



KNOXVILLE
LOCOMOTIVE WORKS

How to Build a Green Locomotive

Presented by: Kris Wysong, Product Manager



KLW – The Only Green Locomotive Manufacturer in Tennessee

Established in 1998, KLW began as a locomotive remanufacturer, restoring old locomotives into running condition. Today, KLW’s main focus is the manufacturing of its own line of green locomotives.



Becoming an Original Equipment Manufacturer

In 2008, KLR recognized that multi-engine green locomotives (Gensets) were not becoming the preferred green solution as expected. With a decade of experience, KLR decided to create its own locomotive.

Design



Before: SD40, Unregulated Emissions

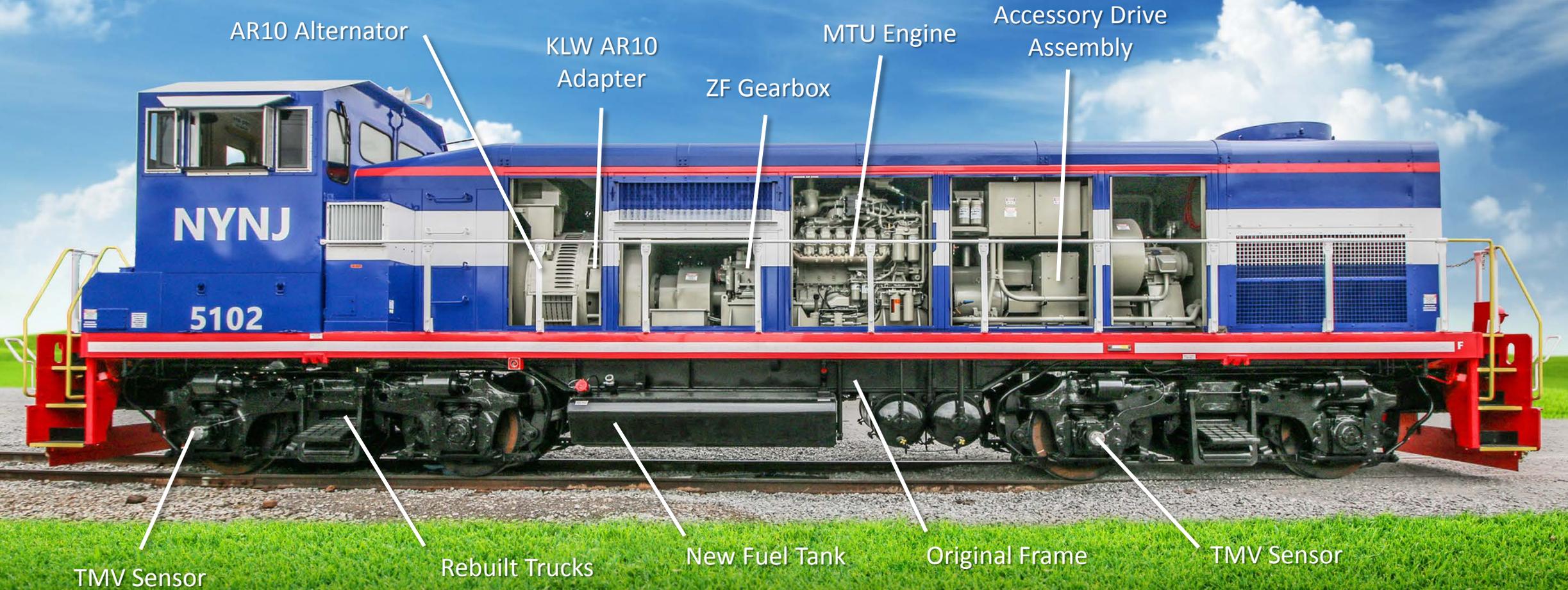


After: KLM SE32C, Tier 3 EPA Certified

Repowering Old Locomotives

KLW repowers old locomotives by removing most of the original components, such as the diesel engine, and replacing them with new or rebuilt components that perform as good or better than the original.

A New Approach to Green Locomotive Design



- Unlike many other green locomotives, KLW uses a **single** diesel engine to generate the electrical power needed to move the unit.

