Electricity to the Rescue

Lower costs, a more resilient grid and reduced carbon emissions could be the future if consumers choose electricity over fossil fuels

CFC

DEFINITION

Efficient Electrification
Replacing direct use of fossil fuels for commercial and residential heating and cooling, water heating, transportation and other applications with electric technologies in ways (such as shifting periods when electricity is used) that reduce energy costs and overall carbon emissions to the benefit of both consumers and the environment. In an era of declining kilowatt-hour sales and increasing penetration of renewable resources, efficient electrification can increase electric consumption while simultaneously greening the grid—linking electric utilities to a clean energy future.

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Introduction

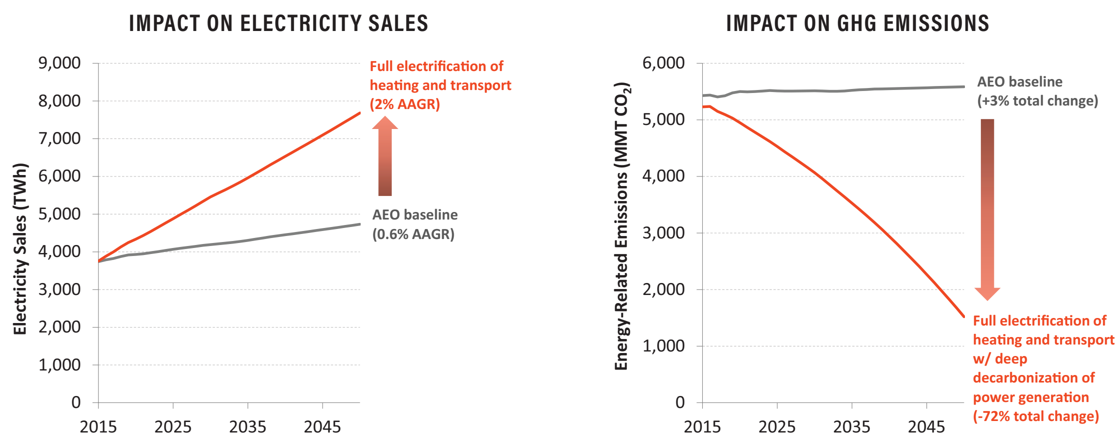
Over the past few years, a significant shift in perceptions about electric consumption has emerged, one that brings together an unlikely alliance of electric utilities, climate change activists, energy efficiency proponents and even "wise use" advocates. The change has been promoted under the terms "beneficial electrification," "environmentally beneficial electrification" or "strategic electrification," but in many ways can more accurately be dubbed "efficient electrification."

Until recently, conventional wisdom held that increased electricity use would lead to more greenhouse gas emissions. That's not the case anymore, thanks to more electric generation flowing from gigawatts of utility-scale renewables coupled with the retirement of hundreds of older coal-fired power plants. The corresponding reduction in carbon dioxide emissions from electricity production means a continual slide in the carbon impact associated with each megawatt-hour of delivered power.

In addition, experts are re-examining the most efficient and emissions-friendly ways to directly power the equipment and appliances we depend on every day. Attention recently has centered on the potential impact of electric vehicles, but immediate results can come from expanding electricity use in space and water heating, industrial processes and agriculture. In its 2017 white paper, "Electrification: Emerging Opportunities for Utility Growth," The Brattle Group, an energy-focused research firm, estimates that if electricity replaced fossil fuels for end-use applications throughout the U.S. transportation, commercial and residential sectors by 2050, electric consumption would rise while greenhouse gas emissions would fall by 70 percent.

Moving to electric-powered vehicles as well as a range of fossil fuel-fired commercial and residential machinery lays the groundwork for a future once thought unlikely—higher electricity consumption alongside huge boosts in solar and wind power as well as energy efficiency that leads to a significant drop in carbon emissions and stable prices for consumers.

