



INTERNATIONAL UNION  
OF RAILWAYS

# THE END of FOSSIL FUELS IN THE RAILWAY SECTOR

ABOUT EXPERIENCE HISTORY BIOFUELS  
IN Russian Railways AND THE TIME OF THE DIESEL  
LOCOMOTIVES

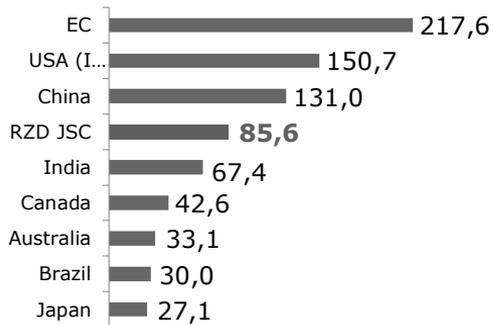
13 November 2019  
ZURICH, SWITZRLAND

Boris IVANOV Russian Railways

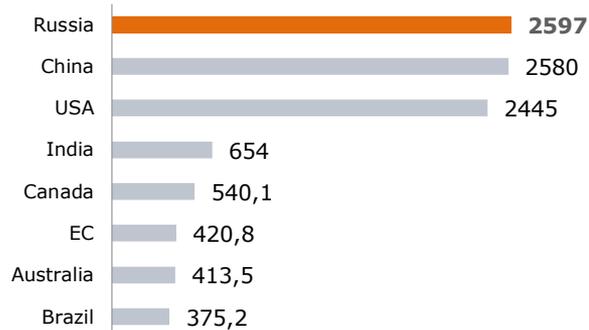


# RUSSIAN RAILWAYS: A GLOBAL LEADING RAILWAY SYSTEM\*

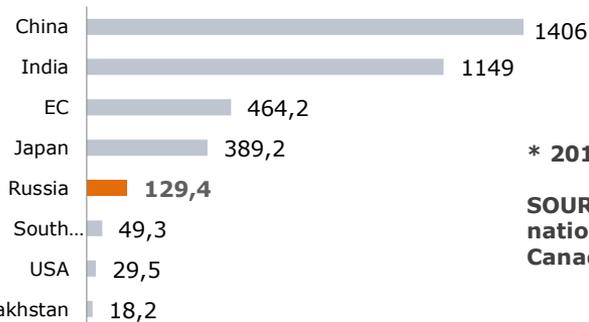
**LENGTH OF RAILWAY TRACK IN USE, THOUSAND KM**



**TURNOVER, BILLION TKM**



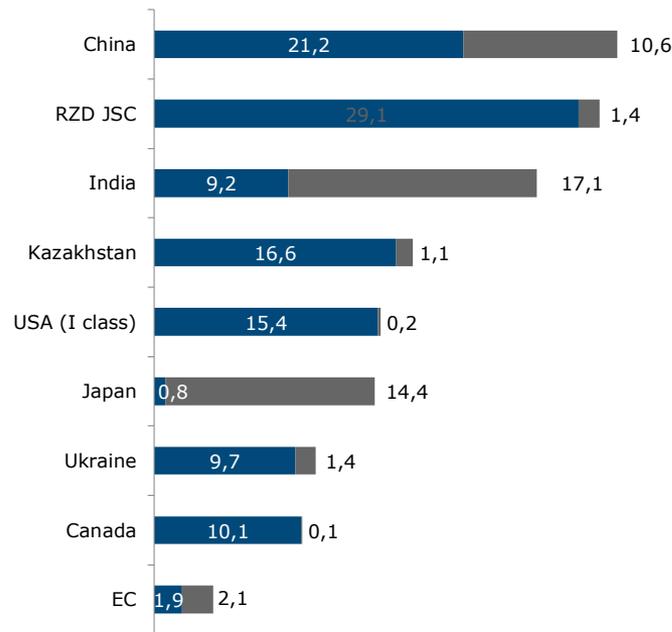
**PASSENGER TURNOVER, BILLION PASS.-KM**



\* 2018 DATA

SOURCES: UIC, OSJD, Eurostat, national statistics agencies, US and Canada railway associations, RZD data

