The Path To Zero

Propane's Role in a Low-Carbon Future

By Tucker Perkins

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Do you remember the song "Saved by Zero" by the Fixx? It came out in 1983 and peaked on the pop charts at #20. It wasn't a smash hit by Billboard standards, still, it did pretty well because it had a remarkably memorable robotic-like tune and an intriguing central idea in the lyrics. A bit of clicking is all it took to find out what the lyrics meant. The idea of being "Saved by Zero" had to do with having nothing to lose. When you have nothing to lose, your head is clear, your panic and fears evaporate, and so in the song, Zero is celebrated as a nirvana-like destination. Even 37 years later, we can learn a thing or two from an '80's new wave song. Today, the world is searching for another zero—a zero-carbon future and we're doing so because we recognize we actually do have something to lose.

Let's agree: The dramatic and negative effects of climate change, driven by increasing carbon dioxide and methane (the biggest contributors) in the atmosphere, are a serious challenge. Most of the scientific community agrees that humans are putting too much carbon up into the air, and even with the massive convulsion and subsequent estimated 8 percent global reduction in emissions projected this year because of the COVID-19 pandemic, the world is still on a problematic track. If you can agree to that, can you work with me on a few more ideas?

BELIEF #1: THE PATH TO ZERO REQUIRES ADDITION AND SUBTRACTION

Climate change conversations are often locked into a subtraction frame of mind.

Well-meaning and very bright people argue that we have to remove all carbon-emitting energy sources and replace them with nothing but perfectly clean alternatives in order to save ourselves. But getting to a low or zero-carbon future cannot just be a subtraction problem.

Transportation, for example, makes up a little over 20 percent of all global carbon emissions. Even if every form of transportation, from battery-powered airplanes to electric-powered trains and propane-powered cargo ships, were completely carbon-free, we'd still have another 80 percent of the carbon dioxide produced in the world going up into the atmosphere. Every day, the world's demand for energy is enormous, and growing.

Seaver Wang, a climate and energy analyst at the Breakthrough Institute said it very nicely in an article he wrote a few months ago. He said, "the real challenge for curbing climate change is both subtractive and additive—namely, replacing existing fossil fuels while providing enough new clean power to meet greatly increased future demand. It's the additive challenge—the difficulty of meeting energy needs of tomorrow that dwarf those of today—that will overwhelmingly decide whether our future is low-carbon."

How do we get to a zero-carbon emissions future if we have to add and subtract at the same time?

Here's what we believe at the Propane Education & Research Council (PERC): Fuels aren't binary. They're not just clean or dirty, good or bad. They exist on a continuum, we'll call it the carbon continuum, from very clean to very dirty.

Let's agree that solar and wind are pretty clean energies once they are produced. If you take out the habitat effects of hydro-electric power, we can say it's on the cleaner end of the continuum as well. Geothermal energy while limited in its ability to scale is pretty clean as well once in production.

Let's also go ahead and call it what it is by saying coal, oil and wood are dirty when they burn, so they're on the other end of the carbon continuum. Regarding the latter, wood burning in the form of biomass facilities is dirtier than proponents would like to talk about because in

order to operate with efficiency, many wood-powered biomass facilities harvest living trees—carbon-capturing factories in themselves—to stoke their electric generation systems, so that form of energy production presents us with a double-whammy.

From a carbon standpoint, natural gas is pretty clean, so it sits closer to the renewables end of the continuum. Now, natural gas has its own problem. It is methane, and methane is a greenhouse gas just like carbon dioxide, only it's more than 80 times more potent than C02. Once in the atmosphere, it absorbs sunlight like a sponge. Still, when it comes to carbon emissions, methane is cleaner than most. You might be surprised to know that propane, made when methane is purified for commercial use, takes its place on the carbon continuum close to the renewables as well, which is why the EPA has designated propane a clean energy alternative and why it is also designated a clean energy alternative under the Energy Policy Act of 1992.

Now if you agree with the carbon continuum, then can we also agree that using less dirty energy and more clean energy is a good thing. It's not quite that easy. Not all energy is equal when it comes to dirty versus clean. To get into our subtraction/addition math, we need to dive into the conversation another layer deep by thinking about what it takes to make energy, to use energy, and the waste that is created in the process—in other words—the life-cycle of energy, often called a "full fuel cycle".

What's more, renewables have their own full cycle draw backs. Both wind turbine blades and solar panels are very difficult and energy-intensive to recycle—and both have limited service life-spans. At present, dealing with these materials at the end of their useful life unfortunately means filling up landfills. All of these trade-offs mean we should appreciate any energy that adds more than it subtracts.

