VDI / YUTONG

WELCOME

Yutong International Profile

VDI / YUTONG

- Yutong has 4 production factories with a total plant area over 3.59 million square meters (Over 500 Football Fields) -
- Maximum daily production capacity > 445 units per day - new energy buses > 375 units per day -

Local Profile

VDI / YUTONG

7 Yutong Sales & Parts Locations

NSW

- Yutong Bus Australia Campbelltown
- Yutong Bus Centre Smeaton Grange, Mascot

Queensland

- Yutong Bus Centre Cairns
- Yutong Bus Centre Brisbane

Victoria

- Yutong Bus Centre Melbourne

Western Australia

- Yutong Bus Centre Perth

AFTER SALES SERVICE

- ✓ After sales staff contactable 24/7
- ✓ Available on site within 24 hours
- ✓ Service options available

Zero Emission Bus (ZEB)

VDI / YUTONG

YUTONG ZERO EMISSION VEHICLES INTERNATIONALLY

- ✓ Over 147,000 zero emission buses and coaches in service
- ✓ 26.8 billion kms
- ✓ Equivalent to 80,000 hectares of forest being replanted
- ✓ Yesterday alone 5.9 million kms equivalent to 16 hectares
- ✓ Over 44,000 E12s in operation globally

YUTONG ZERO EMISSION VEHICLES DOMESTICALLY

- ✓ 20 Zero Emission buses operating in Australia as at end October 2021
- ✓ Total kms operated as at end October 2021 = approx. 770,000kms

Yutong Global Operations

VDI / YUTONG

Yutong

successfully promoted over 147,000 NE buses accumulatively in many cities domestic and abroad.

- Among which , Yutong has achieved sizable sales in France, UK, Bulgaria, Iceland, Denmark, Finland, Singapore, Chile, Mexico, Kazakhstan and other markets.
- It has conducted successfully trial operation in Australia, New Zealand, Russia, Colombia, Argentina, etc.

Section 1 ZERO EMISSION BUS

Zero Emission Bus (ZEB)

VDI / YUTONG

ZERO EMISSION VEHICLE:-

- ✓ A vehicle that does not directly produce atmospheric pollutants

BEV – Battery Electric Vehicle

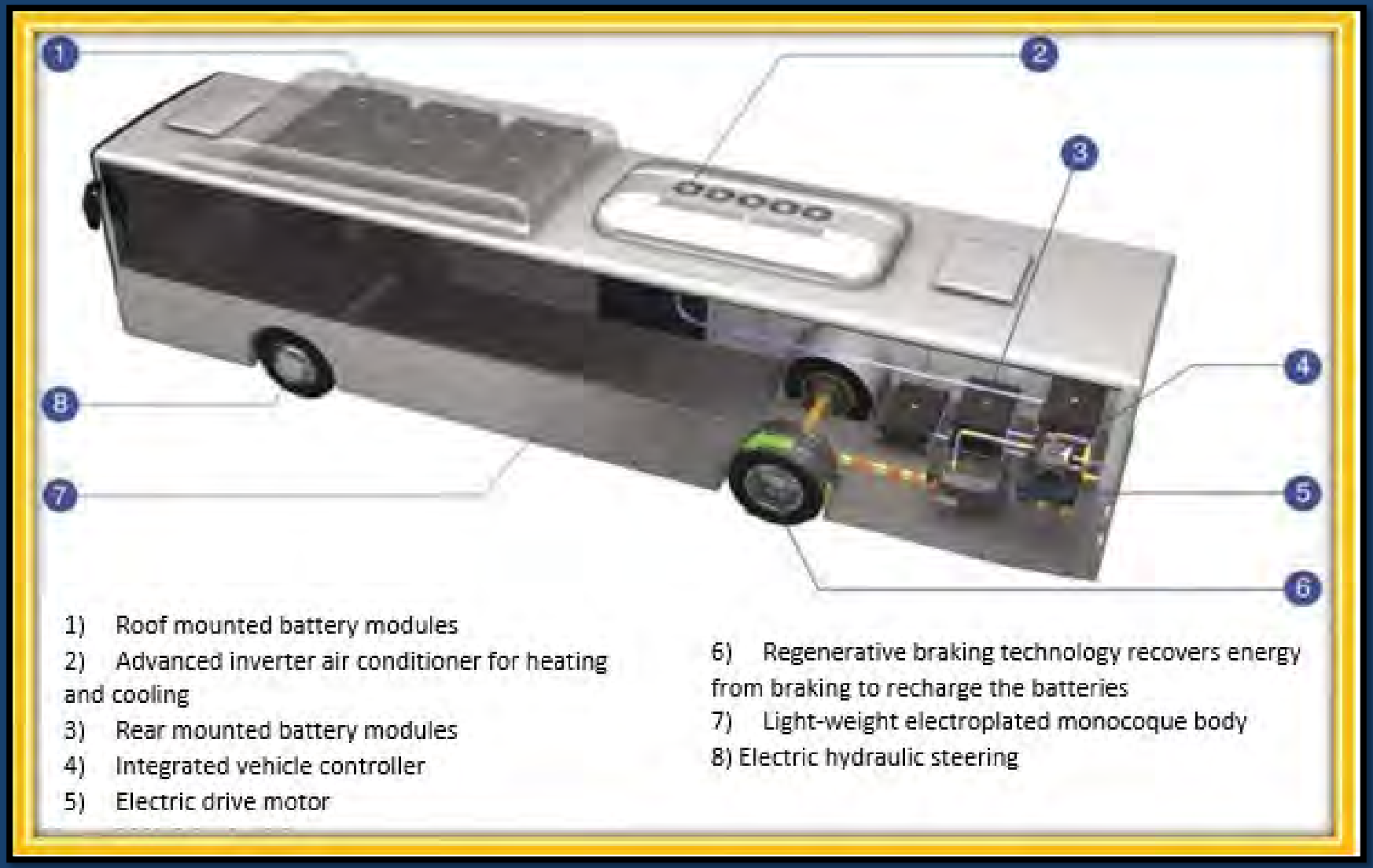
- ✓ A battery electric bus is a bus that is driven by an electric motor and obtains energy from on-board batteries normally charged from external source

HEV – Hydrogen Electric Vehicle

- ✓ A fuel cell bus is a bus that uses a hydrogen fuel cell as its power source for electrically driven wheels, sometimes augmented in a hybrid fashion with batteries or a supercapacitor.

Basic overview of E12 - Principle

VDI / YUTONG



1) Roof mounted battery modules
2) Advanced inverter air conditioner for heating and cooling
3) Rear mounted battery modules
4) Integrated vehicle controller
5) Electric drive motor
6) Regenerative braking technology recovers energy from braking to recharge the batteries
7) Light-weight electroplated monocoque body
8) Electric hydraulic steering

The following video outlines the basic principles of the Yutong Full Electric Bus

https://www.youtube.com/watch?v=H7XGaGc0qek

Zero Emission Bus Major Components

VDI / YUTONG

Batteries

- ✓ While there is a common principle behind Li ion batteries there are varying types, combinations and associated reports promoting the advantages and disadvantages of each, its is arguably one of the most debated issues involving ZEBs
- ✓ As such, I have decided to outline some of the issues that surround ZEB batteries and how they apply to Yutong

