

THE HONG KONG SECTION OF ASME INTERNATIONAL CUM
INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH
TECHNICAL VISIT TO ALEXANDER DENNIS BUS BODY ASSEMBLY
WORKSHOP IN ZHUHAI ON 13 DECEMBER 2014



Joint delegation of ASME-HKS and IMechE-HKB to visit ADL Bus Body Assembly Workshop in Zhuhai (Jimmy Lee)

General

Over a century ago in the U.K., omnibus was already purpose-built double-deck. Since then double-deck buses have become an indispensable part of public transport in the country until this very day. With British influence, in 1949 Kowloon Motor Bus (KMB) of Hong Kong introduced the first double-deck bus into the territory, unveiling the chapter of double-decker bus being the backbone of road public transport. The unique conditions for operation of public buses in Hong Kong, such as the combinations of hilly terrain, frequent start-stop, over-loading, high ambient temperature and relative humidity and the demand for air-conditioning, are onerous and these have made the task of developing reliable and durable double-deck buses particularly challenging for the bus suppliers at all times.



Assembled ADL Enviro500 12 metres buses for KMB lined-up outside Granton office (Edmund Leung)

Alexander Dennis (ADL) is one of the very few companies successful in supplying double-deck buses to Hong Kong consistently. Its Loline double-decker model delivered to China Motor Bus in 1962 was the first double-deck bus on the roads of Hong Kong Island. 13 years later, from 1975 onward it supplied hundreds of units of Jubilant, the bespoke front-engine model tailored proprietarily for the Hong Kong market, and became a principle double-deck bus supplier for the territory. The subsequent breakthroughs of three axle, air-conditioning, low-floor, step-free and others ADL has never been absent from. With the success of and reputation in Hong Kong, ADL has expanded its business beyond the U.K. and Hong Kong, to North America, Oceania and Middle East.



ADL Enviro500 body assembly in Granton workshop (Edmund Leung)

In the past, ADL fabricated both complete chassis and body components in the U.K. and shipped them abroad. Nowadays it shifts the production to location close to the market in order to reduce cost in labour and transport, while the engineering and product development remain in the U.K. For instance, the current Enviro 500 Next Generation chassis supplied to Hong Kong are fabricated in Malaysia using locally sourced steelwork, and the assembly of bus body is done in Zhuhai of Guangdong Province in the mainland China, where is 200 kilometres from Hong Kong.

With the generous support of ADL, for the first time ever for the learned societies in Hong Kong, a 23 member delegation of ASME Hong Kong Section and Institution of

Mechanical Engineers Hong Kong Branch visited the bus body assembly workshop in Zhuhai on 23 December 2014 (Saturday) and appreciated first-hand the process of double-deck bus body assembling from start to finish.

The Company

Formed in 2004, ADL is a U.K.-based supplier of completed buses and coaches comprising three (3) brands, namely Dennis, Alexander and Plaxton. Established by the Dennis Brothers, Dennis first built pedal-bicycles in Guildford, Surry, in 1895 and then motor-cycles and, moved into the bus market and built its first bus in 1903. In Falkirk, Scotland, Walter Alexander was a bus operator and, in 1924 it started to build bus bodies for its own fleet and became a major bus body supplier in the country. Plaxton in Scarborough, commenced coach building in 1924 and continues constructing coaches in the North Yorkshire city. Today ADL headquarters in Falkirk with body and chassis assembly as well as body engineering at the same site, while Guildford associates with chassis assembly and engineering.

ADL engages local contractors to fabricate chassis and assembly bodies abroad. In the fulfilment of orders from Hong Kong and Singapore, ADL contracts Zhuhai Granton Bus Limited (Granton) to assemble bodies with structural components procured and packed from Falkirk. ADL has worked with Granton since 2012. Started with one (1) production line, now it has four (4) production lines outputting 14 completed vehicles per week. In 2014, ADL delivered over 600 double-deck buses to Hong Kong alone, in addition to 101 units for fulfilling the order of 199 buses from SMRT Corporations in Singapore. To meet the demand, 95 staff members (excluding the spray shop workers) from various provinces of China work 48 hours per week.

Engineering and Bus Technologies



Sheer size of Granton's workshop for assembling ADL Enviro500 buses (Jimmy Lee)

Source of Materials

Though assembled in China, ADL emphasises its bus bodies are designed and manufactured in the U.K. Currently all aluminium alloy-made structural members are machined, by either extrusion or CNC, in the U.K. and packed in Falkirk, as well as the jigs on which the components are assembled to become sub-sections. Nevertheless, non-structural components such as glasses and glass reinforced plastic-made (GRP) interior kits, have been sourced locally. Localisation of supply of structural members and other materials currently from the U.K. are actively explored.



Interior accessories are being locally-sourced more (Edmund Leung)

Model Evolution

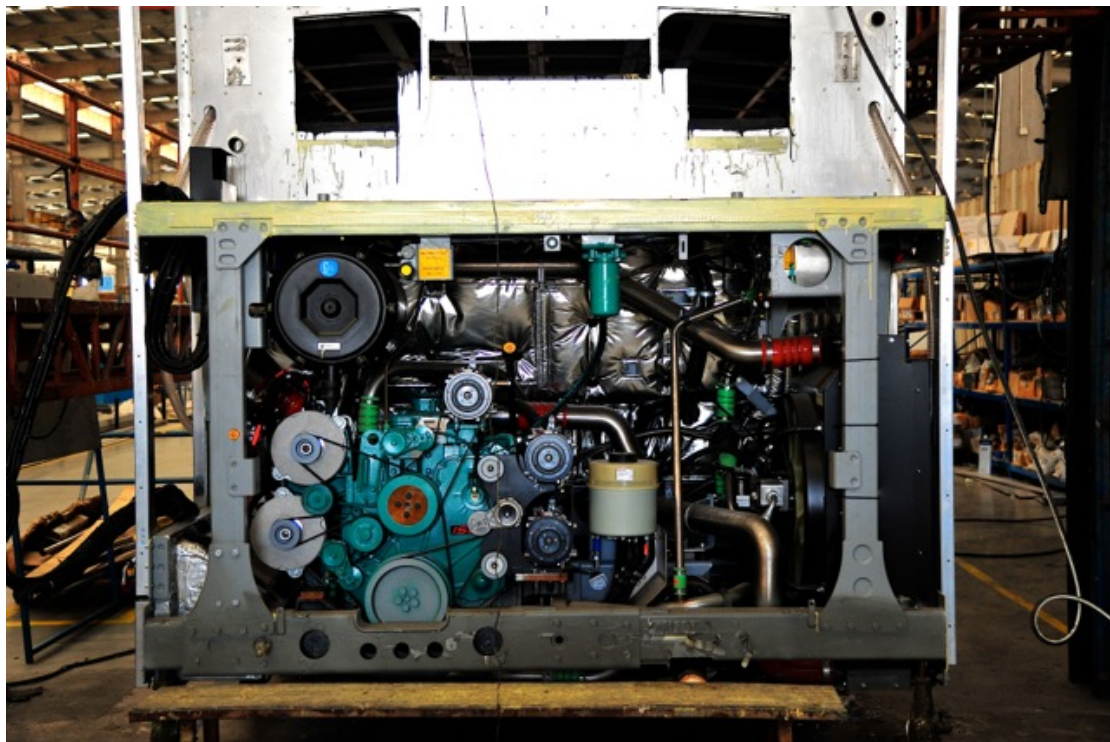
The ADL buses assembled by Granton are the three (3) axle Enviro500 Next Generation (NG) model, which evolution is abstracted as below:-

Model	Trident	Enviro500 (first generation)	Enviro500 NG
Year	1997	2002	2012
Emission	Euro II	Euro III	Euro V
Features	First generation super-low floor entry	<ul style="list-style-type: none"> • Disc-braked front axle • Wider body 	<ul style="list-style-type: none"> • Lower weight • Higher seating capacity • All round disc-braked ZF-made axles • ZF Ecolife transmission

In the development of NG, ADL communicated with customers and referenced their experiences of operating the preceding model in the past ten (10) years. 50 reliability issues were identified and numerous improvements are as a result found on NG, for instance:-

- the cooling system was reconfigured with remote mounted thermostat and aluminium radiator to facilitate better cooling effect;
- the originally Dyner-supplied axles were bespoke design and difficult in parts sourcing and replaced by ZF-made standard products;
- all axles were fitted with disc brakes;
- the engine compartment was designed to accommodate Euro VI engine in future, and integrated with chassis for better performance in heat insulation and noise abatement;
- electronic brake and “bus-stop” brake were adopted for saving of compressed air and hence minimising the loading of compressor and extending compressor life;
- the compressor inlet was deployed with cooling coil in reducing air inlet temperature for the protection of water ingress into the air system.

