SCTE® | STANDARDS

Energy Management Subcommittee

SCTE STANDARD

SCTE 218 2021

Alternative Energy & Microgrids for Cable Broadband Providers: Use Cases, Value Proposition, Taxes, Incentives, and Policy Reference Document

NOTICE

Document Types and Tags

Document Type: Operational Practice

Document Tags:

☐ Test or Measurement ☒ Checklist ☒ Facility

☐ Architecture or Framework ☐ Metric ☒ Access Network

☒ Procedure, Process or Method ☐ Cloud ☐ Customer Premises

Document Release History

Release	Date
SCTE 218 2015	*3/2/2015*

Note: Standards that are released multiple times in the same year use: a, b, c, etc. to indicate normative balloted updates and/or r1, r2, r3, etc. to indicate editorial changes to a released document after the year.

Table of Contents

Title **Page Number**

List of Figures

List of Tables

Title **Page Number**

1. Introduction

1.1. Executive Summary

The 2021 revision of SCTE 218 is a major revision of an SCTE operational practice that looked at selective alternate energy opportunities and where to secure resources to help expedite deployment of such technologies. In this revision, the concept of microgrids is examined along with the application evaluation of alternate energy technology.

1.2. Scope

This document provides cable operators with references and resources to evaluate alternative energy and microgrid technology options based on a given geographic location, facility type, and existing or planned infrastructure. It functions as a tutorial and selection tool to aid in describing various alternative energy and microgrid technologies by recognizing which resources would have the greatest impact on reducing energy costs, electrical grid dependency and environmental impact, as well as, improving system reliability, resiliency, and mitigating climate change risks.

Immediate and long-term benefits of utilizing this document include:

- Potential for reducing electricity costs over conventional electric grid; lower transmission and distribution charges
- Potential for reducing carbon fuel consumption and emissions
- Potential for reducing dependency on the utility based electrical grid
- Potential for reducing purchase of high cost per kilowatt hour (kWh) power during peak usage periods
- Time saving in researching alternative energy technologies
- Time saving in identifying additional state and federal alternative energy incentives availability

This document impacts the industry and cable's energy roadmap by potentially reducing the industry's impact on the electrical grid during peak usage periods, enhancing the customer experience by improving reliability by generating power on site with less grid dependence, reducing the environmental impact, and mitigating adverse climate change risks.

Some of the key provisions of this document are:

- Provides background and history of existing electrical grid and the challenges being faced.
- Provides an introduction to alternative energy sources and microgrids and how they can benefit the cable industry
- Outlines decision-making priorities, evaluation strategies, provides rules, regulations and policies for both energy efficiency, alternative energy technologies and microgrid technologies
- Summary road map of Federal & State incentives and policies with links to information

- Includes links to the U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy (EERE), National Renewable Energy Lab (NREL) research and development, and other alternative energy financial modeling tools

This document can be used as a collaboration tool across regions either internally or with other multiple system operators (MSOs) to leverage lessons learned by in house personnel, project managers, and vendors from prior MSO alternative energy and microgrid deployments.

1.3. Benefits

This SCTE document is needed because existing siloed standards do not provide information on or for alternative energy and microgrid definitions, options, recommendations, nor value propositions for the cable industry. If this operational practice is implemented, stakeholders including cable companies can reduce their electricity costs and carbon emissions by having their electrical supply and loads optimized, supplemented, and controlled to allow for generation sources and smart loads to follow the lowest cost and most sustainable forms of supply. Without proper attention and management dedicated cable companies will have less control over the rising cost of procuring electric power. Short-term benefits include the ability to create and distribute a far-reaching independent electrical infrastructure quickly and easily that allows smart devices that implement this operational participate. Benefits accrue in the short and long-term as more smart devices implement this standard resulting in a greater benefit for all stakeholders in the electricity value chain. The potential impact on the cable industry is reducing energy costs while creating new revenue generating opportunities based on managing alternative energy sources, microgrids and the charging and discharging of cable operator electric fleet vehicles and batteries.

1.4. Intended Audience

The audience for this document is diverse. Within cable operators, the audience is electric power engineers, financial planners, and staff that operate and maintain critical infrastructure, purchase electricity, electric vehicles and microgrid components. Within vendors that supply the cable industry, the audience is power systems product management and engineering. Within the electric utility industry, the audience includes product management, load, and generation planners.

1.5. Areas for Further Investigation or to be Added in Future Versions

The alternative energy and microgrid technologies and policies *should* be updated and supplemented (on an annual basis) as new technologies are developed and introduced to the industry and as policies and regulations change. In addition, cable operators could explore the applications of off-grid power configurations.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

No normative references are applicable.

2.2. Standards from Other Organizations

No normative references are applicable.

2.3. Published Materials

No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

[SCTE 184] SCTE 184 2015, SCTE Energy Management Operational Practices for Cable Facilities

[SCTE 226] SCTE 226 2015, Cable Facility Classification Definitions and Requirements

[SCTE 267] SCTE 267:2021, Optimum Load Shaping for Electric Vehicle and Battery Charging

3.2. Standards from Other Organizations

[IEEE 1547] IEEE Std 1547, IEEE Standard for Interconnection, and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

[IEEE 1547.1] IEEE Std 1547.1, IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems

[UL 1741] The UL 1741, Standard for Safety - Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources

[IEC TR] IEC TR 61850-90-7, Communication Networks and Systems for Power Utility Automation—Part 90-7: Object Models for Power Converters in Distributed Energy Resources (DER)

[IEC 61850] IEC 61850-7-420, Communication Networks and Systems for Power Utility Automation—Part 7-420: Basic Communication Structure—Distributed Energy Resources Logical Nodes.

[NASESB] NAESB RMQ.26, Open Field Message Bus (OpenFMB) Model Business Practices.

[IEC 61850] IEC 61850-7-420 Ed. 1.0 b:2009, Communication Networks and Systems for Power Utility Automation - Part 7-420: Basic Communication Structure - Distributed Energy Resources Logical Nodes

[IEEE 2030] IEEE 2030.5-2018, Standard for Smart Energy Profile Application Protocol

[IEEE 1547.3] IEEE Std 1547.3, IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems

[IEEE 1815] IEEE Std 1815, Distributed Network Protocol (DNP3)

[NREL] NREL Technical Report NREL/TP-5D00-63157; (https://www.nrel.gov/docs/fy15osti/63157.pdf); IEEE 1547 and 2030 Standards for Distributed Energy Resources Interconnection and Interoperability with the Electricity Grid

[IEEE 1547] IEEE 1547:2018, California's Utility DER Electric Rule 21 Interconnection

[IEEE 2030] IEEE 2030.2, IEEE Guide for the Interoperability of Energy Storage Systems Integrated with the Electric Power Infrastructure

[IEEE P1547] IEEE P1547.9, Guide to Using IEEE Standard 1547 for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems

[SAE J3072] SAE J3072, Interconnection Requirements for Onboard, Utility-Interactive Inverter Systems

[SAE J2836] SAE J2836/0, Instructions for Using Plug-In Electric Vehicle (PEV) Communications, Interoperability and Security Documents

[SAE J2836-3] SAE J2836/3_201301, Use Cases for Plug-in Vehicle Communication as a Distributed Energy Resource

[SAE J2847-2] SAE J2847/2_201504, Communication Between Plug-In Vehicles and Off-Board DC Chargers

[SAE J2847-3] SAE J2847/3, Communication for Plug-in Vehicles as a Distributed Energy Resource

[SAE J2894] SAE J2894/1/2, Power Quality Test Procedures for Plug-In Electric Vehicle Chargers

[SAE J29531] SAE J29531_201310, PEV-EVSE, Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)

[IEC 63110] IEC 63110-1 ED1, Protocol for Management of Electric Vehicles charging and discharging infrastructures - Part 1: Basic Definitions, Use Cases and architectures

[IEC 62746] IEC 62746-10-1:2018 (OpenADR 2.0), Systems interface between customer energy management system and the power management system - Part 10-1: Open automated demand response

[ASHRAE 135] ANSI/ASHRAE 135, (BACnet), A Data Communication Protocol for Building Automation and Control Networks

[NEMA 201] ANSI/ASHRAE/NEMA Standard 201 (FSGIM), Facility Smart Grid Information Model

[IEC 14908-1] ISO/IEC 14908-1:2012, Information technology — Control network protocol — Part 1: Protocol stack

[IEC 14908-2] ISO/IEC 14908-2:2012, Information technology — Control network protocol — Part 2: Twisted pair communication

[IEC 14908-3] ISO/IEC 14908-3:2012, Information Technology — Control Network Protocol — Part 3: Power Line Channel Specification

[CTA 245] ANSI CTA 245/CEA 2045, Modular Communication Interface

[IEEE 1547.4] IEEE Std 1547.4, Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

[IEEE 2030.7] IEEE 2030.7-2017, Standard for the Specification of Microgrid Controllers

[IEEE 2030.8] IEEE Std 2030.8, Standard for the Testing of Microgrid Controllers

[IEEE P2030] IEEE P2030.9, Recommended Practice for the Planning and Design of the Microgrid

3.3. Published Materials

[SCTE EMS] The Value of Optimum Electric Load Shaping: A Guide for Procurement and Policy Decision Makers, R.F. Cruickshank, L. F. Asperas, Society of Cable Telecom Engineers, Journal of Energy Management, Vol. 5, No, 1, Mar 2020

[GMLC] GMLC Survey of Distributed Energy Resource Interconnection and Interoperability Standards, National Renewable Energy Laboratory et al., Draft December 2019

[NCTA] NCTA Effects of the Pandemic on Bandwidth Demand https://www.ncta.com/whats-new/how-internet-traffic-changed-during-the-pandemic

[NREL] NREL Increasing Resiliency Through Renewable Microgrids, Anderson, Kate https://www.nrel.gov/docs/fy17osti/69034.pdf

[EPA] EPA What is Green Power? https://www.epa.gov/greenpower/what-green-power

[SEPA] A Comprehensive Guide to Electric Vehicle Managed Charging https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified shall never be used.
should	This word or the adjective "*recommended*" means that there may exist valid reasons circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
should not	This phrase means that there may exist valid reasons circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective "*optional*" means that this item is truly optional. One vendor may choose to include the item because a marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
deprecated	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

AC	alternating current
AE	alternative energy
C	Celsius
CCHP	combined cooling, heating and power
CEV	controlled environmental vault
CHP	combined heating and power
CPV	concentrator photovoltaics
CREBs	Clean Renewable Energy Bonds
CREST	cost of renewable energy spreadsheet tool
CSP	concentrated solar power
CUE	concrete universal enclosure
DC	direct current

DSIRE	Database of State Incentives for Renewables & Efficiencies
DSM	demand side management
DX	direct exchange
EERE	U.S. Dept. of Energy Office of Energy Efficiency & Renewable Energy
F	Fahrenheit
Fleet DNA	Fleet DNA Project
FTTP	fiber to the premise
H2A	hydrogen analysis
HE	headend
HVAC	heating, ventilation, and air conditioning
IREC	Interstate Renewable Energy Council
JEDI	Jobs and Economic Development Impact
kW	kilowatt
kWh	kilowatt hour
MSO	multiple system operator
NREL	National Renewable Energy Laboratory
OTN	optical transport node/network
PEM	proton exchange membrane
PV	photovoltaic
PVT	photovoltaic/thermal
QECBs	Qualified Energy Conservation Bonds
REC	renewable energy credit
ROI	return on investment
RPS	renewable portfolio standards
SAM	system advisor model
SMATV	satellite master antenna television
SOFC	solid oxide fuel cells
SWH	solar water heating
TCO	total cost of ownership
UPS	uninterruptable power supply

5.2. Definitions

Term	Definition
alternating current	In alternating current circuits, the flow of electric charge periodically reverses direction, whereas in direct current circuits, the flow of electric charge is only in one direction. The abbreviations AC and DC are often used to mean simply alternating and direct, as when they modify current or voltage. AC is the form in which electric power is delivered to businesses and residences. The usual waveform of an AC power circuit is a sine wave.
alternative energy	Alternative energy is any energy source that is an alternative to utility power or an energy source that does not use fossil fuels. These alternatives are intended to address concerns about such fossil fuels. The nature of what constitutes an alternative energy source has changed considerably over time, as have controversies regarding energy use. Alternative energy sources are renewable and all have lower carbon emissions when compared to conventional energy sources. These include biomass energy, wind energy, solar energy, geothermal energy, hydroelectric energy sources.
Celsius	Celsius, historically known as centigrade, is a scale and unit of measurement for temperature that is used worldwide. It uses a 100-step scale between the freezing temperature (0°) and boiling temperature (100°) of fresh water. Conversion between Fahrenheit and Celsius is calculated using the following formulas: F = 9/5 * C + 32 C = (F-32) * 5/9
combined cooling, heating and power	Also called tri-generation, refers to the simultaneous generation of electricity and useful heating and cooling from the combustion of a fuel.
controlled environmental vault	Underground concrete vault that is environmentally controlled for protecting vital access-electronics from vandalism and environmental damage. The structural design provides complete environmental protection for equipment and technicians. This underground enclosure blends nicely into residential, commercial, and industrial environments where placement of larger telecommunications enclosures may not normally be accepted by municipal and urban design guidelines.
combined heating and power	Also referred to as cogeneration, a thermodynamically efficient use of fuel. In separate production of electricity, some energy must be discarded as waste heat, but in cogeneration this thermal energy is use. CHP captures some or all the by-product for heating, either very close to the plant, or converts it to hot water which can be used for distributed heating.
concentrator photovoltaics	Concentrator photovoltaics uses optical devices such as mirrors or plastic lenses to capture a large area of sunlight that is focused onto the PV solar cell. The primary reason for using concentrators is to be able to use less solar cell collectors and less sq. ft. of area. Concentrator systems increase the power output while reducing the size or number of solar cells needed.

Term	Definition
Clean Renewable Energy Bonds	Clean Renewable Energy Bonds may be used by certain entities -- primarily in the public sector -- to finance renewable energy projects. The list of qualifying technologies is generally the same as that used for the federal renewable energy production tax credit. CREBs may be issued by electric cooperatives, government entities (states, cities, counties, territories, Indian tribal governments or any political subdivision thereof), and by certain lenders. The bondholder receives federal tax credits in lieu of a portion of the traditional bond interest, resulting in a lower effective interest rate for the borrower. The issuer remains responsible for repaying the principal on the bond.
cost of renewable energy spreadsheet tool	An economic cash flow model designed to allow policymakers, regulators, and the renewable energy community to assess project economics, design cost-based incentives (e.g., feed-in tariffs), and evaluate the impact of various state and federal support structures. CREST is a suite of four analytic tools, for solar (photovoltaic and solar thermal), wind, geothermal, and anaerobic digestion technologies.
concentrated solar power	Use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam.
concrete universal enclosure	Concrete enclosures that is a versatile low-cost solution for protecting vital access-electronics from vandalism and environmental damage. The structural design provides complete environmental protection for equipment and technicians. This enclosure blends nicely into residential, commercial, and industrial environments where placement of larger telecommunications enclosures may not normally be accepted by municipal and urban design guidelines.
direct current	Direct current is the unidirectional flow of electric charge. Direct current is produced by sources such as batteries, solar cells, thermocouples, and commutator-type electric machines of the dynamo type. Direct current may flow in a conductor such as a wire, but can also flow through semiconductors, insulators, or even through a vacuum as in electron or ion beams. The electric current flows in a constant direction, distinguishing it from alternating current.
Database of State Incentives for Renewables & Efficiencies	DSIRE is the most comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United States. Established in 1995, DSIRE is operated by the N.C. Clean Energy Technology Center at N.C. State University and is funded by the U.S. Department of Energy.

Term	Definition
demand side management	Also known as energy demand management, is the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education. DSM, which includes energy efficiency and demand response, works from the other side of the equation – instead of adding more generation to the system, it pays energy users to reduce consumption. Utilities pay for demand-side management capacity because it is typically cheaper and easier to procure than traditional generation. DSM allows energy users of all kinds to act as "virtual power plants." By voluntarily lowering their demand for electricity, these businesses and organizations help stabilize the grid, and they are paid for providing this important service. Utilities and grid operators treat demand response capacity as a dispatchable resource that is called upon only when needed.
direct exchange	System in which the refrigerant circulates through copper tubing. The refrigerant exchanges heat directly with air, water, or soil through the walls of the copper tubing. This simplicity allows the system to reach high efficiencies while using a relatively shorter and smaller set of tubing, reducing installation cost. DX systems, like water-source systems, can also be used to heat water in the house for use in radiant heating applications and for domestic hot water, as well as for cooling applications.
U.S. Dept. of Energy Office of Energy Efficiency & Renewable Energy	The Office of Energy Efficiency and Renewable Energy accelerates development and facilitates deployment of energy efficiency and renewable energy technologies and market-based solutions that strengthen U.S. energy security, environmental quality, and economic vitality.
Fahrenheit	Fahrenheit (symbol °F) is a temperature scale based on one proposed in 1724 by the German physicist Daniel Gabriel Fahrenheit (1686–1736), after whom the scale is named. The scale is usually defined by two fixed points: the temperature at which fresh water freezes into ice is defined as 32 degrees, and the boiling point of fresh water is defined to be 212 degrees, a 180-degree separation, as defined at sea level and standard atmospheric pressure. The Fahrenheit scale is not the predominant temperature scale used throughout the world, but has been adopted by the U.S., Bahamas, Belize, and other western hemisphere countries.
Fleet DNA Project	The Fleet DNA Project aims to accelerate the evolution of advanced vehicle development and support the strategic deployment of market-ready technologies that reduce costs, fuel consumption, and emissions. At the heart of the Fleet DNA Project is a clearinghouse of medium and heavy-duty commercial fleet transportation data for optimizing the design of advanced vehicle technologies or for selecting a given technology to invest in. Designed by the U.S. Department of Energy's National Renewable Energy Laboratory in partnership with Oak Ridge National Laboratory, this online tool will help vehicle manufacturers and fleets understand the broad operational range for many of today's commercial vehicle vocations.

