New York State Energy Research and Development Authority

Demonstration of Idle Reduction Technology for Short-Line Railroads

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Energy. Innovation. Solutions.

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Department of Transportation

DEMONSTRATION OF IDLE REDUCTION TECHNOLOGY FOR SHORT-LINE RAILROADS

Final Report

Prepared for

THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
Albany, NY
Joe Tario – Senior Project Manager

And

The New York state Department of Transportation
Albany, NY
Jeff English – Project Manager

Prepared By

New West Technologies, LLC

4947 Commercial Drive
Yorkville, NY 13495

Paul Windover
Project Engineer

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Notice

Abstract

Through a New York State Energy Research and Development Authority cost-shared research agreement demonstration project The Powerhouse™ product line of anti-idle diesel warming systems for locomotives from Power Drives Inc. (PDI) *w*as demonstrated. Two models of PDI's Powerhouse™ Diesel Warming Systems (DWS) were installed on eleven (11) locomotives from seven (7) short-line railroads operating in New York State. Field testing was conducted between November 2011 and March 2012.

The PDI DWS prevents freeze-up of locomotive engines during extended periods of inactivity during cold weather. Without this technology locomotives are forced to idle their main engine to keep warm. These units use diesel fuel fired heaters and an electric pump to warm and then circulate the locomotive engine's coolant. The DWS system is powered by either diesel genset or grid electricity.

Over 50,000 gallons of diesel fuel savings was displaced during the project resulting in an individual return on investment time period averaging 8.5 winter-months (1 to 3 seasons). Significant emissions savings and noise reductions were also documented.

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Executive Summary

Power Drives Inc., (PDI) based out of Buffalo, NY has been in business for over sixty years. They have recently developed a system to keep locomotives warm in lieu of fuel-wasting engine idling called the Powerhouse, Diesel Warming System (DWS). The patented system has now been deployed on over 130 locomotives, and most recently, has been added to the U.S. Environmental Protection Agency Smartway Transport Program's list of approved technologies.

The project deployed 11 DWS units on locomotives, operated by short-line railroads in New York State, to reduce fuel expenditures and emissions resulting from extended idling periods. While a number of long-haul railroads have been able to invest in this technology, short-lines, including those in this State, have not utilized these units.

The PDI DWS prevents freeze-up of locomotive engines during extended periods of inactivity during cold weather. Without this technology locomotives are forced to idle their main engine to keep vital fluids warm. These units use diesel fuel fired heaters and an electric pump to warm and then circulate the locomotive engine's coolant. The DWS system is powered by either diesel genset or grid electricity. Seven New York State short-line railroads have committed to installing 6 diesel powered units and 5 electric units on their locomotives. To show the economic and environmental benefits of this deployment, the usage of the DWS was monitored and analyzed throughout an entire cold season to determine the fuel, emission, and economic savings.

The demonstrated fuel, cost, and emission savings through the use of the DWS system proved the effectiveness of this idle reduction technology. Over 50,000 gallons of diesel fuel savings was displaced during the demonstration project. Similarly emissions reductions of 193kg of PM, 14,000kg of NOx and 554 tons of CO2 were documented. Noise levels experienced during the 2011-2012 winter season were also reduced from levels requiring ear protection (an idling locomotive) to levels just above ambient. While the warmer temperatures reduced the expected duration of time that the locomotives would have needed to idle had this technology not been installed, reasonable payback periods were shown. Excluding two locomotives that had minimal utilization of their DWS-120 because they were kept in an engine house, the average payback period was 6.7 winter-months. On a year with typically low temperatures during the cold season, the DWS-APU should be expected to return fuel savings equal to the installed cost of this technology, or a 1 year return on investment.

Introduction

Short-line Railroad Operations

Railroads are an efficient means of transporting large amounts of cargo, especially bulk items. Compared to a truck which averages only about 155 ton-miles per gallon of fuel, the average train has an efficiency of 413 ton-miles per gallon of fuel.1 While large railroad operators generally transport cargo much further than could practically be done with a truck, short-line railroads compete directly with trucks because they haul smaller amounts of cargo shorter distances as needed. This competition helps lower transportation costs for the shipping public. Short-line railroads often utilize sections of track that were not deemed profitable by the larger railroads, and generally haul cargo less than 100 miles between local customers and the main rail line. They are a feeder system for the large Class I railroads, picking up or delivering one out of every four rail cars moving on the national rail network. U.S. short-lines serve over 13,000 facilities and haul over 14 million carloads per year, transporting cargo that is critical to the electrical generation, construction, manufacturing, and agricultural industries (Figure 1).2

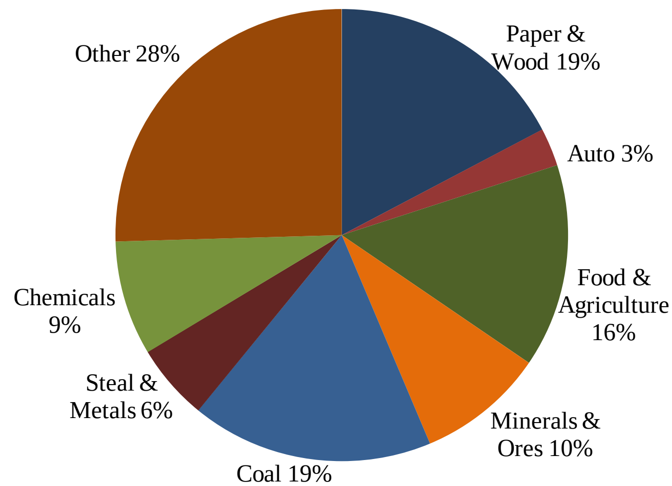

Figure 1: US Short-Line Railroad Carloads by Commodity

Because of limited revenue due to the small volume of cargo transported, short-line railroad operations have little capital to purchase new equipment and advanced technologies. The majority of these operations are utilizing older locomotives without the financial means to outfit them with the latest pollution reduction technology. Because these trains only travel short distances, they also spend a significant percentage of their time idling while loading and unloading cargo, or waiting for their next job.

