

PETRONAS iona

We're engineering
tomorrow, today.



Leading the charge

In 2019, PETRONAS became the first oil company to launch a portfolio of e-fluids for the EV market: PETRONAS Iona.

- PETRONAS Iona fluids are developed specifically for the latest generation of EVs
- PLI aims to deliver energy solutions that fuel responsible progress
- We're committed to contributing positively to society and the environment
- The second generation of PETRONAS Iona e-fluids launched in 2021.

And now, we are going even further.....



Our sustainability pledge

PETRONAS PLEDGE >

A progressive energy and solutions partner enriching lives for a sustainable future.

PETRONAS aspires to achieve net zero carbon emissions by 2050, delivering clean energy and low carbon solutions to people globally.

PLI PLEDGE >

Be the world's leading Fluid Technology Solutions (FTS) partner, enabling our business to grow.

Championing CO₂ emissions reduction through our unique approach to technology and co-engineering – for both now and the future.

We will be **committing 75% of all future R&T investment** behind emission-reducing projects.

IONA PLEDGE

Innovating to solve the world's thermal management challenges.

We will work with more and more customers to innovate and save energy with our **thermally intelligent fluids**, leading the way in our field to help these pioneering partners **accelerate efficiency**, improve performance and **reduce CO₂ emissions**.



Going further, for everyone

To make a universal impact, we must take the lessons we have learned from being the first to market dedicated EV fluids to new places.

- PETRONAS Iona has proven the efficacy of our thermally intelligent fluids. Now, it's time to share these learning with others at the cutting edge – not just within mobility, but other areas where energy efficiency is key
- It's only by staying one step ahead of thermal management challenges, wherever they may be, that we can deliver on our sustainability pledge.



We're opening up our
progress and innovation
to sectors beyond mobility



New industries. Exciting futures.

PLI is developing fluid solutions for

Technology

Application

Benefit

Electric vehicle fluids

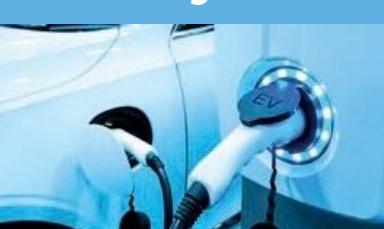


Iona targets the three critical areas in electric vehicles where fluids have a critical role: the engine and gearbox, the battery and the bearings.

EDU, driveline, battery

- Thermal control is needed to:
- Improve efficiency and reduce energy consumption
 - Grant safety and system reliability.

Charging stations cooling fluids

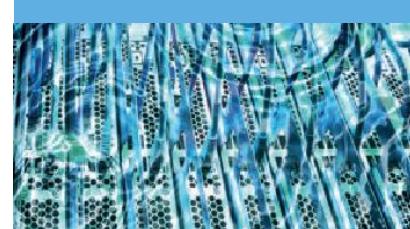


For high-power charging stations, liquid cooled cables and connectors are already state of the art and mandatory standard in future.

Fast charging stations

- Thermal control is needed to:
- Allow fast charging and improve efficiency
 - Grant safety and system reliability.

Immersion cooling fluids



Modern CPU, GPU and computers' hardware require liquid cooling to keep temperatures under control and increase their efficiency.

Servers, hyper computers

- Liquid cooling is needed to:
- Grant system reliability and efficiency
 - Reduce the cost of cooling dramatically (vs standard systems).

Phase change materials



Phase change materials are substances that will melt or solidify at a certain temperature. They absorb or release heat energy by changing their state.

Energy storage

- PCM allows to:
- Save energy and costs
 - Cooling and heating without access to electricity.

Key Requirements

Thermal Management

Efficiency

Energy Saving

Sustainability

Reliability

PETRONAS Iona Fluids



Accelerate efficiency with unrivalled thermally intelligent fluids and expertise from PETRONAS Iona. Constantly innovating to solve the world's thermal management challenges.

By co-engineering bespoke solutions with our pioneering partners, **we're engineering tomorrow, today.**

Developed in partnership with global technology leaders, **we revolutionise thermal management, pushing the boundaries of what's possible** in order to improve performance and reduce CO₂ emissions.

Our technical expertise



Investing in research & technology

We're dedicated to emission reduction.

That's why we've pledged to spend 75% of our research and development budget on CO₂ reduction through the exploration of sustainable operating practices and new research to produce optimum fluids for future applications.

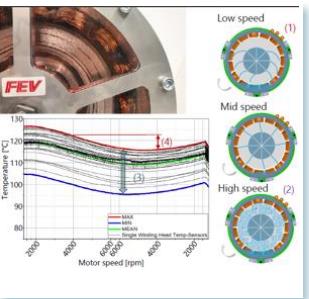


- Our **Technology Centre** in Turin, Italy, is the heart of our global R&D initiatives

- **400% increase** in R&D investment compared to previous years

- Additional **2% of revenues** driven back into R&D

PLI fluid research & testing capabilities



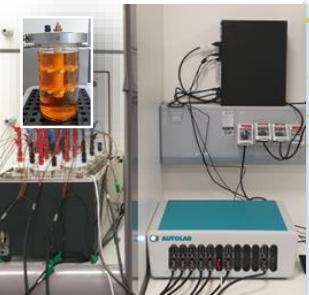
Electrical test

- Electrical conductivity ASTM D2624
- Dielectric breakdown voltage IEC 60156
- Relative permittivity, dielectric dissipation factor, resistivity IEC 60247:2004



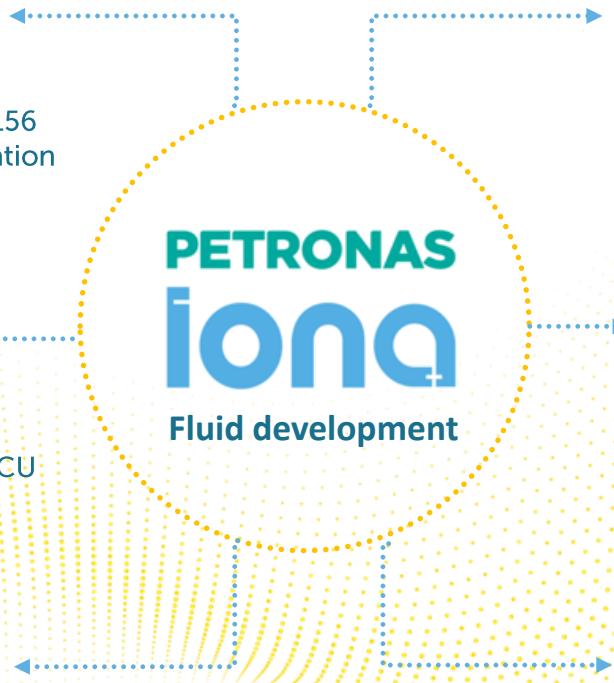
Compatibility test

- Open to customisations
- PCB, integrated microelectronic & ECU components compatibility test



