SAF-HOLLAND

How Powered Axles could change vehicles

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SAF Holland Group

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Heavy-load traffic will be green, quiet & (electric)

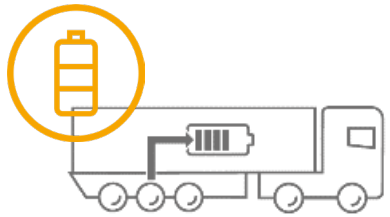
CO_2 reduction, noise reduction and legislation to protect inner cities are the main drivers for electrified CV's

Noise cancelling

- Traffic noise is considered a widespread environmental problem and has become a major health concern in the EU
- Stricter vehicle noise standards encourage manufacturers to produce noticeably quieter vehicles

CO_2 reduction

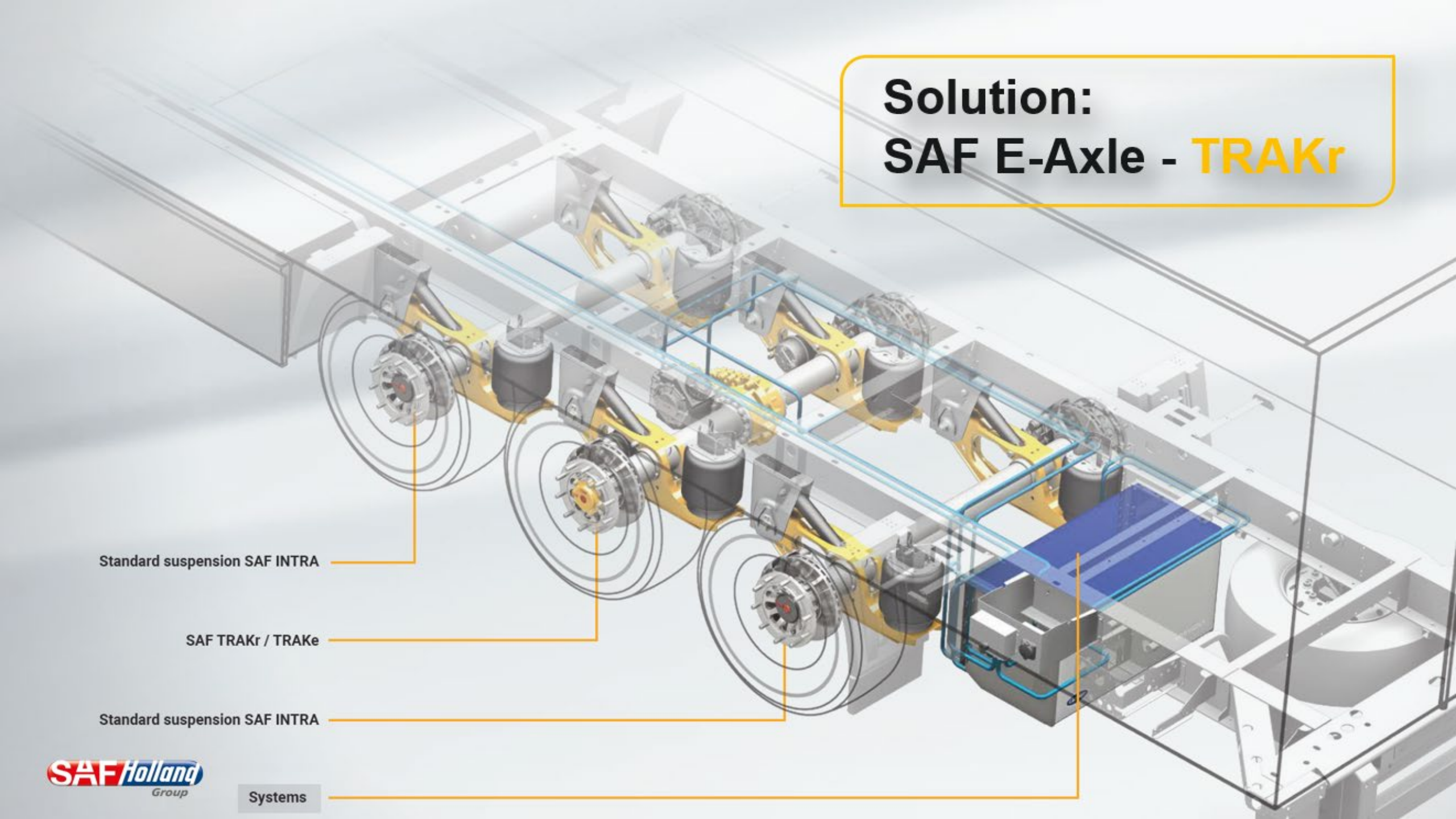
- Limitation of global warming to 1.5° – 2°C requires total CO_2 emission reduction of 80 – 95 per cent until 2050 (vs. 1990)
- CO_2 reduction targets for commercial vehicles unlikely to be reached by diesel measures only
- Customers are more and more focused on "green transports"



