



THE FUTURE OF MOBILITY

August | 2019

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INTRODUCTION

WELCOME

Welcome to this latest Mobility Newsletter from CBMM.

The purpose of this Newsletter is to share news, information and insights – with partners and stakeholders who are interested and involved in progressing important Mobility matters.

This issue explores life after the internal combustion engine and some of the infrastructure challenges to create a sustainable transportation system. The Newsletter also outlines the potential and value of Niobium materials technology in a range of applications – including in the new and exciting Extreme E race series, supported by CBMM Niobium. Also included are highlights and links to the recent CBMM & Partners Mobility Leadership Debates and Mobility Perspectives interviews, filmed in NYC in July. There is also a look at the close to Formula E Season 5 in NYC, plus a sneak preview of Season 6 ahead.

CBMM is committed to developing mutual understanding and partnerships with regard to innovative and effective approaches to... Materials Technology, E Mobility & Smart Cities. It is only possible to cover chosen subjects in high-level detail, so for most

subjects, contact information is provided, to encourage further subject exploration, communication and understanding.

We hope that you find this communication interesting and valuable, and so we look forward to receiving any feedback on this Newsletter issue.



Rodrigo Amado

Head of Mobility CBMM



TRENDS IN MOBILITY

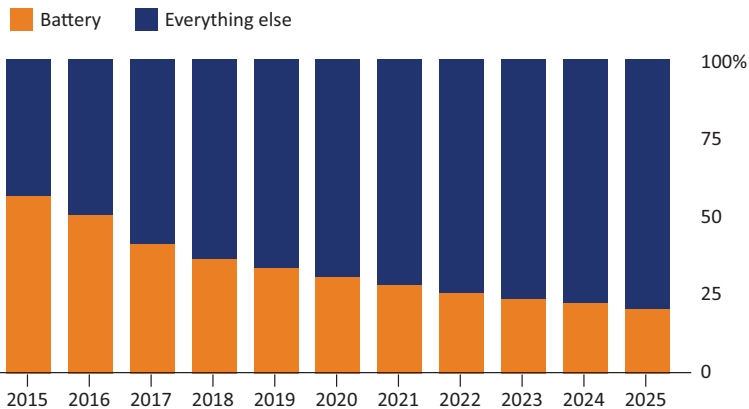
THE END OF THE ICE AGE

7 reasons why ICE is a dead man walking

The age of the Internal Combustion Engine (ICE) is over. Electric cars are the future. The transition has just begun, but the move from ICE vehicles to Electric will happen sooner and more quickly than most people suspect. What are the factors that lead me to say this with such confidence?

The Incredible Shrinking Car Battery

EV battery cost for U.S. medium-size car as a percentage of retail price



Note: Includes profit margins and costs other than direct manufacturing costs
Source: BloombergNEF

1 China says so!

China is now the world's largest car market, accounting for **30% of global car sales annually**. However, China has passed a law which requires **any vehicle maker to obtain a new energy vehicle score of at least 10% by 2019**, which rises to 12% by 2020, and on up to 20% of sales by 2025.

A slew of announcements has followed from car manufacturers about the **10's of billions of dollars** or **Euros they are investing in their EV development programs** and the **partnerships** or **huge investments** they are creating to secure their battery supply chain. **VW for example are retooling 16 factories to build electric vehicles and plan to produce 33 different models of electric vehicles by 2023**. They have said **they will require 300 gWh of batteries a year by 2025** which, if we assume an average 75 kWh battery per vehicle equates to 4 million vehicles. And they say this will double by 2030. For context VW's annual sales today are around 10m vehicles a year.

2 Battery Costs are falling

A significant part of the cost of an electric vehicle is the cost of the battery. However, the price of these batteries is falling 20% per year.

The crossover point – when electric vehicles become cheaper than their combustion engine equivalents is

rapidly approaching. BloombergNEF in their 2017 analysis forecast that this would happen in 2026. In their 2018 report, they predicted it would happen in 2024. Now **their 2019 analysis** puts the crossover point at 2022, just 3 short years away.