Locomotive Idling Issues

Locomotives do not use antifreeze in their cooling systems because the chemicals can cause damage to internal metal components over time. There is also an increased cost in replacing the antifreeze fluid during maintenance, and the preventative measures that would be required to ensure a leak free system. Additionally, pure water provides a higher rate of heat transfer which allows the use of radiators that are 20 percent smaller, as well as more highly stressed engines (which create more heat) that result in more power with a smaller overall size. However, because of water coolant freezing issues, locomotives cannot be shut down during cold weather without potential damage to the engine block, water pumps, radiators, and associated plumbing and hardware. The engine oil must also be kept relatively warm to ensure viscosity is low enough to flow sufficiently and not starve bearings and other engine components that require constant lubrication.

For these reasons, locomotives in cold regions are generally not shut down if the outside ambient temperature could drop below 35°F. In a Northern climate, such as New York State, this can result in locomotives idling between uses during the 22 weeks comprising November through March. Locomotives are powered by large 12- or 16-cylinder diesel engines, displacing over 50 liters, and generating several thousand horsepower. While these engines are quite efficient at producing propulsion power, their sheer size results in 4-7 gallons of fuel consumed per hour while idling.

Locomotive Idle Reduction Technology

Locomotive idle reduction technology has the potential to significantly reduce fuel consumption and related emissions. However, because short-line railroads operate on very limited profit margins, they do not often have the ability to invest in new technology that has not been widely used on locomotives for their particular application. Also with limited off-shift staffing, idle reduction technologies such as automatic locomotive start-stop systems can be problematic if one of their many components or procedures fail.

New York has an extensive network of short-line railroad operations, consisting of 29 separate transportation companies, currently transporting cargo within the State. It is estimated that 42% of the overall railroad infrastructure is collectively owned and operated by these companies. To justify the initial cost to purchase new equipment, short-line operators want to see documented benefits as well as proof of reliability and ease of operation. Therefore, New West Technologies and Power Drives Incorporated, with funding from the New York State Energy Research and Development Authority (NYSERDA) and support from the New York State Department of Transportation, demonstrated the Powerhouse™ Diesel Warming System (DWS) on eleven different locomotives utilized by seven short-line railroads operating in New York State.

Figure 2: Powerhouse™ DWS-120 (left) and DWS-APU (right)

The two Powerhouse™ DWS models demonstrated in this project were the 120V electric plug-in version (DWS-120) and the diesel auxiliary power unit (DWS-APU). Allowing the locomotive to be shut down in cold weather, both models, shown in Figure 2, heat the engine coolant with a diesel fired burner. The DWS-120 circulates the heated fluid with an electric water pump powered from a standard 120VAC source. The APU model generates the electricity required to run the pump using a small EPA-certified onboard diesel genset which provides added flexibility to where and when it can be used.

Fleet Overview

A total of seven NYS railroads were identified by PDI as interested parties for the Powerhouse™ DWS technology. Fleets were given the choice of quantity of locomotives to be up fitted with a DWS, resulting in eleven locomotives being outfitted with Powerhouse™ DWS models. These eleven locomotives, along with their engine information are identified in Table 1 below. Under this project, fleets were able to evaluate the real-world operational experience, benefits and cost savings that can be achieved from the Powerhouse™ DWS models they selected (120v or APU). Following the installation, a complete cold weather field test, during the 2011-2012 winter season, was completed to monitor the fuel savings, carbon reduction, and other benefits of this technology.

Table 1: Locomotives Participating in the Demonstration Project

Railroad	Locomotive Type	Locomotive Engine	Engine HP	Fuel Use (g/h)*
Buffalo Southern (BSOR)	Alco S2	539 6L	1,000	3.0
Buffalo Southern (BSOR)	Alco S4	539 6L	1,000	3.0
Depew, Lancaster and Western (DLWR)	MLW RS-18	251B	1,800	3.5
Finger Lakes (FGK)	GE SB23-7	FDL-12	2,250	4.0
Mohawk, Adirondack and Northern (MHWA)	Alco C425	16-251C	2,500	5.0
Rochester and Southern (RSR)	EMD GP40	16-645-E3	3,000	5.5
Rochester and Southern (RSR)	EMD GP40	16-645-E3	3,000	5.5
Wellsboro and Corning (WCOR)	EMD SD-40-2	16-645-E3	3,000	5.5
Wellsboro and Corning (WCOR)	EMD SD-40-2	16-645-E3	3,000	5.5
Western New York and Pennsylvania (WNYP)	Alco C430	251E	3,000	5.5
Western New York and Pennsylvania (WNYP)	Alco C430	251E	3,000	5.5

**Fuel figures were retrieved for each locomotive where possible and for similarly powered locomotives when specific information was unavailable, data was retrieved from http://www.alkrug.vcn.com/rrfacts/fueluse.htm*

Data Acquisition

Fuel consumption, emission, and noise pollution reductions are all important criteria when evaluating the benefits of locomotive idle reduction technology. The Powerhouse™ DWS is equipped with an hour meter that records the amount of time that the unit is on, which relates to the amount of time that the locomotive's engine would have idled had this technology not been installed. In addition, the DWS tracks the hours of operation for the heater and hours of operation of the genset (APU model only), which can be applied to fuel use and emission factors to quantify the system benefits. Although energy and environmental concerns dominate, neighborhood noise levels are also a common complaint and can have negative health impacts to people in the vicinity of the rail yard. A separate investigation involved field measurements to quantify the noise reduction benefit of the Powerhouse™ DWS over an idling locomotive.