Term	Definition
fiber to the premise	Fiber that terminates at any premise either business or home at a network interface unit which is a weatherproof box on the outside wall of a premise. Passive optical networks and point-to-point Ethernet are architectures that deliver triple-play services over FTTP networks directly from an operator's headend. The simplest optical distribution network architecture is direct fiber: each dedicated fiber leaving the headend or distribution point and terminating at one customers location. Such networks can provide excellent bandwidth but are more costly due to the dedicated fiber and dedicated customer fiber termination equipment.
hydrogen analysis	A spreadsheet-based tool that enables a comparative analysis of costs, energy, and environmental tradeoffs of hydrogen production. H2A was first initiated in February 2003 to better leverage the combined talents and capabilities of analysts working on hydrogen systems, and to establish a consistent set of financial parameters and methodology for analyses. The foundation of H2A is to improve the transparency and consistency of the approach to analysis, to improve the understanding of the differences among analyses, and to seek better validation of analysis studies by industry.
headend	Facility at a local cable TV office that originates and communicates cable TV services, cable modem services and telephony to subscribers. In distributing cable television services, the headend includes a satellite dish antenna or terrestrial fiber for receiving incoming programming. This programming is then passed on to the subscriber.
heating, ventilation and air conditioning	The technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. HVAC is important in the design of industrial and office buildings where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors. The three central functions of heating, ventilation, and air-conditioning are interrelated, especially with the need to provide thermal comfort and acceptable indoor air quality within reasonable installation, operation, and maintenance costs. HVAC systems can provide ventilation, reduce air infiltration, and maintain pressure relationships between spaces.
Interstate Renewable Energy Council	Established in 1982, is a non-profit organization that believes clean energy is critical to achieving a sustainable and economically strong future. To pave this clean energy path, IREC works to expand consumer access to clean energy; generates information and objective analysis grounded in best practices and standards; and leads programs to build a quality clean energy workforce, including a unique credentialing program for training programs and instructors. Since 1982, IREC programs and policies have benefitted energy consumers, policymakers, utilities, and the clean energy industry.

Term	Definition
Jobs and Economic Development Impact	The Jobs and Economic Development Impact models are user-friendly tools that estimate the economic impacts of constructing and operating power generation and biofuel plants at the local and state levels. First developed by NREL's WIND Exchange program to model wind energy impacts, JEDI has been expanded to analyze biofuels, coal, concentrating solar power, geothermal, marine, and hydrokinetic power, natural gas, and photovoltaic power plants.
kilowatt	One thousand watts – metric for measuring the electricity flow through a customer meter
kilowatt hour	The number of kilowatts used in one hour. If a customer uses 100 kW an hour for two hours the total kilowatt hours for the two-hour period would be 200 kWh.
multiple system operator	A corporate entity that owns and/or operates more than one cable system.
National Renewable Energy Laboratory	Federal laboratory dedicated to research, development, commercialization, and deployment of renewable energy and energy efficiency technologies.
optical transport node/network	A set of optical network elements connected by optical fiber links, able to provide functionality of transport, multiplexing, switching, management, supervision, and survivability of optical channels carrying client signals
proton exchange membrane	PEM fuel cells work with a polymer electrolyte in the form of a thin, permeable sheet. Efficiency is about 40 to 50 percent, and operating temperature is about 80 °C (about 175 °F). Cell outputs generally range from 50 to 250 kW. The solid, flexible electrolyte will not leak or crack and these cells operate at a low enough temperature to make them suitable for homes and cars.
photovoltaic	Relates to the production of direct current electricity using semiconducting materials exposed to light.
photovoltaic/thermal	Photovoltaic thermal hybrid solar collectors, sometimes known as hybrid PV/T systems or PVT, are dual purpose systems that convert solar radiation into thermal and electrical energy. The hybrid PV/T system provides more energy than a conventional solar PV system. The PV/T system generates electricity via the incorporated PV system.

Term	Definition
Qualified Energy Conservation Bonds	A bond that enables qualified state, tribal, and local government issuers to borrow money at attractive rates to fund energy conservation projects (it is important to note that QECBs are not grants). A QECB is among the lowest-cost public financing tools because the U.S. Department of the Treasury subsidizes the issuer's borrowing costs. QECB proceeds can be used to fund capital expenditures on a variety of projects including reducing energy consumption in publicly owned buildings, implementing green community programs, developing rural capacity, specifically involving the production of electricity from renewable energy resources, supporting energy-related research facilities, research grants and research, implementing mass commuting and related facilities that reduce energy consumption and pollution, designing/running demonstration projects to promote the commercialization of energy-related technologies and processes, and launching public education campaigns to promote energy efficiency.
renewable energy credit	Sometimes referred to as a renewable energy certificate or "green tag" is an environmental commodity that represents the added value, environmental benefits, and cost of renewable energy above conventional methods of producing electricity, namely burning coal and natural gas.
return on investment	Performance measurement used to evaluate the efficiency of an investment or to compare the efficiency of several different investments. In economic terms, it is one way of considering profits in relation to capital invested or how quickly an investment will repay itself.
renewable portfolio standards	A regulation that requires the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal.
system advisor model	Performance and financial model to facilitate decision making in renewable energy.
satellite master antenna television	Supplies and controls a number and types of channels to multiple televisions, not only TV channels, but FM channels as well. Using a master antenna system video signals, audio signals, and decoder signals can be distributed to hotels, motels, dormitories, hospitals and commercial properties with multiple tenants and schools.
solid oxide fuel cells	Solid oxide fuel cells use a hard, ceramic compound of metal oxides as an electrolyte. Efficiency of these types of cells is about 60 percent, and operating temperatures are about 1,000 °C (about 1,800 °F). The high operating temperature limits applications of SOFC units and they tend to be rather large. While solid electrolytes cannot leak, they can crack. SOFC power output is up to 100 kW.

Term	Definition
solar water heating	Solar water heating systems utilize collector panels containing liquid circulating through tubes to capture and retain heat from the sun. The solar thermal heat is trapped and transmitted to a fluid, usually water, in contact with the absorber collects the trapped heat to transfer it to storage. The most basic approach to solar heating of water is to simply put a tank filled with water in the sun. The heat from the sun will heat the tank and the water inside would absorb the heat.
total cost of ownership	Total cost of ownership is a financial estimate intended to help buyers and owners determine the direct and indirect costs of a product or system. It is a management accounting concept that can be used in full cost accounting or even ecological economics where it includes social costs, a comprehensive assessment of information technology (IT) costs or other costs across enterprise boundaries over time. It does not just evaluate the purchase price, but also the expenses incurred through its use, maintenance, repairs, insurance, and other operating costs such as fuel or power.
uninterruptable power supply	An uninterruptible power supply, also uninterruptible power source or system, , is an electrical apparatus that provides emergency power to a load when the input power source, typically utility power, fails. A UPS provides near-instantaneous protection from input power interruptions, by supplying energy stored in batteries, super capacitors, or flywheels. The on-battery runtime of most uninterruptible power sources is relatively short (only a few minutes to a few hours) but enough to start a standby power source or properly shut down the protected equipment. A UPS is typically used to protect hardware such as computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss. UPS units' range in size from units designed to protect a single computer without a video monitor (around 200-volt-ampere rating) to large units powering entire data centers or buildings.

6. The Current Electric Grid and Microgrids

A microgrid is an electrical system that connects multiple sources and loads that is controllable by the user to allow independent operational choices. Currently, some basic alternative energy and microgrid technologies have been deployed throughout the cable industry. However, the industry has not yet taken full advantage of existing available and relevant advanced powering technologies. Most existing power systems are not ready to work like advanced microgrids. That said, cable operators can, and *should*, continue to leverage already deployed technologies and test the new approaches to powering. This operational practice covers the following microgrid concepts: 1) how alternative distributive energy resources (DERs) and microgrid technologies have continued to evolve, 2) the application of current and future microgrid technologies, and 3) benefits of adopting a proactive rather than reactive microgrid implementation strategy.

Today, traditional deployments of energy infrastructure in the cable industry includes direct current (DC) power plants and alternating current (AC) uninterruptable power systems, long term battery energy storage (BES), transfer switches and switchgear. It also includes generator sets, renewables and other power sources that have been combined in a traditional manner to provide resiliency and sustainability when grid power is lost. While these are many of the basic elements of a microgrid, they often lack the topology and controls required for full microgrid implementation and performance. However, existing deployments can provide a foundation for transition into a more resilient and functional microgrid architecture.

The fundamental premise behind the deployment of alternative energy resources with a microgrid architecture by a cable operator is the increasing opportunity to diversify sources of power and therefore enable a more resilient and reliable service offering to customers. This would also allow new capital models and power system topology designs to reduce cost of ownership.

6.1. The Current Electric Grid and Ageing Infrastructure

The U.S. electric grid ("the grid") constitutes a vital component of the nation's critical infrastructure and serves as an essential foundation for the American way of life.

America's economy, national security and even the health and safety of our citizens depend on the reliable delivery of electricity. The U.S. electric grid is an engineering marvel, with more than 9,200 electric generating units having more than 1 million megawatts of generating capacity connected to more than 600,000 miles of transmission lines, according to the U.S. Department of Energy, Office of Electricity.

This "grid" feeds consumers through an intricate network of transmission lines, substations, distribution lines, and transformers, as shown in Figure 1.

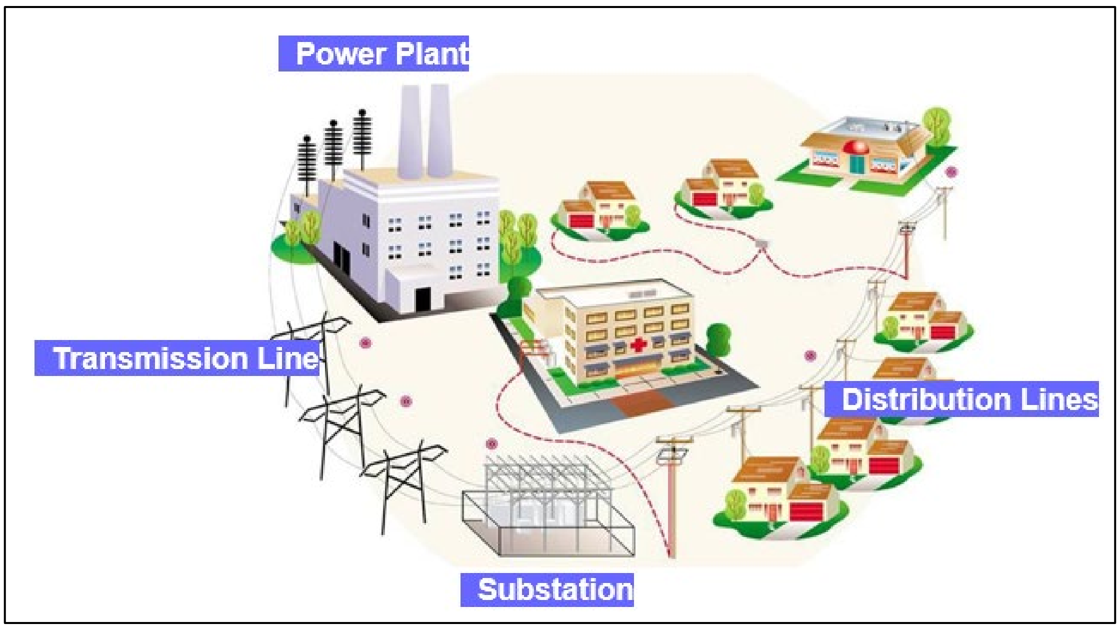


Figure 1 – Simplified Electrical Grid

It is generally understood that the electrical grid is aging. A good assessment is provided by the American Society of Civil Engineer's (ASCE) 2017 Infrastructure Report Card, which described most of the U.S. energy system as predating the turn of the 20^{th} century, with most transmission and distribution lines at full capacity. These systems were constructed in the 1950s and 1960s with a 50-year life expectancy.

Reference: https://www.infrastructurereportcard.org/state-by-state-infrastructure/

As a significant portion of the grid was developed and built half a century ago, it did not include the present-day demand for:

- Higher quality power
- Integration of clean, variable renewable, electric vehicles, and distributed energy technologies
- Remote control and data gathering
- Enabling consumer participation
- Higher security and protection from vandalism, terrorism, and weather

The grid was built to simply deliver power with ease of operation, economically, efficiently, and reliable for the age. The grid connects numerous utilities which are individually focusing on existing system maintenance, replacement and upgrades. In addition, grid operators could be investigating other issues such as aging workforce, regulatory models, and stagnant growth however the prior items typically take priority. Recently, electric utility providers that make up the grid are developing and improving processes and models to manage their assets more efficiently such as:

- New and innovative testing methods, which help to identify and prioritize old equipment that is most in need of repair and/or replacement
- Cable injection and treatment programs
- Breaker refurbishment and upgrade programs
- Wood pole and tower structure testing, treatment, and replacement

6.2. Reliability & Resiliency (eg: Ca. Public Service Power Shutoff (PSPS) Program)

Cable operators are observing compound annual growth rates (CAGR) of 40 – 50% downstream and 20 – 30% upstream driven by streaming video (including 4K content) –(https://www.ncta.com/whats-new/how-internet-traffic-changed-during-the-pandemic). Streaming video caused these growth rates by the newer delay-sensitive gaming applications and a general increase in consumption. Over the next few years, cable operators will be faced with numerous decisions to meet the exponentially growing needs of their customers. This is amplified by work-from-home and home-schooling situations forced by the pandemic beginning in 2020. The upcoming implementations of 10G networks, which promise 10X the bandwidth, assure that there will be an increased need for reliable energy to drive these more powerful devices as they are deployed across the network.

To contend with existing and up-and-coming competitors, cable operators are increasing their dependence on reliable and consistent power to service newer offerings that are being driven by the proliferation of Internet of things (IoT) applications, including in-home security systems, and other “smart devices.” This all increases backhaul requirements and intensifies the demand for resilient and reliable power.

These dynamics are forcing operators to reconsider their investment strategies and the soundness of making longer term capital expenditures to reduce risk, reduce costs, and remain competitive. Microgrids *may* provide a viable strategy, by reducing the dependency on traditional power providers with the possible concurrent benefit of reducing energy-related operating expenses over time.

Fortunately, many cable operators have been quietly engaged in building out what could loosely be considered microgrids. By installing renewables and energy storage systems, operators are adding resiliency and maintaining operations in the event of power failures resulting from disruptions in the power grid. An additional benefit of these hybrid microgrids can be reducing demand charges and possibly reselling power to utilities under power purchase agreements. Other drivers of the trend to increase independence from traditional providers are the increased intensity, regularity, and length of weather disruptions. Issues related to localities objecting to pipeline placement, new power line installations and other regulatory challenges are adding to risks associated with dependency on traditional utility operators. Operators in California have recognized the potential for such grid disruptions and have begun to respond by promoting centers in areas less likely to be impacted. Figure 2 provides a list of electrical infrastructure hazards and associated risks.

Natural Hazards	Human Hazards	Operational Hazards
Ice, snow and extreme cold weather	Physical attacks	Geomagnetic and electromagnetic pulses
Thunderstorms, tornados and hurricane-force winds	Cyber attacks	Aging infrastructure
Storm surge, flooding and increased precipitation	Workforce turnover and loss of institutional knowledge	Capacity Constraints
Increasing temperature and extreme hot weather	Human Error	Dependencies and supply chain interruptions
Earthquakes		Inherent instability from renewable resources
Wildfires		

Adapted from Argonne National Laboratory, 2016

Figure 2 - Growing Risks to the Electrical Infrastructure

Growing energy demand is also a risk to broadband operations. Despite increased efficiency, the US Energy Administration projects that world energy demand will increase by 28% by 2040 as shown in Figure 3. Much of this demand is driven by the increasing digitization of society, data centers, telecommunications systems, and the growth in amount of devices we depend on that continues to require more energy.

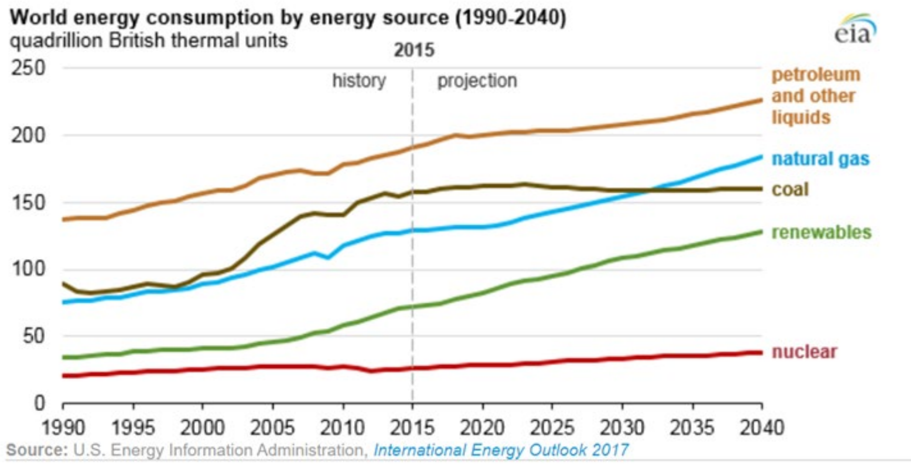


Figure 3 - World Energy Consumption

Also, compounding the problem is the increased intensity and frequency of major storms, fires, and other natural disasters. Outages of more than 24 hours impact every citizen. Food supply, manufacturers, communications networks, and simple changes to every day routine have consequences beyond financial impacts.

