Electrify Everything

Why Electrify Everything?

Experts agree: electrifying everything that uses power is crucial to curbing the worst impacts of climate change. Electric motors are three times more efficient than internal-combustion engines at converting primary energy into useful work. “Electrify everything" has emerged as a simple, unifying principle in combatting the climate emergency while there is still time.

The widely respected report of 2020 by Intergovernmental Panel on Climate Change (IPCC) is clear: To avoid the worst impacts of climate change, the world must dramatically reduce its carbon emissions and prevent global warming from exceeding 1.5 degrees Celsius (2.7 degrees Fahrenheit). To achieve this, we must halve carbon emissions by 2030 and fully decarbonize by 2050.

Rapid electrification is the most effective, economical, and practical way to reach this existential goal. It relies on already well-developed technologies: rooftop solar, heat pumps, electric vehicles, wind and solar power plants, and storage batteries. If everyone uses carbon-free energy to heat their homes and get around, and if renewable fuel sources power all electric generation, the bulk of the problem will be solved.

Every time a natural-gas or oil furnace, or “baseboard” electric heating is replaced, it must be upgraded to a heat pump. Whenever a gas or diesel auto is replaced, it must be replaced with an electric vehicle (EV). Every time a new power plant is built, it must run on renewable energy.

From a jobs viewpoint, Rewiring America, a nonprofit working to launch a movement that electrifies everything, estimates that decarbonizing rapidly through electrification would create 15 to 20 million jobs in the next decade.

Massachusetts is one of the fastest-warming states in the country. We have seen a rapid increase in extreme heat events that threaten our health and the ecosystems we rely on. Rising seas and increased flooding threaten Boston and other coastal communities. Globally, climate change brings significant public health risks, including more and larger wild fires, stronger hurricanes, more heat-related deaths, and worse pandemics and other disease outbreaks. Millions of “climate refugees” are relocating to escape worsening environmental disaster in their home countries.

The Commonwealth has committed to tackle these threats. In March 2021, Gov. Charlie Baker signed a sweeping climate bill into law, signaling a new era in Massachusetts’ plans to cut greenhouse-gas emissions, build a greener economy, and prioritize equity and environmental justice (EJ).

The new law, S.9, "An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy," commits the state to reach Net Zero by 2050. S.9 addresses everything from solar panels and offshore wind to new building codes and state regulatory priorities. It codifies EJ language into law, improves gas-pipeline safety, and helps employees from the fossil-fuel industry advance in the clean-energy industry.

The Regulatory Assistance Project, an independent nonprofit organization, points to three criteria that electrification should meet to count as beneficial:

- Reduce harmful environmental impacts.
- Save consumers money over the long run.

- Enable better grid management.

These standards point to many candidates for electrification. Three of the most critical areas are buildings, transportation, and the grid itself.

Buildings

The Green Worcester Plan of 2020 reports that residential and commercial buildings account for about 40% of the city's overall emissions. Heating buildings alone is one of the largest sources of emissions in Worcester.

Worldwide, buildings account for 32% of energy use and 19% of greenhouse emissions. Buildings pull from natural-gas lines or the electric grid to heat, cool, and light the spaces within them, and to power appliances and machinery. But up to 80% of the energy consumed is wasted. For example, lights and electronics are left on unnecessarily, and gaps in a building's envelope allow air to seep in and out.

A broad swath of research concludes that the lowest-cost pathway to eliminate direct emissions from residential and commercial buildings is to electrify. Here electrification primarily means installing environmentally and economically sound electric heat pumps to replace combustion fuels for space and water heating, and conventional air conditioning.

Although the name can be confusing, an electric heat pump is essentially an air conditioner that is modified slightly so it can run in two directions, cooling the building in summer and heating it in winter. Heat pumps produce roughly half the emissions of burning natural gas in your home, and are even more efficient than fuel-oil heat.