Impact of Electrification Combined with Deep Decarbonization of Power Sector



Source: The Brattle Group analysis based on EIA AEO 2015 data

Water Heater Rescue Changes the Narrative

Beginning in the 1980s, the image of electricity as a great societal advance began dimming. Fossil fuel-fired power plants were identified as one of the leading sources of greenhouse gas emissions blamed for contributing to climate change. Meanwhile, state and federal energy policies started to favor natural gas over electricity for heating buildings and water, citing its higher efficiency after factoring in the conversion of coal to electrons in a power plant and subsequent line losses.

Following the Great Recession of 2007–2009, kilowatt-hour sales flattened, with the U.S. Energy Information Administration (EIA) as late as 2015 projecting an annual electricity use growth rate through 2040 of only 0.6 percent, half that during the previous 25 years. At the same time, a study by the National Renewable Energy Laboratory held that the expansion of distributed commercial and residential solar photovoltaic (PV) systems would wipe out even that modest bump. News coverage of the electric utility industry began focusing on predictions of a "death spiral."

While efficient electrification was not an entirely new idea—harkening back to the "negawatts" concepts of the early 1990s—it gained traction in the aftermath of the federal debate over the future of electric resistance water heaters. In 2010, the U.S. Department of Energy (DOE) proposed new efficiency standards (effective mid-April 2015) for electric water heating appliances with the goal of achieving cost savings as well as slashing carbon emissions. The standards as proposed required an energy factor for large-capacity (55 gallons or greater) electric water heaters that could only be met by heat-pump models. The 75-gallon or greater electric resistance water heaters popular in electric cooperative load-control programs—more than 250 cooperatives in 35 states employ the devices as a key component of demand-side management initiatives—would no longer be available for sale. Over time, through attrition as water heaters were retired, these load management efforts would lose effectiveness.

After a multi-year battle in Congress, electric cooperatives were successful in getting the Energy Efficiency Improvement Act of 2015 signed into law on April 30, preserving the manufacture of large-capacity, grid-enabled electric resistance water heaters specifically for use in demand-response programs. The appliances, by shifting when and how electricity gets consumed (mostly by moving electric use for water heating to off-peak, overnight hours), reduce electric cooperative demand by an estimated 500 MW annually, saving consumers hundreds of millions of dollars. It was noted the thermal energy storage capabilities of electric water heaters can also "stockpile" wind power, which often reaches peak production overnight.

Out of the legislative fight, main elements of the efficient electrification movement emerged. Overlooked in DOE's metrics was the cost savings and emissions-cutting value of being able to heat water during off-peak hours. Storing energy in the water tank offered the potential, with additional controls, of ancillary services to the grid. And the generation that supplied the electricity was, year by year, becoming less carbon intensive as generation portfolios changed.

As a result, electric cooperatives moved the discussion to "electricity is good." Water heaters were rebranded as energy-storage devices and became the focus of community storage efforts. In turn, new alliances were formed. Environmental and clean energy groups like the Natural Resources Defense Council (NRDC) and the Regulatory Assistance Project (RAP) co-authored industry papers with electric cooperatives, questioning the math that seemed to favor fossil fuels for end-use applications, and directing attention to the virtues of using more electricity to lower overall greenhouse gas emissions.

Efficient Electrification Today

In its 2018 Annual Energy Report, EIA now forecasts a slightly-more-favorable average annual electric sales growth of 0.9 percent through 2050. Kilowatt-hour prices are expected to remain flat overall, with a 10 percent drop in generation costs due to the continued penetration of and falling costs for solar, wind and natural gas generation.

Meanwhile, The Brattle Group notes that even a modest upswing in end-use electrification will provide opportunities for electric cooperatives that include:

- Reversing flat or negative load growth
- Increasing value to consumers, opening new service opportunities
- Rebranding utility electric service as environmentally friendly and more consumer-focused.

