

Co-Co LOCOMOTIVE

Dynamic performance

Issued Date: 06/08/2025

Revision Date:

REVISION HISTORY

Rev. No	Revision Info	Date
00	First Issue	06/08/2025

INTRODUCTION

THE PRESENT DOCUMENT:

- DETAILS THE LOCOMOTIVE EFFORT-SPEED CHARACTERISTICS
- PRESENTS THE KINEMATIC AND DYNAMIC CALCULATION DATA
- SHOWS THE LOCOMOTIVE DYNAMIC PERFORMANCE AND THE AVERAGE DIESEL ENGINE DUTY CYCLE AND «LOAD FACTOR» ON THE MALATYA-RAZI LINE
- DEFINES THE PERFORMANCE IN THE ENGINE «IDLE MODE»

EFFORT AND POWER CHARACTERISTICS

@ Average wear wheel Diameter

The mechanical characteristics are based on the main customer requirements:

- Max Effort at wheels ≥ 500 kN
- Continuous traction effort at wheels ≥ 350 kN
- Max Power at wheels ≥ 7200 kW
- Diesel engine max Power ≥ 3000 kW

The propulsion system is based on the same Traction Motors, Traction Converter and Auxiliary Converter as per the Electric Supply locomotive. Nr. 2 braking resistors are added, in order to provide full ED braking.

The table below presents the Effort and Power characteristics in case of Diesel Engine supply, compared to the same data for Electric Supply

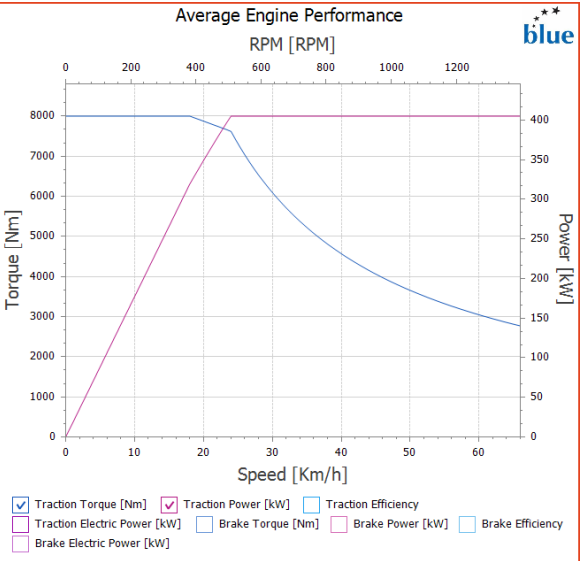
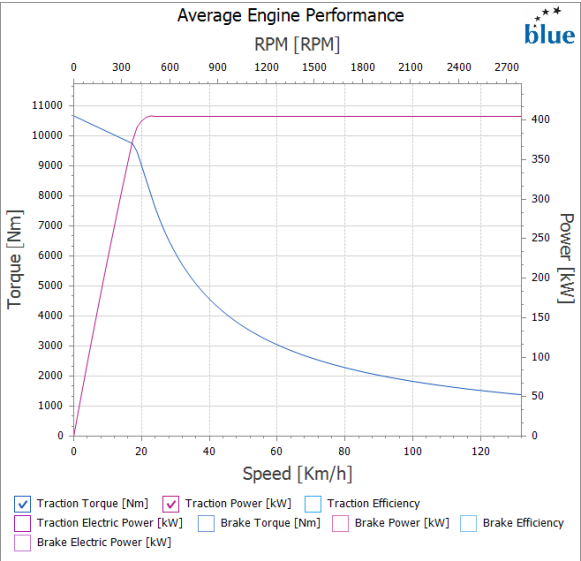
		Diesel supply		Diesel supply (1 Bogie Mode)	
Effort and Power at wheel, half worn ($\Phi = 1200$ mm)	Unit	Motoring	Braking	Motoring	Braking
MAX PEAK EFFORT	(kN)	500	375	250	375
MAX PEAK POWER	(kW)	2385	2385	2385	2385
MAX CONTINUOUS EFFORT	(kN)	375	375	187	375
MAX CONTINUOUS POWER	(kW)	2385	2385	2385	2385