3 Battery capacity is increasing

Lithium-Ion batteries are increasing in energy density at a rate of 5-8% per annum. Mercedes has said that their fully electric Mercedes EQC, which will come to market in 2019, **will have an expected range of 500km**. While the Tesla Roadster, which launches in 2020, **has a stated range of 1,000km**. When Electric Vehicles have a range of 1,000km, it is the ICE vehicles which start to have a range problem.

Moreover, other battery technologies like **solid-state batteries** will come on stream giving us batteries that are cheaper, faster charging, and with even greater range still.

4 Electric car batteries have a very long life

Contrary to what many believe, the batteries in electric vehicles don't degrade over time (or over miles/kilometers driven either).

Data from Tesla owners shows that their cars lose around 1% of range for every 30,000 km driven.



around 1% of range for every 30,000 km driven. So, by 300,000 km, the battery is still at 90% of original capacity, and Elon Musk has stated that in 2020, [Tesla batteries will have an expected lifetime of 1.6m km.](#)

This means that the upfront cost of an electric vehicle can be depreciated over a far longer time lowering the vehicle's total cost of ownership significantly – EVs will just keep on working.

5 Electric vehicles are more reliable

Another factor in favour of electric vehicles is that they are far more reliable. The drivetrain in an ICE vehicle contains 2,000+ moving parts typically, whereas the drivetrain in an EV contains around 20. A quick scan of the [top 10 cars repairs of 2015](#) is telling. Only one of these faults can happen to an electric vehicle (number 4, and it is by far the cheapest to fix).

6 Cheaper to Fuel

Electric vehicles are typically significantly cheaper to fuel as well (unless you happen to live somewhere that has particularly cheap petrol and extremely expensive electricity). And with the price of carbon increasing in many markets, finding somewhere with cheap petrol will become increasingly difficult.

7 Resale value of ICE vehicles

Lastly, as outlined above:

- the number of models of electric vehicles available for sale is about to increase enormously
- the purchase price of electric vehicles is falling significantly
- the range of electric vehicles about to match or even surpass ICE vehicles
- EVs have essentially zero maintenance issues apart from the need to replace brakes and tyres (and with regenerative braking, brake pad wear is minimal)
- the batteries in EVs last hundreds of thousands of miles/kilometers with minimal degradation;
- and EVs are cheaper to fuel.

So why would anyone consider buying a car with an Internal Combustion Engine? Increasingly people won't. And consequently, the resale value of ICE vehicles will collapse.

And if the resale value of ICE automobiles is going to collapse in 3-4 years, why would you buy one today? Think about that for a second. Why would you buy an Internal Combustion Engine vehicle today, if its resale value in 3-4 years will have fallen significantly? You wouldn't. And when people start to realise that, the market will flip. And it will happen quickly. Sooner than most people think.

Finally

And if none of that convinces you, maybe check out the rest of the specs for the Tesla Roadster - 0-100kmh (0-60mph) in 1.9 seconds, top speed of 400kmh (250mph), and range of 1,000km (620 miles).

Or maybe watch a [prototype electric Ford F-150 pull 10 train carriages containing 42 F-150's weighing a total of 544,000kg \(1.2m ibs\)](#) a feat that has never been achieved by an internal combustion truck.

And I haven't even mentioned the growing [list of cities](#) that are passing legislation to [ban diesel engine vehicles from driving on their streets!](#)

One last thought, when electric vehicles start to become more common, drivers of internal combustion engine vehicles will be thought of the way smokers are regarded today. And, as fewer petrol (gas) stations will be needed, so they will either need to close down, or convert to electric fuelling stations. As they are shuttered, people with internal combustion engine vehicles will have to travel further and further to find a place to fill up. This inevitable vicious circle means it really is game over for the internal combustion engine.



