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Eating the Energy Elephant One Byte at A Time

Managing Energy Consumption Across the Cable Network

A Technical Paper prepared for SCTE by

Katie Flynn
Technical Project Manager, Energy Planning & Implementation
Comcast Cable
Philadelphia, PA
267.593.7385
Katie_Flynn2@Comcast.com

Budd Batchelder
Senior Director, Energy
Comcast Cable
Foxboro, MA
617.659.3686
Budd_Batchelder@Comcast.com

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1. Introduction

Cable Operators consume energy in unique ways relative to other industries, making a structured, data-driven approach to energy management a requirement to meet Carbon Neutrality and Network Energy Efficiency goals in an optimized manner. Managing the unique energy footprint of a network can often feel like a massive challenge (like the Desmond Tutu metaphor of eating an elephant) but implementing an energy management system (EMS) that can evolve over time makes controlling network energy possible. The foundation for an energy management program is data. Energy consumption must be measured at actionable levels so that performance can be quantified.

Comcast is implementing a data-driven EMS like never before. In 2022, Comcast set a goal to double network energy efficiency (as measured by electricity per consumed byte) by 2030. To advance on this goal, we have developed a holistic data collection system that quantifies energy consumption at the asset level (i.e., facilities and the outside plant, measured at power supplies). We are empowering our stakeholders to control their energy consumption by providing self-service dashboards to visualize progress and performance.

With the right tools in place to measure and evaluate performance, we now tackle the challenge of eating the energy elephant, one byte at a time. Key influencers of energy consumption are identified and engaged to drive opportunities to execution. Teams can validate and prioritize energy opportunities based on potential impact and available resources. Execution of energy conservation measures is verified. Collectively, these activities are a systematic implementation of the traditional plan, do, check, act continuous improvement cycle. This paper and presentation discuss the evolution of Comcast's energy management program from grassroots, pilot-style ideation to network-wide embedded effort where our team of experts, field personnel, and management collectively make tackling the overall, elephant-sized challenge manageable.

2. Starting an Energy Management System

Starting to develop an EMS can feel overwhelming and there are many aspects to consider. The following steps help to start to define and justify creating an EMS.

2.1. Defining an Energy Management System

When people hear the terms "energy management system" or "energy performance program," images of an online dashboard of internal energy statistics and reports often come to mind. However, a formal EMS is much more than a single analysis or project. The International Organization for Standardization (ISO) 50001 Energy Management Standard states:

> *Development and implementation of an energy management system includes an energy policy, objectives, energy targets, and action plans related to its energy efficiency, energy use, and energy consumption while meeting applicable legal requirements and other requirements. An energy management system enables an organization to set and achieve objectives and energy targets, to take actions as needed to improve its energy performance, and to demonstrate the conformity of its system to the requirements of this document.*

An EMS should include all the above elements and should take a holistic, data-driven, and systematic approach that is aligned with an operator's overall strategy. Every company's EMS will be unique to its own goals, opportunities, and operations that continue to evolve.

2.2. Establishing Need for an Energy Management System

Many companies implement energy efficiency projects without establishing a formal EMS. The need for one should be articulated in the context of efforts to date to make the difference between efficiency projects and an EMS clear. Taking a project-based approach to energy conservation and efficiency may result in energy reductions but will not ensure that investments in efficiency are strategically executed to maximize impacts to reduce energy consumption, expense, and emissions.

An EMS is required to drive a culture of accountability around energy performance and continuous improvement. A data-driven, systematic approach must be taken to focus efforts where the greatest impacts can be made and ensure that results are achieved.

