

# Propane Microgrids for Decentralized Power

**Tucker Perkins, President & CEO**  
**Propane Education & Research Council**

**February 2025**





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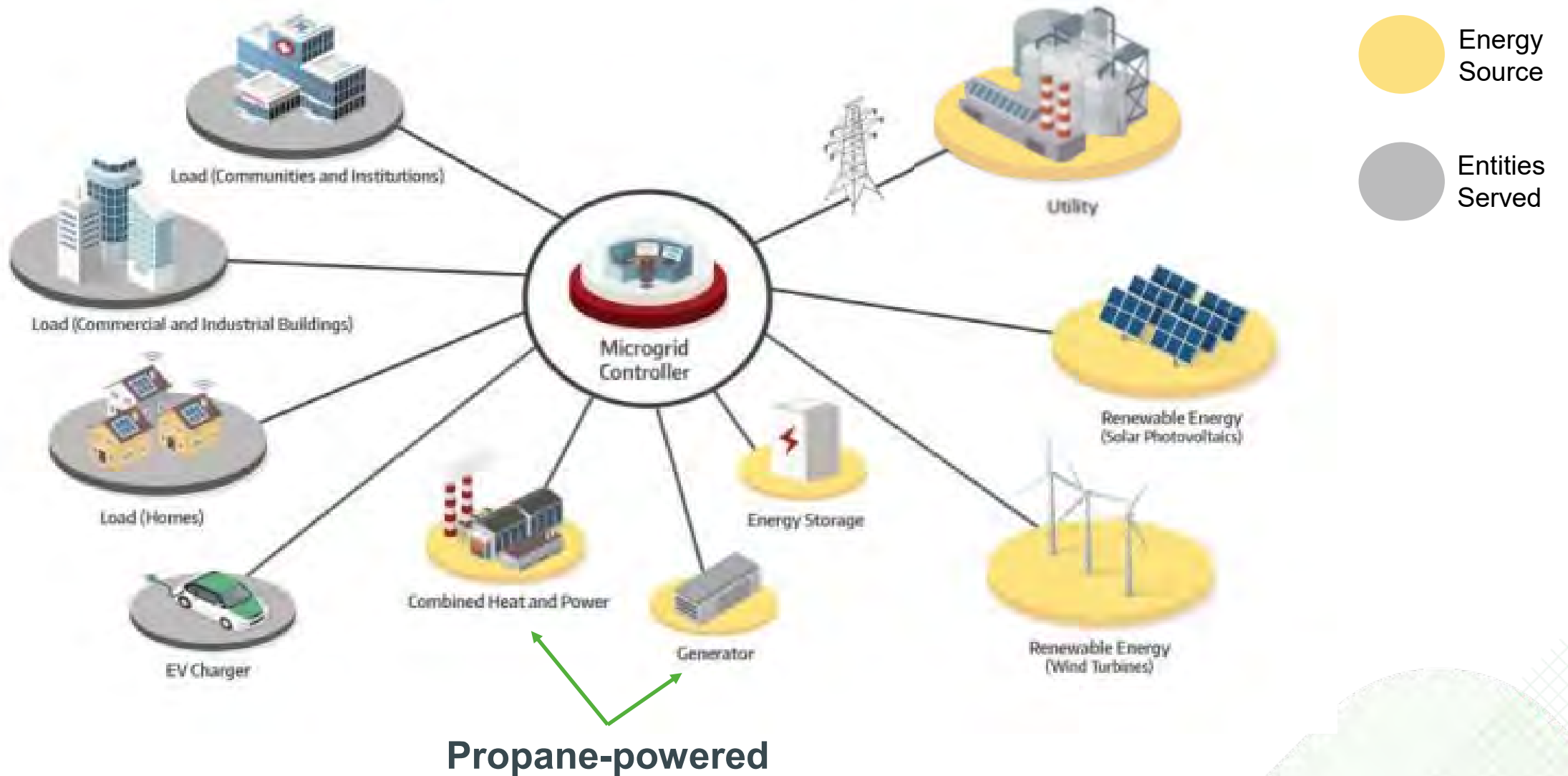
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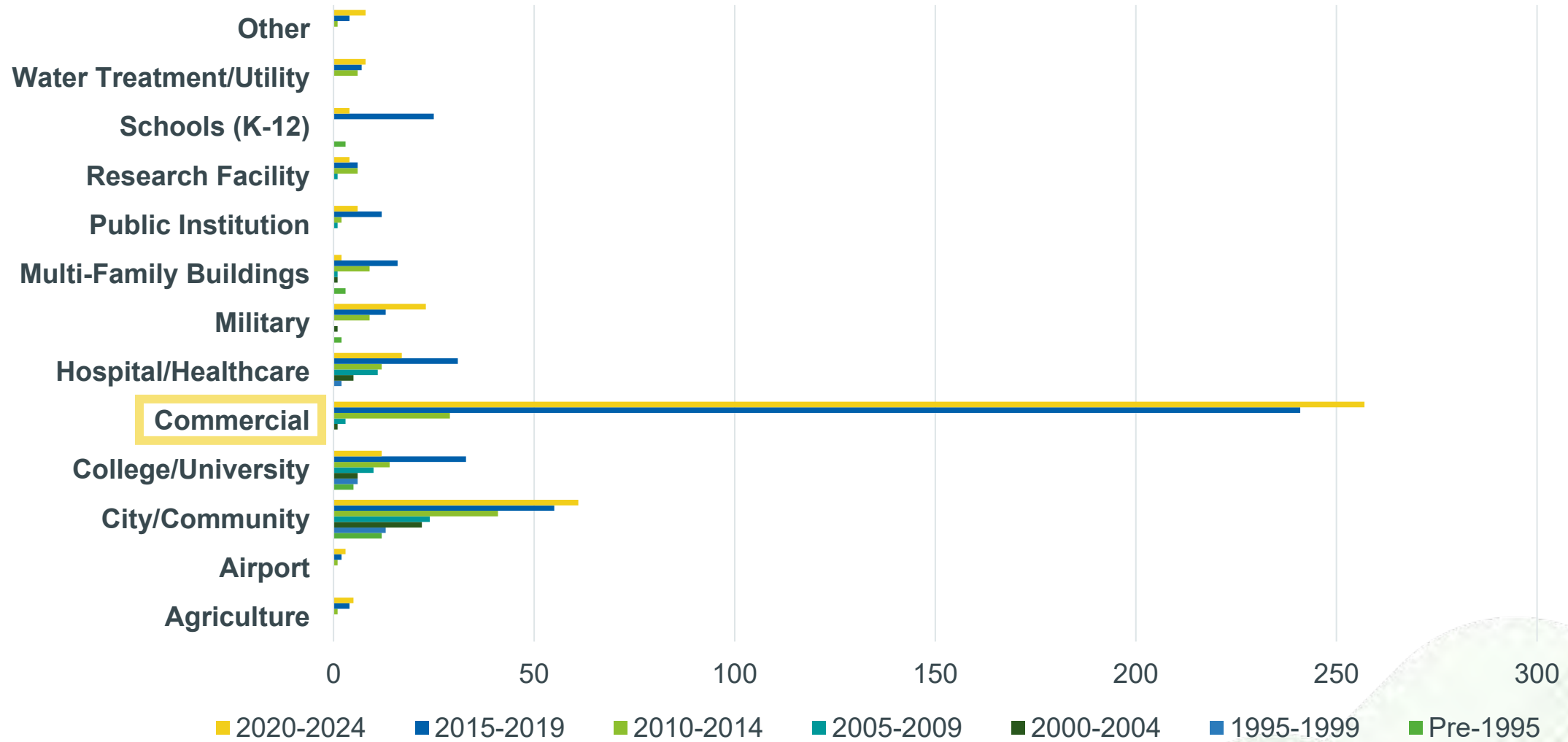
# What is a Microgrid?





