NORTHERN EXPOSURE

IF YOU THOUGHT THE CHILLIEST CONDITIONS ELECTRIC DRIVES EVER FACED WAS IN COLD-STORE APPLICATIONS, THINK AGAIN. A FEW OF THEM ARE OPERATING IN SOME OF THE HARSHEST CONDITIONS ON THE PLANET

Diesel may still be king in the minds of many, but tightening emissions requirements mean that, despite concerns over battery power, electric vehicles are now being taken evermore seriously – even in the harshest of environments.

Perhaps the most extreme example of a working cold-weather EV resides at the Summit Station scientific research base high on the Jakobshavn Glacier in Greenland. The area is 10,000ft above sea level, with average winter temperatures plummeting to -34°C. As many of the samples taken by the scientists are in the 'Clean Air Zone' sector, conventional IC vehicles are not permitted, as their emissions could contaminate readings.

The vehicle of choice (dubbed Edison by the operators) is made by Mogile Technologies, whose president, Simon Ouellette, explains

MAIN IMAGE: **Most often used in temperatures around -15°C, Mogile's Edison snowmobile maintains peace and quiet in the Arctic through the use of electric drive**

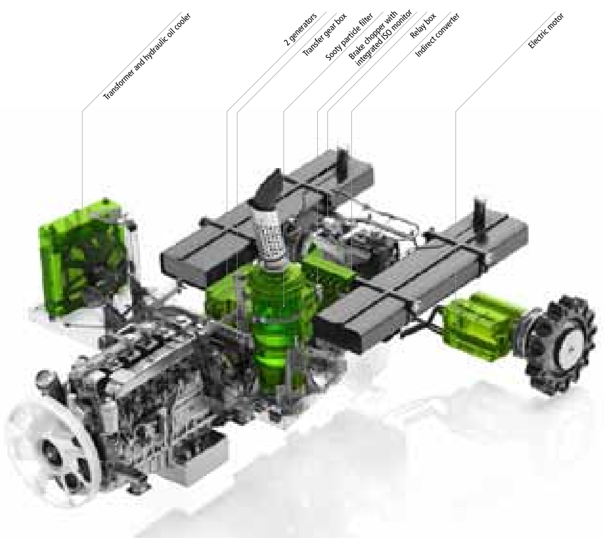
RIGHT: **High torque and no jolting on start-up make towing heavy loads with Edison highly efficient** the origins: "As a student, around 10 years ago I entered a US competition – the Clean Snowmobile Challenge. It was mostly concerned with trying to clean up regular combustion engines, but because I am from Quebec, where 96% of our power is hydroelectric, I thought we should design something that was electrically powered. Although the competition wasn't ready for us, we were welcomed and the concept received quite a lot of attention." As interest grew, the competition developed a standalone electric vehicle class.

From time to time, the Summit Station researchers would borrow the snowmobiles from the students, but eventually realized that greater reliability was required. So, two years ago, the US government contracted Mogile to build something a little more durable.

COMBINED EFFORT

Perhaps one way of avoiding the range issue common to EVs is to combine the best of both worlds with a hybrid. PistenBully's 600 E+ snow groomer features a 400hp-rated six-cylinder Mercedes-Benz diesel engine, coupled to two generators, two drive motors and a tiller motor (each 140kW/650V).

Michael Hemscheidt, PistenBully's head of technical marketing, explains the development process: "Our customers are primarily interested in reducing fuel consumption, more than emissions. We always strive to provide the latest technology; in fact, we actually started researching hybrid technology in the early 1990s. However, at that time the components were just too large and expensive. Nowadays, they may not be cheaper, but at least they are smaller."



The design goal was to get the IC engine to achieve the optimum torque at lower revs, and PistenBully proudly claims a 20% reduction in fuel consumption over a comparable conventional machine. "We know the customers really appreciate this," elaborates Hemscheidt. "It is also a different driving experience. With just a standard diesel engine, there needs to be lots of throttle use to get it to deliver the power. With a hybrid, the torque comes in much earlier, so the driver does not need to be revving it up. Also, this makes it much quieter so, at St Moritz for example, the operators use the hybrids when working close to the hotels."

Looking ahead, Hemscheidt sees further gradual refinement, with no great leaps forward expected for standalone electric power. "Hybrid designs are the future, I see no way a machine this size could rely on a battery alone to power it. Even a small groomer in a snowdome will need improvements in battery technology to really work well."

Edison gets most of its use in the summer, when the days are long and almost 'balmy' at -15°C. This winter, the machine is coming back to Ouellette as lessons have been learned in the field that will require some upgrades.

The specifics have not yet been decided, but he can make general comments about the technology: "From the design perspective, the forklift guys have made great strides with motors and controllers as used in refrigerated warehouses. So the area with the room for the most improvement is battery technology. To be more precise, it is not just an issue of battery performance, but one of price."

The solution, Ouellette believes, lies with economies of scale, and he cites Tesla's expansion as an indication that this is already underway.