Written by
**Tom Raftery, Global VP,
Futurist, Innovation
Evangelist at SAP**

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■ CREATING A SUSTAINABLE TRANSPORTATION SYSTEM

The growth in the electric vehicle (EV) market is undoubtedly gaining pace, with some commentators predicting there will be 559 million EVs on the road by 2040 and 55% of all new car sales and 33% of the global fleet will be electric. ABB is witnessing surging demand for public and private EV charging solutions, having sold more than 11,000 DC fast chargers across 76 countries. We are also supporting stakeholders across the globe to establish electric bus services.

We believe there are three key disruptions aligned to the delivery of sustainable transportation.

Firstly, we need to see continued investment in the sector, both in the development of battery technology to enable greater range and cost efficiencies, but also critically in the development of a widespread charging infrastructure network to satisfy growing demand.

In many markets, the current reality paints a different picture. When we look at the United States for example, while 361,000 EVs were sold in 2018, the country's charging infrastructure is still 'lagging behind', with consumers lacking confidence and 'range anxiety' being a major barrier to EV adoption.

In response, we are proud to be collaborating with charging operators such as EVgo and Electrify America who are transforming the US with nationwide charging networks.

Secondly, we must focus on standardization and

interoperability. The automotive industry only needs to look at the electric public transport sector to see that adoption rates are significantly increased as the number of charging standards decrease. If we want to create positive change for the future, now is the time to replicate this for passenger vehicles.

Thirdly, we need to accept that we have to evolve our energy ecosystem to enable an emission-free future. A reliable power infrastructure with low maintenance costs is key for modern cities to address peaks in demand. That's why enabling safe, flexible and smart electrical networks is of crucial importance.



FUTURE PROOFING WITH HIGH-POWER CHARGING SOLUTIONS

Currently, the pace of change, both in commercial and consumer markets, is being driven by the need for faster and higher power charging. The sector is however faced by one key challenge, the capabilities of current EV batteries.

At the moment, DC charging is still too powerful for most consumer vehicles, but all that may be about to change with the launch of cars capable of taking higher power, like the Porsche Taycan which will be launched later this year or the Tesla Model 3 already on the market, just like the Audi E-Tron.

Technology like our Terra High Power charger, serves as a future proof

solution which will support the development of next generation EVs. Capable of delivering 350kW of power, it can add 200 km of range to an EV in a time frame not much longer than refueling a traditional gas engine vehicle (8 minutes).

Meanwhile, for buses and trucks, the industry is currently limited to a maximum charge of 600kW. We are confident that there is potential for evolution here too, with 1MW charging on the horizon. Our \$10million investment in a new R&D Center, due to launch this September, includes facilities for expanding our capabilities in the rapidly expanding eBus segment and will see us continuing to evolve pioneering solutions in this field.

Written by
Frank Muehlon,
Global Head of ABB's
E-Mobility Infrastructure
Solutions business

For further information
about ABB [click here](#)





■ A BRIGHT FUTURE IN VIEW



As one of the largest and most successful automotive suppliers in the world, Magna is uniquely placed to consider the challenges and opportunities presented in a new and exciting mobility landscape.

By leveraging experience, new technologies, size and scale, no other supplier is or will be as ready to lead the new mobility landscape as Magna is.

There are a lot of bold predictions about electrification and autonomy as the bedrock of future mobility; and new ownership models are entering the market. This is leading to vehicles becoming more connected, more intuitive, safer and smarter. Further, artificial intelligence, VR, AR and ADAS technologies are driving radical changes that will dramatically impact all aspects of our world. All while society is addressing real changes to the planet like

urbanization and global warming. There are two things we know for sure: The world is changing and the way people travel from point A to point B will be different.

Open for Business to Address Changing Needs

The next generation of Mobility is being defined by a new class of service providers. Cities are beginning to dictate requirements for EV's and autonomous capability – making shared mobility multifunctional the next step in improving city access and passenger movement. That's why Magna is collaborating with some of the brightest startups, universities

and auto-qualifying solutions from unlikely industries. These partnerships provide valuable insight and data into use cases, design requirements and how consumers are thinking of future mobility products and services.

The pace of innovation is accelerating; and our industry is not becoming less complex. As we look toward the bright future ahead, we continue to identify, invest and partner to accelerate technologies to automotive maturity, and create a bright mobility future for all.