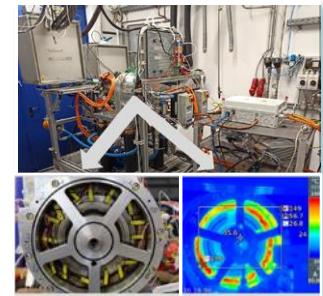
Corrosion test

- Open to customisations
- High temperature corrosion bench test
- Wire corrosion test
- Liquid-vapor & vapor phase corrosion test ASTM D130 modified



Thermal test

- Thermal conductivity D7896
- Specific heat capacity ASTM E1269
- Thermo copper In house



Mechanical test

For example, durability test for reduction gear



Dedicated test

For example, battery immersion cooling test rig



Our scientists and engineers are collaborating with our partners, applying state of the art technologies to co-engineer the future.

Testing of new technologies

There is still a lack of industry standards to define the efficiency of the thermal management, PLI has developed a proprietary set of tests to grant outstanding results and quality levels.

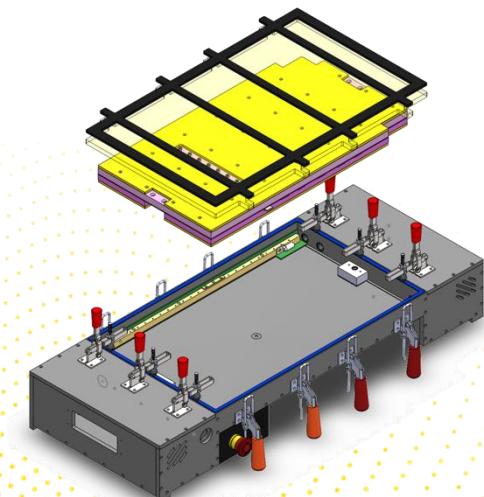
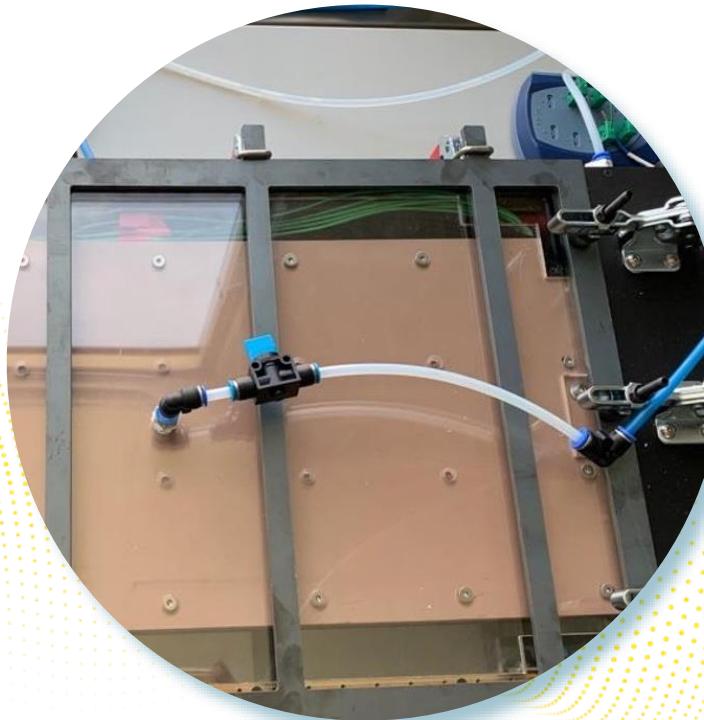
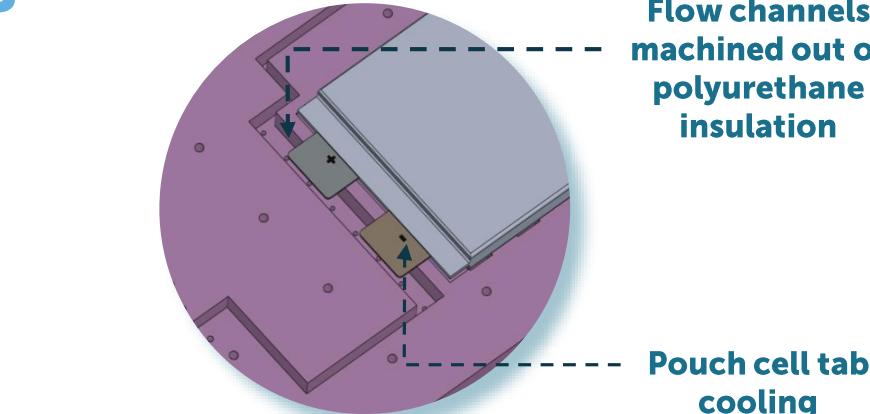
Unique and specific immersion cooling test rig for battery cell.

Simulate a real battery pack coolant system

- Variety of coolant flow designs
- Flow rates as low as 10ml/min.

