Hand warmers go big

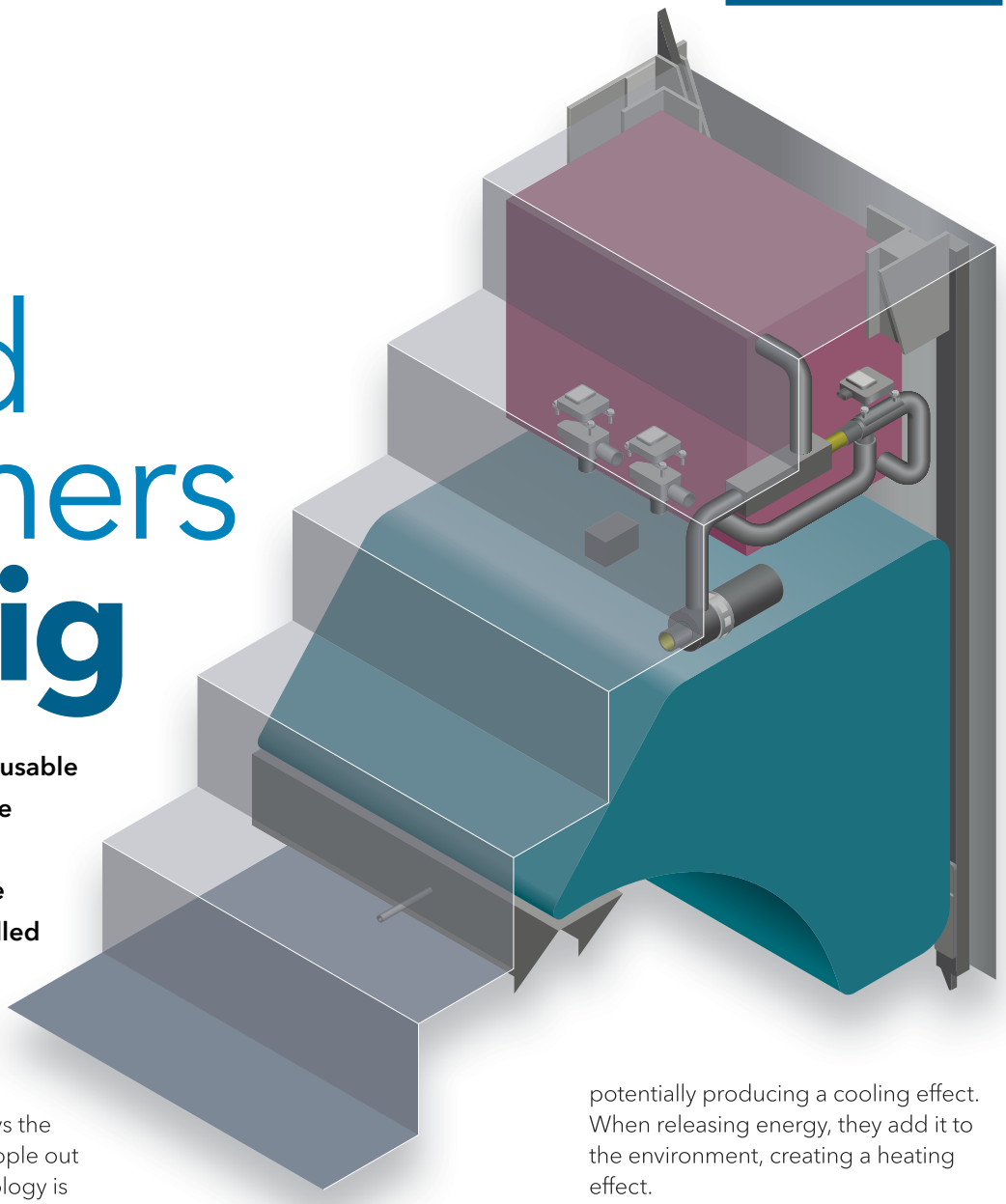


Illustration credit: Phil Holmes

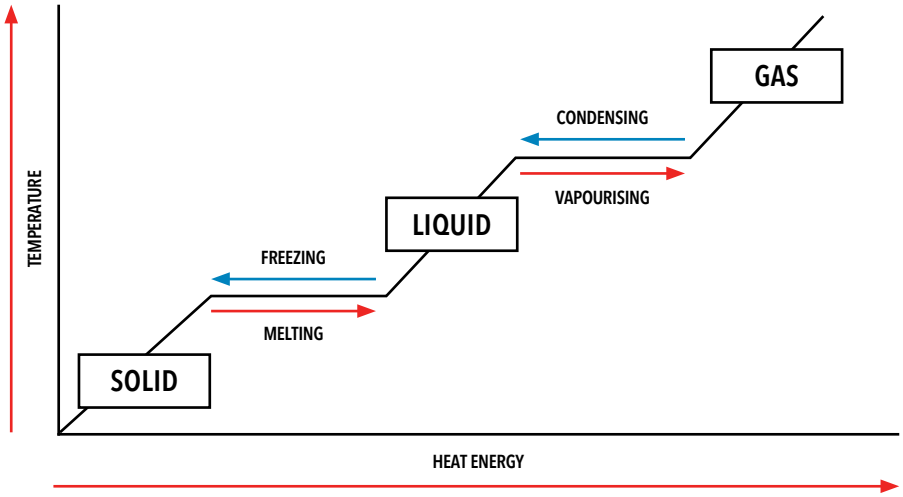
The mineral salts inside reusable pocket hand warmers have been repackaged in trial systems for heating up the cabins of alternatively fuelled buses, reports Lucy Radley

The less obvious problems are always the ones that catch people out when a new technology is being introduced into the mainstream, and diesel-electric hybrid and fully electric vehicles on to our roads have been no exception. In the case of buses, it is interior heating which is the snag. If you draw power from the traction batteries to keep people warm, you inevitably reduce your range, potentially by quite a lot – anyone who has run an electric heater from the mains will know how energy-hungry resistive heating can be. But an East Lothian company, Sunamp, working in conjunction with Vantage Power, bus operator Go-Ahead London and Bristol-based additive manufacturer HiETA, will soon be offering an answer: heat batteries.