For further information about Magna
International visit www.magna.com



NIOBIMUM TECHNOLOGY APPLICATIONS

CBMM AND EXTREME E PARTNERSHIP

Created by the founders of Formula E, Extreme E is a radical new concept, bringing electric racing to some of the most remote corners of the planet – to highlight the climate change challenges faced by different ecosystems, whilst showcasing the performance of all-electric SUVs in extreme conditions.

Extreme E is a competitive platform for accelerating the development of electric vehicles, to help create a low-carbon future powered by renewable energy. Extreme E is committed to supporting and partnering with organisations working to restore the degraded environments in which we race, the precious ecosystems within them and the people who live there.

Above all, the aim is to raise awareness and inspire action to encourage every individual to come together and play their part to safeguard the future of the Earth and all its inhabitants.

In December 2018, CBMM committed to support the launch of Extreme E, with the intention to deliver this unique off-road motorsport series in 2021. Now as a founding supplier, all Extreme E vehicles will feature added value Niobium Technology. As well as playing a key role in championship vehicles, Niobium Technology will also be used on board Extreme E's unique floating paddock – the RMS St. Helena, which will be used to transport the cars, and run the championship's operations and logistics around the world.

"We're delighted that CBMM has chosen to be a founding partner with Extreme E. They are a world leader and global advocate in the application of niobium across a range of products and share our vision of advancing sustainable technology and mobility. Extreme E's unique set of challenges, top-level competition, and harsh, demanding environments will no doubt be invaluable as a research and development platform for the company, and in the push to raise awareness of niobium technology's potential use-cases and its many benefits."

*Alejandro Agag, Founder & CEO of
Formula E - operating partner of Extreme E*

"We are very honoured to be part of Extreme E's journey as a Founding Supplier. We believe niobium will play a key role to increase the safety and the autonomy of cutting-edge electric SUVs. CBMM's ambition is to offer more sustainable solutions to the challenges of modern society. Extreme E's decision to use niobium technology proves its commitment to the environment."

Adalberto Parreira, Commercial Director

CBMM



For further information about Extreme E click [here](#) .
If you want to know more about the role Niobium plays in improving vehicle qualities and performance, click [here](#)."



FUTURE TECHNOLOGIES & VALUE – NOW

Efficient E Engines

Niobium based materials (Nanocrystalline materials) are more efficient than currently used materials in the process of converting electrical energy from the battery into motion, especially in higher frequencies, playing an important role not only in recently developed electric motors, but also in inverter components.

Stronger Structures

Niobium's benefits include increasing lightness, strength and toughness whilst simultaneously improving formability and weldability of key components. In addition, Niobium can significantly improve production process efficiencies making vehicles easier and cheaper to produce. Possible weight savings of between 10% and 20% in vehicle parts and up to a 15% reduction in steel volumes. Typical structural applications include: vehicle chassis frame, body panels, and other steel and aluminium components .

Smart Windows

Niobium oxide glass is under development to create smart windows that can dynamically control the amount of visible sunlight and solar heat into a vehicle. Niobium smart windows improve the driver and passenger experience and enable fuel savings whilst decreasing CO2 emissions.

Advanced Engines

Niobium technologies can make engine blocks and cylinder heads lighter, stronger and more resistant to wear and failure. The inclusion of Niobium also allows for more complex and innovative designs to be produced without loss of performance or reliability.

Resilient Electronics

A range of niobium products can be used to produce capacitors, inductors and other components including... Sensors e.g. rain, light sensor, seat weight, gear box, drive train, temperature, parking, tyre pressure, airbags and battery cell temperature - Electric Controls e.g. seat adjustment and heating, window and mirror adjustment, fuel, water, oil and water pumps, lamp/LED driver and electronic power steering and - Electronic Circuits e.g. air conditioning, GPS location system, infotainment, satellite radio, keyless system, cruise control, remote start, start-stop system, power converters, crash avoidance circuit, telematics control unit, dashboard systems and car alarms.

