

SPE-177308-MS

Environmental Benefits of Electric Powered Hydraulic Fracturing

J. M. Oehring, U.S. Well Services

Copyright 2015, Society of Petroleum Engineers

This paper was prepared for presentation at the SPE Eastern Regional Meeting held in Morgantown, West Virginia, USA, 13–15 October 2015.

This paper was selected for presentation by an SPE program committee following review of information contained in an abstract submitted by the author(s). Contents of the paper have not been reviewed by the Society of Petroleum Engineers and are subject to correction by the author(s). The material does not necessarily reflect any position of the Society of Petroleum Engineers, its officers, or members. Electronic reproduction, distribution, or storage of any part of this paper without the written consent of the Society of Petroleum Engineers is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of SPE copyright.

Abstract

The electric well stimulation fleet has shown great advances in environmental responsibility. The use of electric equipment reduces refueling traffic and has eliminated over 400 diesel deliveries to date. Emissions are reduced by over 99%. Fire risk is significantly reduced with some fire hazards being completely eliminated. The average sound pressure is reduced by 69% on the site. Electric powered hydraulic fracturing is an important step towards conducting well stimulation in a more environmentally responsible manner.

Traditional hydraulic fracturing fleets are powered by over twenty large diesel engines providing up to 2,500 BHP each. These environmental benefits are achieved by removing all diesel engines from a hydraulic fracturing site and replacing them with mobile turbine engine generator units. Then a fleet can be run completely on electric power. This technology was first deployed in 2014 in the Marcellus shale formation in West Virginia, and is the first fully electric, fully mobile well stimulation system completely fueled by natural gas.

The fleet generates electric power with three natural-gas-fueled turbine engine generators at 13,800 volts (V). The power generated by the turbines then runs through switchgear and is stepped down to 600 V using transformers. At this point, the electric fleet is similar to a conventional hydraulic fracturing fleet, except that all the fleet's diesel engines and transmissions are replaced by electric motors and variable frequency drives. Pumps, blenders, hydration, data van, and sand equipment are also all completely electric powered.

Introduction

In July 2014, the first fully electric, fully mobile hydraulic fracturing fleet completely fueled by natural gas was deployed in West Virginia for the Marcellus Shale (see [Figure 1](#)). While a conventional diesel engine fleet can be powered by over twenty large diesel powered engines of up to 2,500 brake horsepower (BHP) each, the electric fleet removes all of the diesel engines for cleaner and safer operations. The electric hydraulic fracturing fleet is composed of natural gas fuel and compression equipment, power generation equipment, power distribution equipment, and stimulation equipment. The electric fleet has significant environmental benefits over diesel powered fleets. It reduces refueling traffic, emissions, fire risk, and sound levels.



Figure 1—Electric powered hydraulic fracturing fleet in West Virginia

Electric Powered Hydraulic Fracturing Fleet

The electric fleet is completely fueled by field gas that is supplied off of a pipeline. Three large compressors boost the natural gas pressure to a constant 300 psi as required by the turbine engines (see Figure 2). Combined, the compressors provide up to 3 MMscf/day for the mobile power units.



Figure 2—Gas compressors for the turbines

The fleet uses the natural gas to fuel three mobile natural-gas-fueled turbine engine generators (see Figure 3) to generate electric power. Each one produces 5.67 megawatts electric (MWe) of three-phase power at 13,800 volts (V) for a total of 17.01 MWe output at ISO conditions. Each mobile power unit consists of two trailers. The turbine engine and generator sit on the first trailer while the electric equipment room (EER) rides on the other trailer (see Figure 4).



Figure 3—Three mobile turbine generators with natural gas filtration units



Figure 4—Turbine Engine and Generator Trailer and Electronic Equipment Room Trailer

The power generated by the turbines then runs through a set of three switchgear trailers (see Figure 5). The switchgear trailers distribute the electricity, provide circuit breakers, and establish safeties in the equipment, such as ground fault detection.



Figure 5—Switchgear for the electric powered hydraulic fracturing fleet

The power then leaves the switchgear and is stepped down to 600 V using multiple transformers (see Figure 6). Each transformer is a dry cast coil type rated for 3500 KVA.