Fuel Displacement

Brake specific fuel consumption rates in gallons per brake-horsepower hour are available for a wide variety of locomotives. To use these in a quantitative calculation, the power level at idle of the locomotive must be known. The throttle control of a locomotive consists of 9 notches, idle through notch 8, which dictates the engine's RPM. The throttle is generally left in the idle notch when locomotives are not being used; however, during extremely cold conditions, the locomotive may idle at a higher RPM, up to notch 3, to ensure sufficient heat is produced. For purposes of this evaluation, it was assumed that the average locomotive idle speed is at the idle notch, because higher idle speeds are only used during very limited incidences of extremely cold weather. Published average brake specific fuel consumption rates in gallons per brake-horsepower hour are based on a typical duty cycle for different types of locomotive applications. Since the power level needed at idle is very low, a calculation using these averages does not properly reflect fuel consumption. Therefore, specific idling fuel use rates were used where data was available and similar sized locomotives were referenced when the specific models used in this demonstration were not documented.3 The eleven project locomotives utilized six unique engines. Horsepower ratings and fuel consumption rates in gallons per hour at idle are shown in Table 2.

Table 2: Locomotive Engine Idling Fuel Use Factors (six unique engines)

Engine	HP Rating	GPH
539 6L	1,000	3.0
251B	1,800	3.5
GE FDL-12	2,250	4.0
Alco 16-251C	2,500	5.0
EMD 16-645-E3	3,000	5.5
251E	3,000	5.5

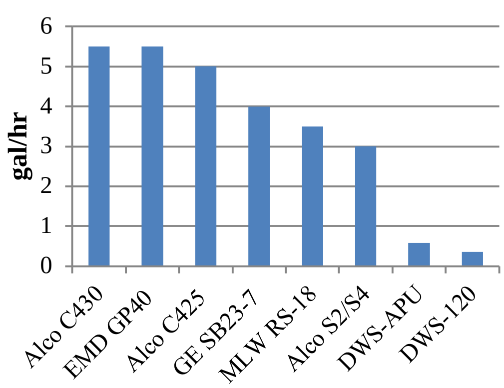

Figure 3: Average Fuel Consumption of Locomotives and the DWS at Idle

The DWS unit also consumes fuel itself, which must be subtracted from the estimated locomotive hourly fuel savings to arrive at the real fuel savings in gallons per hour. The fuel fired heater, used in both variations of the Powerhouse™ DWS, consumes fuel at a peak rate of 1 gallon per hour when firing but is only on for approximately a third of the time when the circulating pump is running. The small diesel genset on the DWS-APU consumes an additional 0.25 gallons per hour while it is operating. The DWS-120 draws 600 Watts when powering the engine coolant circulating pump. On an energy basis, this electricity use is the energy equivalent of 0.016 gallons of fuel consumption per hour. As shown in Figure 3, both Powerhouse™ DWS models have the potential to save significant amounts of fuel when used to reduce locomotive idling.

Emission Savings

Locomotive emission factors can vary greatly depending on the method and test cycle used, as well as the locomotive itself. Due to the age of the locomotives used in this demonstration and the fact that some of the models were never mass-produced (and even fewer remain in actual working condition), specific documented ratings were not available for every locomotive. However, exhaust constituent data from testing an EMD-16-645-E3 engine, which 4 of the 11 locomotives in this demonstration are using, was available for oxides of nitrogen (NO_X), particulate matter (PM), and carbon dioxide (CO_2). 4 Using a ratio of idling power outputs between this engine and the other locomotive engines in the demonstration, emission factors for the remaining locomotives were estimated. These rates are shown in Table 3.

Table 3: Estimated Locomotive Emission Factors (grams per hour)

Locomotive	PM	NO_X	CO_2
Alco S2/S4	6.7	462	19,400
MLW RS-18	12.0	832	34,900
GE SB23-7	15.1	1,040	43,600
Alco C425	16.7	1,160	48,400
EMD GP40/SD-40-2	20.1	1,390	58,100
Alco C430	20.1	1,390	58,100

The emissions calculation must also take into account the emissions created by the idle reduction unit itself to accurately estimate the net savings. The Powerhouse™ system produces emissions from the fuel fired heater as well as the genset (for the DWS-APU) and the electrical system (for the DWS-120). Since the onboard engine for the DWS-APU is EPA-certified for low emissions and much smaller than the locomotive's engine, there is a significant environmental benefit when operating these idle reduction units. For operations that can connect to electric power during idling periods, the DWS-120 provides even greater emission savings because the electricity generation in New York State is primarily Natural Gas, Hydro-electric, and Nuclear as shown in Figure 4 The emissions factors from fuel and electricity consumed by these units (electrical emission factors are averages for electricity produced in New York State) are shown in Table 4 and Table 5

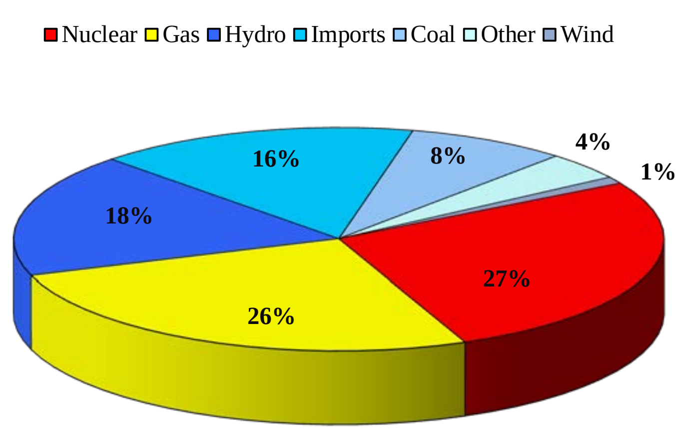

Figure 4: NYS Electricity Generation by Fuel Type

Table 4: Powerhouse™ DWS-APU Emission Factors[6]

	Emissions *(g/hr)*		
Component	PM	NO_X	CO_2
Genset	1.82	44.1	7,090
Heater	0.53	4.9	10,100

Table 5: Powerhouse™ DWS-120 Emission Factors6

	Emissions *(g/hr)*		
Component	PM	NO_X	CO_2
Electric Motor	0.00	2.09	930
Heater	0.53	4.90	10,100

Noise Reduction

To quantify the sound emission reduction benefit of this technology, sound level readings were taken at various locations around the idling locomotive as shown in Figure 5. The baseline sound levels from the idling locomotive engine was then compared to the sound levels taken with the Powerhouse™ DWS operating. This was completed for both the DWS-APU and DWS-120.