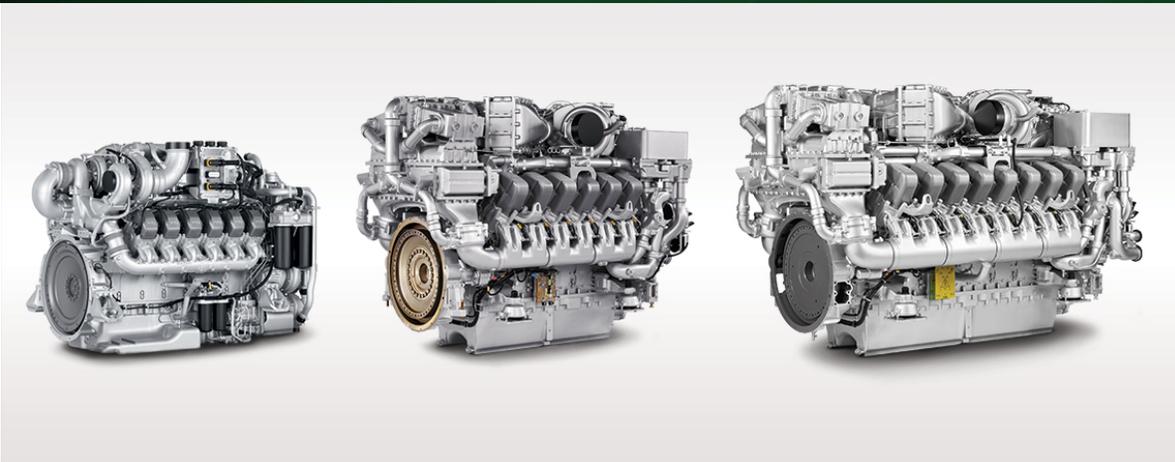
- KLW is **the only company** using a high-speed engine (up to 1,800 RPM) and 2:1 reduction gearbox with the common AR10 alternator.