Figure 6—Step down transformers

At this point, the electric powered fleet is similar to a diesel fleet, except that all of the fleet's diesel engines and transmissions—more than 20 of them—are replaced by electric motors (see Figure 7) and variable frequency drives (VFDs). The electric motors were designed specifically for oilfield operations and protect against overheating with more copper and increased cooling to protect the motor and extend its life.



Figure 7—Electric motors replace diesel engines on the electric powered hydraulic fracturing fleet

The electric fleet has eight dual hydraulic fracturing pump trailers that all run on 600V power. Each is rated at 3,500 hydraulic horsepower (HHP) for a total of 28,000 HHP. The dual pump hydraulic fracturing units have two independent triplex pumps (see Figure 8). On a conventional diesel powered unit, a large radiator typically sits on the gooseneck. On the electric pump units, the large radiator is removed, and in its place sits a VFD house which hold two independent VFDs. Each pump can run separately or together. In addition to the electric pumps; blenders, hydration, data van, and sand equipment are all also completely electric powered and run on 600V three phase electricity.

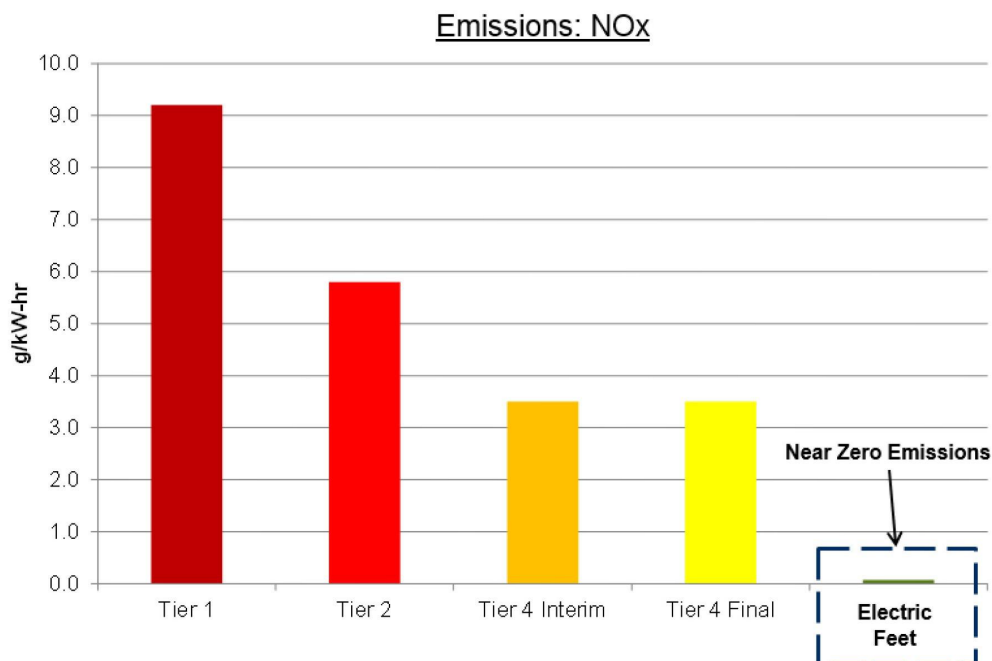


Figure 8—Dual hydraulic fracturing pump trailer, 3500 HHP

Reduced Emissions

The most notable environmental benefit of the electric powered fleet is reducing emissions to near-zero levels. The fleet is successfully decreasing emissions by 99 percent, mitigating environmental exposure to pollutants such as nitrogen oxides (NO_x) (see Table 1). Excess NO_x can lead to acid rain and contribute to unhealthy ground-level ozone and smog. The reduction is primarily achieved by eliminating the conventional diesel engines and using natural gas as a fuel. The emissions on the turbines were measured in the exhaust ports by a third party, and the NO_x levels were found to be less than 0.036 grams per kilowatt hour (g/kW-hr). This is a dramatic reduction when compared to Environmental Protection Agency (EPA) requirements for off-highway diesel engines.