DRIVE-LINE DATA - DIESEL SUPPLY

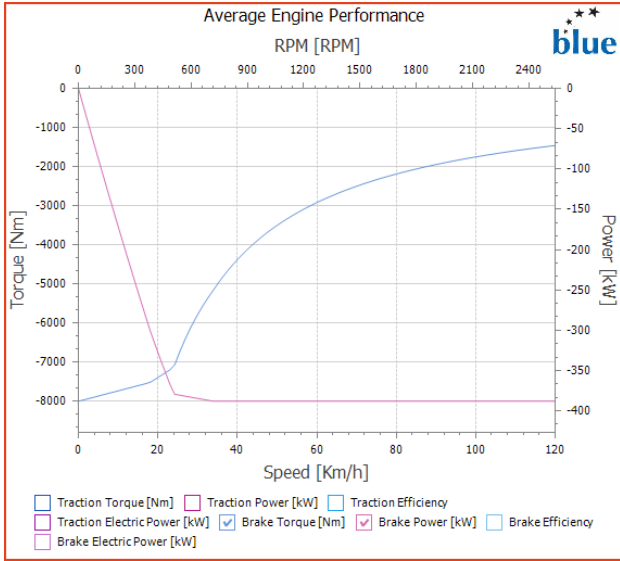
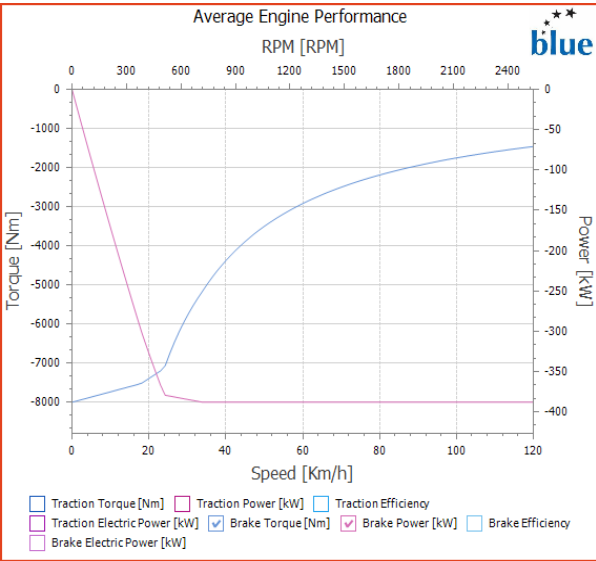
Gear ratio = 4.82 Gearbox efficiency = 0.98

	Unit	Motoring	Braking
MAX PEAK TORQUE	(Nm)	10700	8000
MAX PEAK POWER	(kW)	405	390
MAX CONTINUOUS TORQUE	(Nm)	8000	8000
MAX CONTINUOUS POWER	(kW)	405	390

MOTORIZING
PEAK CONTINUOUS



BRAKING
PEAK CONTINUOUS



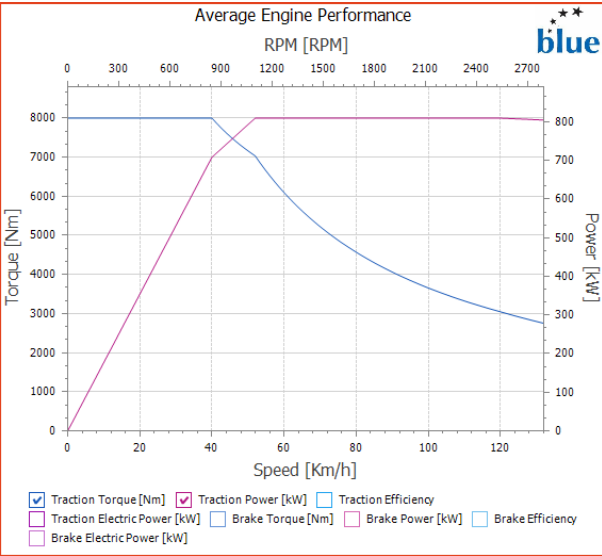
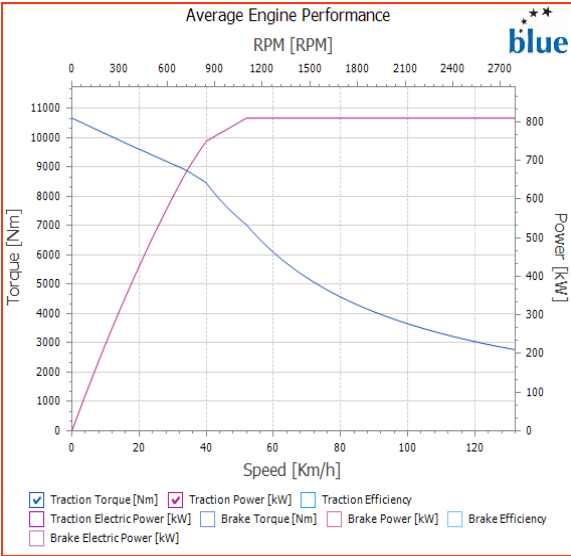
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DRIVE-LINE DATA - DIESEL SUPPLY (1 BOGIE OPERATION MODE)