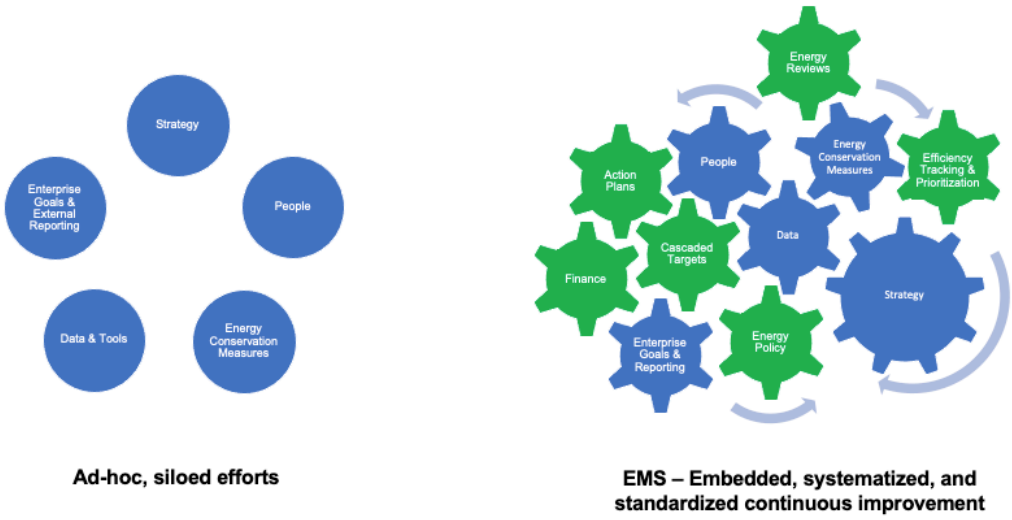

Figure 1 - Visualization of EMS Elements Driving One Another

Comcast set a goal to be carbon neutral in our scope 1 and 2 emissions by 2035. There are many paths to becoming carbon neutral, but those that do not include energy efficiency and performance as part of the strategy will be more expensive and miss opportunities to unlock additional internal value, such as improved reliability.

Communicating the business value of having a formal EMS can be difficult as a program drives, optimizes, and assures return for investments in energy performance and is dependent on the available opportunity and support. To develop a business case for a program, review efforts to date, adoption rates of best operational practices, and potential opportunities. A sense of the financial value of a program can be derived by looking at the opportunity of driving widespread adoption of energy conservation measures (ECMs) and energy efficiency measures (EEMs). Begin by mapping out deliverables for the first few years of a program to get a sense of the need of the program and show what the program will look like.

2.3. Top-down Commitment

Communicating a top-down commitment to treat energy as a controllable consumable by measuring and improving energy performance is an important starting point for an EMS. Energy consumption and expense have been traditionally thought of as overhead. Eliminating this preconceived notion is critical to the success of an EMS.

An internal energy policy documents the top-down commitment to improving energy performance. Many companies have concise policies to commit to continually improving energy performance and strategy. ENERGY STAR has found that successful energy policies:

- Set an objective
- Establish accountability
- Ensure continuous improvement
- Promote goals

A policy must clearly state the objectives of energy management and how it is aligned with the overall organization. Examples of energy management objectives include improving efficiency, embedding consideration for energy impacts in decision-making, and reducing carbon emissions associated with energy consumption. Establishing accountability around energy management is critical as many areas have an impact on overall performance. Clear roles and responsibilities empower teams to drive an energy management program. Committing to continuous improvement is necessary to ensure that energy performance is optimized in operations and considered in long-term strategy. The policy should connect to specific energy, environmental, or overall financial goals of the company to demonstrate how energy management supports other organizational objectives. The policy should be shared with all key stakeholders and made readily available within an organization.

3. Understanding the Elephant

Once the commitment and the preliminary justification of creating an EMS are received, an energy review should be conducted to start to understand the energy footprint.

3.1. Determining How to Measure

Determining the current state of tools and data is a key first step in quantifying energy consumption, expense, and performance. Where data is and is not available should be documented with consideration for the following:

- Types of energy consumed: electricity, natural gas, gasoline, diesel, etc.
- Where energy is used: outside plant, critical facilities, data centers, non-technical facilities, and fleet
- Volume of energy consumed, associated expense, and other variables such as greenhouse gas emissions
- History of available data

A plan should be made to address gaps and estimates starting with the most impactful areas. Ideally, an organization should have a central, single source of truth for tracking energy consumption and expense and should be made readily available to all stakeholders.

Unlike other industries, where energy is primarily consumed in metered buildings, an outside plant is the largest end use of energy for cable operators. Many cable operators have unmetered power supplies in the outside plant which can challenge quantifying and tracking energy consumption. Power supply telemetry can be leveraged where available and is becoming more prevalent and sophisticated. The number of electric accounts associated with the outside plant can also make tracking difficult.

After mapping out the availability of energy data, energy consumption and expense should be calculated for the operator and broken out into significant energy users (SEUs). SEUs can be unique for each cable operator and describe facilities by type, systems, processes, or equipment. An operator's energy footprint is complex and spread out over retail sites, data centers, inside plants, and outside plant. Company

vehicles can also be a significant consumer of energy for an operator. Creating a program that encompasses the entire network may seem daunting. Not every end use of energy needs to be in the scope of an EMS at the start. Focus on the largest energy consumers and areas of opportunity first.