Yutong E12 Batteries – CATL - LiFe Batteries

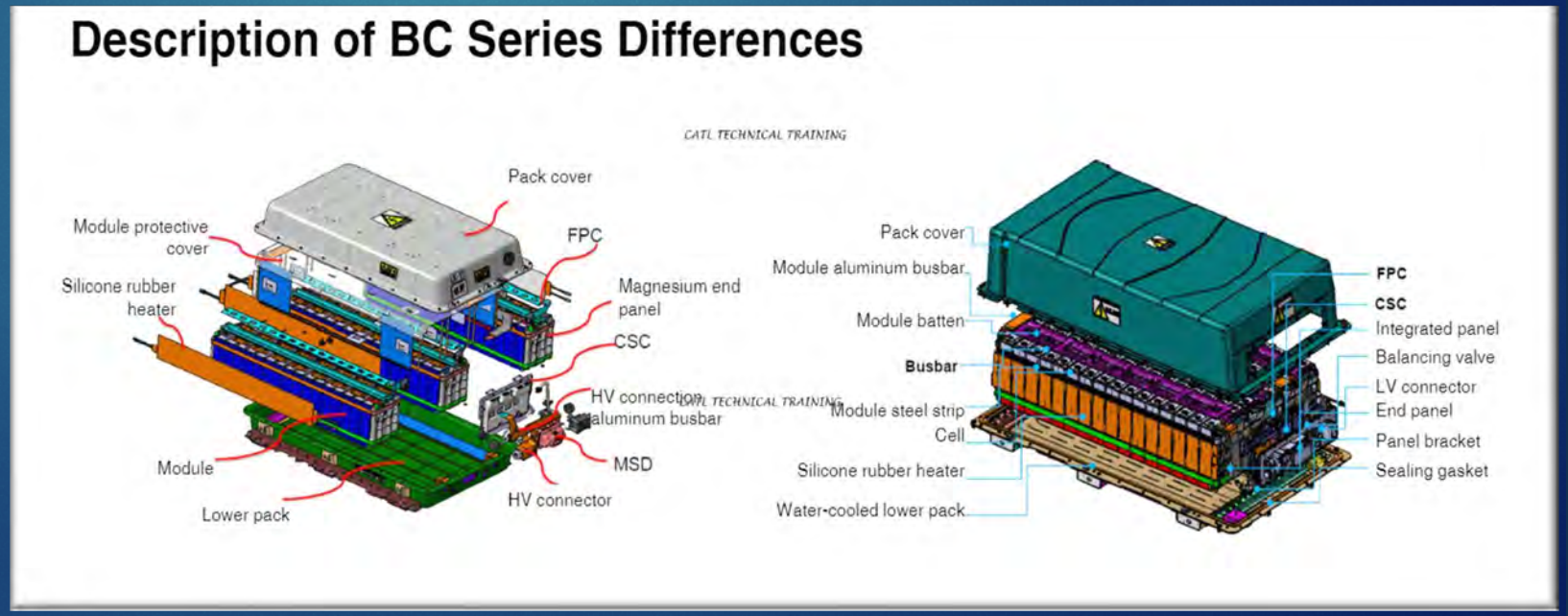
- ✓ LiFe (lithium iron phosphate)
- ✓ Liquid Cooled
- ✓ Cathode and anode in polymer
- ✓Energy Density (WH/kg) - 160

Zero Emission Bus Major Components

VDI / YUTONG

Battery Size

- ✓ Measured in kWh
- ✓ Example:- Yutong currently offer two systems in Australia
  - ✓ 422kWh system
    - ✓ 7 battery packs located on the roof and 5 in the rear of the bus (48 individual cells per pack)
  - ✓ 350kWh system
    - ✓ 5 battery packs located on the roof and 5 in the rear of the bus (36 individual cells per pack)



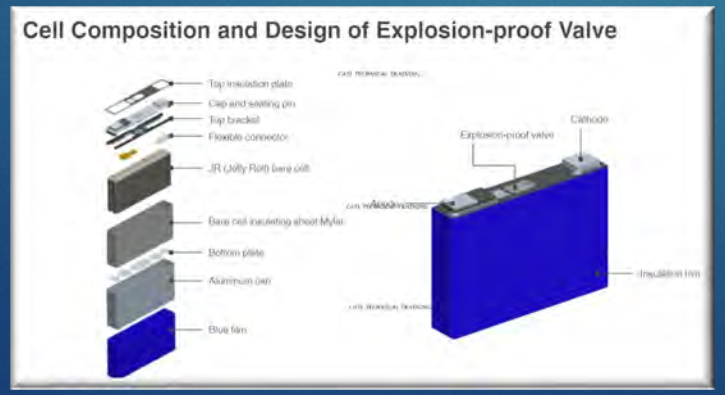
Zero Emission Bus Major Components

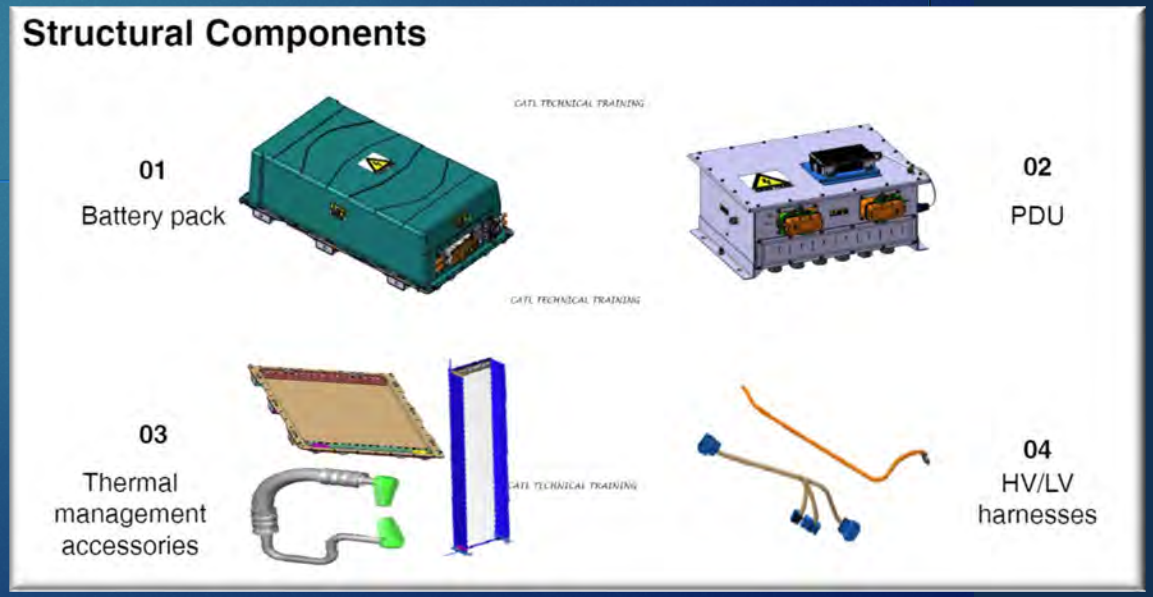
VDI / YUTONG

Battery Warranty, Life and Replacement

Concerns include: -

- ✓ Battery warranty, terms and conditions
  - ✓ Different manufacturers have different warranty periods despite apparently having similar battery products
  - ✓ Terms and conditions of warranties vary, particularly in relation to usage
- ✓ Battery life
  - ✓ Concerns regarding battery life with specific considerations to operational contracts
- ✓ Cost or replacement
  - ✓ The cost for operators to replace the batteries at end of life
  - ✓ Cost of batteries in relation to total bus price
- ✓ Process of replacement
  - ✓ Process required to replace the batteries
  - ✓ Certification and training to enable replacement





Zero Emission Bus Major Components

VDI / YUTONG

Battery Warranty, Life and Replacement - YUTONG

Battery warranty and conditions

- ✓ Yutong's Warranty is up to 8 years / 500,000 kms
- ✓ No charging / operational conditions associated