Retrofitting the Built Environment

Much of the attention paid to green buildings is in new construction, but retrofitting the existing built environment – replacing old heating and cooling devices with new, energy-efficient, economical systems – ultimately improves the experience of being inside the building. Retrofitting starts by examining the systems that cool or warm inhabitants, how heat and cold are escaping or entering the building, and how spaces are illuminated. Yet of the world's 1.6 trillion square feet of extant building stock, a mere 1% is green.

Retrofitting older buildings, such as the thousands of triple-decker houses, and public and historic buildings in Worcester and other communities, can be challenging. It is common for owners of older buildings to not have proper documentation of how the building's heating and cooling systems operate. Incomplete blueprints and missing manuals make it difficult to get a holistic view of how the various machines and sensors are working together, if at all. One solution to this challenge is to recreate the entire documentation on-site.

Retrofitting is a well-understood practice, and good building performance data is making it increasingly effective. For example, a recent retrofit of New York's iconic Empire State Building will cut energy use by 40% and avert 105,000 tons of greenhouse gas emissions annually. Depending on the building, the average payback on retrofits is five to seven years.

Distributed Internet of Things (IoT) assets – "smart" thermostats, water heaters, pool pumps, lighting systems, building-management systems, and countless other devices – are being deployed in homes, buildings, and factories across the globe. These assets play a critical role in keeping the power system balanced by providing flexibility when and where it is needed. They will also enable innovative utility companies to achieve new revenue streams and ways of diversifying. To accomplish this convergence, utilities themselves will need to upgrade and digitize their information and operational systems.

Transportation

Transportation is the largest source of greenhouse gas emissions in Massachusetts (42% of emissions as of 2016), with motor vehicles accounting for most of those emissions. According to the Carbon Free Boston 2019 report, the electric motors propelling electric vehicles (EVs) are three times more efficient than internal-combustion engines at converting their energy sources into motion.

As a report from the World Economic Forum, Electric Vehicles for Smarter Cities: The Future of Energy and Mobility, makes clear, we are at the start of a mobility revolution. By 2040, more than half of new cars sold in the world will be EVs, though the U.S. remains far behind Europe and China.

Our grandchildren will look back at the gas-guzzler the way we associate horse-drawn carriages as something we see only in movies. In the future, virtually all of us will refuel not at gas stations but at EV battery-charging stations, and more and more in the convenience of our homes and workplaces without the need to drive to a charging station.

Electric pickup trucks and buses are becoming more and more popular. Reducing GHG emissions from heavy-duty trucks is a bigger challenge, but these vehicles are just over the horizon in a big way. As gas and diesel vehicles in car and truck fleets reach their end of life, they should be replaced by electric vehicles.

In 2019, air travel produced about 1 billion tons of CO_2 – 2% of global emissions. Electric air travel presents many technical, economic, and regulatory hurdles, but pioneering innovators, including major plane builders like Boeing and AirBus, are working to get e-planes off the ground.

Cargo ships belch almost as much carbon into the air each year as the entire continent of South America. According to one study, a midsize cruise ship can emit as much particulate as one million cars. Modern sails could have a surprising impact.

Electrifying the transportation system will foster national security, energy independence, and a healthier environment. The same cannot yet be said of combustion fuels. No matter how efficient a gasoline-powered car gets, it can't eliminate carbon emissions.

EVs as Grid Assets

Due to its intermittent nature, wind- and solar-generated electricity requires fast-responding backup generators, which are fueled most often by natural gas. EVs represent a significant opportunity to bring more renewable energy onto the grid by managing and leveling those periods of intermittency.

In effect, EVs can be grid assets – batteries on wheels. One EV can store as much as three days' worth of a typical home's energy usage. EVs can charge up on cheap energy from the grid when the wind blows and the sun shines. They can discharge that energy back to the grid during periods of peak, high-priced demand. When aggregated and connected to the electricity grid, EVs collectively mimic a fast-responding backup generator – a very clean and quiet one.

We Need a Shared Vision of Mobility

Simply electrifying transportation will still leave us with congestion and a system that does not meet the needs of a large portion of the population. To address the transportation question adequately, investments not just in electrification, but also in public transit, pedestrian, and bicycling amenities must be considered.

