



# Truck & Bus Builder

The International Newsletter of Commercial Vehicle Manufacturing Developments

FEBRUARY - APRIL 2020

News from Busworld North America & American Bus Association Marketplace.  
Articles from Truck & Bus Builder - February to April 2020 issues.

**BIZ: Exhibition**

## Busworld adds North America to global bus and coach exhibition programme together with American Bus Association

**USA / Belgium** - At what proved to be two days of very high level seminars earlier this year by speakers from around the world on various subjects associated with public passenger transport and mobility at ABA's Marketplace 2020 convention in Omaha, Nebraska - organised by **Busworld Academy** of Roeslare, Belgium ([www.busworldacademy.org](http://www.busworldacademy.org)) together with the **American Bus Association** ([www.buses.org](http://www.buses.org)) of Washington, DC - **Busworld** announced it was taking the partnership a major step further in 2021 with the launch of the first **Busworld North America** exhibition. The new exhibition, seminar and meeting place

convention is to take place in Baltimore over three days from 28th to 30th of January 2021. This exhibition is to take place every two years with Busworld Academy operating annually.

Jan Deman, president of Busworld Academy, said: "Our coming to America is part of an ongoing internationalisation of Busworld and our coming to North America is thanks to The American Bus Association." The Busworld Academy in North America has been four in the making and with the decision to go ahead being agreed at Busworld Russia in Moscow two years ago.

This move to develop an international show in North



From left: Charlie Zelle, 2021 Busworld North America Chair; Don DeVivo, ABA Board of Directors Chairman; Peter Pantuso, ABA President & CEO; Vincent Dewaele, Busworld International Business Development Manager; and Jan Deman, Busworld Academy Director.

America on a biennial basis is to actively encourage greater transmission of best practice in public transport and mobility around the world.

The articles that follow here are a record of just some of the high profile deliveries made during the two day session with speakers coming from Europe, North America as well as Asia and India.

## Industry at a crossroad, says Busworld Academy president

**Jan Deman – president, Busworld Academy (Belgium)**

Moving on to providing an overview of the bus and coach industry, Deman said: "As Busworld, we stand at a crossroads, where bus manufacturers, operators, authorities and knowledge institutions meet, and from this point we notice that never before in our industry so many initiatives have been taken to exchange ideas and insights as today. Worldwide, never before has more money been invested in our sector, whether it is in renewal of our fleets, road and charging infrastructure, in digitalization of our marketing and sales tools, in research and deployment projects of all kinds of innovations, and yet, we still do not succeed and fully deliver on our KPIs."

"We still have a long way to go in establishing our share of the sustainable development goals, which are

approved by 193 countries. We still have casualties, as traffic congestion and air pollution is reducing hardly anywhere. Each and every one of us is convinced the shift towards collective passenger transport can be a giant step in reaching these goals, and already today, we have the technical tools to do - you can find them in each and every Busworld Exhibitions all over the world as well as here at the ABA Marketplace."

"The challenge is to convince passengers to choose our services. **Safety** of course but also **Comfort** level and **Affordability** are the main criteria to convince them to do so; and within this comfort aspect, travel time is essential. For these criteria we remain very reliant on the authorities who are designing our playing field.

Worldwide, Busworld is calling for road infrastructure which favours collective transport, dedicated bus lanes and BRT systems are the perfect examples. In cities with good BRT systems we notice the shift from private towards collective transport just by improving commuting time in comparison with private car use. I'm thinking of cities like Bogota, Istanbul, Darussalam and Tanzania with its new BRT system and so on."

"But also, the price of a bus ticket is very often a political decision. Public transport will always remain a public service that finds its return of investment in health, economical and sociological aspects, rather than in commercial financial gain for society. By taking this holistic balance, the 'profits' for society and its authorities can hardly be overestimated. It is a very important task of all stakeholders of our industry, including our passengers to explain this to the people who are deciding our future city and city to city ecosystems."

## Safety remains priority for transport on Europe's roads - says EU commissioner

**Mathew Baldwin – EU Commissioner (UK/Belgium)**

"25,000 people die on roads in the EU every year," stated Mathew Baldwin – EU Commissioner in a pre-recorded video presentation on transport safety at the Busworld Academy, "a number, which we accept but which is patently unacceptable. It's the equivalent of two fully loaded passenger planes crashing each week in the EU with the death of everyone on board. No one would accept that level of death in the air and we should not accept it on our roads today either. Part of the problem is that we continue to talk about these deaths as accidents as if they are things that just happen, when we know what needs to be done to prevent them.

"Astonishingly, even with 25,000 deaths, the EU is the best in the world at road safety and it is somehow top of a grizzly league table of road deaths! I hate to point it out but in terms of deaths per million of

population, the US is more than 20% worse than our worst performing member states of Romania and Bulgaria! But we're not proud of our numbers in the EU where only in road safety does 25,000 deaths put you at the top of the league!"

Over the last 50 years there has, however, been vast improvements in road safety with road accident rates in the EU falling from over 200 per million to below 50 per million in 2018, Baldwin stated. "Going by bus is one of the safest ways of travelling by road in Europe. Collisions involving buses account for less than 1% of all road fatalities in Europe and just 2% of all fatal crashes." However, when a bus or coach crashes there are often multiple fatalities and people with injuries, he pointed out, and that is why bus safety remains as important in Europe as it does in the USA.

## EU's 'Vision Zero' aiming for Zero fatalities on EU roads by 2050

"A key part of the EU's Safe System approach - sometimes referred to as Vision Zero - is about committing to zero fatalities on the roads by 2050 and with an interim target of reducing our numbers by 50% by 2030! It is about developing safety systems to protect against driver error, which include vehicle safety, infrastructure safety, protection equipment, speed management and so on. No one needs to die from mistakes on the road and no one should die!"

How does society go about achieving these safety measures in practical terms and in terms of regulation, Baldwin asked? "Road traffic law remains with member states in the EU in terms of what speed limits to set, how to enforce and what fines to levy. However, vehicle safety standards have been fully harmonised throughout the EU so that a vehicle (cars, buses and trucks) built in Germany is fully compliant with safety standards of the EU and its member states."

*Continued on p4*

**New joint Busworld / ABA Exhibition - Safety remains priority for transport on Europe's roads**

Continued from p3.

Baldwin said that coaches, since 2006, have had to be fitted with safety belts, and passengers are required to wear them. European rules going back to 2009 include provisions for the strength of the bus / coach superstructure, mandatory lane departure warning, advanced emergency braking systems and now coaches need to be fitted with speed limitation devices to prevent them travelling more than 100km an hour or 62mph.

"Whilst individual driving licences are issued by member states," continued Baldwin, "because so many professional drivers routinely cross borders, licensing is now done under a harmonised European model, which sets out common knowledge and testing requirements, and for bus driver licenses a periodical medical check is required. European rules now also require mandatory training not only for obtaining a professional license but also for testing professional competency (CPD) and includes tests on passenger safety, maximum working hours and so

on, at five year intervals for all professional drivers." "Another part of the on-going EU safety system," Baldwin continued, "is a commitment to continuously improve, as the EU must not accept the current high levels of fatalities on its roads. So future actions are to include a review of current driver legislation and the European legislation for blood alcohol levels." He pointed out that not all member states had, for instance, yet set the level at zero blood alcohol for all professional drivers.

New vehicle safety rules set out in the revised general safety legislation coming into effect later this year setting out Direct Vision Standards for both buses and trucks are designed to significantly reduce deadly blind spots for drivers. This regulation should enable the driver to see much more around the vehicle with a view to preventing the many deaths of pedestrians and cyclists. Baldwin said: "Buses will also need to be required to be equipped with a detection device to warn them of vulnerable road users nearby, as well as driver drowsiness or distraction warnings, reversing safety aids and data recorders like the airplane black box. And last, but not least, we are moving forward with ISA, Intelligent

Speed Assistance, which will, on top of the absolute speed limiter of 60 miles an hour, help drivers manage their speed to ensure that they are in line with the local speed limit and other local factors. The time is not long in coming, in my opinion, before we have non-overrideable speed limiters on all vehicles particularly in the coming age of automation but in the meantime ISA means fewer deaths and serious injuries, fuel and tyre savings, less wear on vehicles and roads, lower CO<sub>2</sub> emissions and ultimately, with a non-overrideable ISA on all vehicles things like speed bumps and other expensive and clunky parts of our infrastructure can be removed."

