Clean Backup Generation

By John Benson

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1. Introduction

In the post “California Dreamin’ about H_2” (linked below), I suggested that hydrogen fuel depots that will be required for hydrail systems (hydrogen-fueled commuter rail transit systems) in California, could also serve a fuel depots for other nearby applications. At the top of this list of these applications was replacing emergency backup generation that use diesel engines with hydrogen-fueled generation.

https://energycentral.com/c/ec/california-dreamin%E2%80%99-about-h2

This post is a brief description of current California diesel regulations, information about the current fleet of large diesel backup generation in California, and a couple of large corporations that starting the transitions away from diesel backup generation.

2. Current Regulations for Diesel Backup Gen-Sets

These regulations are complex and there are multiple layers of them. First there are regulations from the U.S. Environmental Protection Agency (EPA) and then (in my case) there are those from the California Air Resources Board (CARB). Since the latter regulations are stricter, I will mainly draw the information below from these.

2.1. CARB Large Diesel Backup Generator Requirements

The main regulation for Back-up diesel generation is: *Amendments to the Airborne Toxic Control Measure for Stationary Compression Ignition Engines.* This is linked below:

https://ww2.arb.ca.gov/sites/default/files/classic//diesel/ag/documents/finalreg112807.pdf

The above regulation covers a wide variety of applications for large stationary diesel (compression ignition) engines, but the application we are concerned with is an "Emergency Standby Engine,” and this is specified in the above linked document in § 93115.4(a)(29) and others. This engine:

> *(A) Is installed for the primary purpose of providing electrical power or mechanical work during an emergency use and is not the source of primary power at the facility; and*
>
> *(B) Is operated to provide electrical power or mechanical work during an emergency use; and*
>
> *(C) Is operated under limited circumstances for maintenance and testing, emissions testing, or initial start-up testing, as specified in sections 93115.6(a),(b), and (c); or*
>
> *(D) Is operated under limited circumstances in response to an impending outage, as specified in sections 93115.6(a),(b), and (c); or*
>
> *(E) Is operated under limited circumstances under a demand response program (DRP) as specified in section 93115.6(c).*

"Emergency use" is further defined as loss of electric power or natural gas supply to a facility, or failure of the internal facility power distribution system.

There are other emergency use definitions, but these appear to be either using the engine as a prime mover, or other specialized functions, not backup power.

Also defined elsewhere as an emergency use per this regulation is an electric utility Public Safety Power Shutoff (PSPS) event or a grid emergency. The latter events are extremely rare, although we do have "flex alerts" when reserves are low. I don't believe these qualify as emergencies per CARB regulations.

2.2. California Air Districts

California's 35 local Air Districts are responsible for regional air quality planning, monitoring, and stationary source and facility permitting. The districts administer air quality improvement grant programs and are CARB's primary partners in efforts to ensure that all Californians breathe clean air.

These districts may have additional requirements for large stationary diesel engines. A link to list of these is below.

https://ww2.arb.ca.gov/california-air-districts

2.3. Small Diesel Backup Generation

CARB's Airborne Toxic Control Measure (ATCM) for Stationary Compression Ignition Engines (Stationary Engine ATCM) establishes emission limits and operational restrictions for stationary ***compression-ignition engines rated at greater than 50 brake horsepower (bhp)****. Portable engines, as defined by the Stationary Engine ATCM, and spark-ignition engines are not subject to the requirements of the Stationary Engine ATCM...*[1]

CARB's Portable Diesel Engine ATCM establishes requirements for portable diesel engines, including "Emergency-use Engines..."

Small off-road engines, such as those used in small generators (under 50 bhp) sold at retail stores, are required to be certified by CARB to be able to be sold in California. CARB does not establish in-use restrictions for such certified engines, and small generators are generally exempt from air district rules…

Note that I'm not going to drill down any further into actual requirements for the large diesel backup generation as I didn't find any useful summary of these. These rules are very complex. The above linked regulation is over 60 pages long, although I didn't find it difficult to follow given my limited use. Reference 1 below gave me some useful guidance via footnotes.

2.4. Number of Large Backup Diesel Generators

California has a dirty little secret.

