UK-Saudi Electric Vehicles Enhanced Education and Research Network

A report on the workshop carried out at Brunel University during the period from 24 – 30 November 2022

The purpose of this workshop is to provide a more practical and interactive approach to education and research in the area of Electric Vehicles between UK and KSA. Four Students and two academics from KSA attended the workshop as well as 5 academics and 10 students from the UK. Two industrial invited speakers and six academic invited speakers have also attended the work shop. The full programme of the work shop is attached in the appendix.

During a workshop, participants are were introduced to the topic through several presentations. Following this, they are then given hands-on exercises to put the learning into practice. The workshop facilitator provided support and guidance along the way. Three industrial visits were organised during the workshop (Industrial visit to Brill Power Battery Charging; Industrial visit to Braintree GRIDSERVE-EV Forecourt; and a visit to London EV show).

Day 1 activities included a welcome talk to all delegates by Dr Darwish, followed by a brief introduction by the head of department (Professor Gareth Taylor). Dr Eydhah Almatrafi, KSA has then presented a brief introduction about King Abdulaziz University, Rabigh. Project progress was then presented by Dr Darwish. Applications of AI in EV Systems was presented by Professor Abbod (Brunel) followed by industrial presentation on Semiconductors in Autonomous Vehicles by Dr Alaa Alani (Sondrel Ltd, UK). In the afternoon a presentation on Hydrogen Powered Combustion Engine as a range extender for Electric Vehicles was given by Dr Xinyan Wang, Brunel. A Research-Led Teaching in Electric Vehicle Systems talk was delivered by Dr Chun Sing Lai, Brunel. Professor Amr Metwally (Grand Canyon University, Phoenix AZ, USA) has then given a presentation on Regenerative Breaking in EV. There was a networking discussion of all delegates at the end of the first day. Day 1 presentations are shown in the appendix.

Day 2 activities started with a talk by Professor Farrag (Glasgow Caledonian University, UK) on E-Scooter for Sustainable Societies followed by industrial speaker from Jerry Stokes (Executive Chairman, GRIDSERVE) on 'Overview of the GRIDSERVE "Sun-to-Wheel" Eco-system'. Dr Damien Frost, Brill Power, UK has then given presentation on Battery Management System in EV. In the afternoon of the second day all delegates visited Brill Power Battery Charging in Oxford. Presentations and some photos are are shown in the appendix.

Day 3 activities was mainly an industrial visit to Braintree GRIDSERVE-EV Forecourt, where all participants saw a real EV Forecourt located in Braintree. Listened to presentations and have a very informative tour and had the opportunity to ask questions. The appendix contains some of the photos during the visit.

Day 4 activities included a talk "Towards Connected Autonomous Vehicles Technology for Future Smart Cities Applications by Professor M. Shafik, University of Derby. The talk was followed by simulation session on EV driving range modelling and followed by practical session at Brunel electronics lab on EV management system. Activities and presentations of day 4 are given in the appendix.

Day 5 included a visit to the London EV show (one of the biggest EV shows in the world). On return to Brunel the consortium had a networking discussion on the requirements of Curriculum Development, and recommendation on engineering education and smart green technologies with the development of new EV courses for engineering programmes. The appendix contains some photos of day 5 activities.

The workshops covered a wide range of topics, including skills development within the EV industry, personal training during the simulation and practical sessions, and education development required for future engineers in both KSA and UK.

In conclusion, the workshop provided an effective way for individuals from KSA and UK to learn and develop new skills while interacting with others and sharing ideas. Some of the benefits, including increased engagement, hands-on learning, networking opportunities, and a chance to develop new solutions to challenging problems within the EV industry.

Appendix A: Full programme

UK-Saudi Electric Vehicles Enhanced Education and Research Network

Proposed Programme for the "UK-Saudi Electric Vehicles Enhanced Education and Research Network" workshop to be held at Brunel University, UK during the period from 24 – 30 November 2022

All Brunel events will be held in Michael sterling 057, Brunel University

Thursday 24 November:

9:00 – 9:30	Registration and coffee
9:30 – 9:40	Welcome to delegates (Dr Mohamed Darwish, Brunel)
9:40 – 10:00	Brief introduction about Brunel (Professor Gareth Taylor, Head of Department, Brunel)
10:00 – 10:15	Brief introduction about King Abdulaziz University, Rabigh (Dr Eydhah Almatrafi, KSA)
10:15 – 10:30	Project progress (Dr Mohamed Darwish, Brunel)
10:30 – 11:15	Applications of AI in EV Systems (Professor Maysam Abbod, Brunel)
11:15 – 12:15	Semiconductors in Autonomous Vehicles (Dr Alaa Alani, Sondrel Ltd)
12:15 – 13:30	Open discussion/networking and Lunch break
13:30 – 14:15	Hydrogen Powered Combustion Engine as a range extender for Electric Vehicles (Dr Xinyan Wang, Brunel)
14:15 – 15:00	Research-Led Teaching in Electric Vehicle Systems (Dr Chun Sing Lai, Brunel)
15:00 – 16:00	Regenerative Breaking in EV: What is it and how it works? (Professor Amr Metwally, Grand Canyon University, Phoenix AZ, USA)
16:00 – 17:00	Networking and tea break
18:00 – 20:00	Workshop dinner (Lancaster Hotel, Brunel)

Friday 25 November:

9:00 – 10:00	E-Scooter for Sustainable Societies (Professor M. E. Farrag, Glasgow Caledonian University)
10:00 – 11:00	An Overview of the GRIDSERVE "Sun-to-Wheel" Eco-system, Jerry Stokes (Executive Chairman, GRIDSERVE).

11:00 – 12:00 Battery Management System in EV by Dr Damien Frost, Brill Power, UK

12:00 – 13:00 Lunch break

13:00 – 17:00 Industrial visit to Brill Power Battery Charging (23 Park End Street, Oxford, OX1 1HU)

Saturday 26 November:

Free Day

Sunday 27 November:

A social Visit to Windsor (all day)

Monday 28 November:

9:00 – 17:00 Industrial visit to Braintree GRIDSERVE-EV Forecourt (Edison Wy., Braintree CM77 7AP)

Tuesday 29 November:

9:00 – 10:00 Industry 4.0, Drive and Fly by Wire: Towards Connected Autonomous Vehicles Technology for Future Smart Cities Applications (Professor M. Shafik, University of Derby)

10:00 – 10:30 Feedback discussion and tea break

10:30 – 12:30 Simulation session – EV Driving Range Modelling (Dr Chun Lai)

12:30 – 14:00 Lunch

14:00 – 17:00 Practical Lab session (Dr Xinyan Wang, Brunel)

Wednesday 30 November:

9:00 – 14:00 A visit to London EV show (ExCeL London, One Western Gateway, Royal Victoria Cock, London, E16 1XL). To attend the EV show you need to register at: https://londonevshow.com/

14:00 – 17:00 Curriculum Development, Workshop discussion / recommendation on engineering education and smart green technologies with the development of new EV courses for engineering programmes (All)

Appendix (Presentation Slides and Some Photos for the activities)

UK-Saudi Electric Vehicles Enhanced Education and Research Network

(Dr Mohamed Darwish)

Brunel University
24 – 30 November 2022

Brunel University London
BRITISH COUNCIL

UK-Saudi Electric Vehicles
Enhanced Education and
Research Network

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Brunel University London | BRITISH COUNCIL

UK-Saudi Electric Vehicles Enhanced Education and Research Network

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UK-Saudi Electric Vehicles Enhanced Education and Research Network

Progress of the project so far:

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UK-Saudi Electric Vehicles Enhanced Education and Research Network

- **Initial meeting /delivered agreed project plan**
- **3 further meetings**
- **A research paper published and presented in UPEC 2022**

  (Forecourt Electric Vehicles Charging Hubs – UK and Saudi Research and Education Collaboration)
- **Workshop (Brunel University)**

Industrial Support:

- GRIDSERVE
- Brill Power
- HVSS Ltd

UK-Saudi Electric Vehicles Enhanced Education and Research Network

Academic Support:

- **Glasgow Caledonian University** ***(Prof. Farrag)***
- **University of Derby** ***(Prof. Shafik)***
- **Cardiff University** ***(Prof. Liana Cipcigan)***
- **Cranfield University** ***(Prof. Patrick Luk)***
- **Birmingham University** ***(Dr Pietro Tricoli)***

Brunel University London

BRITISH COUNCIL

UK-Saudi Electric Vehicles Enhanced Education and Research Network

Brunel University London

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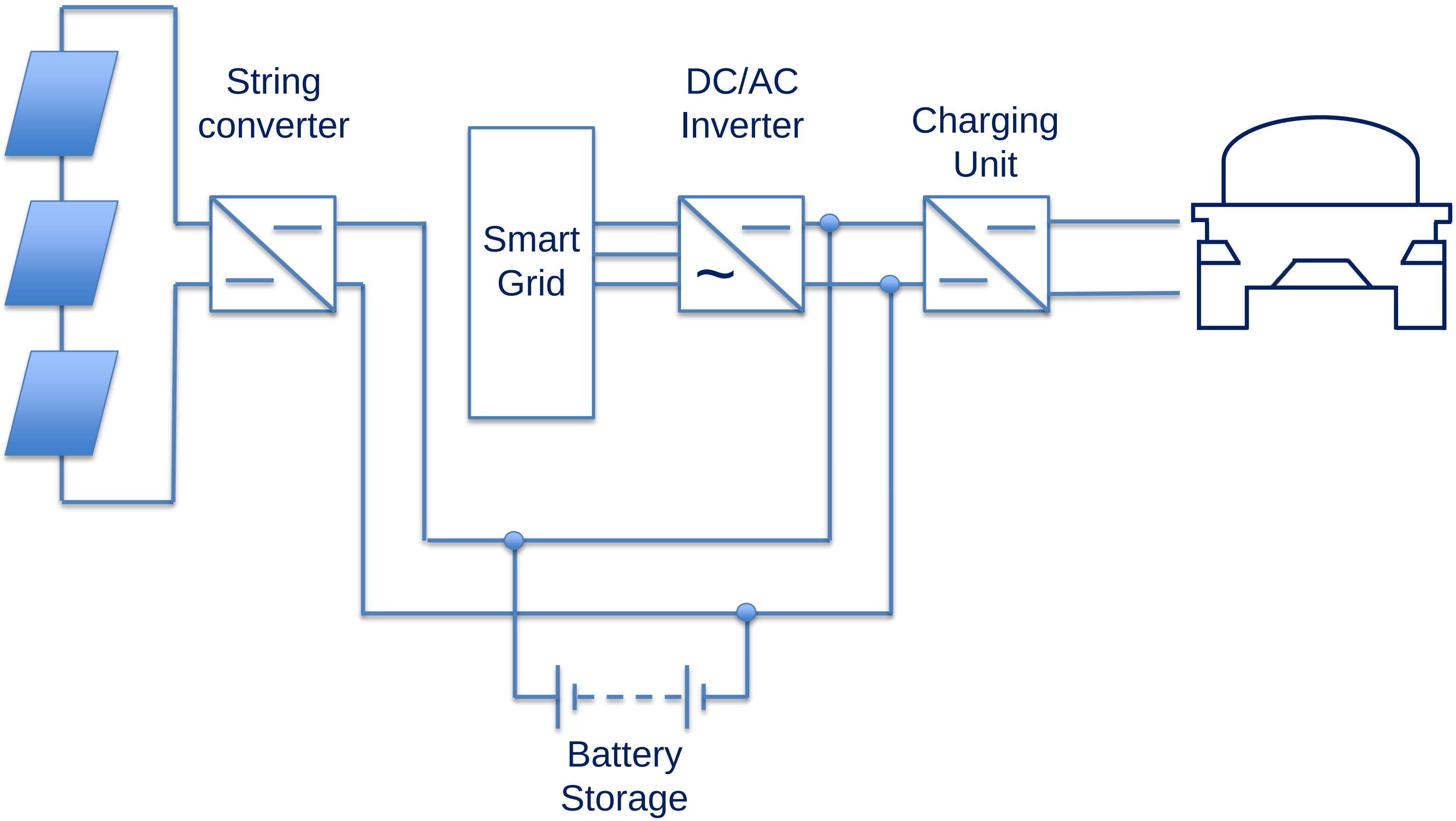
UK-Saudi Electric Vehicles Enhanced Education and Research Network