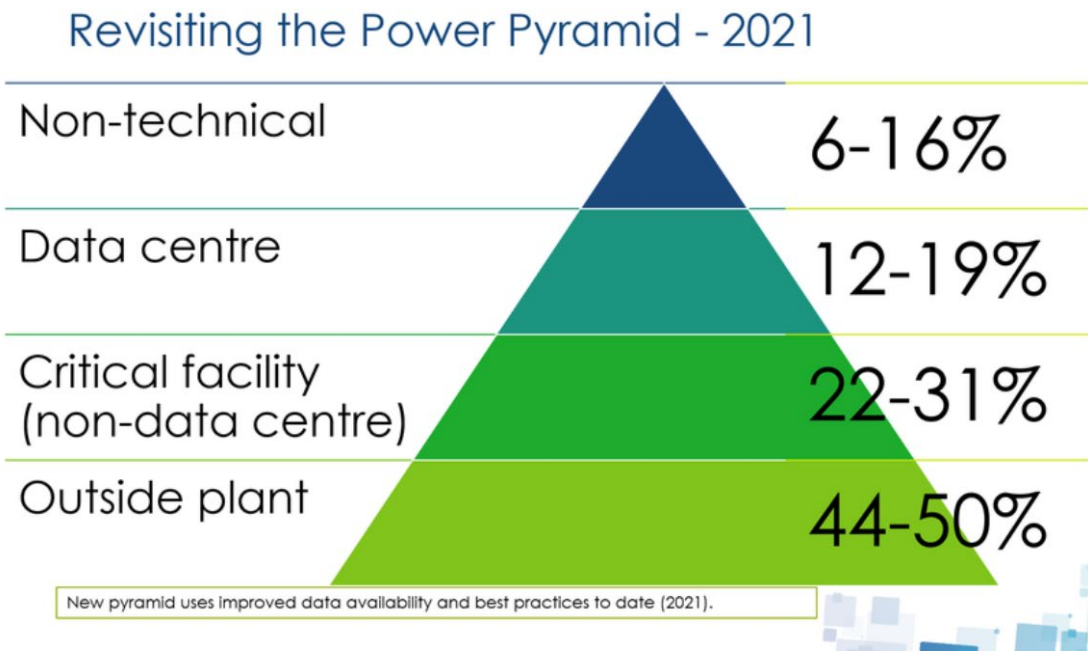

Figure 2 - SCTE Power Pyramid (Source: SCTE)

An operator could choose to review energy consumption by device types, such as cooling systems, power supplies, or IT equipment, or by type of site, such as data centers, headends and hubs, and outside plant. SEUs should align with company structure and how different SEU efforts will be focused. Data should be estimated using documented, repeatable, and logical methodology where data is not available. Expense and consumption data should both be analyzed. Electricity prices can vary by SEU with outside plant electricity rates often higher than critical infrastructure facility rates. Energy rates, especially electricity, can often vary dramatically by geographic location and over time.

Determining where energy is used across the network and how expense varies is key in informing where to prioritize efforts. An informed energy management program focuses efforts on the most impactful areas and can be leveraged to evaluate opportunities more quickly. For example, knowing the range in outside plant electricity rates and how much energy is consumed by power supplies can enable an energy manager to determine the impact of improving the efficiency of power supplies and develop a business case.

Historical data can be leveraged to further inform the energy understanding. Measuring how consumption has increased, decreased, or remained flat over time in different SEUs can provide feedback on the energy impact of different major initiatives.

A model of future network energy consumption should be developed to understand where energy use is expected to grow and shrink. Potential drivers of future energy consumption should be flagged to

prioritize energy opportunities that can reduce future energy consumption and for planning purposes, such as energy procurement.

3.2. Assessing Performance

Once the overall energy landscape is quantified, the next step is understanding energy performance and how well consumption, efficiency, and expense are being managed. Creating a baseline for measuring performance in these key areas enables the tracking of key metrics over time. Assessing performance is not a one-time activity and should be done on an ongoing basis with results being communicated to key stakeholders to validate efforts and reinforce that energy is a controllable consumable.

3.2.1. Baselines & Benchmarking

A baseline year should be created to measure energy performance over time. Reviewing performance over time will show trends and provide high-level feedback on the impact of current strategies on energy consumption.

Energy performance should be benchmarked internally, externally, and over time to inform the energy assessment. Where possible sites and networks should be compared to others internally to understand the range of energy efficiency and opportunities across the network.

Publicly available peer energy and sustainability report data can provide an external comparison and a sense of potential to improve performance.