Table 1—Emission levels for diesel engines and the electric fleet



Natural gas is a cleaner fuel than diesel, and it produces fewer potential pollutants. Natural gas turbine engines also allow for a continuously burning combustion chamber that results in a more complete burn, which greatly reduces emissions when compared to a diesel engine's four-stroke cycle. The gas turbines have a significant advantage because they use lean-premixed combustion technology to ensure a more uniform air and fuel mixture and to prevent the formation of regulated pollutants. Up to 60 percent of the airflow on the turbine engine is allowed to be premixed with the fuel resulting in a much more consistent air and fuel mixture (see Figure 9).

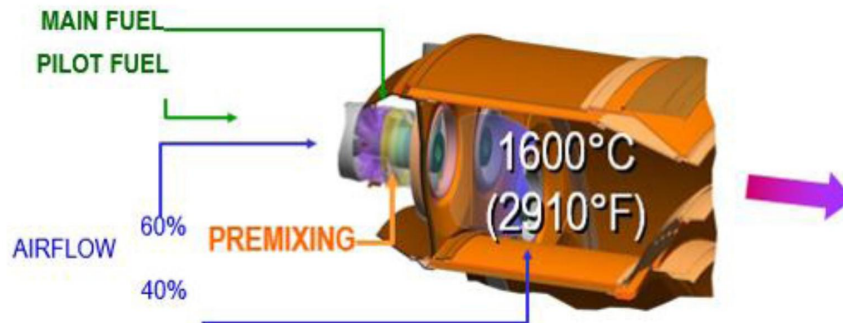


Figure 9—Premixing of air-fuel mixing prior to entering the turbine combustor

Reduced Truck Traffic

In addition to reducing emissions, the electric fleet also reduces refueling traffic. While a diesel powered fleet must transport diesel fuel to the site, natural gas fuel is delivered straight to the electric fleet's turbines much more efficiently from the pipeline. Using field natural gas eliminates the 25 diesel fuel truck deliveries to the well site that are required for an average horizontal well completion of fifty stages in the Marcellus Shale. This reduces traffic in communities as well as spills that may be associated with refueling. To date, the electric fleet has eliminated over 400 diesel truck deliveries, and the related traffic disturbances that can negatively impact local communities.

Reduced Fire Risk

On diesel powered fleets, many fires are caused on pump trucks due to hydraulic fluid igniting from the engine's turbocharger. By removing the diesel engine and related turbo, that ignition source is eliminated from the pad. Moreover, the amount of hydraulic fluid on each dual pump trailer is reduced by 70%. This not only reduces the risk of fire, it also reduces the risk of spills.

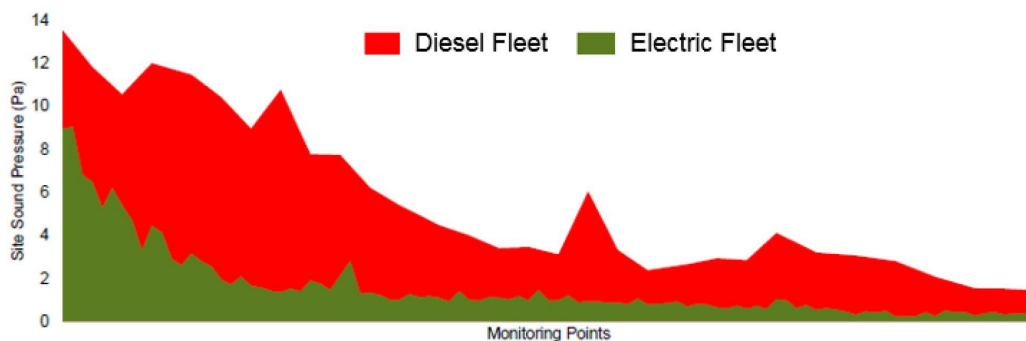
In addition, other fires occur on diesel fleets during refueling. This happens at times because of hot-fueling during zipper frac operations or simply due to refueling spills. By eliminating diesel engines and diesel fuel, the electric fleet has zero hot-fueling and zero ignition sources near the wellhead.