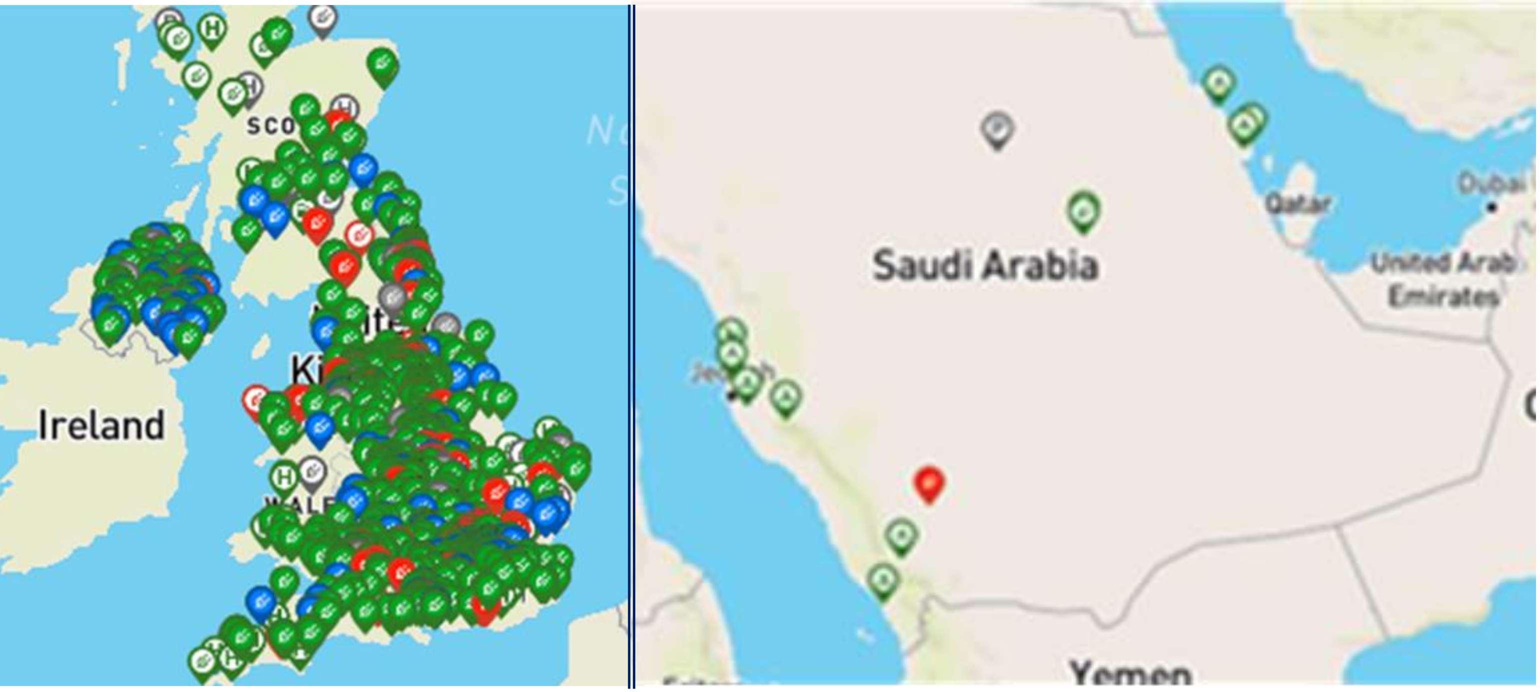
The project deals with how a successful model of electric vehicles (EV) forecourts in the UK can be implemented into KSA for supporting research, knowledge, and innovation in emerging EV technologies.

Example of a layout



UK-Saudi Electric Vehicles Enhanced Education and Research Network

Future EV Charging Infrastructure In UK and Saudi Arabia



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UK-Saudi Electric Vehicles Enhanced Education and Research Network

EV- Curriculum Development at Brunel

Brunel University EV conversion project

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UK-Saudi Electric Vehicles Enhanced Education and Research Network

EV- Curriculum Development at Brunel

Brunel University London

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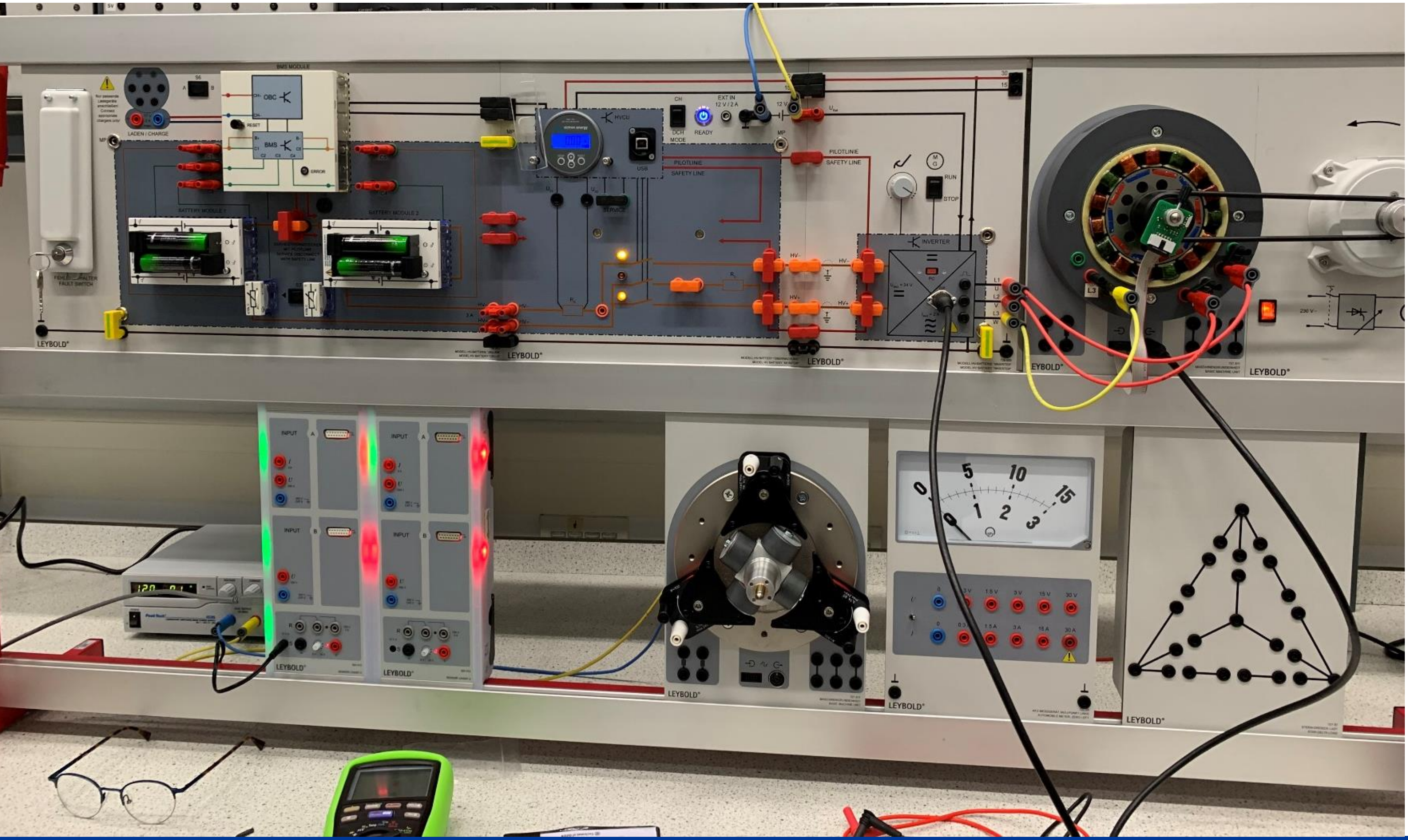
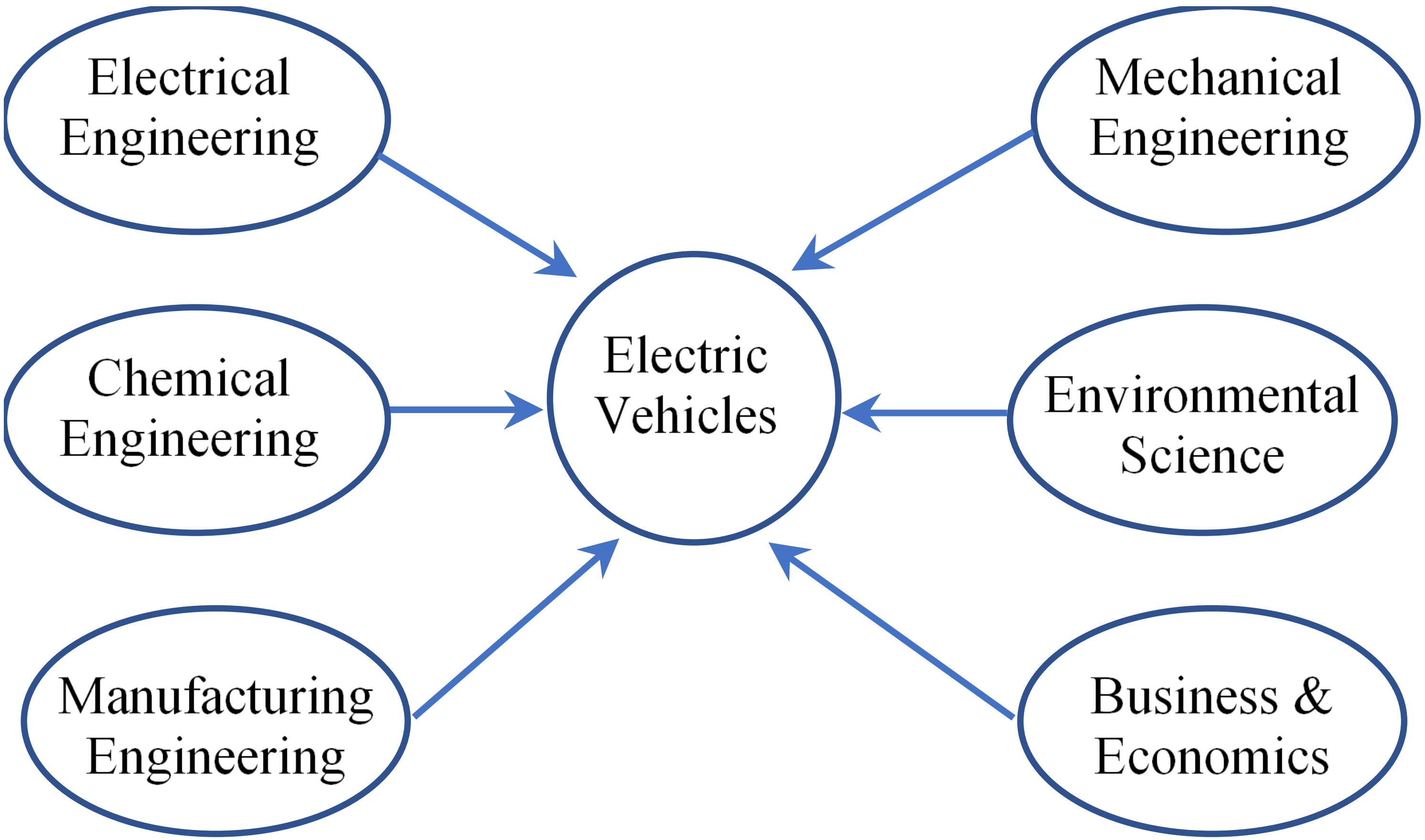
UK-Saudi Electric Vehicles Enhanced Education and Research Network



EV- Curriculum Development in general



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UK-Saudi Electric Vehicles Enhanced Education and Research Network

Research Collaboration

Projects Related to the EV Forecourts

- Optimisation of energy storage devices within the forecourt for maximum efficiency.
- Grid connection of the forecourt.
- Business modelling of EV forecourt.

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UK-Saudi Electric Vehicles Enhanced Education and Research Network

Research Collaboration

UK-Saudi Electric Vehicles Enhanced Education and Research Network

Projects Related to the EV Industry

- Battery management system.
- End of life electric motors.
- Wireless charging.
- Mitigating three-phase power imbalance with EV and grid battery.
- Privacy and anonymity in energy transactions.

Research Collaboration

Brunel University London

BRITISH COUNCIL

UK-Saudi Electric Vehicles Enhanced Education and Research Network

Projects Related to Information and Data Exchange

- Transmission System Operator (TSO)
- Distribution System Operator (DSO)
- Electricity retailer data and information exchange.
- Grid to Vehicle (G2V) and Vehicle to Grid (V2G)
- Real-time power flow optimization with exchange of electricity price and power flow data within different entities should be standardised.