Engine and Emissions



Cummins ISL8.9E5 340B Euro 5 diesel engine integrated in the chassis of ADL Enviro500 (Jimmy Lee)

The current NG is good to Euro V emission standard in reducing nitrogen oxide (NO_x) emission, which is attained by Selective Catalytic Reduction (SCR). Aqueous urea is heated to become ammonia which reacts with NO_x in the exhaust gas formed during combustion to become nitrogen gas and water vapour discharged at the tail-pipe.

An alternative is Exhaust Gas Recirculation (EGR). Since the generation of NO_x is proportional to the combustion temperature, in EGR, part of the exhaust gas is recirculated into the combustion chamber to reduce the oxygen level in combustion;

thus suppressing the combustion temperature and NO_x formation. Soot, or carbon particles causing “black smoke” for diesel engines, is processed by Diesel Particulate Filter, in which Continuously Regenerating Trap is fitted to decompose soot with nitrogen dioxide catalysed by platinum, at temperature lower than the engine combustion temperature to become carbon dioxide (CO₂) gas and water vapour.

Euro VI demands more stringent tightening on NO_x emission and is complied with only by the adoption of both SCR and EGR in conjunction with variable turbo-charger geometry in provision of higher back pressure for the turbo-charger at low speed. Slip Catalyst is also deployed to recover the unreacted ammonia, or ammonia slip, in SCR before reaching the tail-pipe. The new Euro VI-compliance system weights 86 kilograms will be packed in the space reserved for which in the engine compartment.

Pursuit of Low-Carbon Emission

Every litre of diesel emits 2.65 grams of CO₂ and ADL tenders a number of means in fuel saving and hence further reduction of CO₂ emission:-

Means	Feature(s)
Acceleration Rate Management	Limit acceleration rate to 1.2 m/s ² (in the case of operations in London, the U.K.)
Idle shut-down	Shut-down engine when the vehicle idles in depot for longer than certain time
Telemetry	Real-time display of driving parameters in facilitation of fleet management
Driver reward scheme	Material award in promotion of fuel-saving-conscious driving behaviour, translating into maximum 50 % fuel save
Weight saving	Lightweight of vehicle
Driveline specification	Optimised selection of gear ratio in suiting operating conditions
Transmission features	Topographical software on gearbox to optimise gear selection
Tyres	Suitable tyre profile and pressure in minimising undesired road frictions
Hybridisation	Switch of electric drive-line of vehicle

Amongst the above, ADL subscribes and has invested heavily in hybridisation for achieving lower carbon emission. From the first delivery to the U.K. and Australia in 2008 and 2010 respectively, to June 2014 ADL delivered 686 hybrid buses operating on three (3) continents, and 162 vehicles were on its order book in mid-2014.

Hybrid Power-Train

Out of the two (2) hybrid power-train modes, parallel and series which features are compared below, the model supplied to Hong Kong, Enviro500H, adopts the latter mode:-

Feature	Parallel Hybrid	Series Hybrid
Mechanical link between	Retained	No link

Feature	Parallel Hybrid	Series Hybrid
engine and axle		
Electric drive-line configuration	Electric motor-generator blended-in mechanical drive to assist acceleration and retardation	Engine drives a generator, electric motor connected to axle

Hybridisation of buses, according to ADL, achieves better fuel economy by enabling engine to down-size [from about ten (10) litre to 6.7 litre] and recovery of braking power (as much as 200 kilo-Watts), which is transformed into heat and dissipated during deceleration, in electrical form stored into batteries. In a case of U.K. operation, while the hybrid bus was principally stopped by regenerative braking, the base brake was rarely used that the original brake pads broke because they were not maintained by sufficient braking heat.

Notwithstanding the advantages of lower emissions, smoother acceleration and deceleration and quieter operation, hybrid buses are concerned by the additional cost and weight (about 300 kilograms heavier than conventional power-train model), on-board high voltage, battery life and others.

ADL adopts BAE System-developed electric-drive package in hybridising buses. The package comprises generator coupled with the engine, 600-volt motor, battery and control system. Being a dictating factor of the performance of hybrid bus, the high-power density-domain energy storage system is with technical features tabled as below:-

Particular	Performance
Energy	11.6 kWh
Power	200 kW peak
Voltage	635 volt nominal
Operating temperature	From -10 °C to 52 °C
Length	2,170 mm
Width	1,026 mm
Height	304 mm
Weight	365 kg
Coolant	Forced ambient air
Construction	16 replaceable lithium-ion modules in single air-cooled enclosure
Design life	Six (6) years above

In light of the fact that some depots may not have charging infrastructure, the ADL hybrid is charge neutral (no provision of external charging of on-board battery). The system, which is turn-key supplied by BAE System, functions fully automatically, offering indistinguishable driving experience in comparison with conventional vehicles, as well as over 30 % fuel consumption saving (on non-air-conditioned model only).

Translating into operation terms, the system has achieved over 98 % of vehicle availability, and per annum, powered 690 million journeys, saved over 35 million litres of diesel fuel and 100,000 tonnes of CO₂ emission.

The Enviro500H prototypes supplied to Hong Kong were built and tested in the U.K. and delivered in complete vehicles, featuring start-stop device, motor-powered air-conditioning and hand-brake interlocked electric power steering.

“Virtual Electric”

Beyond current constant hybrid drive-line, ADL is advancing into dual electric-hybrid referred as “Virtual Electric”. In addition to diesel engine and on-board battery, “Virtual Electric” equips with two (2) 50 kilo-Watt (30 kilo-Watt for prototype) coils under floor to recharge the battery by induction. Each time the bus recharges at stops fitted with ground-mounted inductor, enabling the bus to carry sufficient power to travel 30 to 40 minutes inside pollution sensitive area at zero emission independently. Once entering non-sensitive area, the bus runs on hybrid; thus overall the carbon emission of the bus is further reduced without compromise on range and operation flexibility.

“Virtual Electric” is being trailed on route 69 of London Buses and also in Scotland in the U.K.

Assembly Workshop



Granton’s assembly line for KMB vehicles (Jimmy Lee)

ADL bus body workshop attached to Granton comprises three (3) halls of 200 metre by 60 metres each. Two body assembly lines are housed in two (2) halls one (1) hall is assigned for storage.

ADL assembles bus bodies for orders from Citybus, New World First Bus and Mass Transit Railways Corporation in Hong Kong and SMRT of Singapore and delivers to these customers in the form of complete build-up (CBU; i.e. the vehicle is completely built upon delivery). Orders from Kowloon Motor Bus (KMB) in Hong Kong are under different arrangement. ADL delivers chassis and complete sets of bus body components only, or complete knock-down (CKD), and KMB appoints contractor(s) to execute the assembly works. Granton is contracted to assemble KMB buses, currently at the rate of six (6) buses per week, and the assembly line is adjacent to that of ADL.

The CBU buses are quality-controlled by ADL personnel though the physical assembly works is conducted by Granton. Quality check is performed at the end of each work stage. From a fully built-up chassis with body components in CKD form to delivery of the completely built-up bus, the process typically takes 4.5 weeks.