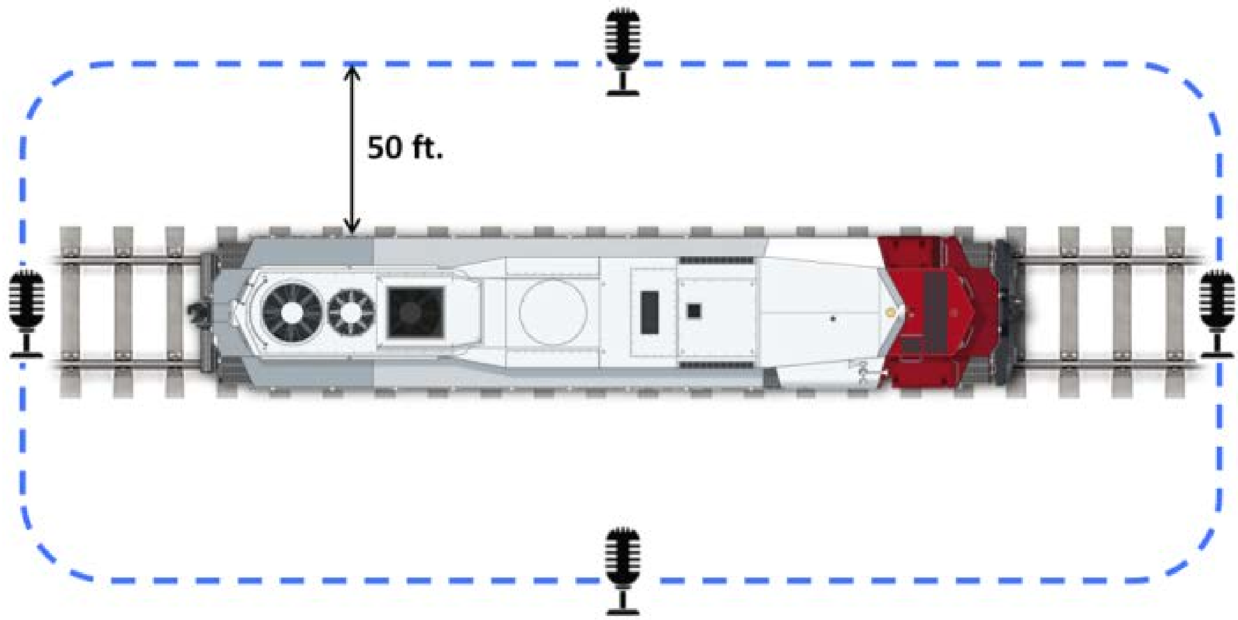

Figure 5: Noise Reading locations (50ft Shown)

Field Testing Results

When the Powerhouse™ DWS systems were installed and being utilized by the railroads, the fuel savings results were as expected. However, due to many external circumstances, including usage cycles and weather extremes during idling periods, the overall results were varied. Table 6 below shows a high level summary of the results for each of the 11 locomotives.

Table 6: Summary of DWS Results During the Demonstration Periods

Railroad/Locomotive	DWS	Locomotive		Genset Use		Heater Use		Net Fuel Savings (gal)
		Engine Off Hrs	Fuel (gal)	Hours	Fuel**	Hours	Fuel (gal)	
Buffalo Southern (BSOR) #93*	120	25	74	25	0	16	16	58
Buffalo Southern (BSOR) #100	120	696	2,089	696	11	600	600	1,478
Depew, Lancaster and Western (DLWR) #1801	120	2,751	9,629	2,751	43	2,611	2,611	6,974
Finger Lakes (FGK) #2308 (GE SB23-7)	APU	1,273	5,091	509	127	243	243	4,721
Mohawk, Adirondack and Northern (MHWA) #2453	APU	1,210	6,051	862	243	1,172	1,223	4,613
Rochester and Southern (RSR) #104	APU	1,664	9,154	540	135	286	286	8,733
Rochester and Southern (RSR) #3106	APU	1,556	8,560	1,333	333	599	599	7,627
Wellsboro and Corning (WCOR) #307	APU	1,237	6,804	1,215	304	200	200	6,300
Wellsboro and Corning (WCOR) #309	APU	1,255	6,903	1,007	252	98	98	6,553
Western New York and Pennsylvania (WNYP) #431*	120	219	1,202	219	3	171	171	1,027
Western New York and Pennsylvania (WNYP) #432	120	644	3,539	644	10	565	565	2,964

*Spent some down time in a heated engine house
**Diesel gallon equivalents

Specific Railroad Results

Each of the seven short-line railroads participating in this demonstration projects were analyzed individually because of varying geographic locations and weather patterns which dictate alternative idling arrangements. Thus, the fuel reduction benefit from the use of the Powerhouse™ DWS are provided for each railroad below. Cross-comparisons of DWS unit performance or utilization of the locomotives or DWS should not be performed from these results.