Electrification

The use of electrified trailer axles gains importance especially for refrigerated trailers and inner-city applications

Solution:
SAF E-Axle - TRAKr

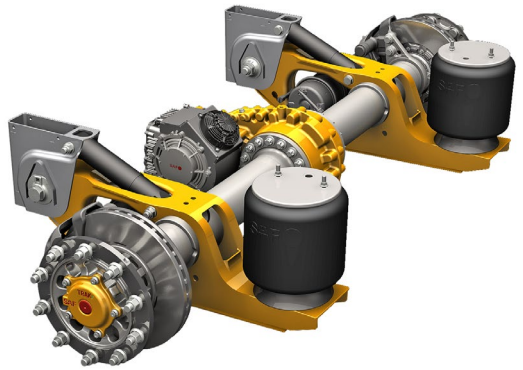


E-Mobility

SAF E-axle family - Electrified solutions for CV trailer applications

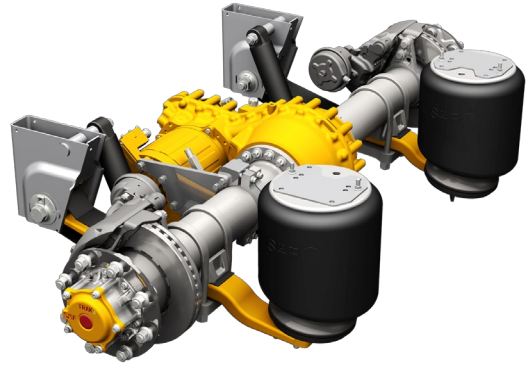
SAF TRAKr for electrical recuperation

- The main design principle is the centrally located high voltage generator unit (max. 20 kW), which converts trailer kinetic energy to electrical energy, which can be used to operate electric consumers of the trailer. The generated energy is stored in a Li-Ion battery.
- Main applications: cooler, tanker, silos



SAF TRAKe for electrical recuperation and traction support

- In principle, the same design as TRAKr, but more powerful high voltage E-machine with a higher output (max. 120 kW, max. 320 Nm). Depending on the operational mode the generated energy can be used to operate electric consumers of the trailer or can be used for the drive mode to support the main engine of the truck (e.g. at slopes). The generated energy is stored in a Li-Ion battery.
- Main applications: car carrier, cooler, tipper, tanker, silos, etc.



Technology

SAF TRAKr: Technology

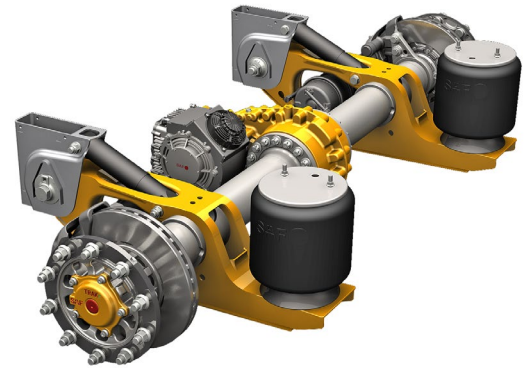
Description of electrified axle SAF TRAKr