The vast majority of California's backup power generators… located at internet server farms, hospitals, police stations and other facilities – are powered by diesel. The state

[1] California Air Resources Board, "Use of Back-up Engines for Electricity Generation During Public Safety Power Shutoff Events," https://ww2.arb.ca.gov/resources/documents/use-back-engines-electricity-generation-during-public-safety-power-shutoff

wants to achieve a 100% clean energy future, investing billions of dollars in renewable energy, while at the same time steadily building a fossil fuel powered shadow grid.[2]

In addition to carbon dioxide emissions, diesel releases significant amounts of particulate matter, volatile organic compounds, nitrous oxides and sulfur dioxide. These pollutants create smog and exacerbate respiratory illnesses, such as asthma, chronic obstructive pulmonary disease and lung cancer, especially in children and older adults…

As the state deals with a mega-drought, rapidly escalating electricity rates and wildfire-related power shutoffs, California businesses and residents are increasingly turning to backup power generators to keep their lights on and servers running.

According to a study by MCubed that relies on data collected from the Bay Area Air Quality Management District, the number of nonresidential backup generators in the Bay Area jumped by 34% in just three years. In Southern California, deployment of backup generators rose by 22% in only one year, according to South Coast Air Quality Management District data. Ninety percent of the generators are powered by diesel. In these two districts alone, backup power generators have the capacity to produce up to 12 gigawatts, equal to 15% of the capacity of the entire California grid.

The key with backup generation is that its capacity factor should be extremely low (I would guess, less than .01 (1%). if it is only used as described above. Capacity factor is the annual generation of a power plant (or fleet of generators) divided by the product of the capacity and the number of hours over a given period. In other words, it measures a power plant's actual generation compared to the maximum amount it could generate in a given period without any interruption. With an extremely low capacity factor, the annual pollution from a modern diesel should also be very low.

Large mission-critical facilities that need backup generation, are almost all located in urban and suburban areas, and our power here (I live in the suburban San Francisco Bay Area) tends to be very reliable. PSPS events are also almost unknown here. The one event that could be somewhat common is (E) in section 2.1 above – demand response. I believe that these events are limited as to the number of times per year that they can be used (maybe in the range of 10 times per year).

The next question is, how effective are the California Air Districts at enforcing the above regulations? I would guess that this varies from district to district, but the urban and suburban districts are probably at least a bit better.

2.5. Plans to Sunset Diesel Backup Generation

I spent quite a bit of time searching for any plans by California governmental bodies to retire diesel backup generators at any specific date, and didn't find any such plans. I would guess that this is because the average net GHG (and other pollutant) emissions per year from this source are pretty tiny compared with other sources, like:

- Diesel-electric locomotives
- Heavy diesel-powered trucks

[2] Cindy Chavez, CalMatters, "Clear the air of diesel generators that power California's shadow grid," Oct 6, 2021, https://calmatters.org/commentary/2021/10/clear-the-air-of-diesel-generators-that-power-californias-shadow-grid/

- Cars and light trucks (especially older ones)
- Wild-fires
- Merchant marine shipping
- Residential natural gas/LPG heaters (especially older ones)

And so on. It should be noted that California does have active programs to mitigate almost all of the above sources (I haven't seen anything on the last bullet yet).

I would guess in the next few years we will start to see proposals to phase out diesel standby generation, and thus this post. Meanwhile, many corporations are setting goals for net-zero GHG emissions, and starting the process of phasing out diesel standby generation (see next section).

3. Leading Corporations Phasing Out Diesels

Honda *announced today that it plans to install a new hydrogen-power generator at its corporate campus in Torrence, California, in 2023. Serving as a proof of concept for the future commercialization of the generator, it will offer zero-emissions backup power to the facility's data centers.*[3]

The new initiative will leverage Honda's existing knowledge in hydrogen fuel cells that it learned in the production of the Honda Clarity Fuel Cell vehicle. Moreover, it will also use components from the Clarity in a four-quad parallel stationary fuel cell power generation system that's capable of generating up to 1,152 kW-DC/1MW-AC from an inverter.

The design was chosen because, as the name suggests, it uses four-cell units that can be organized in a number of different orientations. Depending on where a potential future customer wants to install the generator, it can be organized like a big square, like an L, or like a Z.

In a worldwide first that could jumpstart a long-forecast clean energy economy built around the most abundant element in the universe, hydrogen fuel cells have powered a row of datacenter servers for 48 consecutive hours, ***Microsoft*** *announced Monday.* [4]

The feat is the latest milestone in the company's commitment to be carbon negative by 2030. To help achieve that goal and accelerate the global transition away from fossil fuels, Microsoft is also aiming to eliminate its dependency on diesel fuel by 2030.

Diesel fuel accounts for less than 1% of Microsoft's overall emissions. Its use is primarily confined to Azure datacenters, where, like at most cloud providers around the world, diesel-powered generators support continuous operations in the event of power outages and other service disruptions.