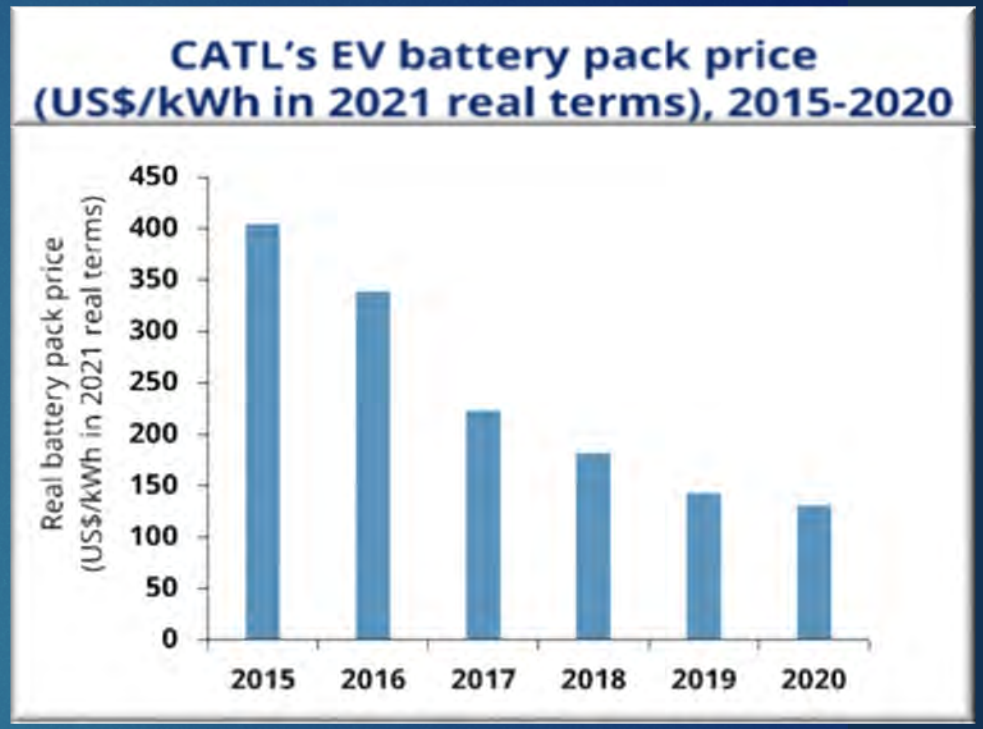
Battery life

- ✓ Battery degradation expected to be less than 20% in 8 years
- ✓ Battery service life is expected to be less than 20% degradation after 3500 charge cycles.
  - ✓ Charge cycle is 0% to 100%.
  - ✓ Charging from 50% to 100% is 0.5 charge cycle

- ✓ All Yutong electric powerpacks units have the same footprint and connections allowing future technology improvements to be compatible with existing system

Cost of replacement

- ✓ Battery packs have reduced by about 65% in the past 5 years
- ✓ While battery pack prices are decreasing significantly, technology, safety and efficiency continue to increase



- ✓ **Battery pack price in 2015 approx.. 450US$ per kWh**
- ✓ **Battery pack price in 2020 approx.. 140US$ per kWh**

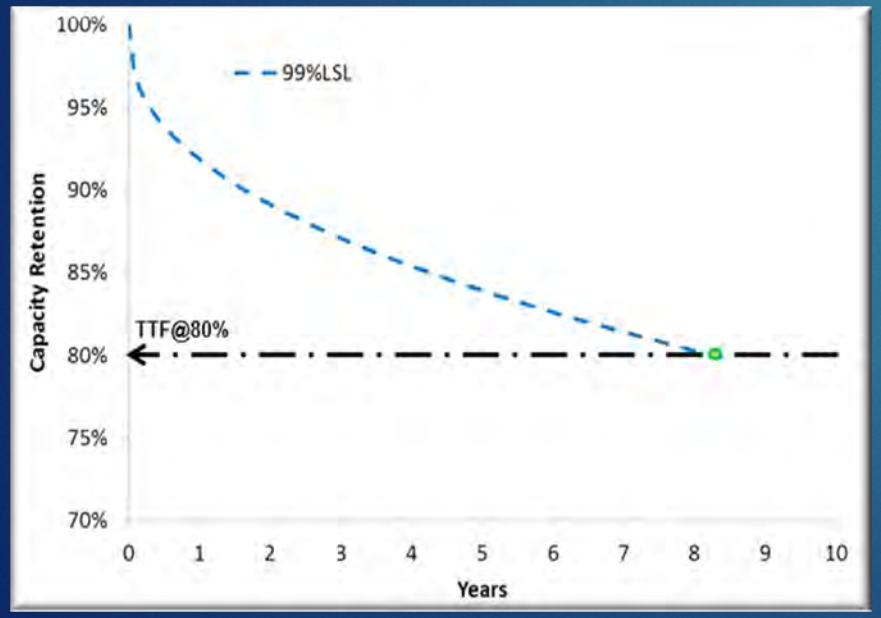
Zero Emission Bus Major Components

VDI / YUTONG

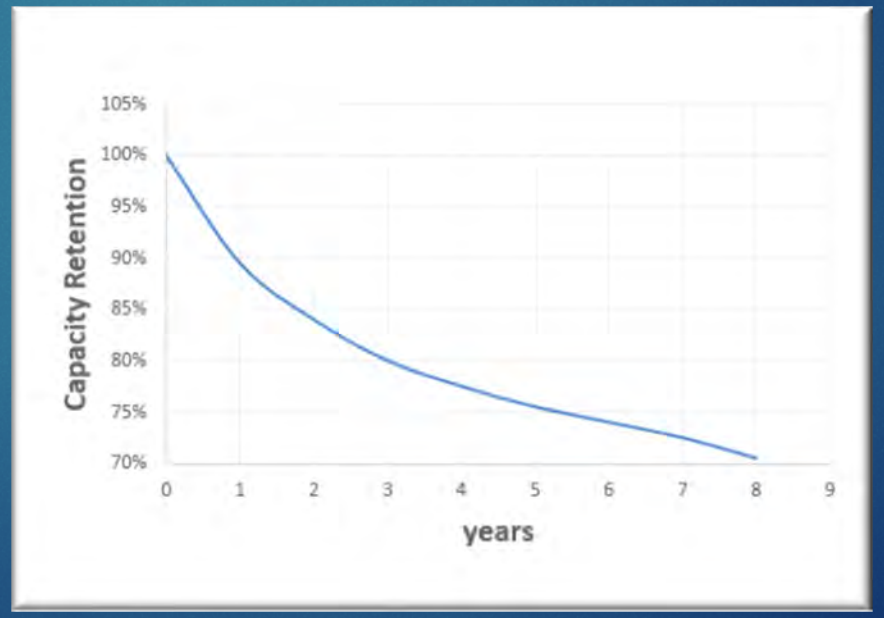
Battery Warranty, Life and Replacement - YUTONG

Examples of Battery life

- ✓ Internationally an order of 600 units delivered in 2014 (China) presently have a battery State of Health (SOH) of between 75% and 85% (7 years operation)
- ✓ The first Australian E12 commenced service in 2019, has since conducted 127,483 kms (as at end October 21) and its present battery SOH is 95%
- ✓ The issue is that by the time there is adequate data available to assess performance, technology has advanced



Capacity retention chart with cooling



Capacity retention chart without cooling

Zero Emission Bus Major Components

VDI / YUTONG

Battery Range

In general terms the range of a ZEB is a combination of battery size and efficiency (energy consumption).

As mentioned, the size of the battery system fitted is measured in kWh

Efficiency is a combination of numerous factors including, but not limited to;

- ✓ Vehicle design including integration of componentry
- ✓ Driving styles
- ✓ Operation type including average speed

Battery Range - YUTONG

- ✓ Yutong's kWh per km ranges from approximately 1kWh / km to approximately 0.65kWh / km - (average is 0.84)
- ✓ While Yutong has no minimum battery % requirement, operators must assess the amount of charge remaining to enable its return to the depot
- ✓ Hence on the above criteria a 422kWh electric bus would have an approximate range of between 400km and 600km
- ✓ Current data will be highlighted in later sections of this presentation

Zero Emission Bus Major Components

VDI / YUTONG

Battery Charging

- ✓ Different battery types have different requirements and warranties depending on the way they are charged including:-
  - ✓ The size of the charger (amount of kw used to charge the bus)
  - ✓ Type of charging AC or DC
- ✓ Yutong electric buses are DC charge compatible
  - ✓ Can accept charging rates from 30kw to 120kw with the current plug-in charging systems (high-capacity systems coming soon)
  - ✓ Can be programmed to work with multiple different charging devices

- Charging system: 2 x 120kw 230amp Yutong Charge pile units
- Plug type: CCS2 (European standard)
- Expected Charge time: 40 minutes to 3 hrs 45 minutes depending on charge strategy used per vehicle
- Charging options: Manual start, Time delay start, SOC stop, Automatic start
- Intelligent control system incorporating fault detection & safety

Zero Emission Bus Major Components

VDI / YUTONG

Battery Safety

Safety is without doubt the most important issue involving zero emission vehicles particularly in relation to batteries.