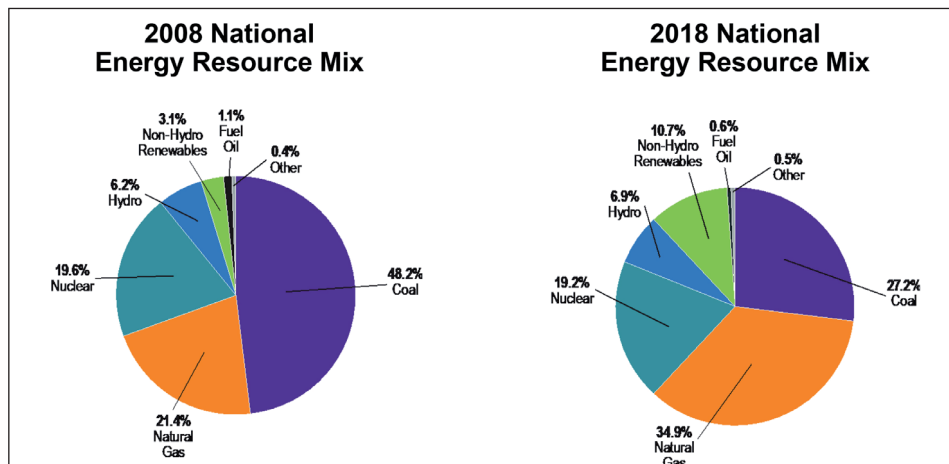
"Last point, this European safety strategy is a floor not a ceiling. In London, for example, for the purchase of new buses by Transport for London, they brought forward rules to require non-overrideable ISA to be fitted to all new buses in 2018 as part of an ambitious overall bus safety standard. Proving just one more part of the Safety System, meaning that we can learn from each other and I hope that London's experience of procurement of new buses will be taken up by others."

**US power generation companies fast transitioning to clean energy, says Edison Electric Institute**

Becky Knox, Edison Electric Institute (USA)

Private investor energy producer companies are leading the way toward reducing carbon emissions and in clean energy transformation, according to Becky Knox of the Edison Electric Institute (EEl), the trade association that represent investor-owned electric companies. Its members, she says, is playing its part to help accelerate electric transportation in the United States.

More than a third of US power generation today is already coming from carbon-free resources, Knox stated - this includes nuclear, hydro-electric and non-hydro-electric renewables (such as solar and wind). The chart below shows this change from a decade ago from a heavily carbon-based energy production to a more carbon emissions-free mix.



Source: EEl The chart shows the change in carbon-based energy production in the USA from 2008 to 2018

Knox said its members are united in their commitment to become as clean as they can as fast as they can, whilst ensuring affordability and reliability for customers remain in the forefront.

Collectively as an industry, it was committed to moving its carbon reduction roles to 50% by 2030 and by 80% by 2050 compared with peak (2005) levels. Knox said at the end of 2018 the industry's carbon dioxide emissions were 27% below 2005 levels: the lowest for over three decades!

Knox said that more than 50% or half of new generation capacity was coming from solar and wind, and electric companies provide 69% of the solar energy in the USA. Knox said EEl members see a great opportunity in promoting electric transportation as the transportation sector is the highest emitting carbon producer. Driving on electricity, produces 54% fewer CO<sub>2</sub> emissions than the average new gasoline car, stated Knox. Its members are investing more than USD1.3bn in customer programmes and projects to deploy charging infrastructure and to accelerate electric transportation. As well as other modes of transport this investment includes transit buses, intercity and school buses.

Knox said that there was still a lot to learn about best practice for adopting and operating electric buses. Subsequently, in December, the EEl issued a guide called: Preparing to plug in your bus fleet - 10 things to consider. This was prepared by the EEl in collaboration with the American Public Power Association, the National Rural Electric Cooperative Association, and the American Public Transportation Association. For information on the study go to [https://www.eei.org/issuesandpolicy/electrictransportation/Documents/PreparingToPlugInYourBusFleet\\_FINAL\\_2019.pdf](https://www.eei.org/issuesandpolicy/electrictransportation/Documents/PreparingToPlugInYourBusFleet_FINAL_2019.pdf).

**Natural gas vehicles remain best solution for transit bus, says NGV America**

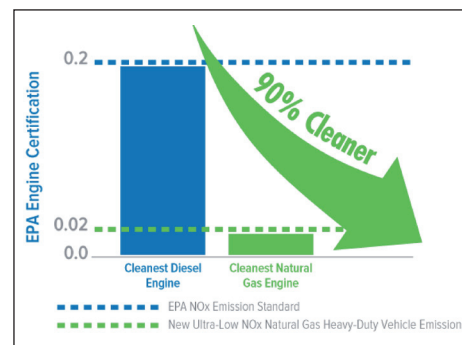
Daniel Gage, president, Natural Gas Vehicles for America (USA)

For heavy duty and medium duty vehicles, natural gas makes a lot of sense, stated Daniel Gage, president, Natural Gas Vehicles for America in his compelling presentation at the Busworld Academy at the ABA Marketplace 2020 event earlier this year.

Natural gas vehicles are proven, tested and commercially deployed. "Natural gas is the number 1, real world alternative fuel workhorse for every passenger transport application," stated Gage. He said natural gas powered vehicles were represented strongly in school and transit and shuttle bus applications. He backed up this statement with key figures. He said: "The cleanest commercially available heavy-duty commercial vehicle engine is powered by natural gas. The Cummins Westport Ultra-Low

NOx engines (available in 6.7-, 8.9- and 11.9-litres) are all certified by the US Environmental Protection Agency (EPA) and Californian Air Resources Board (CARB) to a 0.02 g/bhp-hr standard, which is 90% cleaner than the EPA's current NOx standard and 90% cleaner than the cleanest commercially available diesel engine.

He also pointed out natural gas engines produce even lower NOx emissions in decreased duty-cycles in urban applications than certified. He cited two studies: one in 2016, the UC Riverside Study at CA Ports, showed NOx emissions of 0.01 g/bhp, which were significantly lower than certified in urban stop and go traffic and some five times lower than for diesel engine buses. The second was more recent,



Source: NGV America Note: Chart shows reduction in NOx emissions of €6 gas engines against €6 diesel engines.

in November 2019 (International Council on Clean Transportation (ICCT), Study of Line Haul Trucking) which showed NOx from a diesel equivalent was seven times higher.

Continued on p.3

**New joint Busworld / ABA Exhibition - Natural gas vehicles remain best solution for transit bus**

Continued from p2.

Gage said natural gas powered transit bus, rapid transit and commuter buses in the USA accounted for around a third of buses in this sector. Statistics according to APTA shows this trend – see table.

USA – NG-powered transit, BRT and commuter buses as a % of total buses				
Segment	Urban bus parc	Built in 2018	Ordered in 2019	Potential 2020
NG buses	10,724	778	689	578
All buses total	38,778	2,104	2,500	2,122
NG %	28%	37%	28%	27%

Source: NGVAMERICA

Gage stated that once a transit authority has invested in natural gas buses in mass they tend to reinvest in natural gas. Examples are Washington Metro, the LA Metro system and San Antonio all made significant investments recently.

Use of renewable natural gas (RNG) ie biomethane from landfill, waste-water, food recycling or agricultural digesters (dairy waste), which is either carbon neutral or carbon negative, dependent on the product. Gage said about 32% of all natural gas was renewable. "We think for 2019, the number will be close to 50%!"

**Stricter new Federal Heavy-Duty Emissions are coming**

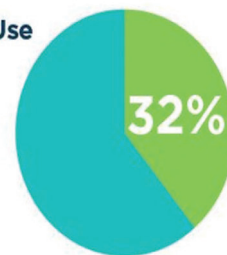
Gage said the EPA announced in January it was about to embark on a Cleaner Trucks Initiative that will take effect in 2027 to reduce NOx from 0.2g/bhp-hr to something close to 0.02. It is not likely now to be that strict, but it is set to take effect in 2027.