MTU Diesel Engines



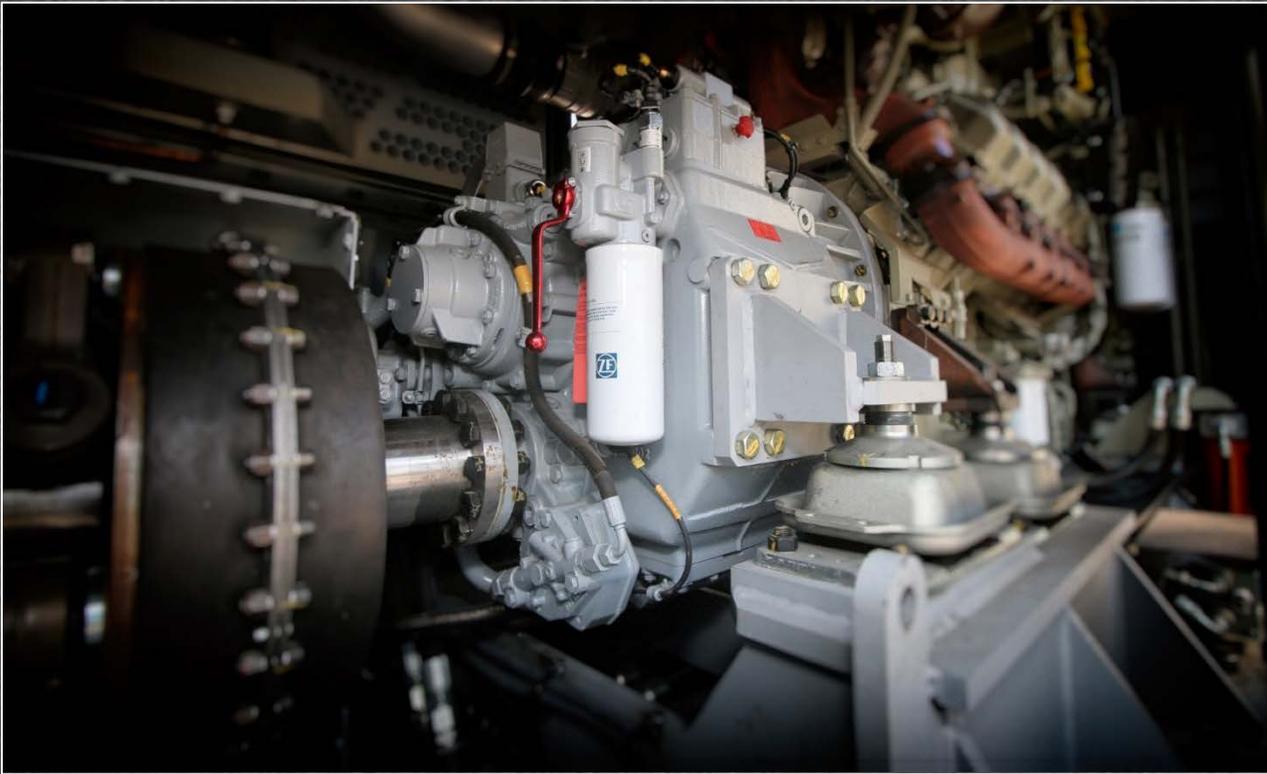
MTU Manufacturing Plant, Aiken, SC

- MTU, founded by Karl Maybach and owned by Rolls Royce, has produced over 20,000 high-speed diesel engines for locomotive use over the past 90+ years.
- MTU engines are used in many other industries, such as: marine, mining, oil & gas, agriculture, and land defense (tanks).
- The engines are the lowest emitting in their horsepower class, so with tough emissions standards to meet, MTU is able to compete in the North American rail market.
- The engines KLW uses are made in Aiken, South Carolina and range from 1,050 brake horsepower (bhp) up to 3,200 bhp.

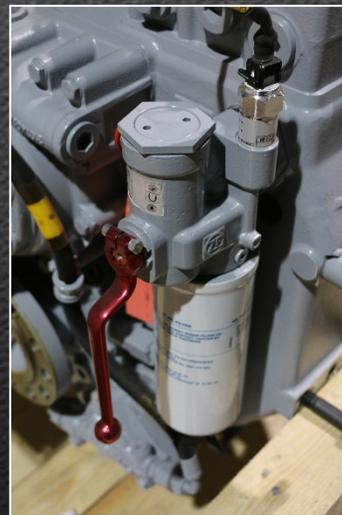


Three of the four MTU engines KLW currently uses for its different models.