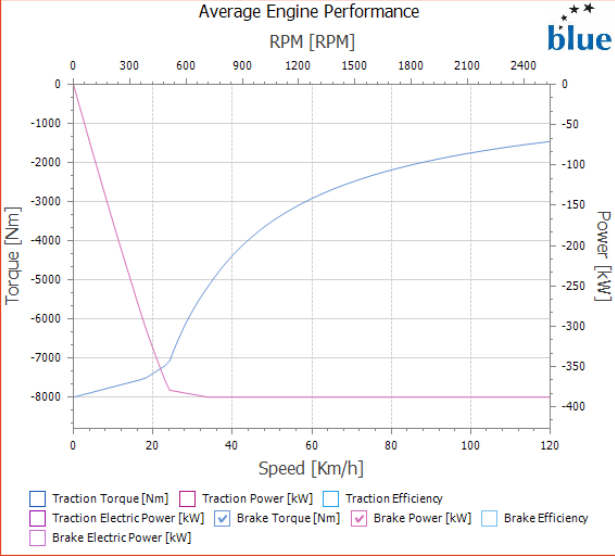
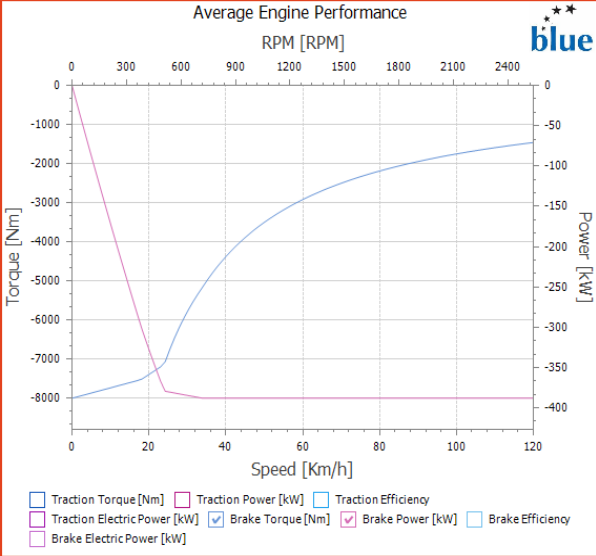
Gear ratio = 4.82 Gearbox efficiency = 0.98

	Unit	Motoring	Braking
MAX PEAK TORQUE	(Nm)	10700	8000
MAX PEAK POWER	(kW)	810	390
MAX CONTINUOUS TORQUE	(Nm)	8000	8000
MAX CONTINUOUS POWER	(kW)	810	390

MOTORIZING
PEAK CONTINUOUS



BRAKING
PEAK CONTINUOUS



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DIESEL SUPPLY

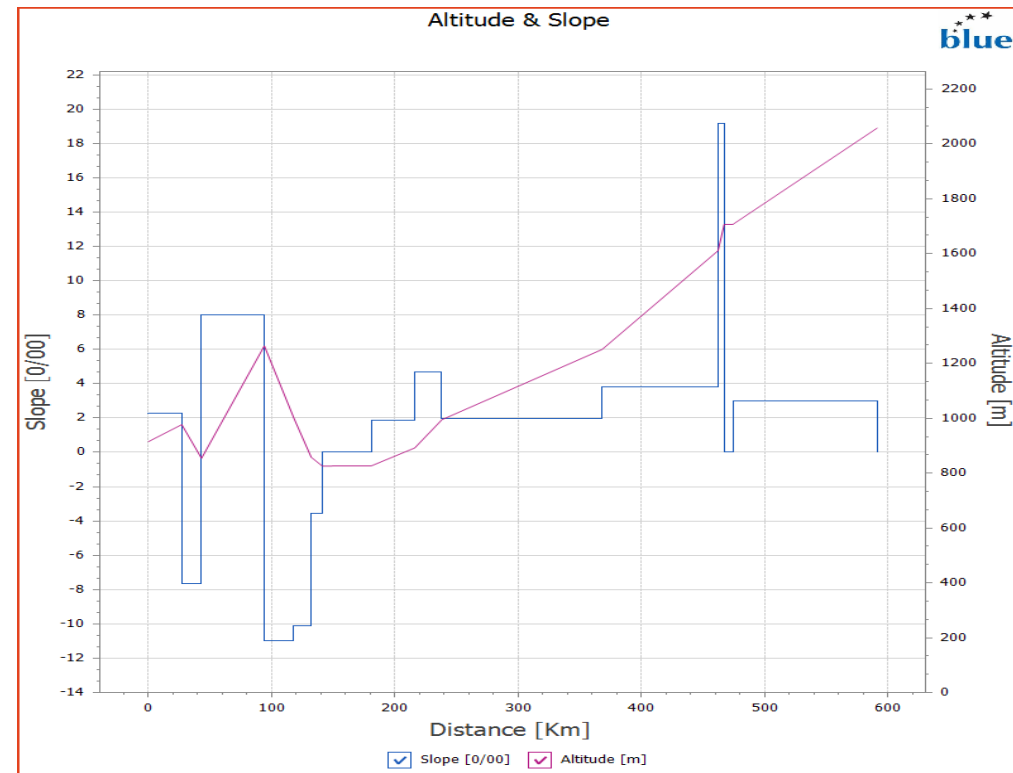
AVERAGE PERFORMANCE CALCULATION INPUT DATA