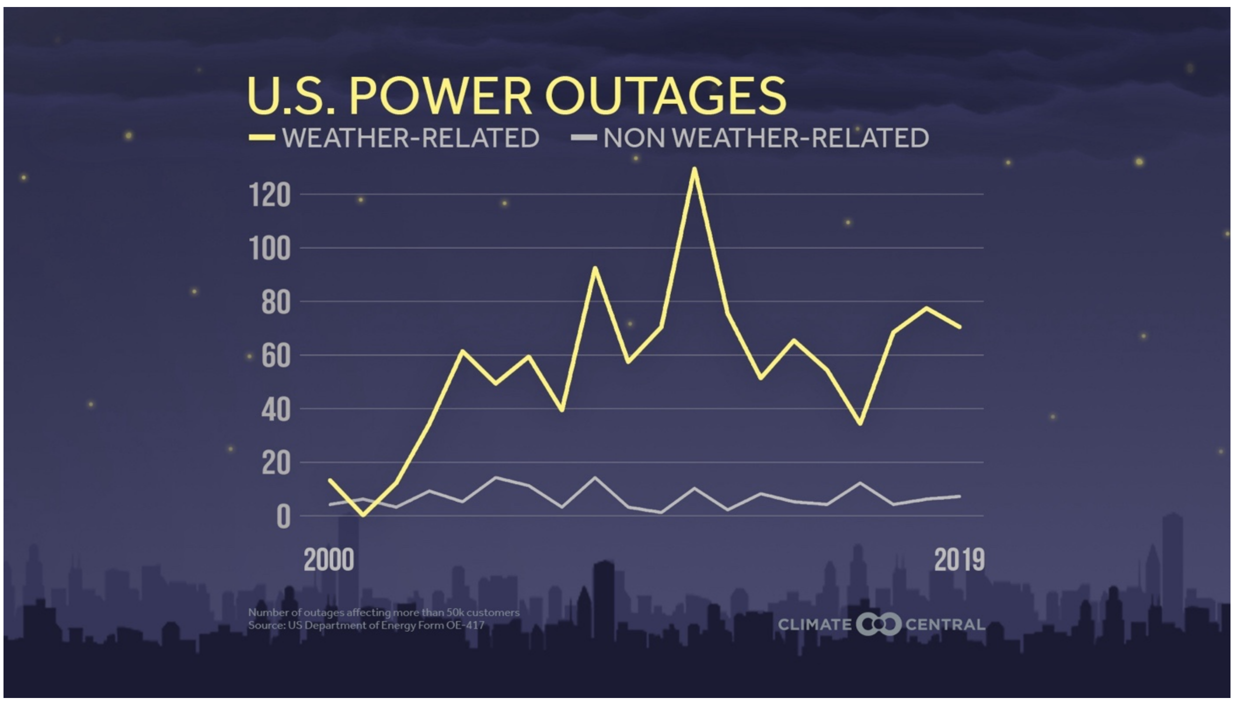


Figure 4 - North American Power Outages

As technology evolves, the demand for quality dependable power is extending beyond the primary cable plant to include the growing demands of peripheral (edge) requirements for power. Utility costs for these edge sites is also increasing along with the risks of losing utility power. Power fundamentals such as native DC vs. AC supply of energy adds to the cost and complexity of supporting cable operations. With recent advances in direct current technologies and deployment capabilities of DC powered networks can increase system efficiency, particularly as the industry integrates native DC powered renewables and energy storage devices into their power networks.

6.3. Growth of Electric Vehicles

In consideration of the information presented above now include the potential impacts of Electric Vehicles (EVs) in the near-term future. A study provided by The Brattle Group, Inc. 2020 provided the following information:

"Electric vehicles (EVs) will be a major disruptor for the US electric power sector, with the number of EVs in the US projected to increase to 10–35 million by 2030. The **new study** released by economists at The Brattle Group concludes that an investment in the range of $75–125 billion will be needed across the electric power sector supply chain by 2030 to serve 20 million EVs, including adding 1–2 million public chargers. While this creates a large opportunity for the electricity industry to increase sales and infrastructure investments, it also comes with new challenges that will need to be addressed."

Several industry drivers such as, declining electric vehicle costs, expanding EV model choices, increasing charging infrastructure, growing market awareness, along with favorable federal and state policies, have created an attractive market for increased EV adoption. The Brattle study shows the following system impacts of the growing EV fleet:

- 20 million EVs will add about 60–95 TWh of annual electricity demand and 10–20 GW of peak load, requiring 12–18 GW of renewable generation capacity and over 1 million public chargers.
- Investments will likely be composed of: $30–50 billion for generation and storage; $15–25 billion for transmission and distribution (T&D) upgrades, and $30–50 billion for EV chargers and customer-side infrastructure.
- Total annual gasoline savings of $12 billion/year translates to an 8.6-year societal payback period for the investment. If the value of avoided greenhouse gas emissions is included at $50/ton, the payback period decreases to 7.2 years.
- The batteries installed in 20 million EVs will have up to 1,600 GWh of electricity storage capacity. They could feed up to 300 GW of power back into the grid to help integrate renewables once large-scale vehicle-to-grid (V2G) operations are viable. This V2G storage capability vastly exceeds the grid's current and projected storage capability."

The cable broadband industry operates large numbers of petroleum based vehicles with the ability to migrate to EV in the coming years. Opportunities for charging stations and leveraging the energy stored in the batteries can impact not only fleet operations but perhaps network operations as well. The pattern of vehicle use will greatly determine how the cable provider can leverage these assists due to deployment schedules and needs. As operators pay greater attention to greenhouse gas emissions, the migration to EVs can provide a strategic means to advancing that agenda.

6.4. Microgrid Defined and the role of alternative energy resources

6.4.1. What is a microgrid?

The SCTE Alternative Energy/Microgrid Standards Working Group (AE/MGWG) developed a definition for microgrids: "Microgrids *may* be defined as a localized group of interconnected and managed electricity sources, storage and loads that can be connected with other local microgrids and/or the traditional electrical utility grid (macro grid) but can seamlessly and selectively disconnect from them and function independently as conditions, policies or economics dictate."

A more simplified definition of a microgrid can be stated as: A microgrid is an electrical system that connects multiple sources and loads that is controllable by the user to allow independent operational choices.

6.4.2. Distributed Energy Resources (DER)

The United States electric grid is comprised of bulk power generation, distribution, transmission, and consuming entities. This infrastructure that enables just about everything in our modern daily lives has remained largely consistent for close to one hundred years. AC power is generated, moved in higher voltage from generation to substations, and voltage is reduced to feed transmission and then ultimately converted into the low voltage AC power typically used at commercial and residential facilities.

With the advent of solar and what we refer to as “alternate energy” sources, the model of bulk power sources begins to be challenged. The traditional grid model is one of stability, predictability, and regulation to uphold high expectations of availability. To satisfy these expectations of high availability the current system is made up of large central base-load fossil fueled power generation plants and supplemented by addition fossil fueled based peaker plants. The fossil fueled based peaker plants are utilized when the demand increases beyond base load capabilities or when base load systems are unavailable. When we plug something into an electrical outlet here in North America, there is no second-guessing power availability. Distributed energy resources can become a viable model to anyone wishing to pursue alternatives to the traditional power grid.

The new challenge of incorporating solar photovoltaic (PV) systems, wind resources and, storage (ie. batteries) raises electrical engineering questions as well as financial market questions. DERs can be defined as: “Distributed energy resources are small, modular, energy generation and storage technologies that provide electric capacity or energy where you need it. DER systems *may* be either connected to the local electric power grid or isolated from the grid in stand-alone applications. DER technologies include wind turbines, solar/photovoltaics (PV), fuel cells, microturbines, reciprocating engines, combustion turbines, cogeneration, and energy storage systems.”[2] Cable operators are in a very good position to evaluate and deploy DERs due to hybrid fiber coax (HFC) communication network architectures, which in itself is a next generation transition to a digital/optical network. The need for remote monitoring and control adds a layer of value to a DER and therefore the cable provider infrastructure, critical facilities, people, space, and even outside plant can be considered for distributed energy adaptation.

There are several use cases that can promote the deployment of a DER for-cable operators. These primary cases include becoming less utility grid dependent and enhancing availability of power. In locations where peak demand charges become very high during seasonal changes (high air-conditioning or heating needs), a local DER such as a grid-tied solar plant can help reduce excess charges. The solar plant can be coupled with energy storage and can match the forecasted spikes in utility grid demands that associate with a higher billing to the cable operator.

In 2019, California power providers began to institute public safety power shutdown (PSPS) events. Weather conditions supporting high fire risks have required grid providers to turn off supply to lower risks of fire. Communication providers need to become less dependent on the grid to ensure service availability. DERs can help address that need. This approach is related to the use case of extending runtime of backup power. NREL conducted a backup power study for cable operators and that report can be found (https://www.nrel.gov/docs/fy17osti/69034.pdf).

Distributed energy resources can play an important role in cable’s infrastructure. Determining the strategic adoption can be done following a few steps. First, identify the electrical requirement and/or problem. Are the bills too high? Is power availability becoming unacceptable? Are there renewable energy requirements needed for positive marketing? Does run-time in the absence of grid or traditional generator backup need to be extended? After the applicable question/s is/are identified and answered, the technology can be identified to address the problem. Solar has been a reliable go-to; however, each situation will dictate what power generation source would fit best. Second, approach the local utility provider to discuss incentives. If the local power provider has a mandate to lower loads or incorporate renewable power sources, there *may* be financial awards to help offset DER deployment costs. Third, build out the project plan to commissioning. As with any change of day-to-day operations, a DER implementation requires a solid project plan to ensure successful incorporation into existing network topologies. Finally, document post commission needs, such as maintenance, system milestones and support providers. Cable operator infrastructure requires working with a multi-vendor ecosystem and the DER turn-up can introduce new providers of power service if the existing pool of resources do not specialize in essential power source management. This relationship will be especially important as a DER investment can extend beyond 20 years.

6.4.3. Alternative verses Renewable Energy Resources

The differences between "alternative energy," "renewable energy," and "clean energy," might not be obvious. Each term is unique and has its own individual definition.

6.4.4. Alternative Energy

Alternative energy refers to sources of usable energy that can replace conventional energy sources (usually, without undesirable side effects). The term "alternative energy" is typically used to refer to sources of energy other than electric grid power from nuclear energy or fossil fuels.

Throughout the course of history, "alternative energy" has referred to different things. There was a time when nuclear energy was considered an alternative to conventional energy and was thus called "alternative energy." The term is ever evolving.

Today, a form of "alternative energy" might also be renewable energy, or clean energy, or both. The terms are often interchangeable, but not the same.

6.4.5. Renewable Energy

Renewable energy includes resources that rely on fuel sources that restore themselves over short periods of time and do not diminish. Such fuel sources include the sun, wind, moving water, organic plant and waste material (eligible biomass), and the earth's heat (geothermal). Although the impacts are small, some renewable energy technologies can have an impact on the environment. For example, large hydroelectric resources can have environmental trade-offs on such issues as fisheries and land use. (Source EPA)

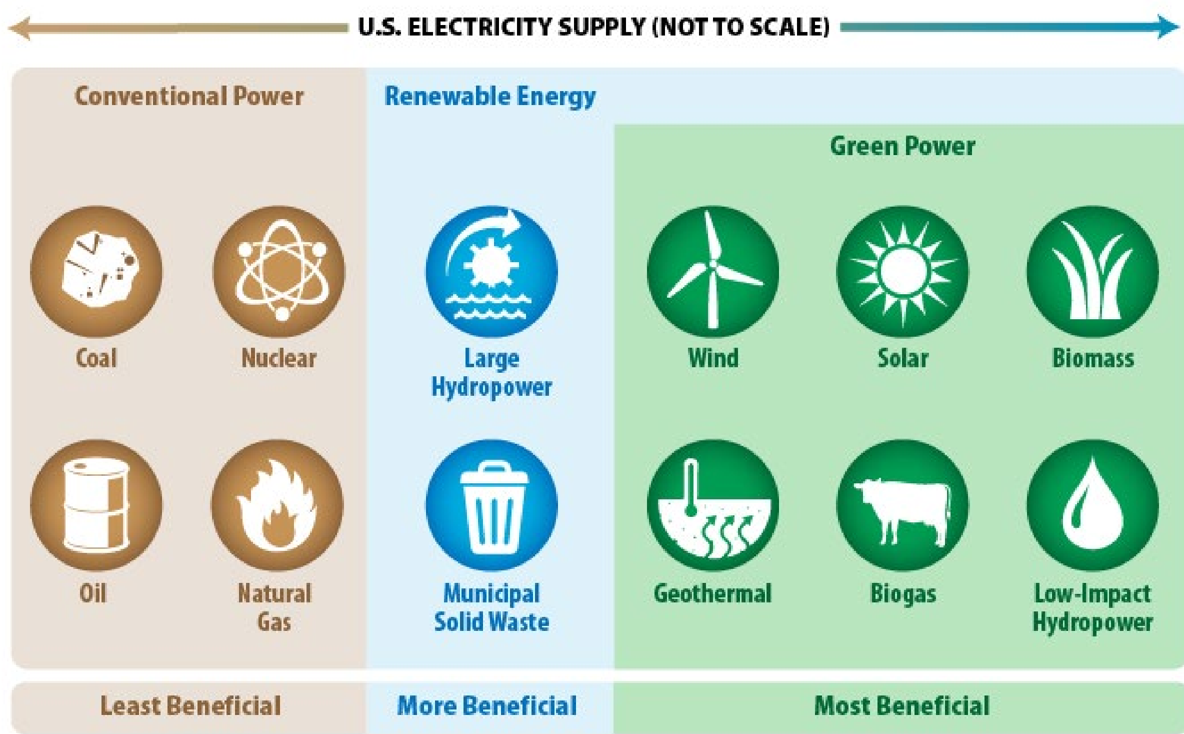
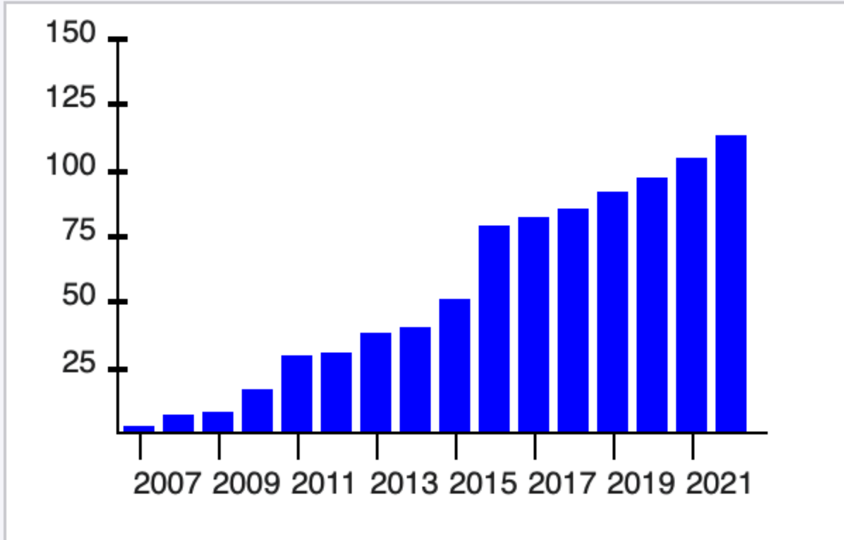


Figure 5 - Power Generation Types (SOURCE: EPA)

People have begun to turn to this type of energy due to the rising oil prices, and the prospect that one day sources of fossil fuels *may* be depleted. Also, concerns about the adverse effects that our conventional energy sources have on the overall environment have played a big role in the advancement and adoption of renewable energy sources.

Among the different types of renewable energy, wind and solar/PV power are ones which continue to grow in use. The number of users who have some form of wind power installed has increased, with the current worldwide capacity being about 100 GW. In addition, the traditional power grid has leveraged commercial wind farms to diversify power sources in environmental correct locations such as the mid-west and parts of Texas. Similar growth has, and continues, for solar/PV capacity per Figure 6.



Historical and projected global demand for solar PV (new installations, GW).
Source: GTM Research, Q2 2017[44]

Figure 6 – Historical and Projected Global Demand for Solar PV

6.4.6. Clean Energy (Green Power)

Clean Energy / Green power is a subset of renewable energy and represents those renewable energy resources and technologies that provide the highest environmental benefit. The U.S. voluntary market defines green power as electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources (https://www.epa.gov/greenpower/what-green-power). Customers often buy green power for its zero emissions profile and carbon footprint reduction benefits.

Clean energy has the smallest environment impact than our current conventional energy sources. It creates an insignificant amount of carbon dioxide, and its use can reduce the speed of global warming – or global pollution (https://www.epa.gov/greenpower/what-green-power).