✓ Submersion, puncture, collision, fire and crush should be standard testing criteria for batteries presently on the market

Yutong YESS Technology - YouTube

Zero Emission Bus Major Components

VDI / YUTONG

Battery Safety

- ✓ Battery Safety is continuously improving and evolving towards Systematic Safety Measures which include;
  - ✓ Incorporating safety in design targeting improvements of the collision protection structure
  - ✓ Multi layer physical isolation using steel and other insulation materials
  - ✓ Nitrogen battery protection systems replacing oxygen in the battery packs with aviation grade nitrogen
  - ✓ Individual battery pack protection including short circuit protection, internal mica cover protection, external ASC cover protection which can withstand burning at 1300 degrees C
  - ✓ Thermal management systems

- ✓ All battery systems should be monitored and controlled electronically providing real time data and management of the system, including;
  - ✓ Real time information about battery charge levels and condition
  - ✓ Isolation of individual cells if any issue is detected
  - ✓ Safety related information

Safety is an area that is the primary focus for all manufacturers including Yutong who's expenditure of over **$295m** annually on Research and Development includes a significant contribution to ZEB safety.

Yutong YESS Technology - YouTube

Zero Emission Bus Major Components

VDI / YUTONG

Drive Types

Drive Motor

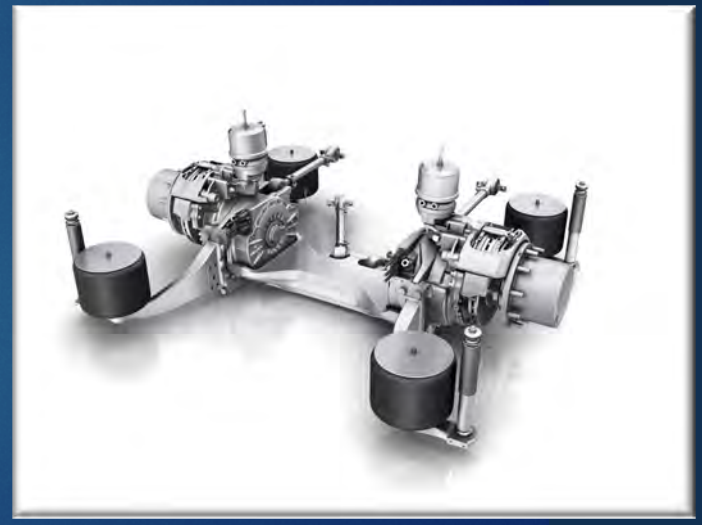
- ✓ Power is transferred from batteries to the electric motor which is connected to the drive axle via a differential and tail shaft as in the case of the Yutong E12
- ✓ Liquid cooled

Hub Drive

- ✓ Normally involve electric motors which form part of the wheel hub.
- ✓ Usually involve 2 hub motors at both rear wheels
- ✓ Liquid Cooled

Drive Type - YUTONG

- ✓ The single TZ368-XSY-TB38 (liquid cooled) electric drive motor is at the heart of all our single deck electric range.
  - ✓ Continuous = 215kw
  - ✓ Peak = 350kw
- ✓ This single motor layout allows the drive motor to be mounted in the chassis itself
- ✓ The motor has a dedicated water cooling system ensuring there is no risk of overheating even during prolonged uphill running.
- ✓ Yutong's Drive Motor is our own product which can be replaced in approx. 4 hours
- ✓ Yutong's warranty on the Drive Motor is up to 8 years / 500,000km



Zero Emission Bus Major Components

VDI / YUTONG

Drive Types - Regenerative braking energy recovery technology

The principle of regenerative braking energy recovery is to transmit the inertial energy of the vehicle through the drivetrain to the motor when braking.

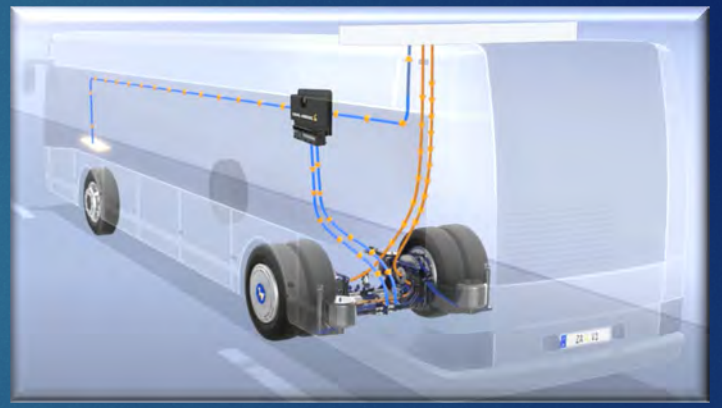
At which point the permanent magnet synchronous motor operates in the generator mode state, charges the power battery, and realizes the recovery of braking energy.

At the same time, the reverse braking torque generated by the motor rotor acts on the drive shaft to the drive axle system to produce braking power.

This reduces the usage rate of mechanical brake system, reducing brake heat decline caused by the increase of temperature in the braking process.

Regeneration

Both Hub Drive and Drive Motor systems offer a regeneration system involving similar principles but differ in operation due to setup and design.



Zero Emission Bus Major Components

VDI / YUTONG

Airconditioning System

- ✓ Inverter AC technology is used to improve efficiency
- ✓ Operating data has revealed that the AC system on the Yutong Electric E12 buses uses between 6% to 9% of the total kWh used during operation.

Passenger cabin

- Type: Cling EZDS-07 full electric reverse cycle
- Capacity 38,000j cooling, 36,000j heating

Drivers area

- Type: Cling ECSQ/02
- Capacity 8kw cooling and heating

Zero Emission Bus Major Components

VDI / YUTONG

Battery Management System, Power Control and Vehicle Control Unit

Battery Management System

The battery management system (BMS) is constantly monitoring the state of the batteries . This includes voltage, and the state of charge. The unit provides communication, safety, cell balance and management control for the batteries whilst also providing communication interface with the application equipment.

- ✓ Manages the charging to batteries from external charger
- ✓ Communicates to every battery pack via module
- ✓ Integrates with power and vehicle controller for vehicle operation
- ✓ Warranty up to 8 years / 500,000km
- ✓ Bolt out bolt in part that can also have internal componentry serviced and / or replaced

Zero Emission Bus Major Components

VDI / YUTONG

Battery Management System, Power Control and Vehicle Control Unit

Power Control Unit

- ✓ Integrates with the BMS and Vehicle Control unit to distribute electricity to all electrical units and controls power regeneration
- ✓ Warranty up to 8 years / 500,000km
- ✓ Bolt out bolt in part that can also have internal componentry serviced and / or replaced

Vehicle Control Unit

- ✓ Integrates with the BMS and Power Control unit to distribute electricity to all electrical units and manage power regeneration
- ✓ Warranty up to 8 years / 500,000km
- ✓ Bolt out bolt in part only