TRAIN DATA (1750 tons payload)

LOCOMOTIVE MASS	135 t
LOCOMOTIVE ROTATING MASS	15%
LOCOMOTIVE FRONT AREA	13 m ²
LOCOMOTIVE Cx	0.8
CONVERTER EFFICIENCY	0.97
ALTERNATOR EFFICIENCY	0.94
LOCOMOTIVE AUXILIARY LOAD	150 kW
TRAIN BUS POWER SUPPLY	0 kW
HAULED TRAIN CARS NUMBER	21
CAR WEIGHT (4 AXLES)	83.3 t
CARS ROTATING MASS	13.8 %
TOTAL TRAIN Cx	2.858
DEAD TIME FOR TORQUE INCREASE	2

REFERENCE LINE DATA – MALATYA - RAZİ (IRAN)

- ☐ Nr. 15 stations (60 sec stop)
- ☐ Curve data NOT included.
- ☐ Maximum speed (60 kmh TBC)



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DIESEL SUPPLY

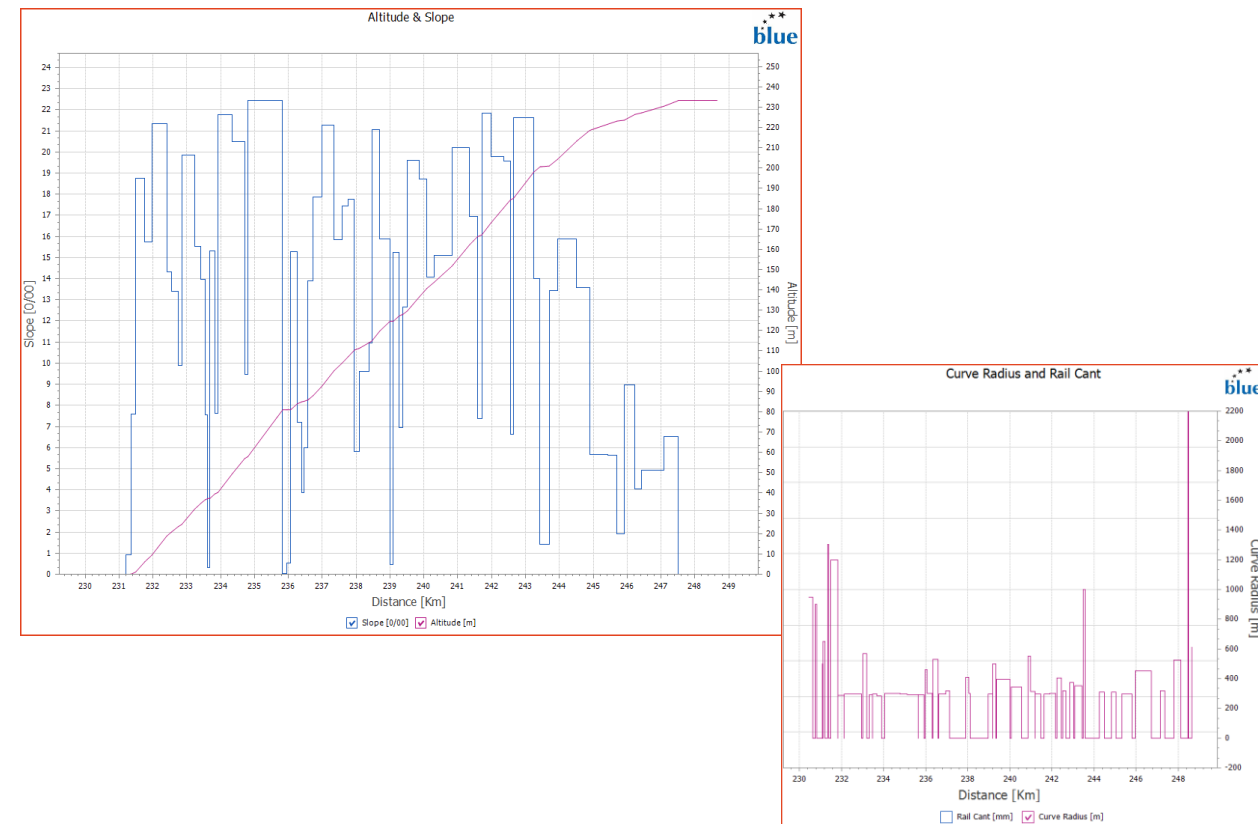
PEAK PERFORMANCE CALCULATION INPUT DATA

TRAIN DATA (1500 + 135 tons payload)

LOCOMOTIVE MASS	135 t
LOCOMOTIVE ROTATING MASS	15%
LOCOMOTIVE FRONT AREA	13 m ²
LOCOMOTIVE Cx	0.8
CONVERTER EFFICIENCY	0.97
ALTERNATOR EFFICIENCY	0.94
LOCOMOTIVE AUXILIARY LOAD	150 kW
TRAIN BUS POWER SUPPLY	0 kW
HAULED TRAIN CARS NUMBER	21
CAR WEIGHT (4 AXLES)	83.3 t
CARS ROTATING MASS	13.8 %
TOTAL TRAIN Cx	2.764
DEAD TIME FOR TORQUE INCREASE	2