Research Collaboration

UK-Saudi Electric Vehicles Enhanced Education and Research Network

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Thank You
M. Darwish

UK – Saudi EV WS

Welcome to Brunel University London

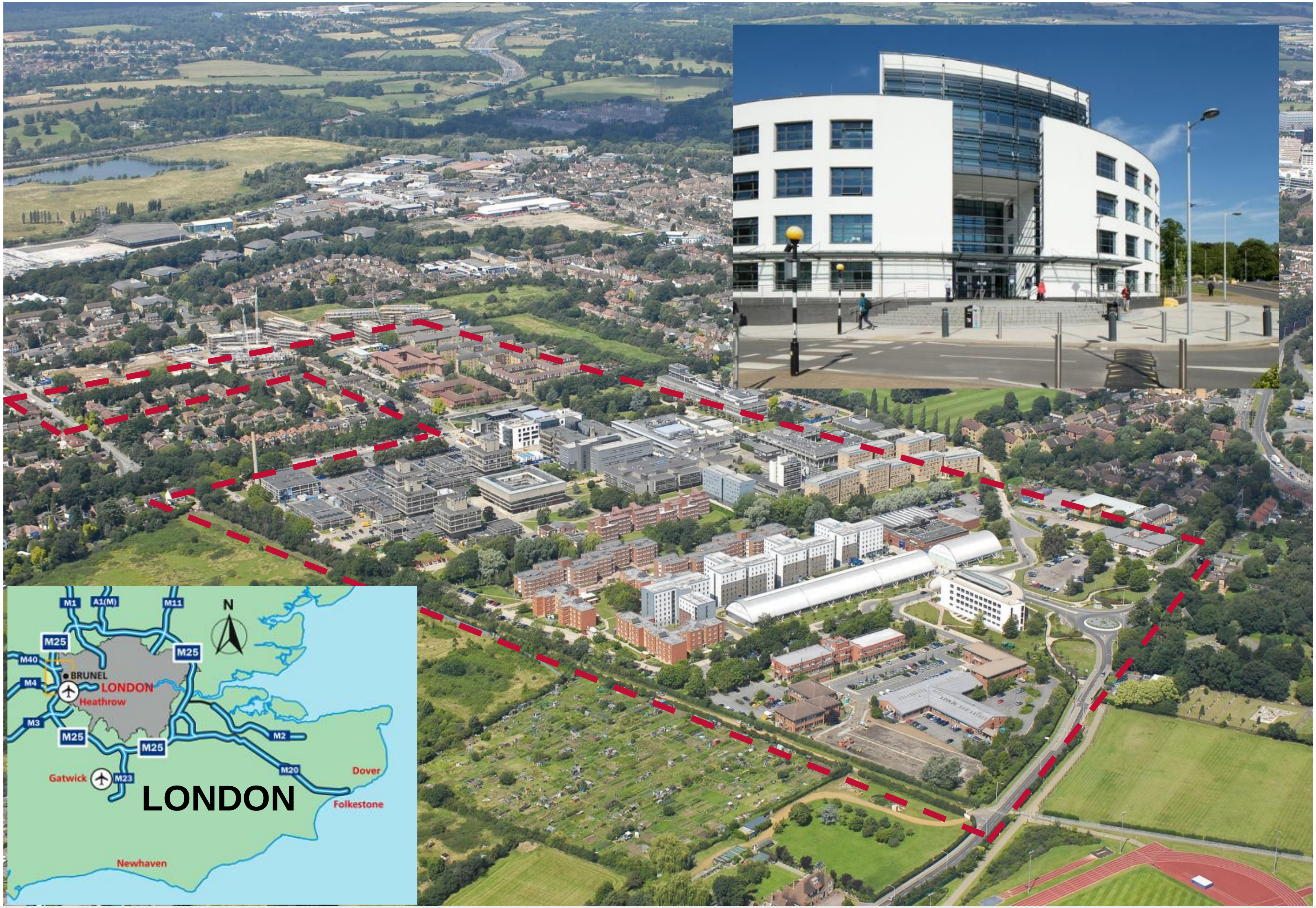
24th November 2022

Prof Gareth Taylor
Director, BIPS Research Centre
Head of Department
Electronic and Electrical Engineering

Department of Electronic and Electrical Engineering

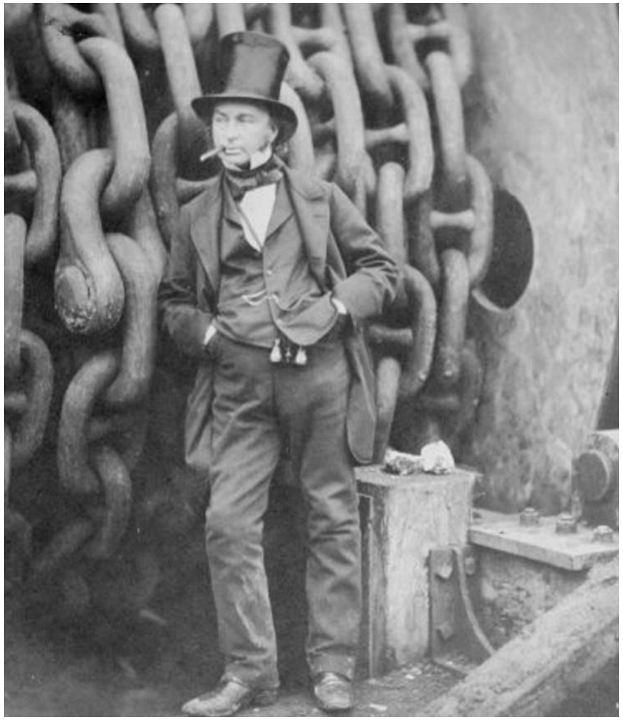
Brunel Interdisciplinary Power Systems (BIPS) Research Centre

Brunel University London Campus

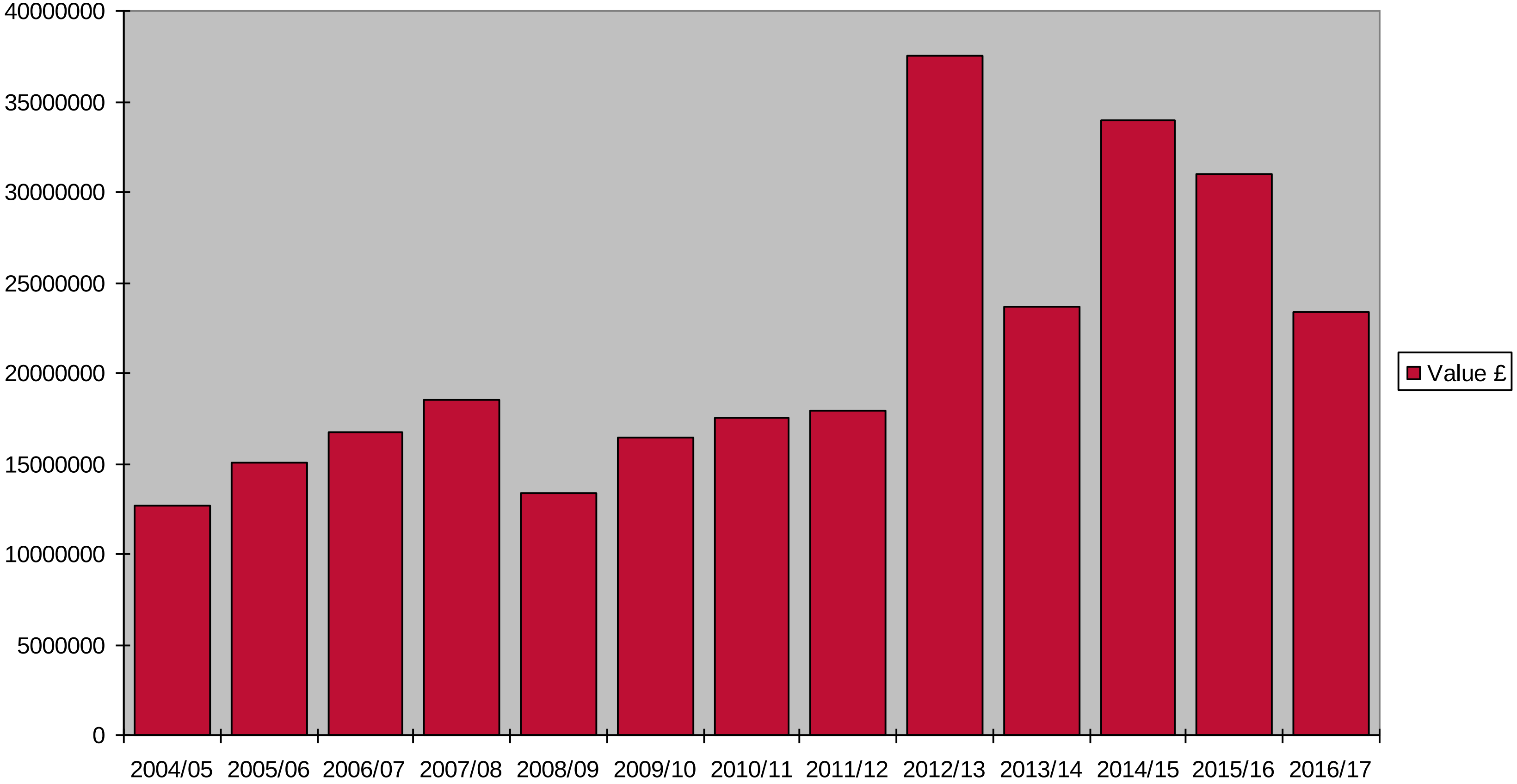


Overview of Brunel University London

- Established as a University in 1966
- Contemporaries include Bath, Loughborough and Warwick
- **~2,500 Staff**
  - 1,300 Academic + 1,200 Support
- **~16,000 Students**
  - ~11,000 UG + ~3,500 Master's + ~1,500 Doctoral
- **Students from >130 countries** (40-50% Postgraduate)
- Leading **research intensive university** in the UK

