCO analysis should become an integral part of any network upgrade decision.

7. Acknowledgements

All the models presented here are developed by access planning software, AP-Jibe, from First Principles Innovations (www.fpinno.com).

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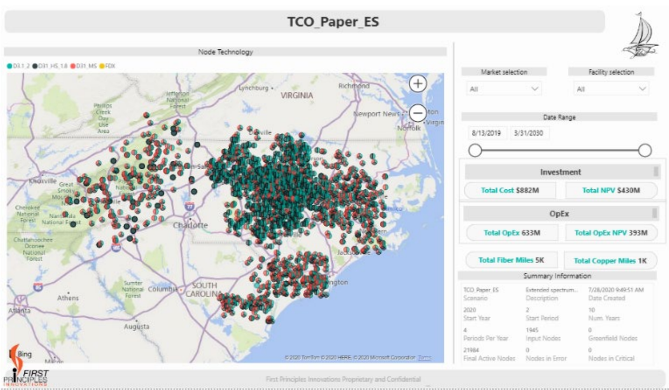
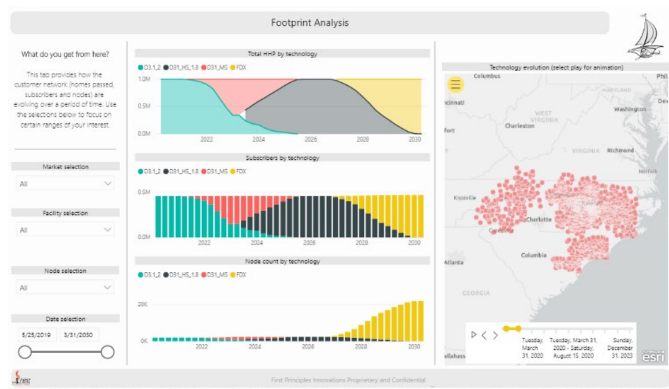
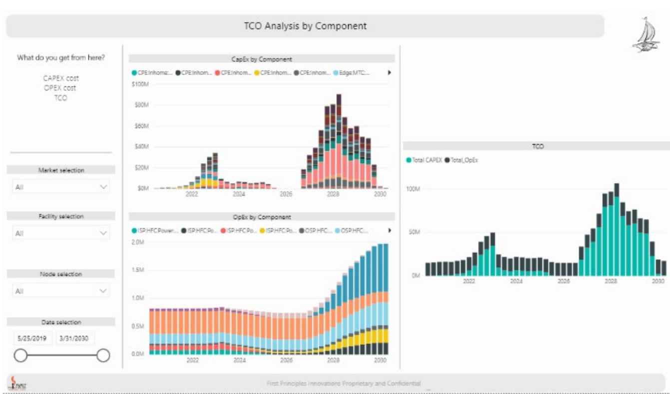
9. Appendix: Detailed scenario graphs

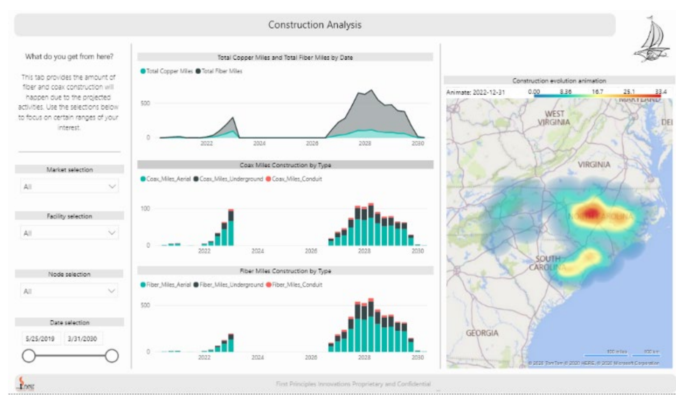
All the scenario analysis was done use the AP-Jibe access transformation planning toolset, with visualization of the results using Microsoft PowerBI templates. Below some of the screenshots for the different scenarios