REFERENCE LINE DATA – BILECIK to KARAKOY

- ☐ One stop in Yayla (60 sec stop)
- ☐ Curve data included.
- ☐ Maximum speed Bilecik to Yayla 70 km/h, Yayla to Karakoy 65 km/h



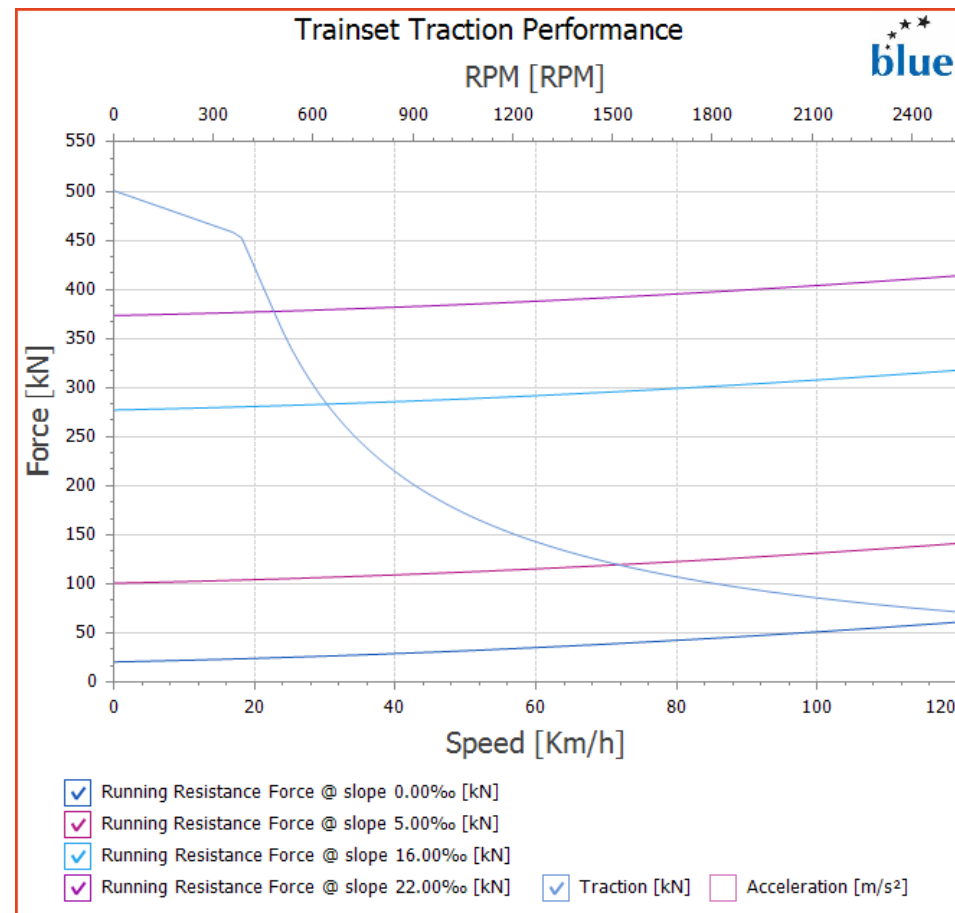
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DIESEL SUPPLY – MAXIMUM SPEED

1500 t PAYLOAD – STRAIGHT TRACK – SLOPE 5, 16 and 22 ‰

SLOPE (%)	RESIDUAL ACCELERATION (PEAK CURVE)(m/s ²)	MAX SPEED (PEAK CURVE) (km/h)	MAX SPEED (CONTINUOUS CURVE) (km/h)
Flat	0.05	70	70
5 ‰	0.05	44	44
16 ‰	0.05	23	21
22 ‰	0.05	16	---