Safer Batteries

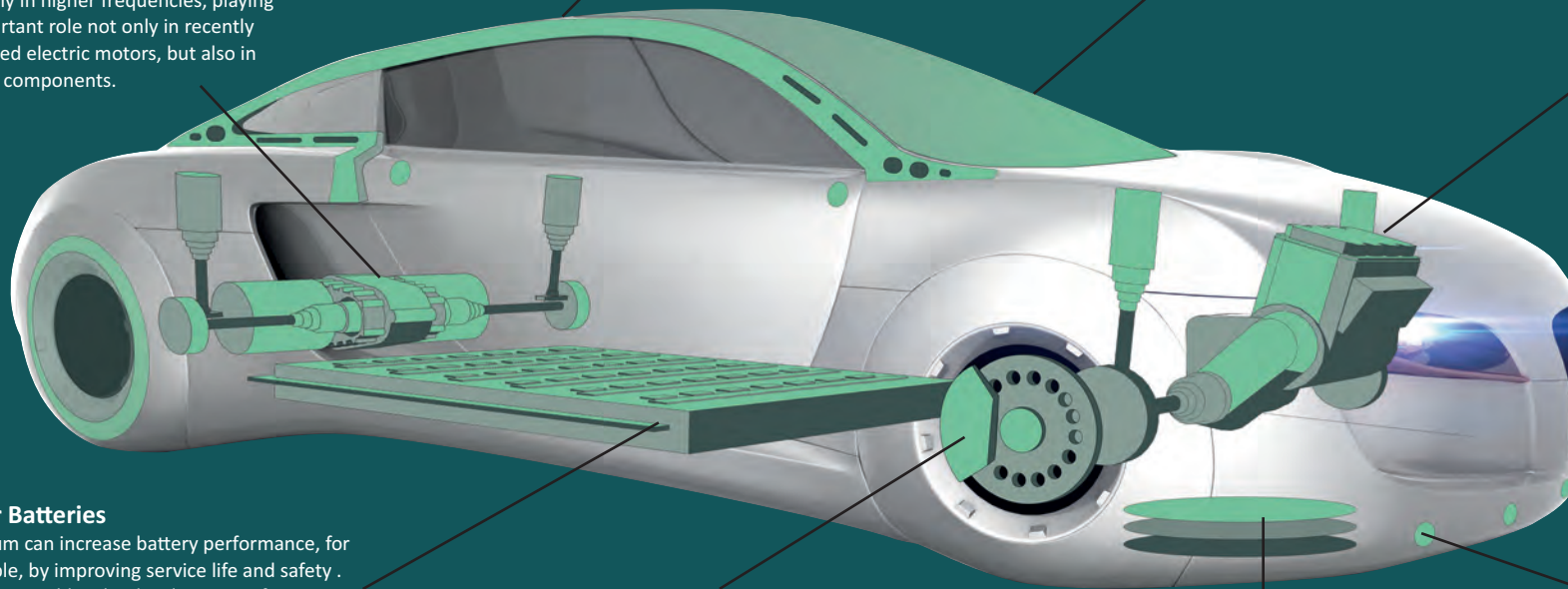
Niobium can increase battery performance, for example, by improving service life and safety . Niobium enables the development of new electrode materials directed towards increasing the amount of stored energy or enabling faster charging times. The niobium-containing electrode capable of fast-charging also helps prevent short circuits that cause fires, resulting in safer batteries with longer life cycles.

Better Drivetrain, Brakes and Wheels

Niobium technologies can make gearboxes, gears, and transmissions lighter, stronger and more resistant to wear and failure. Niobium in aluminium or steel wheels can make them lighter and stronger while also allowing for more innovative designs. The application of niobium in brake rotors significantly increase its fatigue resistance, allowing for longer service life or lightweight designs.

Faster Wireless Charging

Niobium nanocrystalline materials can be used to improve magnetic shielding in wireless charging devices to improve the efficiency of charging, reducing electrical losses.