Natural gas currently meets that standard already,

**2018 NGV Fuel Use**

In 2018, **32%** of all on-road fuel used in natural gas vehicles was RNG

- Total NGV Fuel Use 645 Million GGE
- RNG Component 204 Million GGE



Source: NGVamerica Note: Pie chart shows percentage of gas fuel is renewable natural gas (RNG)

said Gage and there will be (tax) credits for early compliance. He said the EPA was also looking to overall testing protocols to ensure compliance during real world operations.

**Hydrogen has some key advantages says CTE**

**Erik Bigelow, Center for Transportation and the Environment (USA)**

While hydrogen still has less of a market share than many other alternative fuels, it has some compelling advantages as a fuel: It offers zero emissions, especially for heavy-duty vehicles that require fast fill times and a lot of on board energy storage, stated Erik Bigelow, Center for Transportation and the Environment (CTE) of St Paul, Minnesota, USA.

Other advantages are that hydrogen gas is already an industrial gas commodity in the industrial world mainly for ammonia production, but it is also a very important industrial pre-cursor, stated Bigelow. Suppliers of liquid hydrogen already meet all the necessary regulations associated with supply, distribution and storage. Bigelow explained that hydrogen is delivered just like any other liquid fuel to any significant consumer. It is cryogenic so it does require special handling, but delivery occurs every day in significant volumes, and so is very much a conventional industrial gas, stated Bigelow.

CTE says it has been involved in hydrogen transport projects for over a decade. Traditionally fuel station capacity has been small with the liquid hydrogen tanks built above ground. He gave two examples involving CTE; one in Monterrey put in place ten years ago for 12 buses, which at the time was the largest deployment in the USA, and which is being expanded to 30+ buses; and then one in Orange County with a similar footprint capable of supporting 50, 40' and 60' buses. In future, it is more likely the liquid hydrogen tanks will be underground with the fuel pumps above.

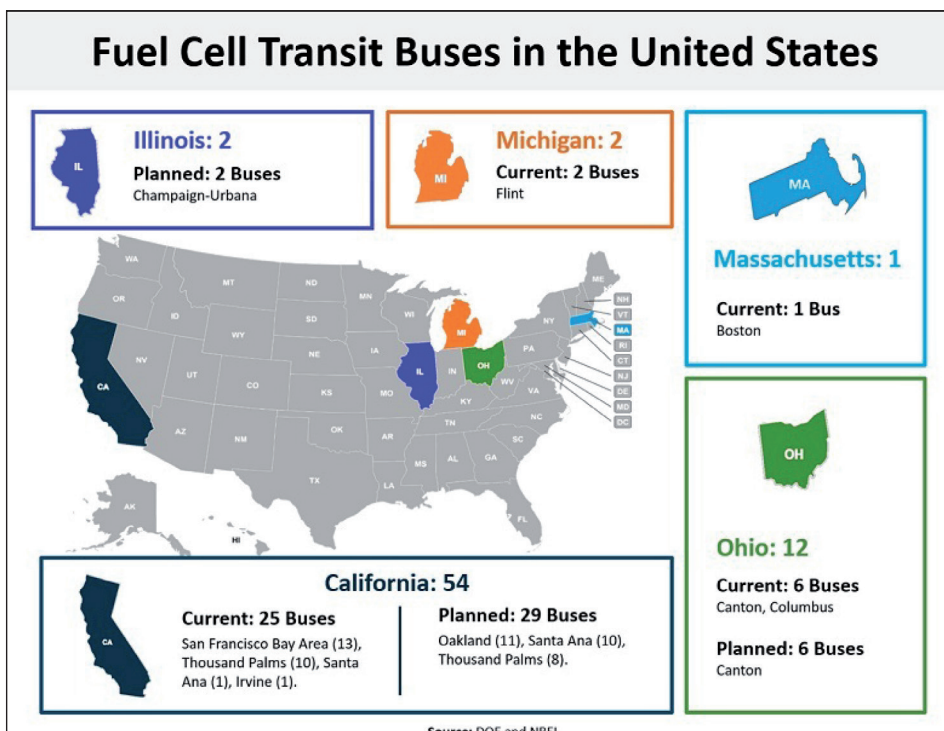
**CTE consortium planning to buy 100 fuel cell buses**

Bigelow said there were some 40 hydrogen-fuelled buses operating in the USA currently with this number rising to 70 by the end of the year. He said there wasn't the same number on the road as battery electric buses, but they were coming. He said, CTE was looking to put a consortium together to enable the purchase of 100 hydrogen buses to get the cost closer to parity with battery electric transit buses.

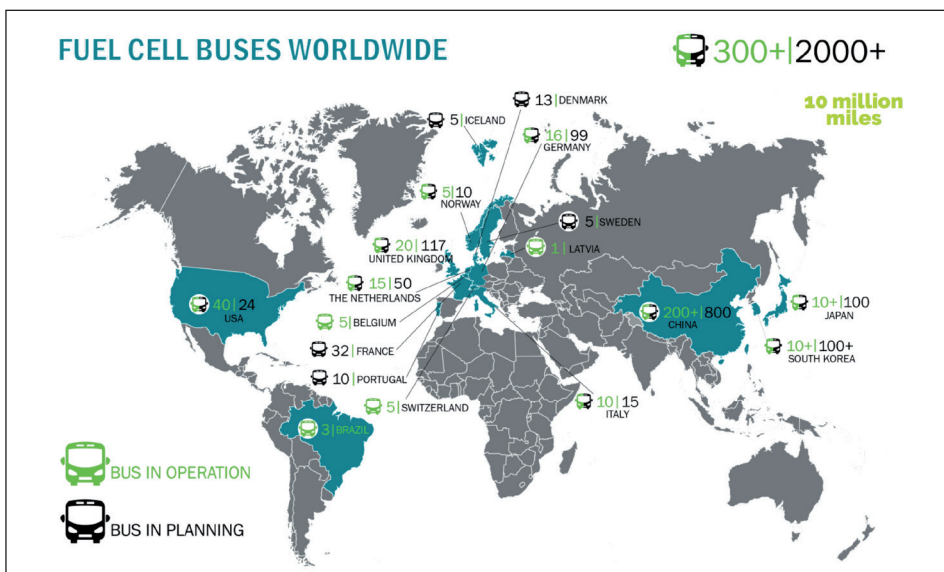
**Global sales of HFC buses set to climb rapidly**

Globally the market is much larger with the market being driven out in Asia. The map below shows HFC buses operating globally at 300+ but this year the numbers are expected to rise fivefold to some 2,000 units.

\*CTE, a USD500m+ engineering and planning agency focussing on zero-emission projects (with 86 projects nationwide), has been involved in numerous hydrogen projects from prototyping to commercial trials with 40 and 60ft transit buses and Class 6 and 8 trucks.



Source: CTE Note: This map shows geographic distribution of current and planned number of HFC buses in the USA.



Source: CTE Note: This map shows geographic distribution of current and planned number of HFC buses globally in 2019 and 2020.

Continued on p4.

# Van Hool – Ready for series hydrogen fuel cell bus series production

Jeff Madura – Van Hool, Director of Public Sector Sales, North America (USA)

“The buzz word right now is zero emissions, and whenever someone talks about zero missions, we go straight to battery electric, but that is not the only option,” were some of the opening remarks made by Jeff Madura – Director of Public Sector Sales, North America in a presentation on Van Hool’s role on new technologies. On solutions for zero-emission, Madura stated Van Hool is technology neutral, and that all options are being developed at Van Hool including trolleybus (rubber tyre with overhead lines), battery-electric (buses run on batteries, which are charged using slow or fast charge systems) and fuel cell buses (hydrogen is used to generate electrical energy to charge batteries to drive the vehicle electrically).

## 131 Van Hool HFC buses on the road

Van Hool to date has sold 131 fuel cell buses across the globe, which include sales in the USA, which was in fact where Van Hool delivered its first fuel cell bus

in 2005. The table below shows the evolution of Van Hool’s fuel cell bus development programme or road map – the number in red shows the major increase in sales since 2016. Both its two and three-axle single deck buses are in their third generation.

Madura then went onto explain the reason for Van Hool’s investment in hydrogen as a fuel for transit buses and other applications.