6.4.7. Bringing Alternative Energy Resources Together = Microgrid.

Typical cable industry critical infrastructures (CIs) are constructed with power systems that contain emergency back-up systems, such as fossil fueled generators and lead acid battery-based DC power plants, to ensure system reliability during utility power outage events. A typical system configuration example is shown below in Figure 7.

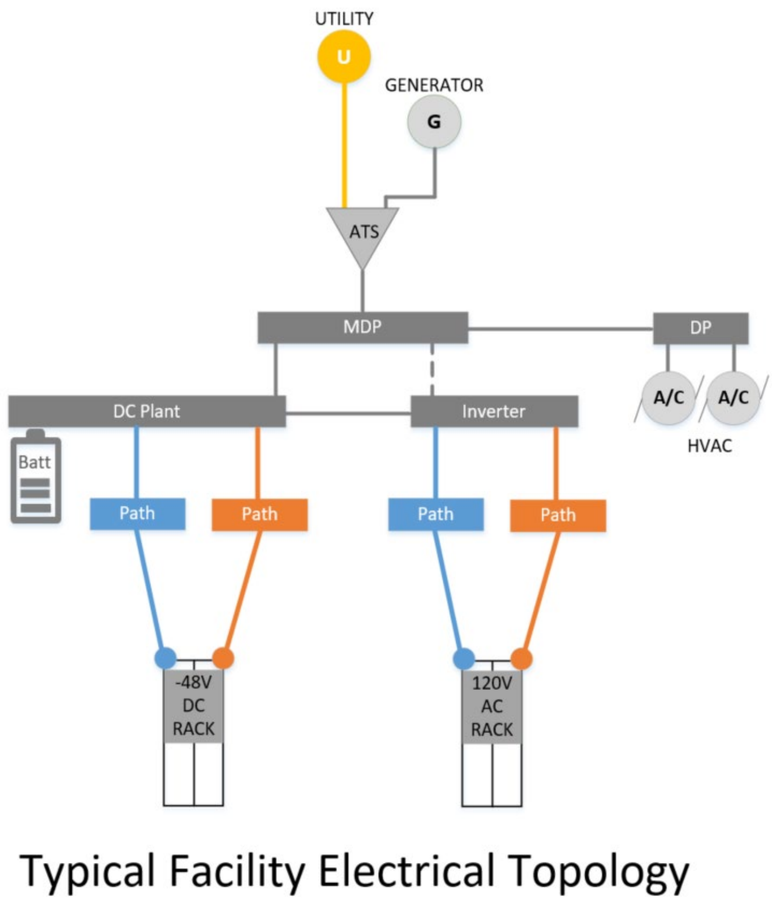


Figure 7 - Typical System Configuration

The current state of this infrastructure is configured with specific technologies characterized by the functions and related adjacent operational functions as described in Table 1.

Table 1 - Infrastructure Operational Functions

Business Function	Technology	Technology Function	Operational Considerations
Primary/Secondary Power Source	Utility Service and Generator	To power the critical load	• Site is dependent upon reliable utility service • Site operates on either utility OR generator • A brief outage is required for generator start-up • Most generators are fossil fuel based • Many sites with dual generators
Source Transfer	Automatic Transfer Switch (ATS)	Monitor utility power and controls transfer of power source	• No parallel operation • No closed transition transfers
Power Distribution	-48v DC/battery plant Dual bulk feeds to critical loads	Service continuity during transition from utility to generator	• High initial investment with stranded capacity costs • Assorted power distribution configurations • System changes and adds are costly with specialized labor and material which can influence time • Power density varies widely but initial build investment needs to anticipate worse case loads • Inverters can allow for elimination of UPS
	Inverter	Critical AC loads through inverter (eliminating UPSs in process)	
Stable Operating Environment	HVAC		• Backed up by generator for power during commercial power outages

Bringing a variety of power sources together to feed and support a load or multiple loads is a microgrid. The cable industry, to some extent, has a head start in the progression path to microgrids. Some examples of microgrid topologies are shown on the following page.

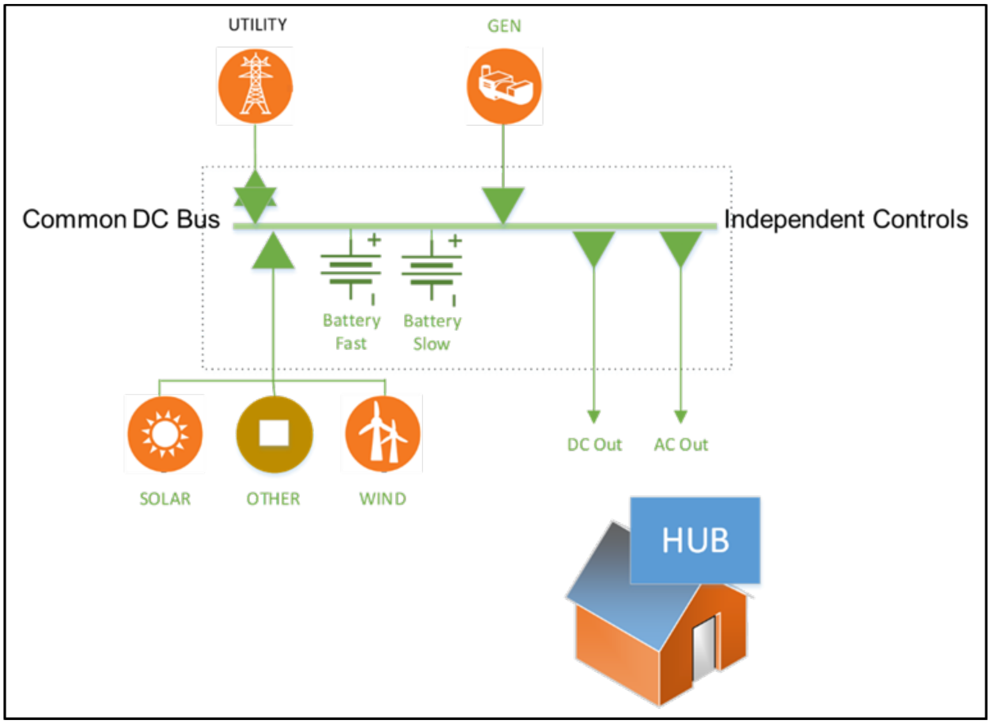


Figure 8 - Microgrid Topology (1)

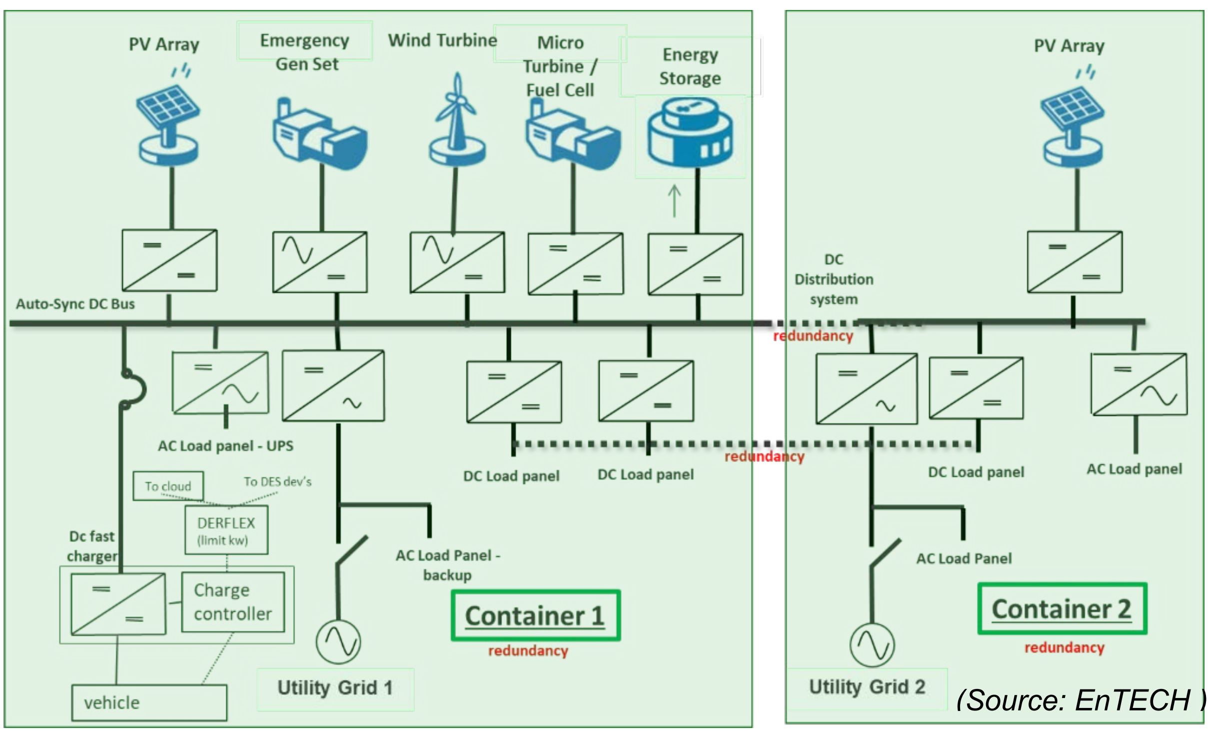


Figure 9 - Microgrid Topology (2)

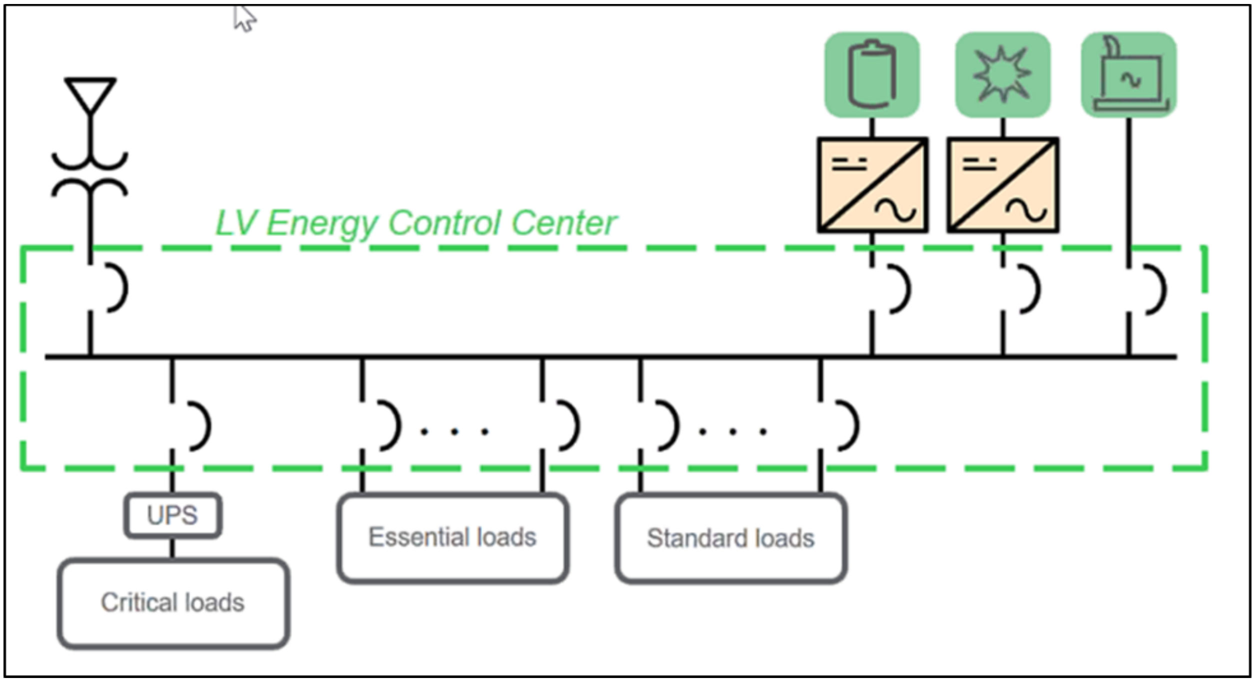


Figure 10 - Microgrid Topology (3)

The preceding configurations use a DC power collector bus topology. An example of an AC power configured microgrid is shown in Figure 8 (Source: Schneider Electric).

7. Microgrids and Uses

Alternative energy use has been increasing in the U.S. and has been largely driven by goals to reduce environmental impact and mitigate climate change risks. Other drivers of this trend include regulatory requirements such as federal air pollution emissions regulations, meeting state requirements to use more renewable sources, and availability and use of federal and state financial incentives for renewable fuels. SCTE has also promoted the prioritization of power management in a strategic manner through standardization, information sharing, and adoption of operational impactful practices.

Businesses are actively implementing alternative energy and microgrid technologies but are faced with numerous challenges. Some major challenges are:

- access to cost-effective solutions especially in comparison to traditional energy rates
- choice in alternate energy solutions
- access to long-term stably priced solutions
- increased access to third-party financing vehicles and standardized and simplified processes
- contracts and financing for renewable energy projects

The growing interest in alternative energy has resulted in a myriad of resources being made available to the public. The following sections provide an overview of some of the most comprehensive resources to assist MSOs in their research, development, and decision-making processes for the implementation of alternative energy and microgrid technologies.

7.1. What's In It for the Cable Industry/Cable Operators?

The DOE and other government agencies have been spearheading the definition of microgrids while documenting their value. Now, with the active involvement of two predominant industry organizations - NREL (National Renewable Energy Laboratory) and SCTE, the ANSI accredited standards organization for the broadband industry- this *should* send a clear message that it is time for the cable industry to grab the lead and create microgrid standards and use cases specifically designed for cable operators.

As introduced earlier in the paper, microgrids are very important to the cable industry for several reasons:

1) They provide additional resiliency and reliability in times of unplanned power outages. During severe weather microgrids can provide the ability to continue providing power to critical facilities.
2) With competitively priced self-generation from renewable and other energy sources, microgrids can provide a hedge to increasing costs of energy for cable operations.
3) Coincident with time-of-use electricity pricing, microgrids can allow cable operators to buy low and sell high for their operational energy needs, as well as the energy needs of their customers.
4) Microgrids provide operational independence from local utilities allowing control and usage of dispatchable power sources independent of local utility performance.

Operational cost containment is an important practice for cable operators, and power is no exception. The idea of purchasing energy at low rates and selling high over a 24-hour period will become increasingly important. Time-of-use rates become pervasive to effectively manage the supply and demand balance of the grid in the presence of increasing renewable energy resources. This is evidenced by the increasing number of cities, states and countries that have made 100% renewable generation commitments, most notably, the states of California, Hawaii and several others by 2045.

While these economic drivers are valid, other areas of the country with lower electrical costs are justifying microgrids by combining other value propositions with time-of-use gains. Such benefits include added resiliency, demand shaving, and the utilization and control benefits of higher voltage direct current in a DC-Coupled microgrid.

Basic microgrid technologies are currently deployed within the cable industry, but they are not positioned to best leverage traditional microgrid techniques. The opportunity exists for the industry to take stock of what is changing in their networks, followed by an exploration of how the industry *should* or can leverage new technologies (including power). As the industry strives to enhance the customer experience, there needs to be a conscious review of how energy use has evolved. As new cable technologies are deployed in the access networks, infrastructure costs to accommodate these changes could end up being fiscally prohibitive in meeting business goals without proper consideration of modular microgrid technology deployments.

The regionalized nature of the cable industry is conducive to microgrid developments. The cable industry could develop microgrids and sell power to/within itself as well as sell power to outside partners. The steadily improving return on investment (ROI) related to microgrid and alternative energy technologies, coupled with regionalized opportunities that exist for the cable industry/cable operators, make a valid argument that there are tangible benefits for microgrid development.

8. Microgrid and alternate energy use cases and drivers for the Cable Industry

8.1. Edge Facilities and Outside Plant

It is well documented by SCTE, and as depicted in Figure 11, that the majority of the cable industry's critical infrastructure power footprint is housed within edge facilities and outside plant.

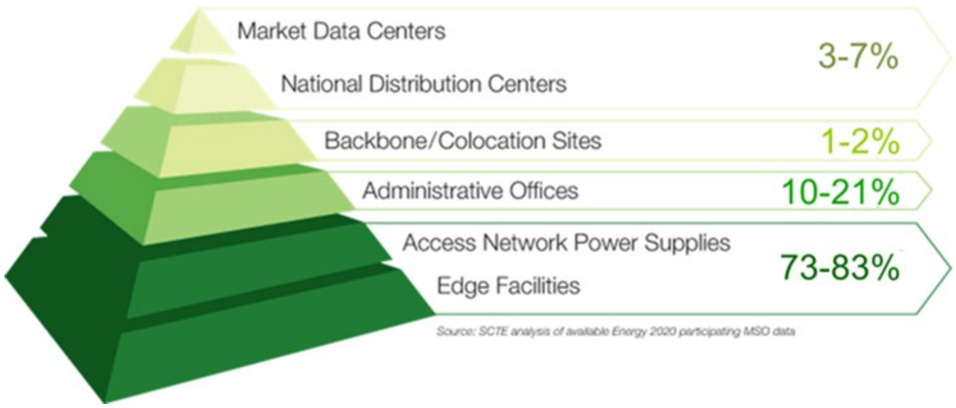


Figure 11 - Critical Infrastructure Facilities

Outside Plant Infrastructure: Unique to cable and telecom providers is the outside plant and especially the hundreds of thousands of power supplies enabling the hybrid fiber coax network (HFC). Typically, power is provided to the center conductor of the HFC plant via a local power supply. The power supply receives power from the utility provider typically on the very same pole the cable infrastructure resides. What kind of creative approach could be taken to address the diverse nature of outside plant powering? Self-generation of power in strategic places could be an opportunity for investigation. New innovative power supplies and infrastructure are being investigated and new standards are in process to allow this innovation. New energy storage technologies will also play an important role.