FUTURE TECHNOLOGIES & VALUE – NOW

ADVANCED MATERIALS TECHNOLOGY

Through its own R&D programmes and collaboration with technical partners, CBMM is constantly developing new product applications where Niobium can improve product qualities and performance characteristics.



NIObIUM ADVANCED MATERIALS TECHNOLOGY DELIVERING POSITIVE BENEFITS AND VALUE



BETTER PERFORMANCE

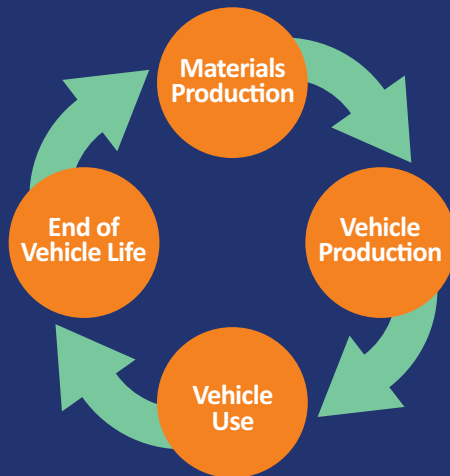
- Niobium produces stronger, lighter and tougher vehicles
- Possible weight savings of between 10% and 20% in vehicle parts
- Up to a 15% reduction in steel volumes
- Vehicles are easier to make and with better product quality



IMPROVED SAFETY

- Niobium components are more wear resistant
- Niobium components are more reliable
- Lightweighting enables additional safety and comfort features

Niobium increases sustainability in all stages of the automotive industry



CLEANER ENVIRONMENT

- Niobium reduces use of materials and emissions
- Niobium reduces fuel consumption due to lightweighting
- Niobium components are 100% recyclable



INCREASED VALUE

- Niobium products last longer
- Lightweighting reduces fuel costs and tyre wear
- Niobium helps to reduce production costs



ADVANCED TECHNOLOGY

- New Niobium applications are continuously being developed
- Stronger, lighter high-performance steels – and innovative Niobium aluminium products
- Niobium technologies are being developed for batteries, sensors, wireless charging and glass

Nb
Niobium
92.90637



MOBILITY LEADERSHIP

MOBILITY LEADERSHIP DEBATES

In New York City in July, a number of leaders in the development of a new mobility sector met to discuss challenges and opportunities to build a better future. Subjects discussed included... the development of passenger and commercial vehicle EVs, the future for AI and autonomous vehicles and micromobility, battery and energy innovations, emerging sector trends, insights and partnerships, technological and advanced materials developments. Overall, across the three panel sessions the debate covered not only mobility sector strategy, but also looked at a number of specific mobility case studies helping to bring to life and make real a bright new mobility future.

Valuable insights were shared and debated in each of the three **Mobility Leadership Debate** sessions, and these insights can be accessed via the links below:

Mobility Trends and Challenges – with panellists from... ABB, CBMM, EY, Formula E/Extreme E, and Porsche Consulting (For Debate Highlights click [here](#). For the un-cut Debate – click [here](#))

Battery and Energy Innovations – panellists... A2Mac1, Boston Strategies International, CBMM, Enel X, McLaren Applied Technologies (Debate Highlights – click [here](#). Un-cut Debate – click [here](#))

Other Mobility Innovations – panellists... CBMM, EDG & Roborace CEO and Formula E Champion – Lucas Di Grassi, SAP, and Urban Arrow (Debate Highlights – click [here](#). Un-cut Debate – click [here](#))

MOBILITY PERSPECTIVES INTERVIEWS

Alongside filming of panel sessions, all panellists were interviewed individually – to capture additional personal perspectives on a number of complementary mobility matters. In addition, later at the Formula E track, further mobility perspectives were obtained from... Formula E team principals (Audi and NIO), Formula E Partners (DHL and Magna).