At the "making" end of the equation and to get to zero, we need energy that is made well. Here's a surprise to many: When methane is purified into natural gas for residential and commercial use, propane is one of the exceptionally useful by-products. It's also worth mentioning that propane is American-made all over America. It is transported in delivery trucks, so nothing is lost in the transfer from the production site to the use locations. In fact, to get one unit of energy at the use end of the process, from propane, the input required is 1.01 units of raw energy. Electricity, no matter how it's made, requires 3.03 units of raw energy to be made and pushed through power lines to get 1 usable unit of power, which means a centralized power plant producing electricity is, at best, about 40 to 50 percent efficient, accounting for the power lost in transit. In 29 states, consuming one unit of electricity produces at least twice as many carbon dioxide emissions as consuming one unit of propane.

BELIEF #2: A PERFECT ENERGY DOESN'T EXIST

This brings us to the second thing PERC believes: If a perfect energy existed, it's likely we clever human beings would have found it. Instead, even the world of renewables has its limitations and they are, unfortunately, unequivocal.

Solar arrays can't convert more photons than the sun provides. Turbines can't extract more energy than exists in the kinetic flows of moving air. Batteries are bound by the physical chemistry of the molecules chosen. These constraints are real and measurable through formulas like the Carnot Efficiency Limit, the Betz Limit for wind, and the Shockley-Queisser Limit for solar.

What's more, renewables have their own full cycle draw backs. Both fiberglass composite wind turbine blades and the photovoltaic glass in solar panels are very difficult and energy-intensive to recycle—and both have limited service life-spans. At present, dealing with these materials at the end of their useful life unfortunately means filling up landfills.

Batteries made to store electricity are made of rare-earth minerals like cobalt and lithium, which is mined in desperately poor countries, often in abhorrent conditions, leaving the land and surrounding habitat much worse for the wear. Hydroelectric power plants suffer equally challenging drawbacks. The diversion of whole river systems into a hydro plant blisters habitat and ecosystems with myriad problems. Nuclear, once thought to be a panacea, now is known to have scary side effects, the most passive of which comes in the form of spent fuel rods that stay with us for tens of thousands of years. All of these trade-offs mean we should appreciate any energy

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that adds more than it subtracts.

Let's talk again about transportation energy. In the last five years, PERC has engaged in a number of discussions with fleet owners about conversion of their vehicles from gas or diesel to propane. To their credit, emission considerations are now as important as range and payload to these owners. In Acadia National Park, for example, the National Park Service has used propane-powered buses for many years to ferry passengers to different locations in the park because cars, and all the challenges they bring (emissions, parking lots, etc.), are not welcome. Mammoth Cave in Kentucky does the same.

Paratransit buses in many communities are now powered by propane because they deliver on the payload and range requirements, offer a low cost of operation in terms of fuel price and reduced maintenance, and deliver emission reductions of more than 50 percent compared to gasoline or diesel. It's no wonder companies like Nestle Waters and UPS have made propane-powered vehicles an important part of their sustainability investments.

Trains and tractor trailers—high horsepower vehicles—aren't typical applications, but new Class 8-ready propane engines have a place in the journey toward a zero-carbon world. They produce power, torque and thermal efficiency well beyond diesel engine performance. You can get more excited about this by knowing that the engine produces 11 percent less CO2 than the very best diesel engine, and carbon-capture science is evolving rapidly to improve upon this number.

Hybrid vehicles—propane paired with electric—in Las Vegas taxi cabs make up a large part of that fleet. The same will be true for the official car for the Tokyo Olympic Games.

All of this is possible with conventional propane—and there's more. We've also worked for some time on the question of renewable propane.

For several years, PERC has been committed to finding a renewable source. The bar we set for ourselves was that the fuel had to come from an inexpensive and abundant feed stock, it had to have low carbon intensity, it had to deliver a

high-energy conversion so BTU's aren't wasted, and finally, it had to be price competitive. We've done it.

We can, in partnership with bio-diesel refineries, produce pro- pane from animal fats and cooking oils before they are made into bio-diesel. These products used to be landfilled without regard. Now, they have new life in an extended way. What our research has found is that renewable propane has an ultra-low carbon intensity—it can be as low as 19 whereas conventional propane has a carbon intensity of 77. Agricultural by-products, biomass for example, will likely provide us with the ability to make renewable propane at scale.

