Final report

AUSTRALIAN MEAT PROCESSOR CORPORATION

DiVA Platform for Transport Emissions

Data-integrated Visualization and Analytics (DiVA) Platform for Transport Emissions, Efficiency and Sustainability

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1.0 Executive summary

In this project, a Data-integrated Visualization and Analytics (DiVA) platform for transport emissions, efficiency, and sustainability was developed and tested via in-field trials. The developed solution included the following components:

1) An Internet of Things (IoT) box equipped with Global Positioning System (GPS) module, onboard diagnostics tools, and sensors to monitor the vehicle telematics, logistics performance and Greenhouse Gas (GHG) emissions

2) A data driven capability to realise intelligent modelling of GHG emissions.

3) A DiVA cloud dashboard for data visualization.

4) A portable emission measurement system (PEMS) was designed and tested on heavy vehicle to measure real-world emission data.

5) As a component of the research, a technology survey and opportunity discovery to propose pilot studies with recommendations on future alternate fuel options was undertaken and reported on.

Accordingly, systems have been designed and developed to meet the objectives delivering successful installations which have been tested and validated in vehicles for real world logistics applications.

The first element that was developed, DiVA, a Data-integrated Visualization and Analytics (DiVA) Platform for Transport Emissions, Efficiency and Sustainability was constructed from commercially available measurement modules from the manufacturer CSS Electronics to be able to connect to the diagnostics output CANbus from heavy duty vehicles and additional measurement systems.

This was able to utilise the range of data being broadcast from the Engine Management System (EMS) diagnostic connection to record the vehicle performance and operational data along with second-by-second GPS location and dynamic vehicle information. The system recorded the data locally before uploading it to Swinburne's IoT system cloud computing platform for storage decoding and processing. The processed data was able to be stored and made available via dashboard to check and assess data records and daily performance statistics. Along with the logistics performance data a first cut Scope 1 GHG emissions estimation was incorporated into the data and made available for environmental team review and analysis. Data was collected from August to December 2023 with this system.

The data collected during this period was further utilised to develop an AI/machine learning driven tool to use the vehicle performance data to develop models for forecasting fuel consumption and major elements of engine performance. The tools' output was able to achieve up to 85% effective modelling of major vehicle engine performance characteristics.

The opportunity to improve arose with the further application of a mini PEMS system built and developed at Swinburne for the purpose of delivering accurate Scope 1 emissions baseline measurements. Working with an AMPC member company in Victoria, this system was able to be installed on one of their prime movers in February 2024 and worked collecting measurements of vehicle performance and emissions gases to the end of May 2024.

The data collected provided the first real world measurements of this type in Australia for heavy duty vehicles undertaking their daily logistics operations without any interference or disruptions which occur with other PEMS systems. A month of data was analysed to determine the CO_2 GHG & pollutant emissions performance. It was able to provide individual results related to each journey analysed for Scope 1 GHG emissions results. Further to this the environmental impact of the vehicle as it travelled is possible to be assessed. If any questions are raised regarding the impact in the areas the vehicle passes through it can now be checked and quantified if needed.

Additional AI modelling was undertaken using the emissions data collected from the mini PEMS trial. With this data set more iterations and refinements were able to be made with assessments of up to 93.8% accuracy for modelling of average CO_2 value across an entire trip being assessed. The result is promising and if further development can be undertaken in future to refine inputs and modelling of other parameters that influence the results, the level of accuracy at any moment and overall can be improved and potentially allow the tool to model results for other vehicle types and applications where data has been collected from real world operational measurements.

The results of this project when considered by AMPC and its members could provide potential information for decisions to further develop and use this type of tool for measuring and determining progress on achieving zero carbon targets within logistics operations.

2.0 Introduction

Transportation and logistics are a key element connecting all aspects of the Australian meat processor sector supporting a thriving value chain which employs over 30,000 people located in both urban and regional areas around the country. Community expectations for decarbonisation of the nation’s industrial sectors is growing with increasing media attention to this topic each year. The Australian Meat Processing Corporation (AMPC) has been progressively supporting companies operating in the sector to take the lead in sustainable operations and responsible business growth. Like other industrial sectors, the red meat industry is also exploring low or no emissions sources of energy and various operational upgrades to minimize its impact on the environment.

This project recognises an opportunity to move forward with developing tools for AMPC member companies to be able to accurately measure and determine Scope 1 emissions for vehicles being utilised as part of their logistics fleets that they either own or have control for their operations. Tools such as these are needed to support the transition to achieve industry carbon neutral gaols by 2030. The industry associated logistics GHG emissions need to be measured accurately to determine a starting point from which they can be managed and reduced to meet targets. Actions need to be envisioned and undertaken addressing the industry targets in transportation to adapt and utilise more renewable energy options and sustainable practices. This is a critical element for ensuring sustainability along a path to improving businesses environmental performance as one of the industry key priorities.

The outbound and inbound logistics of AMPC members heavy vehicles contribute to various types of emissions for which the need to develop an accurate baseline for their environmental footprint exists. The industry needs to move beyond simplistic estimations and productivity assumptions for fuel consumption and utilisation, which exist now. To attain this goal the industry should collect sufficient real-world data from the various logistics vehicles operations undertaken by the vehicles they own and operate to deliver the accurate baseline which is required.

As baselines are determined they could potentially be assessed to determine representative emission modelling for red meat logistics activities utilising machine learning and AI approaches to determine highly accurate outcomes which can in future be more broadly applied across the industry for determining each member company’s logistics related GHG emissions.

3.0 Project objectives

The main objectives of this project are:

- Develop tools for determining an accurate representative baseline environmental footprint for red meat processor owned heavy transport tasks.
- Identify and assess opportunities to improve environmental, social, and economic outcomes for red meat processor owned heavy transport tasks, including recent technological advancement in vehicle and fuel systems.
- Identify and suggest use cases and pilot studies for future actions.

4.0 Methodology

Working from the strategy for the project outlined in the project agreement, a framework of actions was structured and followed to determine details required for the outcomes and assessments to deliver a successful project result.

4.1 EOI & Consultation

Beginning with identification of detailed requirements, Swinburne undertook consultation activities with AMPC and its member companies to gather information relevant to the logistics operations being undertaken. It was necessary to engage with AMPC member companies to gain an understanding of their operations and in consultation with them identify opportunities. The target was to identify at least two companies with experience in fleet ownership, management, diversity in logistics planning needs, vehicles of varying ages for potential utilisation and be willing to deploy potential IoT solutions in vehicles.

Expression of interest (EOI) documents were generated and distributed in September 2022 to a selected group of AMPC members to engage with processors willing to actively participate in the project steering committee, facilitate activities and drive the project from within their respective organisation.