Originally developed for the domestic and industrial markets, heat batteries store thermal energy in a simple way. It all hinges on phase change materials, or PCMs: chemical salt hydrates that change from solid to liquid and vice versa at a given temperature. This is the point at which they either change into a liquid, capturing thermal energy, or solidify, releasing that energy (see also graph, p32). When the salts capture energy, they take it out of the surroundings, potentially producing a cooling effect. When releasing energy, they add it to the environment, creating a heating effect.

Mike Keane, senior automotive engineer at Sunamp, explains: "When it goes from solid to liquid, the material is held at constant temperature – exactly like melting ice in whisky – and stores that thermal energy. Then, at a later point, we can run cold coolant through the heat battery, and that stored energy will then be rejected from the PCM, back into the coolant. That means we can capture what would normally be waste heat and use it at a later point for warming up a system on the vehicle." Other uses could include warming up cold engines (or cabins) in the morning to reduce emissions, or thermal management of the traction battery.

Different PCMs will capture heat at different temperatures, depending on which chemical salt hydrate they contain. Sunamp's range of fully reversible PCMs, developed for more



MAKING THE RIGHT CHOICE

A study by the International Council of Clean Transportation (*www.is.gd/lilowa*) has found that the choice of refrigerant used in vehicle air conditioning systems has a big effect on lifetime costs. It tested three alternatives to the current standard, R134a: R744 (CO_2), R1234yf and R152a. Switching to one of these alternatives – which have many times lower global warming potential than R134a – combined with installing systems that have improved efficiency, reduced leakage and using load reduction and powertrain optimisation strategies reduced lifetime costs by $1,000-$3,000, and cut emissions by 70%.

than a decade, have an operational range of more than 200°C. Keane says: "They currently go from -11°C to over 200°C, which means we can also work with sub-ambient temperatures and capture cold."

This means PCMs can support refrigeration system that use onboard compressors, and exactly this is being explored in a trial involving a fully electric refrigerated truck. "We've put a store at -5°C on board, which means the amount of work the electric compressor has to do is reduced because it's not having to deal with whatever the ambient temperature may be," Keane explains. "This means we're able to reduce the compressor size and, hence, the power draw, which in turn means less power is taken from the traction battery and the range is increased."

Harnessing this phenomenon for the benefit of climate control requires a three-layer construction, says Keane. "There is an internal shell, which is a low-pressure vessel, an external shell and then insulation between," he tells us. Inside the internal shell is a heat exchanger consisting of an array of pipes with fins brazed on to them; they are plumbed into the cooling system of the bus. The heat battery functions as a radiator, capturing waste heat generated during normal operation of an internal combustion engine or motor.

THE BUS PROJECT

Funded by industry consortium the Niche Vehicle Network, the project is now in the production readiness phase, which began in October 2018. This means redesigning the system so it is ready for operation, including building heat batteries and pipework to fit in the space available so they can be hidden from view. This is accomplished while maintaining the bus's operating volume – without disrupting the passenger cabin or luggage space (drawn on p31).

It follows a proof-of-concept stage, in which Sunamp and Vantage Power installed a heat battery into a diesel-electric bus to prove that it could capture the waste heat from the diesel engine, store it in the heat battery, and provide it for cabin warm-up. That project demonstrated the system's capability to provide cabin heat for 20 minutes of electric vehicle (EV) running, or the ability to reduce both CO_2 and NOx emissions during the initial engine warm-up phase by around 50% by using that heat to bring it to operating temperature. This phase was completed in early 2018.

Heat batteries can potentially store thermal energy for up to five days, but they work best on a more frequent cycle, points out Keane. He adds: "On this programme, where the batteries are intended for vehicles in daily operation, they will be constantly charged and discharged, an ideal scenario which aids longevity. So far, Sunamp has put its longest-running batteries through over 43,000 charging cycles, with zero performance degradation."

This project covers installation of two heat batteries with latent temperatures of 58°C and 81°C. The latter is fitted close to the engine, while the other is tucked away in dead space above the fuel tank. Sunamp's PCMs are both non-flammable and non-toxic, qualities which improve safety even in accident conditions in which the battery cases were breached.

"With these two sources of stored heat on the vehicle we can do a number of things," Keane explains. "We can release the heat from the 81°C battery to rapidly warm up the engine for a cold morning start, or from both batteries to warm up the driver and passenger cabins." The production readiness phase of the diesel-electric hybrid solution was due to be completed last month, by which time the system will be ready for field trials.

Then it will be installed into an as-yet-undecided number of Go-Ahead London's buses, which will then continue on their standard operational runs. In addition to this diesel-electric version, a related project of a system for fully electric vehicles has reached proof-of-concept phase. That work continues. TE