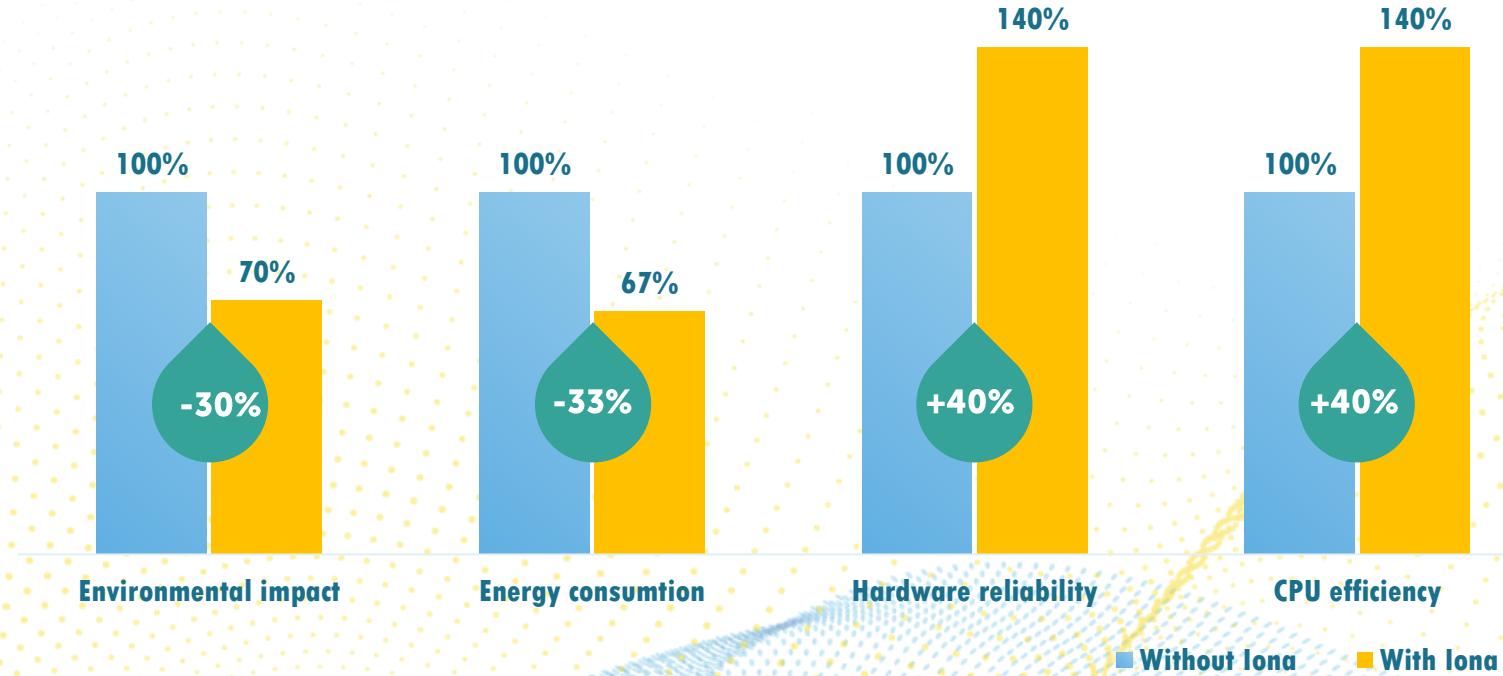
Allow benchmarking of performance

- Measure heat absorbed by fluid
- Measure cell temperatures.



Advanced cooling capabilities

We're developing and testing new-generation immersion cooling fluids to help data centres reduce their environmental impacts by 30%, reduce energy consumption by 33% and improve hardware reliability and CPU efficiency by 40%.



Partnership towards accelerating efficiency, revolutionising e-Mobility

Partnership: an on-going journey towards the latest technologies and trends in the e-mobility space

PLI has been working with a pioneering group of partners – including Imperial College London, vehicle development services provider FEV Group, automotive engineering company IAV and additive companies – since 2018, to co-engineer safe, high-performing and dependable fluids specifically for electric powertrains.

Its portfolio of EV fluids tailor-made for customer applications are borne from this collaborative approach.

Original Equipment Manufacturers (OEMs), Tier 1 suppliers and developers are looking for thought leaders and expert partners that can deliver the kind of revolutionary thinking, helping them stay one step ahead of rapidly emerging technologies and the competition and accelerate uptake of safe, energy efficient, high-performance electric vehicles.