## Hydrogen has the most potential to become disruptive!

“It’s all about physics,” said Madura. “As this slide shows Hydrogen has the most potential to become disruptive!”

“What does that mean? ..... It’s about physics and usable energy. Battery electric uses about 250 kilowatts per hour (250kWh), whereas a hydrogen fuel cell electric bus has 600kWh, so it’s a more powerful fuel. In terms of time to charge, a battery bus will take a minimum of an hour to charge, whereas a hydrogen

tank can be filled in about seven minutes, making it eight and a half times faster.”

“Therefore, we feel, given the current operator habits of the US operators of putting liquid fuel into a tank, this is what is going to drive the success of hydrogen. With a battery electric bus this is a new technology for most operators, requiring a complete change of operation from driver training and infrastructure to operation and maintenance. Whereas with hydrogen re-fuelling, it uses a nozzle to refill the fuel in just a few minutes like diesel or gasoline. Plus, the driving habits are also similar.”

## Ready for large scale production

As you have seen, hydrogen fuel cell buses at Van Hool are not new. This is not just a one off.... “Van Hool has prepared, we have built these vehicles and we have delivered them on a production level basis. These buses are not delivered as a one-off because we have manuals, service documents and training packages. So, if you are going to divert your fleet we are prepared!”

Madura said Van Hool last year at UITP in Stockholm announced an order for 35 HFC buses for Cologne in Germany and this vehicle was now being built as a standardised series bus at its plant in Belgium, where its production capacity for fuel cell buses is 2.5 units a week.

Two low floor city 12m models are offered in series production, said Madura: For urban flat locations it offers a powertrain of 24kWh traction batteries and 85kW hydrogen fuel stack and 36 kWh batteries and 85kW hydrogen fuel stack.

## Van Hool – Hydrogen Fuel Cell bus strategy

Operating range is the key determinant of when to opt for a hydrogen fuel cell bus, suggested Madura. He explained that Van Hool sees 125 miles (200km) a day as the breakover point. “So, if the daily bus operation is over 125 miles, we feel the best solution is to go with a hydrogen fuel cell application. If the operation is less than 125 miles, we feel battery electric is a better solution.”

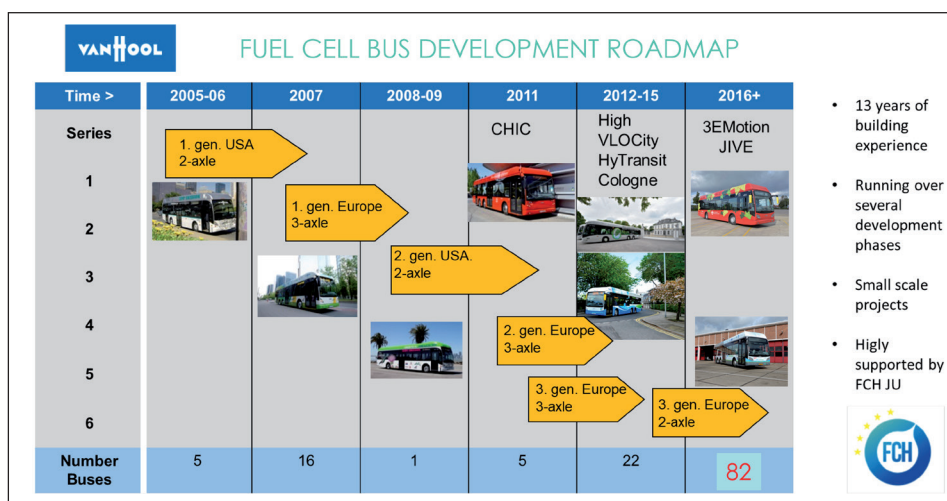
Currently we are seeing battery buses with fuel cells as an extender, to extend the vehicle range. But in the future, we will see more HFC vehicles. Why? Real estate cost and charging infrastructure. A small bus operation of say five buses, the charging infrastructure for electric buses is relatively simple and the depot is probably already set up for it. But more than five, additional electricity is needed to be brought into the facility, which, assuming it is practically possible, adds to cost in terms of charging infrastructure as well as potentially the cost of charging space, which in cities is very costly.

Madura said the key benefit for large fleets of the hydrogen fuel cell buses is refuelling time. Hydrogen fuel cell buses can be charged 8.5 times faster than a battery electric bus, which also means 8.5 fewer charging ‘stations/pumps’ could be required.

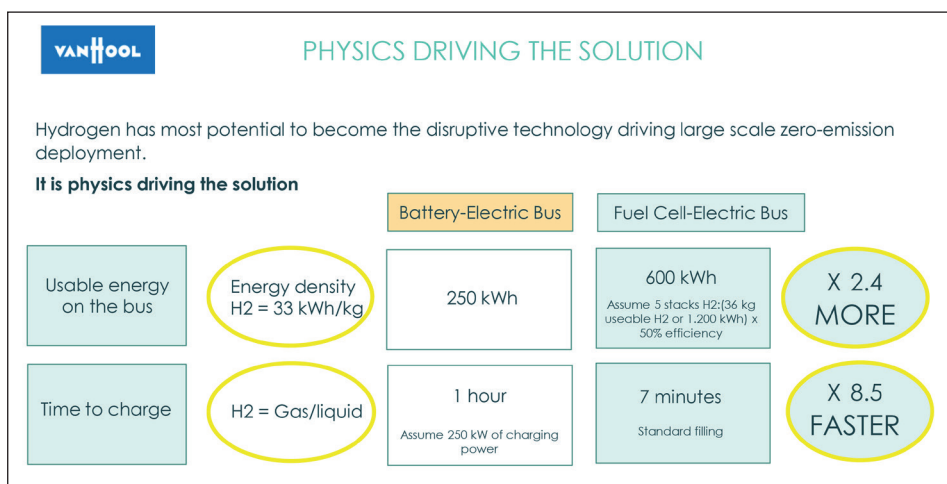
## Background to Van Hool

Van Hool NV – Van Hool NV of Koningshooft, Belgium is a 100+ year old family-owned and managed commercial builder with experience of building electric buses for 70 years. It

- exports 90% of its products worldwide.
- 4,900 employees in two production facilities (Belgium and Macedonia) with a third under construction in Morristown, Tennessee.
- 1,200 output of buses and coaches annually
- 4,000 Industrial vehicles (trailers) annually.



Source: Van Hool. Note: This image shows the hydrogen fuel cell road map at Van Hool



Source: Van Hool. Note: This image shows the disruptive potential of hydrogen fuel cell deployment

# Navistar targets electric school bus market

Gary Horvat, Navistar, Vice President eMobility

“At Navistar we are power agnostic, we offer diesel (Cummins), gasoline (PSI), gas (PSI) and in the near future, electric powered vehicles,” stated Gary Horvat, Navistar, Vice President eMobility.

The main cost driver for electric vehicles is battery cost, stated Horvat. Horvat presented a graph relating to battery technology, showing that as the volume of electric vehicles increases the battery cost continues to

decrease. The demand for electric vehicles was initiated by early adopters who wanted a zero emission vehicle which produces less noise and pollution than diesel alternatives, he said. Future sales of electric vehicles will drastically increase when the total cost of ownership reaches parity with diesel vehicles, attracting new customers to purchase.

“So now,” he said, “battery costs are becoming

competitive, and therefore the total cost of ownership now makes sense; ten years ago, it didn’t because the battery cost was so high. The battery cost is continuing to drop as the market for electric vehicles and fleets rise,” he added.