[3] Sebastien Bell, CarScoops, "Honda Will Install A Hydrogen-Powered Backup Generator At Its California Campus," March 15, 2022, https://www.carscoops.com/2022/03/honda-will-install-a-hydrogen-powered-backup-generator-at-its-california-campus/

[4] John Roach, Microsoft Innovation Stories, "Microsoft tests hydrogen fuel cells for backup power at datacenters," July 27, 2020, https://news.microsoft.com/innovation-stories/hydrogen-datacenters/

“They are expensive. And they sit around and don’t do anything for more than 99% of their life,” said Mark Monroe, a principal infrastructure engineer on Microsoft’s team for datacenter advanced development…

In recent years, hydrogen fuel cell costs have plummeted to the point that they are now an economically viable alternative to diesel-powered backup generators.

“And the idea of running them on green hydrogen fits right in with our overall carbon commitments,” Monroe said.

What’s more, he added, an Azure datacenter outfitted with fuel cells, a hydrogen storage tank and an electrolyzer that converts water molecules into hydrogen and oxygen could be integrated with the electric power grid to provide load balancing services.

For example, the electrolyzer could be turned on during periods of excess wind or solar energy production to store the renewable energy as hydrogen. Then, during periods of high demand, Microsoft could start up the hydrogen fuel cells to generate electricity for the grid.

Hydrogen-powered long-haul vehicles could pullup at datacenters to fill their tanks.

“All of that infrastructure represents an opportunity for Microsoft to play a role in what will surely be a more dynamic kind of overall energy optimization framework that the world will be deploying over the coming years,” said Lucas Joppa, Microsoft’s chief environmental officer.

The above Microsoft article points out several advantages of fuel cells over diesel backup generators (other than the obvious). The image below is the hydrogen storage tanks that were used for the above pilot.

4. Cost of Hydrogen / Generation Infrastructure

As with battery energy storage systems, decreases in costs for the title systems will be driven by mobility deployments and the shared volume, economies of scale and declining costs drive by these. For large backup power systems as described above these will be mostly driven by three long-term trends. The first will be deployments fuel cell electric buses as will be mainly used in long-range (coach) applications. The second will be replacement of diesel-electric train-locomotives with fuel cell electric locomotives, and the third will be the evolution of centralized backup power systems currently using

diesel gen-sets to distributed backup power systems in large facilities, especially data centers. There is a fourth option for facilities directly replacing diesel gen sets in the near future. This section will explore these trends.