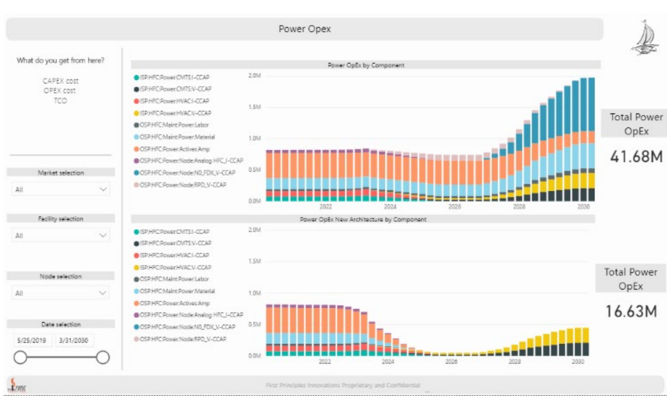
Extended Spectrum DOCSIS screenshots



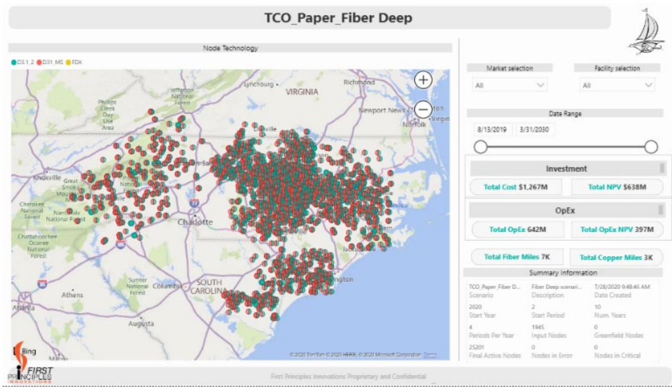


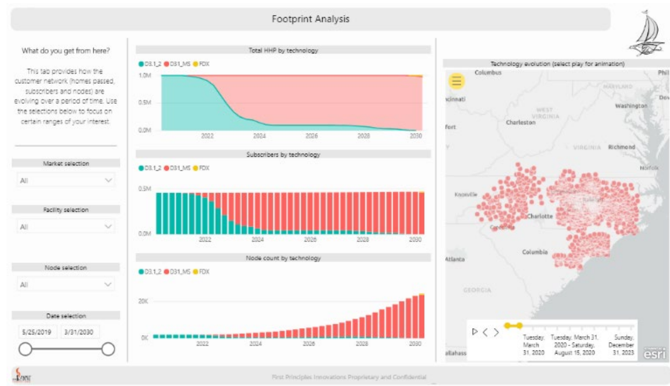


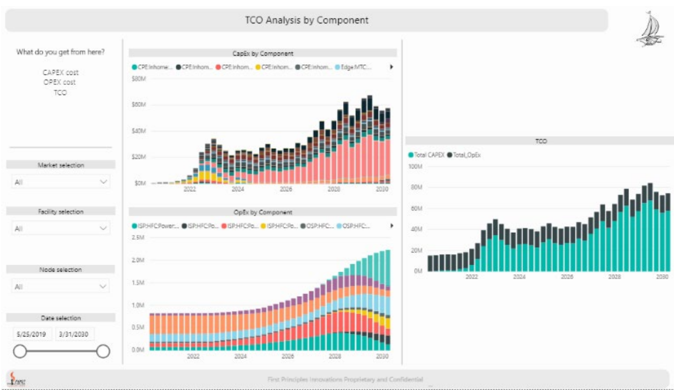


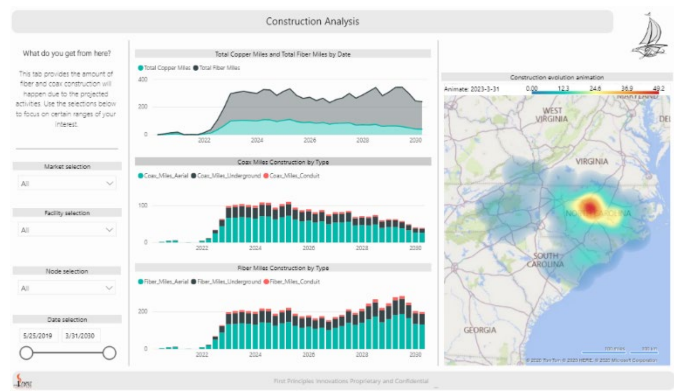


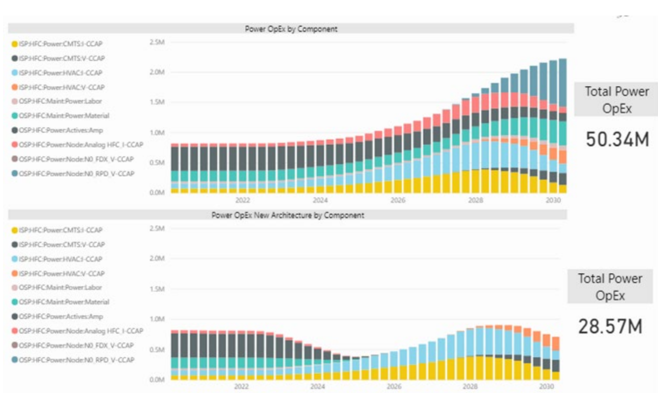
Fiber Deep screenshots











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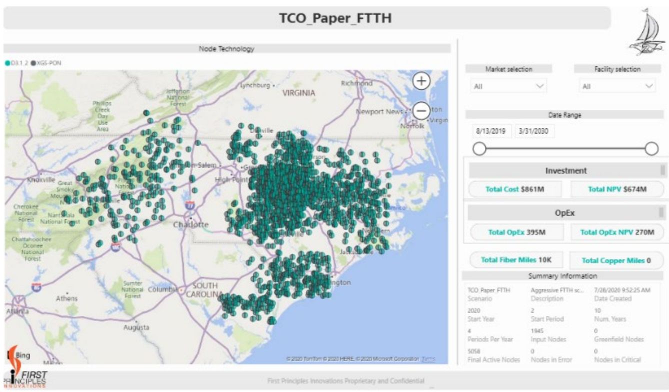