## Market opportunities

Looking at market for electric commercial vehicles, he said, the market for transit buses in North America was about 5000 units a year, school bus is around 35,000, medium duty truck 100,000 and 200,000 for Class 8 heavy truck. So, the opportunities for electrification are really the three latter markets, he said. *Continued on p5.*

**New joint Busworld / ABA Exhibition - Navistar targets electric school bus market**  
Continued from p4.

Navistar sees school bus as a good fit for electrification for the following reasons:

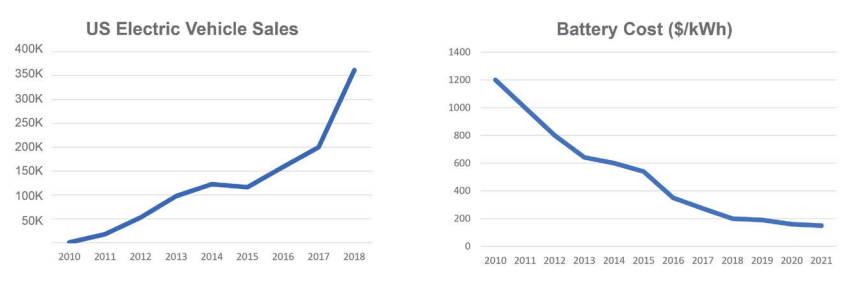
- Low average daily mileage: 60 to 70 miles a day
- Known, fixed route and return to base each day
- Possibility to charge during the middle of the day
- Start & Stop operation (helps with regenerative braking and to improve fuel economy)
- High availability of grant funding (including money from VW litigation)

Horvat said battery-electric fits school bus routes of 150 miles or less. In 2018 it did a customer road show with its chargE electric school bus, and it found customers falling into three categories: *Early Adopters*, which are those that truly want to be green and are interested in the latest technology; *Volunteered Owner*, they have been forced to take on the new technology due to funding or school board dictates and then, *Laggards*, those that will adopt when they ultimately must.

**Navistar's electrification strategy**

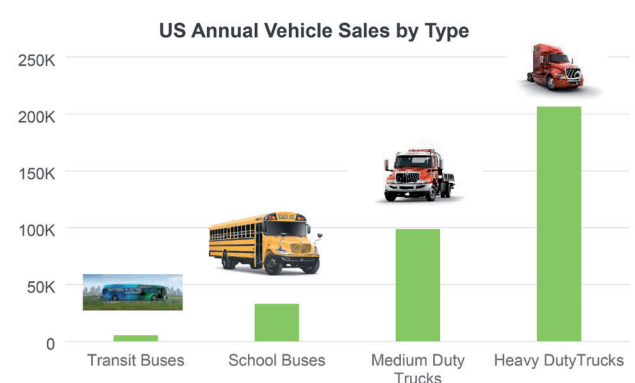
This research, said Horvat, was important and is important to best understand the speed of roll out of the electric school bus. Its strategy for roll out is based on a four point strategy. Consulting: This includes route analysis and simulation, grant funding available and battery options (the battery size needs to be optimised for the application); Constructing: Our production process is designed to be able to build to scale, when volumes increase – Horvat said, IC Bus builds 75 conventional school buses a day; Charging: Recommend and assist in determining charging hardware infrastructure, and Connecting: Once in service, Navistar can connect to vehicles with its telematics system to monitor vehicle and battery during operations and relay this information to the operator via its dealer network.

**ELECTRIC VEHICLE ECONOMICS CONTINUE TO IMPROVE**



As Electric Vehicle Volume increases, Battery Costs continue to Decrease

**Market for Electric Commercial Vehicles**

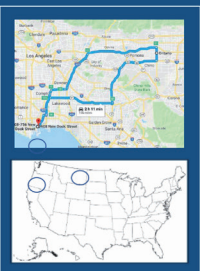


Electric Vehicle Adoption is already happening with US Transit Buses, but the larger market for electrification is with other Commercial Vehicles

**NAVISTAR'S APPROACH TO ELECTRIFICATION IMPLEMENTATION 4C'S**

Work with Customer Through Entire EV Procurement and Implementation

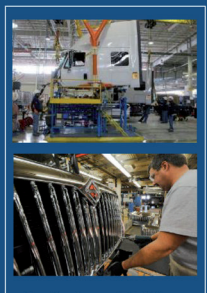
**CONSULTING**



Route Simulation to determine EV requirements and efficiencies

Share EV Funding Opportunities

**CONSTRUCTING**



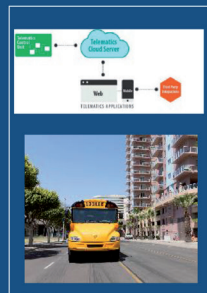
Configuring and Building Trucks and Buses in Navistar Facilities

**CHARGING**



Provide Requirements of charger, infrastructure and assist in charger installation

**CONNECTING**



Monitor and communicate EV vehicle performance with telematics and assist through dealer network

**DATES FOR THE DIARY 2020 / 2021**

**INDIA**  
**August 27 to 29: Busworld India 2020**  
Venue: Bangaluru International Expo Centre  
Organiser: Messe Frankfurt Trade Fairs India  
Contact: Sagar Nanal  
E: sagar.nanal@india.messefrankfurt.com  
W: <http://india.busworld.org>

**RUSSIA**  
**October 26 to 28: Busworld Russia 2020**  
Venue: Crocus Expo venue, Moscow  
Organiser: ITEMF Expo, a member of Messe Frankfurt and ITE Group  
W: <http://www.busworldrussia.org>

**USA**  
**January 28 to 30: Busworld North America 2021**  
Venue: Baltimore Expo Centre  
Organiser: ABA & Busworld International  
Contact: Melanie Hinton, Director of Communications & Media Relations, ABA  
E: mhinton@buses.org  
W: [www.busworldnorthamerica.org](http://www.busworldnorthamerica.org)

**MCI spearheading alternative drive technologies in North American coach**

JP Pelletier, VP Engineering MCI NFI Group - Coach Business

This year, coach building specialist, MCI\* of Des Plaines, Illinois is offering 100% battery electric versions of its best-selling coach models for tour, charter and employee shuttle application, the 35ft, J3500 model and the 45ft, J4500 coach model, according to JP Pelletier, VP Engineering MCI NFI Group - Coach Business, announcing this during a presentation at the Busworld Academy North America held during the ABA Marketplace 2020 in Omaha earlier this year.

Pelletier said: "There will be a handful of limited

production electric vehicles available this year moving into full production in 2021."

"Our legacy MCI D Series coach will continue to be available in CNG, ..... which we consider to be a low or close to zero emission solution that is much better than diesel and we can continue to see transit agencies invest in this technology."

"Another model is our new D Series next generation solution with low entry vestibule with ramp for people with mobility devices (D45 CRT LE, a 45ft model). This is also going 100% electric," announced Pelletier.

"We have one unit going from California to Texas and then it will be going for Altoona testing very shortly."

**MCI focuses on new models including BEV range**

"The last couple of years we have been investing in our product line. So the J 4500 went into production in 2019; our new generation D series, which we unveiled at the last APTA show and is now in production, we're offering the Tour version of that model later this year and the high floor commuter version next year. We've been very focused on battery electric; first we did our J model and then our D45 CRT LE coach. We have two (D45) units now operating in testing and we will be building production units in 2020."

Continued on p6.

**New joint Busworld / ABA Exhibition - MCI spearheading alternative drive technologies in North American coach**

Continued from p5.

“For the coach market we see the need for another solution meaning range extender. If you’re operating a motor coach, you’re away from home quite often and sometimes months at a time - you won’t have a charging station to park at every night and so you will need some on-board generation to charge the batteries. This could be a hydrogen fuel cell or an internal combustion engine – these are the solutions we are looking at for the very near future.”

**California initial target market for MCI's electric coaches**

“Turning to the market, MCI sees California as a leader to move away from diesel, they have already put in legislation to do that and we see that as where we will start with electric motor coaches. We do see some applications for electric coach in other areas of the country but primarily we will see this come into California. (See reasons for this strategy in table below). On the transit business side they are in full production there with battery electric buses and are delivering on a daily basis for a number of authorities nationwide. So its happening on the transit side and we see it happening in coach but we will need other solutions to bridge the gap, where the batteries can be the equivalent to on a tank of diesel fuel and get the 1,000 mile range.”


“MCI (Motor Coach Industries) is a coach building specialist and North America’s largest coach manufacturer based in Des Plaines, Illinois. It is part of the NFI Group, which produces a range of mobility solutions ranging from low floor cutaways, medium-duty transit and shuttle buses and specialty trucks to heavy-duty transit buses 4260 foot in length, charter and premier coaches.

JP Pelletier, VP Engineering MCI NFI Group - Coach Business said: “Our focus at New Flyer and at MCI is propulsion agnostic, providing a variety of solutions in diesel, diesel-electric, CNG, and now zero emission

**Significant Product Advancements**


**J3500 (2019 New)**

- Available NOW
- Commonality with J4500
- Best in class interior space, luggage and payload.