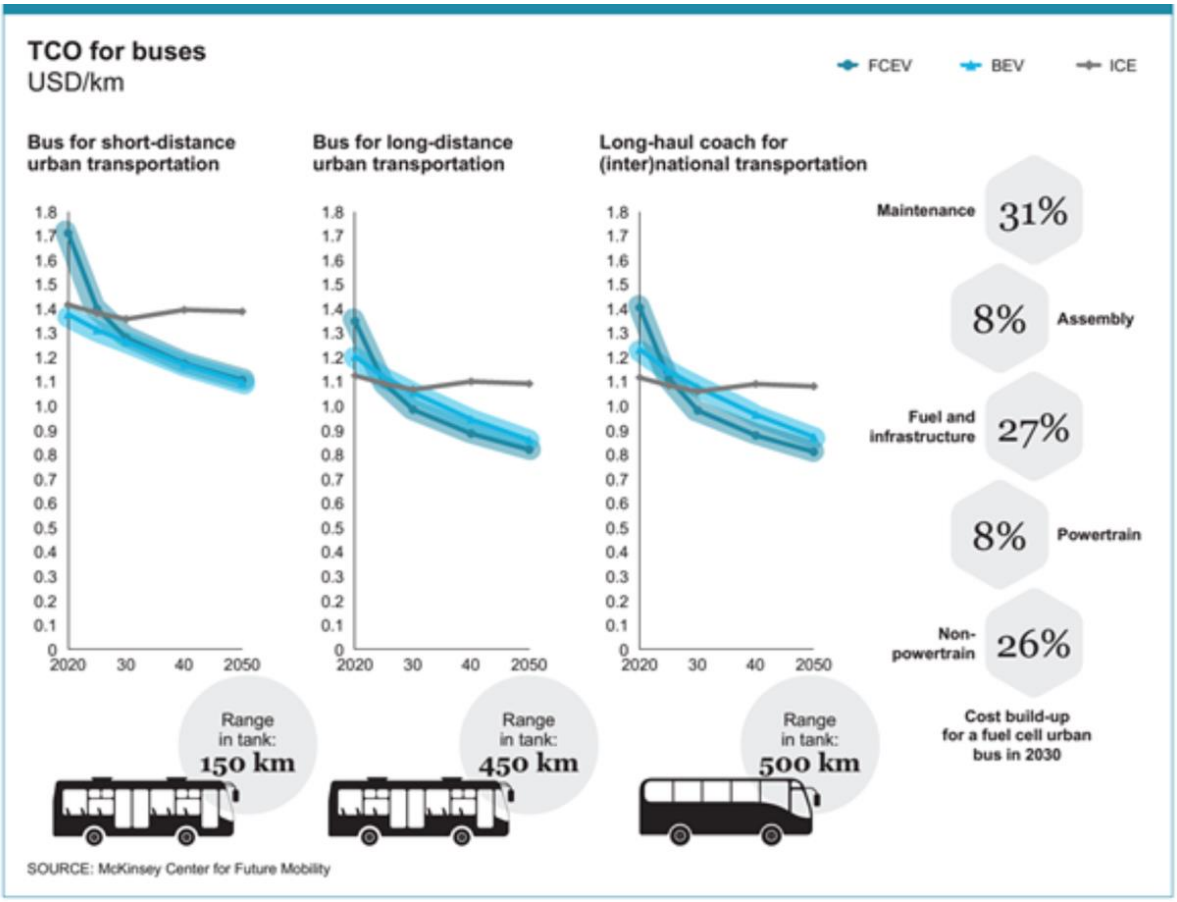
4.1. Fuel Cell Electric Buses

There are several applications for large buses. Most daily routes run by U.S. transit agencies are relatively short, and this market will be dominated by battery-electric buses, at least in the short-term. The longest routes are run by inter-city applications, and the buses used for these are commonly called coaches.

Today, in certain locations, fuel cell electric buses offer a total cost of ownership (TCO) on par with battery electric buses. The buses in the H2Bus Project in Europe are among those with the lowest TCO for zero-emission vehicles in a number of regions. [5]

Additionally, the recently published Deloitte-Ballard report, Fueling the Future of Mobility and the McKinsey study published by the Hydrogen Council projected it will be less expensive to run a fuel cell vehicle than a battery or diesel vehicle within the next 10 years.

See the chart below for the trends observed by this report:



[5] Nicolas Pocard, Ballard Blog, "Fuel Cell Price to Drop 70-80% as Production Volume Scales," Feb. 11, 2022, https://blog.ballard.com/fuel-cell-price-drop

I'm guessing that large facility fuel-cells will benefit from the technology used by buses and thus provide economies of scale, particularly in trends seen in last subsection below (distributed fuel cells).

4.2. Fuel-Cell Powered Locomotives

Rather than describing this application I will send readers to an earlier post that describes in detail. This post is described and linked below. Sections 2 and 3 contain the information.

Hydrail: *In July of last year I posted an update on California's various rail projects, including our High-Speed Rail (HSR, under construction, first segment is planned to be operational before 2030), and the Northern California and Southern California commuter rail systems that are planned to connect to the HSR.*

The one word title of this post is an abbreviation for Hydrogen Rail, and I found much information about this subject for this post.

https://energycentral.com/c/ec/hydrail

4.3. Distributed Facility Fuel Cells

Although the discussions below apply to any large facilities, it is particularly applicable to large data centers, as they use large amounts of power and are particularly sensitive to average electric costs.

One major issue with the diesel back-up power facilities used by most facilities (outside of the obvious emissions) is that they can only be used for backup power, testing and emergency grid demand response (at least in California). Thus they sit unused for 99% of the time.

A fuel-cell back-up power system can be used for the above functions, plus for offsetting peak-power prices.

Also, the fuel cells can be moved closer to their loads, reducing the amount of extra distribution wiring required. Hydrogen storage tanks will probably be outside (see above picture), somewhat distributed and connected to the fuel cells via fairly thin tubing.

Green hydrogen can be generated on-site by electrolyzers using renewable electricity delivered by the grid (or locally produced), and the generation can use minimum-price electric energy for the lowest green hydrogen cost.

4.4. Direct Replacement of Diesel Gen Sets

Hydrogen will probably be the fuel if existing diesel gen sets are replaced with a non-polluting source, but the generation method may be via an aero-derivative turbine rather than a fuel cell. For large facilities that are well into their lifetime, and there is no other reason for a major electric distribution system upgrade, it may be cost effective to replace the building housing the diesel gen sets with a nearby building with aero-derivative turbine gen sets. The latter are already available in versions that can burn 100% hydrogen, and although they are probably less efficient than fuel cells, they are a proven technology and probably significantly less expensive. See the paper linked below, section 2.

https://energycentral.com/c/gn/reasonable-transition