# U.S. Microgrid Growth

Microgrid Count 1995 - Aug 2024





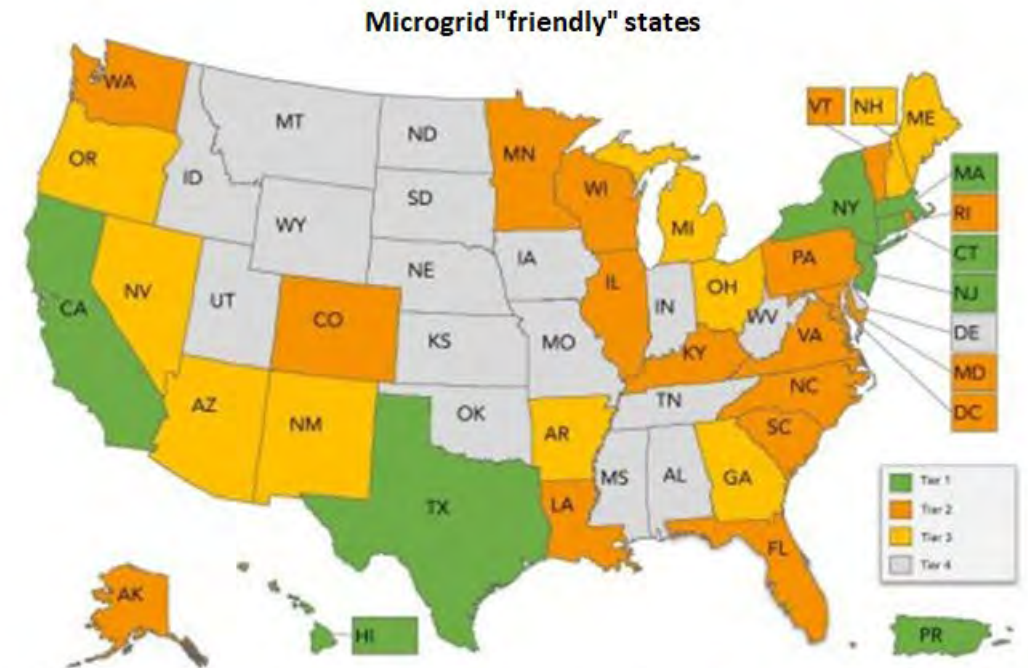
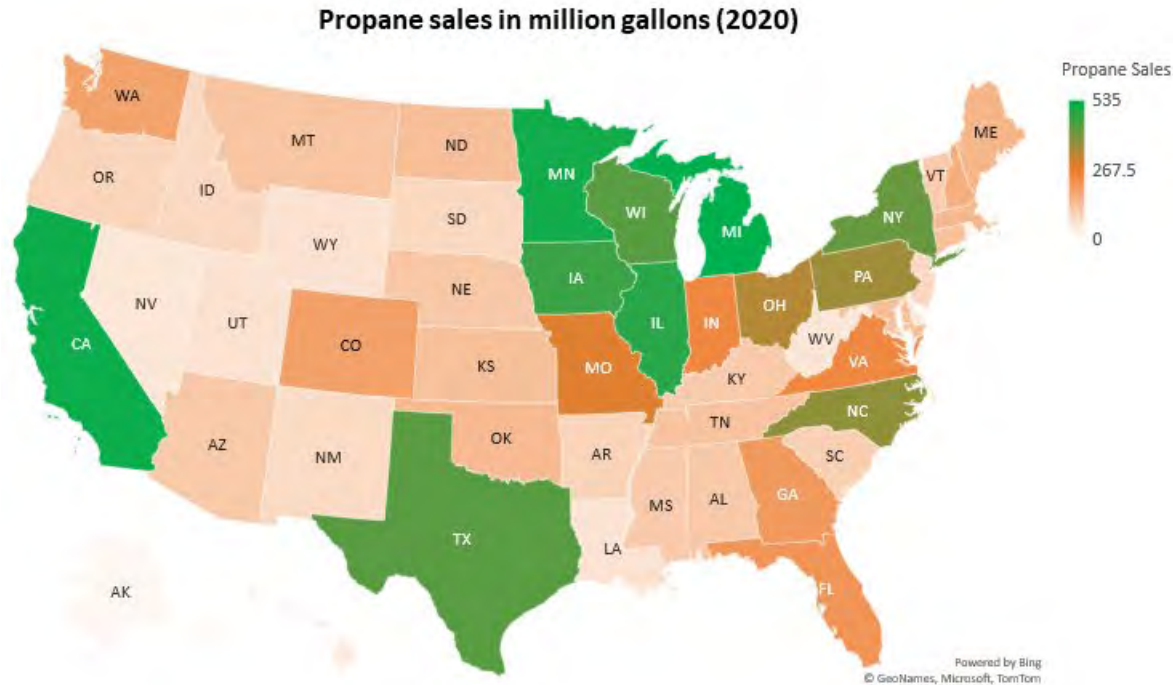




# Kahauiki Village Honolulu, HI



# Opportunity for Propane



Terrific alignment between the leading states for both categories

# Learn More!



April 2021

## The Opportunity for Propane in Microgrids

By Dr. Gokul Vishwanathan  
Director of Research & Sustainability  
Propane Education & Research Council