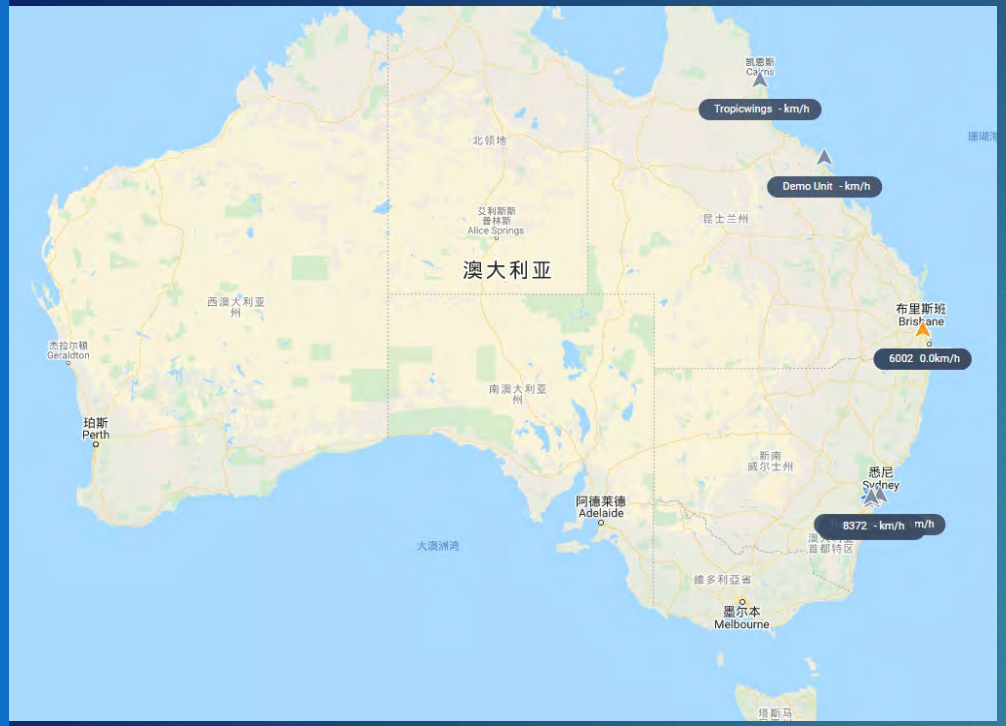
Major service requirements – Yutong E12

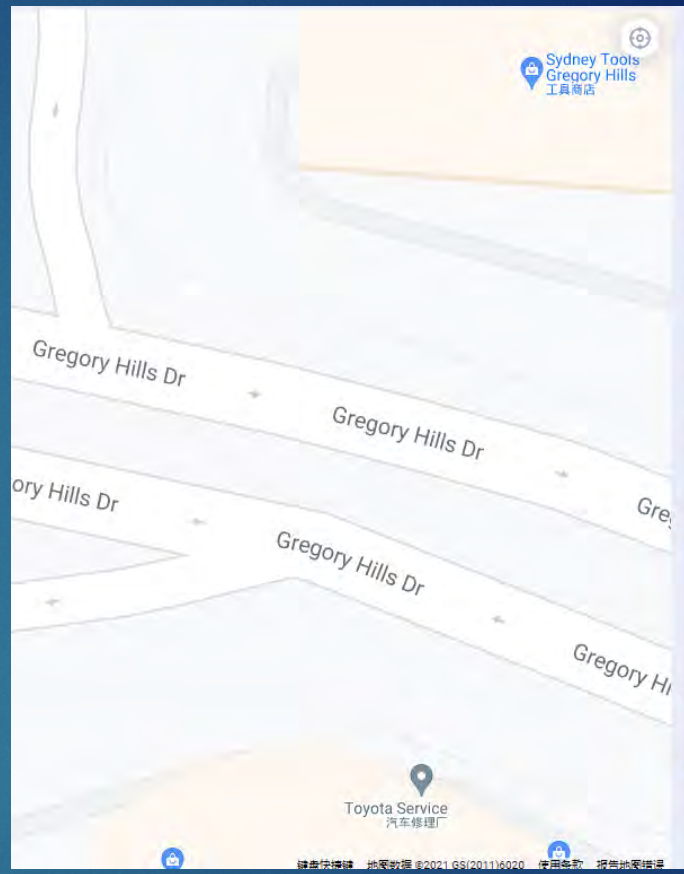
- ✓ Wheel hub bearing grease replacement at 250,000km
- ✓ Drive axle oil replacement 250,000km
- ✓ New energy cooling system coolant replacement at 24 months
- ✓ Drive motor bearing inspection at 4 years and 12 monthly thereafter
- ✓ Battery stabilisation every 12 months (vehicle to be left on for 24hr period)

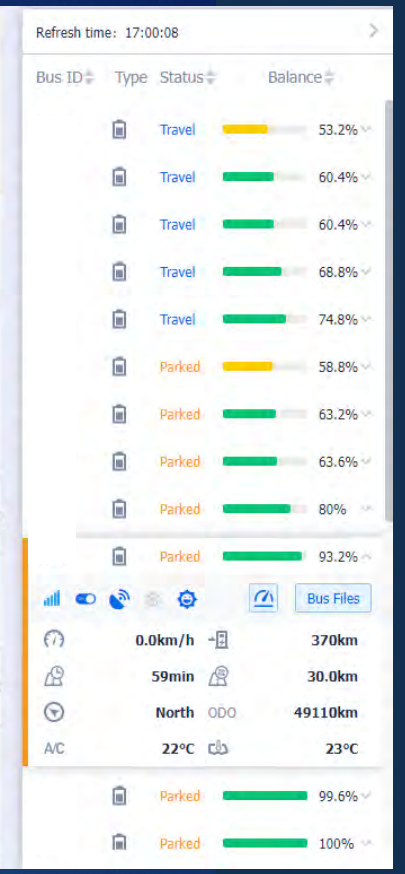
Section 2 Data - Reports

Operational Data

VDI / YUTONG







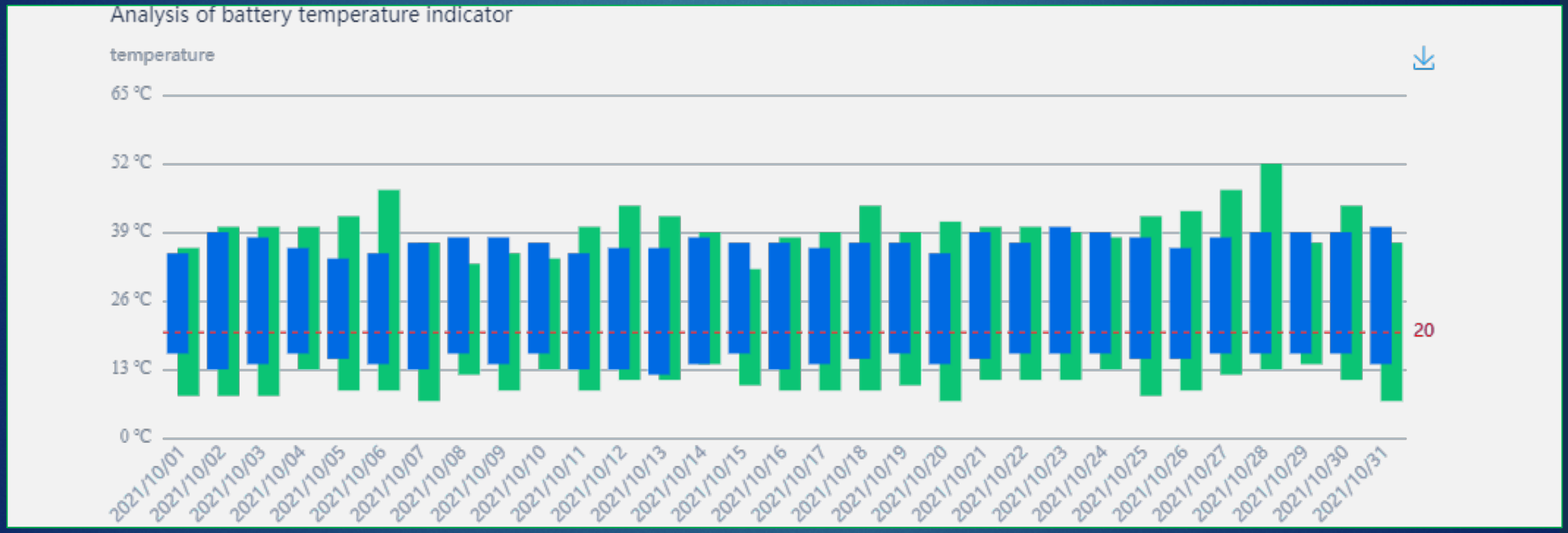
Yutong's telematic system is available online and via an APP which provides instant access to vehicle location, operating data, maintenance data and battery information

Operational Data

VDI / YUTONG

Battery Data

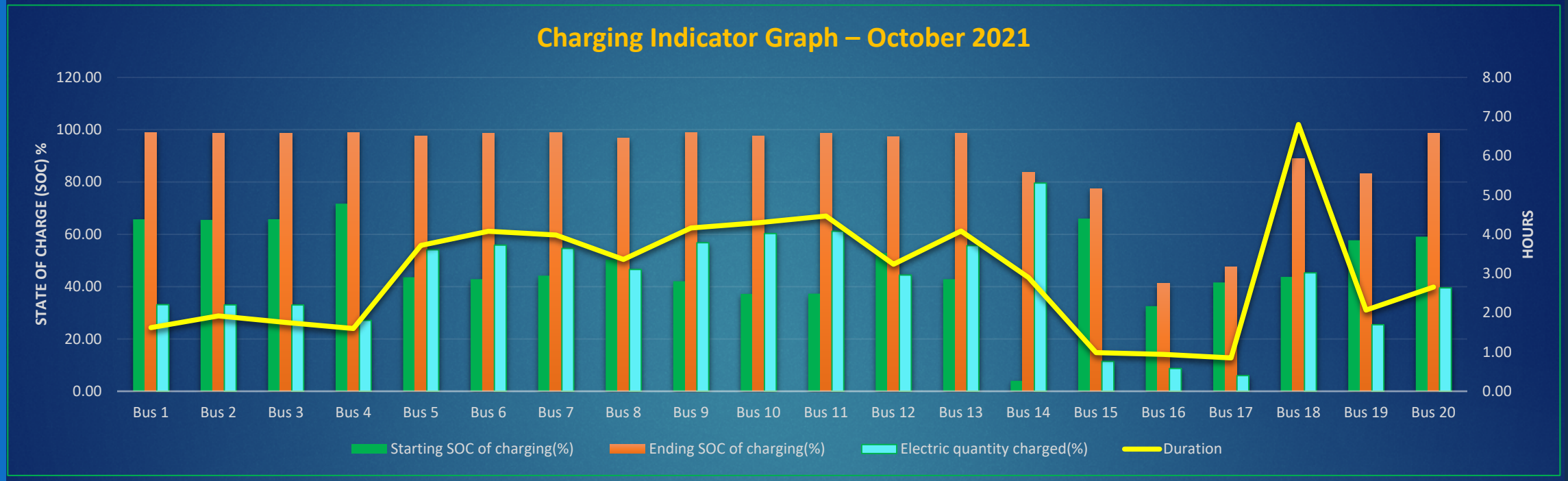
Battery Temperature
Green = Outside temp
Blue = Battery temp