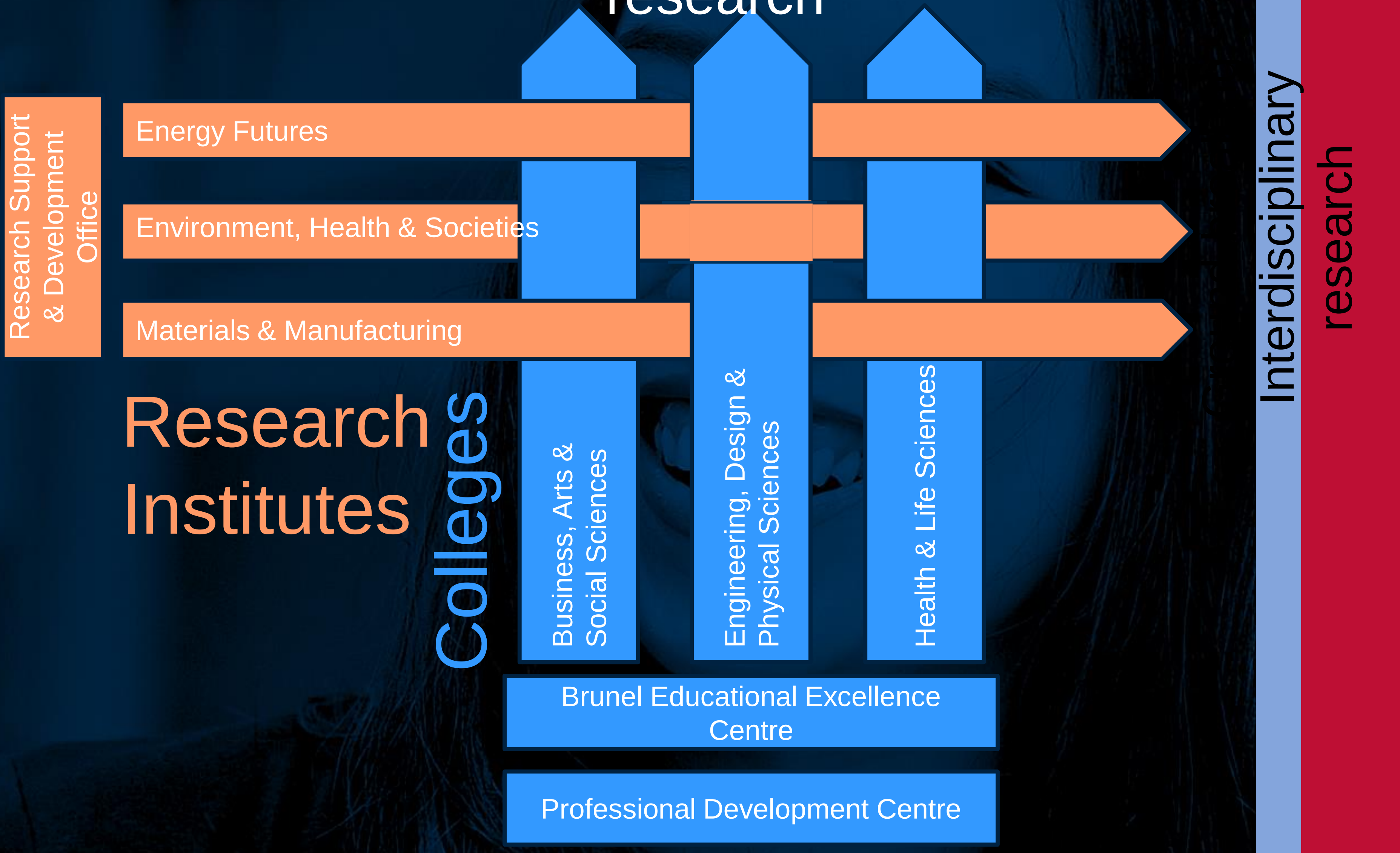


Annual Research Grant Income

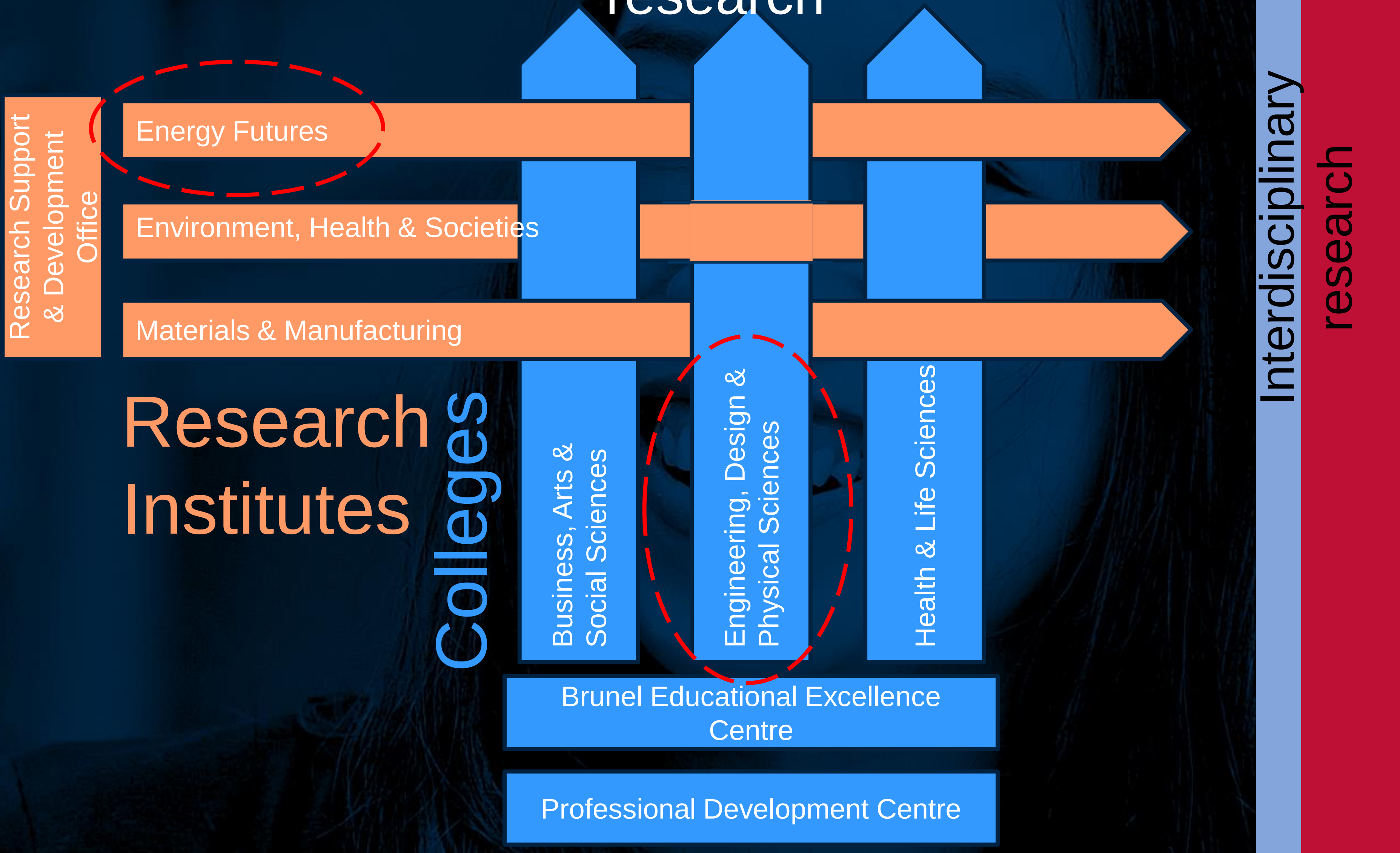


- 13th largest research income from Innovate UK (>100)
- 34th largest EPSRC portfolio in the UK
- Two prestigious Innovative Manufacturing Research Centres (IMRCs) from EPSRC (~20 in UK)

Teaching and disciplinary research



Teaching and disciplinary research



College of Engineering, Design and Physical Sciences - CEDPS

Currently four Engineering Departments within CEDPS college

- Chemical Engineering
- Civil Engineering
- Electronic and Electrical Engineering (EEE)
- Mechanical and Aerospace Engineering

Electronic and Electrical Engineering (EEE)

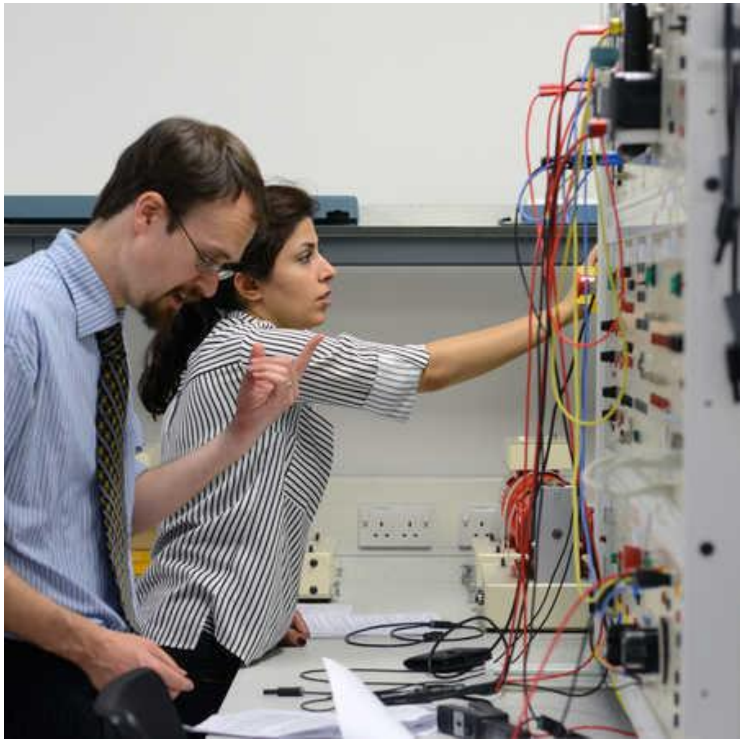
Electronic and Electrical Engineering at Brunel is highly regarded both nationally and internationally

- Ranked in top 4 Universities in London (~20) over the last three years
- Included in top 30% of UK Universities over the last 3 years
- Included in top 200 Universities internationally in both teaching and research

Electronic and Electrical Engineering (EEE)

All Electronic and Electrical Engineering academic staff are research active in the following internationally recognised research areas

- 5G and Beyond
- Digital Media & Technology
- Electrical Power Systems
- Electronic Systems
- Industrial and Applied AI
- Sensors and Instrumentation



BIPS Research Centre

Director: Prof Gareth Taylor (EEE)

- Originally established at Brunel in 1991
  - Prof Sir Michael Sterling and Prof Malcolm Irving
- Interdisciplinary **Power Systems** Research
  - Institute of Energy Futures
  - Smart Grids and Renewable Energy Systems
- Current Research Centre Membership
  - EEE (10): Taylor; Li; Abbod; Darwish; Zobaa; Pisica; Huang, Lai, Zhang, Ekwue (RAEng VP)
  - CEDPS (2): Date, Louvieris; CBASS: Manika
  - Researchers: 4 RAs/RFs, 30 Doctoral Researchers

Key Expertise

- Power Transmission & Distribution Systems
- Power Electronics & Power Quality
- DC Transmission & Distribution
- Digitalisation of Future Power Systems
- Renewable Energy Systems
- Decarbonisation of Power Systems
- Smart Grids
- Energy Economics & Power Markets
- Power System Informatics & Communications

Thank you for your time

Any questions?

Email: Gareth.Taylor@brunel.ac.uk

بسم الله الرحمن الرحيم

King Abdulaziz University

Rabigh –Faculty of Engineering

24 November 2022

Universities Role

- 5 Saudi universities in the 200 list of best world universities
- Build effective international collaboration for knowledge transfer, research, and students training
- Quality education with national and international accreditation
- Filling gaps with local market
- Generate income (self finance)

University Mission

- Community Responsibility
- Knowledge Development
- Research

Rabigh Branch –KAU

- About 7000 students
- Faculty of Business
- Faculty of Computing & Information Technology
- Faculty of Medicine
- Faculty of Science & Arts
- Faculty of Applied Medical Sciences
- Faculty of Applied Studies
- **Faculty of Engineering**

Faculty of Engineering-Rabigh (FER)

- Established in 2009
- To develop the industrial community in Rabigh and its vicinities .

- Six undergraduate programs:
  1. Architectural Engineering
  2. Civil Engineering
  3. Chemical Engineering
  4. Electrical Engineering
  5. Industrial Engineering
  6. Mechanical Engineering

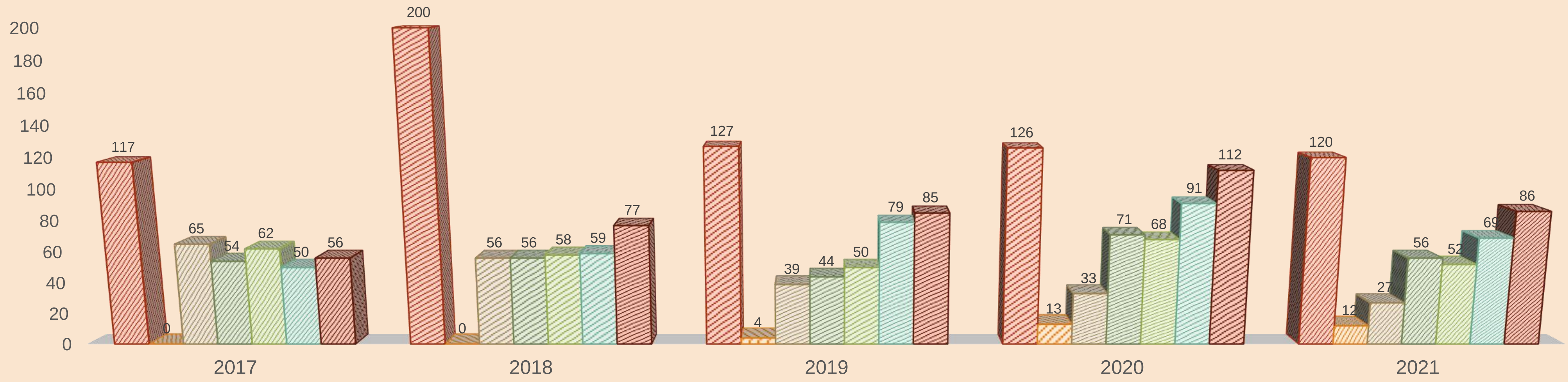
- Three graduate programs:
  1. Chemical Engineering
  2. Electrical Engineering
  3. Mechanical Engineering

FER Main Objectives

- National and international accreditation for all programs
- Developing graduate programs
- National and international collaboration
- Additional technical training programs for students
- Center of expertise