Like all the others discussed earlier, propane isn't a perfectly clean energy. When it burns, carbon dioxide and water are produced and released into the atmosphere, but for the same reason forklifts can operate in closed warehouse spaces without issue, the volume is substantially lower than traditional engine fuels, and that's worth appreciating.

You'll continue to see us innovate in renewable propane and in blended fuels. California, in fact, is leading a worldwide study to measure the carbon intensity of different fuels with propane, renewable propane and Dimethyl Ether (a synthetically produced gas alternative to diesel for use in specifically designed compression ignition diesel engines) all in the mix.

BELIEF #3: ON BALANCE, GOOD SHOULD CONTINUOUSLY OUTWEIGH BAD

The idea of mix is a good one. Even if we're forced to add and subtract at the same time, isn't is reasonable to agree that we ought to feel like we're doing more good than harm? The path to zero means we should replace more bad while we add more good to the energy grid. Carbon, however, isn't the only problem.

Particulate matter—tiny particles of chemicals, soil, smoke, dust, or allergens, in the form of gas or solids—is a serious challenge as it adds to ground-level air pollution we call smog. Smog is dangerous because it penetrates the lungs and bloodstream and worsen bronchitis, asthma and has been linked to increases in heart failure. With propane, particulate matter emissions are virtually zero when used in our most modern engines.

Nitrogen dioxide and nitric oxide are referred to together as NOx. NOx gases form whenever combustion occurs in the presence of nitrogen—e.g. in car engines. They are also produced naturally by lightning. NOx reacts with sunlight to form smog and is central to the formation of particulate matter and ground-level ozone. NOx is bad news, but here's good news: With a simple three-way catalyst, propane reduces NOx in engines by 96 percent compared to a best-in-class diesel counterparts. Our best propane-powered engines certified to the ultra-low NOx standard of .02 operate at half that rate through a full duty cycle, even in stop-and-go applications like delivery trucks or school buses.

Propane puts us on a positive path toward a low carbon future because it's chemically cleaner than other fuels. The Global Warming Potential (GWP), a measure of how much energy the emissions of 1 ton of a gas will absorb over 100 years, of carbon dioxide is 1. CO2 is the baseline reference gas used by the EPA for this measurement. The GWP of unburned propane is 4, methane is 36, NOx is 298, and for CFC's and a handful of other gases, the GWP is in the thousands or tens of thousands. This means propane, relative to other energy sources, is cleaner right from the start. It's not zero, though, so we have to keep working.

At some point in time, however, the cost of crushing the corona virus has to be borne by the reduction of investments in other areas. Energy subsidies are a likely target because there is little political downside. We simply cannot live our lives at the standard we expect without the energy to power daily living, and so we will be willing to pay for it.

Here's just one thing we could do: If we converted all the school buses in the country from diesel to propane, we would save enough money in fuel and maintenance costs to hire 23,000 new school teachers, and protect the planet. Georgia State University did a study that found children who ride to school in low-emission

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propane-powered buses attend school more days. Childhood asthma is a real problem for young lungs, and teachers tell me routinely that children who ride on propane-powered buses come to school calmer and ready to learn. Bus drivers have far fewer headaches than when operating a diesel bus and tell me they no longer have breathing issues themselves. Drivers talk about their buses as being cleaner, quieter and cheaper and it's no wonder. Diesel exhaust is considered a human carcinogen that causes lung cancer and increases the risk of bladder cancer. To improve the safety of work environments, the American Federation of State, County and Municipal Employees recommends replacing diesel-fueled engines with propane-fueled engines where possible. This is a lot of good, and there's more to like:

- Propane-powered school buses produce up to 22 percent fewer greenhouse gas emissions, 24 percent fewer nitrogen oxide (NOx) emissions, and 44 percent fewer sulfur oxide (SOx) emissions compared to gasoline-fueled school buses.
- Propane-powered school buses using new low-nitrogen oxide (NOx) engines produce 95 percent fewer NOx emissions than comparable diesel-fueled school buses and 88 percent fewer NOx emissions than comparable gasoline-fueled school buses.
- Propane-powered vehicles have a lower total cost of ownership than comparable electric-powered, gasoline-fueled, and diesel-fueled vehicles.

BELIEF #4: GOVERNMENT INVESTMENT IS VANISHING

The entire energy industry up to now—solar, hydro, wind along with big oil and coal, all of us—have long received government subsidies in the form of investment tax credits. According to the Energy Information Administration, in 2016 (the most recent year for which complete data is available), the federal government spent just shy of $14 billion in energy subsidies and support. Renewables made up $6.7 billion of that and fossil fuels got about $500 million. Those investments have allowed renewables to become a big part of the energy mix in the U.S., and that's a good thing to know as we move toward a zero carbon ideal.