**Next Generation D-Series (2019-21)**

- D45 CRT LE available NOW
- Groundbreaking patented new Low Entry Vestibule.
- D4520 in 2020
- D45 CRT in 2021



**Charge Electric (2020-2021)**


- J4500e – Customer demo and 2020 production
- D45CRTe LE – Customer demo and Altoona testing for 202



leadership in ADAS (Advanced Driver Assistance Systems)


100% Electric CHARGE Drivetrain (2020).

Integrated with MCI Connect Telematics = Max Uptime and Low TCO



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**MCI focussing on California as key market for initial electric motor coach sales**

The California Air Resources Board (CARB) regulation in the United States has set a state-wide goal for public transit agencies to gradually transition to 100 percent zero-emission bus fleets by 2040.

As long-time partners for clean air in California, the state’s 200 public transit agencies play a pivotal role in transitioning vehicle fleets away from fossil fuel-powered technologies to zero-emission alternatives. Eight of the ten largest transit agencies in the state are already operating zero-emission buses, including battery electric and hydrogen fuel cell vehicles.

Deployment of zero-emission buses is expected to accelerate rapidly in the coming years –from 153 buses today to 1,000 by 2020.

Altogether, public transit agencies operate about 12,000 buses state-wide.

battery electric buses and coaches. We’re also a leader in battery-electric infrastructure following the formation of the New Flyer Infrastructure Solutions Business team based in the Vehicle Innovation Centre in Anniston,

Alabama. So it’s not just a product but it’s the solution for the infrastructure to be able to use those products. There is a big focus on Telematics and Connected Vehicles as well as Advanced Driver Assistance Systems (ADAS).”

**BIZ: Product TECH: Electric Drive – BEV MKT: Export**

**Temsa USA targets green states in the USA with launch of TS45E electric coach**

Turkey / USA - TEMSA North America Inc of Orlando, USA (a subsidiary of Temsa Ulasim Araçları AS of Istanbul, Turkey) in January at the UMA Motorcoach EXPO 2020, held in Nashville, Tennessee, launched its first ever full size three-axle electric coach, the TS45E.

The TS45E uses the same integral coach structure as used for the TS45 diesel powered version – ie it is 45ft long, 102inches wide, 138 inches high, has a maximum capacity for 46+1 including a toilet. The drivetrain consists of a TM4 permanent magnet motor, which offers an output of up to 350kW and 3500Nm of torque at just 200 rev/min and 528kWh Li-ion NMC batteries. Charging is by CCS Type 2 charging unit offering either a six hour charge at 90kW or four hours at 150kW.

Burçin Erdem, brand manager for the Temsa Group indicated the new electric coach was the product of over seven years of development. Temsa, Erdem explained, started with the Canadian electric motor and systems supply company, TM4, back in 2013, before Dana was not its majority owner and partner. “We built strong relations with TM4. We integrated the motor directly into our existing axle without any transmission. We used battery cells from the Envision Group (a subsidiary of Envision AESE of Shanghai, China - the current supplier of batteries to Nissan Leaf). We built our own battery pack and our own Battery Management System (BMS). In this way, we can be very flexible for changing battery cells to another supplier, if needed, and the cost is much lower than supplying a pack from a battery pack maker. We believe this is our advantage among our competitors. We can also supply the energy pack to other customers as long as it fits their purpose,” he added.

For electric charging, Erdem said: “We currently work with Eko Energytka from Poland for charging stations {in Europe for its city bus (Avenue) and electric midi-coach, MD9}. Efacec from Portugal is also our other supplier. Efacec has service centres in the USA.” Recently, it has been in touch with ABB and plans to work with them also in North America.

Temsa said the TS45E is to go on demonstration runs in the states of California and Florida, once some FMVSS tests are completed.

T&BB asked why launch its first full size electric coach in the United States, and Erdem replied: “Coaches are used for different purposes in each country. In Europe, a coach sometimes can run 24 hours a day in order to get the most out of the investment. However, in the USA a coach can be used as a shuttle service, which means it has time for charging during the night. A coach can also be used for moving tourists to an attraction where it picks them up after a long wait in the park. Basically, utilization of a coach tends to be lower in the USA, which gives the vehicle an opportunity for charging.”

“Electric coaches will be widely used in university campuses, shuttles for malls or attraction points or to providing an airport service to nearby cities,” Erdem continued. “There will be a market about 800 vehicles starting from the year 2022 for these vehicles.”

Currently, like the other TS45s, the electric coach is built in Adana, Turkey. Whilst there are incentives in the USA for domestic manufacturers for publicly funded routes, based on the above comments there is a reasonable opportunity for Temsa with TS45E in the private coach hire market.

For electric charging, Erdem said: “We currently work with Eko Energytka from Poland for charging

stations {in Europe for its city bus (Avenue) and electric midi-coach, MD9}. Efacec from Portugal is also our other supplier. Efacec has service centres in the USA.” Recently, he said the company has been in touch with ABB and plans to work with them also in North America.”


Erdem stated the next step is demonstrations of the electric coach; it plans to focus on these on routes in the states of California and Florida states after some FMVSS tests have been completed.

**Background to Temsa’s electric vehicle development:**

**TEMSA**

Length (m)	45
Width (m)	102
Height (m)	138
Front Overhang (m)	78.5
Rear Overhang (m)	112
Maximum Seating Capacity	46+1 with restroom
Total Luggage Volume (m <sup>3</sup> )	160
Electric Motor	TM4, 3 Phase x 3, Permanent Magnet Motor
Motor Power	350 kW
Torque	3500 Nm @ 200 rpm
Gradeability	14%
Range	Up to 200 miles
Battery Type	Li-Ion NMC
Total Battery Capacity	528 kWh
Charging System	CCS Type 2
Charging Time	6 Hours with 90kW Charger 4 Hours with 150kW Charger

**TS45E**



Continued on p7.

**Temsa USA targets green states in the USA with launch of TS45E electric coach**

Continued from p.6.

Temsa's electrical vehicle journey started in August 2010, when it was part of a European Funded project called ECOGEM. Details can be found at <https://cordis.europa.eu/project/id/260097>.

With a budget of approximately three million Euros, this project was about estimating the electric consumption of a vehicle on a given route. The range was a critical issue a decade ago because the industry was concerned if the electric vehicle could make it to the target destination. There were a lot of different parameters to account for such as traffic, weather conditions and waiting time for charge stations. "During this research we realized that we needed to produce an electric bus because using electric instead of diesel offers many advantages. Zero emission we saw as the biggest advantage, the diesel bus in city centres contaminate the air constantly. Plus, city buses do not need much range to complete their daily tasks and electric is more efficient than diesel," commented Erdem.

"We searched for companies that could help us design an electric bus. We contacted **Pininfarina, FEV, Bombardier, Siemens** and **BAE Systems**.

The systems they were offering were already being developed and designed for some other brand and did not suit us well. We also wanted to develop the software and vehicle programming ourselves so that we could be flexible to meet our customer's needs."

Eventually, Temsa decided to build its own electric vehicle. "We applied to The Scientific and Technological Research Council of Turkey for funding. The project was to build a 9 metre full-electric city bus. The project started in 2013, resulting in a city bus with electric motors from TM4 and batteries from **Liyuan New Energy China**. The battery capacity was about 160kWh and our range was 120km. It was hard to find the electric vehicle components especially for electric buses in 2013. We retrofitted some air compressors and a steering pump, so it could be used in an electric bus. There were no automotive grade EV part suppliers at that time and so utilised connectors and cables from electric train part suppliers."

The 9m electric city bus project was successfully completed in 2016 with the bus being operated in Gaziantep (a city in southern Turkey) for over a year. The initial sale of this model, MD9 electricITY, was to Sweden.

"From these projects we found that 60% of the cost of an electric bus is the energy management and storage system. So, we decided to produce our own

energy pack. We designed the battery management system, battery case, printed circuit boards. Two years on, we now produce our own Temsa Battery Pack with Lithium Ion Cells from Envision (old name AESC-Nissan). With our own battery pack system, the energy pack cost was reduced by 40%; also, by having the flexibility of adjusting the battery storage capacity, power storage capacity can range from 60kWh, up to 960kWh. When we added our own Temsa energy pack, the capacity of the 9 meter bus improved to 240kWh and the range extended to 230km. We have also reduced the energy consumption by using a 'one pedal drive' system in the bus. One Pedal Drive means driving the bus just by using the throttle pedal and when the throttle pedal is released this starts the battery charging (recuperation) and slows the bus.