Highlights from the valuable perspectives and insights obtained can be accessed via the links below:

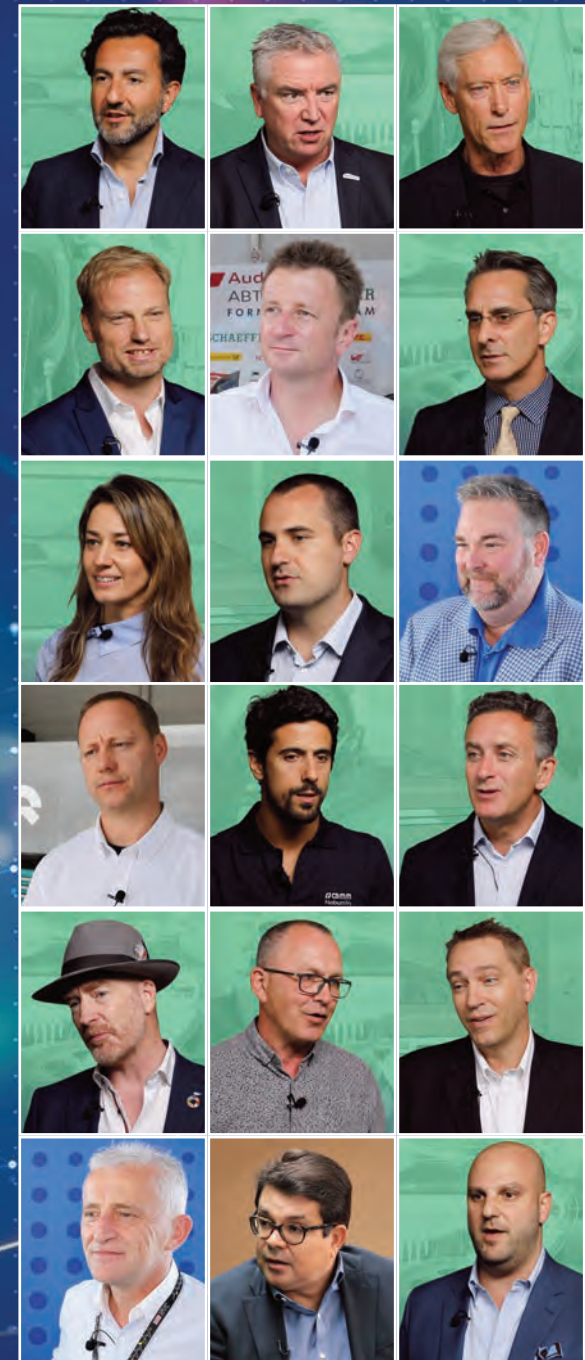
Mobility Perspectives : Technology Innovation – [click here](#)

Mobility Perspectives : Advanced Materials – [click here](#)

Mobility Perspectives : Partnerships – [click here](#)

Mobility Perspectives : Future View – [click here](#)

For further information about participating in future CBMM & Partners Mobility Leadership events, please see contact information at the end of this Newsletter.





FORMULA E

FORMULA E BMW i BERLIN E PRIX PRESENTED BY CBMM NIOBIUM

CBMM was 'Presenting Partner' for the Formula E BMW i Berlin E Prix.

Once again, CBMM ran a highly successful Mobility Tech Day Workshop in Berlin, with over 75 VIP guests attending from across Europe and the rest of the world. Interactive presentations were delivered by a number of sector leaders. Subjects covered included... Mobility Trends, Materials and Lightweighting, Battery and Energy Innovations and a number of Mobility Innovation Case Studies were shared.

As with all CBMM and Partners Tech Day Workshops, there is a balance between presentations, Q&A discussion and networking, to create the ideal platform for further exploration and development of mutually rewarding business collaboration.

Guests at the Tech Day Workshop also went on to experience the full VIP race day experience at the track - including presentations at team Garages and once again seeing Formula E Champion and CBMM Partner Lucas Di Grassi win the Berlin E Prix.

"Great event - congratulations. Well done as always"

Aperam

"Thanks for this wonderful workshop and Formula E experience!!"

Avicenne Energy

"Thanks for the perfect organisation of the event"

Fiat FCA

"Thanks to all the CBMM team for a fantastic couple of days"

University of Huddersfield



SEASON 5 FINALE

New York City saw the conclusion of the Season 5 Formula E Championship - with the winner being Jean-Eric Vergne, driving for DS Techeetah - who also won the Team Championship. Past Champion Lucas Di Grassi came 3rd in the Championship.