From the EOI activities two companies who responded with interest to participate in the project were selected and online consultation workshops were organised. The workshops were organised with two red meat processor businesses who at the time of this survey were operating a large heavy vehicle fleet. The outcome of the workshops identified the candidate vehicle types being used to move livestock and processed goods in refrigerated trailers.

In parallel to the work with AMPC members, investigations into the range of commercially available IoT sensors was undertaken to identify potential hardware that could be utilised to collect GPS, vehicle dynamics and truck operational data. A shortlist of products from Arduino and CSS Electronics were determined as potentially suitable candidates for the project. Beyond these commercially available products a range of bespoke solutions which could be developed for specific needs were identified as well. Although they were suitable for the application, costs were prohibitive and lead-times for supply were significantly longer effectively excluding them from selection. A summary report of activities, Milestone 2, detailing these points was collated and submitted to document progress.

4.2 Solution Development

Utilising the collected information, steps were taken to design and develop the solution to collect the data identified from the consultation exercise and research into vehicle performance and emissions. The overall system architecture outline was developed to describe and highlight the features and aspects of the DiVA system. See Figure 1 for details of DiVA platform architecture.

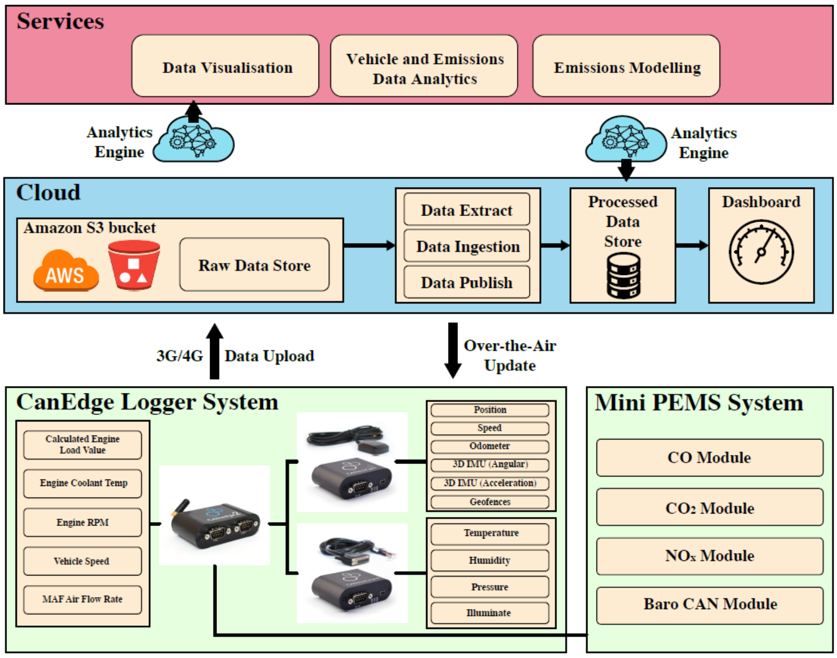

Figure 1:Solution Architecture of DiVA Platform System

The system is configured to capture baseline data which is used to assess performance and to determine emissions factors and Scope 1 GHG emissions. Vehicle related data is collected from a connection to the vehicle EMS via the diagnostics connector using either the SAE J1939 or On-Board Diagnostics (OBD) CANbus communications protocols. Location and dynamic data are collected via a Global Positioning System/Global Navigation Satellite System (GPS/GNSS). From this information basic performance and emissions profiling information can be determined for the vehicle being measured. It is noted that without any verification this data would be considered indicative of actual emissions performance. To provide verified emissions data and scope 1 GHG performance requires emissions related data to be collected by a separate system installed on the vehicle. This capability would collect environmental, pollutant and flow related data which could be used in conjunction with the vehicle and GPS/GNSS data to deliver accurate vehicle, pollutant and GHG emissions results. It was determined from the hardware evaluation to utilise the CSS CANEdge2 datalogging system as it could connect to all the necessary systems and is capable of decoding the SAE J1939 or OBD data saving it to onboard storage before being uploaded to cloud computing services via 4G and Wi-Fi at regular intervals whilst the vehicle is in use on road.

The cloud architecture and design utilised for the project was broken down into various data handling phases. The first phase collected the raw data being transmitted from the vehicle being used and checks that it has been transmitted OK without loss or degradation. This data is stored securely until the next step is activated. For the second phase the raw data is extracted from storage, processed, and transformed into sets of useful parameters that can be utilised for calculations and analysis. The third step returns the processed data into the online database ready for use. The fourth step involves the processing of data for reporting, developing analytics and generating the dashboard interface for uses to run enquires for reporting or analysis purposes. The analytics provide daily performance reports including the GPS location, vehicle performance, fuel consumption and driving parameters, load based calculations of pollutants, GHG emissions and Scope 1 reports which can be utilised by the business or provided to clients for their Scope 3 processing. See Figure 2 for details of the DiVA trip dashboard delivered.

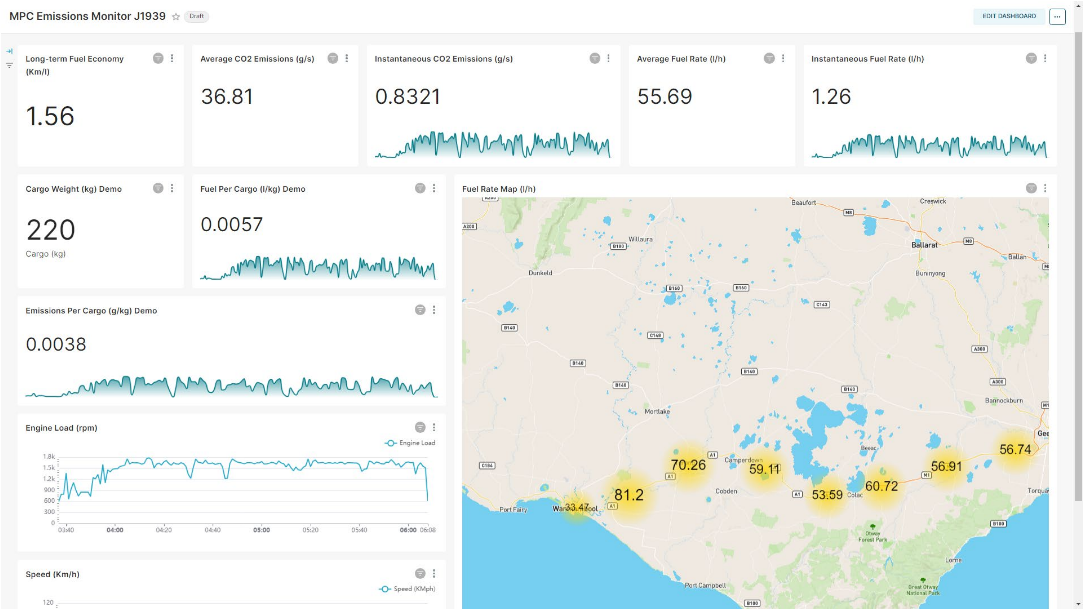

Figure 2:DiVA user interface - Trip Dashboard

Along with this concept a mini–Portable Emissions Measurement System (PEMS) was developed to measure emissions gases which could be connected to the CSS CANEdge2 data logger to deliver real-time emissions measurement, fuel consumption and performance for the project. This system has been developed in line with the measurement principles which are used for the European Emissions Regulations, Euro 6 / IV, so results recorded could be utilised and simply compared to other data generated using this regulation. See Figure 3 for the mini PEMS concept. A summary report of activities, Milestone 3, detailing these points was collated and submitted to document progress.