Buffalo Southern Railroad (BSOR)

BSOR is a locally owned short-line operation founded in 1982. They maintain 12 locomotives out of their main shop located in Hamburg, NY. Their core business is their mainline which runs 32 miles from the Buffalo River (just south of downtown Buffalo) south to Gowanda, NY. At the northern end of this line is the interchange to the Norfolk Southern (NS), CSX, Canadian Pacific (CP), Canadian National (CN), and Buffalo & Pittsburgh (BP) lines, while the southern end connects to the New York & Lake Erie short-line. One Powerhouse™ DWS-120 was installed on locomotive #100, an Alco S2 (Figure 6). A second DWS-120 unit was installed on locomotive #93, an Alco S4. These locomotives work inside of the ex-Bethlehem Steel Plant at Lackawanna, NY where they utilize the lake docks and rail sidings to transload materials between the Lake and rail. The locomotives are operated on an as-needed basis, though it can be as much as a couple of trains per

Figure 6: BSOR Locomotive #100 with a DWS-120

week. The locomotives are heavily utilized during the lake shipping season which runs from April until December. Typically once the lake freezes and shipping ends, the stockpiled material is used up, the locomotive is drained and put into storage for the winter months. The addition of this heater is expected to extend the economical use of the locomotive longer into the winter season than for other transloading opportunities that don't require the use of the lake for transport.

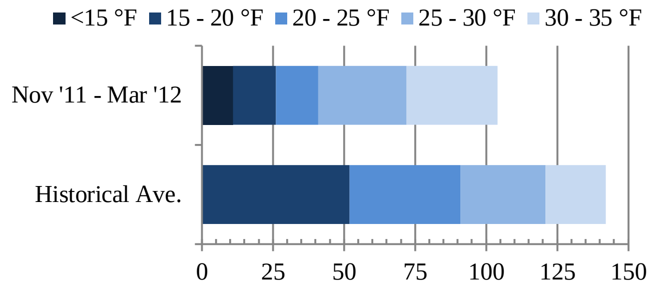

Figure 7: Number of Low Temperature Days in Buffalo, NY

For two months at the end of 2011, the unit on locomotive #100 was activated for 696 hours and the heater was operating for 600 hours while stationed at an industrial park on the shores of Lake Erie. Only 25 hours of use and 16 heater hours were recorded on the DWS-120 for locomotive #93 because it spent the majority of the season parked in an engine house due to lack of work. The average temperatures were 6°F higher than normal during this period with fewer days than normal reaching a low below 35°F (a common threshold used to determine if the locomotive should idle overnight for freeze protection), as shown in Figure 7. Taking locomotive #100 out of service due to a manufacturing shutdown reduced the expected operational time for that DWS and associated fuel savings. However, the idle reduction technology was still able to save 1,478 gallons of fuel across the two locomotives, which equals $5,300 in savings (8.6 winter-month payback).

Depew, Lancaster and Western Railroad (DLWR)

DLWR a subsidiary of Genesee Valley Transportation, is a Class III railroad formed in 1989 to operate former Delaware, Lackawanna and Western Railroad and Lehigh Valley Railroad infrastructure from Conrail. This railroad operates three divisions with terminals in Batavia, Lancaster and Niagara Falls, NY. The DLWR utilizes exclusively Alco locomotives for its switching and hauling needs; including two RS-11 locomotives, a RS-18 locomotive, and an S-6 which is pooled with other, partnering railroads. DLWR elected to use a Powerhouse™ DWS-120 which was installed on their MLW RS-18 locomotive, seen in Figure 8. This locomotive operates out of Batavia, NY on the DLWR's four miles of track. This stretch of track connects to CSX rail lines at both ends and locomotive #1801 regularly shuttles railcars back and forth on their line every

Figure 9: DLWR Locomotive #1801 with a DWS-120

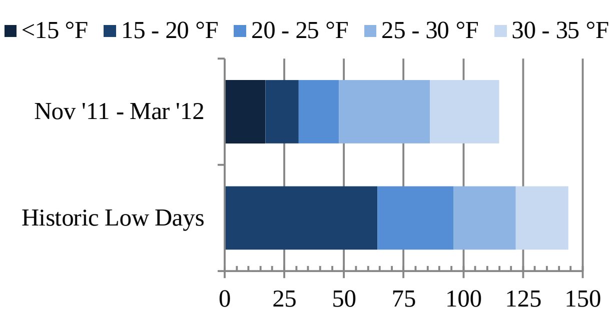

Figure 8: Number of Low Temperature Days in Batavia, NY

weekday.

In the four months of field testing demonstration, the DWS-120 was operated for 2,751 hours with the heater firing for 2,611 hours. At this location, daily minimum temperatures were significantly warmer than average with 32% less days than normal that reached a low below 35°F, as shown in Figure 9. While the average temperature was 6°F warmer than normal during this period, DLWR regularly used the DWS-120 during extended periods of inactivity to ensure engine protection. Thus, the idle reduction technology was still able to save 6,974 gallons of fuel, resulting in an economic saving of approximately $29,900 (3.4 winter-month payback). Most importantly, the fuel savings with this system has enabled DLWR to keep this locomotive economically viable during the winter while in service, which increases their capabilities and may reduce the maintenance typically needed on this old engine if it did not operate for the season.

Finger Lakes Railway (FGLK)

FGLK is a privately owned, Class III short-line railroad headquartered in Geneva, NY. Since July 1995, FGLK operates, markets, and maintains over 154 miles of track in six upstate counties including: Onondaga, Cayuga, Seneca, Ontario, Yates, and Schuyler. The rail line runs east to west starting at Solvay, NY through Auburn to Geneva and continuing west to Victor and Canandaigua. FGLK provides daily or weekly rail switching services, based on the industry needs. Locomotive #2308, a GE SB23-7, was equipped with the DWS-APU idle reduction unit and is assigned to local switching duties that generally operate approximately 12 hours per day. This locomotive, pictured in Figure 10, must be idled constantly when not in use during the winter months to avoid freeze up and maintain availability for the next job. Significant amounts of idling can be experienced when it remains unused 12 hours a day (no night shifts) and all weekend. The use of the diesel powered idle reduction technology allows a significant amount of fuel to be saved during idling while still maintaining flexibility in its out of service locations and not requiring any additional infrastructure.