In 2016, Temsa started its 12 metre full-electric full low floor bus project (named Avenue Electron) and this was completed in 2019. "There are three different capacity options: 240kWh, 300kWh and 360kWh. We target European Countries such as France, Germany, Romania, Bulgaria, Serbia, Poland, Netherlands, Sweden with this bus. In 2019, we started the American all-electric coach project TS45E. The coach will have a 200 mile range and we plan to target eco-friendly states in North America."

**MKT: Statistics / Forecast**

**Global transit and intercity/coach markets to grow at 3.9% (CAGR) per year says Frost & Sullivan**

**World / USA** - Transit buses, school buses and intercity / tour coach segments are on different trajectories when looking at global bus demand, stated Veerender Kaul, global vice-president commercial mobility at Frost and Sullivan talking at **Busworld Academy North America** about the global and North American bus and coach markets.

Transit bus or city bus sales account for around 56% of world demand and this segment is forecast to grow at a compound annual growth rate of almost 4% per annum from the base year in 2018 to 2025. This growth is to be driven by the expansion of transit networks globally, said Kaul, as well as the introduction of many new modes of mobility, including ride hailing, which, he said, would provide seamless first and last mile transport to the transit transportation system. "We also see the introduction of demand response transport as complimentary to the fixed route transit network, which will add to the demand for fixed transit operations."

The intercity / tour coach segment, which accounts for some 14.3% of total bus sales globally is also forecast to grow at just under 4% (3.9%).

For the school bus market, while there aren't many countries that require purpose-built school buses with higher standards of safety and crash resistance, the countries pre-dominantly specifying bespoke school buses are four large countries, the USA, Canada, India and China, and these represent substantial demand - see table. In Europe, whilst there is demand for school buses but mostly, they do not have a requirement for dedicated school buses, stated Kaul.

The total school bus demand globally is expected to dip in 2020 and 2021, which is largely due to the introduction of BSVI standards in India from April this year, which prompted pre-buying in 2019. As a result, Frost and Sullivan expects the impact on the school bus market to last for a couple of years until the end of 2021 and this will also impact total bus demand globally in the short term. Overall over the forecast period, school bus sales growth will be lower at around 2.0% than the other two market segments.

**Bus sales in Latin America going to grow at fastest rate**

In terms of regional sales, the largest market is by far China followed by India and then North America. Given the dominance of demand in China and India and the softening of the global economy, which is expected to last a couple of years, the overall bus markets are expected to stagnate, before returning to substantial growth in the

outer years of the forecast period, stated Kaul.

The Latin American market is recovering, and the strongest growth is going to come from this region. The other two growth regions are going to be India and China due to rapid urbanisation rates. This trend will drive the expansion of transit bus networks in these regions, stated Kaul, as well as creating demand for transit bus replacement. So, India and China will continue to drive bus demand globally, but Latin America will emerge as the biggest growth market.

Looking at the individual regional markets, China bus sales in 2018 include around 18% school buses with transit and intercity buses accounting for 82%. Unit shipments in 2018 in China totalled 120,300 units, which Frost & Sullivan is forecasting to grow at around 3% CAGR to 147,000 units. However, right now it is experiencing a slow-down in bus demand primarily due to high penetration of electric buses already in operation in the transit bus market and due to the stricter performance requirements for electric-bus subsidy qualifications as well as reductions in subsidy amounts. These factors have caused a slowdown in bus demand in the transit sector as well as intercity coach. With an urbanization rate of 60% and on which is growing at 2.0% per annum, this offers decent long-term potential, said Kaul.

**Europe** is mostly focused on transit (city bus) and intercity and touring coaches. Frost & Sullivan indicated that it did not see strong growth in either segment because Europe is already highly urbanised at around 82% of most countries. So, Kaul suggests there is little scope for expanding the transit networks and it will be predominantly replacement demand. The introduction

of shared mobility modes will help provide transport for the first and last mile and this should help to maintain and possibly expand transit demand. Frost & Sullivan forecasts a CAGR of 0.7% with the market rising from 33,700 units in 2018 to 35,500 units in five years' time.

In **India** about 24% of total bus sales were purpose-designed school buses in 2018. India currently has low rates of urbanisation at around 34%, but this is growing at a rate of 2.4%, which, says Frost & Sullivan, offers strong long term potential. The overall market is expected to experience healthy growth of 3.6% CAGR, driven mainly by fleet expansion, stricter emissions and the need for better fuel economy standards. Frost & Sullivan said the Indian bus market in 2018 was around 64,800 units and this is expected to rise to 82,900 units in 2025.

In **North America** around 80% of bus sales are school buses. With an urbanization rate of 82% and a strong car culture, stated Kaul, North America offers only moderate growth potential for either transit or intercity segments. Growth, he said, however, was expected to be strongest in the electric bus segment. Frost & Sullivan forecast CAGR growth rate of 2.3% from 53,600 units in 2018 to 62,900 in 2025.

In **Latin America**, there is strong recovery in the economies of main countries like Argentina and Brazil, stated Kaul, and this would drive demand for both transit and intercity buses. The markets in Latin America overall are expected to grow strongly at around 8.1% CAGR from some 30,700 units in 2018 to 52,800 units in 2025. Kaul also forecast the school bus market would contribute heavily to this annual growth rate.

**Transit ridership in North America not expected to grow but forecast to become more efficient through use of smart mobility apps**

The North American bus market, which includes the USA and Canada only close bracket (Mexico is

World* - Bus market (in1,000s) by application 2018 to 2025**									
	2018	2019	2020	2021	2022	2023	2024	2025	CAGR
School Buses	90.8	90.1	90.6	94.4	97.7	97.2	98.0	104.0	2.0%
Intercity Buses	43.3	47.8	46.0	46.3	48.1	51.1	54.6	56.5	3.9%
Transit Buses	169.0	182.6	183.5	182.9	189.2	199.0	210.9	221.1	3.9%

Source: Frost & Sullivan Notes: \* Excludes MENA region \*\*Forecast 2019-25

World* - Bus sales (in1,000s) by region 2018 to 2025**									
	2018	2019	2020	2021	2022	2023	2024	2025	CAGR
Europe	33.7	33.5	33.5	32.3	32.7	33.7	34.6	35.5	0.7%
LATAM	30.7	38.1	44.3	47.5	49.4	49.3	50.9	52.8	8.1%
NA	53.6	54.1	53.8	56.5	58.0	59.1	61.6	62.9	2.3%
India	64.8	70.3	62.3	62.2	67.6	71.6	77.2	82.9	3.6%
China	120.3	124.5	126.1	125.1	127.3	133.0	139.2	147.5	3.0%

Source: Frost & Sullivan Notes: \* Excludes MENA region \*\*Forecast 2019-25

Continued on p2

**BIZ: Product**

# Temsa reintroduces TS30 after 2-year absence in the United States

**USA** - At the annual American Bus Association (ABA) marketplace event held in Omaha, Nebraska, USA, last month, **Temsa North America Inc (TNAI)** displayed the TS30 30-foot (31.1ft) integral coach model it is reintroducing to the North American market after an absence of two years.

Deniz Cetin, country manager for Temsa North America Inc, which is a new organisation set up some 18 months ago and based in Orlando, Florida, said the new model has been reintroduced following a major upgrade with details to specifically meet fleet operator requests. For instance, it has increased luggage capacity by some 35%, Cetin indicated. It has the latest low emission rear-mounted diesel driveline featuring the **Cummins B3000 6.7-litre six-**

cylinder 187kW (250hp) engine coupled to the **Eaton** Precision automated manual transmission. Standard safety features include ABS, ASR and ESP with engine compartment fire extinguisher system. It has front kneeling and body lifting system as standard and new front- and rear design with LED headlights and indicator lights front and rear. The step heights are lower to incorporate a fourth step for easier access.