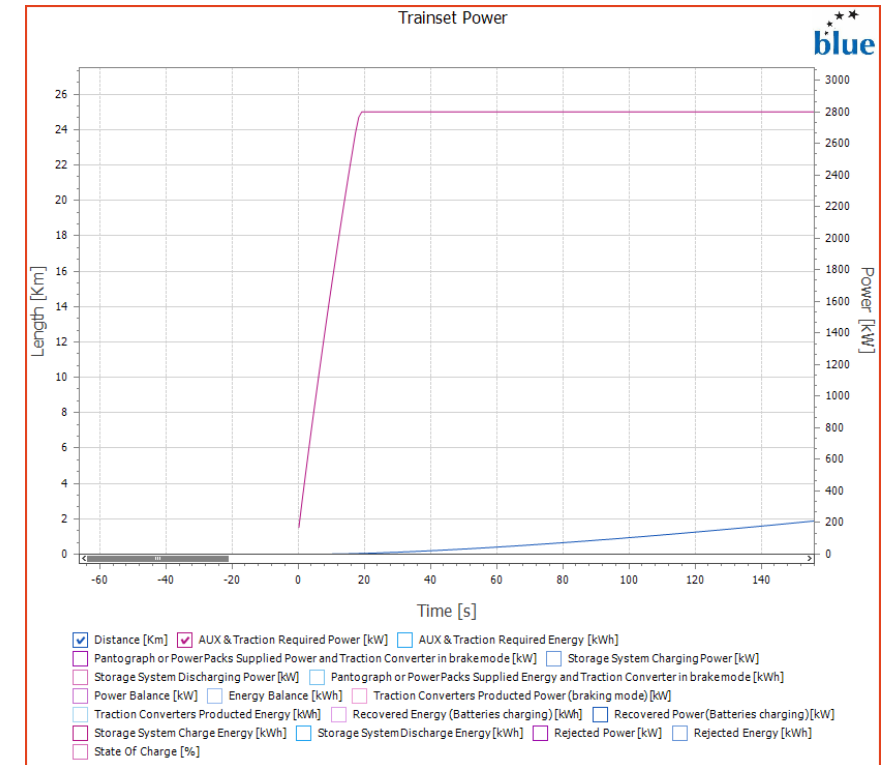
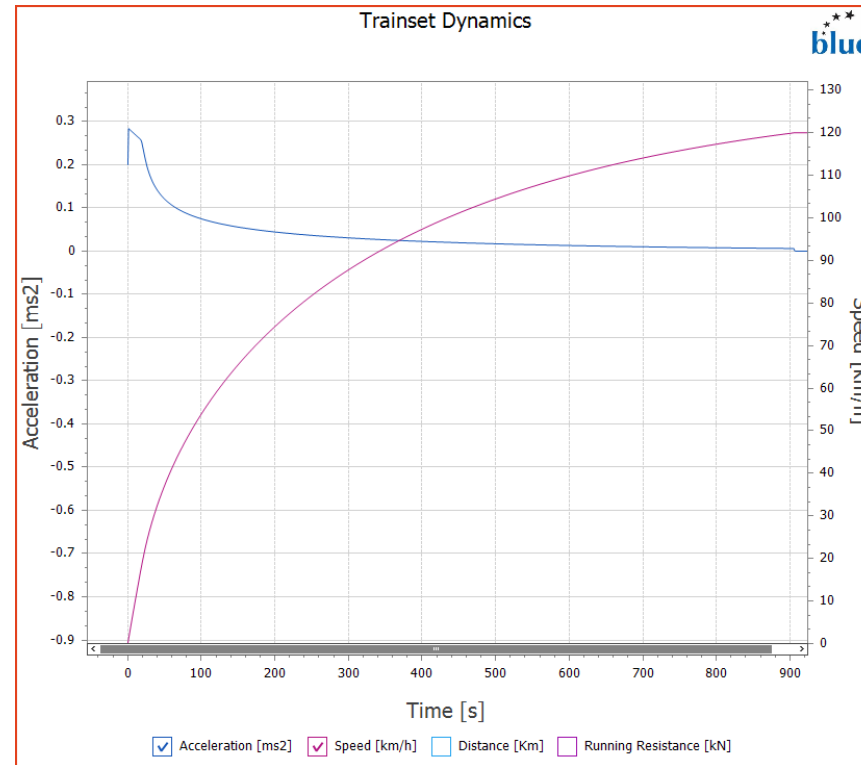
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DIESEL SUPPLY – STARTING AND AVERAGE ACCELERATION

PAYLOAD 1500 t - STRAIGHT AND FLAT TRACK

SPEED RANGE	AVERAGE ACCELERATION (m/s ²)
0 (starting)	0.27
0 to 40 km/h	0.19
0 to 120 km/h	0.09



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DIESEL SUPPLY SLOPE/TRAIN MASS TABLES

SLOPE / TRAIN MASS TABLE

The slope / train mass tables are calculated considering straight tracks.

The speed is calculated as the maximum speed which is possible to be achieved with a residual acceleration of 0.05 m/s^2 .

The payload is the mass of the hauled train (the locomotive mass is not included).