Operational Data

VDI / YUTONG

Charging Data



Comments:

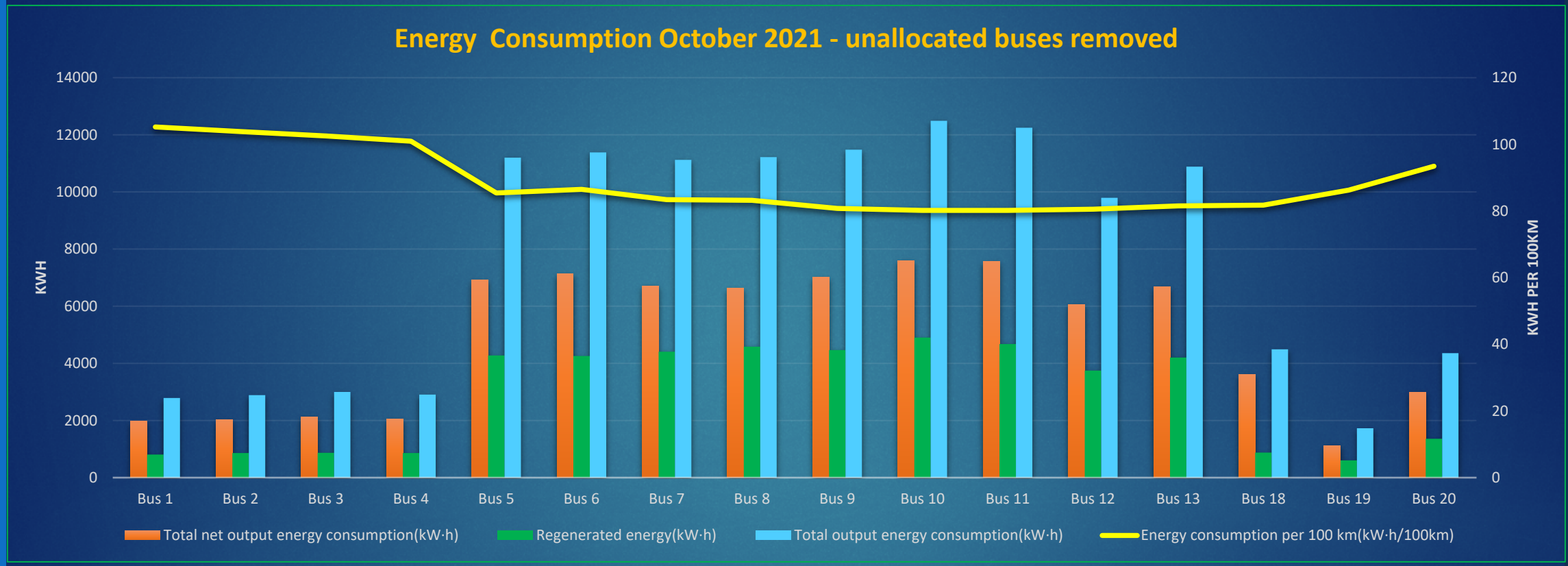
- ✓ Bus 18 is the demonstration bus supplied with 40amp slow charger (for ease of implementation)
- ✓ Charging rates are influenced by the particular infrastructure and charging configurations
- ✓ The above graph includes data from varying battery kWh systems

NOTE – As mentioned earlier, one charge cycle is from 0% to 100%.
However, operational reality thus far indicates that average Starting SOC (October 2021) is 48.35%. That is equivalent to approx. 0.5 charge cycle.

Operational Data

VDI / YUTONG

Energy Consumption



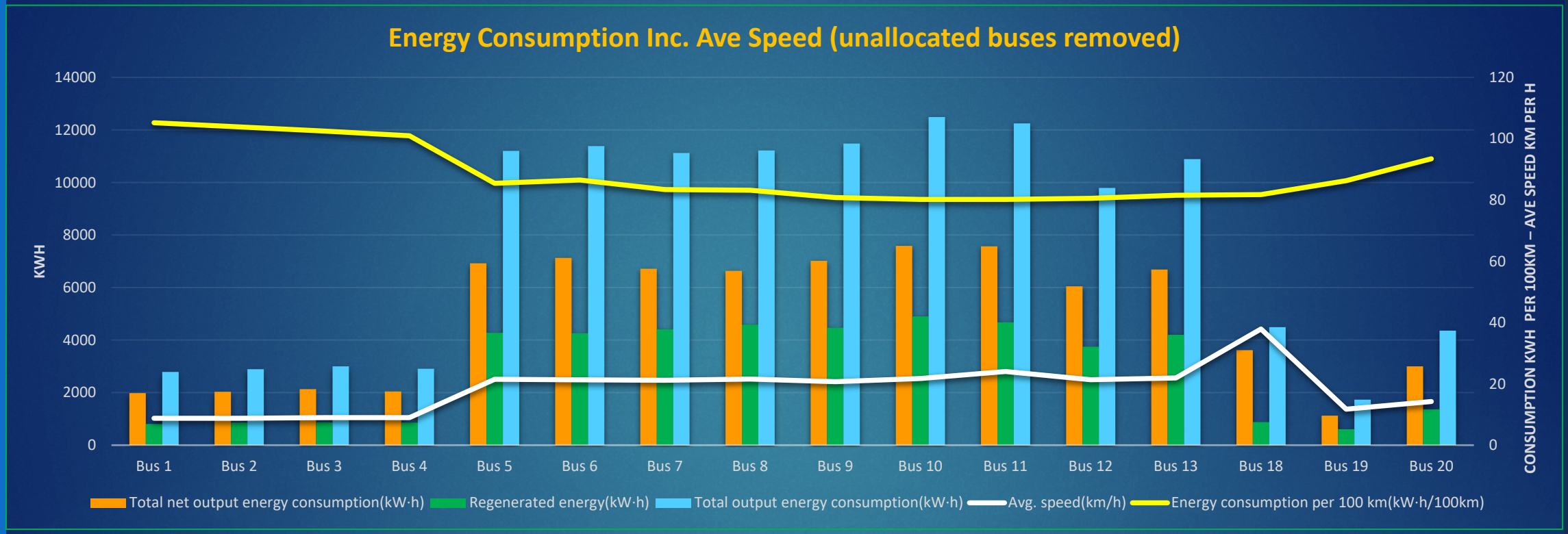
Comments:

- ✓ Non-operational buses removed from calculations
- ✓ Vehicles are conducting a range of shifts including CBD loop services, metro services and charter services.