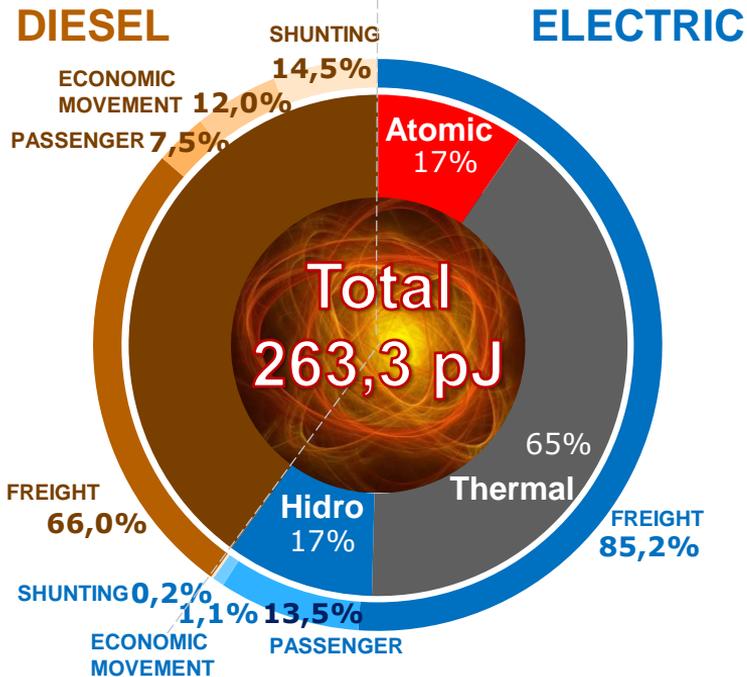
**OPERATION INTENSITY OF RAILWAY NETWORKS, M TKM EQ./KM**