Edge Facility Infrastructure: According to [SCTE 226] Class B-D facilities are smaller in nature, support, and design criteria than the larger Class A data center type facilities. This does not mean that the importance of these infrastructure rich points of presence are small. Evaluation of microgrid deployment options are not easy to determine. Careful examination of each facility *should* be conducted, and a reusable model built to evaluate the benefit and application of microgrid options at the smaller facilities. The model needs to consider multiple data points such as downtime, cost of power, number of subscribers, and types of subscribers (commercial vs. residential). Network architecture dependencies are important factors when determining microgrid investment. All new infrastructure power solutions must be modular and scalable.

8.2. Electric Vehicles (EVs) and Microgrids

The cable industry maintains a fleet of nearly a quarter million vehicles worldwide. In recent years, the industry often encourages technicians to overnight company vehicles at their homes. Continuing to do so will create unique financial opportunities to leverage the industry's broadband infrastructure to manage the charging of cable's future fleet of EVs—and perhaps even private vehicles—across small and large geographic areas (https://sepapower.org/resource/a-comprehensive-guide-to-electric-vehicle-managed-charging/).

EVs and hybrid EVs will play an increasingly important role in cable operations. Due to technological advances and continuing declines in battery costs, personal EVs provide fuel savings of nearly $1,000 per year and EVs overall are cheaper than equivalent combustion-engine models for many applications. Deployment of EVs are increasing every year and *should* be part of microgrid applications and growth. This will help fill the need for increased power reliability and resiliency.

Global decarbonization is driving the further electrification of our world and this will result in increased electricity consumption of 38% by 2050[6]. Electricity is rising in popularity as it is easier to transport, deliver, store, and use. Society's growing dependence on electric power is resulting in an exponential rise in consumption in applications such as data centers and EVs. In and of themselves, EVs are likely to create 20%-30% additional load on the electric grid[6], helping to make the case for the optimization of charging strategies. As such, time-of-use pricing of electricity is legislated in several states and, along with variable pricing is expected to be pervasive.[7] The departure from fixed electricity rates raises crucial financial questions of 1) when to charge EVs based on varying electricity cost, and 2) how to enable the cable industry to specify methods that monetize the value stack created by managed fleet vehicle charging. As mentioned earlier, cost management of operations for cable operators is important to the business.

8.3. Monetizing Optimum Load Shaping (OLS) and other EV-Based Grid Support Services

Several technologies and market trends are at play that can both negatively and positively affect the cable industry in terms of energy cost. With the increased deployment of EVs, the production, distribution, and use of electricity is rapidly evolving for the charging infrastructure that will be needed, creating critical functionality gaps in managing the grid. EV charging is already stressing grid capacity and affecting the cost of electric power. Yet, when networked and managed in a coordinated fashion, batteries and EVs are proving their ability to provide grid support services such as load shaping, peak reduction, and active power quality management via reactive power and frequency support. Together, grid support services from EVs can create a value stack consisting of reductions in operational costs, maintenance, and new construction of power plants, transmission, and distribution facilities. If cable operators can reap the rewards of selling power via a microgrid and leverage the collective energy storage across a massively large EV fleet, the benefits could be substantial. Communications and controls will play an important role in such a scenario.

Since 1882, the grid has operated such that supply from power generators anticipates and follows the demand for electricity. In recent years, the continuing decline in the levelized cost of energy from wind and solar power, in much of the world, construction and operation of new renewable energy sources are less costly than the ongoing operation of existing fossil-fueled power plants. Yet, the demand for electricity is often not coincident in time with the supply from renewables, which themselves are variable and not dispatchable (i.e., not controllable). Widespread, pervasive coordination of demand will become more and more valuable in orchestrating electric loads, such as EV charging, to follow the least costly forms of fossil-based and renewable supply.

A growing body of research as found in a “Survey of Distributed Energy Resource Interconnection and Interoperability Standards”, from several U.S. Department of Energy National Laboratories and throughout the industry indicates that load shaping will be increasingly important in reducing the cost of operations in the grid, microgrids, and nano grids. What is missing are methods to optimally shape load based on the holistic consideration of generation, distribution, and storage. Optimum load shaping (OLS) is a newly developed software-based open protocol based technology to minimize power generation costs and carbon dioxide emissions that informs electrically powered devices of the forecast times of the lowest cost and cleanest supply. OLS uses an end-to-end generation-to-load algorithm that jointly optimizes supply (part 1) and demand (part 2). The SCTE Energy Management Subcommittee, Alternative Energy/Microgrid Working Group created a standard for OLS [SCTE 267]. This standard defines in simplistic terms how to create, transmit, and act upon a forecast optimum load shape (OLS) that *may* be used to manage the charging of electric vehicles (EVs) and facility batteries, or otherwise used to manage electrical load. This OLS standard provides for end-to-end, generation to load control of the electric power grid towards the goals of reducing energy costs, maximizing the use of renewable energy, and accelerating the adoption, monetization, resiliency, and societal benefits of microgrids, EVs, and batteries.

Forecast optimum load shapes (OLSs) can help monetize the cable industry's future fleet of electric vehicles and facility batteries to provide the critically needed end-to-end, generation-to-load control of the electric power grid. OLS provides grid control and consists of a set of numbers (e.g. target load for hours 1-24) that forecasts the most efficient electrical supply in grids, microgrids, and nano grids, so that all stakeholders **-** generation entities, utilities, distributors, retailers, and consumers—can reduce their electricity costs and carbon emissions.

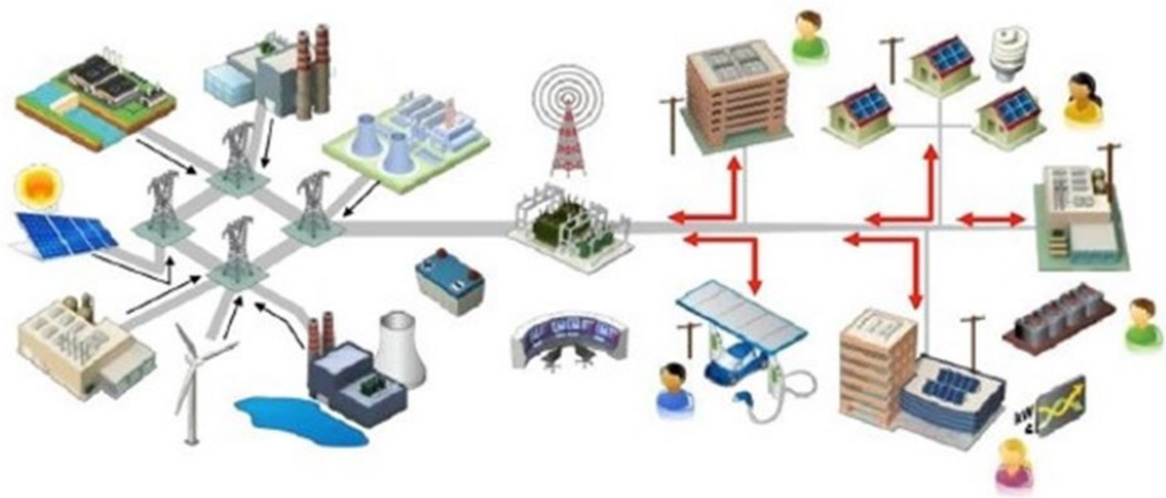
9. The Developing Microgrid Technologies and Industry Trends

As microgrids are developed in greater and greater numbers, microgrid interconnections will also increase. Interconnections will occur directly between adjacent microgrids, but in most cases will be interconnected through the existing electric utility infrastructure. Microgrids and the interconnection of microgrids require new ways to track energy use, power generation by distributed energy resources, and load control. In a way that new types of transactions between microgrid owners and operators are being developed. These new transactions and ongoing engineering developments are what make up the new "Transactive Energy" evolutions as described below.

9.1. New term: "Transactive Energy"

The increased use of renewable energy and distributed energy management technologies offers the potential for significant efficiency improvements through market-based transactive exchanges between energy producers and energy consumers.

To enable these sorts of exchanges, however, the modernized grid will require new economic tools and processes. "Transactive energy" is the broad term used to describe this new approach and can be defined as *"a system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter."*



Source: EPRI

Figure 12 - Modernized Electrical Grid

9.2. Transactive Energy's Potential Benefits to Consumers

The following list outlines the benefits of moving to a more transactive-based energy model:

- Better utilization of grid assets: Everything from transformers and switches, to vehicle-charging stations and smart meters, can lower costs when optimized, especially during peak demand conditions.
- Greater resilience and reliability: During large storms, a reduced length and frequency of outages
- Greater control over personal energy use: Empowerment of choice and information provided to consumers
- Increased use of renewable energy resources: Gives individual consumers the satisfaction of contributing to larger societal environmental sustainability goals

The growth of a cable operator's business intelligence that is required for this evolution, including the development of artificial intelligence (AI), will evolve into a big data management platform. This platform could make for a new business opportunity for cable operators as well as provide market participation opportunities in various regions of the country.

9.3. The Natural Progression Towards Independent Energy Sourcing and Control

Originally driven by economics (cost savings) and social responsibility (energy management), the first step is the installation and application of renewable energy technologies and systems. The next steps are the progression paths to the future with a corporate version of self-actualization (maximizing potential) by participating in the energy market as both a supplier and consumer, with the ability to self-determine the most appropriate energy source based upon real-time availability and needs. Figure 13 describes the steps in the progression path to the Transactive Energy future

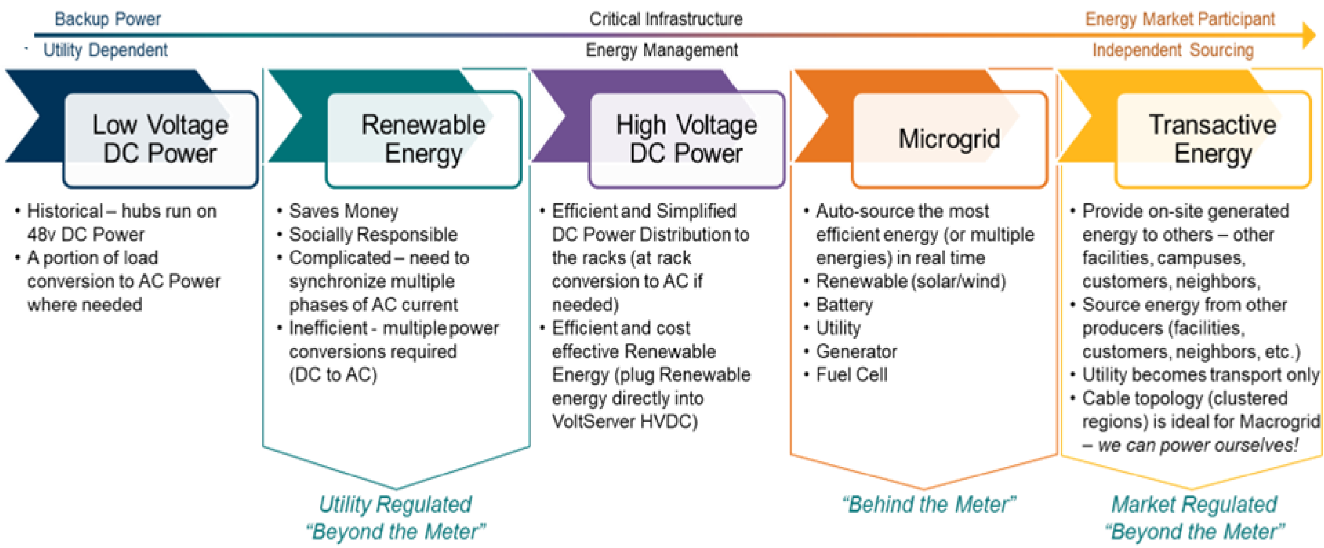


Figure 13 - Steps to Transactive Energy Market and Critical Infrastructure Resiliency

10. Decision-Making for Alternative Energy and Microgrid Solutions

Resources providing information on multiple alternative energy (choice in technology), financial models and incentives (cost and financing options) and provide location-specific information across the country are included in section 10. It is important to note that this is not an exhaustive list as there are additional resources available. The resources referred to in this document appear to have been regularly updated and hence current and relevant however it is very important to verify that a resource is still available early in your research process.

Table 1 summarizes the types of alternate energy technologies suitable for the typical facility classes across the footprint of the MSO network and plant.

10.1. Proposed Decision-Making Process for Alternative Energy and Microgrid Solutions

1. Determine interest in alternative energy and microgrid (AE/MG) technologies and the motivation for pursuing AE/MG technologies (reducing dependency on grid; corporate sustainability & social responsibility; trial, financial, operational and/or, strategic).

2. Select location

   a. Resource maps are available to guide selection based on productivity and potential system performance. However, availability of incentive programs is a primarily driver of site selection.

3. Research available incentives/rebate programs

   a. Research structure of program.

i. Is registration required prior to design and implementation?

ii. Do you have to use certified/approved contractors?

4. Determine costs for multiple technologies (financial modelling).

5. Determine budgetary allocation and economic performance criteria (e.g. ROI, TCO (Total Cost of Ownership), etc.)

6. Design system (before or after contracting vendor)

   a. System integration model (Digital Twin) development and operational scenario simulations as part of design

   b. System monitoring and control

7. Determine permitting and zoning requirements

8. Adjust financial model

9. Install and commission system

10. Reduce grid dependency, reduce environmental footprint, save/avoid costs

11. Monitor and track progress, measurement, and verification

12. Reporting and disclosure. Share information to foster industry-wide change.

Note: You *may* decide to work with a contractor for steps 2-9; however, it is important to understand the process and financial models.

11. Alternative Energy Technologies

The following is a summary of the use cases, value propositions, and use scenarios of microgrids with alternative energy technologies for the Cable Industry:

1. USE CASES: (Refer to [SCTE 226])

   a. Market Data Centers

   b. National Distribution Centers

   c. Backbone /Colocation Sites

   d. Administrative Offices

   e. Access Network Power Supplies

   f. Edge Facilities

   g. Outside Plant

   h. Fleets – EV Charging/Discharging

i. https://www.nrel.gov/docs/fy15osti/63157.pdf Energy Efficiency: Use free renewable energy when possible to increase site power efficiency

j. Resiliency: The ability to reduce the magnitude and/or duration of disruptive events.

k. Reduced Utility/Grid Dependency: The ability to operate without need of a utility power service connection for a prolonged period of time.

l. Sustainability Goals: Sustainability focuses on meeting the needs of the present without compromising the ability of future generations to meet their needs. The concept of sustainability is composed of three pillars: economic, environmental, and social—also known informally as profits, planet, and people.

m. Auto-Source of lowest cost generation and power delivery: the ability to continually communicate and diagnose surrounding market and weather data to allow for a microgrid to decide how to operate to maximize lowest cost of operations.

2. MICROGRID USE SCENARIOS:

a. Demand Response: as a change in the power consumption of an electric utility customer to better match the demand for power with the supply.

b. Peak Shaving: the reduction of power consumption ("**load shedding**") quickly and for a short period of time to avoid a spike in consumption. This is either possible by temporarily scaling down production, activating an on-site power generation system, or relying on a battery.

c. Black Start: process of restoring an electric power system or a part of an electric power system to operate without relying on the external electric power transmission network to recover from a total or partial shutdown.

d. DER flexibility: The ability to independently choose which distributed energy resource or collection of distributed energy resources operate together at any given time to supply the power needed.

e. Islanding: The ability to disconnect and operate without connection to a utility power service grid.

f. Paralleling: Two or more power sources operating together in parallel and sharing load as prescribed by the system controller and power source capabilities.

g. Transactive Energy: a system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter.

h. Improved reliability w/multiple sources of electricity

i. Increased resiliency with dispatch capabilities before predicted events

11.1. Alternative Energy Technologies by MSO Site Type

MSO site types per current edition [SCTE 226]:

Table 2 - Suggested applications of Alternative Energy Technologies by MSO Site Type

Class	Class A	Class B	Class C	Class D	Class E	Class Z
Facility Type	**Enterprise/ National**	**Market**	**Regional**	**Edge**	**Access Network**	
Existing Facility Type(s)	Enterprise Data Center, Enterprise HE	Geographical Market Data Centers, Headend	Regional HE, Super Hub, Core Aggregation	Standard Hub	Transport Repeat (cabinet, OTN, CEV, CUE, iHUB, FTTP cabinet, etc.), SMATV, Cell backhaul aggregation enclosure, power supply, etc.	Office Space, Warehouse, call center, etc.
Alternative Energy Opportunities	Geothermal	Geothermal	Geothermal	Geothermal	Geothermal	Geothermal
	Solar - PV	Solar - PV	Solar - PV	Solar - PV	Solar - PV	Solar - PV
	Microturbine CHP (Combined Heating and Power); CCHP (Combined Cooling, Heating and Power)	Microturbine CHP; CCHP	Microturbine CHP: CCHP	Biomass - Methane Source		
	Wind - utility and Traditional	Wind - utility and Traditional	Wind - utility and Traditional	Wind - Micro	Wind - Micro	Wind - utility and Traditional
	Fuel Cell	Fuel Cell	Fuel Cell	Fuel Cell	Fuel Cell	Fuel Cell

11.2. Alternative Energy (AE) Technologies and Descriptions

There are many alternative energy technology options – some more practical than others for MSO deployment. Below is a list and description of some of the existing AE technologies which have been categorized as “Practical” or “Not Practical” for MSO deployment. When considering deploying an AE technology an evaluation *should* be performed based on the specific needs and current infrastructure technology of the Facility. AE technologies identified as “not practical” *may* be practical for your specific deployment.