Human Resources

إحصائيات طلاب الكلية

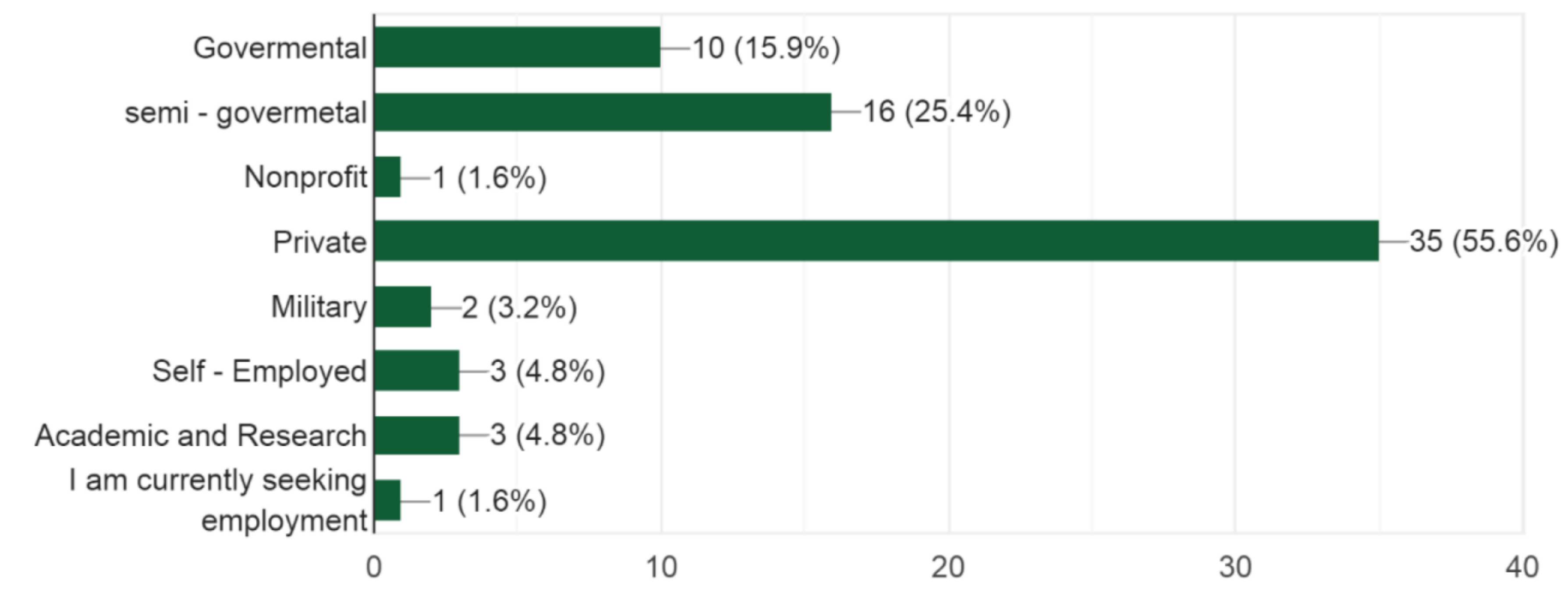


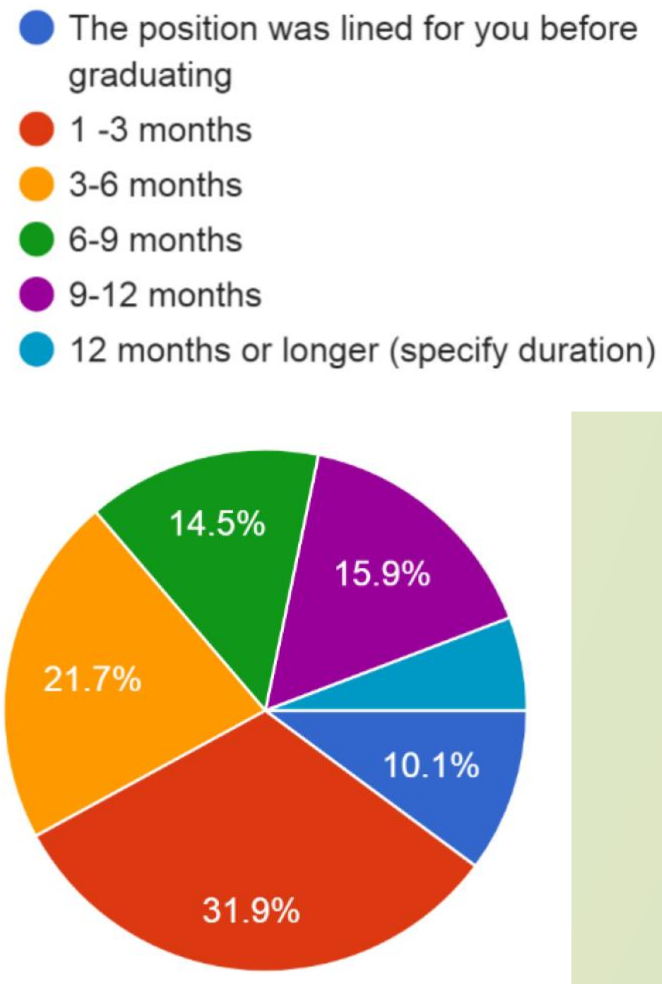
	2017	2018	2019	2020	2021
الطلاب المستجدين بالكلية	117	200	127	126	120
قسم الهندسة المعمارية	0	0	4	13	12
قسم الهندسة المدنية	65	56	39	33	27
قسم الهندسة الكيميائية و هندسة المواد	54	56	44	71	56
قسم الهندسة الكهربائية	62	58	50	68	52
قسم الهندسة الصناعية	50	59	79	91	69
قسم الهندسة الميكانيكية	56	77	85	112	86

Current Students = 422

Graduates = 582

الخريجون





الشركة الوطنية للإسكان	أرامكو السعودية
الشركة العربية للاسمنت	الشركة السعودية للكهرباء
اسمنت الصفوة	سابك
شركة اي ام سي الالمانية	جامعة الملك عبدالعزيز
الشركة السعودية لمعدات الديزل	عبداللطيف جميل
شركة سفاري	المؤسسة العامة لتحلية المياه
شركة تطوير المباني	وزارة الدفاع

المعامل والورش

الهندسة الكيميائية وهندسة المواد

- هندسة المواد
- التحكم و هندسة التفاعلات
- إنتقال الحرارة
- العمليات الطبيعية
- الأبحاث المتقدمة
- ميكانيكا الموائع
- العمليات الطبيعية

الهندسة المدنية

- الهندسة الجيوتقنية
- التشييد والخرسانة
- المساحة والنقل
- الهيدروليكا
- الهندسة البيئية
- ماكينة الإختبار العامة

الهندسة الكهربائية

- الدوائر الكهربائية
- التحكم والإلكترونيات
- القوى والآلات الكهربائية

الهندسة الميكانيكية

- التبريد والتكييف
- ميكانيكا الموائع
- الورش

قسم الهندسة الصناعية

- التصنيع بالحاسب
- التعليم التفاعلي
- بيئة العمل وهندسة الجودة

Accomplishments

Student Chapters

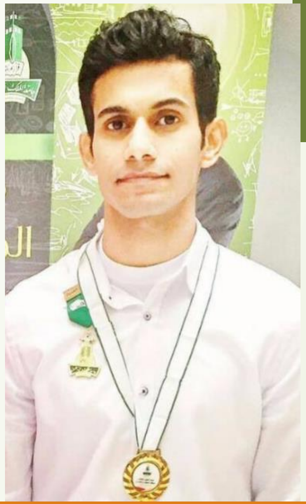
- Institution of Civil Engineering (ICE)
- Material Advantage chapter
- American Institute of Chemical Engineers
- Institute of Electrical and Electronics Engineers
- Industrial Engineering and Operations Management
- American Society of Mechanical Engineers

انجازات الطلاب

- علي الغامدي: حامل السكاكين الأمن
  - جائزة تايوان للاختراعات
  - جائزة الجمعية اللبنانية للمبتكرين

- عبدالله الشهري وعبدالله الدهاسي: مخرج الطوارئ للمصاعد
  - معرض جنيف الدولي للإختراعات: ميدالية برونزية من معرض جنيف الدولي للابتكارات ، ميدالية من بعثة رومانيا ، ميدالية من بعثة تايوان ، ميدالية من بعثة تايلان

- تمثيل الجامعة معرض وزارة التعليم للإبتكارات في الرياض: سلطان ياقوت وتركي البلادي
- داخل الجامعة:
  - الملتقى العلمي الثامن:
    - المركز الثاني والثالث في محور الابتكارات
    - المركز الاول والثالث في محور الابحاث
  - الملتقى العلمي التاسع:
    - المركز الثاني والثالث في محور الابتكارات
    - المركز الثاني والثالث في محور الابحاث



- الملتقى العلمي العاشر: المركز الأول في محور الإبتكارات
- مسابقة ابتكاري: المركز الرابع والخامس
- الملتقى العلمي الأول برابغ (2020):
- جائزة الريشة الذهبية، المركز الأول والثاني والثالث في محور البحث العلمي، المركز الأول والثاني في محور الإبتكار، وجائزة الوسام الذهبي


عمادة شؤون الطلاب برابغ
@DSA_Rabigh

Replying to @DSA_Rabigh

اعلان اسماء الطلاب الفائزين في
#مسابقة_أجمل_إلقاء_خطابي
1 - عبدالعزيز هاني جمبي من كلية الهندسة برابغ

نبارك للطالب الفائز ونتمنى لجميع المشاركين دوام النجاح والتوفيق 🎊🎉🎊🎉

Translate Tweet

10:17 AM · Dec 2, 2020 · Twitter Web App


عمادة شؤون الطلاب برابغ
@DSA_Rabigh

Replying to @DSA_Rabigh

اعلان اسماء الطلاب الفائزين في #مسابقة_ثمار_العقول
🥇 عبداللطيف شادي حريري من كلية الحاسبات برابغ
🥈 خالد وصل الله المطيري من كلية الاعمال برابغ
🥉 غازي حمد العتيبي من كلية الهندسة برابغ

نبارك للطلاب الفائزين ونتمنى لجميع المشاركين دوام النجاح والتوفيق 🎉🎊🎊🎉

Translate Tweet

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فوز فريق كلية الهندسة برابغ لكرة القدم على المركز الأول ببطولة دوري كليات جامعة الملك عبدالعزيز فرع رابغ.

المركز الثاني في السباحة

المشاركة في فريق الجامعة (3 طلاب) في الدورة الرياضية الثامنة لجامعات ومؤسسات التعليم العالي بدول مجلس التعاون الخليجي

Collaboration

- إتفاقية مع شركة تكنيا جي إم بي إتش

- إتفاقية مع المعهد العالي لتقنيات المياة والكهرباء

- High Institute for Elastomer (HIEI)
- Universiti Teknologi Malaysia (UTM): Students Internship Summer Program
- Institute of Membrane Technology (ITM-CNR), at University of Calabria - Italy
- Indiana University–Purdue University, Indianapolis, IN, USA
- Universitat Rovira i Virgili (URV), Spin

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&
Accreditaton

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Mechanical Engineering (Bachelor of Science in Mechanical Engineering)

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Awarded to
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Kingdom of Saudi Arabia

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Scope: **Faculty of Engineering Rabigh Branch Providing education, training, research and community services in the field of engineering.**

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Date of Current Registration: *10/11/2020*
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منذ 4 ساعة
الدردشة


ملتقى رؤساء ومشرفات الأقسام العلمية
حفل إعلان نتائج الفائزين وتسليم
جائزة معالي رئيس الجامعة للقسم العلمي المتميز
الثلاثاء 26 صفر 1442هـ الموافق 13 أكتوبر 2020
KAU.SNAP50 .
منذ 5 ساعة
الدردشة


عمادة الجودة والاعتماد الأكاديمي
تهنئة
لكلية الهندسة
وذلك لحصولها على المركز الثاني (فرع الكليات فرع رابغ)
في مؤشرات الجودة والإعتماد الأكاديمي للعام الدراسي ١٤٣٩ - ١٤٤٠ هـ
معالي مدير الجامعة
أ.د. عبدالرحمن بن عبيد اليوبي