Production



Assembled chassis parked outside workshop, waiting to be bodied (Jimmy Lee)

The chassis arrived at the start of the production line is first water-levelled (levelling is attained by the use of laser in the U.K.). In parallel, the aluminium alloy-made and CNC-profiled body kits from the U.K. such as pillars and beams are put together against jigs to become sub-assembled sections such as side frames, intermediate roofs and top roofs.



The bus formed its shape with body components integrated together and attached on the chassis (Benny Sit)

The side frames are attached to the chassis by mono-bolts. Once the intermediate roof, front and rear panels and the top roof are attached, the bus takes its shape. The connection of all components and integration of the body with chassis is attained by mechanical fastening and no welding is involved. The sections are well-engineered so that the components fit with each other with minimal requirement on workmanship.



Close-up of aluminium-made nearside body frame (Edmund Leung)

The chassis integrated with body skeleton is pushed manually to the next bay for the fittings. Glasses, GRP kits, aluminium sheets for interior surfaces and accessories are local-sourced. The skin panel adopts etalbond of Elval Colour in Greece, a sandwich-type composite panel consisting of a non-toxic polyethylene core firmly bonded between fine aluminium facing and backside sheet. It enjoys high strength-to-weight ratio, light weight and importantly low thermal expansion coefficient, meaning that pre-tensioning of panels to avoid corrugation in high temperature and maintain flatness is unnecessary; thus simplifies the body assembly process. Attachments and fixtures are met by mechanical fastening or adhesion.



GRP-made ladder module installed in the cabin (Edmund Leung)

The next stage is painting. The prepared and masked grey bodies are first prime-coated and then sanded-down for refining the surfaces. First and second coating with PPG-made non-water borne automotive paints from the U.S. and baking is performed in a temperature- and humidity-controlled spray booth.



Surface preparation for painting (Edmund Leung)

After the under-body is coated with under-body wax one (1) week prior to delivery to protect from corrosion, the bus undergoes pre-delivery inspection including tyre alignment examination. Finally, where the road test is satisfactory, the bus is ready for hand-over to customer.

Remarks



Citybus and New World First Bus vehicles under assembly (Jimmy Lee)

Though monstrous in size on roads, buses were assembled not complexly. The process of body assembly does not require heavy equipment other than overhead cranes for easy lifting of sub-sections, whereas hand-held tools to put components together orderly by means of bolting or adhesion. Being well-engineered, ADL buses need not be completely built in its country of origin and there is obvious cost saving by assembling bus bodies in Zhuhai where the labour cost is relatively low and the location is close to the customer in Hong Kong. This explains why ADL buses have been so receptive in Hong Kong and increasing number of new buses of this brand have been put on the Hong Kong roads in the recent years.

The ADL buses in Hong Kong have been designed for future. While Hong Kong may impose more stringent emission control regime for the improvement of air quality, the ADL models are ready to comply with it by advancing into Euro VI. In addition, ADL is well-positioned in developing hybrid so that vehicular emission is further lowered, while development of new technologies may enable it to leap into zero emission.

ASME-HKS and IMechE-HKB thank Mr. Andrew Boulton and Mr. Steve Campbell for their generous support to and hospitality in the visit.

- END -

Encl.
AW/WHT

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TECHNICAL VISIT TO ADL BODY ASSEMBLY FACILITY IN ZHUHAI

Alexander Dennis (ADL) has supplied passenger transport vehicles, principally double-decker buses, to Hong Kong for over three decades. Since 2011, ADL assembles buses in Zhuhai, Guangdong Province of China and ships the completed vehicles to Hong Kong for delivery.

For the first time ever, together with IMechE Hong Kong Branch, ASME Hong Kong Section is privileged to arrange a technical visit to witness first-hand the complete process of bus assembly and testing, as well as appreciate the basics of bus engineering. Members interested in automotive, transport, manufacturing or buses should not miss this rare opportunity.

IMechE member: HK\$310 (Round trip tickets and lunch are included)

Date: 13 Dec 2014 (Sat)

Time: 0700 hrs – 1630 hrs

Gathering time and venue:

0700 hrs. Gather at in Hong Kong China Ferry Terminal, 33 Canton Road, Kowloon

0730 hrs. Ferry departure from Hong Kong China Ferry Terminal

By courtesy of Alexander Dennis with compliment

Places are limited to 25 with priority given to IMechE and ASME members. Event details and enrolment please visit <http://www.asmehk.org/events.html/> or contact industrial@asmehk.org



**ALEXANDER
DENNIS**

Alexander Dennis Welcomes HKIMechE to Zhuhai

13th December 2014

Welcome to GT in Zhuhai



Andy Boulton

13th December 2014



Agenda

- **Background**
- **Innovation**
- **Double deck Evolution**
- **Euro VI**
- **Fuel Consumption**
- **Hybrid developments**
- **ADL hybrid experience**
- **What's next?**

History of ADL



- 1895 Dennis Brothers started in Guildford, England
- 1903 Bus manufacture started in purpose built factory
- 1924 Walter Alexander started in Scotland
- 1962 First Dennis Loline delivered to Hong Kong
- 1975 Became major suppliers to Hong Kong market
- 1988 Launch of Dennis Dart midibus
- 1997 Launch of low floor accessible d/d buses in Hong Kong
- 2004 Formation of Alexander Dennis
- 2009 Launch of 2-axle double deck in Hong Kong
- 2010 JV with Kiwi Bus
- 2012 JV with New Flyer in North America
- Market leader in UK, Hong Kong, USA, Canada, New Zealand
- 2013 Launch of NEW Enviro500 in Hong Kong
- 2014 Launch of first hybrid 3 axle double deck to Hong Kong





**ALEXANDER
DENNIS**



Falkirk, Scotland

- 900 employees (Factory + Central HQ)
- ADL HQs
- Body and chassis assembly plant
- Body engineering