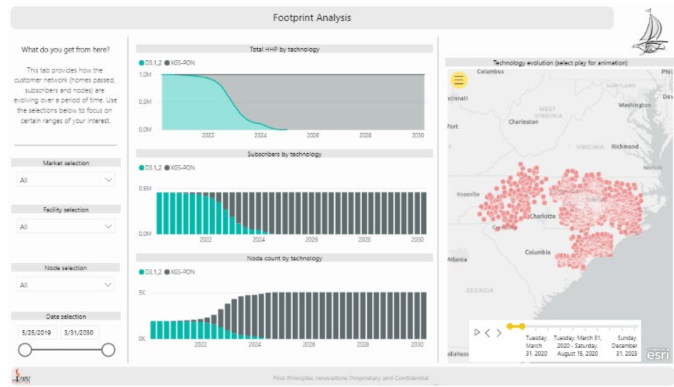

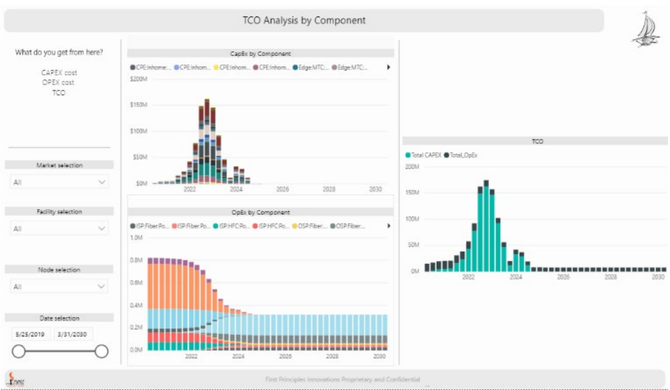

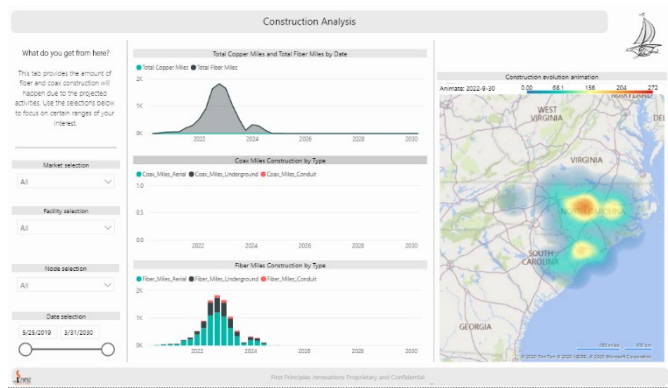

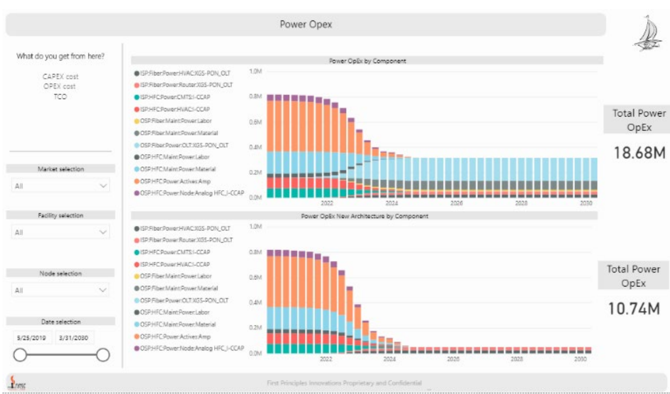

StormProof Your Facility

Strategies to Ensure 100% Uptime When the Power Grid Goes Down

Letter to the Editor prepared for SCTE•ISBE by

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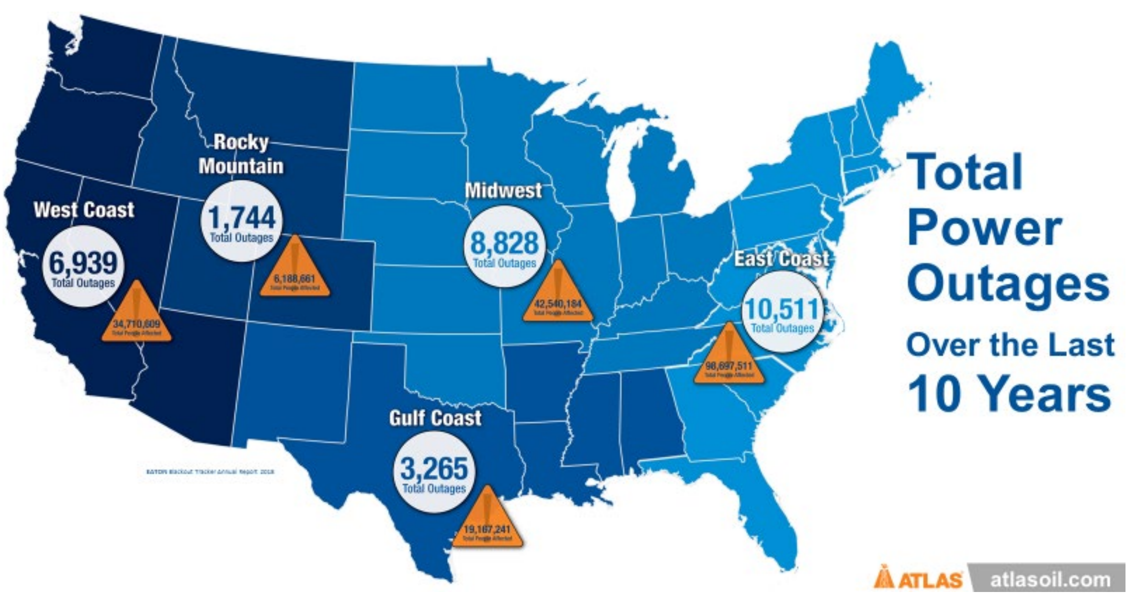
1. Introduction

Atlas Oil is a leading emergency fuel supplier that delivers over 2 billion gallons of fuel annually and helps thousands of mission critical organizations across the nation prevent fuel supply challenges, reduce annual maintenance costs and maintain 100% uptime. In addition to emergency fueling services, Atlas has an active real estate division and is engaged in transportation logistics and fueling including bulk, fleet, event, onsite, marine and oilfield services. The company was founded in 1985 by Sam Simon, who now serves as Founder, Chairman and Owner. At the young age of 19, Sam purchased his first tank truck on credit, and has since, grown Atlas into a multibillion-dollar business as one of the largest fuel distributers in the nation.