A Complicated Proposition

For electric utilities with slow or declining kilowatt-hour sales, efficient electrification can be seen as a new take on an old concept—load building. Consumer advocates, in turn, may be drawn to the potential for savings when new electric technologies with lower operating costs replace less efficient ones (although they might balk at the resulting increased electricity sales—and higher electric bills). Environmentalists will focus on renewables and the impact of lower carbon emissions. Of course, utilities that lose commercial and industrial loads to third-party providers may not see the change positively.

The Brattle Group points out that accelerating end-use electrification faces hurdles on the policy and regulatory fronts. “The kinds of utility actions that facilitate electrification would boost electricity use at a time when regulatory incentives are focused on reducing electricity use, primarily through energy efficiency measures. Also, many of the investments needed to facilitate electrification may be beneficial to customers and society only when looking beyond the classic electricity sector. Put simply, electrification would increase customer electricity bills and electricity use, both of which could be viewed critically by the regulatory community if not understood in a broader context. Specifically, customers’ overall energy bills might tumble as a result, and society would benefit from lower greenhouse gas emissions.”

In June 2018, RAP published “Beneficial Electrification: Ensuring Electrification in the Public Interest” to help policymakers think differently about electricity. It sets out this simple definition: “For electrification to be considered beneficial, it must meet one or more of the following conditions without adversely affecting the other two:

1. Saves consumers money over the long run;
2. Enables better grid management; and
3. Reduces negative environmental impacts.”

Principles outlined by RAP suggest new ways of evaluating utilities in future policy decisions:

- **Recognize the value of flexible load for grid operations.** By being able to shift when power is drawn from the grid, the electric system can serve loads ranging from water heating to charging cars with power that is both cleaner and less expensive.
- **Understand the emissions impact of load changes.** Knowing the source of the generation used to power a device, and how that source may vary by time and place, reveals the emissions impact of an electrified end use.

- **Use emissions efficiency to measure the air impacts of efficient electrification.** Consumers may use more kilowatt-hours but still require less energy overall, at lower levels of pollution.
- **Design rates to encourage efficient electrification.** Time-sensitive pricing can encourage consumers to use power when it is cheaper and cleaner, while helping grid managers become more efficient with infrastructure.

Resolving Conflicting Instincts

For all the potential efficient electrification offers electric cooperatives, several internal obstacles must be overcome. Factions within the efficient electrification movement don’t always agree on whether to emphasize environmental or consumer benefits. In turn, the coalition is currently working to hammer out a load-building message that won’t cause unease among allies in the efficiency, consumer and environmental communities. They are also looking for ways to promote electricity over fossil fuels without alienating companies—sometimes even cooperative subsidiaries—that sell natural gas, propane and heating oil, or appearing to overlook natural gas as the dominant generation fuel source.

Finally, they are hopeful of getting electric cooperatives comfortable with including all types electric generation under the efficient electrification tent—coal, natural gas, nuclear, hydro, biomass, utility-scale wind and solar, consumer-owned renewable systems like rooftop solar PV or backyard wind, and energy storage—thermal or battery.

Advocates believe consensus will be reached. After all, the goal remains clear: making sure consumers choose electricity first to achieve an ever-more-electrified economy.

TIP ONE

Ways Cooperatives Can Expand Electricity Use

Proponents of efficient electrification note that new end-use electric technologies can rein in costs, improve energy efficiency and further lower grid emissions. However, in many instances, a compelling market seems to be missing.

Nationally, mini-split ductless air-source heat pumps have seen sales growth in excess of 10 percent annually in recent years, and some states with strong tax incentives are experiencing similar expansion in whole-house air-source heat pumps. But this progress has not been commensurate with the striking advances in efficiencies of these appliances over the last 20 years.

Despite creative marketing and new incentive programs (offering greater savings tied to the ability to better manage electric use based on grid conditions), heat pumps and water heaters face pragmatic barriers, the biggest being the low cost of natural gas. In rural areas where other heating fuels options are limited to propane, oil or wood, heat pumps can compete on cost—although that's only about 10 percent of the U.S. residential market. Even then, homes often need to be retrofitted with ductwork to accommodate a central HVAC system—an added expense.