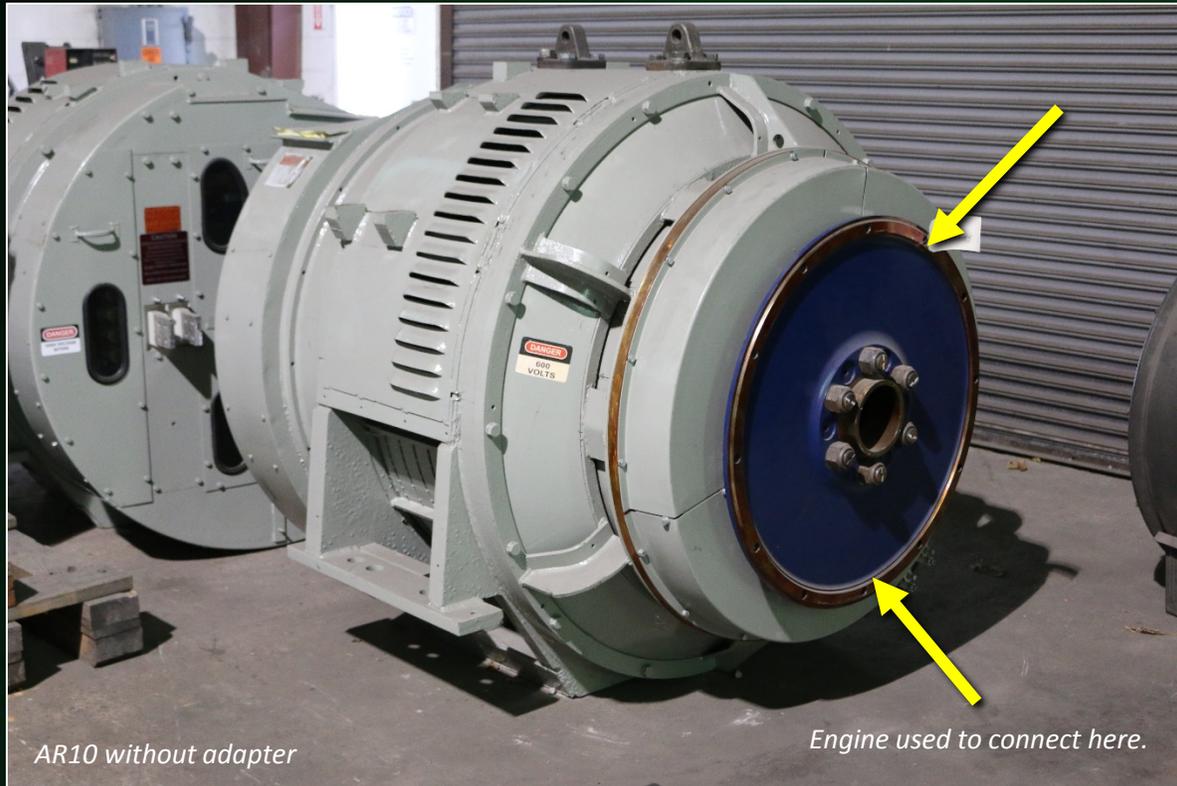
Marine Proven, Railroad Ready



- The ZF 2:1 reduction gearbox makes the MTU engine compatible with the AR10 alternator.
- Single multi-plate clutch automatically engages after six seconds, allowing the **engine to start with virtually no load.**
- Operation is seamless to the operating crew, no shifting or special procedures.
- ZF gearboxes are commonly used with MTU engines in marine vessels.
- Used on mine detecting vessels, the gearbox is designed to withstand shock forces of up to 10 g's.



KLW AR10 Double Bearing Adapter



- Since the AR10 traction alternator is designed to attach to an EMD engine, KLW had to figure out how to connect the AR10 to the ZF gearbox.
- KLW designed a special double-bearing adapter that attaches to the AR10 and gives the AR10 an output shaft. With the use of a Geislinger or Centa coupling, the AR10 can be attached to the ZF gearbox.
- KLW owns the patent for the AR10 adapter.



Before: SD40 with "Dash II" Computer System



After: KLM Unit with TMV TECU System

TMV Traction and Engine Control Unit

Every KLM locomotive is equipped with a TMV Traction and Engine Control Unit (TECU) which controls all major functions of the locomotive (engine speed, cooling fans, etc.). The system is much smaller than traditional systems and also features Automatic Engine Start Stop (AESS) to reduce emissions and fuel use.



This train only needs 3 TMV-equipped locomotives where it previously used 5 conventional locomotives.

Increased Traction Reduces Emissions

The TMV system also prevents wheel slips from occurring which can increase starting tractive effort by up to 40%. At one of our affiliated railroads, we upgraded 3 locomotives with the TMV system and as a result they could pull a train that previously needed five conventional locomotives. This means two locomotive's worth of emissions, fuel, and other savings all because traction improved so dramatically.

Models

KLW SE32C



- 3,200 bhp six-axle locomotive
- Tier 3 certified, reduces emissions up to 80%
- Reduces fuel consumption up to 25%
- Increases starting tractive effort (pulling power) up to 40%



KLW SE24B

- The KLW SE24B is a 2,400 bhp four-axle locomotive
- The MTU engine is Tier 3 rail certified and can reduce emissions by over 80%
- It also reduces fuel consumption up to 20% while increasing starting tractive effort up to 40%

KLW SE10B & SE15B



- 1,050 & 1,560 bhp
- Reduces fuel usage up to 60%
- Tier 4i non-road certified, estimated emissions reductions of up to 90%



KLW SE10B: Great for Smaller Switching Operations



KLW SE32C: For the Largest Switching Operations

Solutions for Railroads Big or Small

KLW is **the only** green locomotive manufacturer to offer four single-engine green locomotive models that range from 1,050 horsepower up to 3,200 horsepower. As a result, we are able to offer green locomotives for operations of any size, making green locomotive adoption a reality for any railroad.