Figure 10: FGLK Locomotive #2308 with a DWS-APU

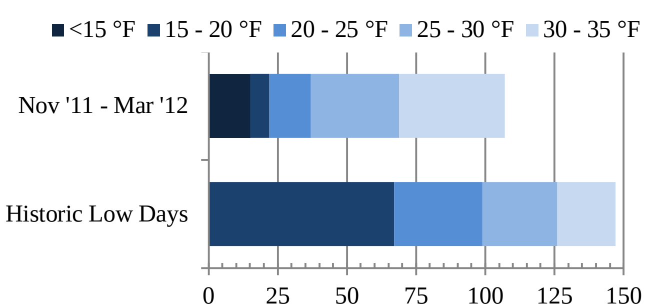

Figure 11: Number of Low Temperature Days in Geneva, NY

From November to March, this unit was utilized to displace approximately 1,273 hours of idling and the heater was functioning for 243 hours. The DWS-APU genset ran for 509 hours during this time. The number of cold days during this period was significantly less than average with 27% less days reaching a low of 35°F or lower, as shown in Figure 11. The average temperature was also 6°F above normal. This reduced the potential for fuel savings attributed to the DWS because the locomotive could have been shut down without needing any additional heat to protect against freezing. However, the idle reduction technology was still able to save 4,721 gallons of fuel, which equals $18,398 in savings. At this rate, the unit will have a payback of 8.1 winter-months.

Mohawk, Adirondack and Northern Railroad (MHWA)

MHWA, a subsidiary of Genesee Valley Transportation headquartered in Utica, NY, serves the Mohawk Valley and the Adirondack Region with 124 miles of rail line. In Rome, NY this railroad serves multiple steel manufacturing and processing entities. MHWA's Alco C425 locomotive #2453 was outfitted with a Powerhouse™ DWS-APU as shown in Figure 12.

Figure 12: MHWA Locomotive #2453 with a DWS-APU

This locomotive was used at the GVT rail yard in Scranton, PA during the 4 months of the demonstration project. The idle reduction unit displaced 917 hours of idling, while using the genset for 1,210 hours and the heater for 1,172 hours. The average temperature was 6°F warmer than normal with fewer days reaching a low below 35°F (Figure 13). The DWS was able to save 4,670 gallons of fuel, which equals $17,540 in savings (8.2 winter-month payback).

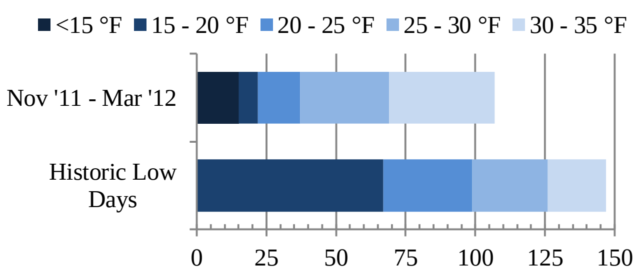

Figure 13: Number of Low Temperature Days in Scranton, PA

Rochester and Southern Railroad (RSR)

RSR, a subsidiary of Genesee & Wyoming Inc., is a Class III short-line that operates between the city of Rochester and Silver Springs, NY. It began operations in 1986, when the Baltimore and Ohio Railroad sold off its Buffalo and Rochester branches. In 2003, RSR acquired the Genesee and Wyoming Railroad in Caledonia and Norfolk Southern's Southern Tier Line in Silver Springs. Two Powerhouse™ DWS-APUs were installed on

Figure 14: RSR Locomotive #3106 with a DWS-APU

RSR's EMD GP40 locomotives, Numbers #104 and #3106 (Figure 14). These locomotives are utilized coupled together the majority of the time and are both operated out of Rochester and Southern's rail yard at Brooks Ave. in Rochester NY. These locomotives generally haul in two 12-hour shifts between Rochester and Silver Springs and Rochester and Brooks Mount Morris. These routes are taken daily, resulting in the locomotives operating nearly 24 hours a day. With this operational profile, the locomotives are generally only idled for limited periods when picking up and dropping off loads and over the weekends.

From November to January, the DWS unit on locomotive #104 had 540 run hours on the genset and 286 hours on the heater to displace 1,664 hours of locomotive idling. The DWS unit on locomotive #3106 prevented 1,556 hours of locomotive idling through the use of 1,333 hours of genset operation and 599 hours running the heater. Weather conditions were 6°F warmer than average with almost 19% less days than normal reaching a low below 35°F, as shown in Figure 15. However, the DWS-APUs were still able to save 16,359 gallons of fuel, which equals $54,486 in savings. At this rate, the units will have a full payback in approximately 5.2 months.

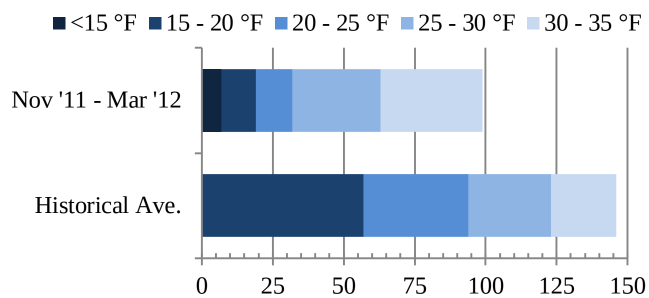

Figure 15: Number of Low Temperature Days in Rochester, NY

Wellsboro and Corning Railroad (WCOR)

WCOR operations include the most significant portions of the Marcellus Shale Formation, which is currently being explored for natural gas. The railroad, in partnership with its sister company, Industrial Waste Group (IWG) Logistics, provides comprehensive railroad, transloading, logistics, and railcar repair services.