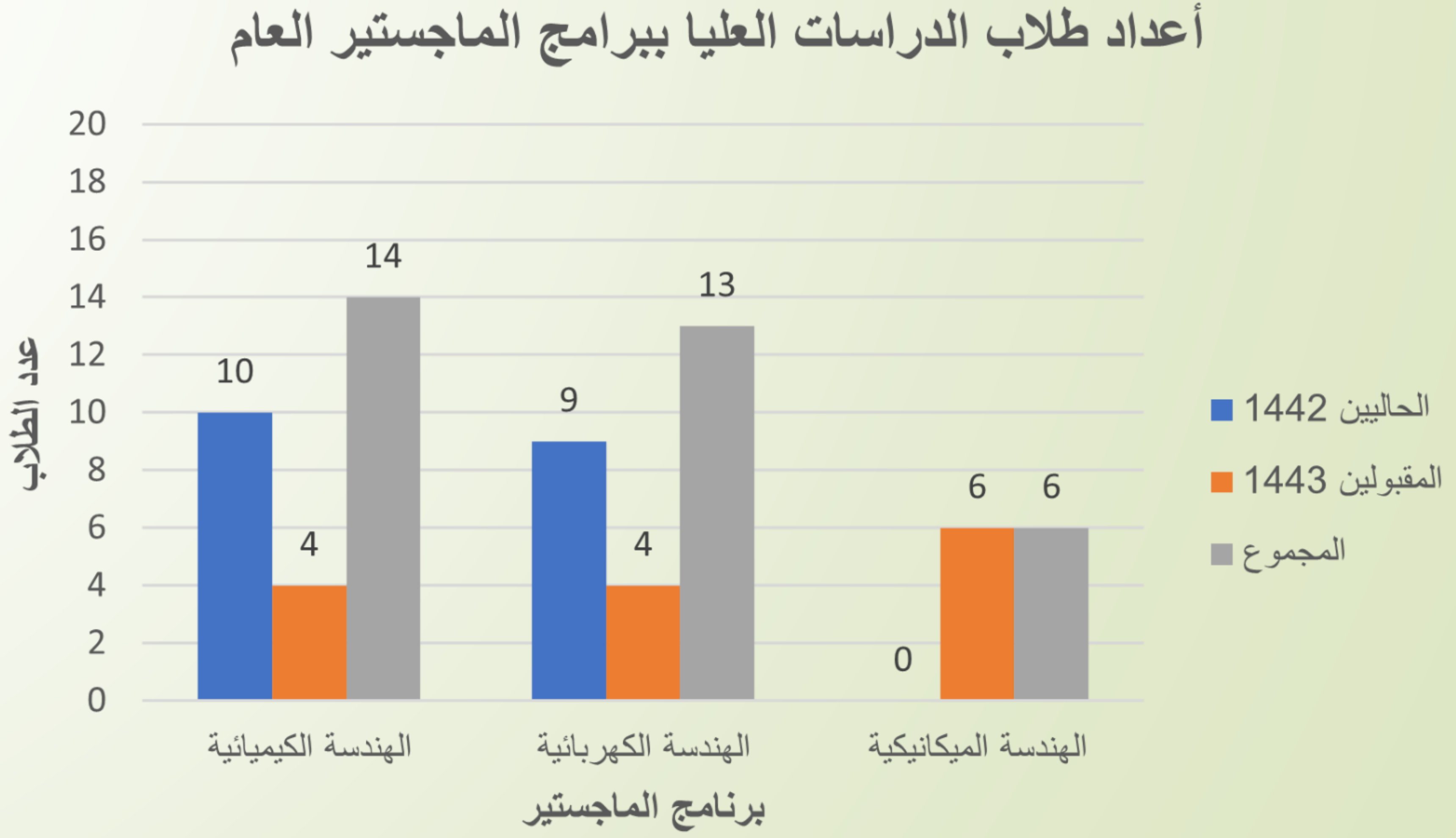
Graduate Studies
&
Scientific Research

الدراسات العليا والبحث العلمي

برامج الماجستير الأكاديمية

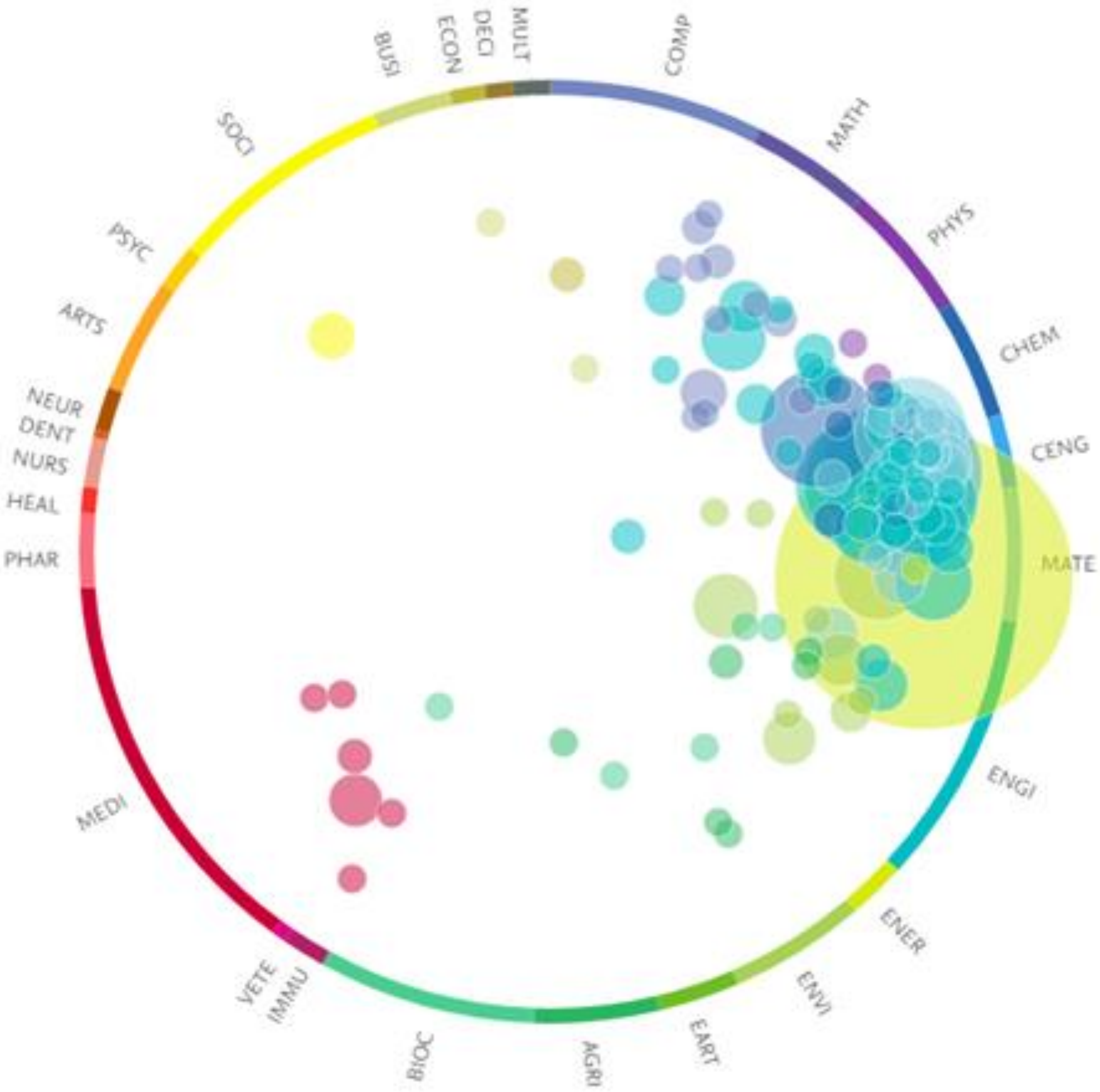
- ماجستير الهندسة الكيميائية
- ماجستير الهندسة الكهربائية
- ماجستير الهندسة الميكانيكية

الدراسات العليا والبحث العلمي



المجموع = 33 طالب دراسات عليا للعام 1443

الدراسات العليا والبحث العلمي



COMP	Computer Science
MATH	Mathematics
PHYS	Physics and Astronomy
CHEM	Chemistry
CENG	Chemical Engineering
MATE	Materials Science
ENGI	Engineering
ENER	Energy
ENVI	Environmental Science
EART	Earth and Planetary Sciences
AGRI	Agricultural and Biological Sciences
BIOC	Biochemistry, Genetics and Molecular Biology
IMMU	Immunology and Microbiology
VETE	Veterinary
MEDI	Medicine

* The categories on the rim of the wheel are based on the ASJC categories. The area closest to the center of the wheel are multidisciplinary.

الدراسات العليا والبحث العلمي

برامج الماجستير النوعية

- ماجستير هندسة الطاقة المستدامة
- ماجستير هندسة التصنيع
- ماجستير الإدارة الهندسية (تحت الإنشاء)

The End

ELECTRIC VEHICLE IN THE AGE OF ARTIFICIAL INTELLIGENCE

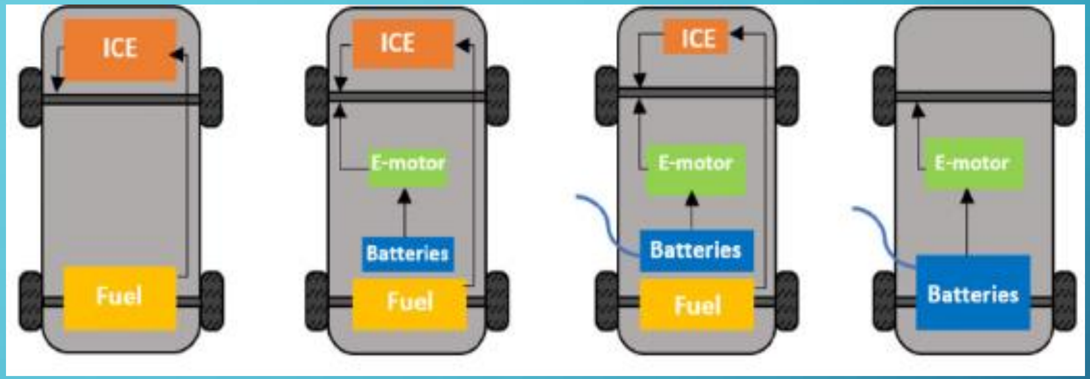
MAYSAM ABBOD

CONTENTS

- Electric Vehicle
- Battery Management
- Car Management
- Traffic and Routing
- Travel Planning
- Network Management
- Fleet Management

KEY DEFINITIONS

- The term 'electric vehicle' or 'EV' covers any vehicle that operates on an electric motor or traction motor instead of an Internal Combustion Engine (ICE). This includes not only cars but electric trucks, planes, trains, boats and two- and three-wheelers.
- Powertrain technologies include full electric vehicles and plug-in hybrids, as well as hydrogen fuel cell vehicles that convert hydrogen into electricity.
- Electro mobility (or e-Mobility) represents the concept of using electric powertrain technologies, in-vehicle information, and communication technologies and connected infrastructures to enable the electric propulsion of vehicles and fleets.



Battery Types of EVs

- Battery Electric (BEVs)
- Plug-in Hybrids (PHEVs)
- Hybrid Electrics (HEVs)

- Hydrogen Fuel Cells

WHAT EXACTLY IS AI?

The science of AI can be simply translated as the science of making machines and appliances smart enough to give them the ability to perform all the tasks that humans do.

THE POWER OF EV BATTERIES

The scope of the global battery market is rapidly increasing. EV models like Tesla S 100D offers 355 miles, Hyundai Kona offers 198 miles, or MG ZS EV could offer 214 miles on average and none can be fully charged in a matter of minutes. For instance, at Tesla supercharging station, EVs will take 75 minutes to reach full charge.

HOW AI IS ACCELERATING THE POWER OF EV BATTERIES

In every aspect of a vehicle's life, battery performance is a crucial factor to consider. The battery accounts for 25% of the entire cost of an electric vehicle and when it comes to EV developments, nothing is more important than increasing battery life. Artificial intelligence has made aspirations like partial recharging an electric vehicle in the time it takes to stop at a petrol station, and it might help enhance other elements of battery technology as well.

BATTERY LIFE CYCLE

Machine Learning helps to explore the opportunity of battery life cycle management. The key to improving battery life lies in the data. By blending advanced electronics with IoT, data science and digital twin, Machine Learning uses the power of predictive intelligence to predict battery life, identify potential breakdown and their causes, fix errors even before they arise. All this data can be stored in the cloud.

BATTERY LIFE CYCLE - MONITORING

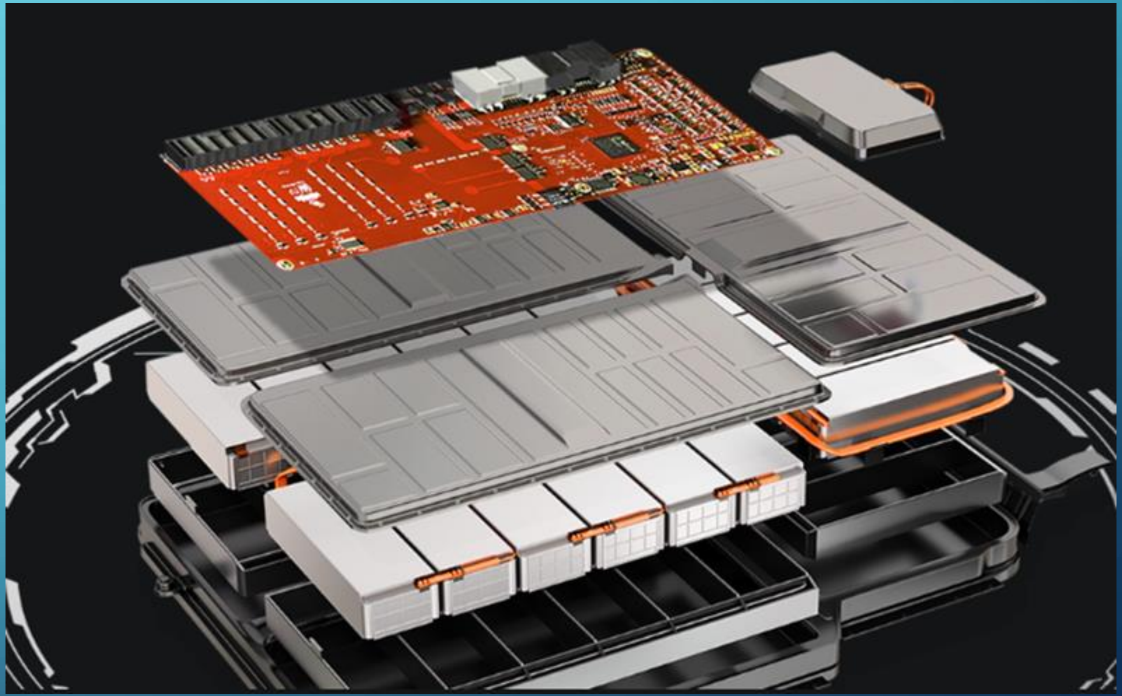
AI is contributing significantly in the overall battery management in electronics. It has been there for some time now in smartphones where AI helps to increase the charge of a battery, reduce time to charge and also improves the life of the battery. For instance, AI keeps a check on the temperature of the battery and responds with safety measures in case of overheating, etc. Similarly, it's helping optimize the energy efficiency in EVs as well.

BATTERY LIFE CYCLE - MANAGEMENT

Artificial intelligence is analysing battery usage, recharge data and constructing a mathematical model to optimize the fast-charging capabilities without compromising the life span of the vehicles, which is improving battery performance and battery life cycle management, including driving range and charging time, and life span of the vehicles. It can also help accelerate the battery field research by speeding up the search for better materials and testing.