Peak traction curve

Slope Payload (ton)	0.0‰	2.5‰	5.0‰	10.0‰	15.0‰	20.0‰	22.0‰	25.0‰	27.7‰	30.0‰
250	120	120	120	113	94	79	75	68	64	60
500	120	115	99	76	61	50	47	43	39	37
750	110	91	76	56	44	36	34	31	28	27
1000	92	74	61	45	35	28	26	24	22	21
1250	80	63	51	37	29	23	22	19	13	
1500	70	54	44	32	24	19	16			
1750	62	48	38	27	21					
2000	56	43	34	24	17					
2250	51	38	31	22						

Continuous traction curve

Slope Payload (ton)	0.0‰	2.5‰	5.0‰	10.0‰	15.0‰	20.0‰	22.0‰	25.0‰	27.7‰	30.0‰
250	120	120	120	113	94	79	75	68	63	60
500	120	115	99	76	60	50	46	42	39	37
750	109	90	76	56	44	36	34	31	28	26
1000	92	74	61	44	35	28	26	24		
1250	80	63	51	37	28	21				
1500	70	54	44	31	24					
1750	62	48	39	27						
2000	56	42	34	24						
2250	51	38	31							

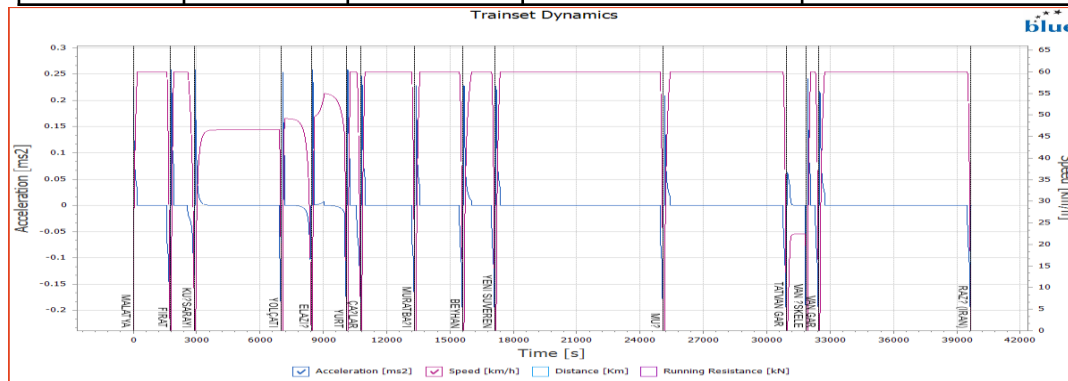
AVERAGE PERFORMANCE CALCULATION – DIESEL SUPPLY

RUN CALCULATION ON THE MALATYA - RAZI LINE (ED Brake Only) – 1750 tons PAYLOAD

The run calculation has been performed using the peak traction curve, as the thermal load has to be compatible with the motor and traction chain thermal capability, and the output power of the GenSet.

Forward

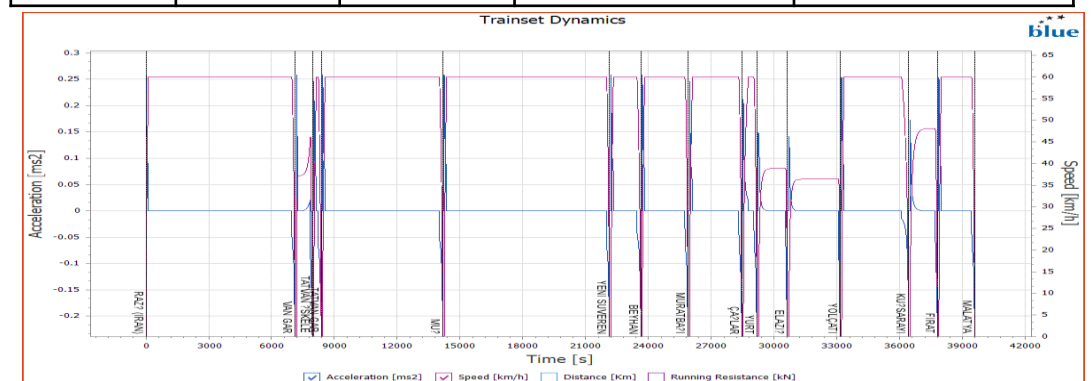
PAYLOAD (tons)	MISSION TIME (sec)	AVERAGE SPEED (km/h)	AVERAGE RMS MOTOR TORQUE (Nm)	Approximate Fuel Consumption (l)
1750	39768	53	3054	4755



Forward track Diesel output Power Distribution	
2980-2660 kW	18.3%
2660-1330 kW	57.9%
1330-800 kW	6.6%
800-0 kW	15.6%
Average kW	1864

Reverse

PAYLOAD (tons)	MISSION TIME (sec)	AVERAGE SPEED (km/h)	AVERAGE RMS MOTOR TORQUE (Nm)	Approximate Fuel Consumption (l)
1750	39704	53	2520	2245



Overall Diesel output Power Distribution	
2980-2660 kW	16.4%
2660-1330 kW	29.9%
1330-800 kW	6.4%
800-0 kW	45.4%
Average kW	1285

Reverse Track Diesel output Power Distribution	
2980-2660 kW	14.6%
2660-1330 kW	1.8%
1330-800 kW	6.2%
800-0 kW	75.3%
Average kW	704