Reminder: alternative energy is considered an energy source that is an alternative to using fossil fuels. Renewable energy is generated from natural processes that are continuous and replenished. While renewable energy is an alternate energy source, not all alternative energy sources and technologies are renewable.

Battery Energy Storage System (BESS) system considerations: Multiple BESS solutions are available today and new technologies are beginning to enter the market. BESS costs are dropping with deployment numbers on the increase and as new technologies become available. As such, since some alternative energy technologies are intermittent with limited predictability, supplemental BESS solutions *should* be investigated for all potential systems/solutions.

11.3. Practical AE Technologies

11.3.1. Geothermal

Geothermal systems can be used for a variety of applications including electricity generation, heating, and cooling. The most common type of geothermal system can leverage relatively stable ground temperatures while the less common, rare type requires elevated ground temperature, such as hot springs. The principal characteristic of a geothermal system is it utilizes sub-surface temperatures to absorb heat in winter and dissipate/remove heat in summer. Utilizing the natural temperature characteristics of the Earth’s resources is generally considered environmentally friendly and does not cause significant pollution concerns as with natural gas or reciprocating internal combustion engine (RICE) powered electric systems.

Geothermal systems typically utilize water piped through closed loop deep or shallow wells to tap steam and very hot water for heating or utilize cool in-ground water for air conditioning. Air systems also utilize wells to tap the Earth’s resources for heating and cooling purposes, but they use air to transfer heat instead of water. Geothermal resources are naturally replenished and renewable; they are generally considered environmentally friendly and do not cause significant amounts of pollution.

Initial capital costs to install geothermal systems can be high including drilling costs, which account for over half the cost. Most systems have payback periods often exceeding 10 years. Typically, there are minimal maintenance costs and reduced consumption of carbon fuels can result in lower operating costs. These systems can be installed in both new construction and retrofits, but the costs are higher in retrofits because they often require HVAC and piping controls modification and ductwork and other mechanical system modifications.

Savings Characteristics of Geothermal Systems

- Reduces operating costs over conventional systems
- Lower heating and cooling costs
- Less moving parts – less repairs
- Lower maintenance costs
- Reduced carbon fuel consumption, no emissions of carbon dioxide, carbon monoxide or other greenhouse gases.

Geothermal Direct Exchange (DX) Heat Pump
The oldest type of geothermal heat pump technology is the DX Geothermal system in which copper tubing is placed directly in the ground in a closed loop and filled with refrigerant. The refrigerant circulates through the tubing, exchanging heat from the refrigerant directly to soil through the walls of the copper tubing. DX systems can be used to provide hot water for heating and for domestic hot water.

Table 3 - Geothermal Direct Exchange (DX) Heat Pump Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	x
Reduce grid dependency *	x	x

* Grid connectivity required for supplemental, redundant or back up power

Closed Loop Geothermal Heat Pump

The key difference between a Geothermal DX Heat Pump system and a Closed Loop Geothermal Heat Pump is that there are two heat transfer processes in the closed loop system. the closed loop system includes water or glycol filled tubing installed horizontally as a loop field in trenches or vertically as a series of long U-shapes in wells – this tubing and the liquid inside provides the heat transfer to the earth. Closed loop systems also include a heat exchanger between the closed loop and the refrigerant loop and pumps in both loops. The closed loop system is the most deployed geothermal heat pump option.

At least one MSO has deployed this technology.

Table 4 - Closed Loop Geothermal Heat Pump Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant or back up power

11.3.2. Solar

Solar power is the conversion of sunlight into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaics convert light into Direct Current (DC) electric current using the photovoltaic effect.

System components *may* include collectors, collector mounts (intrusive or non-intrusive), power cabling and/or fluid piping, switchgear, pumps, inverters, utility interconnect, controller, and power monitoring and metering. These systems have limitation on deployments due to the physical size of the collectors and the watts per sq. ft of collector surface area. Solar PV systems are currently deployed at MSO locations for non-critical loads and are being evaluated by the industry for uninterruptable power supply (UPS) battery recharging.

PV – Photovoltaic

PV Systems are recognized by many names including photovoltaic system, photovoltaic power system, solar PV system, PV system or casually, solar array. A PV system is a power system that utilizes photovoltaics to covert the suns solar power into usable electric power. PV systems include several components including a solar collector that absorb and convert sunlight to DC power, an inverter or micro-inverter which changes the collector output DC power to alternating current (AC) power and an electrical distribution system to distribute the AC power to where it can be utilized which is typically through switchgear or power buss. Some PV systems have sun tracking devices which rotate the collectors on a pivot and continually align collectors with the track of the sun to maximize power generation.

PV systems can be small – similar to what is used to power yard lights and recharge cell phones – or can be multi-megawatt generating systems encompassing hundreds of square feet of land or roof space. Larger systems are typically connected to the utility power grid to reduce peak demand or so that excess power can be sold and supplied to the grid as distributed power generation. Selling and supplying excess power generated to the utility grid can reduce the payback period and increase the return on investment (ROI).

Table 5 - Photovoltaic Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

11.3.3. On-Site Power Generation

Microturbine

Microturbines have become more widespread in distributed power generation systems and combined cooling heat and power (CCHP) applications. These close coupled systems generate electricity and heat close to where the electricity and heat will be used and thus reduces line loss caused by transporting power over long distances. Advanced electronic control systems which permits unattended operation and electronic power switching technology that improves commercial power grid synchronization have led to an increased deployment of this technology.

Microturbine technology is based on micro combustion. Turbines generate lower emissions, have just one moving part (turbine shaft) and most of the waste heat is contained in the relatively high temperature exhaust making it simpler to capture. However, reciprocating engine generators are quicker to respond to changes in output power requirements and are usually slightly more efficient, although the efficiency of microturbines is increasing. Microturbines also lose more efficiency at low power levels than reciprocating engines.

Reciprocating engines typically use simple motor oil (journal) bearings. Full-size gas turbines often use ball bearings. The 1000 °C temperatures and high speeds of microturbines make oil lubrication and ball bearings impractical; they require air bearings or possibly magnetic bearings.

Natural Gas

A natural gas-powered electric generator uses a reciprocating or turbine engine that is powered by natural gas to turn an electric generator. The electricity generated is used to reduce the amount of power purchased from the electric utility grid. The power generated by the natural gas generator is typically less expensive per kilowatt hour (kWh) than the cost of purchasing power from the grid, but there are additional operating and maintenance costs associated with operating the natural gas generator due to the additional electrical distribution components required to connect the generator to the facility electrical distribution system. Utilizing a gas generator for primary or supplemental power also increases generator run time which increases generator maintenance requirements as well as increases natural gas costs to power the generator. Notwithstanding a catastrophic event, the natural gas used to fuel the turbine is considered extremely reliable and does not require a truck roll to refuel.

Table 6 - Natural Gas Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

11.3.4. Fuel Cells

A fuel cell is a device that generates electricity via chemical reaction. Fuel cells are being deployed more often to reduce grid dependency and total cost of electricity. Every fuel cell has two electrodes, one positive and one negative, called, respectively, the anode and cathode. The reactions that produce electricity take place at the electrodes. Each type of fuel cell has advantages and drawbacks compared to the others. None of these is inexpensive and efficient enough to widely replace traditional ways of generating power, such coal-fired, hydroelectric, or even nuclear power plants.

Individual fuel cells produce relatively small electrical potentials, about 0.7 volts, so cells are "stacked", or placed in series, to create enough voltage to meet an application's requirements. Fuels cells of various types and capacities have been deployed by cable operators. The payback or ROI is long term, making them difficult to get funding approved for installation. They typically are used within the industry for base load capacity and not for back-up power.

Table 7 - Fuel Cells Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant or back up power

Hydrogen

The hydrogen-oxygen fuel cell was designed and first demonstrated publicly in 1959. It was used as a primary source of electrical energy in the Apollo space program. Hydrogen is the fuel for this classification of fuel cell, but fuel cells also require oxygen as part of the combustion process. One great appeal of this type of fuel cell is that they generate electricity with very little pollution–much of the hydrogen and oxygen used in generating electricity ultimately combines to form a harmless byproduct, namely water.

New electrolysis techniques powered by solar and/or wind with BESS integration are being developed and deployed and will make this powering option more cost effective and deployable.

Table 8 - Hydrogen Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Solid Oxide

Solid oxide fuel cells (SOFC) use a hard, ceramic compound of metal oxides as an electrolyte. Efficiency of these types of cells is about 60 percent, and operating temperatures are about 1,000 °C (about 1,800 °F). The high operating temperature limits applications of SOFC units and they tend to be rather large. While solid electrolytes cannot leak, they can crack. SOFC power output is up to 100 kilowatt (kW).

Table 9 - Solid Oxide Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Hybrid

Hybrid fuel cells operate without the pollution associated with the combustion of fossil fuels. However, there are also disadvantages in that it cannot store energy, the response is slow, it is difficult to cold start and its output voltage fluctuates with the load. Hybrid fuel cell technology can be applied to various fields: electricity power plants, automotive manufacturing, cogeneration, smartphone, construction, and other industries. Hybrid fuel cells have the following advantages: cleanness, high efficiency, and high reliability.

Table 10 - Hybrid Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant or back up power

Proton Exchange Membrane (PEM)

PEM fuel cells work with a polymer electrolyte in the form of a thin, permeable sheet. Efficiency is about 40 to 50 percent, and operating temperature is about 80 °C (about 175 °F). Cell outputs generally range from 50 to 250 kW. The solid, flexible electrolyte will not leak or crack and these cells operate at a low enough temperature to make them suitable for homes and cars. However, their fuels must be purified through filtration and the use of platinum, a precious and expensive metal used as a catalyst on both sides of the membrane, raises the costs. The U.S. Department of Energy estimates that platinum-based catalysts will need to use roughly four times less platinum than is used in current PEM fuel cell designs in order to represent a realistic alternative to internal combustion engines.

Table 11 - Proton Exchange Membrane Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant or back up power

Natural Gas-Powered Fuel Cell

Fuel cells powered by higher efficiency hydrocarbons such as natural gas can be used to generate electricity. Unlike batteries, fuel cells require a continuous source of fuel and oxygen/air to sustain the chemical reaction that generates electricity. Fuel cells can produce electricity continuously for as long as the source of fuel and oxygen/air are supplied.

Table 12 - Natural Gas-Powered Fuel Cell Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

11.3.5. Wind

Wind energy has enormous potential for supplying electricity on both small and large scale. It is considered a green energy source, does not cause pollution, does not run out since wind energy originates from the sun, and has the potential to generate more power than can be used by the world’ ’population. However, wind power accounts for a very low percentage of total worldwide electricity production but is growing increasingly more popular due to declining prices of wind generators, efficiency and low operating costs. The Energy Information Administration (EIA), the statistical arm of the Department of Energy, finds wind energy to be one of the most affordable options for new electricity generation, alongside new natural gas units.

However, wind turbines are not suited for supplying base load power due to the intermittent supply of wind which can be forecasted and predicted but cannot be controlled. Wind turbines can also be a threat to the environment, can be intrusive, unsightly for some people, and be difficult to get approval from local building code officers.

Vertical Axis Wind Turbines

Vertical axis wind turbines are often referred to as spinning soda or beer cans due to their appearance. They appear to be cans that are sliced open to expose flaps or blades that provide a surface area to capture the wind. They spin vertically on shaft that is attached to a generator that produces electricity. They are the least intrusive wind turbine due to their physical appearance and supporting base.

Table 13 - Vertical Axis Wind Turbines Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis		
Energy cost reduction on a unit basis	x	x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Horizontal Wind Generators

Horizontal wind generators are the traditional type of wind generator that sits atop a tall tower with large propellers. These are the most deployed generator for converting wind energy to electricity. The blades or propellers are attached to a horizontal shaft and generator that are turned by wind energy. The spinning of the propellers generates electricity. The manufacturing and installation of horizontal wind turbines requires significant upfront investments – both in commercial and residential applications.

Table 14 - Horizontal Wind Generators Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis		
Energy cost reduction on a unit basis	x	x
Reduce grid dependency *	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Microgeneration Wind Turbine

These turbines *may* be as small as a fifty-watt generator for boat or miniature refrigeration unit. Additional uses include generating electricity for agricultural, residential, stadiums, and arenas. As opposed to large commercial wind turbines, a small wind turbine is a wind turbine used for micro generation. Micro wind generation has a higher cost-per-kilowatt than large wind generators due to their physical size, technological limitations on the amount of power they can generate individually and the requirement to have multiple wind turbines in order to make an impact. These generation systems are being evaluated in the context of a national distributed wind energy source by combining multiple devices to generate more capacity.

Table 15 - Microgeneration Wind Turbine Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis		
Energy cost reduction on a unit basis	x	x

Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Utility Wind Generators

Utility wind generators are typically deployed in generator farms which are basically a large concentration of propeller driven horizontal wind generators with capacities often exceeding hundreds of megawatts. These generator farms can be located on vast expanses of land or more recently, in offshore, ocean or bay environments. Large wind farms provide a clean, renewable source of electricity and are a necessary component to utilities that are mandated to reduce their carbon footprint from traditional electric generation plants. Wind power is a serious and important component of utility generation and the largest and most readily deployable form of new clean energy available. Wind energy generation costs due to improvements in technology continue to decline and will decline even more as the technology continues to mature. According to the American Wind Energy Association wind turbine technology is improving including lower cost wind turbines, increased performance, and advanced operations, causing the cost of wind electricity to decline significantly in recent years.

Table 16 - Utility Wind Generators Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis		
Energy cost reduction on a unit basis	x	x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

11.4. Not Practical AE Technologies

11.4.1. Geothermal Direct Air

Geothermal direct air utilizes air instead of water as the heating or cooling medium. The direct air systems air is conditioned by pushing and/or pulling the air through closed loop deep or shallow dry well piping or ducts that tap the Earth's resources for heating and cooling purposes. The conditioned air is returned to the internal air handler unit where it transfers heat via an air-to-air heat exchanger or is pumped directly into the conditioned space.

Table 17 - Geothermal Direct Air Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	x
Reduce grid dependency *	x	x

* Grid connectivity required for supplemental, redundant or back up power

Geothermal Power Production

Many power plants still use fossil fuels to boil water for steam and some power plants utilize this steam to generate electricity. Geothermal power stations are like other steam turbine thermal power stations but the steam in the geothermal plant is derived from reservoirs of hot water found a couple of miles or more below the Earth's surface.

Geothermal electricity generation is currently used in 24 countries. Geothermal power is sustainable because the heat extraction is small compared with the Earth's heat content and the water that is formed when steam cools is returned to the earth.

Table 18 - Geothermal Power Production Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Concentrated PV

Concentrator photovoltaics (CPV) uses optical devices such as mirrors or plastic lenses to capture a large area of sunlight that is focused onto the PV solar cell. Concentrating optical devices used in CPV include Fresnel lens, parabolic mirrors, reflectors, and luminescent concentrators.

CPV technology differs from flat-plate PV modules in several ways: they are usually made using high-efficiency, multi-junction PV solar cells and they use mirrors or lenses to concentrate sunlight onto the solar cells. The primary reason for using concentrators is to be able to use less solar cell collectors and less sq. ft. of an area. Concentrator systems increase the power output while reducing the size or number of solar cells needed.

Concentrating light, however, requires direct sunlight rather than diffused light, limiting this technology to clear, sunny locations. It also means that, in most instances, sun tracking is required. Sun tracking devices rotate the collectors on a pivot and continually align collectors with the track of the sun to maximize power generation. Despite having been researched since the early '70s, it has only now entered the solar electricity sector as a viable alternative.

Table 19 - Concentrated Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Salt

Heat storage and retrieval technology allows for producing electricity at night and on overcast days as well. One thermal storage medium used is molten salt. Heat is transferred from the sun through concentrators to the molten salt in an insulated storage reservoir during the day, and then withdrawn from storage for power generation at night.

This molten salt heat storage technology can be utilized to reduce power costs during high cost per kWh periods and can also be utilized as a peak demand and demand limiting strategy. This solar powered base load generation system has the potential to someday replace both coal and natural gas electric generation plants.

Table 20 - Salt Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant or back up power

Photovoltaic/Thermal (PV/T)

Photovoltaic thermal hybrid solar collectors, sometimes known as hybrid PV/T systems or PVT, are dual purpose systems that convert solar radiation into thermal and electrical energy. The hybrid PV/T system provides more energy than a conventional solar PV system. The PV/T system generates electricity via the incorporated PV system.

Additionally, the heat energy captured from the PV modules is transferred and then ducted into the building’s Heating, Ventilation and Air Conditioning (HVAC) system where it is used to displace heat generated through conventional fossil fuel methods. The additional energy provides PV cooling by reducing the operating temperature of the PV modules, which improves the electrical performance. The capture of both electricity and heat allow these devices to have higher exergy (energy available to be used) and thus be more overall energy efficient than solar photovoltaic (PV) or solar thermal alone.

Table 21 - Photovoltaic/Thermal Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

SWH Solar Water Heating

Solar water heating (SWH) systems utilize collector panels containing liquid circulating through tubes to capture and retain heat from the sun. The solar thermal heat is trapped and transmitted to a fluid, usually water, in contact with the absorber collects the trapped heat to transfer it to storage.

This heated water can be used for domestic water purposes (showering, washing dishes, clothes, etc.) or for environmental heating of space.