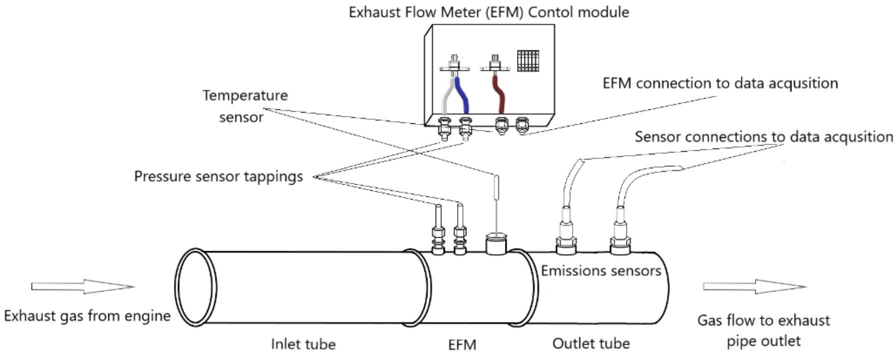

Figure 3:Mini PEMS – Exhaust flow meter and sensors concept.

4.3 Mini PEMS Hardware & IoT Configuration

With each of the system architecture elements having been developed the procurement of hardware to implement the system proceeded with hardware being purchased from CSS Electronics. The system consisted of a CANEdge2 datalogger along with associated hardware for SAE J1939/OBD connection, GPS signal, temperature, and additional signal measurement. The equipment was assembled and initial testing trials for verification of data recording and collection were initiated over a series of short and long trips. These series of tests utilised a passenger vehicle operating in the suburbs of Melbourne to trial connection to vehicle EMS, GPS, hardware modules and trialling of 4G and Wi-Fi for data transmission. Data collection was successful with recorded raw data being uploaded for setting up cloud storage and establishing the decoding processes for the project. Initial analysis allowed verification of signal validity which was matched to the routes taken and driving operations. Data upload quality requirements were confirmed and development of assessment criteria of fuel consumption performance in l/h, l/100km, l/km and km/l were established. With these in hand the determination of estimated CO_2 GHG scope 1 emissions rate followed.

As the baseline for the calculation methods were established, the programming proceeded to develop automated processes to deliver information that had earlier been highlighted in the consultation workshops and from published literature research. This allowed for individual data records to be selected and results generated that could be shown in charts or delivered as individual trip or daily average summary reports. Testing of the system with data collected over a series of journeys showed the recording and measurement met the necessary requirements for continuous operational data collection whilst a vehicle is being operated. The data show trends in driving speeds, traffic congestion, variation expected from driving on different road types all of which could be assessed on time scales varying from hours, minutes, and seconds. With this data it could provide the opportunity for analysis and monitoring of vehicle performance and emissions, thus contributing to more efficient and sustainable transport operations. A summary report of activities, Milestone 4, detailing the points was collated and submitted to document progress.

4.4 Site visits and Heavy-Duty Vehicle Compatibility Testing

Validation of the DiVA system with heavy duty vehicles was performed through a series of site visits. The first to a vehicle manufacturer supporting our work and then to the business locations for the two AMPC member companies who had expressed interest in the trial. The initial trial was a stationary test undertaken at the PACCAR Australia manufacturing facility located in Bayswater Victoria. A new K200 model Kenworth Truck was made available for connecting the CANEdge2 datalogger using the SAE j1939 CAN communication port. The trial moved through steps of connecting, powering on, starting and extended idling during which communication to and from the vehicle EMS was able to be made and recording of data channels successfully completed. The post visit assessment showed that all critical data channels needed for development of the performance, emissions, and Scope 1 GHG estimation were functional and available through the datalink.

A site visit to the Victorian processor logistics centre followed, where they provided access to the vehicle, they proposed to make available for the DiVA trial. A Kenworth K200 cabover prime mover which is utilised round the clock daily moving goods in refrigerated containers of A double or B triple trailer combinations for deliveries to Melbourne from Warrnambool. The Swinburne team undertook two tasks during the site visit. The first was to connect, configure and conduct a short driving trial of the vehicle with the DiVA datalogger system installed. The second was to investigate the exhaust system installed for the potential to install mini PEMS working out what supporting hardware and power systems would be needed to conduct a successful trial. See Appendix 1 for details of the DiVA System. Both activities were able to be completed. The DiVA datalogger was successfully installed and collected data on a short trial drive to validate each of the operational systems. An installation plan was discussed with the heads of logistics and maintenance which required some additional hardware for secure installation and operation to be configured. Additionally, the areas were identified where the mini PEMS could be potentially installed for operation. Follow up checks to confirm safety and compliance to VicRoads requirements and Australian Design Rules per the National Heavy Vehicle Regulator requirements were checked and complied with before installation.

Following this site visit the additional hardware modifications for the installation were made and the system and datalogger were sent to the Victorian processor t and installed in the K200 truck. The trial with the DiVA system and datalogger commenced on August 21st, 2023, and ran until December 6th, 2023. Data was continuously recorded and uploaded to the IoT cloud computing platform and processed for dashboard operations. A series of sites visits were made to the Qld processors Melbourne site to check installation of the DiVA system datalogger in a Volvo Globemaster prime mover. This vehicle utilised an extended OBD protocol which the team was able to connect to and configure successfully for recording and datalogger operation whilst on site. Although the installation proved successful, after leaving the system in the vehicle there were unforeseen challenges with the datalogger installation powering down operations and in turn shutting down the system unexpectedly. As maintenance and logistics support was not available through the Brooklyn site solving this issue without support was determined to not be a feasible option. The trial whilst initially successful with the setup was halted and the DiVA datalogger system was retrieved from the vehicle.