■ FREIGHT TRAFFIC DENSITY, M TKM/KM ■ PASSENGER TRAFFIC DENSITY, M PASS.-KM/KM

# COST BALANCE AND LOKOMOTIV PARK Russian Railways

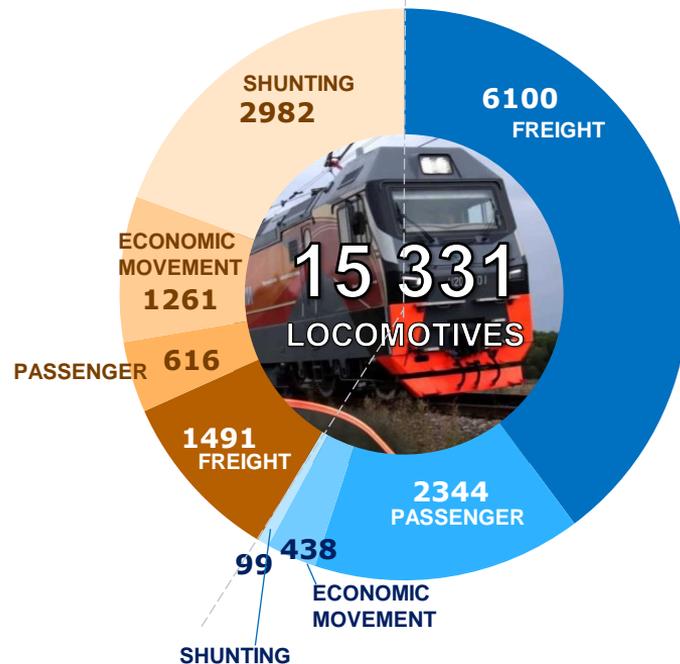
## COST BALANCE Russian Railways



2018 Total electricity consumption **42 823,7 GWh**  
 Total diesel consumption **2,24 million tons**

**Diesel lokomotives**  
6350 units

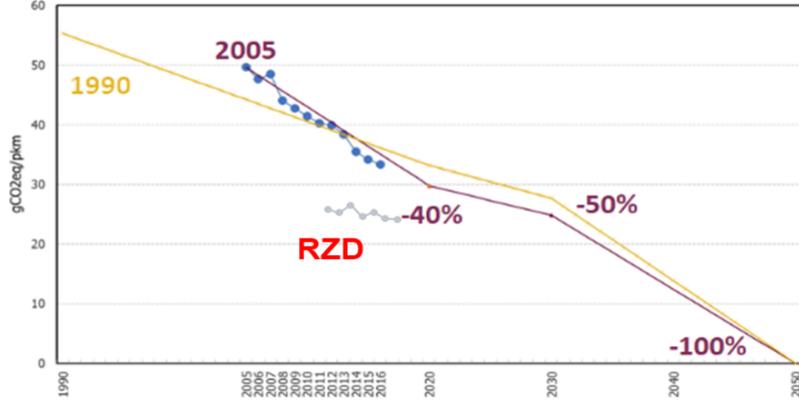
**Electric lokomotives**  
8981 units



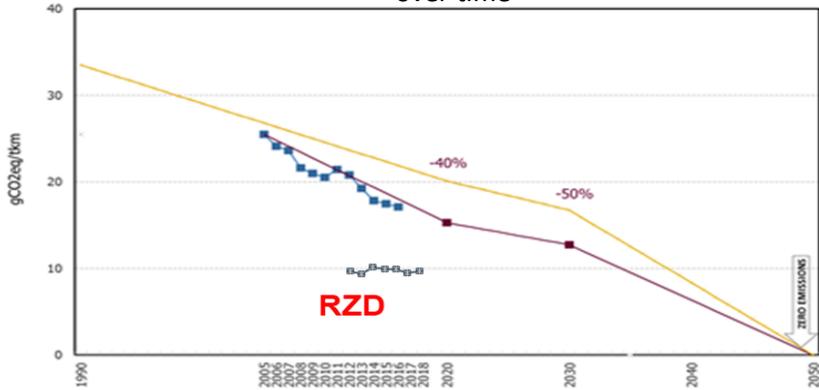
**THE COMPOSITION OF THE LOCOMOTIVE PARK**  
Russian Railways

# RZD OPERATING RESULTS

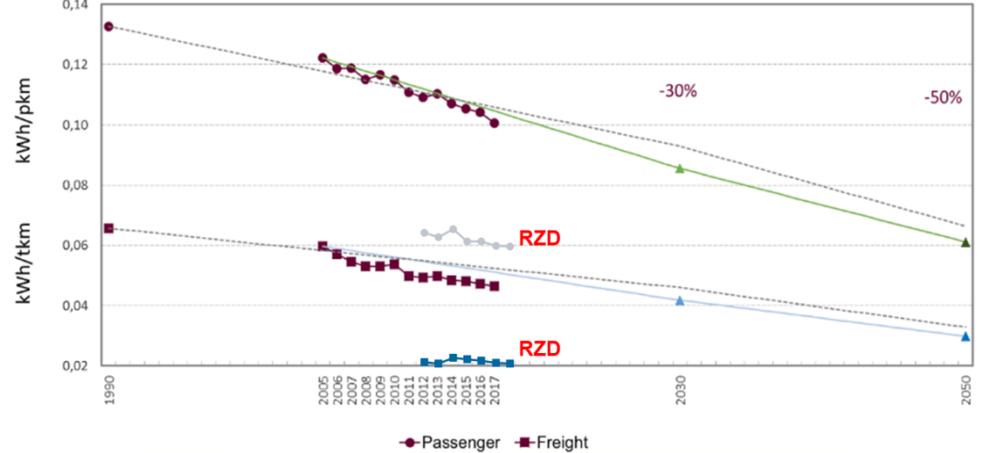
Greenhouse gas emissions by CER and RZD passenger trains over time



Greenhouse gas emissions by CER and RZD freight trains over time



Specific energy consumption by CER and RZD passenger (top) and freight (bottom) trains over time



# BIODIESEL TEST CONDITIONS



## Locomotive specifications

- Axle wheel configuration: 3<sub>0</sub>-3<sub>0</sub>
- Diesel power: 993 kW
- TEM power: 6×134 kW
- Maximum Speed : 95 km/h
- Design weight with 2/3 fuel, water and sand reserves: 123 t

- The test was performed on four ChME3 diesel locomotives  
Locomotive No. 1 operated on pure diesel fuel (annual consumption: 128 t)  
Locomotive No. 2 operated on diesel fuel with 5% added biodiesel (annual consumption: 69 t)  
Locomotive No. 3 operated on diesel fuel with 10% added biodiesel (annual consumption: 38 t)  
Locomotive No. 4 operated on diesel fuel with 20% added biodiesel (annual consumption: 69 t)
- The locomotives were equipped with diagnostic instruments
- The share of idling was comparable for all the locomotives
- Diesel locomotives working on mixed fuels exhibited increased specific fuel consumption