Scarborough, England

- 560 employees
- Coach, body and chassis assembly



Skelmersdale, England

- 250 employees
- Aftermarket HQs.
- Product Engineering support



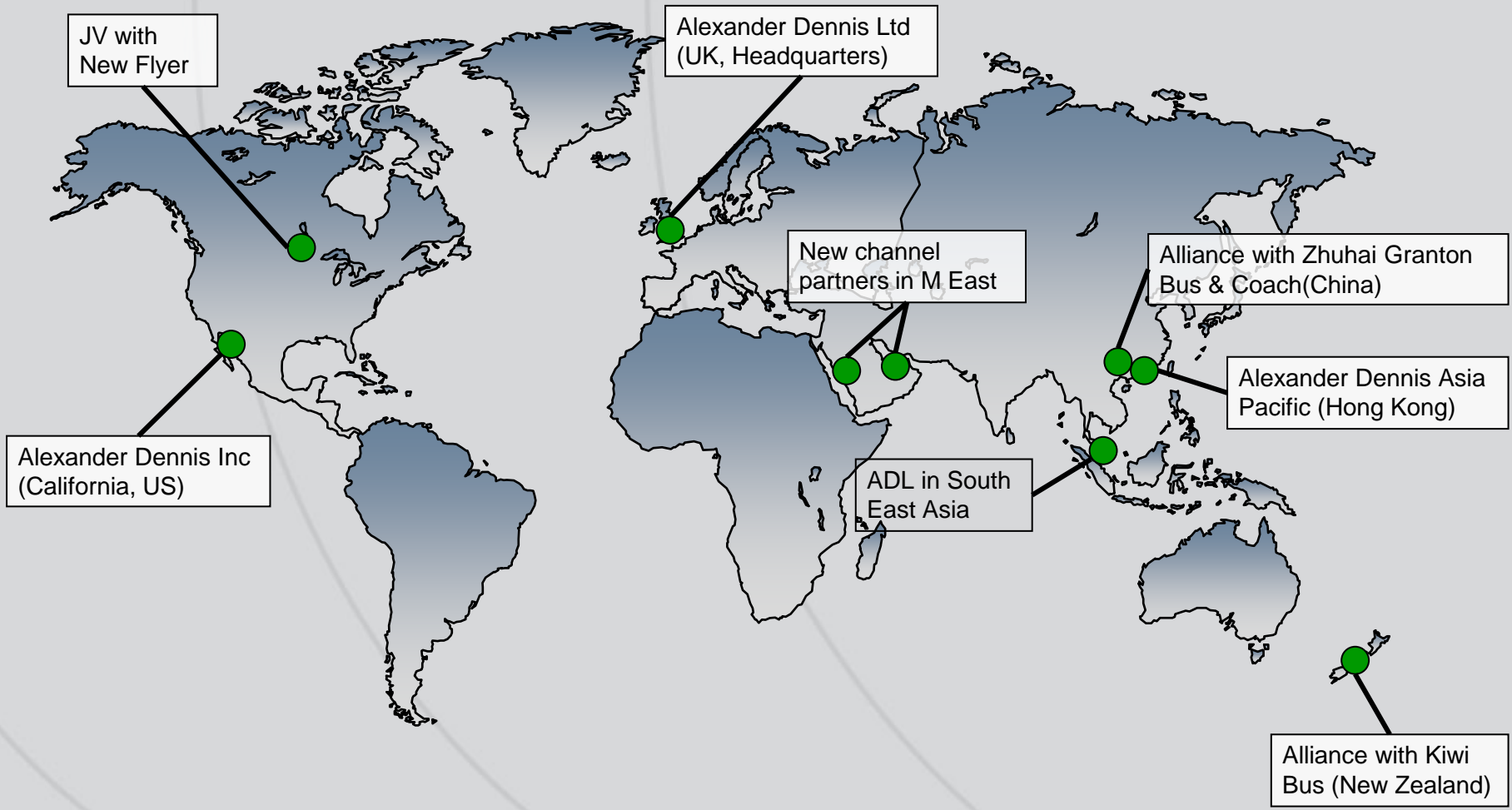
Guildford, England

- 310 employees
- Chassis assembly plant.
- Chassis engineering





ADL INTERNATIONAL PRESENCE





Innovation

- **Innovation is not about producing a ‘flashy’ concept vehicle, it is using technology to develop and deliver a product to customer’s specification which delivers flexibility, reliability and economy in the demanding bus depot environment.**
- **We do not want to experiment with customer’s livelihoods**
- **No compromise on component selection**
- **Process of evolutionary design, learning from experience**

ADL 3 axle Low Floor Double Deck Development



Trident launched
Super Low Floor entry
EuroII emissions engine

1997



Enviro500 launched
Wider body, straight staircase
Disc braked front axle
EuroIII emissions engine

2003



Enviro500 Next Generation
Lighter weight
Increased seating capacity
ZF axles – disc brakes all round
Major focus on all-round improvements
Euro5 emissions engine
ZF Ecolife transmission

2012



Reliability Analysis Results



- **Reviewed last 36 months of warranty and campaign data**
- **Rated by frequency and customer impact**
- **Identified 50 key reliability issues**
- **Analysis by**
 - Engineering
 - Customer Feedback
 - Local Engineers



IMPROVED RELIABILITY

Bus stop
brake

Reduce air
consumption
to reduce
compressor
loads

Full test and sign off program
including durability. Service
access and maintainability
review - Design Protect for
Euro VI



ZF axles with
disc brakes

Improved
braking
system with
change of tag
axle spring
actuator

Cooling coil in
front of radiator
to reduce air
temperatures

New cooling system
with remote mounted
thermostat and
aluminium radiator

Urea system
installation to
focus on system
temperatures and
locations

ENVIRO500

1,436

- E500 diesel Hong Kong

6

- E500 hybrid Hong Kong

40

- E500 diesel Malaysia (RapidKL)

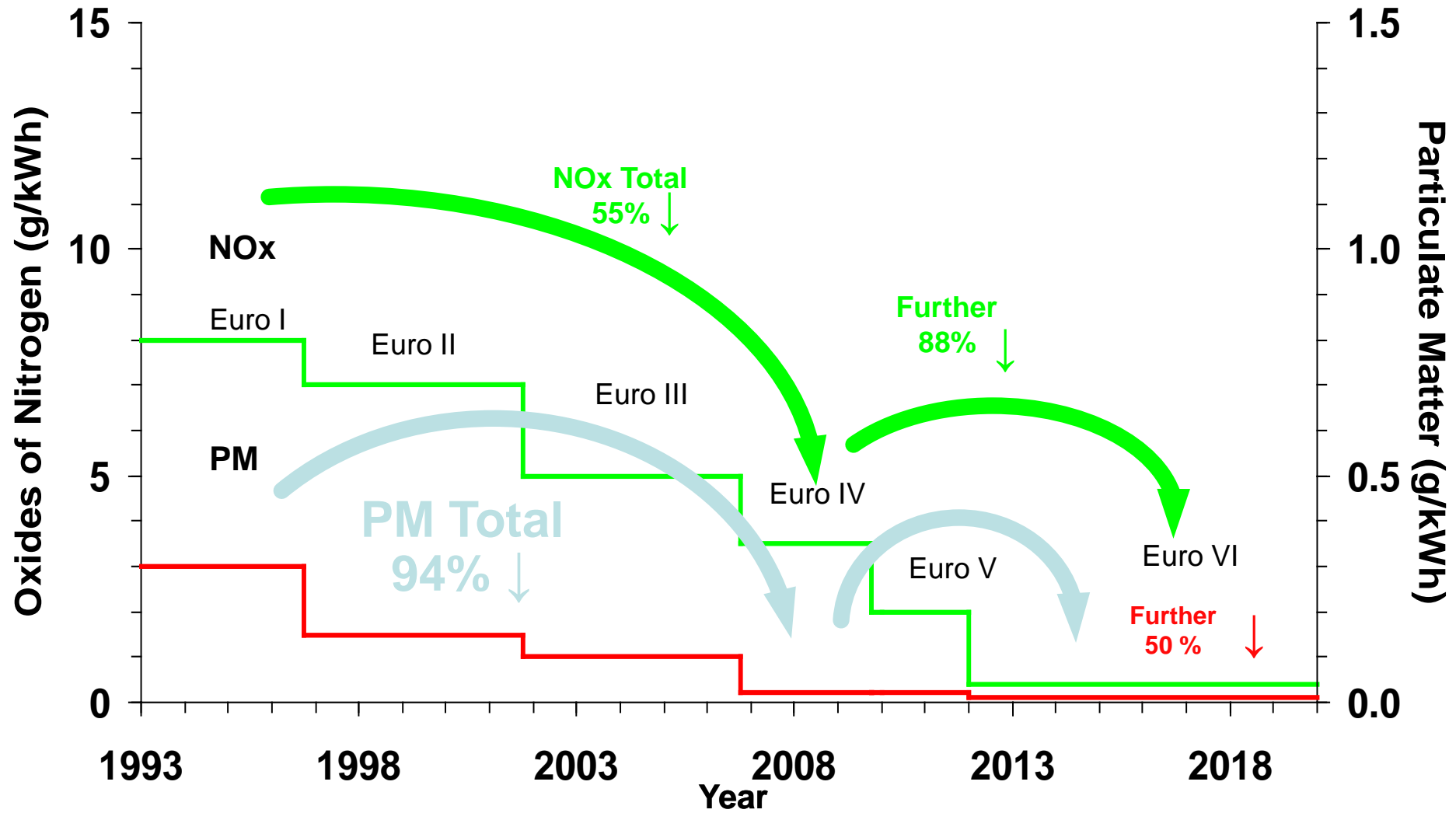
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- E500 diesel Singapore (SMRT)