3.2.2. Energy Efficiency

Measuring energy efficiency allows an operator to measure how effectively the company consumes energy over time in relation to the output of customer services while normalizing for growth. Energy efficiency metrics drive innovative thinking about how a network delivers customer bytes with fewer kilowatt-hours of electricity, which provides better visibility into performance than measuring strictly absolute consumption and expense metrics.

Efficiency can be measured at the site level in addition to the overall network level. ANSI/SCTE 213 2020 *Edge and Core Facilities Energy Metrics* defines Electricity per Consumed Byte (EPCB) for a facility. Additionally, SCTE is currently developing additional enterprise energy-related metrics. Leveraging industry-standard efficiency metrics enables organizations to benchmark their efficiency to peers knowing that metrics are consistently calculated.

By measuring efficiency across all sites with consistent metrics, direct comparisons can be made. Sites with high efficiency could be indicative of following best practices in terms of operations and equipment in place. Sites with high intensity or low efficiency could be indicative of candidates for deploying energy efficiency opportunities.

Relevant efficiency metrics for other areas of consumption, such as retail or office spaces, should also be developed. Consideration must be given to the behaviors that will be driven as a result of the leading metrics chosen. For example, Power Usage Effectiveness (PUE) is the ratio of total facility power to IT power and is often used as a measure of efficiency in data centers. Leveraging PUE may drive focus on reducing energy consumed for cooling rather than an overall energy conservation plan and may drive focus toward cooling system optimization rather than IT equipment decommissioning.

3.2.3. Energy Consumption and Expense

Tracking both consumption and expense separately is important as the price of energy can vary over time and solely tracking consumption or expense may tell an incomplete story. Often energy expense is the main data point reviewed and if fluctuations in price are not taken into account, results of energy management efforts cannot be verified. For example, if an operator upgrades lighting at office buildings to LEDs over the same period that electricity rates increase, electricity expense stays flat post-upgrade and the project may appear to be unsuccessful. However, if the project had not been completed, electricity expense would have increased. This is why both energy variables need to be tracked and progress in each area quantified.

Additional data may be needed to contextualize energy performance over time. Homes passed, number of sites, and ambient temperature are all additional data points that can help to assess energy performance over time. Complimentary metrics and data can be included in energy performance reports, but leading metrics around efficiency, consumption, and expense data should drive overall performance assessments.

4. Tackling the Elephant

Once the size and current state of the elephant are known, plans need to be made for how to start to tackle and manage the energy elephant.

4.1. Setting Goals

Overarching goals for energy management should be created and explicitly shared. Energy goals should be aligned with sustainability or other related goals. Goals should be SMART- (specific, measurable, attainable, realistic, and timebound) and drive the focus of a program. For example, goals related to reducing costs will drive different results than goals focused on reducing absolute consumption.

Comcast set the goal to double our network efficiency by 2030 to ensure that efficiency is a key part of the strategy to progress on its carbon neutral goal and demonstrate that energy efficiency is a priority internally and externally. The mission of the Comcast energy management program is to optimize our processes, systems, and resources to maximize energy efficiency and support our goals to be Carbon Neutral by 2035 and Double Network Efficiency by 2030 in a fiscally responsible manner.

4.2. Identifying Opportunities and Prioritizing Energy Conservation Measures

Opportunities for reducing energy consumption, expense, and associated emissions should be considered on an ongoing basis. The rapid rate of equipment refreshes and innovation in the cable operating space means that new opportunities are always developing. A framework for capturing, comparing, and tracking potential ECMs and EEMs is necessary for prioritizing efforts based on their impact and alignment with other initiatives. ECMs should be tracked throughout their lifecycles. Tracking prioritized measures from ideation through adoption ensures continued progress and may highlight opportunities for automation.

Figure 3 - Energy Conservation Measure Tracking

The first step in evaluating ECMs and EEMs is to document the business cases and measured savings for what has already been implemented. Efficiency projects and studies may have been done prior to establishing an energy program and should not be overlooked. Document the costs, time, and benefits of each project. Identify what worked well, areas for improvement, and lessons learned. Understanding what has worked in the past will help inform future efficiency project deployments and increase the likelihood of success.

Low-cost and low-effort ECMs and EEMs should not be overlooked. Implementing projects that target "low-hanging fruit" first has been the guidance for decades when starting on an energy management journey. All too often these opportunities are taken for granted as having already been implemented. Simple, best practices, such as standard temperature setpoints, timely decommissioning, and airflow management have proven returns and are included in internal standards. However, adherence to these best practices can be overestimated. When evaluating ECMs and EEMs, the adoption of best practices should be quantified where possible, so that "low-hanging fruit" is not overlooked. Additionally, low-cost and low-effort opportunities are a way to embed energy efficiency as a part of the culture around energy management.