# KEY PHYSICO-CHEMICAL PARAMETERS OF DIESEL AND BIODIESEL FUEL



Parameter	Unit	Diesel fuel EN 590:2004	Biodiesel EN 14214:2003
Net calorific value	MJ/kg	42.5	37.5
Density at 15 °C	kg/m <sup>3</sup>	820-845	860-900
Lubricity	µm	460	344
Pour point	°C	-5 ÷ -45	-15
Cloud point	°C	-	-4
Flash point, not less than	°C	55	101
Cetane number	-	51	51
Ash, not more than	weight %	0,01	0,02
Copper plate corrosion	-	Class 1	Class 1
Water content, not more than	mg/kg	200	500

# ALTERNATIVE FUEL TEST RESULTS

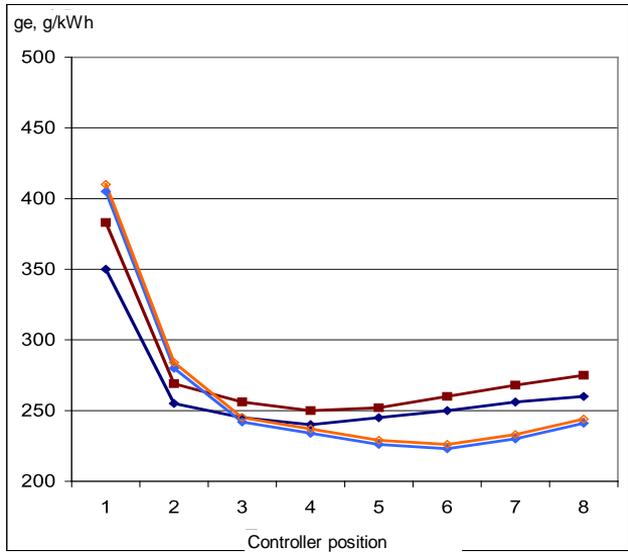


Fig. 3.11. Specific fuel consumption in brake resistor load tests of ChME3 diesel locomotive No. 5193 (20% rapeseed methyl ester) before (2006) and after (2007) driving tests.

- 2006, diesel fuel
- 2007, diesel fuel
- 2006, biodiesel
- 2007, biodiesel

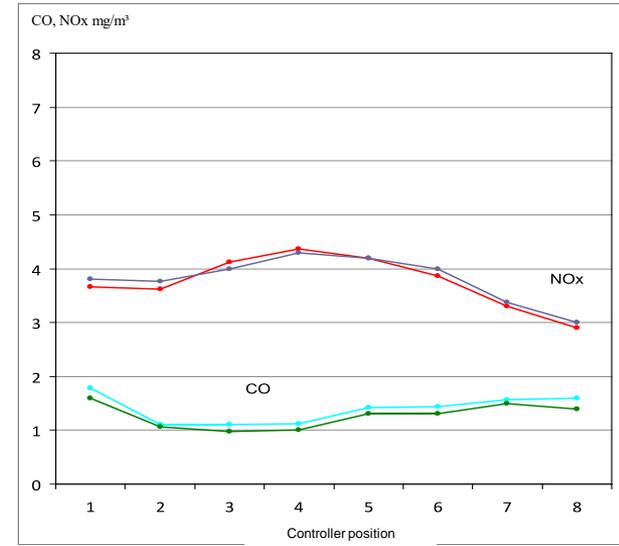


Figure 3.15. Carbon and nitrogen oxide content in the exhaust gases of ChME3 diesel locomotive No. 5193 (20% rapeseed methyl ester) before (2006) and after (2007) driving tests.