Operational Data

VDI / YUTONG

Energy consumption and Average Speed



Comments:-

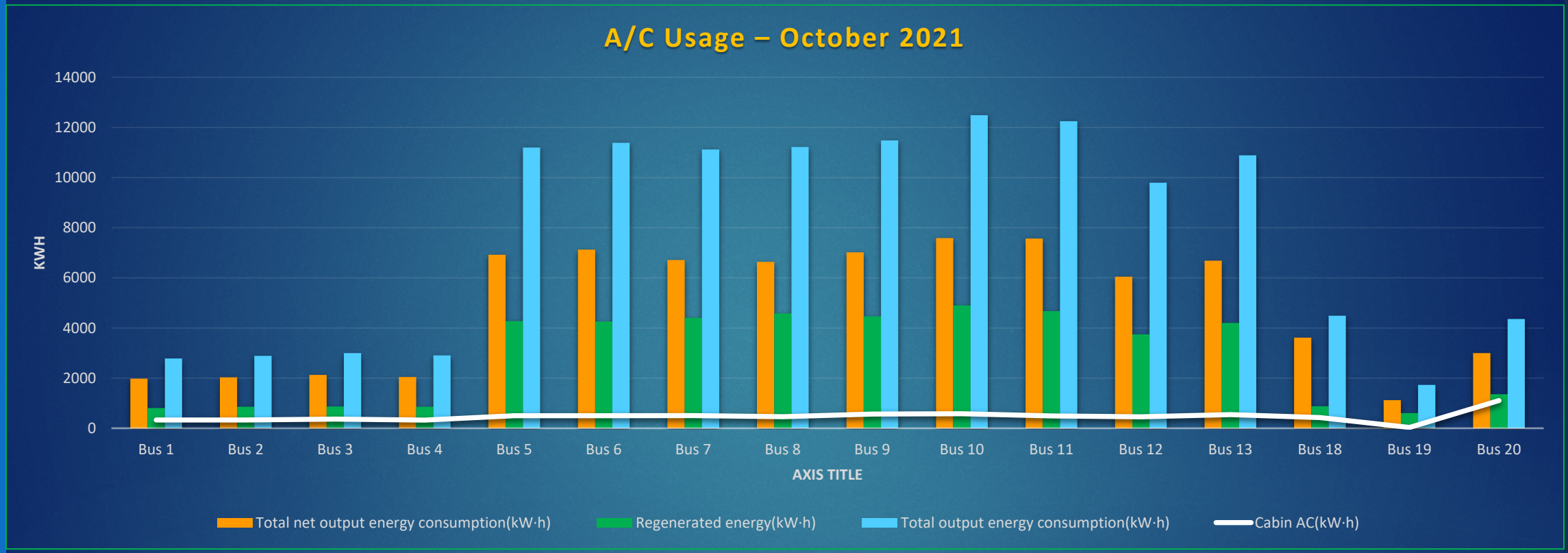
- ✓ Note the impact that average speed has on energy consumption
- ✓ Average speed and driver behaviour are 2 x key factors in energy consumption rates
- ✓ Bus 18 (demo bus) anomaly due to frequent changes and different operating conditions

Note – Demonstration buses are excellent for operator familiarization, however the data does not appear to reflect true operational data due to the nature and frequency of work undertaken.

Operational Data

VDI / YUTONG

A/C Usage Data



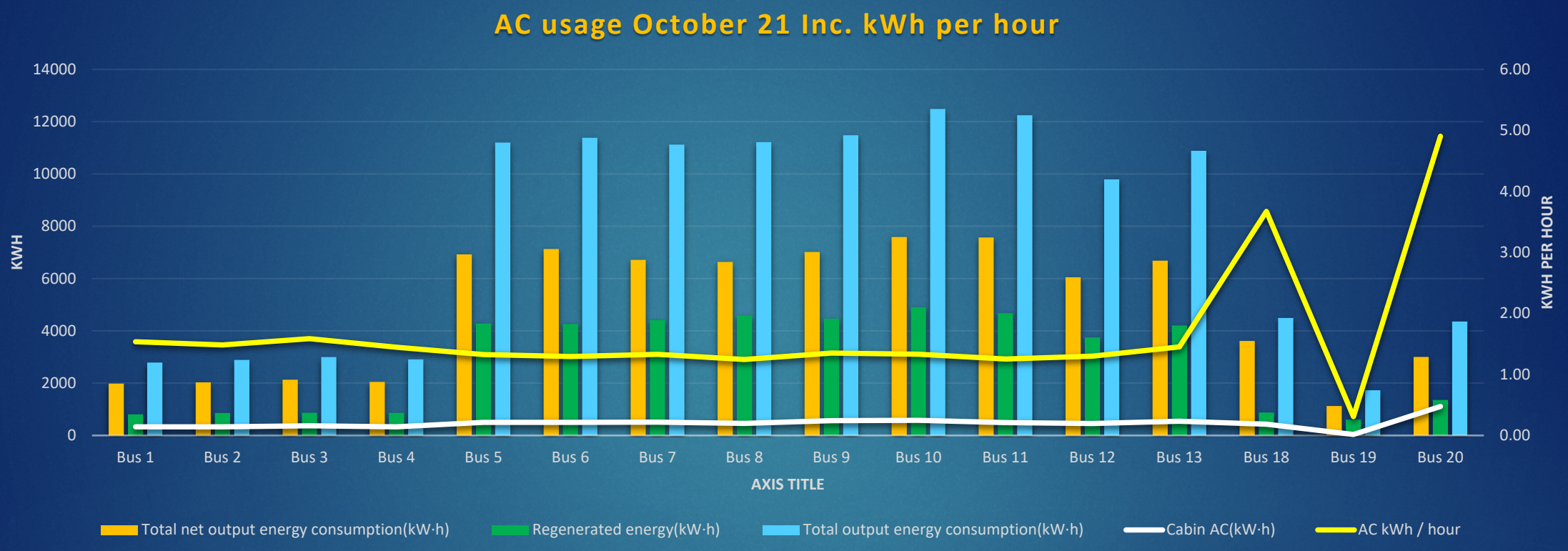
Comments:

- ✓ Non operational buses removed
- ✓ Bus 20 operates full time in the Cairns, North QLD region

Operational Data

VDI / YUTONG

A/C Usage Data



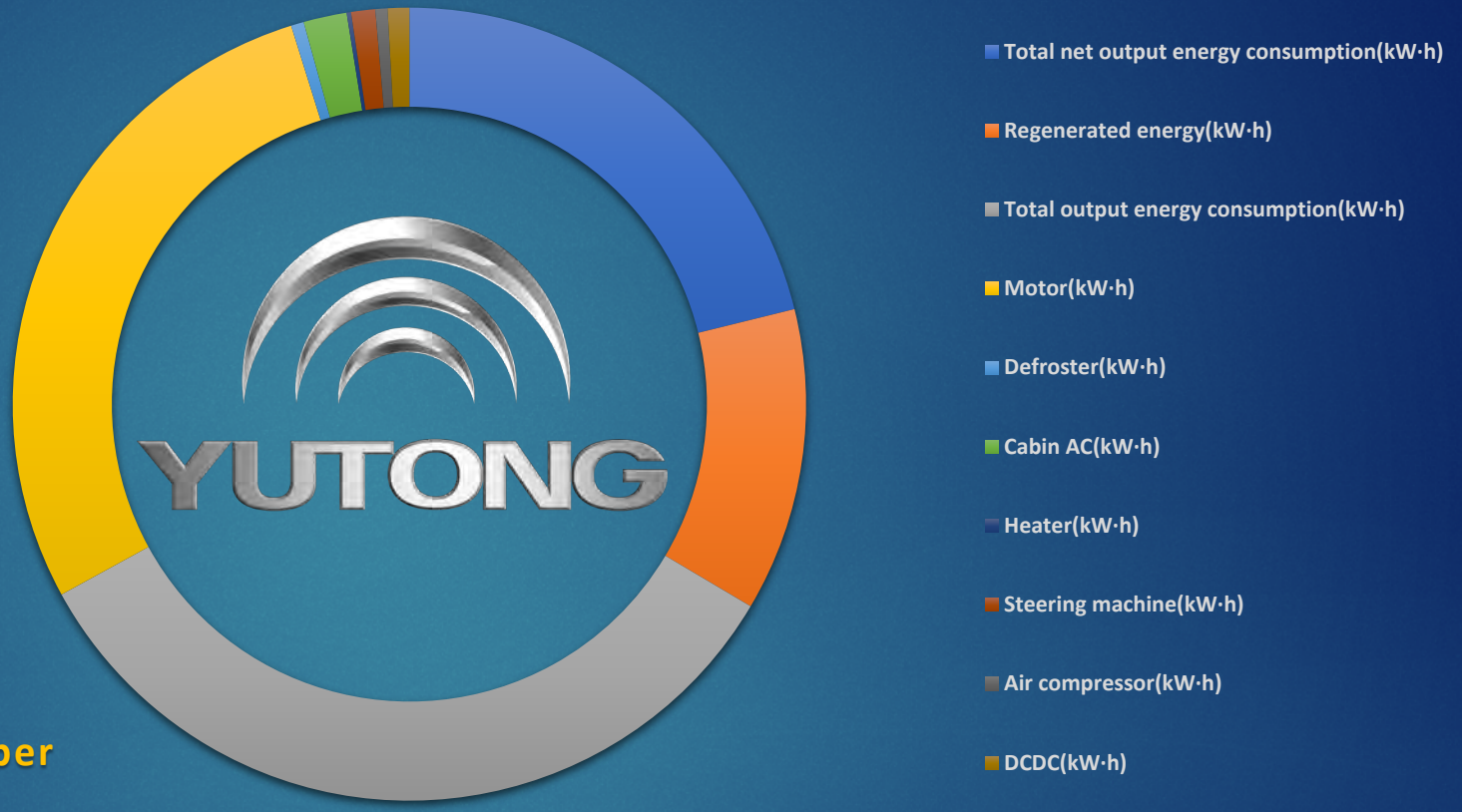
Comments:

- ✓ Bus 20 operates full time in the Cairns, North QLD region
- ✓ Bus 18 was operating in North Qld during October
- ✓ Spikes in Bus 18 and 20 due to type of use

Operational Data

VDI / YUTONG

Energy Usage



Componentry energy usage - October

Comments:

- ✓ From the graph above the motor uses the majority of energy
- ✓ A distant second is the AC

Operational Report

VDI / YUTONG

Bus type
Electric

Period:
20211001-20211031

Distance

92655.6 km Distance amount	**4412.2** km Distance avg.	**142.3** km Distance avg. per day

Consumption

78251.9 kW·h Consumption amount	**3726.3** kW·h Consumption avg.	**84.5** kW·h/100km Consumption avg. per 100km

Working hours

4876.4 Hour Working hours amount	**232.2** Hour Working hours avg.	**7.5** Hour Working hours avg. per day

Operational Report

VDI / YUTONG

Distance

73531.0 km Previous month's distance amount	**92655.6** km Selected month's distance	**26.01%** ↑ Month-on-month
4412.2 km Distance avg.	**142.3** km Distance avg. per day	

Consumption

61439.8 kW·h Previous month's consumption amount	**78251.9** kW·h Selected month's consumption	**27.36%** ↑ Month-on-month
3726.3 kW·h Consumption avg.	**120.2** kW·h Consumption avg. per day	

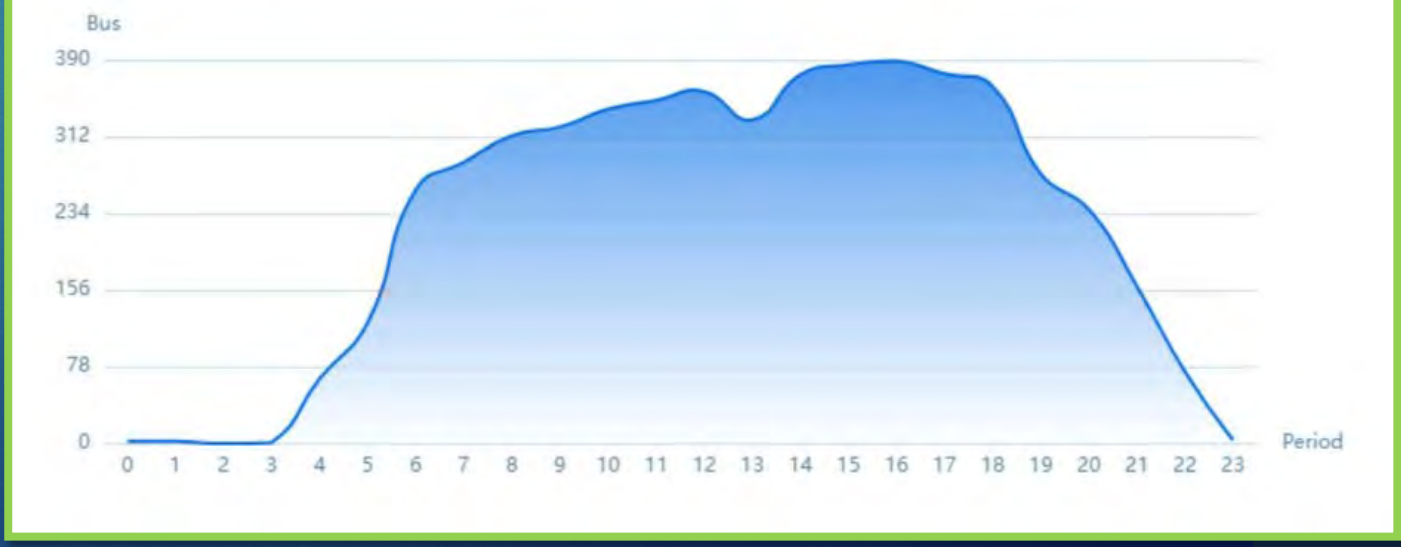
Operational Report

VDI / YUTONG

Working hours

4242.9 Hour Previous month's working hours amount	**4876.4** Hour Selected month's working hours	**14.93%** Month-on-month
232.2 Hour Working hours avg.	**7.5** Hour Working hours avg. per day	

Operational period statistics



Section 3 Challenges

Challenges

VDI / YUTONG

Manufacturing Challenges

Vehicle Safety

- ✓ ZEBs have added safety related issues including high voltage and battery related fire risks

Vehicle range

- ✓ Selecting the most suitable battery manufacturer and type was a key factor

Vehicle efficiency

- ✓ Integrated building processes to enable efficiencies to be created across several areas

Integration

- ✓ Ensuring integration of key componentry, developing products and forming partnerships with major suppliers such as CATL

Vehicle Price

- ✓ One of the major challenges was and is to ensure that the price of the ZEB is competitive to encourage and assist operators and authorities move toward zero emissions

Challenges

VDI / YUTONG

Implementation / Operation

Infrastructure and electricity supply to depots appears to be a major implementation challenge in Australia.

- ✓ The ability of the grid to handle large amount of electricity
- ✓ The age of depots and their ability to handle higher electricity loads
- ✓ Confusion about infrastructure and possible lack of cohesion between the various supply chain suppliers

Uncertainty about the ZEB product in regard to performance, operational range, contractual adherence.

- ✓ Due to the fact ZEBs are relatively new to Australia some have concerns about the ability to perform in Australian conditions

Transition Targets

VDI / YUTONG

TfNSW Transition Targets

I wish to begin this section by commending the NSW Government on the implementation of the Zero Emission Strategy as it establishes a pathway forward to the reduction of Greenhouse gas emissions in our industry.

The transition strategy identifies Key Considerations of which I believe the following to be most significant:

- ✓ Grid upgrades – ensuring that systems are established to manage the power required for the increase in ZEBs is critical
- ✓ Depot upgrades – depot age, depot location, vehicle density, availability of land to build fit for purpose depots are all considerations that must be addressed
- ✓ Hydrogen – availability of vehicles, infrastructure and Green H2 need to be addressed and encouraged

- ✓ For hydrogen to be the preferred choice for many rural and regional operators as stated in the transition plan, transportation issues involving hydrogen need to be considered

- ✓ I believe that H2 is better suited to hydrogen HUBs as mentioned in the strategy

- ✓ Infrastructure, both grid and depot will, in my opinion, determine the speed of transition

Transition Targets

VDI / YUTONG

TfNSW Transition Targets

- ✓ Investigating higher ZEB replacement numbers earlier, for those operators in a position to do so, may ease some of the issues faced by the increase in vehicle procurement numbers predicted from 2023
- ✓ Encouragement and support for Outer Metro and in particular Rural and Regional operators should commence immediately with the implementation of programs to aid introduction of different vehicle types including hydrogen
- ✓ Due to the pace of development in the Zero Emission vehicle industry, bus replacement frequency may need to be investigated to ensure that optimal benefits are gained from industry advances
- ✓ Managing the demand cliff is extremely important as operators need to know that the ZEBs they buy today will be supported in the future

Yutong Do Not consider the market as a test ground.

We consider the test ground as the market.

YUTONG

YUTONG

TRANSPORT
YOU CAN
TRUST