Beyond that, we can look at advancing ways to reduce the need for travel at all, such as telecommuting and redesigning our urban environments to be more conducive to non-powered transit. We must view these systems holistically and aim to address some of the problems that won't be solved by electrification alone.

A Path to the Zero-Carbon Grid

In the developed world, most consumers get their power from the electricity grid. When it is connected to a grid, everything that runs on electricity is, in carbon/climate terms, only as clean as the grid. This has profound implications: As long as we are reducing carbon on the grid, every single electrical device is getting cleaner throughout its life.

Consider two home-heating systems, a natural-gas or oil furnace and a heat pump that runs on electricity. The fossil-fuel furnace's rate of carbon emissions is basically fixed by its design. It will emit the same level of carbon emissions per unit of heat throughout its, say, 20-year lifespan. Over the same 20 years, the power grid, from which the heat pump draws its electricity, will get cleaner – less coal, more renewables. That means the heat pump's carbon emissions per unit of heat will decline throughout its life. Its environmental performance improves as the grid improves. The same is true for autos. An internal-combustion engine vehicle will emit roughly the same level of carbon emissions per mile throughout its decades of life.

Electrification will decarbonize only if there is ample and affordable clean energy on the grid to feed the growing demand. If all buildings, vehicles, and industry were suddenly electrified via today's grid, emissions actually would increase in the short term. This is because, depending where you live, the electricity grid isn't that clean. More than a quarter of energy in the U.S. still comes from coal.

But the grid is not static. The electrify-everything movement is about anticipating and preparing for a clean-energy future. Appliances that households and businesses buy today will be around for the next 10 to 30 years. In that timeframe, the grid will become much cleaner.

Energy conservation must also grow. With the world population projected to reach 10 billion by 2050, resources required for the batteries and other technologies that make it possible to electrify everything will be limited. Fortunately, battery technology is advancing at light speed. Reducing energy consumption is first achieved by simply using less of a service, especially where that service itself is frivolous, wasteful, or not benefiting people. After all, the least polluting, least expensive megawatt-hour is the one that is not generated.

The Value of Distributed Microgrids

More than 40% of Americans live in a state with goals for 100% clean-energy, net-zero, or carbon-neutrality. Getting there will be complicated, given that utilities are tasked with ensuring accessible, reliable, affordable electricity to rate-payers. "Microgrids" can become a key part of achieving these seemingly incongruent goals and obligations.

A microgrid is a local energy grid with control capability: it can disconnect from the traditional grid and operate autonomously. A microgrid consists of energy generation and energy storage that can power a building, campus, or community when not connected to the conventional electric grid, e.g., in the event of a disaster.

Microgrids have obvious benefits in powering critical resources, such as hospitals, in the event of planned or unplanned outages of generation or transmission assets. In addition, renewable sources of generation, such as solar and wind, don't require transport of fossil fuel, which may be restricted during a disaster.

To understand how a microgrid works, first consider how the grid works. The grid connects homes, businesses, and other buildings to central power sources, enabling us to have – even expect –

electric power 24x7 without fail. But this interconnectedness means that when part of the grid needs to be off-line for repairs – both planned and unplanned, i.e., disaster-caused – everyone is affected.

This is where microgrids can help. Microgrids generally operate while connected to the grid, but importantly, can break off and operate on independently using local energy generation in times of crisis, such as hurricanes. Microgrids can be powered by distributed renewable resources like solar, wind, or batteries, or by conventional generators.

As the grid uses more and more solar and wind, one challenge grid operators may face comes at especially sunny or windy times. At these times, renewables may generate more power than the grid can use, or they may generate only a fraction of the demand. To absorb the variable nature of renewables, the grid needs ways to smooth out those swings. One way is "dispatchable load," power consumption that can be scheduled, such as industrial production. This approach draws more energy in times of peak energy generation and releases clean power back to the grid during the valleys.

Learn more at How to drive fossil fuels out of the US economy, quickly.