



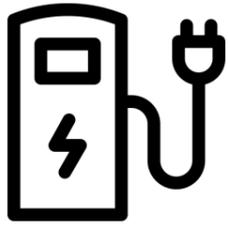
HEATING AND COOLING THE CLEAN BUS JOURNEY

A future of clean bus transportation is within reach, where communities can look forward to cleaner skies and quieter streets.

As exciting battery electric and hydrogen fuel cell advancements accelerate the path to emission-free mobility, the role of thermal management has never been more crucial.

Discover how heating and cooling is helping this zero-emission transformation, from source to service.





The battery electric bus journey: Heating and cooling every step



The rise of battery electric technology is leading to a complete rethinking of the energy supply chain, from how energy is generated to how it is used to power battery electric buses. And, at each step, thermal management has an important part to play.



1. Energy generation

The capture of carbon-free energy

The zero-emission journey starts with harnessing renewable energy sources, such as solar and wind, to generate electricity without emitting carbon dioxide. This renewable process is the first important step in reducing our dependence on fossil fuels and embracing an emission-free future.



2. Energy storage

Energy available for a rainy day

Once the power is generated, the question is where to store it so it can be accessed when needed? Stationary energy storage systems are a key solution to addressing the challenge of intermittent energy generation, allowing for consistent power availability, even when the sun isn't shining or the wind isn't blowing.

The role of thermal management



In most cases, a stationary energy storage system will include a bank of batteries and an electronic control system within an enclosure. Our Battery Thermal Management Systems (BTMS) manage the temperature, ensuring the heat generated through chemical reactions within the batteries does not become harmful to the system.

5. Bus maintenance

Extending the lifespan of batteries and vehicles

The electric bus journey doesn't end there. To ensure the vehicles continue to provide emission-free and reliable mobility for communities long into the future, regular servicing and maintenance of thermal management systems is essential.

4. Energy usage

Providing clean public transportation

The stored energy from the bus' batteries are used to power the entire electric drive system for clean and quiet propulsion, alongside its heating, ventilation and air conditioning (HVAC) system to provide a comfortable climate for drivers and passengers.

The role of thermal management



Our Vehicle Thermal Management System (VTMS) plays two crucial roles in the safe operation of a battery electric bus. The first is the thermal management of drivetrain components, such as high-capacity batteries and essential electric motors. The second is providing a comfortable climate for drivers and passengers through efficient heating, ventilation and air conditioning.



3. Conversion and release

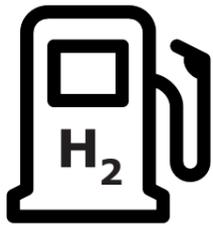
Turning energy into usable power

Once renewable energy has been generated and stored, it is converted via the use of power electronics into a usable voltage which can then be released to the bus' batteries. Charging stations serve as an intermediary, transferring the energy to the vehicle.

The role of thermal management



Our cooling systems ensure that vital components involved in the energy conversion and transfer process, such as power electronics and charging cables, operate within optimal temperature ranges. Additionally, our BTMS units fitted to the bus keeps the batteries cool during rapid charging cycles where significant heat is generated.



The hydrogen fuel cell bus journey: Heating and cooling every step



Over recent years, the exciting development of hydrogen technologies has opened up a brand-new raft of clean energy possibilities, with hydrogen fuel cell buses being at the forefront of this revolution in public transportation. To turn this innovative technology into a viable option in the future, pioneering thermal management solutions has a significant part to play.



1. Hydrogen generation

The capture of carbon-free energy

The start of the hydrogen bus journey starts with the generation of hydrogen. There are a variety of ways to produce hydrogen, however, the most sustainable is through electrolysis using renewable energy. This process splits water into hydrogen and oxygen using an electric current in a unit called an electrolyser, creating 'green' hydrogen.



2. Hydrogen storage

Storing hydrogen ready to transport

Once generated, the hydrogen is purified and compressed before being stored in high-pressure tanks designed to safely contain the gas until it is needed. The stored hydrogen can then be taken to refuelling stations, often as compressed gas via high-pressure tubes transported by tractor trailers.