CAR MANAGEMENT

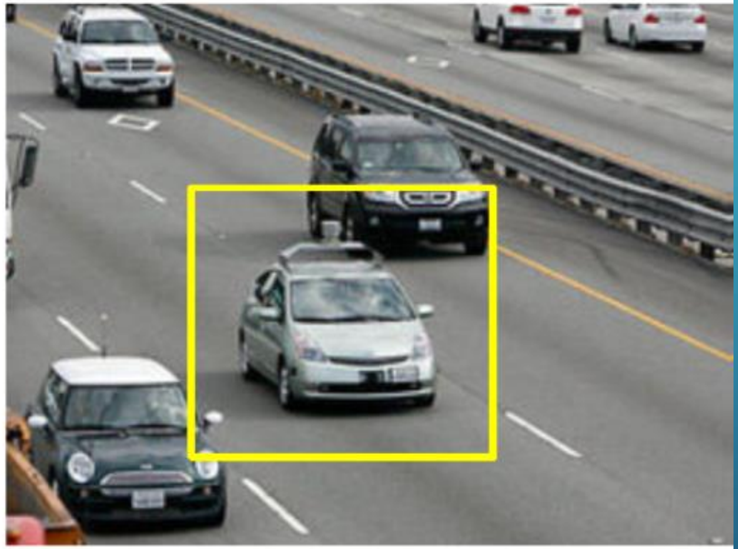
- Power utilisation
- Traction control
- Collision detection
- Charge management
- Driving Conditions
- Self Driving



SMART CARS

- Sense the road
- Control the speed
- Avoid collision
- Check the traffic

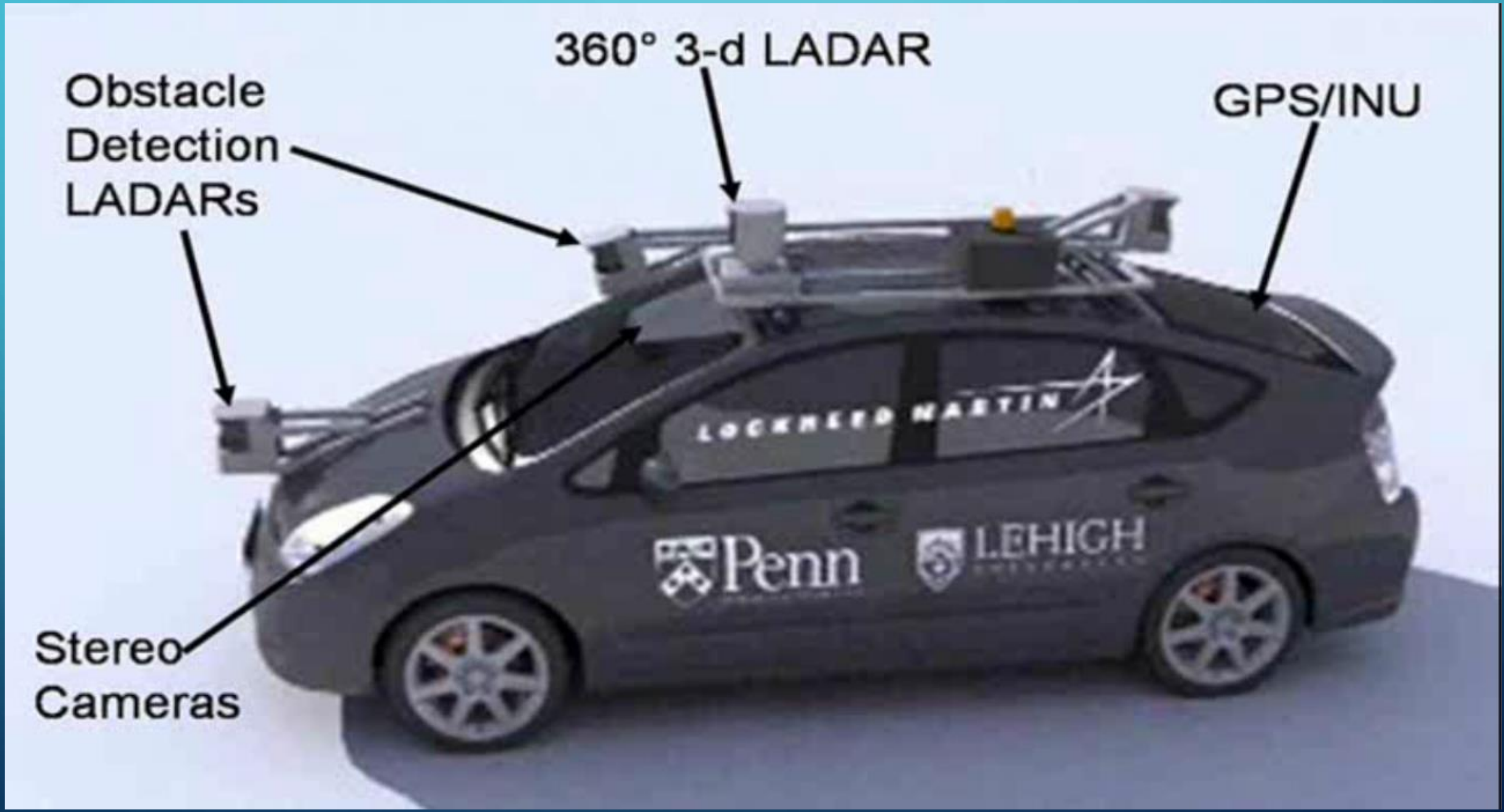
SELF DRIVING CARS



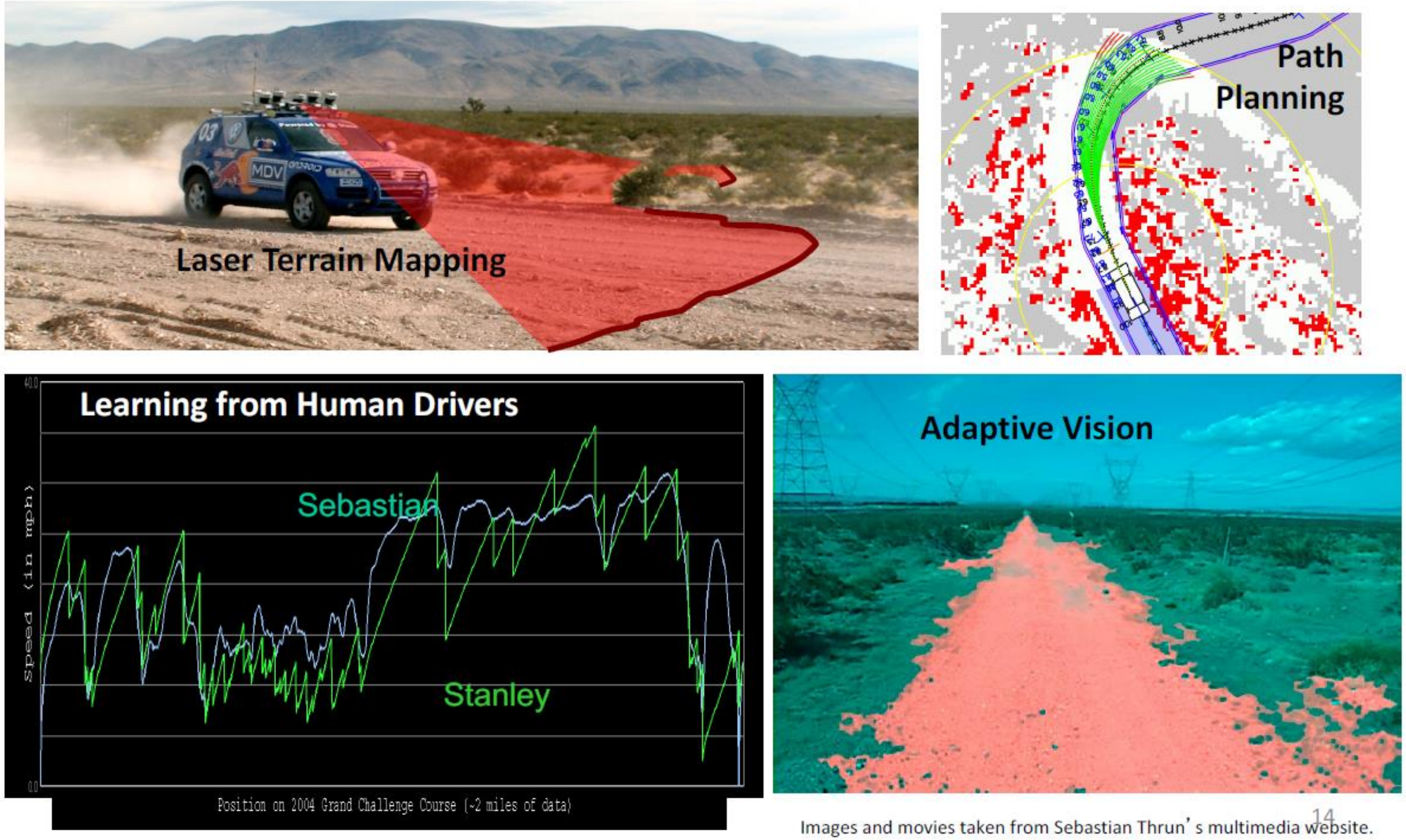
- Nevada made it legal for autonomous cars to drive on roads in June 2011
- As of 2013, four states (Nevada, Florida, California, and Michigan) have legalized autonomous cars

Penn's Autonomous Car →
(Ben Franklin Racing Team)

AUTONOMOUS CARS



AUTONOMOUS CARS



Images and movies taken from Sebastian Thrun's multimedia website.

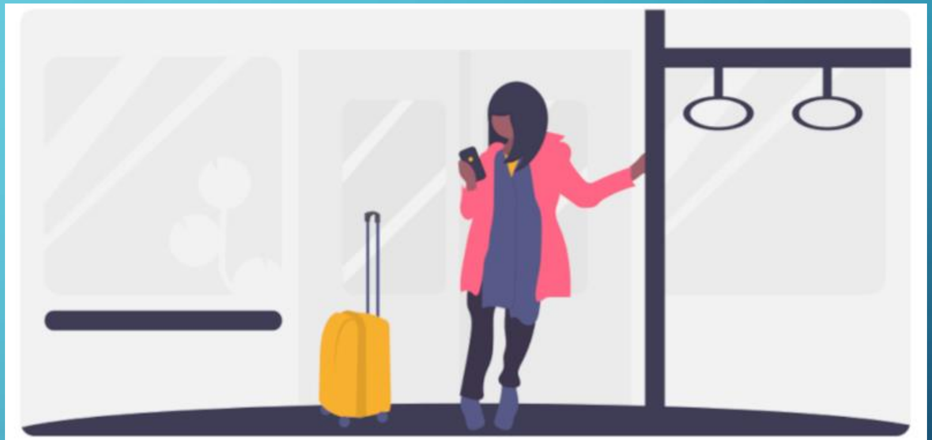
SCENE LABELLING USING DEEP LEARNING

TRAFFIC MANAGEMENT

AI is used in road traffic management to help analyse real-time data from various means of transportation, including cars, buses and trains. AI analyses this information for patterns that could indicate safety risks. This information is then used to suggest ways to mitigate these risks and reduce the number of accidents that occur.

TRAVEL PLANNING

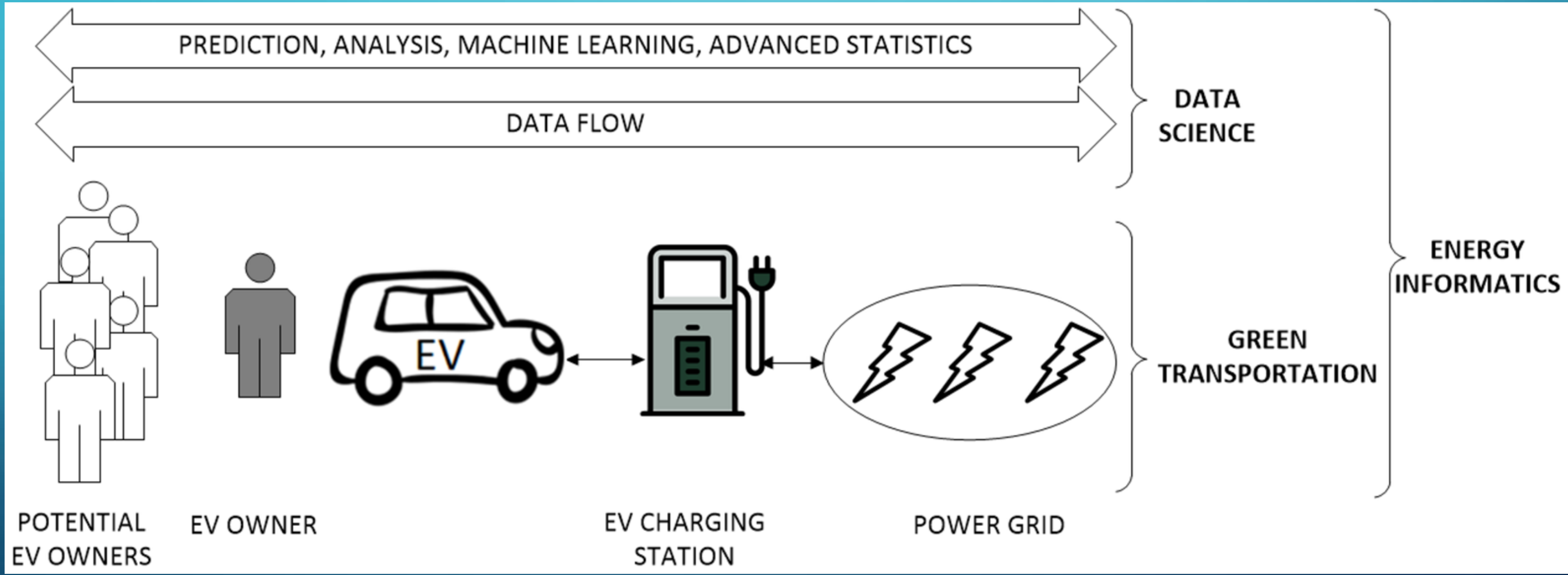
- Adaptive traffic control system (ATCS)
- Automated vehicles
- Intelligent parking planning
- Safety and Emergency Situations
- Transit Planning – Intelligent Transportation Systems
- Urban Planning



V2G MANAGEMENT

Vehicle-to-grid (V2G) is one of the future key technologies for the smart grid. Electric vehicles (EV) are potential power consumers that can play a crucial role by delivering the power back to the grid in order to meet the power demand. However, the V2G network has some crucial security and privacy challenges.