Once in place, heating appliances last a long time. Replacement often does not result from a planned decision but one made hurriedly when a unit fails. Often, a homeowner opts for the familiar or "whatever is on the truck."

Arguably, a more compelling efficient electrification opportunity lies in charging electric vehicles (EVs). It's a potentially enormous market, as Americans currently buy more than 15 million new vehicles each year and replace cars, SUVs and pickups much more frequently than they do oil or gas furnaces.

There are currently about 750,000 EVs on U.S. roads, with sales rising. The Center for Automotive Research estimates that by 2030 roughly 20 percent of the North American transportation fleet will feature some form of electrification, with battery-only EVs comprising 6 percent to 9 percent of new vehicle sales annually.

What Are The Prospects for EVs in Cooperative Service Territories?

EVs, whether plug-in hybrids (PHEV) that rely on the combination of an internal combustion engine and rechargeable batteries for propulsion or all-electric (battery-only) models—will impact utility operations both in terms of electricity sales and accommodating an emerging demand for electric charging stations.

EV batteries (16 kWh and larger) are generally fully charged after 8 to 12 hours when connected to a regular 120-V outlet (Level 1 charging, up to 16 A) or more quickly (four hours) using a Level 2 (240 V, usually around 30 A) charging station. Fast-charging stations using AC current (Level 3, 240 V, drawing up to 96 kW) and high-speed DC chargers (at 480 V DC and up to 90 kW) can replenish fully depleted EV battery packs to 80 percent strength in approximately 30 minutes. Fast-charging stations are being deployed at public locations (e.g., airports, shopping centers and highway truck stops) around the country to address the growing demand for EVs.

Currently, the majority of EV buyers are college-educated, upper-middle income people living in metropolitan areas. Cooperatives with those demographics are the most likely to see members connecting EVs to their grids in the near term. But interest will expand as word spreads about the EV driving experience, battery range increases and the economics of "filling up" with electricity at the average cost of only $1.20 for the same miles delivered via a gallon of gasoline.

Electric cooperatives are taking action or developing programs to support the nascent EV market in the following areas:

- **Education.** This includes not just information but hands-on experience, including "ride-and-drives" of cooperative-owned EVs.
- **EV rates.** Shifting charging to off-peak hours and working on options for encouraging or ensuring that charging takes place at the appropriate time.
- **Support for charging.** Taking an active role in owning and leasing residential charging stations, as well as supporting providing information on equipment options and qualified vendors.

Examples of co-op programs in support of electric vehicles:

- **Establishing public EV charging stations.** Many electric cooperatives have installed what the industry calls EVSE (electric vehicle supply equipment) charging stations at their headquarters for the benefit of their members and the public at large. At least two generation and transmission cooperatives—Maple Grove, Minnesota-based Great River Energy and Raleigh, North Carolina-headquartered North Carolina Electric Membership Corporation (NCEMC)—have initiated plans for public EV charging station networks. NCEMC and its members have installed 30 EVSEs—both Level 2 and high-speed DC chargers (480 volt)—in 23 locations along underserved rural corridors and near state parks and other attractions. The G&T plans to expand the program to 100 charging stations by the end of 2019. Great River Energy and some of its members have installed charging stations in similar settings in Minnesota.
- **Rebates and financing.** At least five electric cooperatives—New Hampshire Electric Cooperative, Plymouth, New Hampshire; Gunnison County Electric Association, Gunnison, Colorado; Randolph Electric Membership Corporation, Asheboro, North Carolina; Wright-Hennepin Cooperative Electric Association, Rockford, Minnesota; and Lake Region Electric Cooperative, Pelican Rapids, Minnesota—are offering rebates of between $200 and $650 on consumer purchases of EVSEs. In November 2018, Holy Cross Energy in Glenwood Springs, Colorado, began providing free chargers and less than 3 percent financing on installation to members. Illinois Electric Cooperative in Winchester, Illinois, offers 0.6 percent member financing for an EV and EVSE.
- **Group purchasing for co-ops.** Today's Power, a subsidiary of the Electric Cooperatives of Arkansas (statewide), handles group purchasing of EVs from four manufacturers for electric cooperative fleets.
- **Testing EVs.** While many co-ops encourage members to take a look at cooperative-owned EVs, Gunnison County Electric Association of Colorado takes that a step further by letting members borrow either a Chevrolet Spark or a Nissan Leaf for a week of unlimited test driving at no cost.