Across the final 2 race days in NYC, panellists from the Mobility Leadership Debate sessions, plus a number of other specially invited CBMM mobility sector guests, experienced a VIP Formula E experience.

"It was an amazing experience, deeply enriching and valuable" SAP

"A big thank you to CBMM. The electric future has already started today" Ford

"True leadership! Thanks for making all this happen" Boston Strategies International

"A great event and opportunity to meet others shaping the mobility sector" ABB

If you have not already seen the CBMM & Partners Formula E & Mobility Tech Day Season 5 Review document click [here](#) to view.





SEASON 5 AWARDS

As a returning sponsor of the annual Formula E Awards, CBMM presented the Season 5 CBMM Niobium WOW Moment Award. Fittingly, the Award went to Lucas Di Grassi, for his dramatic last lap win at the CBMM Niobium E Prix in Mexico City. For full details of Season 5 Award winners click [here](#).

SEASON 6 SNEAK PREVIEW

Planning is already underway for Season 6. New teams are entering Formula E including Porsche and Mercedes, which will make the championship even more exciting and competitive. In addition, new race locations have been announced, including Seoul and London.

Yet again, CBMM will evolve and grow its Mobility Tech Day and Mobility Debate event programmes, with expanded events being planned in Asia, Europe and North America. More details on these events will be announced later in 2019.

For further information about the Season 6 Formula E calendar click [here](#). To register interest in attending a future CBMM & Partners event and Formula E race please see contacts at the end of this Newsletter.



■ OPPORTUNITIES TO COLLABORATE

BUILDING THE FUTURE TOGETHER

A team of 1,800+ CBMM professionals is committed to providing cutting-edge niobium products and technology to more than 300 customers in 50 countries.

CBMM's technology initiatives and innovations are developed in two ways. First, the company's Technology Center is located at the world leading industrial complex in Araxá, Brazil and focuses on enhancing the production processes of existing niobium products and at the same time developing exciting new products.

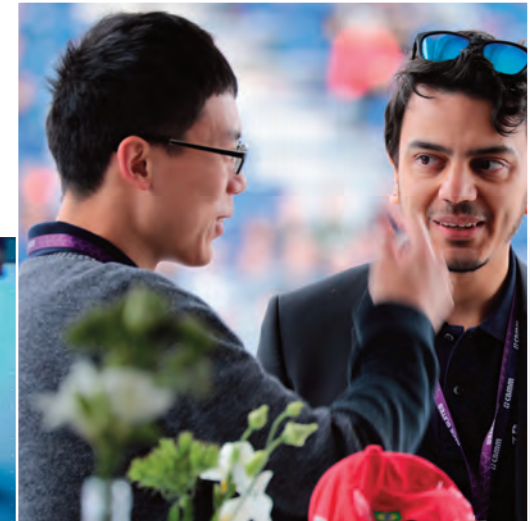
The company also has a technology subsidiary, CBMM Technology Suisse, based in Geneva which coordinates efforts to develop new niobium applications worldwide.

For over 20 years CBMM has successfully partnered with a number of leading international organisations to research, develop and introduce new technologies to automotive, mobility and other markets.

Current partners include:

- Leading Universities in China, Europe and North and South America
- Technology R&D and Innovation Consultancies around the world
- Tier 1 & 2 Suppliers around the globe
- Established OEMs and new entrants into the automotive and mobility sectors.

To explore and discuss opportunities for potential partnership to develop and apply new high-value materials technologies, please contact CBMM Head of Technology Rafael Mesquita at rafael.mesquita@cbmm.com



CONTACT

FOR MORE INFORMATION

If you would like to know more about CBMM's mobility programmes – please contact CBMM Head of Mobility Rodrigo Amado at: rodrigo.amado@cbmm.com

And you can click [here](#) to find out more about niobium technologies and mobility programmes.

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