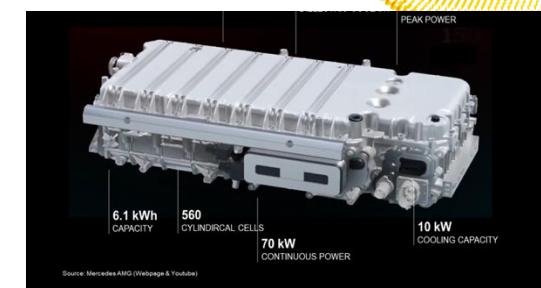


Imperial College
London
Consultants

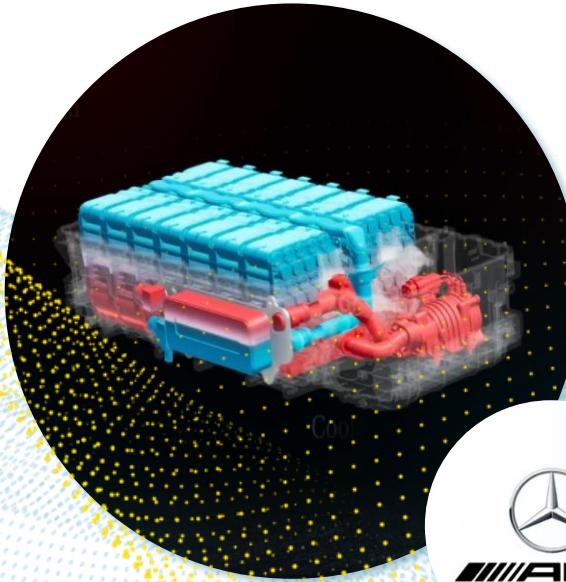


vitesco
TECHNOLOGIES

GKN
Driveline

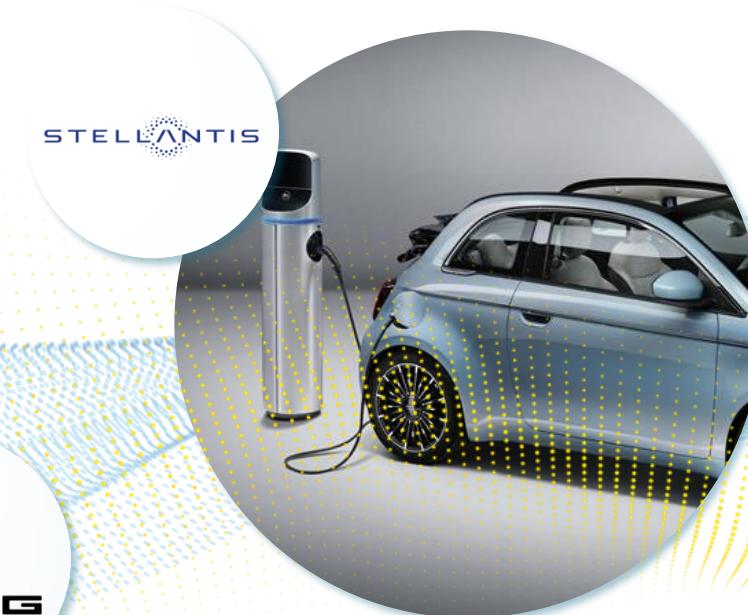


Outstanding results with our partners



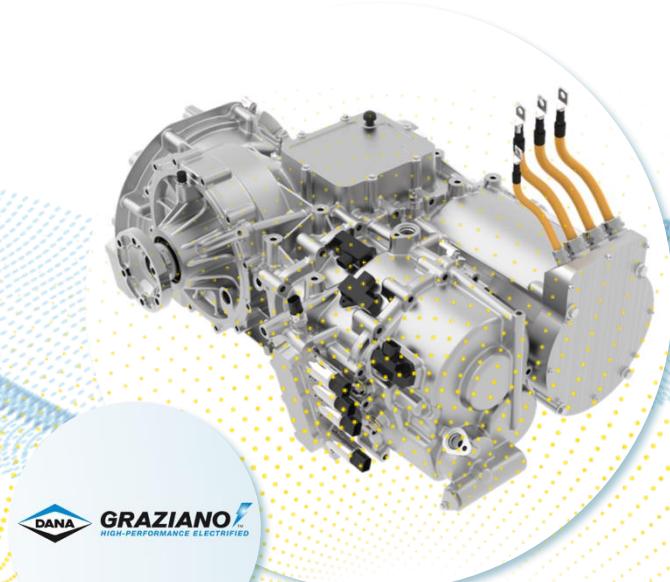
We co-developed a new Iona fluid with AMG **to cool the high-capacity battery** of a sport supercar PHEV.

It allows fast charging, with 150 kW peak power.



We pioneered **tailored fluids for single-stage gearboxes** and two-stage cylindrical gear with differential, improving their efficiency and reliability.

All new 500E and E-Ducato are equipped with Iona e-fluids at first fill.



We collaborated on tailored e-fluids for gears and electrical axles to **solve scuffing and pitting problems.**

Thanks to outstanding results, these solutions are now in production for premium OEMs applications

We have developed three advanced fluid solutions tailored for automotive partners



Battery Thermal Management

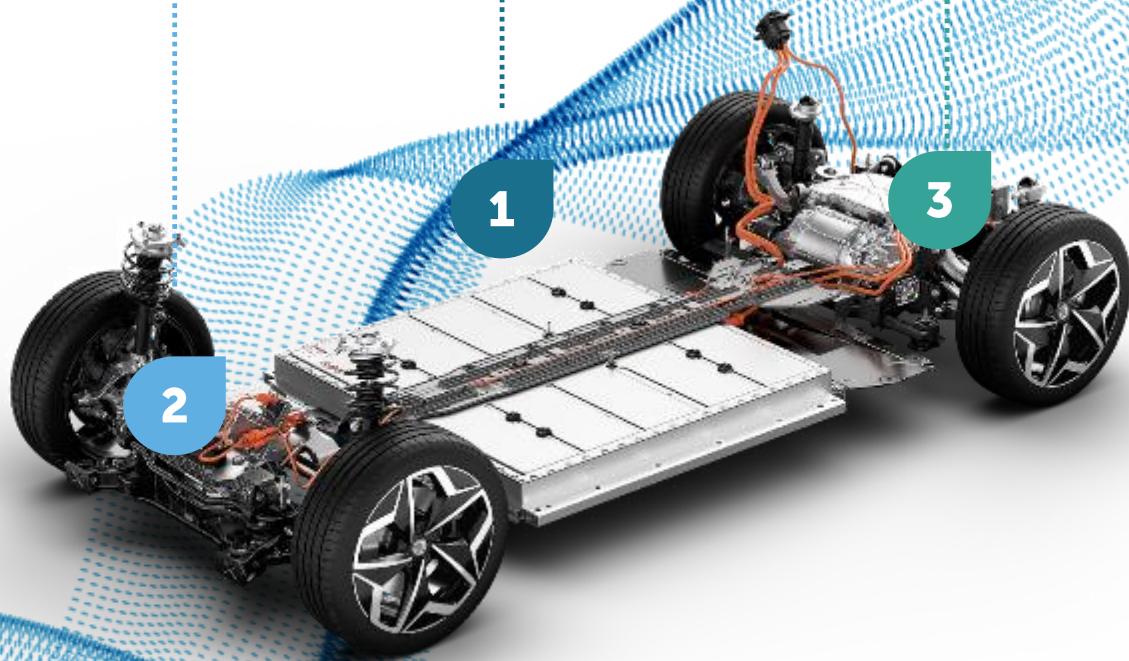
- Efficient delivery of electrical energy
- Long-life battery performance
- Corrosion protection

Integrated Driveline System

- Low viscosity
- Reduced friction
- Long-life gear box performance
- An extra-smooth ride

Quiet Running

- Ultra-quiet running in the powertrain
- Long-life performance and durability



PETRONAS Iona portfolio evolution

Our Gen II products mark an important step forward in the e-fluids development, offering improved thermal management and components reliability



PETRONAS
Iona
Gen I

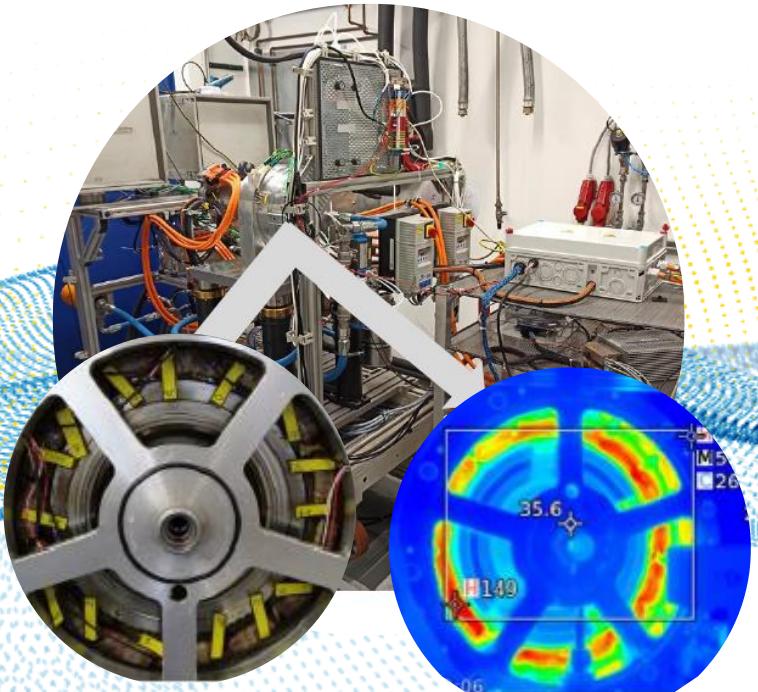


NEW
PETRONAS
Iona
Gen II

Key Properties	Standard Transmission Fluid	Electric / Hybrid Transmission		
		Indirect Cooling	Direct Cooling	
		Hybrid Cooling	Oil Cooling	
Anti-wear	reference	+	+	+
Anti-corrosion	reference	=	++	+++
Anti-oxidation at high temperature	reference	=	++	+++
Thermal transfer	reference	+	++	+++
Foam Prevention	reference	+	++	++
Friction Reduction	reference	+	+	+
Dielectric Properties	NA	NA	++	+++
Material Compatibility	reference	+	+++	+++
Compatibility with Electronics	NA	NA	++	+++
Fill for life	reference	=	+	+