COVID-19, however, is creating more than just healthcare havoc. It's likely by the end of 2020, the U.S. government will have committed more than $3 trillion to fight the disease. We can all agree this is an investment worth supporting, especially in the wake of the devastating loss of life so many American families have suffered. At some point in time, however, the cost of crushing the coronavirus has to be borne by the reduction of investments in other areas. Energy subsidies are a likely target because there is little political downside. We simply cannot live our lives at the standard we expect without the energy to power daily living, and so we will be willing to pay for it.

At the same time, it's reasonable to assume private investment dollars may swing away from oil, now selling at historic lows, to energy sources capable of reassuring consumers and business who fear power outages.

This is a great opportunity to see the nexus between sources like solar, wind and propane. In states like California where widespread power shut-offs to prevent wildfires have affected more than a million customers, resilient, grid-independent energy is experiencing substantial growth. The flexible form-factor of propane storage makes it a perfect tandem energy source for both residential and commercial users; even for those with limited space around a building. Storage container flexibility is also important to those who want reliable energy that doesn't destroy habitat when installed or pose a toxic release hazard. Propane is a great answer to both of these concerns. A 500-gallon tank can hold enough propane to meet energy needs of an average single-family home for an entire year and if a release did occur, propane vaporizes into the air with virtually no impact to ozone.

The bans [fossil fuels] cannot help but ride on top of a false premise—that the electricity flowing out of every outlet is produced by zero-carbon sources. That's not our reality—100 percent electrification does not automatically translate to decarbonization.

To achieve a zero-emission energy grid, one estimate says a massive fifteen-fold increase in clean energy investment will be needed every year going forward to meet increased energy demand

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and reduce carbon emissions. In the wake of COVID-19, that investment money in the cleanest possible energy is going to be very hard to find. At the same time, capital constraints have the beneficial effect of reminding us we can use the choices at our disposal today that allow us to add while we subtract.

BELIEF #5: NOTHING AND ZERO AREN'T THE SAME

Just a few weeks ago, I listened to a story on NPR radio about the city of Tacoma Park, Maryland. The report focused on the city's consideration of a ban on fossil fuels—no gasoline, no heating oil, no natural gas. The proposed ordinance would require switching all appliances to electric, but of course, the source of the electricity at present is likely coal or natural gas. City staff estimated that the requirement proposed could run "between $1,500 and $4,000 for the least efficient homes and that new appliances could cost between $15,000 and $25,000 spread out over time." Not even a good song from the Fixx could make these numbers more palatable if you're the one being presented with the bill.

Bans like these presume that using the energy choices we have today to move toward a low carbon future is essentially the same as doing nothing. We're out of time. It's not enough. We all don't get it. The bans cannot help but ride on top of a false premise—that the electricity flowing out of every outlet is produced by zero-carbon sources. That's not our reality—100 percent electrification does not automatically translate to decarbonization. It's not even Tacoma Park's reality. Its own website says its electricity, supplied by Standard Pepco, "is generated from over 55 percent coal and natural gas, leading to 930.6 lbs of CO_2 per MWh of electricity created."

When you hear the price tags and the all-or-nothing rhetoric attached to stories like this, you can feel people digging in their heels, can't you? It's one thing to be pro-planet. It's a different thing to be told you'll be the one to pay thousands of dollars to reduce the effects of climate change.

The attraction to zero is understandable. When the concept of zero was invented around 500 AD by Hindu mathematicians, it immediately made the whole numbering system clear—something Roman numerals couldn't achieve. Clarity is a wonderful thing, but when it forces us into either/or conversations, it's not helpful. Where do debates like Tacoma Park's leave us on the path to zero? In most cases, people—especially elected officials—wear themselves out fighting with one another over all-or-nothing propositions. This leaves us with nothing accomplished, no progress, and no movement forward.

We don't have to accept nothing. The path to zero means we can, and we should, do something. We can choose from among the clean energy alternatives we have right now and begin to make our way toward a low carbon future.

I understand many people will take exception with the beliefs articulated in this piece. I also believe many, many more want to make progress toward a low carbon world as a waypoint to a zero carbon future. I invite everyone reading this to join the journey. Our industry can be a useful contributor along the way. We can add insight and goodwill while we subtract together.