Following the effective trial at the Victorian processor plant with the DiVA datalogger, it was decided to extend the measurement trial so mini PEMS could be installed in the plant's K200 Kenworth prime mover. To match hardware for the engine size it was necessary to engage with the vehicles engine manufacturer to determine flow rates, emissions systems details and operational pressures for the K200 engine installation. Detailed discussions and negotiations were undertaken with the engine manufacturer, Cummins, to win their support to obtain this information. It is not normally information that is freely available and being granted access was part of establishing a successful relationship to respect their intellectual property and ensure we could configure our flow meter to the necessary measurement range without impacting performance or changing any ADR compliance requirements.

The mini PEMS installation was closely co-ordinated with the Victorian processors logistics and maintenance team who provided the welding, fitting and electrical supply elements of the installation. The team working together was able to fit and secure hardware and sensors in afternoon between deliveries being undertaken by the truck as client delivery demands were high at this time. The system was fitted and commissioned on February 23rd, 2024, and ran successfully recording and uploading measurement data until the end of May 2024. See Appendix 2 & 3 for details of the mini PEMS components and its installion on the K200 truck.

5.0 Project outcomes

5.1 DiVA System

A successful operational system was able to be developed and deployed for extended operations. The DiVA system could run continuously when the vehicle was turned on and in use providing significant operational details via the Dashboard system. Truck locations could be followed, and daily progress of delivery completion evaluated.

From the first trial conducted between August to December 2023 which the DiVA system operated to collect data from the vehicle EMS and GPS there were 93 individual days of data records collected allowing characterisation of the driving, traffic impacts, driving duration to delivery locations, unloading, and loading times. Logistics data for fuel consumption was able to be collected providing data in l/h, l/s, l/100 km, l/km & km/l based on the EMS data signals collected. In addition to this an initial estimation of daily CO_2 GHG emissions was able to be prepared. Analysis of the DiVA daily data recorded collected provided the following baseline for the logistics activities. See Table 1 below:

Table 1: Average Logistics results from DiVA data trial

Average Logistics results from DiVA data trial								
All Trips	Measured Results							Estimation Method
	Estimated Emissions Factors			Daily Fuel Consumption				Scope 1 GHG Emissions
	Daily CO_2							NGER method
	kg	g/km	g/t-km	Litres	l/100km	km/l	l/km	CO_2e (kg)
Average	984.04	3443.32	-	413.52	144.70	1.574	0.635	1123.24
Minimum	0.69	944.72	-	0.29	39.70	0.433	2.311	0.78
Maximum	2557.84	5097.82	-	1074.87	214.22	1.389	0.720	2919.65

The data from this phase of the trial was collated into daily summaries for all journeys undertaken each day both outbound loaded and return unloaded trips. Fuel usage figures for the vehicle from bowser dispensing records was not available at the time of reporting to provide comparison to the consumption figures collected by the DiVA system. Although loading data of the truck was made available for part of the trial measurement period, it wasn't able to be processed with the dashboard data output as it was only available to the team after the measurement period ended in December. To generate the logistics reporting with g/t-km would require the Dashboard coding to be rewritten along with correlating elements identified for each load to the journeys across the daily reports. It is suggested that this could be incorporated in future with planning and discussions if it is a desired reporting mechanism.

An initial comparison for Scope 1 GHG emissions being generated from the vehicle can be determined from the fuel consumption using emissions calculation methods and the NGER estimation method. These values are 984.04 kg and 1123.24 kg per day, respectively. The difference in these CO_2 estimated values is 12.4%. It would suggest that there could be some variation in estimated fuel consumption rates being generated from data when a vehicle is heavily loaded. Further investigation of this with against fuel bowser records would provide an indication of where the variance exists so it could be addressed as needed.

Most daily figures show the fuel consumption figures to be realistically grouped around the average values with a distribution that indicates variation on factors of variable loads, varying traffic conditions and/or congestion factors, different drivers and the impact of weather conditions as well. There are some very high and low values recorded and noted in the minimum and maximum results (aside from the litres of fuel consumed). These have occurred on days when the vehicle hasn't been driven very far and the engine has been idling for either a very short duration or conversely a very long time. These figures are occasional and have a very low impact on the overall fuel consumption or average performance of the vehicle and are effectively minimised or practically disappear in the performance figures over time.

5.2 Mini PEMS System

The mini PEMS system was installed on the Kenworth K200 prime mover on the 23rd of February 2024 and began operations in the evening following the installation. The vehicle was driven each week 5 to 6 days per week, with one, two or more journeys on a given day pending client delivery requirements. In the period from the 23rd of February to the 18th of May the vehicle was driven 44,277.4 km with 759.65 hours of driving operations.

The emissions analysis focussed on the 1st month of driving with reports being generated from the 23rd of February through to the 22nd of March 2024. During this period there were 61 journeys analysed with 14,740.8 km being driven over 261.5 hours of vehicle operations.

The mini PEMS system data was measured independently of the vehicle systems, collected and analysed to deliver the logistics performance results along with the pollutant emissions results which weren't available earlier. The measurement of this data was being conducted following the techniques for Euro 5/V and 6/IV and USEPA PEMS regulations which allows comparison to other testing results following these techniques. Data was analysed and separated into outbound loaded journeys from Warrnambool to major delivery locations in Melbourne or other local destinations as required and into return unloaded or partly loaded journeys back to Warrnambool. Summaries of performance and emissions data are shown in the following tables.

Table 2: Average Logistics results from mini PEMS trial

Average Logistics results from PEMS trial								
All Trips	Measured Results							Estimation Method
	Emissions Factors			Fuel Consumption				Scope 1 GHG Emissions
	CO_2							NGER method
Loaded	kg	g/km	g/t-km	Litres	l/100km	km/l	l/km	CO_2e (kg)
Yes	567.04	2235.142	39.208	215.02	84.754	1.198	0.848	584.04
No	399.95	1780.05	-	151.661	67.496	1.517	0.675	411.96

Table 3: Average GHG & Emissions results from mini PEMS trial

Average GHG and Emissions results from PEMS trial										
All Trips	Measured Results									Estimation Method
	Emissions Factors									Scope 1 GHG Emissions
	NO_x			CO			CO_2			NGER method
Loaded	kg	g/km	g/t-km	kg	g/km	g/t-km	kg	g/km	g/t-km	CO_2e (kg)
Yes	9.422	36.925	0.643	1.507	5.937	0.104	567.04	2235.142	39.208	584.04
No	6.818	29.464	-	1.063	4.635	-	399.95	1780.05	-	411.96

Of particular interest, the separation between loaded and unloaded vehicles can be clearly seen fuel consumption figures and logistics calculated values being in the range of 20 to 30% lower when vehicles are unloaded. This is expected and represents an anticipated outcome when assessing the data delivered by the mini PEMS system. It furthermore shows the next step development of the system from the initial DiVA installation with individual journeys now being analysed for performance and their impact upon business operations. The emissions measurements were being measured with flow meters and sensors so they could be analysed each second of a journey if required. The emissions factors for GHGs and the major pollutants are available from this for a company so they can assess the environmental impact of their vehicles undertaking daily business operations. It can be noted in this case that CO_2 and other pollutant emissions rates reflect the trends seen in the fuel consumption performance which suggests that the vehicle being measured is well maintained and operating consistently on an on-going daily basis. The range of variation between measured gases is again in the range of 20 to 30 % lower for unloaded vehicle journeys.