Performance



2250 on NS's Starkey Hill

- Tractive effort testing at Norfolk Southern's Starkey Hill in December, 2012
- Starting tractive effort was 77,600 lbs, which is 29.4% adhesion
- The 2250 was able to accelerate faster and pull more cars than other locomotives



2250 at BNSF

- Tractive effort testing at BNSF's Alliance Yard near Fort Worth, TX, mid-2013
- Out of three attempts, the KLV 2250 accelerated to 10 mph 30% faster on average than a GP39-2 and over 50% faster on average than a 3GS Genset
- Used at Alliance Yard for over 1 month, BNSF was pleased with KLV 2250's performance



KLM SE10Bs for NYNJR

- KLM delivered 3 KLM SE10Bs to NYNJR in 2015
- The 3 units replaced GP38-2s that were being leased at the time
- The units do the work required and are saving approximately 30% on fuel consumption



3200 at BNSF

- KLM 3200 visited BNSF's Alliance Yard in early 2016 for yard and road switching tests
- The 3200 was put up against an SD39-2, SD70MAC, and 3GS to see which unit could achieve the highest speed in 1,000 ft. from 0 mph
- The 3200 beat the MAC, 3GS, and went the same speed as the SD39-2

Current Projects



The KLU 3200 with a DOC installed for testing purposes.



A close up of the diesel oxidation catalyst (DOC).

Creating a Tier 4 Locomotive

KLU is currently testing aftertreatment devices in an attempt to lower emissions to Tier 4 levels. Because the MTU engine is already low-emitting, we believe we can achieve Tier 4 with very little aftertreatment. If we succeed, KLU will be the only manufacturer to offer a Tier 4 “locomotive” certified product that is below 4,000 horsepower.



A KLW unit in the early stages of construction.

Texas Locomotives

KLW recently started manufacturing a multi-unit order for a customer in Texas. These locomotives are partially funded by the Texas Emissions Reduction Plan (TERP) and will be completed by May of next year. This is our largest green locomotive project to date.



Large sections of the shop floor were removed to install new railroad track.



The new tracks extend out of the south end of the shop and will soon connect to a "run-around" track.

Shop Expansion

KLW is currently in the process of upgrading the shop by extending two tracks out the south end of the building and connecting them to an adjacent track. This will create a run through process so that units can flow through the shop in stages, decreasing build time and increasing efficiency.

Challenges

EPA Standards for “Switch” Locomotives

Tier (Date of Manufacture)	NOx	PM	HC	CO
Tier 0 (1973-2001):	11.8	0.26	2.10	8.0
Tier 1 (2002-2004):	11.0	0.26	1.20	2.5
Tier 2 (2005-2010):	8.1	0.13	0.60	2.4
Tier 3 (2011-2014):	5.0	0.10	0.60	2.4
Tier 4 (2015 or later):	1.3	0.03	0.14	2.4

Making a Locomotive that Meets EPA Standards

In 2015, Tier 4 requirements for new locomotives became active. Despite significant gains in technology, Tier 4 diesel engines that are “locomotive certified” do not yet exist under 4,000 horsepower. Therefore, the ONLY way to make a green locomotive today is by repowering old locomotives.

For repowered units over 2,300 hp with 50% or more used parts, the unit does not have to meet Tier 4 standards.



With less than 50% used parts, unit is required to meet Tier 4 standards, making the unit ILLEGAL to sell, even though it is 80% cleaner than its original configuration.

New Versus Used Parts

In addition to using older locomotives, KLM is restricted to using a certain percentage of “previously used” otherwise we would have to meet Tier 4 requirements. Locomotives under 2,300 HP only need at least 25% previously used parts, but units above 2,300 HP must have at least 50% previously used parts. Since the new engine needs many new components to work properly (computer system, cooling system, fuel tank, etc.) this is a huge challenge when repowering a locomotive.



Traditional locomotives consume and pollute more while pulling less freight. However, they only cost \$100k-\$300k and can still do a lot of work.



With reductions in emissions, fuel consumption, and gains in pulling power, the KLM product line has significant economic value. However, a railroad typically needs funding assistance to justify a purchase.

Competing Against Older Locomotives

Even though our units offer significantly reduced emissions and fuel consumption, many railroads prefer to use old locomotives because of their lower initial cost and familiarity. **So far, ALL of the green locomotives KLM has built or is building were made possible with the assistance of government funding.**



In Conclusion

KLW has created a line of single-engine green locomotives that meet the needs of any operation. These units offer significantly reduced emissions, fuel consumption, and gains in pulling power. However, without funding assistance, most railroads are unable to justify the cost of this new technology.

Thank you for your time.

Kris Wysong

Product Manager – Knoxville Locomotive Corp.

865-522-7078 ext. 233

kwysong@goklw.com

Visit us online at:

www.goklw.com