HD On-Highway Emission Regulations EU Standards & Effect Dates



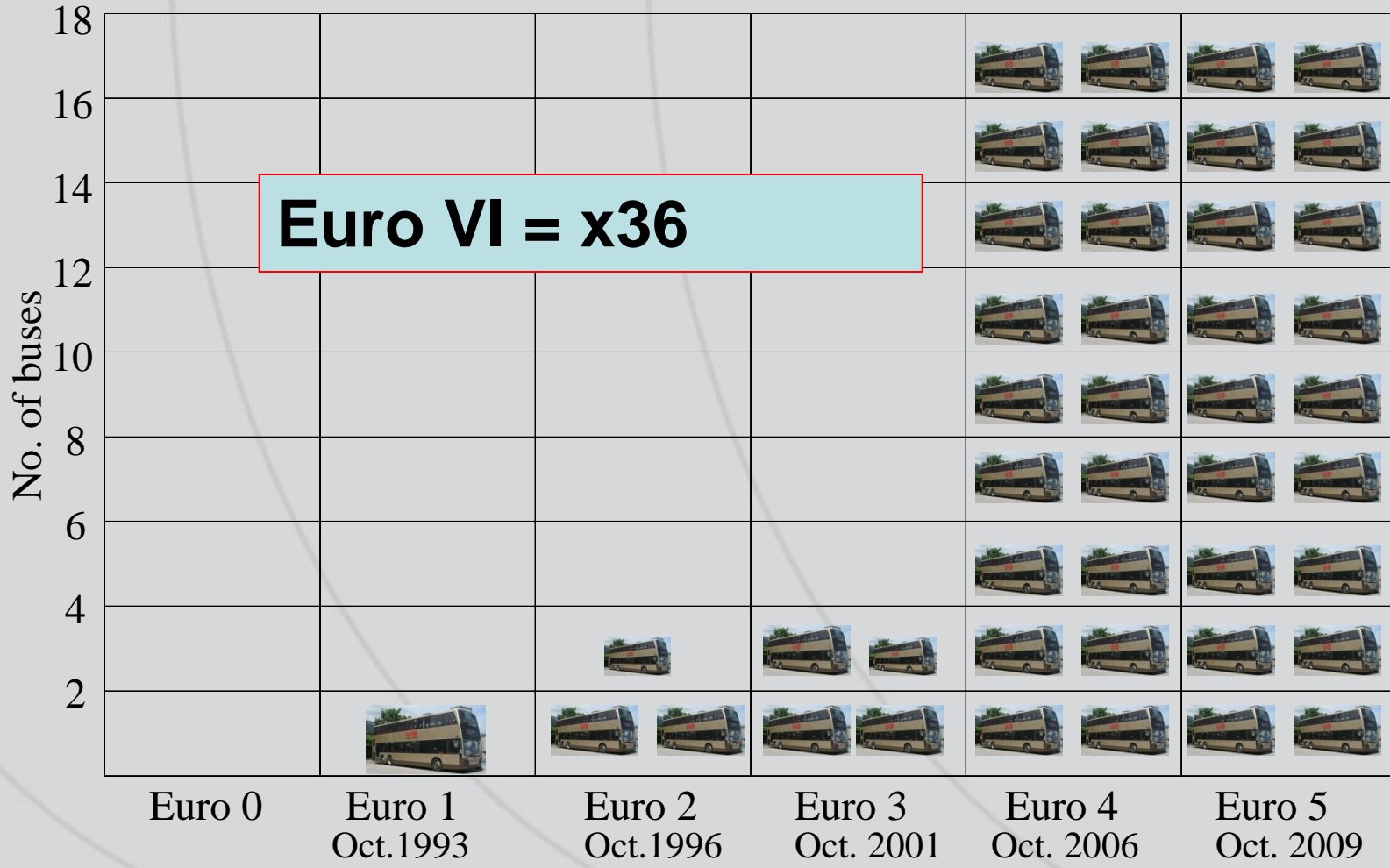


Equivalent Nox Emissions



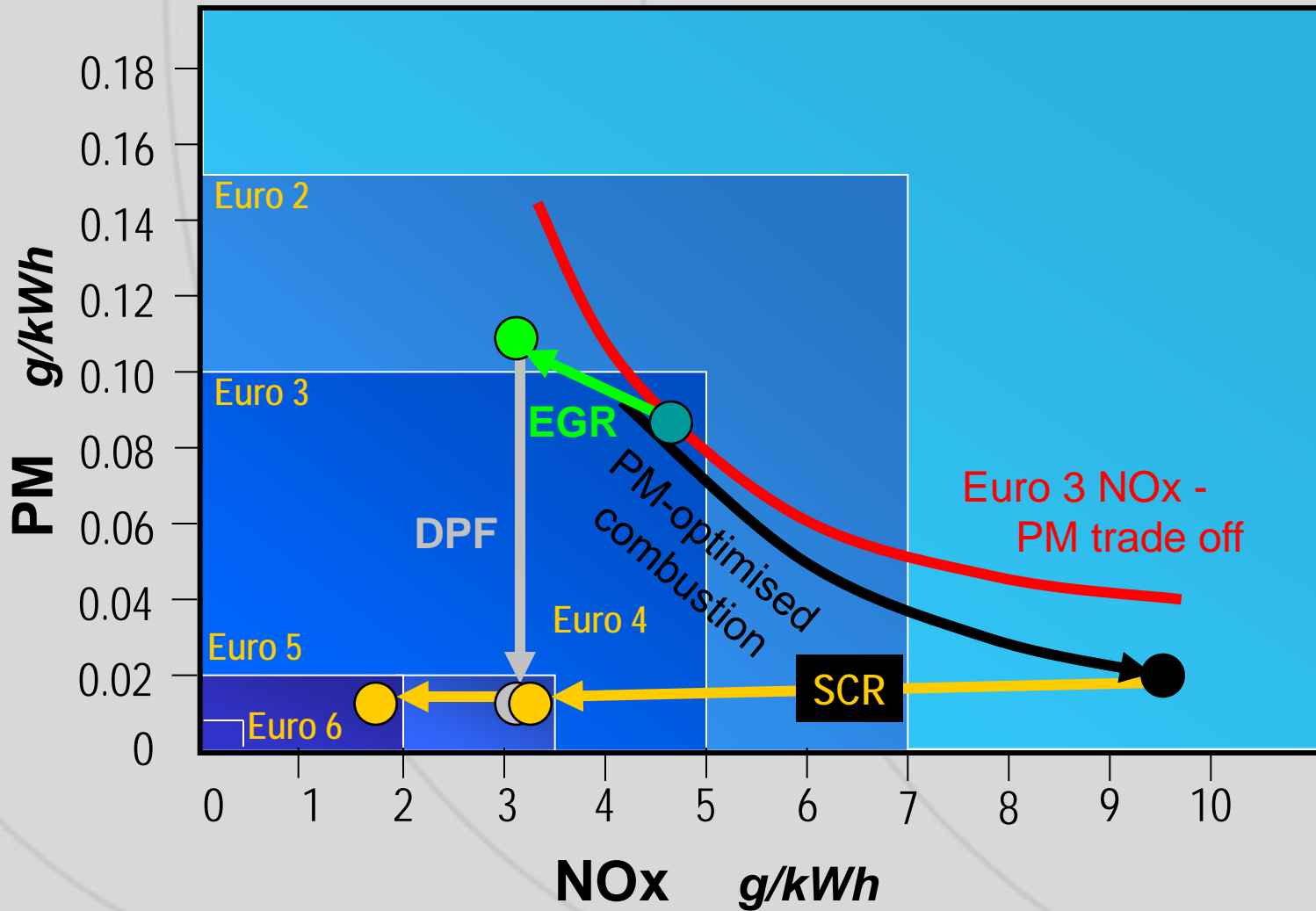


Equivalent PM Emissions

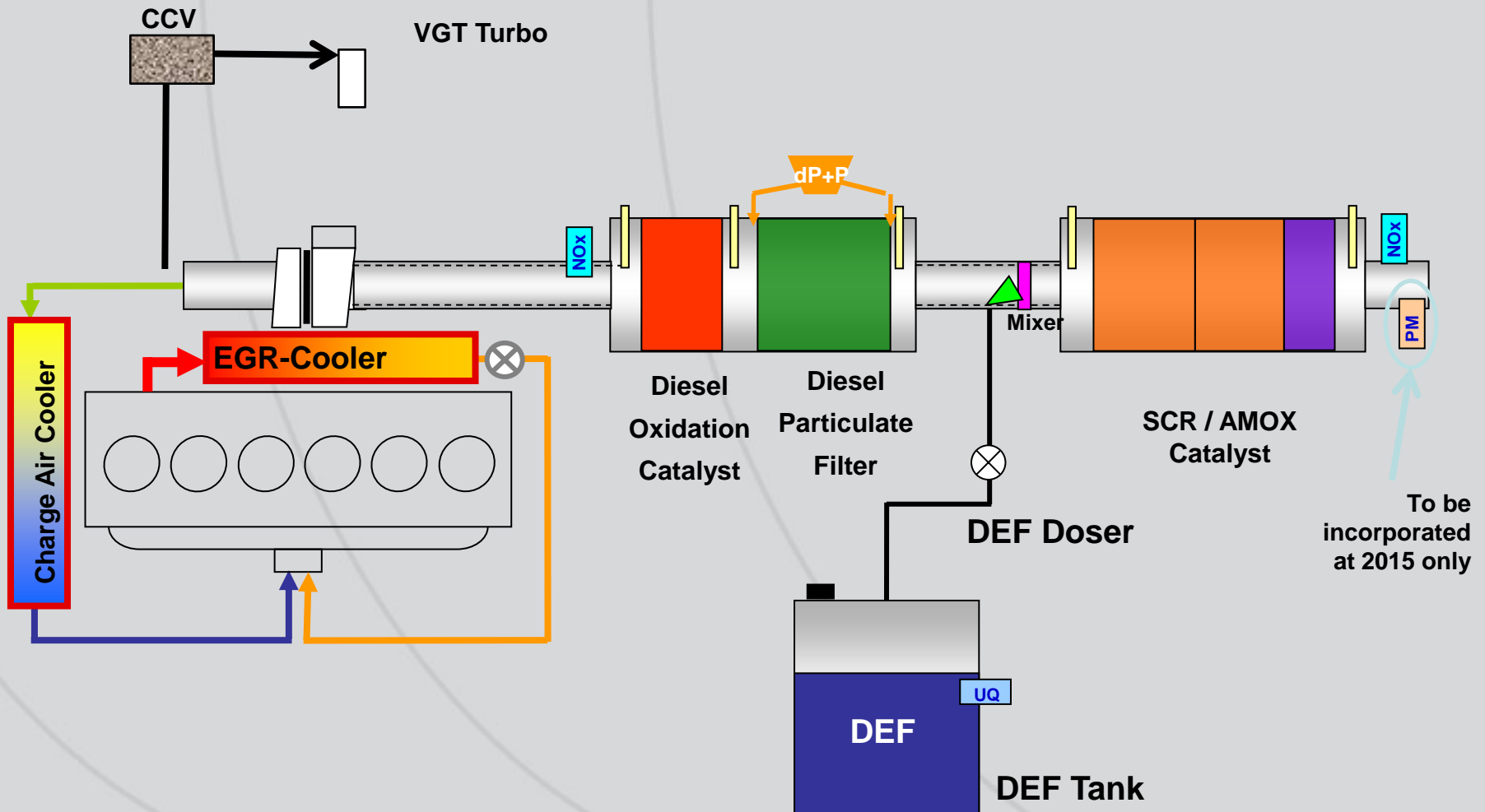




NOx - PM trade off



Euro VI System Architecture





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Lowering Carbon Emissions

- Acceleration Rate Management
- Idle shut down
- Telemetry
- Driver reward scheme
- Weight
- Driveline Specification
- Transmission Features
- Tyres
- Hybridisation

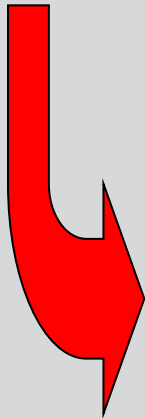




What is a Hybrid?

Electric driveline + energy store

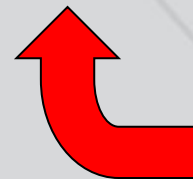
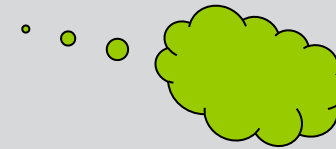
Downsize engine



Reduced fuel consumption



Reduced emissions



Recover free braking energy



Hybrid Benefits

- **Low emissions**
 - Global warming – CO₂
 - Local air quality – NO_x, PM
- **Better fuel economy**
- **Smooth acceleration and performance**
- **Quieter operation**
- **More reliable than alternative fuels**

Customer Concerns

- Added cost and weight
- Relatively immature technology
- Training & maintenance requirements
- High voltage concerns
- Battery life