Accelerating efficiency

The PETRONAS Iona range of new, tailor-made ultra-low viscosity EV fluids have been engineered to accelerate the efficiency of second-generation EDUs, when compared to a standard DEXRON 6 fluid.



Up to 10% increase of EDU efficiency without compromising system durability.

Ultra-low viscosity EV fluids

Advanced thermal management properties

Up to 10% increased e-motor power

Reduced energy consumption

Extended driving range

Optimal protection and durability

Full compatibility with materials and electronic components – even under electrical load.

Temperatures around **3°C lower** across the entire application range.

Increasing the EDU's efficiency without compromising system durability

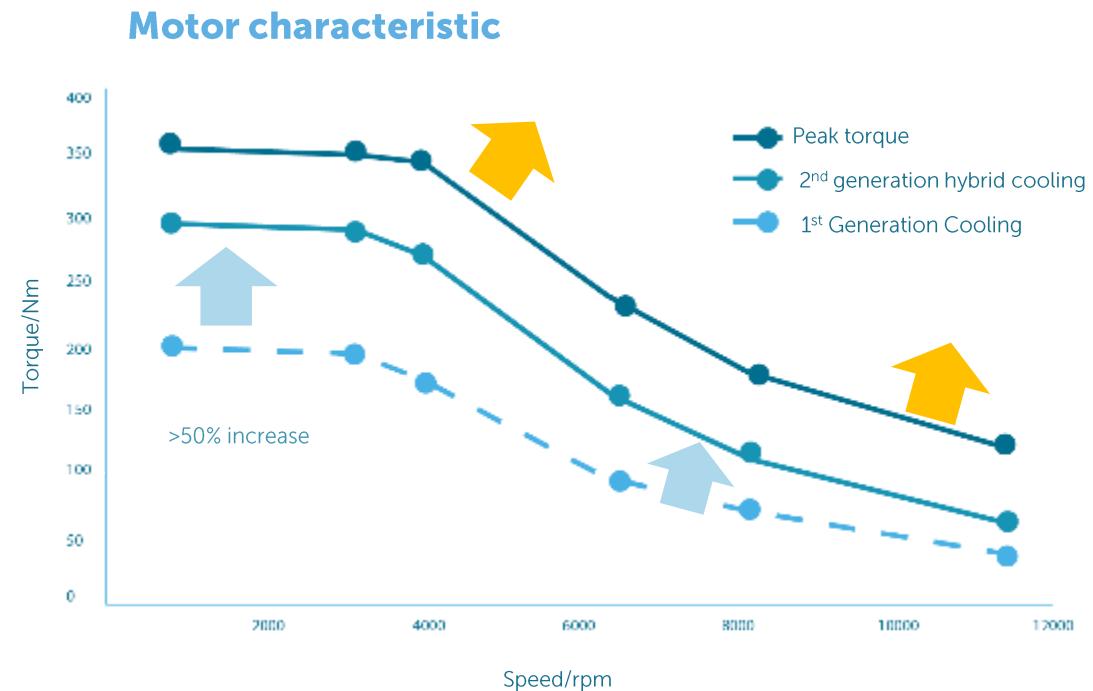
Increasing continuous torque/power with 2nd generation hybrid cooling

Technical advantages of direct oil cooling EDU

- Peak power is typically covered by thermal inertia
- Continuous power is driven by cooling
- Moderate increase of peak performance
- Significantly faster recovery after operation in peak region
- Faster heat-up of transmission for further friction reduction
- Downsizing of electric motor

Direct oil cooling significantly improves continuous power, thus allowing significant electric motor downsizing.

Ongoing developments will increase these benefits even further, including advancement in direct oil-cooled inverter.



The advanced fluid cooling properties allow to generate more torque at the same e-motor speed and temperature

PETRONAS Iona dielectric coolants main properties

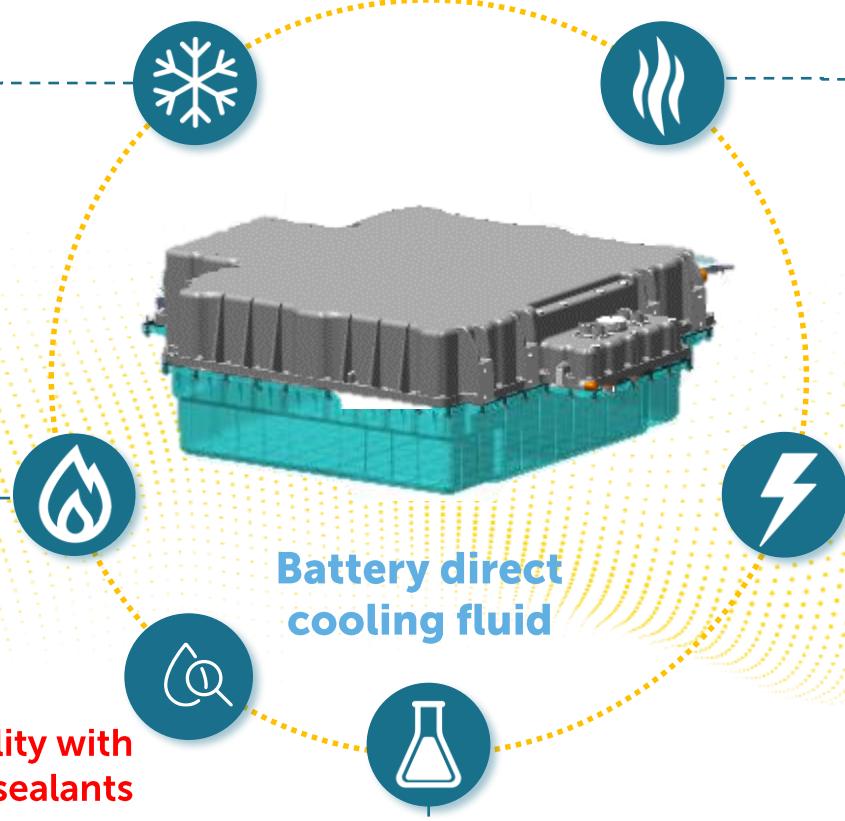
Low pumping energy losses

Minimum viscosity
between -30°C and 0°C.
Low pour point.