### Introduction

Microgrids and distributed energy resources play a critical role in enabling renewable energy market penetration, reducing electricity transmission and distribution (T&D) losses (which average 5% in U.S.), providing resilience and partial or total independence from the electrical grid. Typically, microgrids are composed of kilowatt (kW)/Megawatt (MW)-scale solar-PV system, kilowatt-hour (kWh)/Megawatt-hour (MWh)-scale battery energy storage (4-6 hours discharge capacity) and a backup generator system or a backup fuel cell system; operating with hydrogen, natural gas, propane, diesel, gasoline or other suitable fuels. The backup generator provides an immediately dispatchable firm resource needed for microgrids as the capacity factor for solar and wind is roughly only 30% and Lithium-Ion (Li-Ion) battery storage systems are uneconomical beyond 4-6 hours of discharge capacity. Backup generators have a critical role and are powered today with conventional fuels but will be steadily displaced by drop-in replacement renewable fuels in the future. These act as the firm resources until long duration energy storage systems, such as flow batteries for example, become economical and commonplace in the future. Firm and dispatchable resources are needed to balance microgrids and avert blackout situations such as those experienced in Texas, Louisiana, California, and other states. Recently, the state of New Jersey granted \$4 million for studying detailed microgrid designs as part of its ongoing Town Center Distributed Energy Resources Microgrid Program. Interestingly, the board has allowed the use of fossil fuel generators in microgrids for ensuring resilience<sup>2</sup>. In places where a natural gas pipeline is not available, diesel is used for backup engine generators. Propane, on the other hand, is easily transported and is the best low carbon fuel choice compared to diesel. Also, since most propane engines are stoichiometric or rich burn engines, emissions control is typically achieved using a three-way catalyst, which results in very low nitrogen oxide (NOx) emissions compared to diesel engines. Propane also does not contain any aromatics (e.g., benzene) or polycyclic aromatic hydrocarbons (PAHs) and since it is a low carbon alkane, it produces less particulate matter or soot than diesel. According to recent research at Oakridge National Laboratory (ORNL), much of the soot formed from propane

1. <https://www.energy.gov/eere/transportation/2018-09-13/2018-09-13-ORNL-REC-2018-09-13>

engines could be attributed to the lubricant oil rather than fuel

Figure 5(a-c) show the unincitized breakdown of the annualized costs of the hybrid microgrid with the baseline diesel generator, propane COTS generator and propane SOFC generators systems. In all these cases, all the other components of the micro-grid (viz. PV, battery, converter, and balance of plant) were all assumed to be identical. Figure 6 shows the associated impact on the unincitized levelized cost of electricity (LCOE) for all the above cases.

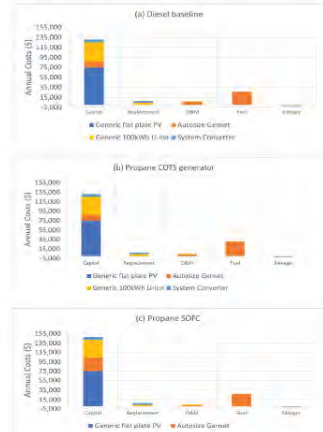


Figure 5: Unincitized annualized costs for the hybrid microgrid with (a) Diesel generator (b) Propane COTS generator, and (c) Propane SOFC generator systems

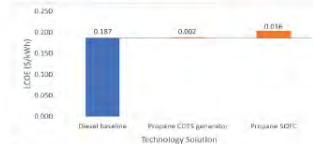


Figure 6: Unincitized LCOE of the hybrid microgrid system with different generation systems

28. <https://www.energy.gov/eere/transportation/2018-09-13/2018-09-13-ORNL-REC-2018-09-13>

As can be seen from the figures, a hybrid microgrid with the propane COTS generation solution is competitive to the backup diesel system. The slightly higher fuel costs with propane, due to the lower propane generator efficiency (35%) compared to diesel generator (39%), is equally balanced by the lower operations and maintenance (O&M) costs of the propane generator to yield the same levelized cost of energy (LCOE) as the Incumbent diesel solution. The fuel cell solution, though the most efficient (40%), leads to a higher LCOE (~9% higher than the baseline diesel solution) due to its higher capital cost.