4. Hydrogen usage

From hydrogen to clean propulsion

This is where the magic happens. In the bus' fuel cell stack, hydrogen from the tank is combined with oxygen from the air to create electricity that is used to charge the vehicle's battery. The only other by-products are water vapour and heat. The result? Clean and quiet public transportation.



3. Hydrogen distribution

Ready for fuelling

At the filling station, the transported hydrogen is transferred to the on-site storage tanks at the depot, ready to distribute to hydrogen fuel cell buses. The refuelling process for hydrogen buses is very similar to a conventional diesel bus – in fact, it takes just seven to ten minutes to refuel!

The role of thermal management



Hydrogen buses require many of the same heating and cooling solutions as their battery electric counterparts (chillers for the batteries, cooling systems for power electronics and HVAC systems for climate control). Unlike battery electric buses, however, the high waste heat from hydrogen fuel cells also needs cooling (we can recycle this waste heat to the HVAC system for even greater efficiency).

The role of thermal management



Due to the nature of hydrogen gas and its storage conditions, correct thermal management is critical and a number of systems are required. This includes chillers for storage tanks, pressure control systems and heat exchangers between components.

5. Bus maintenance

Extending the lifespan of fuel cells and vehicles

Just as with electric buses, hydrogen fuel cell buses' thermal management systems also need regular servicing and maintenance to guarantee cost-effective ownership, reduce downtime and prolong operational life. By prioritising upkeep, operators can provide sustainable, reliable and comfortable hydrogen-powered transport to communities long into the future.

Did you know?

Hydrogen is the lightest element in the periodic table – it is 14 times lighter than air! It is also the most abundant element in the universe.



Heating and cooling the zero-emission chain: From source to service



Each link in the zero-emission chain requires precise thermal management to ensure efficiency and safety. As specialists in heating and cooling, Grayson Thermal Systems has developed a portfolio of trusted and proven solutions ready to support every step of the emission-free journey, from energy storage to vehicles on the road and beyond.

Battery Thermal Management Systems

The third-generation of advanced battery chillers

Innovative battery electric and hydrogen fuel cell applications require accurate and efficient management of battery temperatures to achieve essential performance and service life.

Providing intelligent heating and cooling, our field-proven range of Battery Thermal Management Systems (BTMS) are the solution of choice for many leading global OEMs.



HVAC Systems

Providing the ideal climate for drivers and passengers

Delivering the perfect temperatures in all conditions, our advanced reversible heat pump and HVAC solutions deliver heating and cooling for the driver cabin and passenger saloon.

Our varied HVAC portfolio has the right option to meet your application's needs.



Vehicle Thermal Management Systems

Complete thermal management for batteries, drivers and passengers

Designed to enhance driver or passenger comfort while simultaneously extending the service life of temperature-sensitive batteries, our Vehicle Thermal Management System (VTMS) saves costs and increases efficiency by pairing our battery chiller technology with our proven HVAC and electric motor cooling modules in one complete system.



Cooling Systems

Keeping critical components cool in any climate

Prevent overheating, derating and shutting down of an electric driveline system with our comprehensive range of cooling systems.

Our cooling modules use ambient air to efficiently remove heat and keep your application's critical system components at the correct temperature for optimum performance.



Servicing and Maintenance

Ensuring optimal performance into the future

High-quality thermal management systems need equally high-quality servicing and maintenance to ensure their long operating life and continued performance. Our team of knowledgeable engineers have years of experience servicing and maintaining a wide range of heating and cooling products in the bus and coach sector. It is the reason why major operators across the UK trust us to keep their buses on the road, and their drivers and passengers comfortable in any climate.



Discover more about the Grayson Thermal Systems product range at www.graysonts.com



Generations of knowledge at your service

For 45 years, we have worked closely with leading manufacturers to meet their thermal management and HVAC needs, delivering advanced solutions that perform in the most extreme conditions.

Discover how our dedication to innovation, precision engineering, flexibility and customer service is helping manufacturers to create the next generation of zero-emission applications.

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