Resistance to thermal runaway

High flash, fire points,
dedicated tests on
battery fire.

Compatibility with electronics and sealants



Thermal transfer /heat dissipation

High thermal conductivity,
heat capacity and heat
transfer coefficient.

Dielectric properties

Low electric conductivity,
high breakdown voltage, low
permittivity, high resistivity.

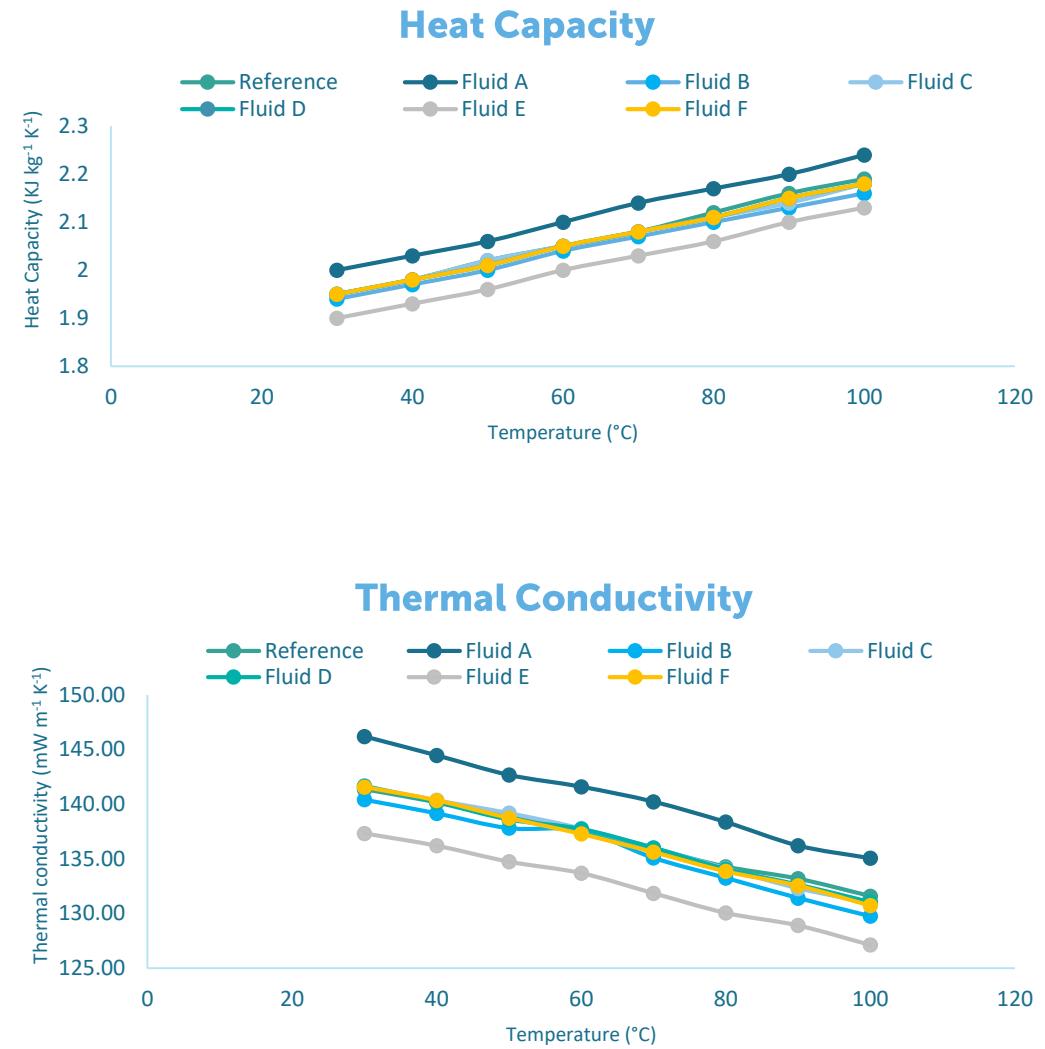
Ageing resistance

Resistance to oxidation
compatibility with elastomers
and power electronics.

IONA candidates design approach

1. Thermal Management

High Heat Capacity & Thermal Conductivity are some of the key prerequisites in EDU fluid design, strongly contributing to cooling efficiency