EV lover

The operator experience is very different with Edison. According to Ouellette, the high torque that is instantly generated means that towing the heavy research materials is easily achieved, and with no IC engine engaging a CVT belt-driven clutch, there is no jolting when starting out. The quietness means it is more pleasant for the driver, with walkie-talkies able to be heard over the hum, unlike with petrol engines.

However, there are downsides, and safety features were designed in to counter these. Ouellette says, "When it is turned on, it is dead silent so it is easy to forget that it is running. As the slightest touch on the thumb actuator will make it move, we installed a 'screen saver' type function, meaning it will power down if left unattended."

Range is also difficult to calculate accurately, and at the moment it appears as if the only real solution to this is operator training. "It is not like a forklift in a warehouse or a car, which drives on a similar surface all the time," explains Ouellette.

"A change in traction on the snow can happen rapidly due to the environmental conditions, drastically affecting the range, so just fitting a charge gauge is not really enough. It's actually a really nice engineering optimization puzzle – the bigger the range buffer, the bigger and more expensive the battery."

BELOW: **The Legacy Arctic Battery features special electrolyte solution, a five-fold plate insulation system and a thermal tray insulator that improves the performance of the outer cells, which are most affected by cold applications**

BELOW: **Defence R&D Canada sponsored this Mogile Technologies research project, dubbed Loki (pronounced 'low key'). It can run with a conventional petrol engine and switch to electric when required. Simon Ouellette says, "The military were primarily interested in the acoustics of the vehicle, and with a quiet drivetrain, this was easier to study"**

Better batteries?

However, battery design for cold-store use is not an area where great technological leaps are being made forward – at least not according to Jason Osadac, manager at Westrock Battery. "In the 20 years I've been in the battery business, and in the 20 years prior to that, there has been very little change to the lead-acid unit," he notes.

"The major difference between a cold-store forklift battery and a regular-use battery remains in the construction. It's a bit heavier with slightly thicker plates, so it can hold up to the cold better. I don't expect any significant changes in design or electrolyte in the near future."

GOING FOR COLD

Mark Ankers, VP of product management at Curtis Instruments, spells out a few of the technology challenges for designing EVs for use in cold climates.

How can condensation and moisture ingress be managed?

For controllers, the typical construction is an alloy heatsinking baseplate and a moulded plastic cover, with a perimeter gasket for sealing the interface between, O-rings or some other method to seal around the high-current bus bar connectors for the motor and battery, and a sealed connector for the low-current harness such as an AMPseal. The typical IP rating is IP65 with the mating low-current connector fitted.

However in reality, due to changes in ambient temperature and/or atmospheric pressure, it's economically impossible to maintain absolute sealing. To counter this, the state-of-the art solution is to include a Gore-Tex breather into the controller's cover so that pressure is always equalized and moisture can exit, but its entry is minimized.

Furthermore, controllers themselves will generate considerable heat during operation. On a typical 48V, 1.5-ton counterbalance truck, the pump and traction controllers are outputting 300-500A, and as a result each controller is generating a few hundred watts of heat. Coupled with the breather, this means that operation in cold areas isn't such a problem – it's actually the transition from hot to cold areas that can cause condensation.

Older controller designs – say 12 years ago – didn't have the Gore-Tex or sealed connectors and attempted to combat condensation with conformal coatings on the PCBs, or complete encapsulation. The issue with both these methods is that they are not suited to series electronic manufacturing. It's extremely difficult to ensure such coatings/encapsulants have been correctly applied to each and every production unit, and the big problem here is that a partial coating, or an encapsulant that hasn't correctly adhered, does not form a complete barrier against the ingress of moisture. Instead, it can often 'trap' it, increasing the chance of localized corrosion or contamination.

How will the technology develop?

In the future, I'd expect to see increased use of autonomous or semi-autonomous trucks to reduce the need for operators to work inside the cold rooms.

With outdoor cold climates, I don't think there is such a thing as a typical electrical forklift destined for a cold climate. Today a diesel truck is more cost effective when talking about solely outdoor use. Emission legislation may become a factor, but if you think about where in the world the really cold climates are, there are not many countries that will be strictly enforcing emissions rules, and it's typically a remote frontier mentality where it will be far easier to service diesel/gas trucks than sophisticated electrical trucks.

So could construction machinery use electric drives in cold conditions?

The cost of making large diesels compliant with the ever-tighter emissions regulations is already fueling the adoption of diesel-electric hybrid systems in construction vehicles. For the colder regions of the world, the solution today is to simply control the ambient temperature around the key components so that they never get exposed to really cold or hot temperatures.

Osadac is keeping an eye on the high-cranking lithium batteries, but sees no scope for their industrial use. "It's not just the cost – some of these batteries are US$1,500 – but lithium just isn't good enough in cold environments."

However, more progress seems to be happening with battery charger design, Osadac concludes. "We have definitely seen improvements here, with smart boards that can tell the charger what the battery needs, so it can adjust itself accordingly. This can make these systems more economical to run." **iVT**