Cetin indicated many of the design features are now shared with its two other coach models for the North American market (TS35 and TS45), largely to improve accessibility for maintenance purposes. For instance, a drop-down front bumper gives direct access to the spare tyre as well as a quick release latch to open the headlight assembly. Likewise, at the rear, the taillight

swings out for easy bulb replacement as well as giving access to the engine compartment.

The TS30 was first sold in the USA in 2012 with sales growing year on year, until 2017 when the vehicle needed an upgrade to meet regulations. Cetin said the market for this product is around 100 units per year in a good year.

The market for intercity and touring coaches is around 2,500 units a year, the majority of which are three-axle 45ft models. Temsa says it has been marketing the TS30 since its unveiling at BusCon in Chicago last September, which has generated strong interest amongst its customers.

Cetin said since the formation of the new sales organization in June 2018, the company has sold some 100 coaches. In mid-2019, Temsa appointed, **Damera Bus Sales Canada Corporation** of Mississauga, Ontario (a subsidiary of the **Mississauga Bus Group of Companies**), as its dealer for Canada. It has since sold 10 units (35ft and 45ft) in Canada - this is the first time the company has sold north of the border.

**MKT: Statistics / Forecast**

*Continued from p1.*

included in Latin America figures at Frost and Sullivan), as previously stated is dominated by the school bus segment. Overall, Frost & Sullivan forecasts a CAGR 2.3% over the next seven years taking the market from 53,550 to 62,900 vehicles. The school bus segment will grow modestly, said Kaul at around 2.3% CAGR to 2025 and tempering the overall demand for buses in North America. It sees strong growth for the smallest intercity segment overall at around 6.1% CAGR.

The suburban lifestyle (55% of population lives in the suburbs) and the dominant car culture in North America remains a major inhibitor of transport use from the private car to shared mobility and mass transit systems. The US ridership of transit buses peaked in 2012 at around 5.3 billion rides annually and is shrank since then. And although the ridership has been markedly reduced the number of transit buses have increased as the government has endeavoured to

North America: School, transit and intercity bus forecast 2018 and 2025*				
Segment	2018	Mkt %	2025	CAGR%
School Bus	44,400	82.9%	51,900	2.3%
Intercity	2,550	4.7%	3,850	6.0%
Transit	6,600	12.3%	7,150	1.3%
<b>Total</b>	<b>53,550</b>	<b>100%</b>	<b>62,900</b>	

*Source: Frost & Sullivan Note: Includes USA & Canada \* Forecast*

expand the availability of transit in the USA. Despite the increasing use of ride hailing, which is a complementary service to transit buses, Frost & Sullivan, does not see an overall increase in ridership of buses during the forecast period. However, there have been several cities where developments have been built around transit transportation systems, and this is where there ridership growth is expected during the outer forecast period.

Application of technology including electric buses, AI, big data, new business models will make transit more efficient and more effective in terms of routes and timings, said Kaul. North America is also seeing the application of transit in multi-modal applications. For example, google and other navigations Apps include transit services in multimodal apps for seamless transportation. "So, combining technology and using big data and AI will help to optimise the US transit transportation network."

## Evolution of electric buses in North America

A major trend in North America is to electric buses, said Kaul. Electric bus adoption, he said was set to increase, particularly in transit application, due to introduction of Phase II GHG regulations, US DoT and CARB grants and incentives for electric buses, and fleet electrification plans of transit agencies. Under

the Transportation Electrification Action Plan, Quebec and Ontario provinces are also providing incentives for purchasing electric buses and charging infrastructure. The introduction of electric buses, which will contribute to cleaner air and the environment, is seen as having a positive impact on ridership and could reverse the downward trend.

Turning to the electric bus market in North America, Kaul said the three market segments of transit, intercity and school buses all have different operational characteristics. It was becoming clear that transit buses of 150-250 miles daily was best suited to battery electric vehicles with FCEVs used for extended bus routes. However, the cost premium over the IC engine remained high at between USD250,000 and USD600,000.

For intercity coach, Kaul said they obviously drive longer distances and are bigger requiring more power. Electric charging facilities would be required along the routes and then recharging time of an electric coach would also become an issue. Intercity coach do not present a strong case for electrification for either battery electric or fuel cells, Kaul said. However, whilst there is a stronger use case argument for hydrogen fuel cells, said Kaul, the cost premium currently over diesel is somewhere between USD400,000 to USD600,000 per vehicle!

The overall economics of the school bus operation, given the limited distance driven (25 to 75 miles a day) albeit in a stop and go type operation, which is good for recharging the battery, it doesn't make sense, stated Kaul, but the key drivers for electric school buses is student health and lower emissions. On this basis BEVs make sense, said Kaul. Premium over diesel, he estimated at USD120,000.

One of the factors that will drive adoption of electric buses will be technology advancement and technology maturations, said Kaul, which will coincide with reduction in key component costs such as electric motors, batteries and fuel cells. There will remain a significant gap between electric buses and diesel buses, but the gap will come down over time.

There are predominantly three electric motors being used, said Kaul. Permanent Magnet Synchronous Motors (PMSM), which has been used mostly by the Chinese OEMs. In Europe and the USA, most of the electric motors are magnet-less AC induction motors, said Kaul. In the future, Kaul anticipates use of the switched reluctance motor, which combines the performance attributes of a permanent magnet motor and the lower cost attributes of an induction motor. These are the future motors for traction applications, Kaul stated. In terms of motor placement, the market started with the conventional central drive motor, which was followed with the wheel-hub and electric axle drive, to which a third, the in-wheel motor drive, followed. All three have their place in the future, he said.

In terms of battery trends, the first buses tended to use Lithium-ion combinations followed by NMCs (Nickel Magnesium Cobalt) and then LTO (Lithium Titanate Oxide), a chemistry that has been increasing in bus applications, said Kaul. LTO, he explained, offers the benefit of a longer cycle life as well as a very high charge

rate. This allows for use of a small battery that can be charged using opportunity charging at a very high rate. The high charging capacity and lifecycle allows the battery to be optimised for a specific transit application. Future chemistries include Lithium Sulfur and Solid State Lithium, the cost of which over the next decade are expected to fall from around USD500kWh today to 150kWh. The SSL battery, Kaul pointed out, is a safer battery chemistry with a much higher energy density, lower mass and offers a much faster rate of charging. So, for the bus applications the battery industry is to move from liquid electrolytes to solid electrolytes.

## By 2025, as much as 60% of the transit bus market in North America could be electric

Looking at the percentage of full electric drivetrain penetration in the transit bus industry in North America, Frost & Sullivan figures indicate that currently diesel and natural gas buses make up 90% of the new annual transit bus market. In 2018, the percentage figure was lower at 6.4% with HEV's accounting for 16.1%. However, Kaul forecast that by 2025, as much 60% of the transit bus market in North America could be battery electric and fuel cells. Adoption would be as a result of subsidies and incentives, said Kaul. But as costs come down and technology improves there will be economic arguments as well as the benefit of zero emissions for faster adoption.

Moving on to the school bus market currently there are virtually no electric buses today but by 2025 the number of electric school buses in North America is forecast to account for around 24% of the market. This rise in electric school buses will be pre-dominantly from incentives at a Federal, State and County level, stated Kaul.

Currently, there are virtually no electric heavy-duty intercity coaches in North America. In 2018, 86.1% of the 2,350 unit market was fitted with diesel engines, and the remaining 13.9% with natural gas engines. This year, said Kaul, will see introduction / testing of hydrogen fuel cell intercity coaches, building upon growing FCEV interest from HD trucks. By 2025, whilst the market is expected to be substantially larger at 3,500 units, and 70.9% will still run on diesel and 17.3% on NG, Frost & Sullivan forecasts the remainder percentages will be split 2.1% HEV, 2.9% HFC and 6.9% electric.

HD Transit - North America Powertrain forecast in 2025		
HD Transit	2018	2025
<b>Total</b>	<b>6,100 (100%)</b>	<b>6,400 (100%)</b>
Diesel	2,739 (44.9%)	915 (14.3%)
NG	1,988 (32.6%)	1,690 (26.4%)
HEVs	982 (16.1%)	134 (2.1%)
Electrics	390 (6.4%)	3,181 (49.7%)
HFCs	(0%)	480 (7.5%)