Reduced Noise

Finally, electric well stimulation significantly reduces noise pollution, making the workplace safer and less disturbing to communities and wildlife. Diesel powered well stimulation sites are extremely loud with some locations measuring as high as 129.5 decibels one foot away from the equipment. The well servicing company employed a third party to perform a sound survey of the electric fleet and compare it to a diesel engine fleet. More than 140 total monitoring locations were used, and the result was up to a 69 percent reduction in the average sound pressure for the electric well stimulation site (see Table 2).

Table 2—Average sound pressure for the site reduce 69% on an electric fleet compared to a diesel fleet

Sound Pressure For Entire Site

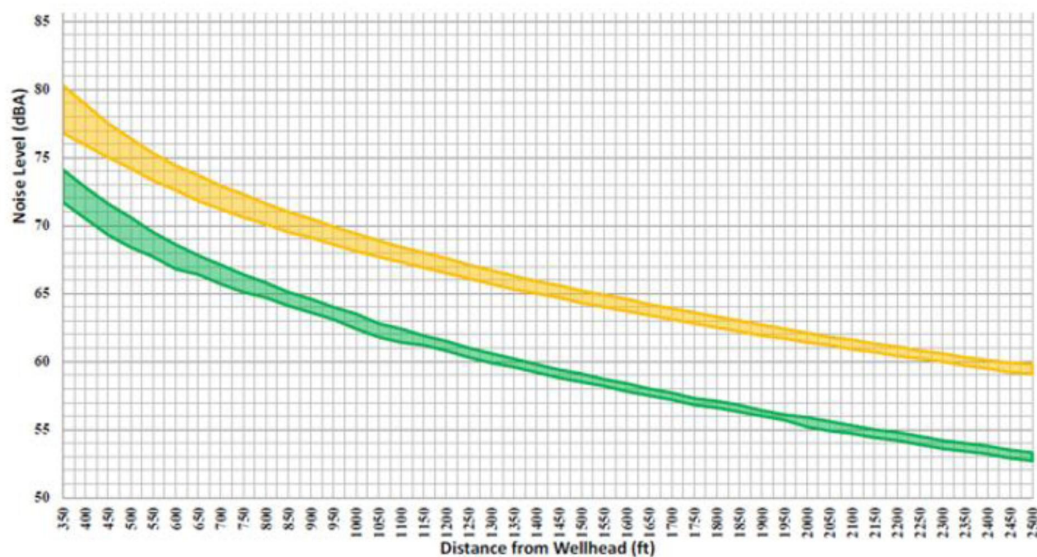


Much of the noise reductions come from eliminating the diesel engines. Additional gains come from adding a silencer to each of the turbines, enclosing them, and adding noise insulation to the turbine enclosures. The turbines were measured to be 85 dBA at a distance of five feet. Other noise reductions came from removing the large radiators on the gooseneck of each of the pump trailers. The large fans on the radiators generate significant amounts of low frequency noise.

At the edge of a pad 350 ft away from the wellhead, a diesel powered fleet was measured to be over 80 dBA, while at the same distance from the wellhead, the electric powered fleet was measured to be 74 dBA (see Table 3). The electric hydraulic fracturing fleet had a 6 dBA decrease in noise. A decibel is a logarithmic measure of sound, and it is based on the threshold of human hearing. Since it is a logarithmic scale, every 3 dB increase in sound level requires twice the amount of sound pressure to produce. Operations personnel have repeatedly reported that these dramatic decreases in noise make communication much easier. The reduced noise levels are very beneficial to local wildlife as well as nearby communities.

Table 3—Diesel powered noise levels in yellow; Electric powered noise levels in green

Noise Level (dBA) vs Distance



In conclusion, the electric well stimulation fleet has shown great advances in environmental responsibility. The fleet reduces refueling traffic and has eliminated over 400 diesel deliveries. Emissions are reduced by over 99%. Fire risk is significantly reduced, and some fire hazards are completely eliminated. Average sound pressure is reduced by 69% on the well site. Electric powered hydraulic fracturing is an important step to conducting well stimulation in a more environmentally responsible manner.