Capital opportunities should be reviewed, and the business cases developed to complete the list of opportunities and begin to prioritize and plan. The business cases should be holistic and account for the overall impact on energy consumption, expense, and carbon emissions in addition to the capital and non-energy operation expense impact. Opportunities will have varying impacts across these business case variables which is why holistic business cases must be developed and variables prioritized based on a company's specific energy management objectives.

The ability to implement ECMs and EEMs will also be dependent on other factors including:

- Financial, people, tool, and other resource requirements
- Alignment with other priorities such as reliability, tech-refresh, network expansion, and branding
- Timeline and/or feasibility to deploy

The outcome of this prioritization should be a preliminary roadmap for how energy performance will be improved over time. Opportunities that are not ready for implementation should remain on the list and periodically reevaluated to assess feasibility.

4.3. Executing Efficiency through Empowerment

The number of employees who are dedicated to energy management is small relative to the size of the organization. An energy management program needs to engage with key leaders, managers, site operators, and network technicians to gain traction to implement solutions and improve performance. An elephant cannot be eaten alone and a team approach must be formed.

An energy management program should map out the key influencers across the network to understand who makes decisions that impact the energy efficiency of existing and future networks. Identifying all energy influencers can feel overwhelming, but focusing on SEUs and who has the most influence can help. While key influencer business units will vary and be dependent on an individual company's structure, typical areas that are key influencers of energy performance include:

- Finance
- Engineering
- Operations
- Sustainability
- Design & Construction
- Procurement

When energy influencers have been identified, a framework for engagement needs to be created to ensure that opportunities are evaluated, action plans are created, and performance is reviewed compared to targets. The value of managing energy proactively needs to be communicated. Public commitments around energy and carbon can be leveraged as a proof point of a company's charge to improve energy performance. Internal education and engagement programs are needed to show employees how their work connects and impacts goals.

Figure 4 - Energy Accountability through Collaboration

No one person is entirely responsible for the energy consumption and efficiency of the overall network or an individual site. Many stakeholders make decisions that impact energy performance, from what type of equipment to install, to the setpoint for an air conditioning system. Accountability around energy performance must be shared through educating influencers on how their role impacts energy performance, empowering them to act, and providing feedback on energy performance. Energy consumption forecast

models should be developed and shared with influencers who impact future energy consumption and highlight the energy implications of decisions.

4.4. Setting Energy Targets and Action Plans

Energy action plans must be created to ensure funding, secure required resources, and develop a timeline for implementing prioritized energy opportunities. The plans must be approved by the appropriate leaders and communicated.

Energy targets must be developed to hold people accountable for energy performance. Target development should be informed by the energy consumption forecast model and energy action plans. Annual targets should align with overall energy goals. At Comcast, we are creating site targets that are aligned with our overarching goal to double network efficiency by 2030.

Creating targets at an actionable level is important so that people can be held accountable for performance within their control. Energy targets reinforce the priority of implementing the energy action plan and highlight where energy performance is not as expected. If energy targets are not achieved, the root cause of the energy performance variation should be identified and corrected if possible. Variables such as weather can impact actual performance and some allowances should be made where reasonable and out of the accountable influencer's control.

Energy performance should be measured against targets and regularly communicated to appropriate energy influencers. A monthly review provides an appropriate cadence to evaluate performance and take corrective action if necessary. Depending on the scale and timing around the implementation of ECMs or EEMs, a separate measurement and verification plan may be needed in addition to measuring performance against targets.

5. It Never Ends: Continuous Improvement

Energy management is not a program that is completed in a year. Once the initial elements are stood up, the energy management program follows a plan, do, check, act continuous improvement cycle. Each element of the program is critical to systematize and move the program forward with the result being improved energy performance.

Over time, efficiency should be embedded into the organization to create a culture of responsible energy use. Tools should be leveraged to reduce manual work and intervene as much as possible. The more energy management becomes embedded within an operator's ways of working, the more optimized the network will become over time. The energy management program will not feel like an additional effort, rather it will become the business as usual.

Figure 5 - Evolution of Energy Management Program

As progress is made, new opportunities should be considered to continue to optimize energy performance and challenge the organization to improve. If the network becomes more innovative there will be new opportunities to improve performance.

Abbreviations

ECM	energy conservation measure
EEM	energy efficiency measure
EMS	energy management system
PUE	Power usage effectiveness

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