Atlas is licensed in 49 states and has supply contracts at over 1,000 fuel terminals nationwide. In addition to its large geographic footprint and robust fleet, Atlas has an extensive third-party carrier network that helps to support its mission critical clients across the nation. The company is constantly leveraging technology to optimize operations at every touch point for its customers. Atlas built an e-commerce solution, which allows customers to place orders and make payments online with real-time access to key information, and has a cloud-based mobile application, the StormProof app, that enhances its nationwide emergency fueling response.

In this paper, we will utilize our team's extensive emergency management experience to reveal the vulnerabilities of the diesel fuel supply chain for backup power and uncover where companies lack the proper infrastructure for emergency readiness. We will then outline a series of tangible solutions that can be implemented to enhance business continuity planning and help mission critical organizations achieve 100% uptime during power outages.

2. The Cost of Downtime



The power grid, like much of the critical infrastructure throughout the United States, was built many years ago, and is steadily aging. Year after year, we are seeing an uptick in power outages while simultaneously seeing an increase in the costs associated with downtime. Since 2010, the cost of downtime has increased by almost 80%, costing the United States economy between $80 and $188 billion per year. When power is disrupted to IT systems, 33% of impacted companies lose between $20,000 and $500,000, 20% lose $500,000 to $2 million, and 15% face catastrophic losses, facing more than $2 million in damages.

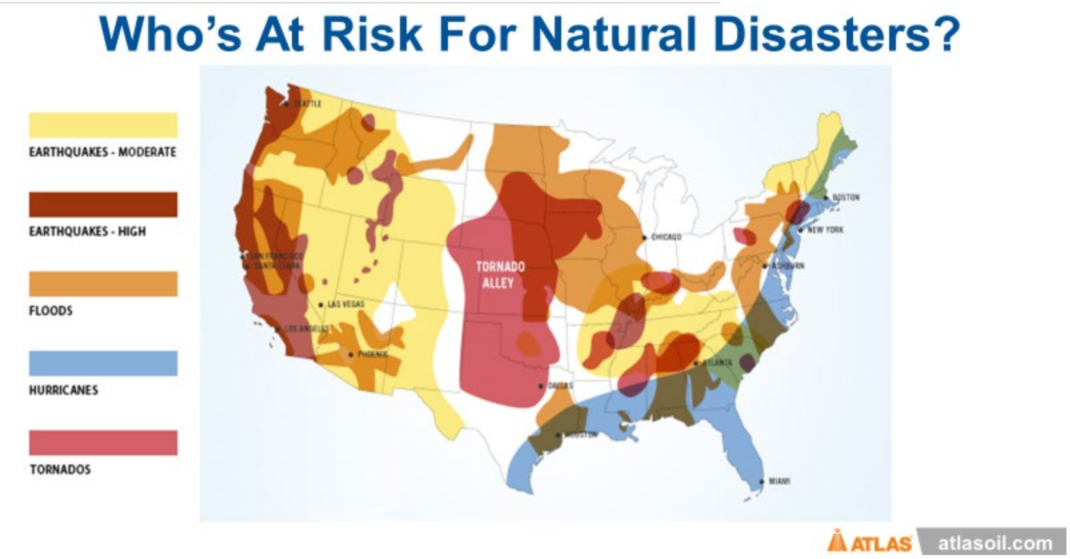
Looking at data specific to telecommunications service providers, downtime can be particularly costly, with the highest cost of a single event topping $1 million. This adds up to more than $11,000 per minute. When also factoring in the costs associated with loss of brand reputation, it is often very difficult to recover.

3. Who's At Risk?

Market research commissioned by Atlas in 2019 shows that nearly half of mission critical organizations in the United States do not have an emergency preparedness plan in place. In 2019 alone, 65% of these organizations had to rely on generator power for more than 12 hours but still, a third don't have a guaranteed agreement to ensure the generators at their facility will have the necessary fuel to maintain operations.