TIP TWO

Meshing Efficient Electrification and Demand Response

For decades, federal and state policies have been built on the premise that to slash carbon emissions as well as utility bills electric use must be curtailed. But even hard-core climate change advocates are beginning to accept that's no longer the case. Studies over the past three years from a wide range of sources show that boosting electricity—especially replacing fossil fuels in end-use applications—directly correlates to lowering greenhouse gas emissions.

In a July 2017 report "Northeastern Regional Assessment of Strategic Electrification," the Northeast Energy Efficiency Partnership examines "how electrification can work with efficiency and clean electric supply to drive deep decarbonization." Pulling from a diverse set of stakeholders, "electric utilities, equipment suppliers, environmental and clean energy advocates, and auto manufacturers," the report details how states in the Northeast "are already taking actions that encourage electrification, including encouraging adoption of electric vehicles and recognizing the thermal value of heat pumps as part of renewable portfolio standards."

But a key to achieving the most dramatic gains in productivity, cost savings and emissions reduction entails maximizing the time(s) when electricity is consumed while still delivering desired productivity. In its 2015 study "The Economics of Demand Flexibility," the Rocky Mountain Institute claims that "in the residential sector alone, widespread implementation of demand flexibility can save 10 percent to 15 percent of potential grid costs, and customers can cut electric bills 10 percent to 40 percent with rates and technologies that exist today."

To reap benefits of efficient electrification, three major areas for improvement are outlined. First, utilities need to offer rate structures and control technologies to shift more electricity use to times of low market prices (off-peak periods) and high renewable supply (such as nighttime for wind power).

Second, regulations focused on conservation alone must be modified. In Minnesota, for example, all utilities, including electric cooperatives, are required to reduce kilowatt-hour sales by 1.5 percent every year as a means to reduce carbon emissions.

Third—and perhaps most important—stronger market drivers for end-use electrification must be adopted. These include incentives (from price signals to rebates) and greater consumer acceptance of electric technologies through a combination of pricing, operating costs and superior performance, or perceived value.

How Great River Energy Tackles Efficient Electrification

Great River Energy, a Maple Grove, Minnesota-based generation and transmission cooperative (G&T), and its 28 distribution cooperative members, have taken a lead in the efficient electrification arena.

"It's one of our board's key strategies and something we talk about all the time," says Jeff Haase, Great River Energy's leader of member technology and innovation.

For more than 30 years the G&T and its members have helped reduce wholesale power costs by shaving load during periods of peak demand through a demand-side management program. Today, it can shift up to 350 MW to off-peak hours through controls on appliances like electric resistance water heaters, electric thermal storage units, irrigation systems, heat pumps and air conditioners.

Great River Energy has also been a major player in wind power, which currently makes up 25 percent of the energy it sells to member cooperatives.

"We also believe there are batteries hidden in basements all across our service territory," points out Haase. "Overall, we can warehouse 1,000 MW of energy each night by controlling large-capacity (80 gallons or more) water heaters in 66,000 homes. When the wind blows or the sun shines large-capacity electric water heaters can be enabled to make immediate use of available renewable generation to heat water. The devices can then be shut down when renewables are scarce or wholesale prices climb."

Since 2005, Great River Energy has reduced carbon emissions by 37.5 percent through improved coal plant efficiency and coal plant retirements. In June 2018, the G&T established a goal of having 50 percent of its power supply mix come from renewables by 2030 and sees wind becoming the new "baseload" source of electricity.