- 2006, NOx
- 2007, NOx
- 2006, CO
- 2007, CO

# TEST RESULTS



- Diesel locomotive maintenance revealed increased fouling of fine fuel filters
- As the proportion of biofuel in the fuel mixture rises, so does the intensity of carbon buildup on the sides of the combustion chambers, piston surface and valves of engine cylinders.
- Brake resistor load tests of diesel locomotives demonstrated that addition of biofuel to diesel fuel has almost no effect on locomotive power
- Specific effective fuel consumption falls by 1.8–3.6% relative to pure diesel fuel, owing to the low calorific capacity of biofuel
- When fuel with 20% added biofuel is used, the level of carbon oxide is reduced by 30% relative to conventional fuel, whereas the nitrogen oxide content remains almost constant
- As the cost of biofuel is higher than that of pure diesel fuel, it was considered economically unviable

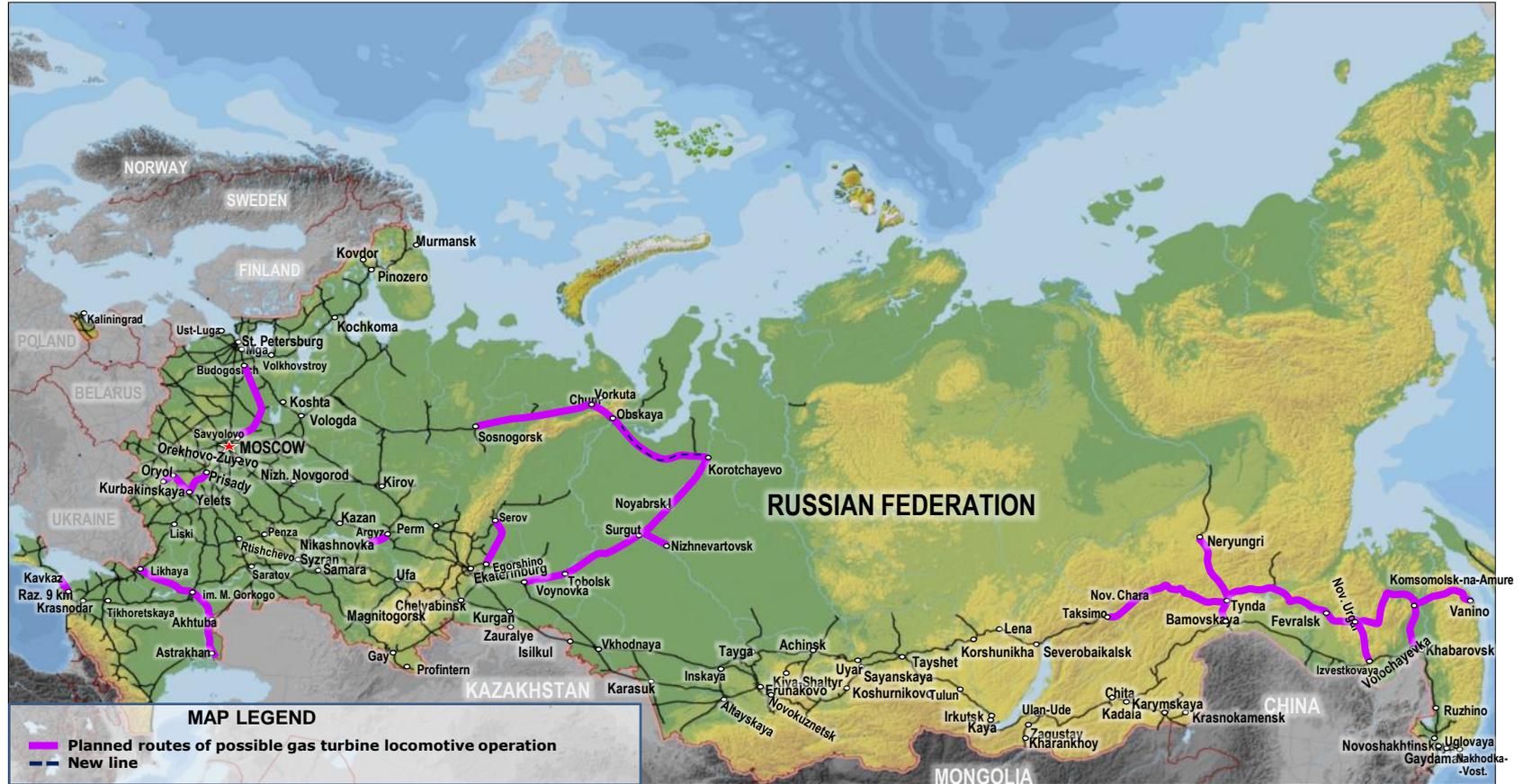
# TEST RESULTS



The tests established that biodiesel fuel can be used with RZD diesel locomotives as long as several conditions are met:

- As biodiesel has stronger detergent qualities, fuel tanks and the fuel system must be thoroughly washed before biodiesel is used. Otherwise pumps and nozzles will be fouled and may be damaged
- Use of biofuel leads to higher deposition of unburned particles in the engine relative to pure diesel fuel
- Owing to the higher acidity of biofuel, the wear and replacement rate of rubber seals of the diesel is accelerated, requiring specialised additives to reduce the adverse impact of biofuel on rubber seals
- As biofuel is hygroscopic, it freezes at temperatures as high as  $-15\text{ }^{\circ}\text{C}$ , requiring use of additional additives.