For mission critical industries, not having a dedicated plan in place for fuel supply poses incredible business continuity risks as billion-dollar disaster events are rising. Looking at data from the National Oceanic and Atmospheric Administration (NOAA), there were an average of 6.2 billion-dollar disaster events from 1980-2018. These events include everything from winter storms and wildfires, to floods, droughts and tropical cyclones. Honing in on 2014-2018, the average number of billion-dollars disaster events jumped up to 12.6 per year. Contributing factors include:

- Increase in population
- Building codes are often insufficient in reducing damage from extreme events
- Climate change increasing drought vulnerability, lengthening wildfire seasons in the West and increasing heavy rainfall in the East
- Population centers and infrastructure concentrated in vulnerable areas like coasts and river floodplains



Geographically, each region of the United States faces their own unique challenges; all of which can cause debilitating fuel supply shortages and delays. Looking specifically at NOAA’s data surrounding tropical cyclones, 42 took place between 1980-2018 that qualified as billion-dollar events, with the average cost at $21.9 billion. Out of these 42 storms, 39 made landfall in the United States. Therefore, it is accurate to say that most tropical storms making landfall in the United States can be classified as a billion-dollar event.

While not all mission critical organizations face the risk of tropical cyclones, disaster events taking place in one region can easily trickle into all aspects of the fuel supply chain.

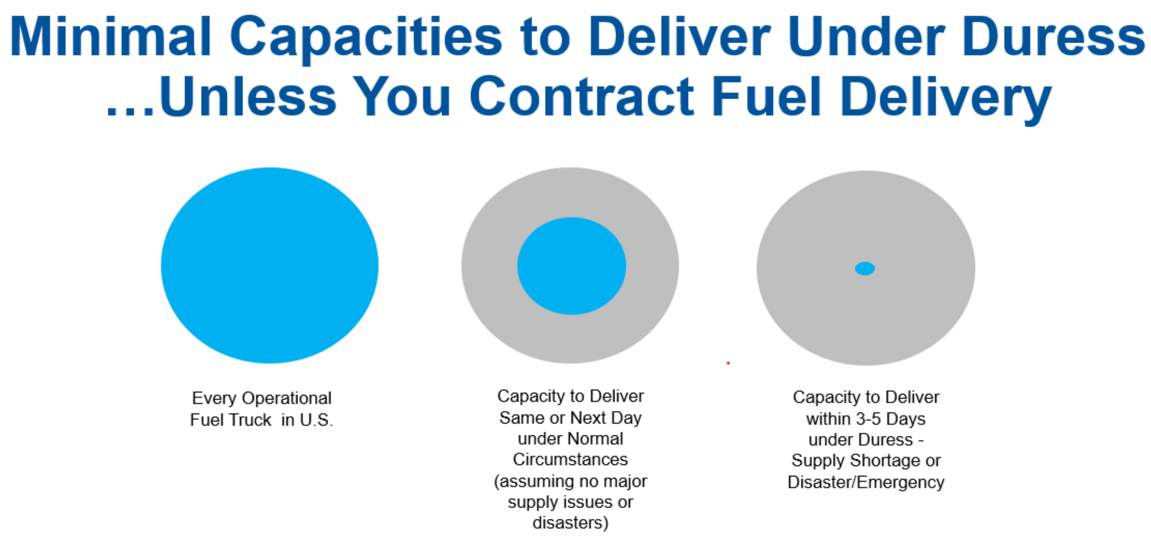
4. Vulnerabilities Within The Diesel Fuel Supply Chain

What happens to local fuel supply when the power grid goes down? Many organizations do not know the answer until it is too late, and the fuel tanks for their generators are nearing empty. When disaster strikes, fuel is one of the very first community lifelines to become constrained. Implications from tornadoes, hurricanes, flooding, snowstorms or even something as seemingly low risk as a thunderstorm can bring the fuel supply chain to a screeching halt.

As we approach the 15th anniversary of Hurricane Katrina in 2020, this storm serves as a perfect example on how quickly the upstream, midstream and downstream stages of Oil & Gas industry operations can become affected, causing local and national fuel supply challenges.

The day after Katrina made landfall in Louisiana, 95% of oil production ceased in the Gulf of Mexico, a key supply point for the United States. This drop in production, in combination with the shutdown of many refineries throughout the region caused gas prices across the nation to surge to $3.78 a gallon, a 50-cent jump from the previous day. Reports of gas shortages, in combination with rising prices, caused panicked consumers to rush to the pumps to top of their tanks, leaving many service stations out of gas.