Reference = standard transmission fluid

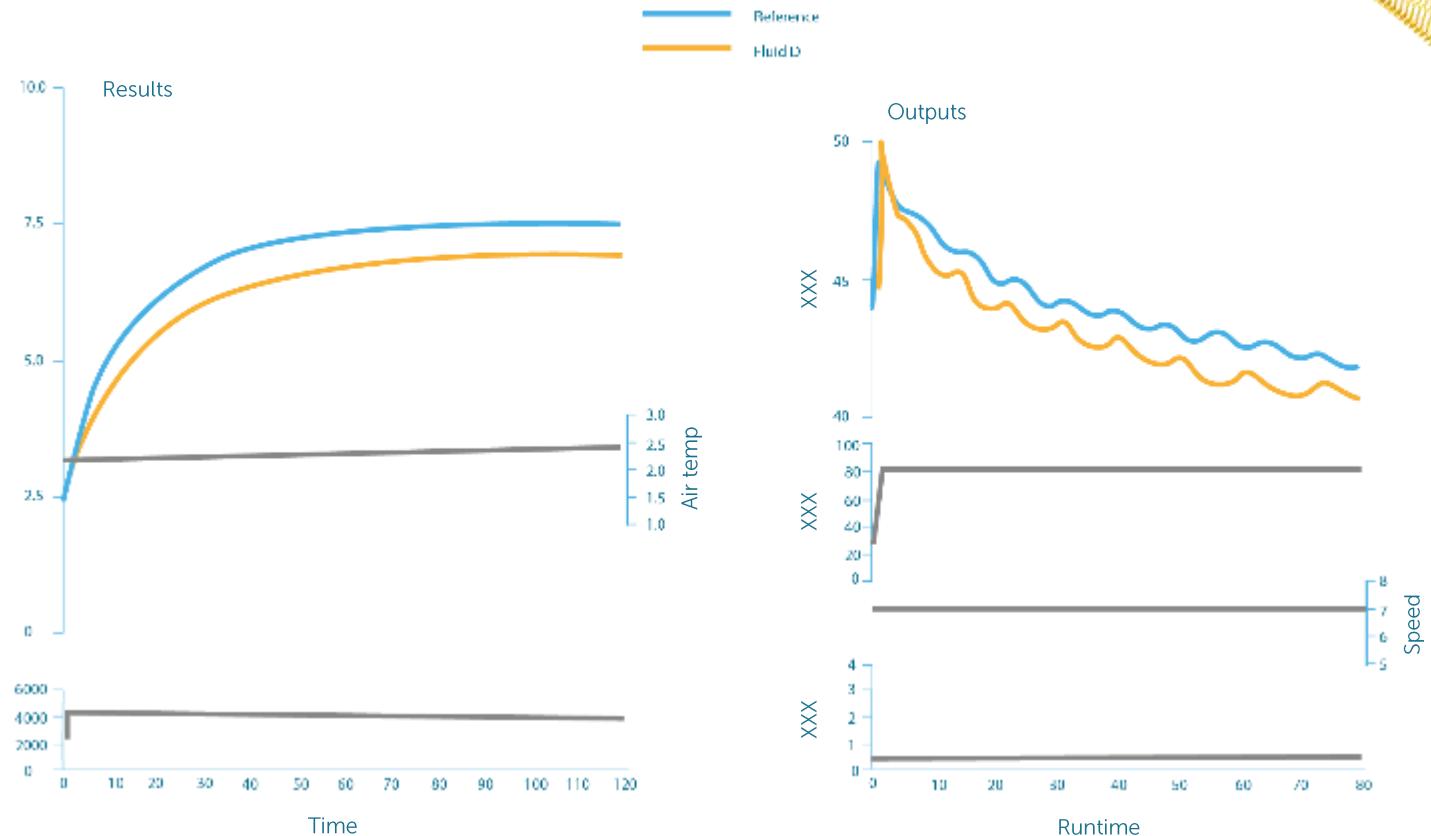
IONA candidates design approach

2. Lubrication of Reduction Gear

Together with advanced High Heat Capacity & Thermal Conductivity, the friction reduction is a key contributor to the cooling capacity.

IONA fluids developed by PETRONAS are able to noticeably reduce the friction without compromising the system durability, offering high efficiency & protection potential for the reduction gear

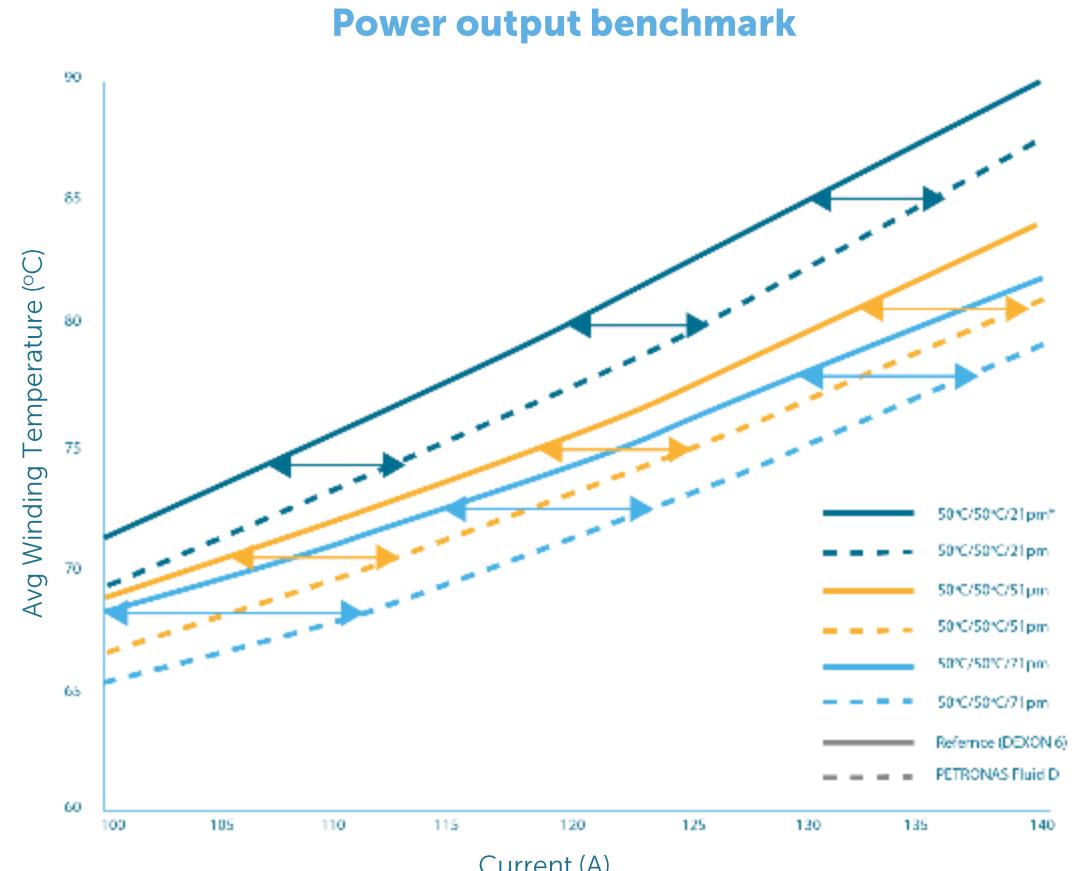
Thermal Gradient Shows Efficiency in Gears



IONA candidates design approach

3. Performance

- Thanks to the outstanding thermal efficiency IONA fluids allow the use of higher current input generating higher power output at the same temperatures, increasing the e-motor power up to 10% compared to standard transmission fluids;
- The lower friction on reduction gears can further improve the thermal efficiency and the overall performance;
- Ongoing developments will increase these numbers even further;