# FUTURE REGION OF OPERATION OF LIQUID NATURAL GAS-FUELLED LOCOMOTIVES



# LINE OF MAINLINE GAS-FUELLED LOCOMOTIVES FOR THE NLR

GT1h gas turbine locomotive



Engine power	8500 kW
LNG reserve	40 t
Wheel configuration	40-40x2-2x40-40

Gas-piston main-line locomotive (draft design)



Engine power	2x3500 kW
LNG reserve	20 t
Wheel configuration	40-40x2-2x40-40

Reduced life cycle cost of up to 8.5 %

# ADVANCED DESIGNS OF GAS-FUELLED SHUNT LOCOMOTIVES

## TЭМ19-002



Engine power	880–900 кВт
LNG reserve	5 t
Wheel configuration	3o-3o

## TEMG1

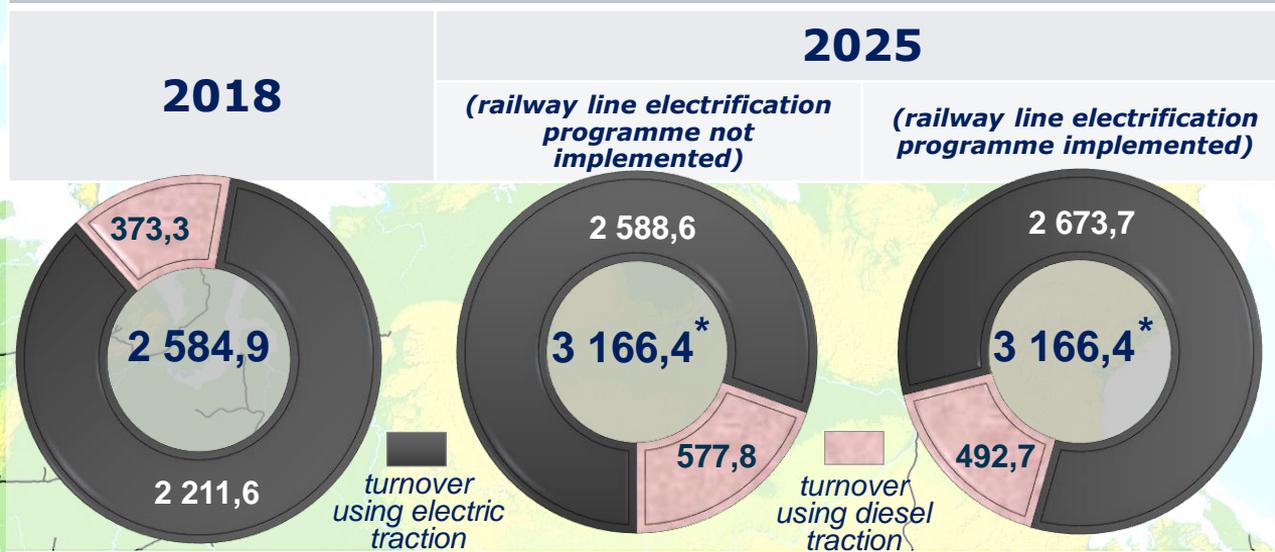


Engine power	2×428 kW
LNG reserve	2.5 t
Wheel configuration	2o-2o

# ENERGY EFFICIENCY OF RAILWAY LINE ELECTRIFICATION FOR THE PERIOD UP TO 2025



## Freight turnover, billion tkm



## CHANGES IN ENERGY INTENSITY OF RZD OPERATIONS DURING RAILWAY LINE ELECTRIFICATION, kJ/tkm-eq, net



\* According to the basic scenario for Long-term Development Programme of RZD

**THANK YOU!**