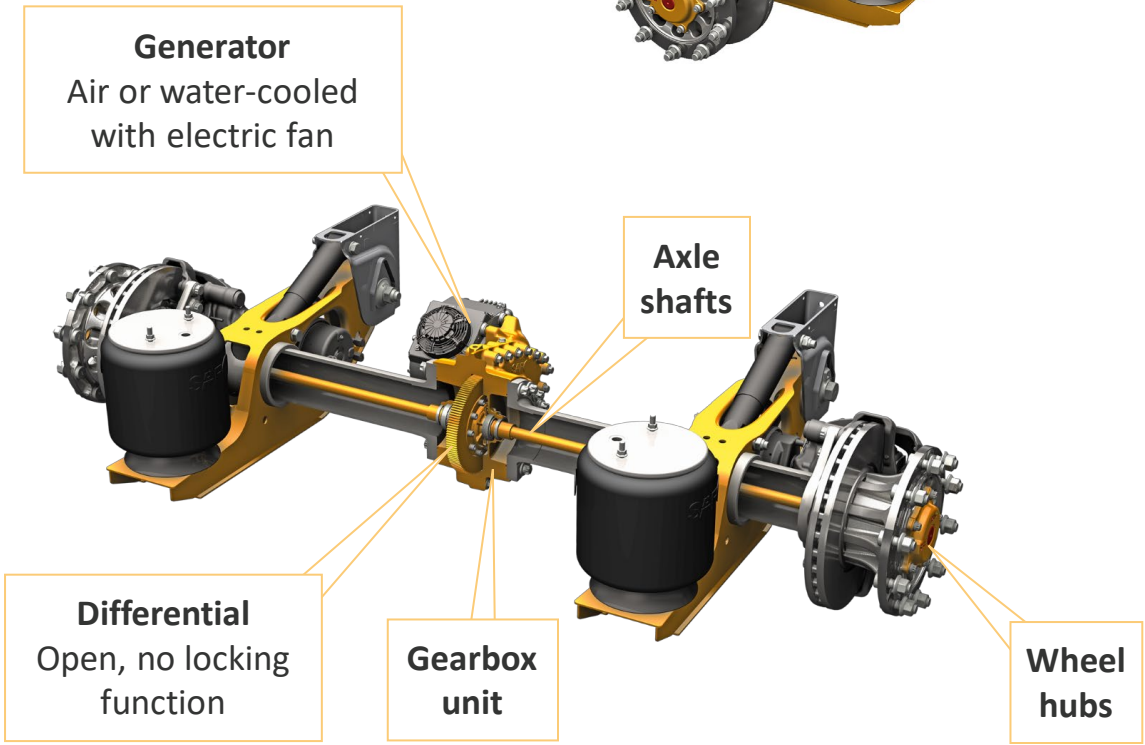
Gearbox unit

- Central one-speed gearbox with differential
- Ratio i = 1 : 14,0
- Differential of gearbox is connected to both wheel hubs with 2 axle shafts
- Open differential: No locking function
- No clutch
- High efficiency up to 95%

Generator

- Switched reluctance E-Machine (SRM)
- Max. power: 17 kW cont. / 20 kW peak (700 V)
- Max. torque: 27 Nm cont. / 32 Nm peak (700 V)
- High efficiency up to 96% and no drag torque
- Rare earth-free (no permanent magnets)
- Air-cooled with electric fan