WCOR elected to have two Powerhouse™ DWS-APUs installed on their EMD SD-40-2 locomotives numbers #307 (Figure 16) and #309. These locomotives required the use of a split configuration Powerhouse™ DWS-APU because of limited space as shown in Figure 16. WCOR operates two of these similar locomotives for a daily fresh water delivery train which supports the Marcellus Shale Natural Gas activity in the region. Daily movement is between just north of Mulholland Rd. in Erwin Township, NY to just south of Lawrenceville Highway in Lindley Township, NY. The WCOR locomotive fleet includes four virtually identical SD40-2 locomotives that are used in similar

Figure 16: WCOR Locomotive #307 with a Split DWS-APU

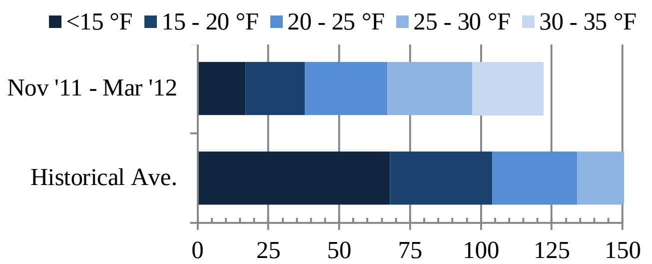

Figure 17: Number of Low Temperature Days in Corning, NY

service applications. Diesel consumption in the winter months is typically much higher than average due to the increased idling time necessary to keep the locomotive's systems warm in below freezing temperatures.

During the demonstration, the temperature dropped below 35°F on 122 days (shown in Figure 17). The DWS-APU on locomotive #307 had 1,215 hours on genset operation with the heater operating for 200 hours. 1,007 genset hours and 98 heater hours were recorded on locomotive #309's DWS-APU. The minimal number of heater hours is reflective of the warmer than normal weather conditions and limited amount of down time for these locomotives. However, a savings 12,853 gallons of fuel, which saved the railroad $44,990, was still realized for an average payback of 6.5 winter-months for these units.

Western New York and Pennsylvania Railroad (WNYP)

WNYP operates the ex-Erie yard and has its operational headquarters located in Olean, NY. Since 2001, when the short-line railroad began operation of the Southern Tier Extension from Corry, PA to Hornell, NY, train frequency has increased from less than one train a day to several each day.

Figure 18: WNYP Locomotive #431 with a DWS-120

Two Powerhouse™ DWS-120s were installed on locomotives in WNYP's fleet, specifically on locomotive #431 and #432, two of only five Alco C430s that are still in service (Figure 18). The Western New York and Pennsylvania Railroad operates locomotive #431 and #432 out of their Olean, NY yard. While these locomotives generally haul cars out of Olean, they are often used at Olean for yard duties.

From November to March, the unit on locomotive #431 was activated (circulating coolant) for 219 hours with the heater operating for 171 hours. 644 operational hours and 565 heater hours were recorded on locomotive #432's DWS-120. Weather conditions were warmer than average with only 25% fewer days than normal reaching a low below 35°F as shown in Figure 19. The average temperature during this time period was 7°F warmer than normal. This reduced the expected operational time for the DWS and associated fuel savings, particularly for locomotive #431 which was kept inside the engine house. However, the DWS on locomotive #432 was still able to save 2,964 gallons of fuel, which equals $10,104 in savings (9.7 winter-month payback).

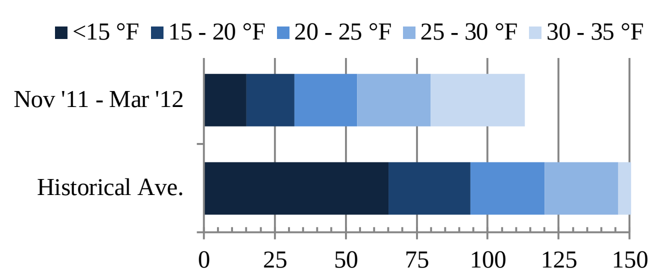

Figure 19: Number of Low Temperature Days in Olean, NY

Emissions Reduction

Utilizing emission data for the idling locomotive, fuel fired heater (for the DWS-APU and DWS-120), genset (for the DWS-APU), and electricity (for the DWS-120), the total emission savings resulting from the use of these idle reduction units can be calculated. The pollution reduction is important because locomotives often idle overnight in highly developed transportation hubs that have poor air quality from many types of vehicle traffic. Some of the locations where these locomotives operate have been designated by the US Environmental Protection Agency as non-attainment areas where any reductions in emissions are beneficial to the health of the population there. This includes operations in both Buffalo and Rochester. The actual emissions reductions from November 2011 to January 2012 are shown in Table 7.

Table 7: Actual Emission Reductions during Test Period

Locomotive	DWS	Emissions Savings (kg)		
		PM	NO_X	CO_2
#93 (Alco S2)	120	0.1	11	400
#100 (Alco S4)	120	4.1	320	12,800
#1801 (MLW RS-18)	120	20.2	1,513	61,900
#2308 (GE SB23-7)	APU	10.1	738	29,100
#2453 (Alco C425)	APU	13.6	1,036	40,600
#104 (EMD GP40)	APU	20.4	1,457	59,000
#3106 (EMD GP40)	APU	18.0	1,301	51,800
#307 (EMD SD-40-2)	APU	13.2	951	38,000
#309 (EMD SD-40-2)	APU	11.8	864	33,600
#431 (Alco C430)	120	1.0	70	2,900
#432 (Alco C430)	120	10.8	778	32,100
	Total	**123.4**	**9,039**	**362,300**

Noise Emissions Reduction

Noise from idling locomotives can pose a significant issue in certain areas due to health issues, such as hearing impairment, hypertension and ischemic heart disease, annoyance, sleep disturbance, and decreased school performance (for children exposed to prolonged noise pollution).7 These effects become even more pronounced when locomotives are idled outside of the rail yard in more rural locations that might also be near residential areas. Even within a rail yard, the noise from idling locomotives can increase the ambient noise level for several miles which can be irritating to any individuals living in the vicinity.

