



Technology

Union Pacific is finding ways to improve the technology used to move our trains and run our operations, resulting in improved environmental performance.

Distributed Power Units

Distributed power units (DPU) are locomotives that operate in the middle and/or end of trains rather than only having all locomotives at the front end. Distributed Power technology carries fuel and safety benefits – a win-win for Union Pacific and the communities where Union Pacific operates. As a result, Union Pacific moves nearly two-thirds of its gross ton miles using the technology.

For safety, distributed power reduces the physical forces on the train, making it less prone to derailments and facilitates more even braking to reduce wheel and track wear. Distributed power also provides a fuel savings of 4-6 percent compared to standard locomotive power, depending upon the route and topography, reducing emissions.

Genset

The Genset locomotive is an engine that, by using multiple smaller diesel engines and generators instead of one large single engine, can achieve a better emissions profile than a conventional locomotive. Union Pacific created and pioneered Genset locomotive technology, and we have more than 180 Genset locomotives in our fleet representing more than half of all Gensets in America. Genset locomotives are now used by railroads around the world.



Compared to conventional diesel locomotives, Gensets reduce greenhouse gas emissions by as much as 37 percent, emissions of oxides of nitrogen by up to 80 percent, and emissions of particulate matter by 90 percent. Gensets use only as many engines as necessary. Some rail yard work might demand the power of all engines, but many other tasks may require less power. Running fewer engines translates to burning less fuel and fewer emissions. As a result of the Genset's environmental benefits, the California Air Resources Board designated them as "ultra-low-emitting locomotives."

The Genset switcher pulls more rail cars at low speeds than other yard locomotives because the electric, or "traction," engines are independently powered and controlled, giving it superior adhesion compared to a conventional switch locomotive with series-parallel motor connections.

A retrofitted Genset also included the addition of diesel particulate filters (DPF) in California to evaluate the DPF's viability to meet operational requirements as well as Tier 4 standards for particulate matter, carbon monoxide, and hydrocarbons. In 2015, Union Pacific introduced the first Gensets certified to Tier 4 standards in Dolton IL, a Chicago suburb.

Our Genset efforts earned Union Pacific multiple awards, including the U.S. Environmental Protection Agency's Clean Air Excellence Award, the California Governor's Environmental and Economic Leadership Award and the Texas Environmental Excellence Award. Read more about the Genset's development.

Other Emissions-Reducing Technologies

Exploring new technologies is a hallmark that Union Pacific has pursued for decades. This focus on research and development serves as a catalyst for greater reductions in emissions.

Advanced experimental locomotives are testing three emissions-reducing technologies including exhaust gas recirculation (EGR), diesel oxidation catalysts (DOC), and diesel particulate filters (DPF) in intermediate-length hauls of approximately 200 miles. UP 9900 is the signature unit in a series of 25 locomotives that Union Pacific is analyzing as part of a broad test of various emissions-reduction techniques in northern and southern California. A reduced freight locomotive engine size in UP 9900 creates space needed to install EGR, DOC, and DPF. Known as "aftertreatment," all three technologies are used simultaneously and have helped further pursue developing a locomotive that meets the U.S. EPA's Tier 4 emission standard.

Fast Facts

Since 2000, Union Pacific has spent about \$7.5 billion to purchase more than 4,400 fuel-efficient locomotives.

Successful technology development happens collaboratively. Union Pacific has worked with the U.S. Environmental Protection Agency, California Air Resources Board, and other local, state and federal agencies to comprehensively test and evaluate new emissions-reducing

technologies:

- › The Advanced Locomotive Emissions Control System includes a stationary emissions treatment unit that is connected to diesel locomotives with flexible ducts and a hood designed to fit over and attach to the exhaust stacks. Diesel-related emissions are then captured and treated, rather than being released into the air.
- › Union Pacific incorporated hybrid electric technology into locomotives, hoping to achieve emissions reductions and fuel-efficiency improvements similar to those of hybrid electric cars without hindering normal yard operations. The Green Goat locomotives used a conventional engine to charge a bank of batteries, which in turn power the train. The limitations of current battery technology and safety and performance issues prevented the Green Goats from achieving the anticipated and desired results. Lessons learned help guide the development other new technologies.
- › The "Oxicat" utilizes oxidation catalyst converter devices. As the diesel engine's exhaust flows through these converters, microscopic particles – known as "particulate matter" – generated by the diesel combustion process will be converted into water and carbon dioxide.
- › The Diesel Particulate Filter uses high-temperature silicon carbide blocks to trap particulate matter in the exhaust. As the gases containing the particles accumulate, the device periodically heats the carbon, causing it to ignite and burn off as water and carbon dioxide.
- › We helped develop and test a revolutionary intermediate line-haul locomotive that significantly reduces nitrogen oxide emissions by routing exhaust through a selective catalytic reduction unit (SCR). The technology was not right for our route structure, but we expect it to serve as a stepping stone for other innovative ways to reduce fuel usage and emissions. These locomotives are now being used in Southern California on the Pacific Harbor Line, a short line railroad, helping to reduce emissions in the Los Angeles area.

Alternative Fuels

Union Pacific has evaluated alternative fuels for more than half a century including bio-diesel, propane, liquefied natural gas and hydrogen.

- › Read more about liquefied natural gas as a potential locomotive fuel source.

Union Pacific conducted extensive gas turbine tests as far back as 1952. While this and many other test projects have not proven viable for systemwide implementation, we continue to look for new ways to reduce fuel consumption and increase operating efficiency.

While diesel consistently comes out on top as the fuel to most efficiently and effectively power the locomotives on Union Pacific's network, we anticipate a combination of fuels and technologies will power tomorrow's railroad. Union Pacific is once again studying the benefits of converting locomotive engines to LNG fuel. We are working closely with locomotive and engine manufacturers, cryogenic fuel tank suppliers and natural gas/LNG suppliers to complete our analysis. Whether diesel or other fuels, Union Pacific is pioneering and researching technologies to remain the industry leader in locomotive exhaust emission reductions.

We also use solar panels to power many facilities in areas without access to electricity grids. This solar-generated electricity powers our microwave communications transmission systems, track circuits, detector fences, intermediate signal locations and control points.

R&D Efforts

As technology improves and our employees continue to focus on innovation, Union Pacific is always exploring opportunities to further reduce the railroad's environmental footprint. The railroad is evaluating several emerging technologies, including:

- › Wheel/Rail Lubrication;
- › Friction Modifiers;
- › Locomotive and Car Aerodynamic Enhancements, such as the Arrowedge [http://www.uprr.com/newsinfo/releases/environment/2013/0903_arrowedge.shtml] , an aerodynamic structure placed on the top of the first rail car of a double-stack container train;
- › Fuel specifications
- › Consist management technology to improve train handling.