The GHG measurements for Scope 1 in these results can also be seen. For loaded journeys the CO_2 measured by PEMS is on average 567.04 kg journey whilst the NGER estimated value is 584.04 kg per journey. For the unloaded journeys, the PEMS average is 399.95 kg and the NGER estimated value is 411.96 kg. In both comparisons the variation shows the PEMS measured results to be around 3% lower than the values estimated from NGER calculations. The operational performance of the mini PEMS has been consistent with data being collected each day of operations. From 261.5 hours of driving there were around 15 minutes of data which was missing for evaluation. This indicates there was around a 0.095% loss rate of data from the mini PEMS system when connected to the DiVA system for this project.

6.0 Discussion

The project has successfully developed a system which can integrate with heavy duty vehicles from various manufacturers to collect operational performance data. The data collected was able to be uploaded for storage, decoding and assessment to the IoT cloud computing system being operated by Swinburne University of Technology. The process of consultation and design undertaken provided a solid foundation of information from the AMPC member companies that were interested and willing to join in this undertaking. It was key to learn about the nature of the logistics operations that they undertake on a daily basis and to consider how a system to measure vehicle performance for the target of developing an accurate environmental footprint for the businesses involved could proceed. Key to this was researching and uncovering a range of measurement tools that could be purposed for the task and integrated into vehicles without impacting performance or driving operations.

Early on a number of systems were identified and all considered a workable candidates for the proposed DiVA operating system. The CSS Electronics suite of equipment was finally selected as it had the most complete system of modules, accessories and support database software that could operate in the environments the vehicles worked in along with being suitable for IoT integration with Swinburne's cloud computing platform to develop and deliver a storage, operations and dashboard solution for handling of data and delivering the environmental information desired to determine the baseline for AMPC members logistics operations.

The development and testing of the IoT platform elements and hardware components undertaken by the team prior to the trials at AMPC members allowed for generating systems which could work robustly and avoid problems with power drains, noisy data connections and effective sequencing of information so that it could be collected and analysed for the project goals. The elements when engaging with the AMPC member companies that helped the development and implementation of the project was the capability to provide support for visits and enabling communication channels to the individuals who could help support and deliver the installation requirements that were needed. It was challenging as daily and weekly demands often made this difficult to organise deliveries, visits and follow up communication. The desire of the organisations to ensure that results are achieved and that their participation is valuable showed through in our installation with Kenworth Trucks, Cummins, and the Victorian processor with their being able to facilitate local or remote interactions needed to complete our goals.

The support provided when installing the PEMS with vehicle operating demand being high and having very limited windows of time to work in showed the professionalism and capability of the individuals working in the logistics and fabrications operations of AMPC companies to be exceptional and very rewarding individuals to work with. This level of support is appreciated and delivered success throughout the project. Reviewing the data that was collected during the DiVA and mini PEMS trials there were some observations that arose which were unexpected. Whilst the vehicles being utilised in the testing were very reliable and able to perform to deliver large amounts of heavy goods every day, it appears when the vehicles are loaded to high capacities some of the data available from the diagnostics systems appears to have a higher degree of uncertainty of measurement. This could be seen when looking at fuel rates calculated and provided. There would often be an offset of values when comparing data collected from measurement instruments to that from diagnostics sources. It is expected that there will be some differences, although in our observations the range of variability was higher than expected.

The opportunity to address this can be made if future investigations are undertaken where a more complete suite of data can be provided to the research team for cross checking of measurements from different sources. Not having fuel usage records or exact load data close to the time when data is uploaded to IoT systems leaves a gap in assessment which isn't simple to return to later and insert information into database records for processing. The logistics resources were often stretched and without the time available to easily provide the data as they had client orders which could not wait to be delivered along with many unplanned logistics issues arising daily to address before being able to respond to an external data request which had to wait in these circumstances. It is suggested this be discussed and planned if future investigations requiring this data arise so it can be handled smoothly and without difficulties for those all involved.

The performance data collected along with the emissions factors and GHG emissions results generated from the project provide a window into the performance of these heavy-duty vehicles in real world circumstances which no amount of development and certification testing by manufacturers and government regulators can easily replicate. It shows detailed information on individual journey basis's, the grouping of like journeys, where and how much emissions occur and the type of emissions being either GHG or pollutant emissions. For companies, these results provide a clear picture of scope 1 emissions being generated by logistics and can help set the baseline to work from to reduce carbon emissions over time to net zero targets. Combining this knowledge along with data on new innovations in conventional technologies along with those being developed in alternative vehicle powering options, decisions on investments can be made to take small or large steps at the time best suited to company resourcing or the opportunities in the marketplace.

From the research undertaken to investigate the potential technical opportunities available in the marketplace today along with those which are developing now and those that will be available in the coming handful of years or even one or more decades away. Several opportunities were highlighted for consideration for AMPC members in their logistics operations. First and foremost, there isn't just one technology choice that will deliver a transition to net zero carbon goals for each type of transport and logistics demand companies will need to meet. With understanding this an approach to reviewing needs in each of the vehicle segments that used a series of choices emerge.

In the LGV segment the advancement of Battery Electric Trucks (BETs) has moved ahead at the fastest pace for logistics demands. For operations being undertaken in urban areas and with lower mileage demands there is a growing range of BETs available now with more coming onto the market each year with longer driving range and faster recharging options available for selection that can provide a significant step in reducing the carbon emissions today. This segment will grow as recharging networks improve and more capable vehicles arrive in the market. In the MGV and HGV sector BETs and Fuel Cell Trucks (FCTs) are becoming available but are not suited to the demands of long-distance heavy haulage that many AMPC members need to deliver their products to urban areas from processing facilities or to sea ports or airports for growing demand of export markets. At the time of writing the report the best choice for delivering carbon reductions was to utilise renewable diesel fuel which has the potential reduce carbon emissions by up to 75 to 95% depending on raw materials used and process operations. The down side is the costs are around 3 times that for conventional mineral diesel and until a significant local supply of renewable diesel is available it is unlikely change in the next 5 years.