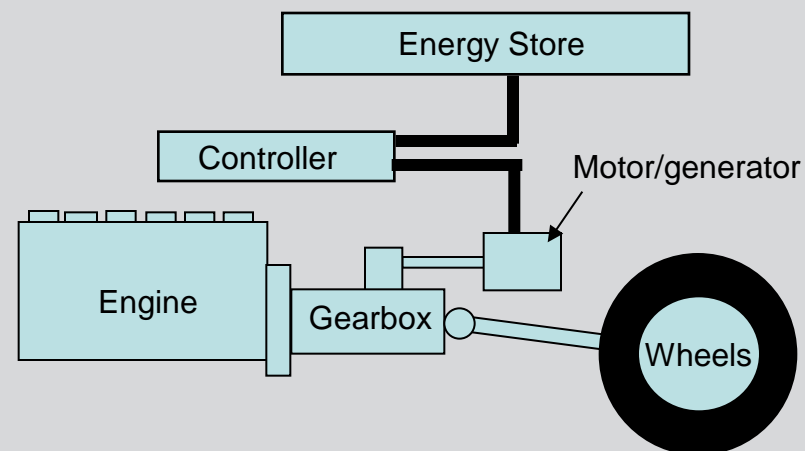


Parallel Hybrid

Retains mechanical drive between engine and axle

Electrical motor / generator blended in to assist acceleration and retardation

As used in Enviro500 with the Allison hybrid drive and Volvo B5

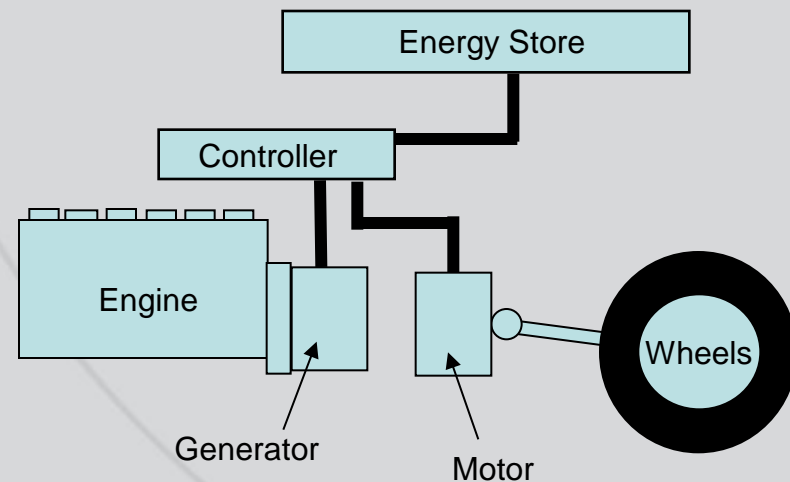


Series Hybrid

No mechanical link between engine and axle

Engine drives a generator, electric motor connected to axle

As used in Enviro200 & Enviro400 with the BAE Systems Hybridrive

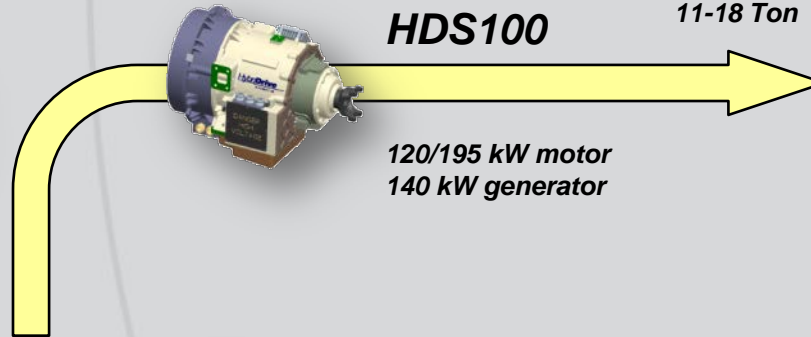
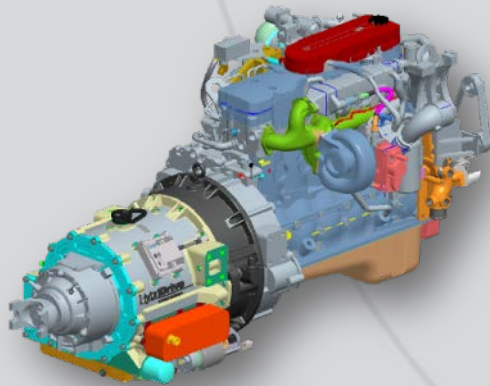
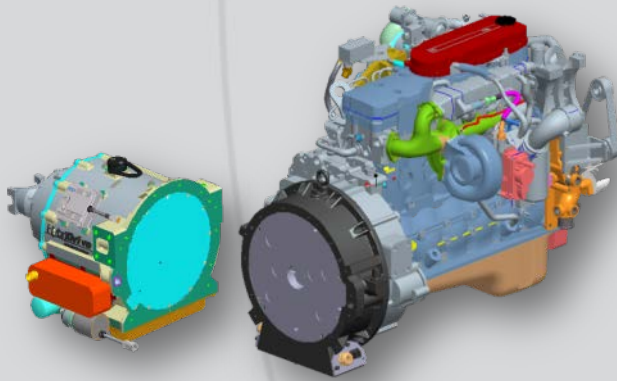




A family of products



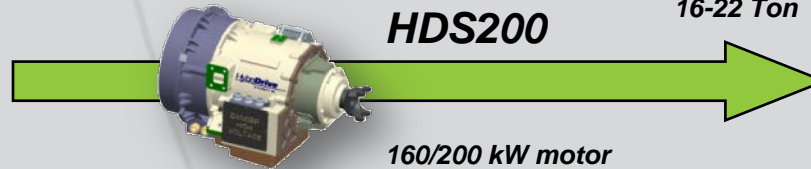
ALEXANDER
DENNIS



HDS100

11-18 Ton

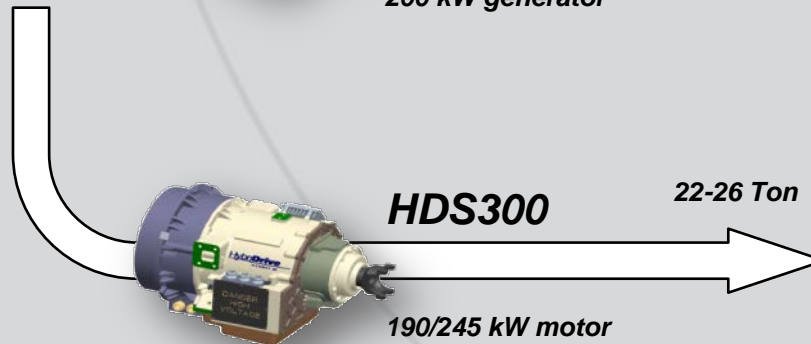
120/195 kW motor
140 kW generator



HDS200

16-22 Ton

160/200 kW motor
200 kW generator



HDS300

22-26 Ton

190/245 kW motor
230 kW generator

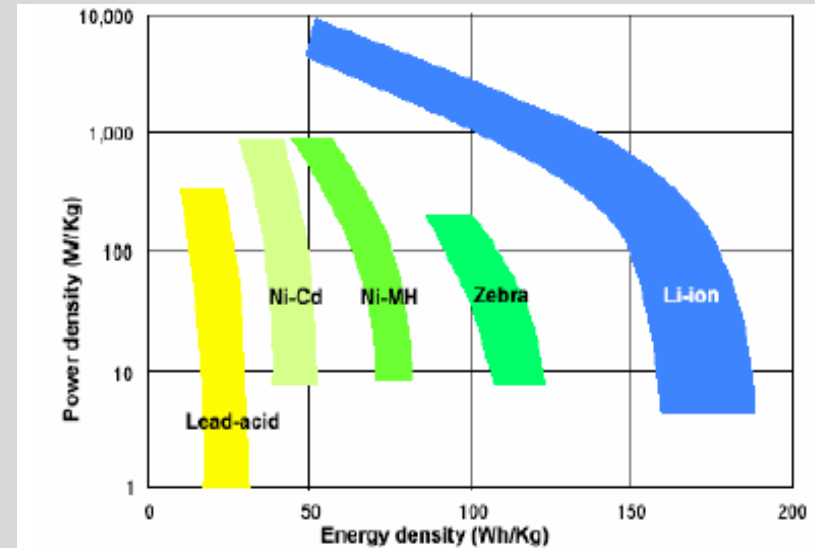




Lithium-ion energy storage system



- Best power and energy density of any commercially available solution
- Nano-phosphate technology
- Design life 6+ years
- Ambient air-cooled
- Superior energy storage supports full ZEV operation



RATINGS

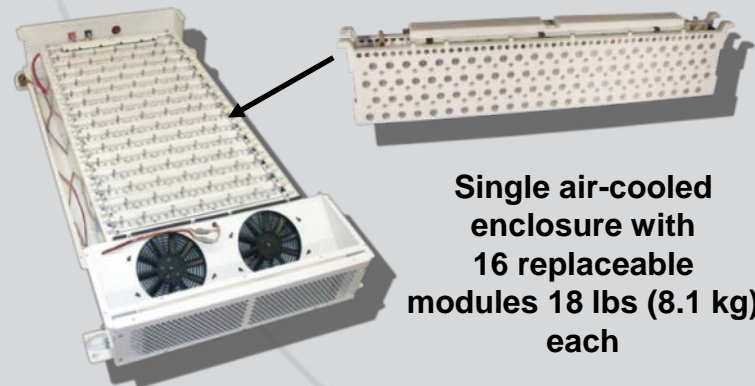
- Power: 200 kW peak
- Voltage: 635 Vdc Nominal
- Operating Temperature: -10C to 52C (-40C to 52C w/cold weather package)

SIZE

- Length: 85.4 in. (2170 mm)
- Width: 40.4 in. (1026 mm)
- Height: 12 in. (304 mm)

WEIGHT: 800 lbs. (365 kg)

COOLANT – Forced Ambient Air





ADL Philosophy



- **Maximise brake energy recovery**
- **Load following - not charge following – not exercising the battery**
- **Emulate conventional driving characteristics**
- **Charge neutral**
- **Onboard equalisation**
- **Turn-key systems with supplier support**

ADL Hybrid Performance to June 2014



- 686 hybrid buses in service
- 162 hybrid buses on order
- Operating on 3 continents
- Hybrid product range are LCEB compliant
- >30% fuel consumption improvement met
- Better than 98% vehicle availability achieved
- Very positive customer feedback for hybrid drive system
- Popular with drivers and operators alike





BAES Global Fleet Summary



- **More than 4,200 systems in service**
- **The most successful series hybrid system in the world**
- **Powering 690 million passenger journeys every year**
- **More than 35 million litres of fuel saved every year**
- **100,000 tons of CO₂ emissions prevented every year**





**ALEXANDER
DENNIS**

2008

**1st Generation HybriDrive® - Propulsion Only
First vehicles enter TfL trial: 12 E400H & 5 E200H
25% fuel savings**



2010

**1st Generation HybriDrive® - incremental improvements
E400H sees sales outside the TfL trial with GBF1
30% fuel savings**



2011

**2nd Generation HybriDrive® - Propulsion Only
Continued UK sales with GBF2
35% fuel savings**



2012

**2nd Generation HybriDrive® Stop Start
Continued UK sales with GBF3
40% fuel savings**



2014

**Enviro500H HybriDrive® with Stop Start
and electric a/c entering service in Hong Kong**

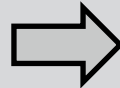
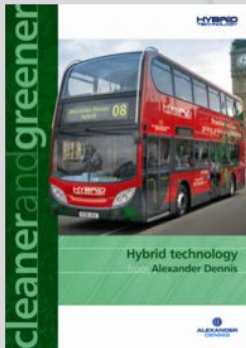


2014

**Virtual Electric bus trial running in Scotland,
with Enviro350H with On Route Recharging**



Today's
Hybrid
Electric



ADL “Virtual Electric” concept: *A Range Extender EV with Opportunity Recharge*

Operates as Zero Emission EV in City Centre zone or other AQ hazard zones on route

Elsewhere it operates as low emission hybrid vehicle

ZE range typical 30 - 40 min between charge phases

Contactless Inductive Recharge capability out on route means bus can make use of “fuel” from the grid without lengthy re-charge layovers or return to depot.