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Diesel Dynamic performance

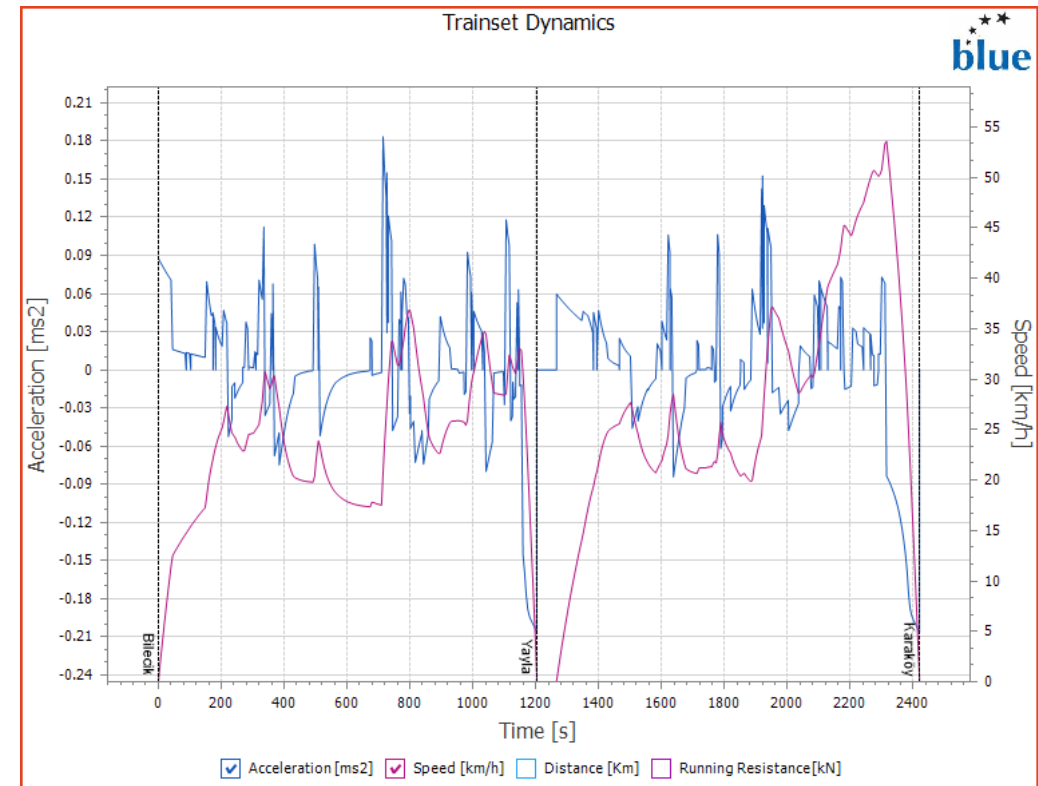
PEAK PERFORMANCE CALCULATION – DIESEL SUPPLY RESCUE

RUN CALCULATION ON THE BILECIK to KARAKOY LINE – 1500+135 tons PAYLOAD

The run calculation has been performed using the peak traction curve (ED Brake Only), as the thermal load has to be compatible with the motor and traction chain thermal capability, and the output power of the GenSet.

PAYLOAD (tons)	MISSION TIME (sec)	AVERAGE SPEED (km/h)	AVERAGE RMS MOTOR TORQUE (Nm)	Approximate Fuel Consumption (l)
1500 + 135	2419	25	7345	440

Diesel Output Power Distribution	
2980-2660 kW	81.30%
2660-1330 kW	6.50%
1330-800 kW	2.00%
800-0 kW	10.20%
Average kW	2313



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SUMMARY OF RESULTS DIESEL SUPPLY

Max Speed on 16 ‰ slope (km/h)	Starting Acceleration (m/s ²)	Average Acceleration 0-40 km/h (m/s ²)	Average Acceleration 0-120 km/h (m/s ²)	MALATYA - RAZİ 1500ton Forward Run time (sec)	MALATYA - RAZİ 1500ton Forward Average speed (km/h)	MALATYA — RAZİ 1500ton Forward RMS torque (Nm)
23	0.27	0.19	0.09	38666	55	2694

	1750 Ton Payload	
Diesel GenSet Electric Output	Average Electric Power (kW)	Load Factor (%)
Forward track	1753	63%
Reverse Track	662	24%
Overall	1208	43%

TEMPERATURE CALCULATION ON ROUTE PROFILES

The data in numeric format are shown in the document TCL-2_BC21 rev. 02

- The temperature calculation for the evaluation of the lifetime of the traction motor and the mechanical life of the rolling elements of the drive-line has to be executed using the run profile in page 1 and 2 (MALATYA - RAZİ LINE uphill and downhill, 1750 tons) as a sequence, up to the temperature steady state
- The temperature calculation for the evaluation of the maximum stress of the traction motor and the mechanical life of the rolling elements of the drive-line has to be executed using the run profile in page in page 3 (BILECICK – KARAKOY uphill, rescue of a 1500 t train).

THANK YOU!