In the last 6 months a technology option from the USA which can utilise B100 biodiesel in conventional heavy-duty engines have come to our attention. It has experienced a high uptake in the USA being installed in new vehicles in the factory for large fleet operators such as Pepsico in their new Class A 18-wheeler prime mover trucks being made by Volvo local each week. The system is made by Optimus Technologies and called the Vector System (Optimus Technologies, 2024).See Appendix 5 for an overview of the Vetor system. It has the potential to reduce carbon emissions from existing fleet vehicles by up to 85% using primarily B100 fuel with some conventional diesel for starting and stopping the engine. This product can be incorporated into existing fleets without the need to change infrastructure or make major investments in new technologies. It is suggested that this be considered as realistic short-term option to jump ahead of the field in making carbon emissions with B100 being at almost a price parity with conventional mineral diesel and it is available as a locally manufactured and supplied product in Australia now.

A further technology that has come to the fore in the last half a year is the application of e-Axles in the trailers being towed by heavy duty prime movers. These e-Axles have the ability to transform conventional trailers and refrigerated trailers into e-trailers being able to supply motive power from batteries to assist in driving the trailer and also being able to regeneratively charge their batteries when vehicles are slowing down. Manufacturers such as Dana corporation (Dana Corporation, 2024) and SAF Holland (SAF Holland Group, 2024), have a range of products they are beginning to bring to market which could potentially be fitted to existing trailers along with new trailers in the near future. See Appendix 4 for product details. It is suggested that utilisation of this assisting technology be followed closely as it can work with vehicles being powered by renewable diesel or B100 with option of fitting new fuelling system hardware to step even closer much faster than thought possible half a year ago to zero carbon targets for logistics in a short to medium term.

7.0 Conclusions / recommendations

Engagement with AMPC and two of their member companies,, was conducted and information collected to determine the nature of their heavy duty logistics operations and what vehicles types are in these fleets. From this foundation an integrated system, DiVA, was developed along with another innovation being a mini PEMS to bring to fruition the desire to accurately measure and know what are the real-world baseline emissions for heavy duty vehicles working in AMPC member companies logistics operations. The DiVA system was successfully designed and tested using IoT cloud computing solutions along with integrated CAN based data measurement and acquisition systems that were installed in the Victorian processors Kenworth K200 prime mover and successfully tested over a period of 4 months in 2023 proving effective in measuring data, uploading to the cloud for storage, decoding along with a Dashboard interface for assessing daily reports and trip information.

The mini PEMS system was installed on the same plants K200 truck in February 2024 and ran for 3 months of data collection. The data collected in the first month was analysed in detail to determine the scope 1 GHG and pollutant emissions being generated. The scope 1 emissions for the truck in its daily logistics role have been successfully recorded and reported in the Milestone 8 report for the consideration of AMPC and its members. The Mini PEMS when coupled with the DiVA system can successfully profile the scope 1 GHG and pollutant emissions being generated by a vehicle when used in real world applications. This can provide the baseline from which an organisation or company can begin to move towards reducing their carbon emissions from a measured and known point to their net zero target. It is suggested that further applications of the system could provide a broader baseline of information which could be used on a wide basis across the red meat industry to guide member companies in firmly knowing where they are starting from to meet the industry targets for 2030 and beyond.

In addition to the Milestone 6 report, additional references for the Optimus Technologies Vector system for B100 fuelling and e-Axle technologies have been included to supplement knowledge regarding additional new technologies which can assist organisations make larger steps in reducing carbon emissions in the short term and it is suggested they be considered by AMPC members to see if they can be utilised in their business operations now.

8.0 Bibliography

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SAF HOLLAND GROUP. 2024. *Trailer Axles and Suspension Systems - Electrified Axles - SAF TRAKe* [Online]. SAF Holland Group. Available: https://safholland.com/au/en/download-center/document/resource/environment/project1_p/documents/documentationP/2022/2022_09/SAF-HOLLAND_E-Axles_en-DE.pdf https://safholland.com/au/en/products/saf-trake [Accessed 2024-05-28 2024].

9.0 Appendices

9.1 Appendix 1 – IoT Hardware

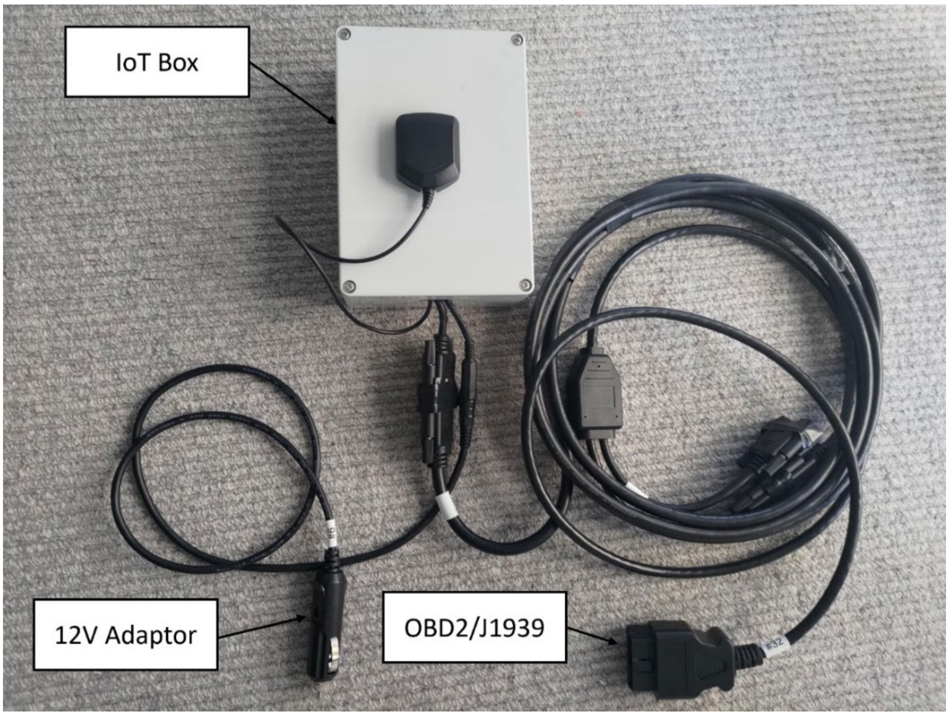


Figure 4: IoT Sensor hardware as installed in Trucks.