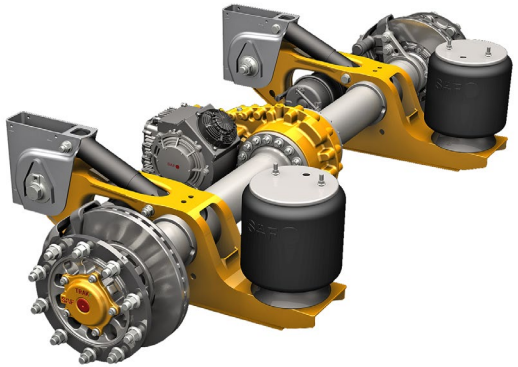
Technology

Comparison SAF TRAKr vs. SAF TRAKe

SAF TRAKr

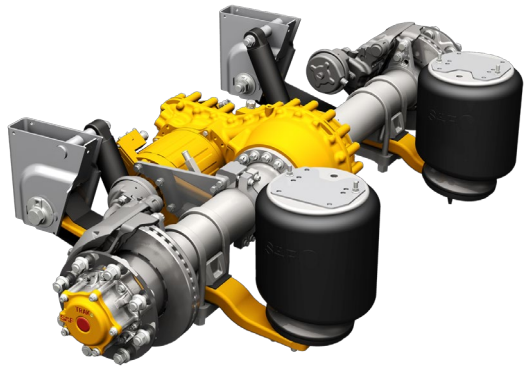
- For electrical recuperation
- Air-cooled E-machine (SRM)
- Max. power: 17 kW cont. / 20 kW peak *
- Max. torque: 32 Nm peak ► Up to 224 Nm per wheel*
- Gearbox ratio: i = 1 : 14,0
- Additional weight of axle: approx. 150 kg

* at 20 °C ambient



SAF TRAKe

- For electrical recuperation and traction support
- Fluid-cooled E-machine (PSM)
- Max. power: 60 kW cont. / 120 kW peak
- Max. torque: 320 Nm peak ► Up to 1.930 Nm per wheel
- Gearbox ratio: i = 1 : 12,08
- Additional weight of axle: approx. 300 kg



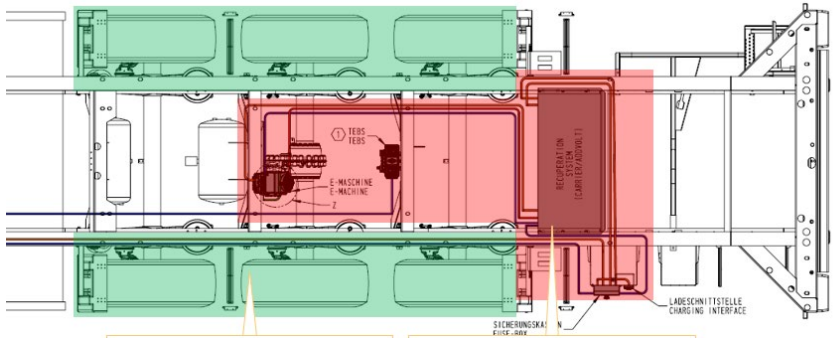
SAF TRAKr: Technology

Operational strategy

- The generator charge during driving only (Dyno mode)
- Does not charge during braking or during driving stability events.
- The system is connected to the CAN interface of the Trailer EBS to use the signals for the operational strategy.
- The system starts to charge the battery below a SoC (net) of 99% and charges the battery within a SoC range (net) from 10 to 100%.
- The system deactivates the generator
  - below vehicle speed of 15 km/h
  - during braking including emergency braking events
  - during stability events
- The system works autonomously from the truck
- Advanced operational strategy will include recuperation during braking phases in the future

Charging options

- Recuperation and energy generation through axle while driving
- Grid charging with power supply unit



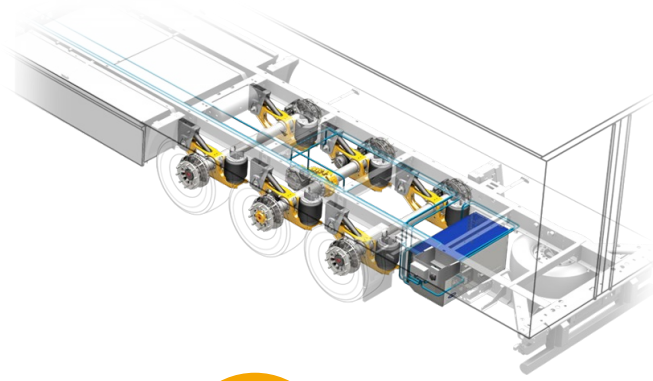
SAF TRAKr

Electrical recuperation system
CARRIER/ADDVOLT

Reality

SAF TRAKr: Numbers…

Weight and charging time



Elimination of Diesel generator of reefer unit and fuel tank

+191kg (approx.)

Complete battery driven system **without** TRAKr

200l fuel tank	Diesel generator	System incl. battery (68 kWh)	Addi-tional parts
-200 kg	-259 kg	640 kg	10 kg

External charging time (80% with max. 11 kW/h): min. 4h 57 min

Dimension of system (L x W x H in mm): < 1.250 x 580 x 590 (e.g. 1.250 x 1.000 x 590)

Elimination of Diesel generator of reefer unit and fuel tank

+71kg (approx.)