The most basic approach to solar heating of water is to simply put a tank filled with water in the sun. The heat from the sun will heat the tank and the water inside would absorb the heat. This was how the very first SWH systems worked more than a century ago and is still in use in many third world countries as well as with individuals seeking low or reduced cost hot water. However, this configuration is inefficient due to lack of insulation to help retain the heat.

Basic components in a solar water heating system include:

- Collectors to absorb heat from sun – transfer it to a fluid
- Fluid – typically water
- Heat exchanges - transfer heat from the fluid to domestic hot water system.
- Pumps - move the fluid through the collector and/or the exchanger
- Controllers to operate the pumps when there is collector heat available.

Table 22 - Solar Water Heating Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis		
Energy cost reduction on a unit basis	x	x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

11.4.2. Other On-Site Power Generation

Combined Cooling and Heating CCHP

Combined cooling, heat and power (CCHP) or Trigeneration refers to the simultaneous generation of electricity and useful heating and cooling from the combustion of a carbon-based fuel or a solar heat collector. Electricity is generated using a carbon or biomass fired engine that drives an electric generator or that utilizes a solar heat collector. The byproduct of this electric generation process is heat. The heat is then transferred to water using a heat exchanger and piped into the buildings HVAC system and used for environmental heating. The heat byproduct also provides environmental cooling by utilizing the heat to power an absorption chiller that generates chilled water.

However, according to companies that have deployed this technology and that have experience in operating them, these systems can be very complex to operate due to the additional building management system controls and system component sequencing. They can also be costly to design and build and require an advanced skill set for the operating engineer also due to the additional building management system controls and system component sequencing and require capacity to utilize the multi-purpose heated and chilled water systems. Furthermore, the facility requires a significant hot water and chilled water piping systems which are not deployed in all facilities.

Table 23 - Combined Cooling and Heating Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Diesel

Like the natural gas-powered electric generator, the diesel fuel powered electric generator utilizes a carbon fuel (Diesel fuel) to power an electric generation motor. The electricity generated from this turbine is used to reduce the amount of power purchased from the electric utility grid. The power generated is typically less expensive per kWh than the cost of purchasing power from the grid, but there are additional operating and maintenance costs. Utilizing a gas generator for primary or supplemental power increases generator run time which increases generator maintenance requirements as well as increases natural gas costs to power the generator associated with operating the diesel fuel powered electric generator.

There are inherent risks with relying on diesel fuel generators. Severe weather events can hinder the ability of fuel trucks to deliver the necessary diesel fuel required to power the turbine. Recent storms in the south created icy road conditions that exposed the risks of relying on diesel powered devices. In some locales diesel fuel trucks were unable to make deliveries for days due to icy road conditions and the resultant snarled traffic. Some diesel operated devices ran out of fuel before their tanks could be refueled and thus had no power.

Table 24 - Diesel Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant or back up power

Biomass

Biomass is fuel that is developed from organic materials, a renewable and sustainable source of energy used to create electricity or other forms of power. In biomass power plants, wood waste or other waste is burned to produce steam that runs a turbine to make electricity, or that provides heat to industries and other users. The biomass used for electricity generation varies by region. Forest by-products, such as wood residues, are common in the United States.

Biomass power is a renewable source, carbon neutral electricity generated from renewable organic waste that would otherwise be dumped in landfills, openly burned, or left as fodder for forest fires. Scrap wood, mill residuals, forest resources, and properly managed sustainable forests will produce more trees. With a constant supply of wood and waste – from construction and demolition activities, to crops, to wood not used in papermaking, to municipal solid waste – green energy production can continue indefinitely.

Table 25 - Biomass Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis		x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Enabling Systems/Programs

Electric utilities are reluctant to fund large capital projects to update their electrical distribution systems. Additionally, the electric utilities are being mandated to reduce their carbon footprint from traditional electric generation plants. Out of necessity electric utility providers are offering incentives to customers willing to invest in alternative power generating sources. These alternative energy sources are then attached to the electricity grid and excess power generated is distributed through a net meter to the grid and purchased by the utility company.

Microgrids

Microgrids are like centralized electricity system, but are modern, small-scale, specifically designed versions. They deploy alternative energy sources – wind generators, fuel cells, solar, etc. - and are typically built for a specific need such as carbon emission reduction, to meet local capacity, reduce electricity purchase costs, diversify electricity sources, or to supplement grid power.

Microgrids also support distributed generation objectives by enabling renewable energy sources to provide relief for overburdened utility production and grids and can also be used successfully as a demand response tool to reduce peak loads.

Table 26 - Microgrids Goals

Supports Goal	Short Term	Long Term
Reduce power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	x
Reduce grid dependency*	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Demand Response

Increased electric consumption, increasing age, and decreasing condition of electric grids have put pressure on consumers and utilities to reduce consumption during high use, peak electricity consumption periods. To induce electricity consumers to reduce power consumption during peak usage periods utility companies offer incentive payments through demand response programs. Consumers are offered payments to voluntarily go off the electric grid and run back-up power generators, shift consumption to lower consumption periods, shut off unnecessary equipment, or utilize other strategies to reduce consumption during high peak usage periods. Demand response programs and specifically demand response payments can be utilized to reduce operating expenses by using the payments to offset utility costs.

Table 27 - Demand Response Goals

Supports Goal	Short Term	Long Term
Reduction of power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	X
Reduction of grid dependency*	x	X
Establishment of vendor partnerships - hardware development	x	X

* Grid connectivity required for supplemental, redundant, or back up power

Demand Limiting / Optimum Load Shaping (OLS)

Increased electric consumption, increasing age, and decreasing condition of electric grids have put pressure on consumers and utilities to reduce consumption during high use, peak electricity consumption periods. By voluntarily limiting peak electric consumption to under a predetermined usage amount consumer receive payments from utility companies. Consumers are offered payments to go off grid and run back-up power generators, shift consumption to lower consumption periods, shut off unnecessary equipment, or utilize other strategies to reduce consumption. Demand limiting and specifically payments received for limiting demand can be utilized to reduce operating expenses by using the payments to offset utility costs.

Table 28 - Demand Limiting Goals

Supports Goal	Short Term	Long Term
Reduction of power consumption on a unit basis	x	X
Energy cost reduction on a unit basis	x	X
Reduction of grid dependency*	x	x

* Grid connectivity required for supplemental, redundant or back up power

Peak Shaving / Optimum Load Shaping (OLS)

This is like demand limiting in that consumers shift consumption to lower consumption, but they also shift consumption to lower cost per kWh periods. Peak Shaving is often associated with an electricity rate class called “Time-of-Use.” Under the “Time-of-Use” rate consumers pay a lower cost per kWh during off peak, low grid consumption periods and a higher cost per kWh rate during peak or high use periods. By reducing the peak or highest consumption period consumers by shifting consumption to lower cost per kWh periods consumers can lower their total cost of power.

Table 29 - Peak Shaving Goals

Supports Goal	Short Term	Long Term
Reduction of power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	x
Reduction of grid dependency *	x	x

* Grid connectivity required for supplemental, redundant, or back up power

Net Metering

Net metering allows consumers with alternative electric generating sources to feed electricity they do not use (excess capacity) back into the grid and receive payments for this excess capacity. As an example, a consumer with a Solar PV system *may* generate more power during the day than their home can consume. The excess power is put back into the grid and, in doing so, the electric meter runs backwards or registers a credit against evening consumption.

Net metering benefits can vary widely by state. Many states have implemented regulations requiring utilities to purchase the excess electric generation from consumers. However, the cost per kWh rate paid for the consumers excess capacity is often lower than the cost per kWh rate charged by the same utility company.

Table 30 - Net Metering Goals

Supports Goal	Short Term	Long Term
Reduction of power consumption on a unit basis	x	x
Energy cost reduction on a unit basis	x	x
Reduction of grid dependency *	x	x

* Grid connectivity required for supplemental, redundant, or back up power

12. Financials

12.1. DSIRE

The Database of State Incentives for Renewables & Efficiencies (DSIRE) is one of the most comprehensive collections of data and information available regarding current incentives, rules, regulations and policies for renewable energy and energy efficiency technologies.

The database includes over 900 financial incentives for renewable energy, over 1,300 for energy efficiency, and 15 for energy storage. It also includes over 600 rules, regulations and policies for renewable energy and energy efficiency and an additional 9 for energy storage. The database identifies these programs at the utility, local (municipal), state and federal levels as well as those offered to and for non-profits.

DSIRE is a partnership between the U.S. Department of Energy, the North Carolina Clean Energy Technology Center and the Interstate Renewable Energy Council (IREC). The database and website are hosted by the staff of the N.C. Solar Center at the N.C. State University and IREC. There are four main resources available through DSIRE. Each resource has a depository of information on the program.

The information is provided by state and program type, e.g. Federal, State, Utility, Local and Non-profit. Color-coded links are provided for details on available program types by State. Links to these resources and screen shots of the websites are presented below.

12.1.1. Bonds

Qualified Energy Conservation Bonds (QECB) are issued by state, local, and tribal governments in order to finance energy conservation projects. New Clean Renewable Energy Bonds (CREBs) *may* be issued by public power utilities, electric cooperatives, government entities (i.e. states), and some lenders in order to finance renewable energy projects. Examples of qualified projects include renewable energy and energy efficiency capital expenditures project financing, green infrastructure bonds in commercial, industrial, nonprofits, schools and institutions public buildings, green communities, renewable energy production, various research and development, and energy efficiency education campaigns.

12.1.2. Corporate Tax Incentives

Deductions, depreciation, exclusions, or exemptions from tax liabilities are offered as an enticement to engage in a specified activity (such as investment in alternative or renewable energy). These tax incentives are only available for a finite period. In some cases, the incentive is based on the amount of energy produced. In addition, some states allow a tax credit only if a corporation has invested a minimum amount in an eligible project and there is usually a maximum cap on the amount of credit or deduction.

12.1.3. Grants

There are varied types of grant programs used to encourage research, development, and deployment of renewable energy technologies. These are available for a range of renewable energy technologies including wind and photovoltaics and each grant is structured differently. They are available to commercial, industry, education, and the government sectors.

12.1.4. Industry Support

Some states offer financial incentives to stimulate the manufacturing and development of renewable energy systems and equipment, which is used to promote economic development and the creation of jobs. These can be in the form of tax credits, exemptions, and grants. The amount of incentive can depend on the amount of eligible equipment that a company manufactures. These incentives apply to several renewable energy technologies and are designed to be temporary and usually include a sunset provision to encourage self-reliance.

12.1.5. Loans

Loans provide financing for the purchase of renewable energy or energy efficient systems. Low interest or zero interest loans for energy efficiency projects is a common DSM (demand side management) strategy for electric utilities.

12.1.6. Property Tax Incentives

Most property tax incentives for renewable energy systems exclude the added cost of the system in the overall assessment of the property for taxation purposes. These incentives include exemptions, exclusions, and credits.

12.1.7. Rebates Programs

State and local governments 'pair up with utility providers in order to promote and offer rebates for the installation of renewable energy systems and energy efficient technology. Solar water heating and photovoltaics are common renewables that receive these rebates and most are administered by the utility provider.

12.1.8. Sales Tax Incentives

There are sales tax exemptions, typically at the state sales tax level, for the retail sale of renewable energy systems or any other energy efficiency implementation.

12.1.9. Resources on Financial Incentives Rules, Regulations and Policies for Renewable Energy, Energy Efficiency and Energy Storage

Information on financial incentives and regulatory policies for renewable energy, energy efficiency and energy storage by federal, state, utility local and non-profit organizations can be accessed at http://programs.dsireusa.org/system/program/tables and https://www.dsireusa.org/resources/detailed-summary-maps/

12.1.10. Financial Incentives for energy efficiency

To access this information, filter category on financial incentives and select the technology of interest.

12.2. Rules, Regulations & Policies

To access, filter category on regulatory policies and select technology of interest. Examples of regulatory policies are summarized below.

12.2.1. Contractor Licensing

Specific licensing for contractors who want to install a renewable energy system that guarantees that they are experienced in the system install process as well as have the knowledge necessary to properly maintain it.

12.2.2. Equipment Certification

A policy that requires that renewable energy equipment meets specified standards. This helps guarantee the quality of the equipment sold to consumers which reduces issues with faulty equipment sales.

12.2.3. Generation Disclosure

States that implement this policy are required to provide their customers with detailed information on the electricity that the utility company provides. Examples of this information, which is typically provided on an invoice, include emission statistics and fuel mix percentages. In addition, the utility provider *may* be required to supply a certification stating that any renewable energy resources they use are certified as such.

12.2.4. Green Power Purchasing and Aggregation Policies

Government agencies, businesses, residents, schools, non-profits, and others can support renewable energy by buying electricity from these sources or by procuring renewable energy credits (REC). Green power purchases are implemented through project developers or green power marketers through utility green power programs or community aggregation, which is when two or more communities aggregate their electricity loads to buy green power.

12.2.5. Interconnection Standards

These standards govern the technical and procedural process through which an electric customer connects an electric-generating system to the grid. They identify the technical, contractual, metering, and rate rules that system owners and utility providers must adhere to. Standards for systems that are interconnected at the distribution level are usually adopted by the state's public utility commission. Not all states have these standards and some standards only apply to investor owned utilities and not to municipal utilities and electric cooperatives.

12.2.6. Line Extension Analysis

When an electric customer requests service for a home or facility that is not currently being serviced by the electric grid, the customer typically must pay a distance-based fee for the cost of extending power lines to the home or facility. According to DSIRE, which supports renewable energy and energy efficiency in the United States, in most cases it is more cost effective to use an onsite renewable energy system and many states require the utility to provide renewable energy options to the customer.

12.2.7. Net-metering

Regarding customers who create their own electricity, net-metering allows for the flow of electricity both to and from the customer. When a customer's generation is larger than their use, the excess can flow back to the grid which offsets electricity consumption at a future time. This is typically done using a bi-directional meter. In most states net-metering is required by law but in some cases this regulation *may* only apply to utilities that are investor owned.

12.2.8. Public Benefit Funds

Programs at the state level that ensure continued support for renewable energy resources, energy efficiency initiatives, and low-income energy programs. These programs are usually supported through a small surcharge on electricity consumption and it is sometimes referred to as the system benefits charge. Public benefit funds can support rebate programs for renewable energy systems, loan programs, research and development, and energy education programs.

12.2.9. Renewable Portfolio Standards (RPS)

There is a regulation that requires utility providers to obtain a given percentage of their power from renewable sources by a predetermined date.

Summary maps of incentives and policies are also available at http://www.dsireusa.org/resources/detailed-summary-maps / . See Figure 14. There is an option to search maps through an interactive map interface or detailed color-coded maps updated quarterly see Figure 15.