### B. Environmental Benefits

As earlier, emissions of NOx, CO, CO<sub>2</sub>, and HC for the baseline diesel system without an exhaust after-treatment system are available from Homer QuickStart. The engine-out NOx, CO and HC emissions factors of the propane COTS generator were taken from the Department of Energy CHP e-catalog for the Martin Energy Group MEG S450P-Hw system<sup>3</sup>. It is noted that this package is also available with lower emissions factors but with a penalty in fuel conversion efficiency.

Figure 7 shows the exhaust CO<sub>2</sub> emissions for the different generation systems. As can be seen, the COTS propane generator system leads to ~4% reduction in CO<sub>2</sub> emissions relative to the diesel generator, while the propane SOFC system can lead to ~16% reduction in CO<sub>2</sub> emissions.

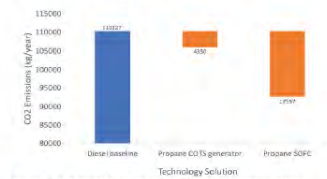


Figure 7: Tailpipe CO<sub>2</sub> emissions for different generation systems

Table 6 shows the engine-out NOx, CO and HC emissions for the baseline diesel generator and COTS propane generator systems, both without exhaust after-treatment systems. In terms of criteria pollutants, the propane engine-out emissions are significantly lower for NOx (~63% lower) and CO (~40% lower) but higher in HC as compared to the diesel generator (diesel generator is ~90% lower in engine-out HC emissions). Engine-out HC emissions can be effectively mitigated via the use of an oxidation catalyst, which will be required in all these engines. In addition, the incremental cost of adding exhaust after-treatment systems such as urea-selective catalytic reduction (SCR) for NOx mitigation, oxidation catalysts for CO and HC mitigation, urea consumption costs and exhaust after-treatment controls are assumed the same between the diesel and propane generation systems and hence the LCOE should be comparable. Table 6 also provides projected tailpipe-out emissions and projected tailpipe-out emissions factors for the criteria pollutants assuming a 90%



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## The Opportunity for Propane in Microgrids

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resilience<sup>2</sup>. In terms of commonly used fuels, propane, or liquefied petroleum gas (LPG) falls in a sweet spot between hydrogen, at one end of the spectrum, and gasoline and diesel, at the other end of the spectrum. This sweet-spot, or tradeoff, is characterized by the liquid energy density, carbon to hydrogen ratio (C/H) of the fuel and ease of liquefaction. Table 1 shows this tradeoff between the various fuels in terms of liquid energy density, C/H and ease of liquefaction, transportation, and storage. For each category, green represents the most desirable property, yellow to the tradeoff and red is undesirable. As can be seen, propane or LPG is the only system that offers the best tradeoff in terms of ease of liquefaction, transportation and storage, while having a reasonable energy density and low C/H.

As shown in the table, though propane is gaseous at standard conditions, it is easy to liquify without the necessity of cryogenic infrastructure. Ammonia could be easily liquefied as well, like propane, and is carbon free but ammonia is produced by Haber-Bosch process using hydrogen, which in turn is obtained from steam methane reforming (SMR) using natural gas (in the U.S., about 95% of the hydrogen is produced by SMR). In addition, ammonia has a lower energy density. From a C/H ratio standpoint, propane falls in between hydrogen (H<sub>2</sub>) or Ammonia (NH<sub>3</sub>) and diesel (D). Interestingly, as noted before, much of the hydrogen is currently being produced via SMR. This landscape may change if "green" hydrogen is produced from water electrolysis by using electricity generated purely from renewable sources. Natural gas has a lower C/H ratio as compared to propane but is a potent greenhouse gas and needs stringent infrastructure to liquify. Currently, from an economic standpoint of the customer, the usage of propane makes sense in areas where there is no supply of natural gas and/or reliable supply of electricity. Hence, propane currently occupies a sweet spot for immediate reduction in carbon emissions using low-cost infrastructure for its transportation goals can be achieved by utilizing propane without any additional costs to the customer.

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# The Opportunity for Propane in Microgrids

In this paper, the Propane Education and Research Council presents two case studies illustrating the benefits of using propane generators in hybrid microgrids. First, they look at use of propane generators in light commercial applications, specifically a community housing development in San Diego, California. They compare test results from a generic diesel backup generator, an off-the-shelf propane generator, a combined heat and power (CHP) engine generator, and a propane solid oxide fuel cell. They then present findings from a large commercial operation in Mammoth Lakes, California.

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# Discussion Q&A

# Thank You

## Tucker Perkins

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