During onsite testing, sound readings were taken at incremental distances away from the locomotive at the rail yard with everything off (ambient level), the locomotive engine idling, only the DWS heater and circulator operating (maximum noise level for the DWS-120), and with the anti-idling technology's onboard diesel genset running (maximum noise level for the DWS-APU). Ambient noise levels fluctuated slightly during measurement due to additional operating vehicles and equipment nearby; however, it was determined that the baseline ambient noise level is approximately 45-55 decibels (dB). Once the locomotive's diesel engine was started, the readings were 65-90 dB. With the idle reduction technology, the noise readings were 45-62 dB for the DWS-120 and 45-72 dB for the DWS-APU.

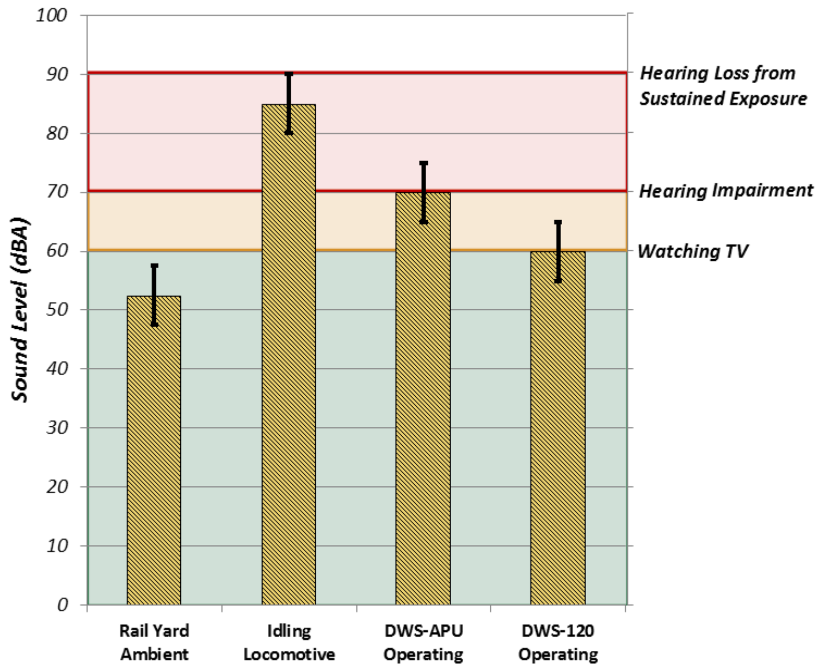

Figure 20: Locomotive Comparative Sound Levels

The ambient sound reading in the rail yard during non-working hours is a similar sound level to a moderate rainfall or normal conversation. The operating DWS-120 is louder than ambient close to the locomotive but is considered safe for extended periods of time with no risk of adverse health effects. At farther distances (>100ft), the DWS-120 cannot be distinguished over the ambient noise level. When the locomotive is running, the sound level has been shown to cause hearing damage from long term exposure and is comparative to power tools and lawnmowers where ear protection is recommended. In fact, according to the US Environmental Protection Agency, sustained noise levels should not exceed 70 dB8 which is the noise level of the DWS-APU and about half as loud as the locomotive (10 dB increase in noise level is approximately double the sound level).9 The comparative data is shown in Figure 20.

Conclusions and Recommendations

The demonstrated fuel, cost, and emission savings through the use of both the DWS-120 and DWS-APU prove the effectiveness of this idle reduction technology. While the warmer temperatures reduced the expected duration of time that the locomotive would have needed to idle had this technology not been installed, reasonable payback periods were shown. Excluding the 2 locomotives that had minimal utilization of their DWS-120 because they were kept in an engine house, the average payback period was 6.7 winter-months. On a year with typically low temperatures during the cold season, the DWS should be expected to return fuel savings equal to the installed cost of this technology, or a 1 year return on investment. Unfortunately, even a payback period of 1 to 3 seasons may not be short enough for a short-line railroad that has very thin operating margins and would have to take out a loan to pay for the equipment. Through NYSERDA, New York State has loan programs used to offset the initial cost of energy-efficient technologies that are paid back through energy savings while reducing consumption and air pollution. Currently, this program is for residents seeking to make energy-efficient upgrades to their homes. However, an analogous program is being considered for NYS commercial truckers to finance the purchase and installation of idle reduction equipment. Based on the promising results of this study, it is recommended that consideration be given for expansion of the program to include NYS rail companies.

Active railroad operations in colder climates can justify the investment into idle reduction technology such as the DWS if there are financial means to make the purchase. While long-term reliability of this system could not be documented through this project, the mechanics that installed and are operating the DWS have been pleased with its performance. They are able to rely on its ability to protect the locomotive during freezing conditions. The DWS-APU, in particular, provides the operators an idle reduction strategy that performs its function with minimal user interaction.

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New York State Energy Research and Development Authority

17 Columbia Circle
Albany, New York 12203-6399

toll free: 866-NYSERDA
local: 518-862-1090
fax: 518-862-1091

info@nyserda.ny.gov
nyserda.ny.gov

New York State Department of Transportation

50 Wolf Road
Albany, New York 12232

telephone 518-457-6195

dot.ny.gov

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