Complete electrical recuperation system **with** SAF TRAKr

200l fuel tank	Diesel generator	Axle SAF BIR9 incl. generator vs. SAF BI9	System incl. battery (34 kWh)	Addi-tional parts
-200 kg	-259 kg	150 kg	360 kg	20 kg

External charging time (80% with max. 11 kW/h): min. 0h 0min

Dimension of system (L x W x H in mm): 1.250 x 580 x 590

SAF TRAKr: Numbers…

Date	km	Diesel consumption [l]	Needed kWh	Reefer op time in h	average speed km/h	average truck consumption l/100km	max amb temp in °C
26. Mar	0	0,00		0	0	?	
29. Mar	596,55	176,76	7,82	1,54	59,07	29,63	27,35
30. Mar	749,30	238,98	14,73	1,85	56,04	31,89	31,9
31. Mar	634,09	190,96	17,14	1,94	63,20	30,16	33,85
01. Apr	102,09	31,02	0	0	63,71	30,38	27,34
02. Apr	603,49	178,74	1,26	0,3	69,00	29,62	17,63
07. Apr	245,85	77,3	20,2	5,05	48,32	31,44	11,66
08. Apr	652,39	197,48	6,45	1,74	64,11	30,27	13,05
09. Apr	591,74	171,94	18,02	3,92	54,04	29,06	14,13
10. Apr	304,13	84,46	1,2	0,27	67,45	27,77	16,21
17. Apr	598,07	179,62	6,98	1,91	47,33	30,03	16,45
18. Apr	589,42	178,48	???	0	???	30,28	15,57
19. Apr	579,26	184,24	4,48	0	66,28	31,81	15,33
20. Apr	599,99	180,58	18,45	4,44	64,36	30,1	13,81

Total travel range: 6,453.57km

Total fuel consumption: 2,148.76l

Total fuel for cooling saved: 165.95l

Additional fuel consumption – truck:

- cooling on diesel: 29.85l/100km
- cooling by electrical: 30.19l/100km

$$l_{\Delta e} = +0{,}34\,\frac{l}{100km}$$

Total diesel savings (lds) by travel range and consumption:

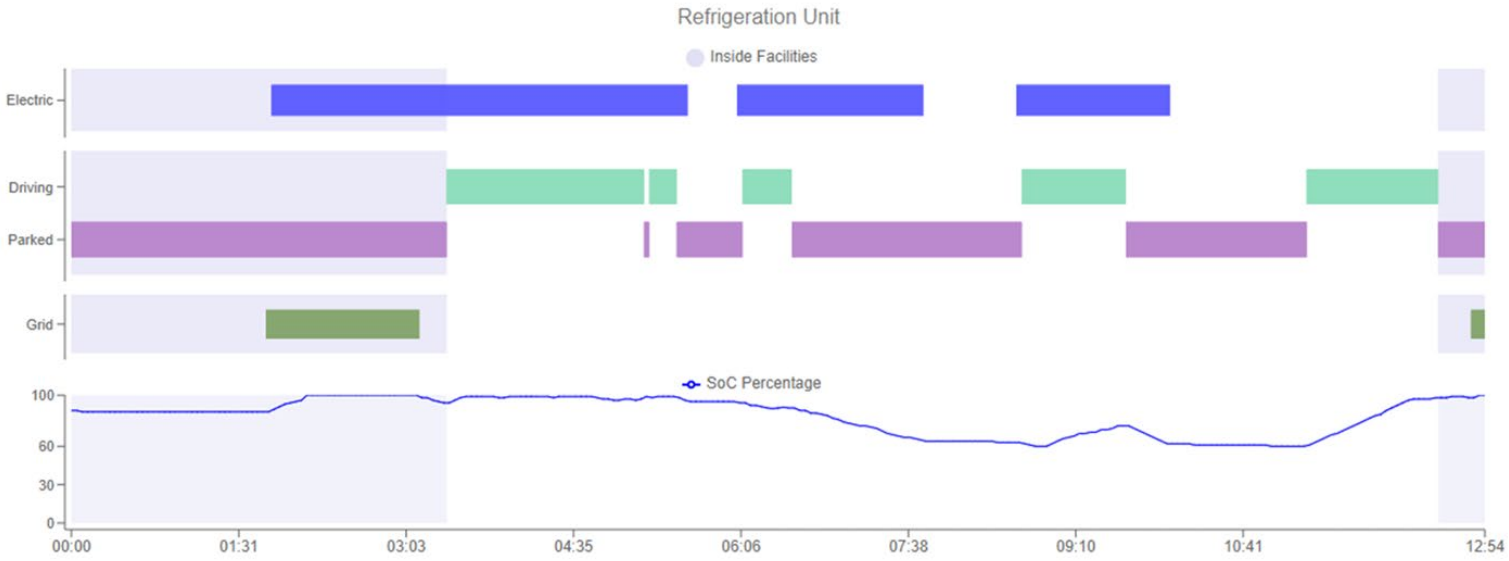
$$l_{ds} = 165{,}95\text{l} - 0{,}34\,\frac{l}{100km} \cdot 6453{,}57km = 144l \quad \Rightarrow \quad l\,\frac{1}{100km} = \frac{144l}{\frac{6453{,}57km}{100}} = 2{,}23l\,\frac{1}{100km}$$