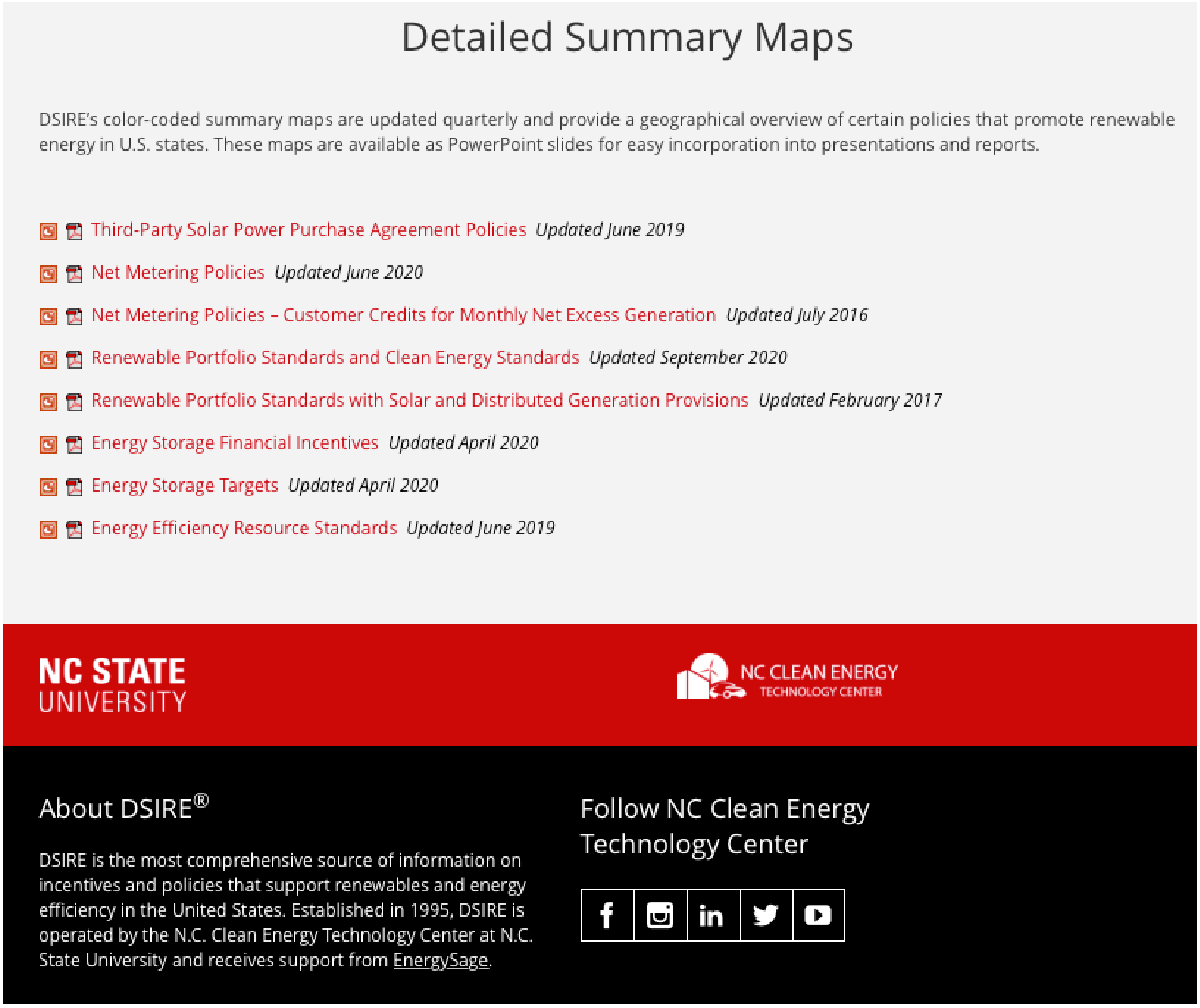


Figure 14 - Map key for Overview of Promoted Policies

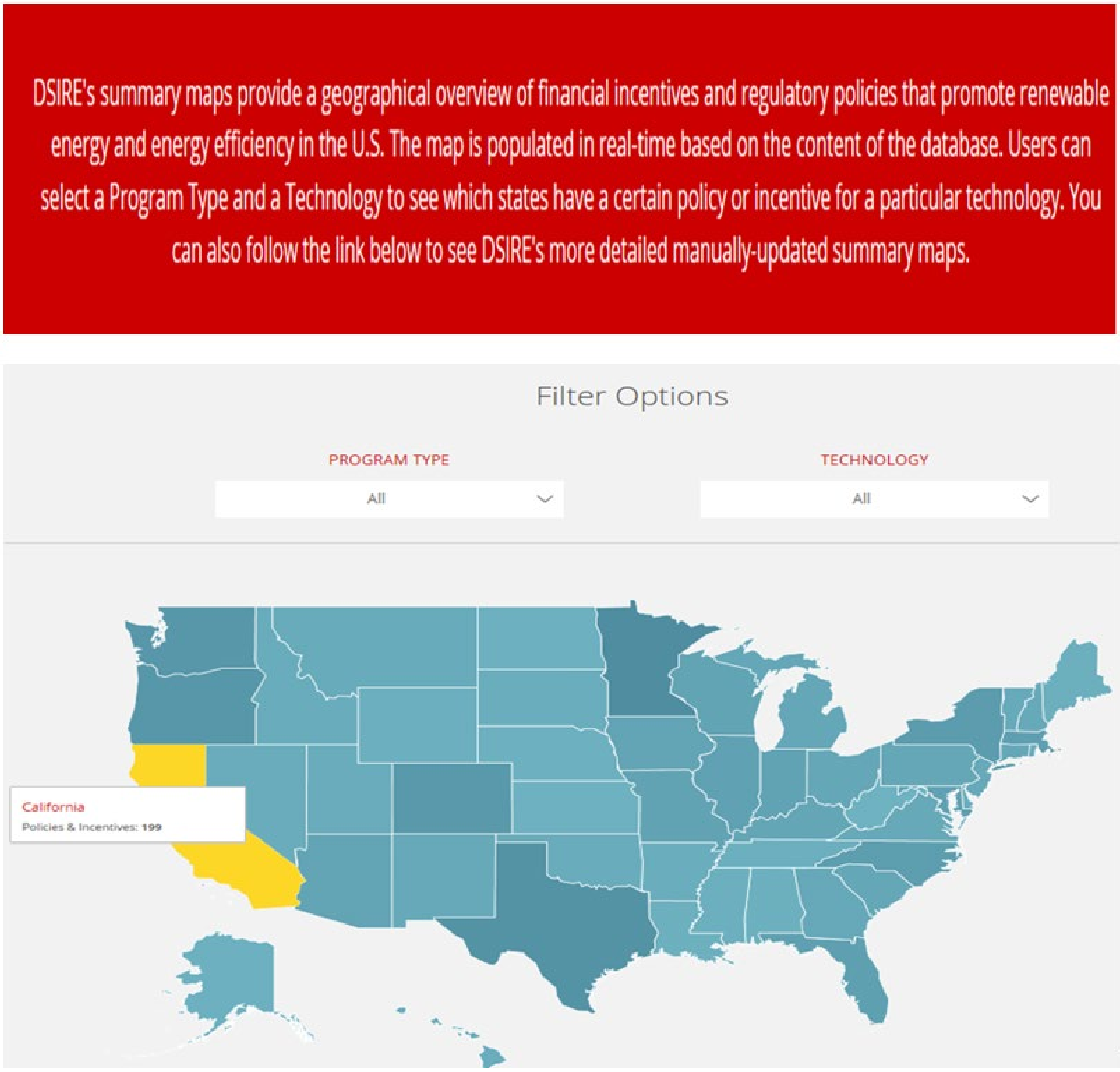


Figure 15 - DSIRE's Summary Map of Incentives and Policies

12.3. U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy (EERE)

EERE provides oversight for two overarching areas relevant to the Energy 2020 Alternative Energy goals. These are:

12.3.1. Renewable electricity generation

- Solar - http://energy.gov/eere/renewables/solar
- Geothermal - http://energy.gov/eere/renewables/geothermal
- Wind - http://energy.gov/eere/renewables/wind
- Water - http://energy.gov/eere/renewables/water

12.3.2. *Sustainable transportation*

- Vehicles - https://www.energy.gov/eere/vehicles/vehicle-technologies-office
- The Alternative fuels data center - provides information on federal and state laws and incentives for alternative fuels http://www.afdc.energy.gov/laws/
- Active funding opportunities are provided by the Vehicles Technologies Office - http://energy.gov/eere/vehicles/vehicle-technologies-office-financial-opportunities
- Bioenergy - http://energy.gov/eere/transportation/bioenergy
- Hydrogen fuel cells - The site provides information based on various technologies, the main issues to take into consideration when thinking about renewable energy solutions to advance technical information are based on sound scientific research. There is also information on existing programs and initiatives and financing options and incentives. Each program also offers email notifications that bring relevant up to date information to your fingertips. http://energy.gov/eere/transportation/hydrogen-and-fuel-cells

Information on financial opportunities is hosted by the Department of Energy's Office of Energy Efficiency and Renewable Energy. Please note that you will be redirected to the DSIRE site for information on incentives. http://energy.gov/eere/sunshot/financial-opportunities

12.3.3. *National Renewable Energy Lab*

F is the national laboratory of the U.S. Department of Energy, EERE program, operated by the Alliance for Sustainable Energy, LLC. NREL focuses on research, development and commercialization, and deployment of renewable energy and energy efficiency technologies. Renewable energy sources included in NREL's portfolio are solar, wind, biomass hydrogen, geothermal and water. Systems integration around grid integration, distributed energy interconnection, battery and thermal storage and transportation, are other areas of focus.

NREL partners with private industry, federal agencies, state and local government and internationally in their programs. There is a cadre of resources in their Energy Analysis Program to assist in the decision-making to advance from concept to commercial application to market penetration for renewable energy. Featured analysis, models and tools, data and resources are available at http://www.nrel.gov/analysis/.

12.3.3.1. *System Advisor Model (SAM)*

SAM is a performance and financial model to facilitate decision making in renewable energy, are also provided in Section 8 of this document. According to the NREL, SAM can automatically download and populate data from DSIRE, OpenEI Utility Rate Database, other NREL resources data as well as other self-inputted variables to model performance, financial metrics, levelized cost of energy and cash flow, incentives, etc. Additional information on SAM can be accessed at https://sam.nrel.gov /.

12.3.3.2. *Fleet DNA*

NREL's transportation research includes a Fleet DNA resource which provides data, charts, and reports on various types of vehicles that help in the selection of technologies for fleet. Access information at https://www.nrel.gov/transportation/fleettest-fleet-dna.html Links to additional tools are also available at this site - https://www.nrel.gov/transportation .

12.3.3.3. ***Resource Maps***

Below are several links to interactive maps that include geospatial tools for renewable energy resources. These can be used to help determine which energy technologies are viable solutions in a specified region. The maps include data for wind, solar and geothermal energy resources.

Solar Prospector resource data, tools and maps are available at https://www.nrel.gov/gis/solar.html. These tools can be used to access solar geospatial data for determination of utility-scale solar plants. The data can also be downloaded from the site in several different file types. See Figure 16.

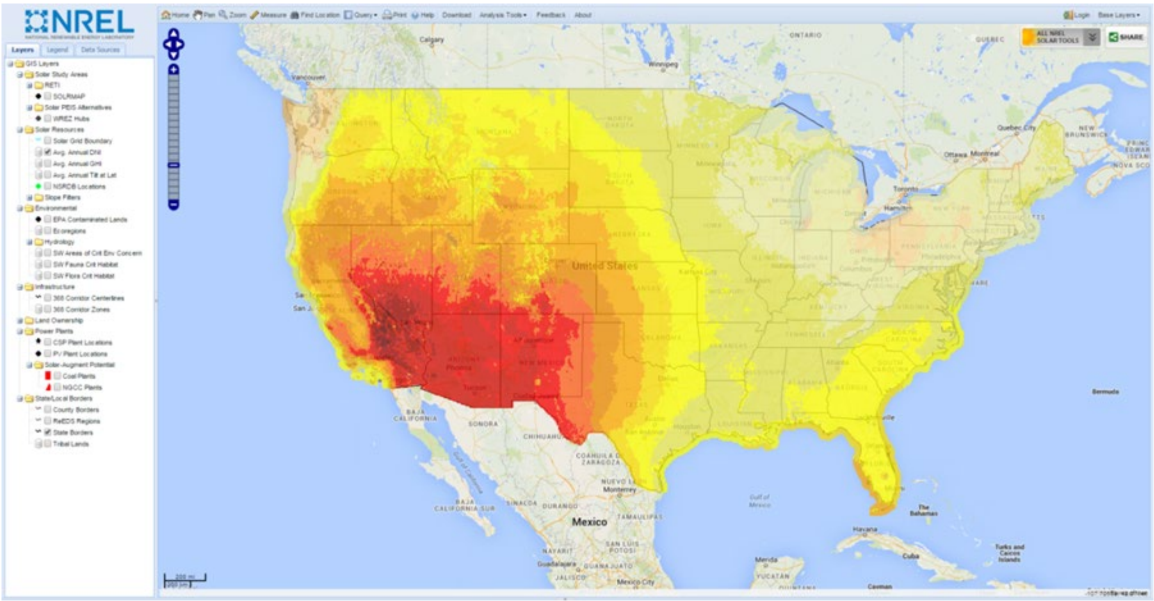


Figure 16 - Solar Prospector Map and Analysis Tool

Wind Prospector (https://www.nrel.gov/gis/wind.html) is a mapping and analytics tool that provides the user with wind speeds across the continental United States. This allows for better or more informed site selection

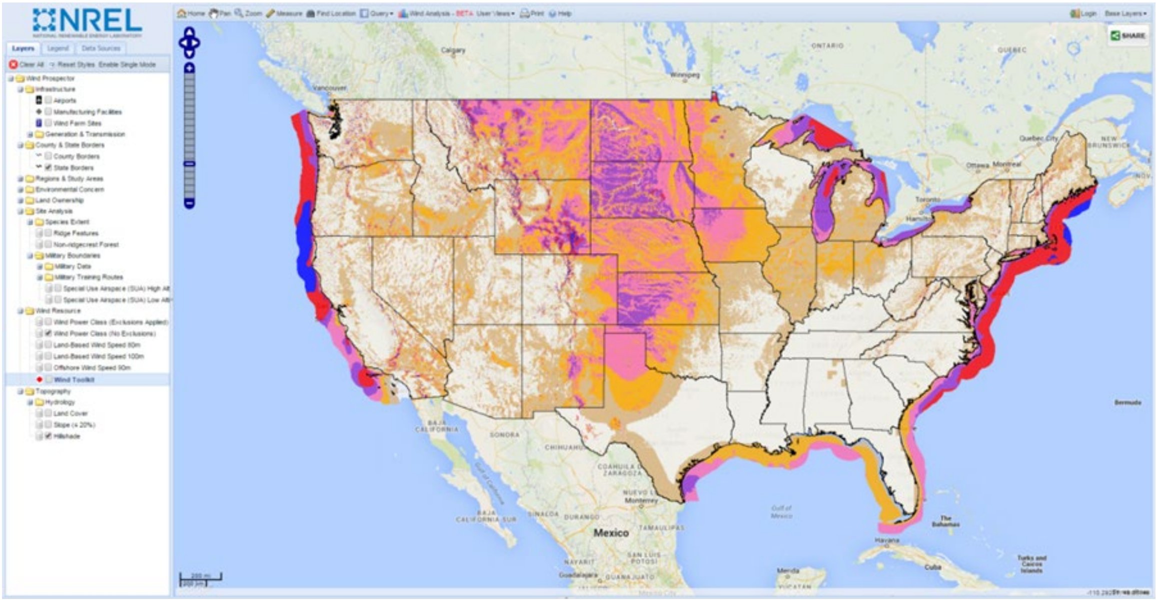


Figure 17 - Wind Prospector Map and Analytics Tool

Geothermal Information: https://www.nrel.gov/geothermal/2-point-0.html allows users to identify locations that are favorable to geothermal energy development. See Figure 18.

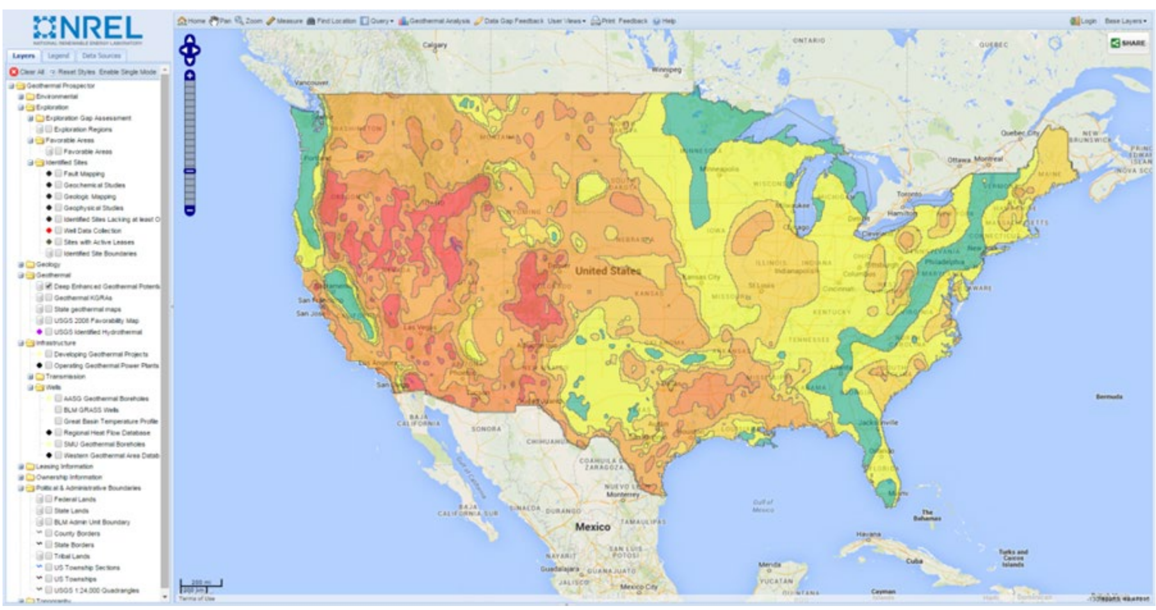


Figure 18 - Geothermal Prospector Map Tool

12.3.3.4. *Cost of Renewable Energy Spreadsheet Tool (CREST)*

NREL publishes a Cost of Renewable Energy Spreadsheet Tool (CREST), which enables economic cash flow models. It assesses project economics, design cost-based incentives and evaluates the impact of various state and federal structure. The tool is available for solar, wind, geothermal, anaerobic digestion, and fuel cells. The spreadsheets are available at https://www.nrel.gov/analysis/crest.html and https://financere.nrel.gov/finance/content/crest-cost-energy-models. A manual, informational webinars, supporting documents and information are available at the link.

.

12.3.3.5. *Job and Economic Development Impact (JEDI) Model*

The Job and Economic Development Impact Model estimates the economic impacts of constructing and operating power generation and biofuel plants. Available models include wind, biofuels, solar, natural gas, hydroelectric, and geothermal. Traditional fuel sources such as coal and petroleum are also modeled. A web-based JEDI PV SAM (https://www.nrel.gov/analysis/jedi/) .

12.3.3.6. *H2A Hydrogen Analysis (H2A) Model*

The Hydrogen (H2AModel) is a spreadsheet-based tool that enables a comparative analysis of costs, energy and environmental tradeoffs of hydrogen production
http://www.hydrogen.energy.gov/h2a_analysis.html

13. Conclusion

As the cable industry looks to further standardize on strategic energy concepts like microgrids, opportunity presents itself for continued development, trial and ultimate deployment of microgrid technologies. It has been shown that microgrids are being deployed within many industries and use cases globally. Economics, the rising cost of electricity, and the focus on a more sustainable future are the drives for the widescale deployment of solar, wind and other distributed energy resources. New technology large scale energy storage is also becoming more cost effective and is playing a bigger and bigger role in the new energy future. These will enable a foundation of new network ideas, as envisioned and embodied in the announcement early in 2019 of the broadband 10G platform.