Flexibility of operation is at the heart of this concept. That means near-zero compromise vs standard diesel bus operations:

- charge time aligned to service timetables
- capable of diesel-equivalent shift length
- compact package size means OK for Double Deck
- no reduction in passenger capacity

“Conventional EV”

Conventional concept battery only bus is:

- Range limited
- Heavy

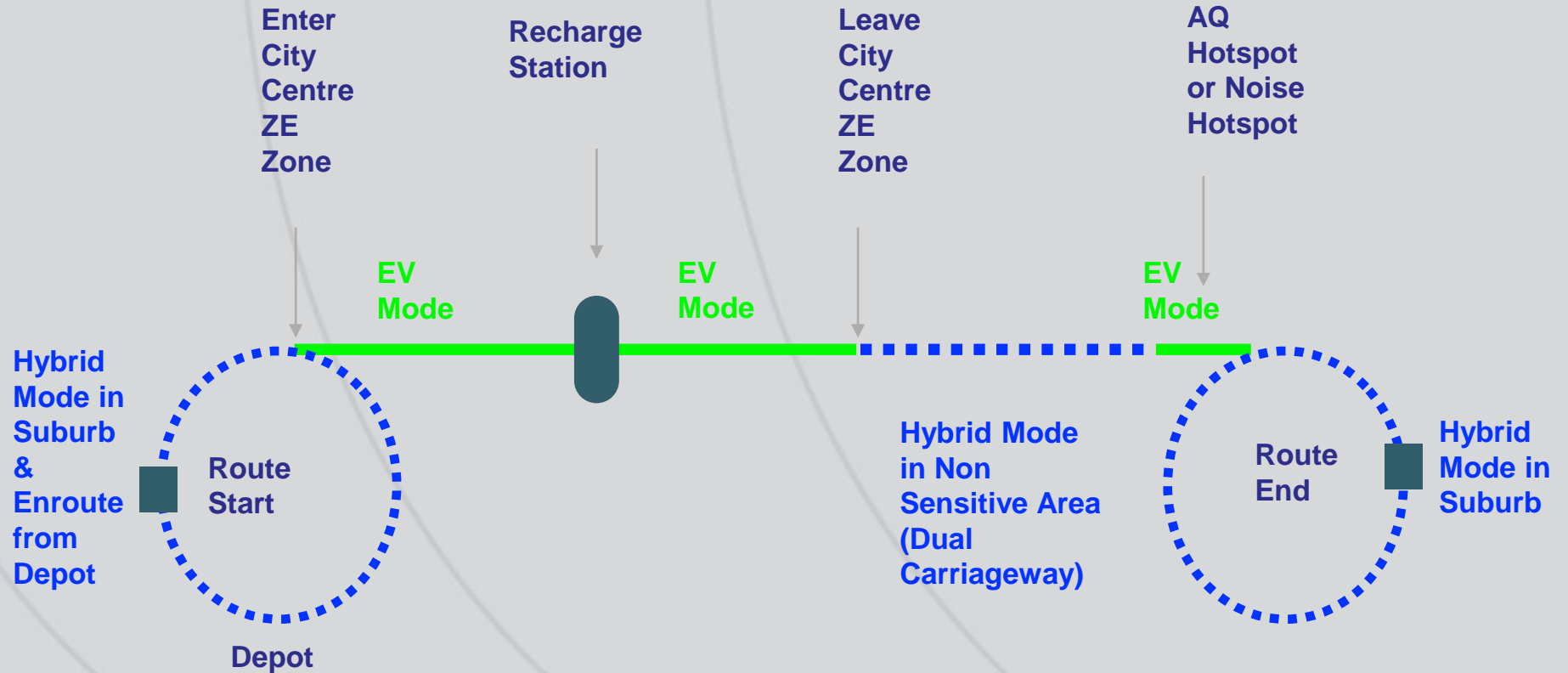
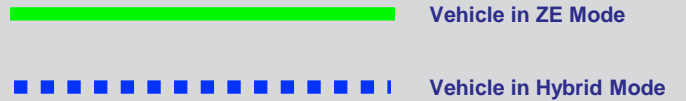




Virtual Electric Vehicle



Operational Concept:
EV with all day Operation Capability



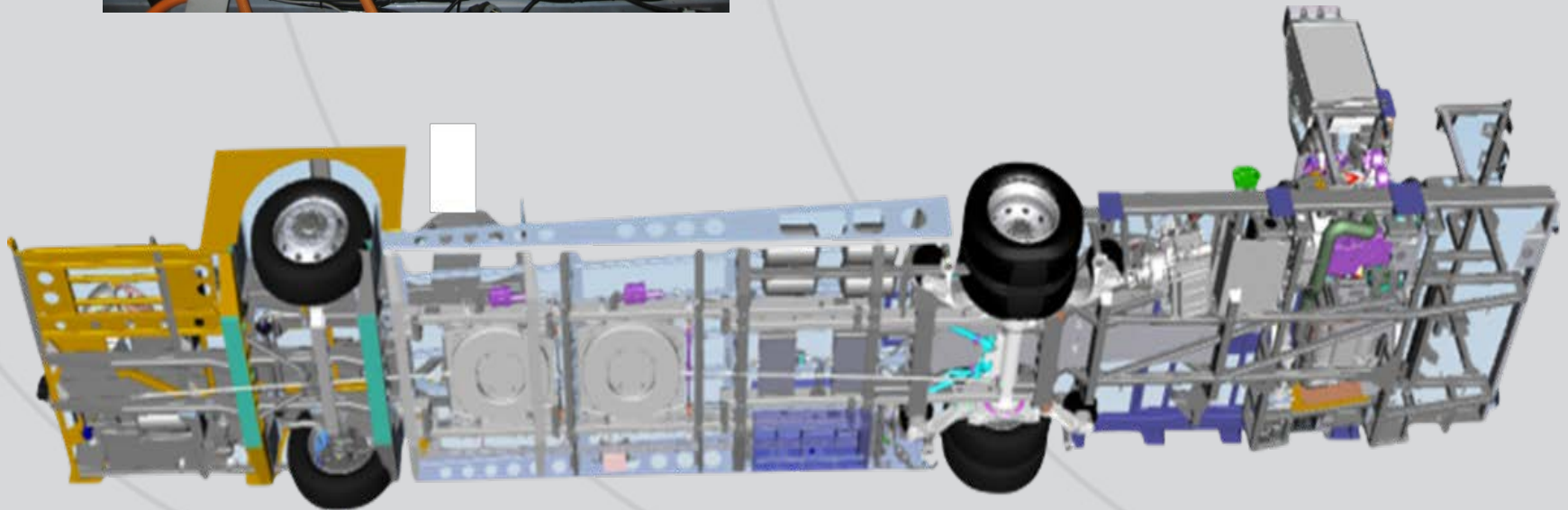


**ALEXANDER
DENNIS**



Control Cabinets

2 x Primary Coils,
connected to Grid
Electricity





Thank You, Any Questions?