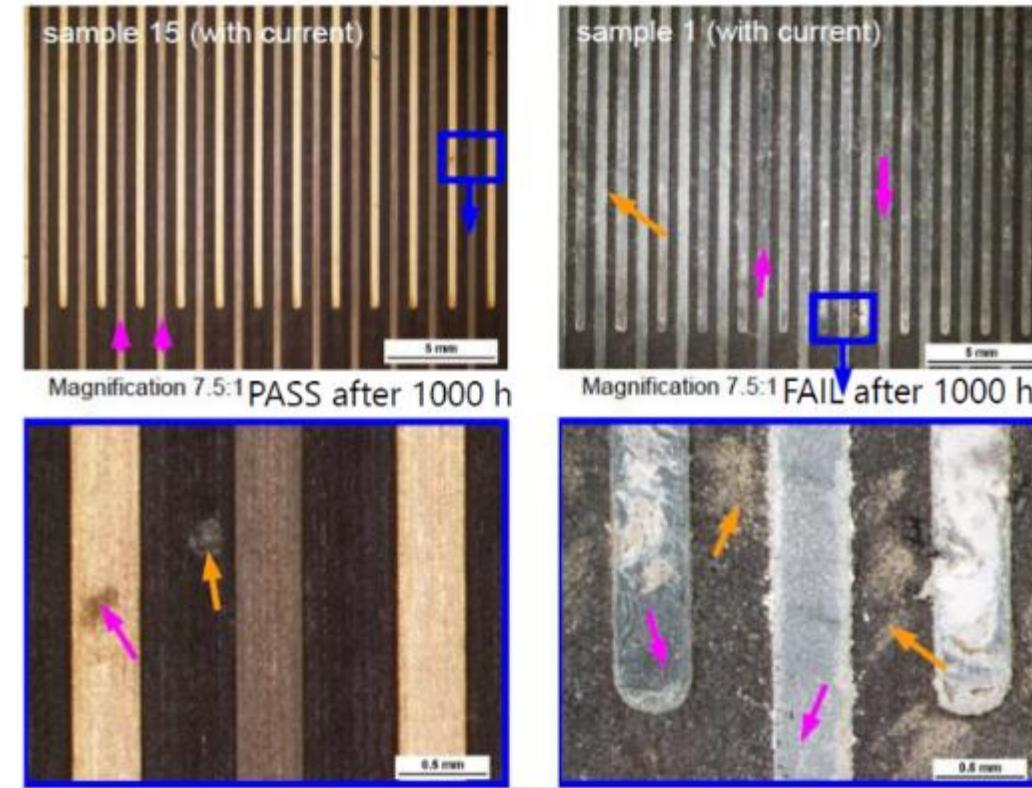
*Oil temperature/water temperature/flow

IONA candidates design approach

4. Material Compatibility

- Dedicated corrosion tests need to be used for the development of fluids for Integrated Electric Drive Unit, only such methods allow to verify the real compatibility between fluid and components
- IONA fluids are designed and tested ensuring full compatibility with electronic parts and last generation plastic materials, keeping high system reliability.

Material corrosion test



Iona Thermal key design approach

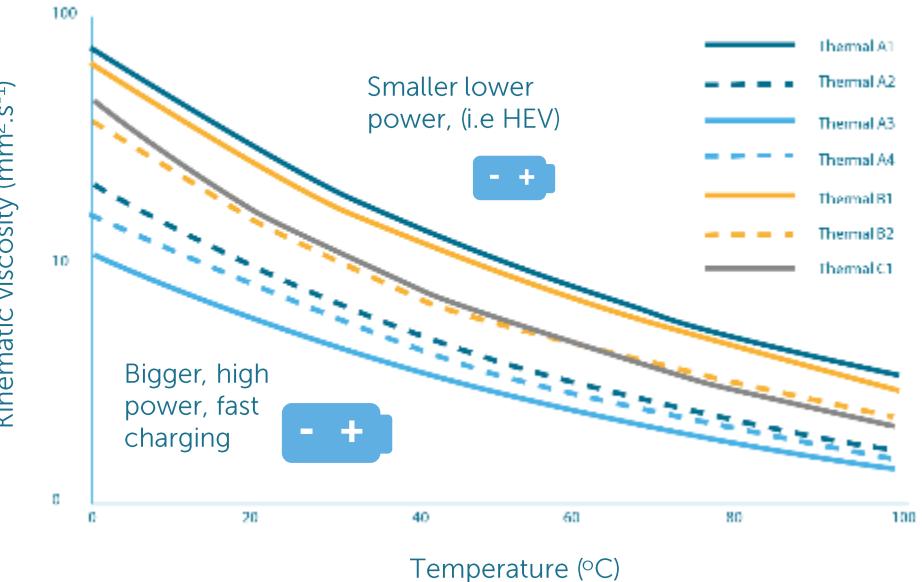
Batteries protection

- The fluid viscosity is an important feature for efficient thermal transfer
- In the application temperature range, the battery characteristics define the viscosity requirements
- At low temperatures (down to -40°C), the fluid must provide the correct working of the pumps to keep the system working;
- At high temperatures, especially during fast charging operations, the fluid must provide the proper cooling to avoid batteries damages;

PLI has developed a full set of IONA thermal fluids to satisfy the various requirements of EV batteries, allowing:

- Optimized thermal management in the different temperature's ranges;
- Advanced batteries protection during the charging cycle to improve lifetime.

Viscosity in application temperature range & at low temperatures



Accelerating efficiency with Immersion Thermal Management

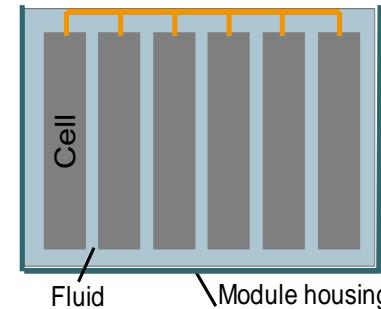
Main advantages of direct cooling

- Less complex battery pack design
- Higher performance battery packs
 - ⑩ System cooling coefficients are higher with immersion cooling compared to indirect cooling (up to + 40% overall)
 - ⑩ Minimised thermal gradient within the cells
- More integrated battery design allows for new thermal management strategies



Submerging

Cells submerged in dielectric coolant

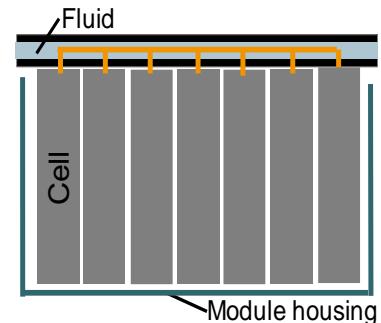


- Complete cell surface
- Homogeneous heat dissipation
- Difficult fluid flow control



Cell tab

Cell tabs/busbars in direct contact with dielectric coolant



- Electric conductor acts as heatsink
- Heat transfer at hottest spot