Haase notes that with increasing amounts of wind and solar, utilities are grappling with the question, "Is there a better way to manage our load, to accommodate the variability of these resources? Traditionally, we have managed generation to meet load. Now, we're going to manage load to meet the generation. It's a real paradigm shift."

The G&T focuses efficient electrification on three strategies that work in concert:

- Building new load based on converting end-use equipment from fossil fuels to electricity,
- Ensuring that electricity uses are efficient, save consumers money and improve the emissions profile of the source and
- Finding ways to control and shape use of that electricity.

Haase says the G&T sees the greatest long-term potential in electric vehicles (EVs), which "offer a new way to engage with consumers and talk about electricity."

More than 1,000 EVs are connected across the G&T's system right now, with growth accelerating as the operating range of EV batteries exceeds 150 miles between charges. "The improvements in battery performance are reducing range anxiety and attracting buyers from outside the early adopter segment," Haase asserts.

In 2016, Great River Energy rolled out its Revolt program that allowed cooperative members who own, lease or purchase a plug-in electric vehicle or plug-in hybrid electric vehicle to charge their cars using 100 percent wind energy. The G&T achieves this by retiring renewable energy credits to cover every kilowatt-hour used, ensuring that every dollar spent on EV charging goes toward purchasing wind power.

"Consumers still pay standard or off-peak rates from their local co-op when they charge their vehicles," Haase points out. "But Revolt upgrades the energy to 100 percent wind energy at no additional cost. We were the first utility in the country to offer this kind of program."

Inroads are also being made on replacing fossil fuels in heating, particularly with newer cold climate air-source heat pumps. "They excel in the 'triple play' of saving money for the consumer, saving money for the utility and reducing carbon emissions during spring and fall," Haase explains. "When temperatures run between 10 degrees to 50 degrees Fahrenheit, heat pump efficiencies can exceed 300 percent. Fossil fuel heating systems, which experience a fair amount of cycling in this temperature range, see efficiencies slump below their typical 90 percent to 96 percent."

He adds: "The ideal temperature range for air-source heat pumps corresponds with relatively low system load and market prices, generally when wind reaches its highest capacity factors."

Challenges to Electrification

Haase contends EV growth may be constrained by infrastructure, especially if EVs are going to meet consumer expectations for charging that's competitive with the convenience and speed of filling a gasoline-powered car at a pump. While Level 1 and Level 2 charging stations take hours to fully charge an EV, high-speed DC chargers can "top off" a plug-in car in less than 30 minutes. Unfortunately, the high demand (50-kW draw) and low energy characteristics of DC fast chargers are concerns.

"The structure of traditional demand billing makes high-speed DC charging very difficult to defend," Haase comments. "For example, at a co-op with a general service rate that includes a demand charge component at 50 kilowatts, a DC fast charger used once a month will incur the demand charge, but will only generate 20 kilowatt-hours or so of energy. If the demand rate is $10 per kilowatt and the energy rate is 5 cents per kilowatt-hour, the total cost for that one session would be $501—with nearly all of the expense being associated with the demand component. It's the type of issue we're encountering in the buildout of EV charging infrastructure."

When it comes to converting existing space and water heating loads from fossil fuels to electricity, other constraints emerge, including a lack of consumer interest. "There's a lot of market potential for heat pumps," Haase remarks, "but people don't get as excited about using a heat pump as they do about driving an electric vehicle. Heat pumps and electric thermal storage units are not as competitive in the areas where natural gas is available."

One area of success entails piggybacking load management with community solar farms being built by distribution members. Steele-Waseca Cooperative Electric, in Owatonna, Minnesota, leveraged the popularity of its solar garden to attract more members to install 105-gallon electric water heaters. By giving a discount on the subscription price of a solar panel—$170 instead of $1,225—along with the installation of a free water heater, the co-op has enrolled one-third of its members into demand response, reducing peak demand costs by more than 20 percent.

NOTES

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March 2019