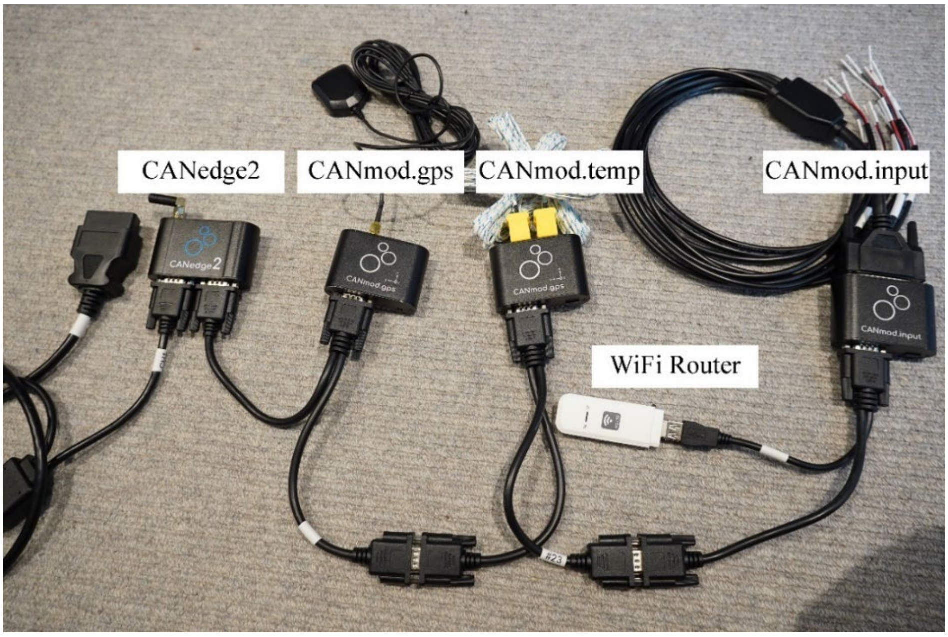


Figure 5:: IoT box connection with various sensor modules.

9.2 Appendix 2 – Mini PEMS Hardware

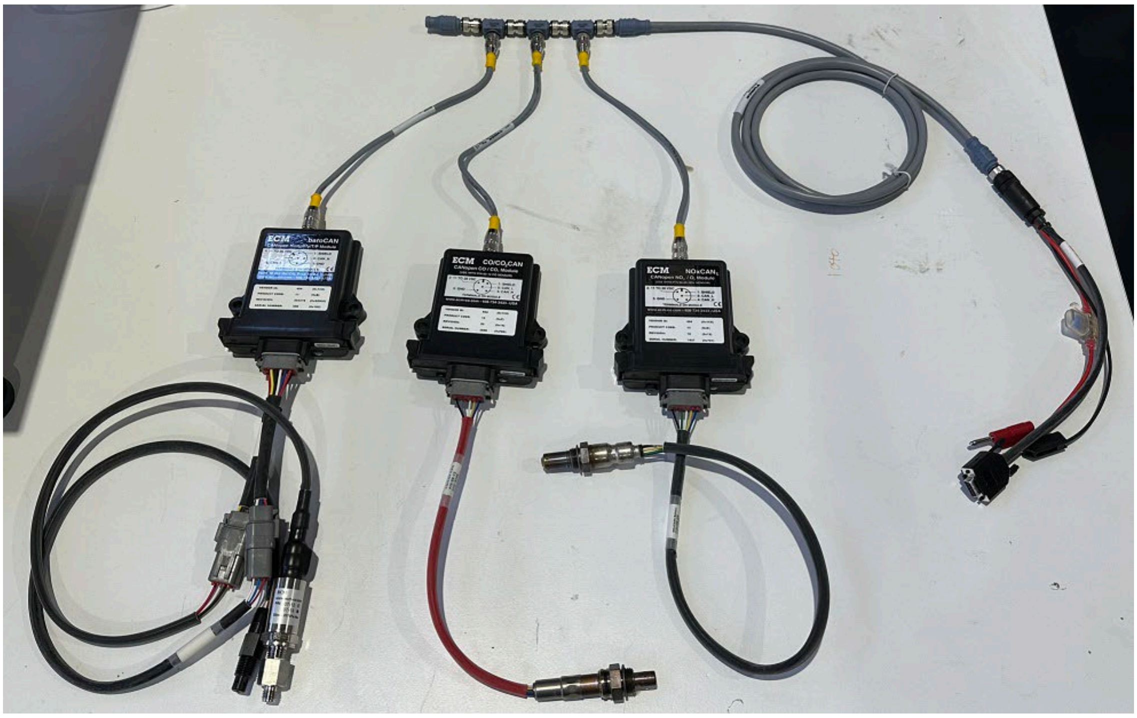


Figure 6:Emissions sensors connected for commissioning testing.

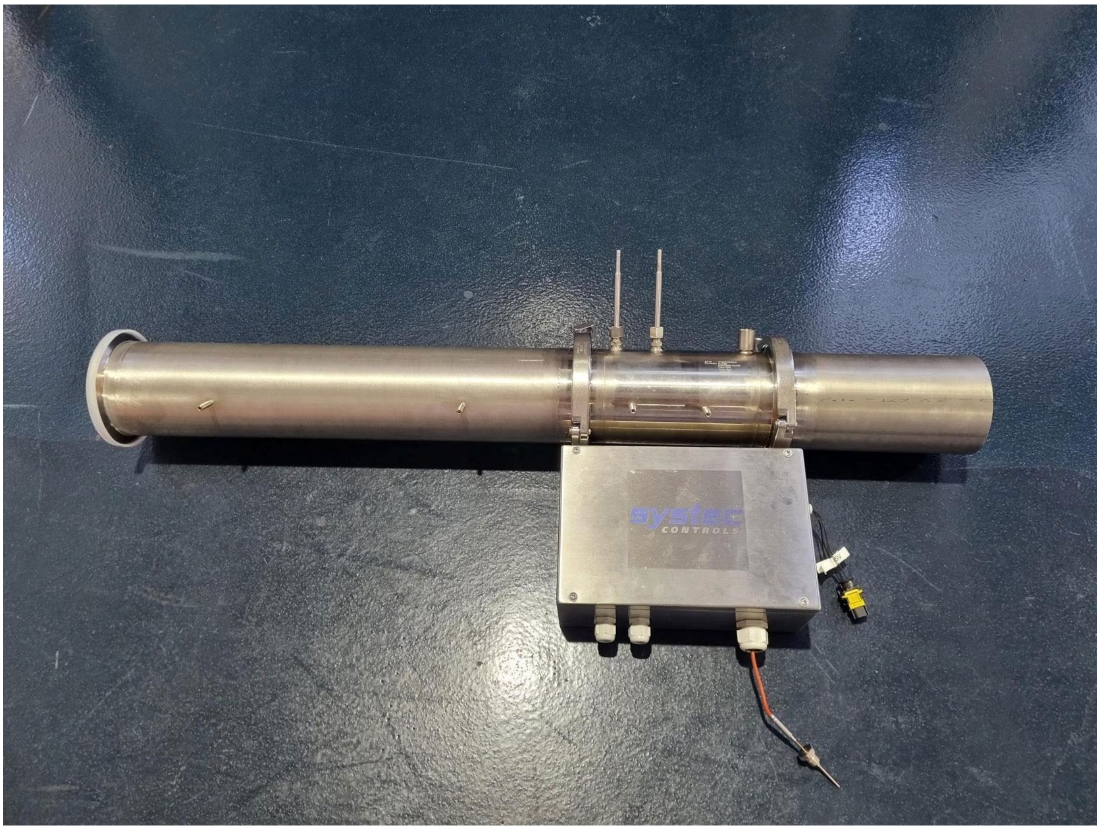


Figure 7:Exhaust flow Meter (EFM) and control module.