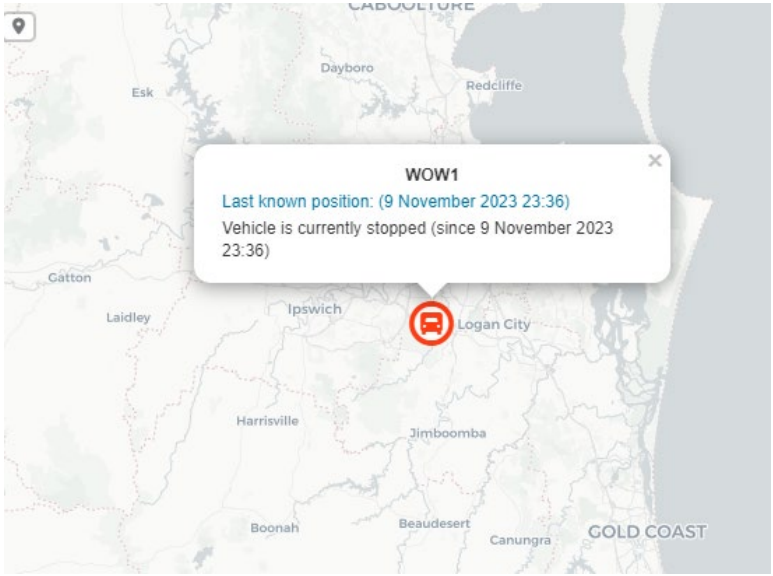
Australia: Two SAF TRAKr Axles in Service

Primary Connect (Woolworths Group)

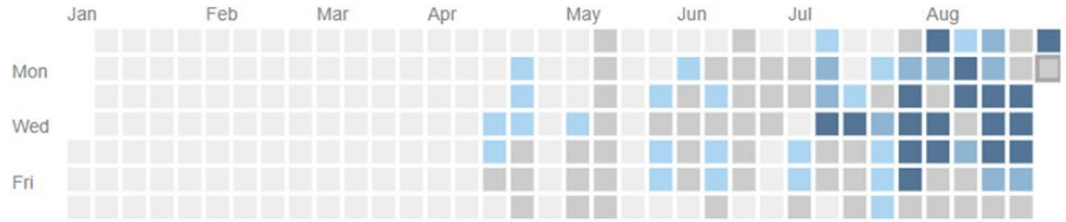
Martin Brower (McDonald's)

Live Monitoring: Data Presentation





History



From - To

Savings

Electric
1585 hrs
-4754 litres
12551 kg CO2

Diesel
0 hrs
0 litres
0 kg CO2

Total refrigeration hours
1585 hrs

Future Options

Cooler/Reefer

Tankers/Silos

Operate electrical compressor independently from the truck

Walking floor trailer

Electrical operation of the floor system.

Liftgates

Operate electrical pump for hydraulic liftgate independently from the truck.

Transportable e-forklifts

Charge e-forklifts during driving for loading operations during stops.


Thank you for
your attention