With 2.3 million facing power loss, businesses also began to panic, knowing they were in a fight again the clock before their generators ran out of fuel– the survival of their operations dependent on when they received their next fill. Because mission critical organizations are heavily reliant on diesel-powered generators during power loss, fuel becomes an operational lifeline. An organization can have the most extensive business continuity plan in place but if it lacks a strategy for securing fuel supply, all other components will quickly fall flat.



Another factor to consider when looking at the fuel supply chain are the United States pipelines. Pipelines are used to safely and efficiently transport raw materials from areas of production to refineries across the nation. They then move the finished products to gasoline terminals, power plants and other end users. When these pipelines break or even undergo regular maintenance, trucking companies cannot keep up with the logistics. Not because they do not have the trucks or dedicated assets, but because there are simply not enough truckers to deliver product. Throughout the past 15 years, the trucking industry has struggled with a shortage of truck drivers. The American Trucking Association predicts that the United States trucker shortage will reach 175,000 by 2026 so the capacity to deliver is only going to get worse, as the number of catastrophic billion-dollar disasters continues to rise.

5. Achieving 100% Uptime

Atlas Oil's Emergency Fueling team works with mission critical organizations across the nation to build, fortify and fill gaps within their business continuity planning. It is not easy to maintain 100% uptime when the power grid goes down, but it is possible with the right steps in place.

When consulting with mission critical clients, Atlas recommends the following:

- **Emergency Backup –** Ensure your facilities have fixed / backup generators and understand if your facility is wired to accept a portable generator in the case the alternatives fail, and you need to contract a portable generator.
- **Maintain Your Equipment –** More than 40% of the diesel fuel sampled from generator storage tanks present problems that lead to out of specification fuel. Often, these issues are directly related to poor quality tanks that are rusting or leaking. Perform regular tests, load tests and preventative maintenance for your generators, tanks, and fuel.

- **Audit Your Vendors** – Make sure your critical supply chain vendors are responsive and have proven 24/7 capabilities during disaster scenarios. Find out if they themselves have backup generators for their operations in order to support yours. Ask for case studies, referrals and concrete examples on how they have supported their other mission critical clients. Performing simple performance stress tests or tabletop exercises to see if vendors respond after hours or under the duress of an emergency is a best practice.
- **Fuel Quality** – Poor fuel quality is responsible for 85-90% of all generator failures. When diesel fuel is stored for long periods of time, it can naturally form sediments and accumulate water or other contaminants. Left untreated, these contaminants can cause catastrophic engine failure and other serious mechanical issues. Our team recommends annual fuel testing at a certified, third-party laboratory and regular polishing to ensure the fuel in your tank is up to specifications such as ASTM D975 for diesel fuel.
- **Contractual Guarantees** – Stop buying fuel on the "spot market" and ensure you have a contracted vendor to secure supply when demand spikes. Ensure your supply contract is legally binding and outlines obligations relative to how quickly your supplier will respond, how much fuel they will supply, and what circumstances qualify under contract. A simple Memorandum of Understanding or MOU has traditionally been used by many in the healthcare space for example; however, it is not strong enough in most cases to be successful. Getting specific requirements into a contract that stipulate things such as delivery response time and the number of gallons of fuel for generators to be delivered during an emergency are critical to success.
- **Outside-In Strategy** – When disaster strikes, a local or regional fuel supplier is far more likely to run into issues securing product**.** We recommend partnering with a nationwide supplier with diversified supply points that can quickly source fuel from various outside markets to eliminate single points of failure when local supply becomes constrained. A robust and diverse supply chain is crucial to maintaining uptime.
- **Cloud-Based Technology –** Last but certainly not least, seek out vendors that prioritize innovation and utilize technology throughout their emergency operations. Having a cloud-based solution in place to deploy emergency assets, schedule and track deliveries, and communicate with stakeholders in real-time makes for faster, more accurate service when you need it most.

6. Conclusion

In conclusion, there are many contributing factors causing an increase in power outages that can catastrophically impact an organization. It is extremely important to thoroughly vet your mission critical suppliers, contract fuel instead of buying spot market to avoid supply chain challenges, embrace technology for improved data and logistics, and assume you have a fuel problem until you have proven otherwise. With these action items top of mind during annual business continuity planning, you can achieve 100% uptime, every time.

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