9.3 Appendix 3 – Mini PEMS Installation photos

Figure 8: Before mini PEMS installation.

Figure 9: mini PEMS installation in progress.

Figure 10: mini PEMS installation and wiring.

Figure 11: Completed mini PEMS installation.

Figure 12: Which truck is it installed on?

9.4 Appendix 4 – E-axle information

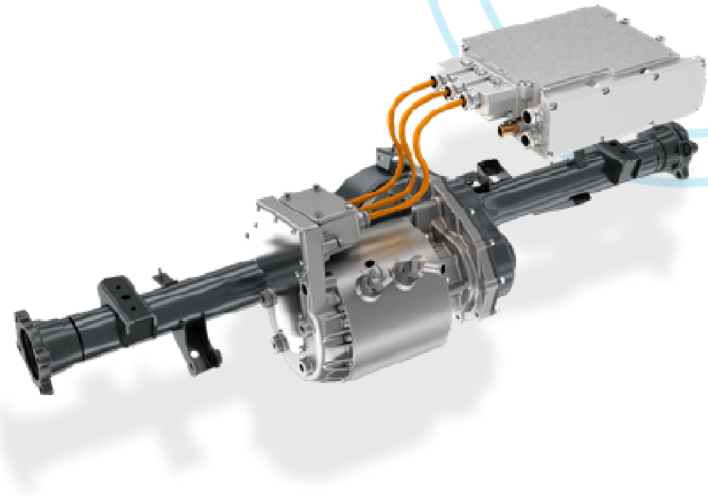
DANA SPICER ELECTRIFIED

eS4500r

Spicer® Electrified™ e-Drive Axle

Product Features

- Maximum GVW of 1.9T
- Maximum GAWR of 1.1T
- Rated for 14,000 RPM
- Peak Power of 180 kW
- Maximum output torque of 4,500 Nm
- Open differential
- Reduction ratios: 14.88, 11.83, 10.86, 9.13, and 7.71
- Differential size: M180 / M190



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Application Policy
Capacity ratings, features, and specifications vary depending upon the model and type of service. Application approvals must be obtained from Dana; contact your representative for application approval. We reserve the right to change or modify our product specifications, configurations, or dimensions at any time without notice.

 CVSPa-J1589-eS4500r Spec Sheet_v1-0121

Figure 13: Dana ES4500r e-Drive Axle

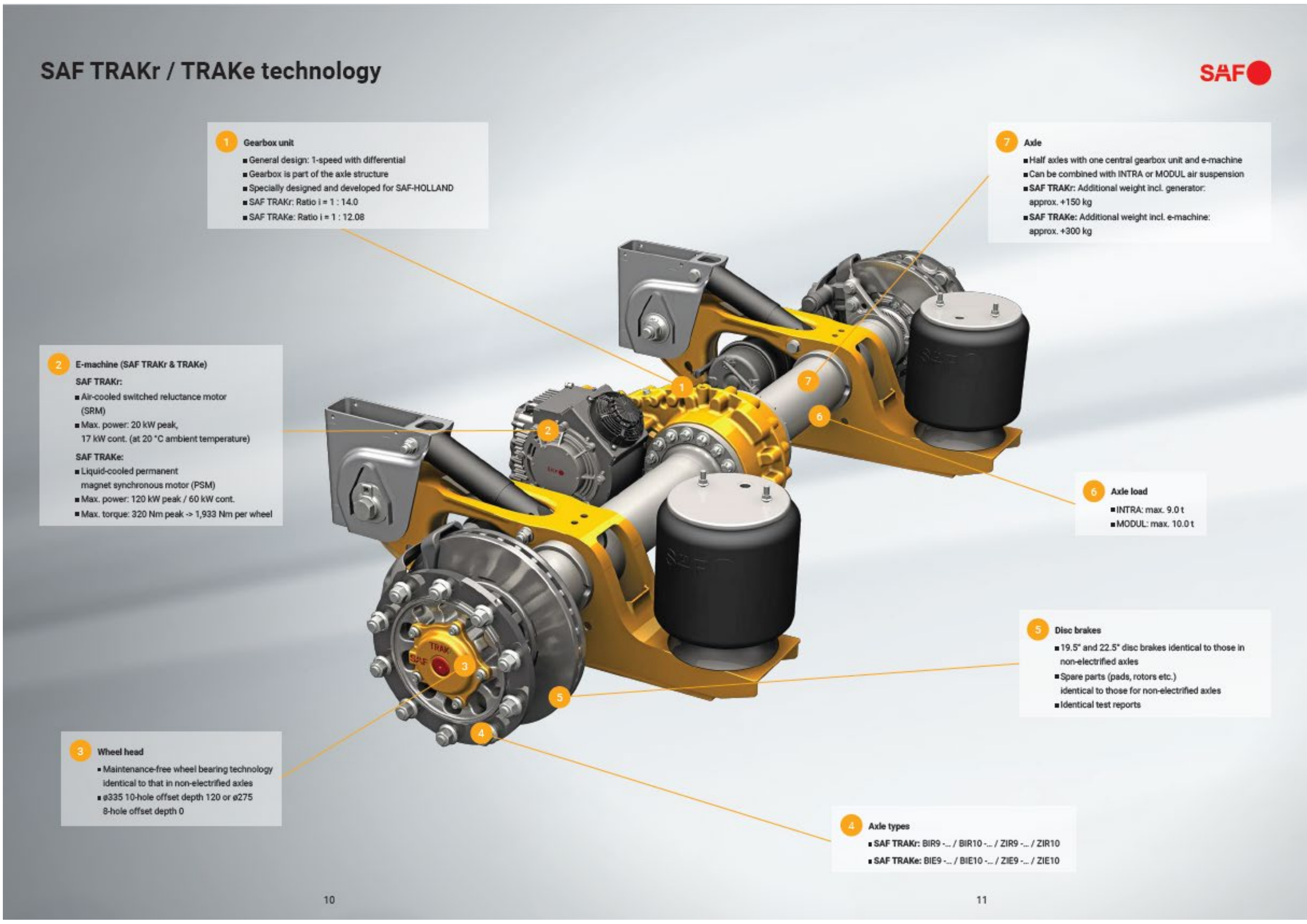

Figure 14: SAF Holland E-Axle Family.

9.5 Appendix 5 – Optimus Vector B100 Fuelling System

Figure 15: Optimus Vector B100 Fuelling system for heavy duty vehicles.