EV AND THE GRID



EV FLEET MANAGEMENT

EV fleet management considers the big issues of fleet electrification and electric vehicle charging requirements. The volume of vehicles and distances travelled must be analysed to determine the number of depot and/or "on the road" charge points required and the distance between them – whether owned and operated by the fleet owner, public charge points, or home-based charge points for lighter vehicles. This directly addresses the issue of range anxiety, ensuring vehicles have access to charge points when and where they need them, whether on the road or at the depot, so they can complete their missions.

OPTIMISING CAR CONFIGURATIONS

There are thousands of possible combinations of features that could be chosen to configure a car. Powerful machine learning algorithms find the optimal combinations of features (body type, powertrain, options package etc.) to place on a car dealership lot, in order to minimise turn time and maximise revenue.

FUTURE OF ARTIFICIAL INTELLIGENCE IN EV INDUSTRY

With various applications such as autonomous driving, user behaviour monitoring, and smart navigation systems, AI is playing a key role in the EV Industry. It can be used for safety applications:

- Predictive maintenance of equipment
- driver behaviour monitoring
- vehicle security.

Different companies are using AI in their vehicles, some use this technology to change current transportation systems with self-driving services, while some use it for strengthening the battery power of their EVs.

AI ROLE IN EV INDUSTRY

- Maximising the charge utilisation
- Reducing the charging time
- Increasing the life of the battery
- Optimizing the use of battery in all electronics including lights
- Optimising the car speed
- Optimising acceleration
- Safety and security

AI TO EASE EV ELECTRICITY DEMAND

With an influx of investment being poured into electric vehicle (EV) charging infrastructure, the number of EVs and EV fleets is on the rise.

- How to manage EV charging while preventing blowouts, asset wear and tear and power outages.

There is an equation that needs to be formulated to best approach EV grid integration in light of the expanding electrification.

EV DEMAND FORECASTING

By predicting demand ahead of time for new and existing car models, car manufacturers and dealerships can plan ahead and optimise operations and marketing.

CONCLUSION

- EV is developing fast and new technologies are introduced every year.
- AI can help refining these technologies and improve the performance of EV
- Integration of EV with the electric grid is the future direction.

Semiconductors in Autonomous Vehicles

24 November 2022

Alaa Alani PhD MIET CEng
Sondrel Plc.
UK

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Agenda

- Electronics in Cars
  - Historical data
  - Electronic systems
  - Cost of electronic parts
  - Three categories
- Semiconductors
  - Evolution of microchips
  - Semiconductor regions/countries
  - The Middle East
- Autonomous Vehicles
  - Sensors and systems
    - Camera, Radar, LiDAR
  - Challenges
  - Levels of driving automation
- Summary

Electronics in Cars

A. Alani 2022
Semiconductors in Autonomous Vehicles

Historical Data

- Electronic systems have become an increasingly large component of the cost of an automobile
- From only around 1% of its value in 1950 to around 30% in 2010.
- Modern electric cars rely on power electronics for the main propulsion motor control, as well as managing the battery system.
- Future autonomous cars will rely on powerful computer systems, an array of sensors, networking, and satellite navigation

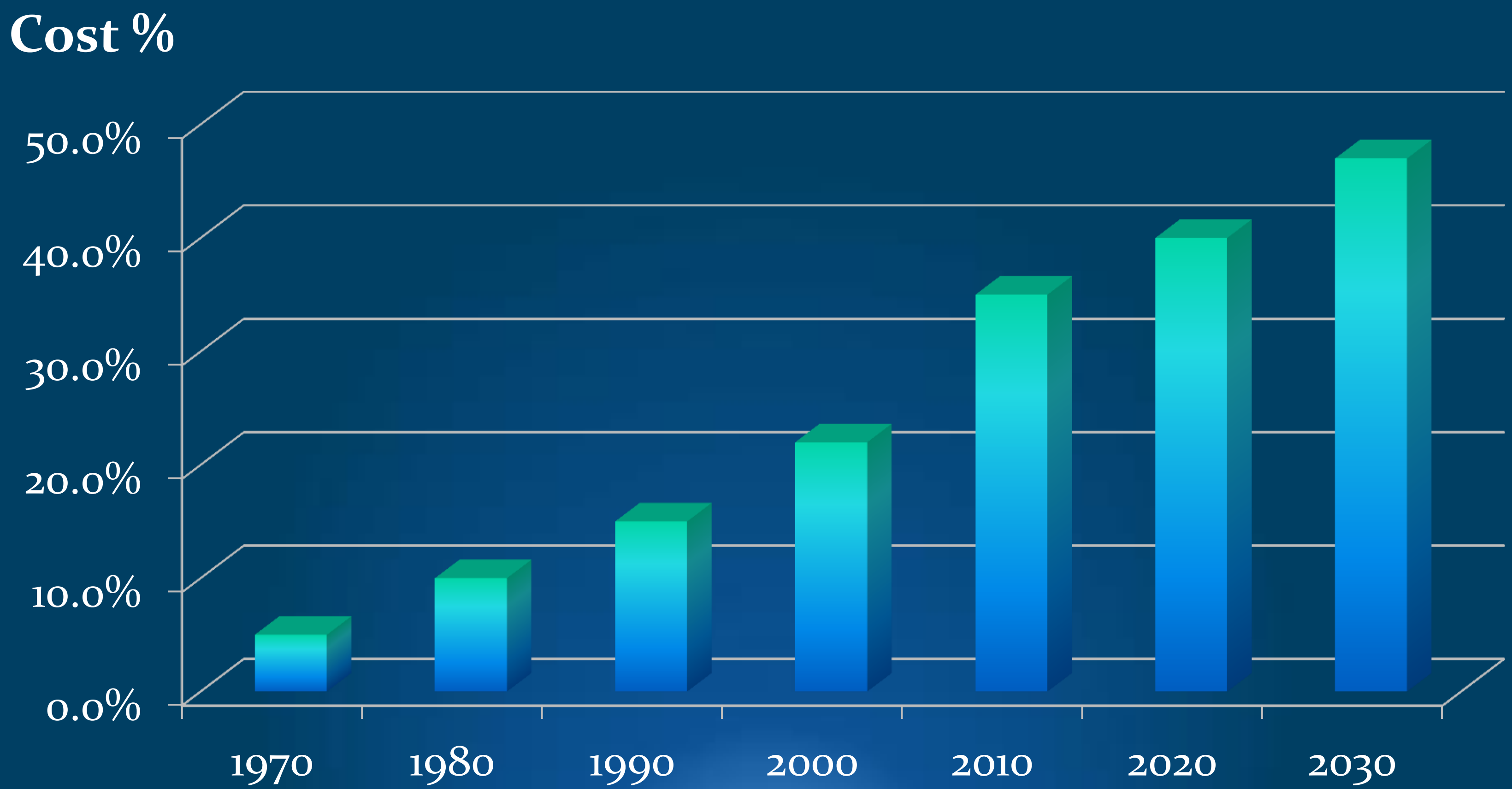
Historical Data

- The earliest electronic systems available as factory installations were vacuum tube car radios in 1930's.
- The development of semiconductors after WWII greatly expanded the use of electronics in automobiles in the 1960's onward (e.g., solid-state diodes alternator, transistorised ignition system, etc.)
- In the 1980-90's, most car manufacturers started using microprocessors in ECUs for engine management
- In the 2000's first attempts of self-drive vehicles powered by microchips from Renesas, Mobileye, Nvidia, Intel, etc. began
- Since 2014, car makers such as Google, Apple, Tesla, Toyota and others entered the race in self-drive cars
- In parallel, most self-drive cars are being powered by electric engines using an ever increasing number (>2000) of semiconductor chips

Electronic Systems

- Transmission control unit (TCU)
- Adaptive cruise control (ACC)
- Alternators
- Automatic headlight dimmers
- Electric fuel pumps
- Electronic fuel-injection
- Electronic ignition control
- Electronic tachometer
- Sequential turn signals, speed indicators
- Tyre-pressure monitors
- Voltage regulators
- Windshield wiper control
- Electronic Skid Prevention (ESP),
- Heating, ventilation, and air conditioning (HVAC)

Cost of Electronic Parts



Three Categories

Estimates say that there are roughly around 1,000+ chips in a non-electric vehicle and twice as much in an electric one

Three Categories:

- **Safety, Security, and Access**
- **Powertrain and Electrical Systems**
- **Comfort, Infotainment, and Connectivity**

Three Categories

- **Safety**
  - Air bag
  - Parking Assistance
  - Collision avoidance
  - Breaking assistance
- **Security**
  - Door lock
  - Alarm
  - Tracking
- **Access**
  - Fob
  - Keyless

- **Powertrain**
  - Engine
  - Fuel injection
  - Hybrid electric control
  - Transmission control
- **Electric systems**
  - Lighting
  - Diagnostic system
  - signalling

Three Categories

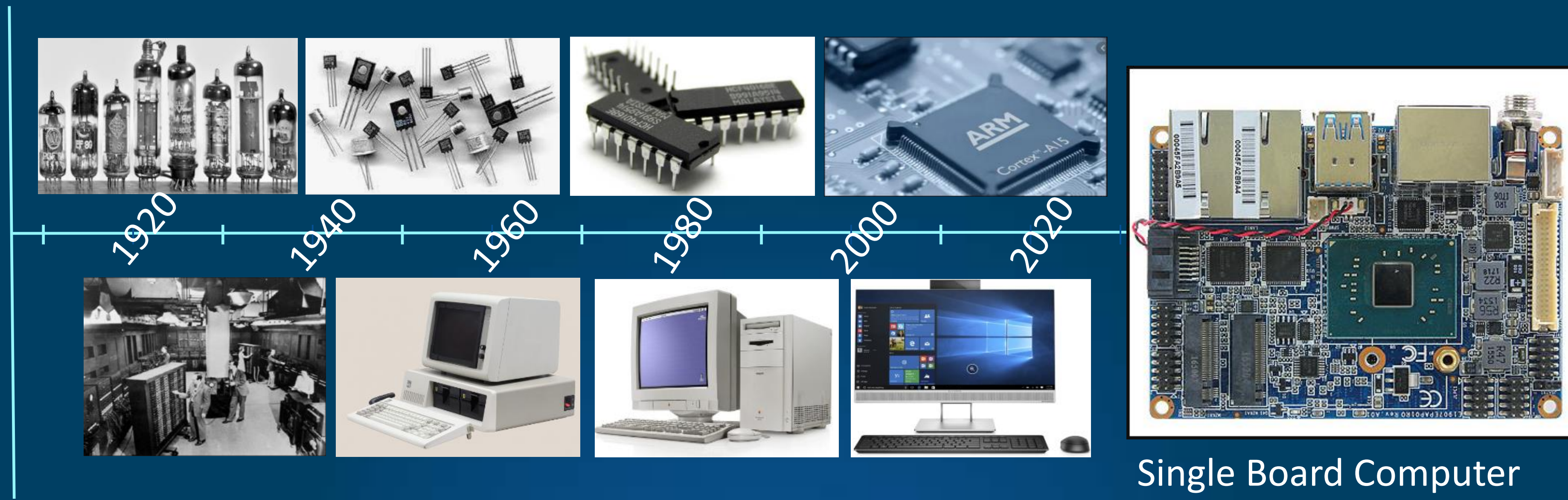
- **Comfort**
  - Wind/mirror control
  - Seat heating
  - Climate control
- **Infotainment**
  - Audio/video control system
  - Driver displays
  - Navigation
- **Connectivity**
  - WiFi
  - Bluetooth
  - Over the air s/w update

Semiconductors

- Devices contain hundreds of millions transistors integrated in tiny chips used in consumer goods, telecom, computers, space, robots, cars, etc.
- Advanced nodes 16nm, 12nm, 7nm, 5nm, 3nm
- Global semiconductor market size is ~$500 billions
  - Design
  - Manufacturing
  - Assembly
  - Test

Evolution of Microchips

Electronic Devices



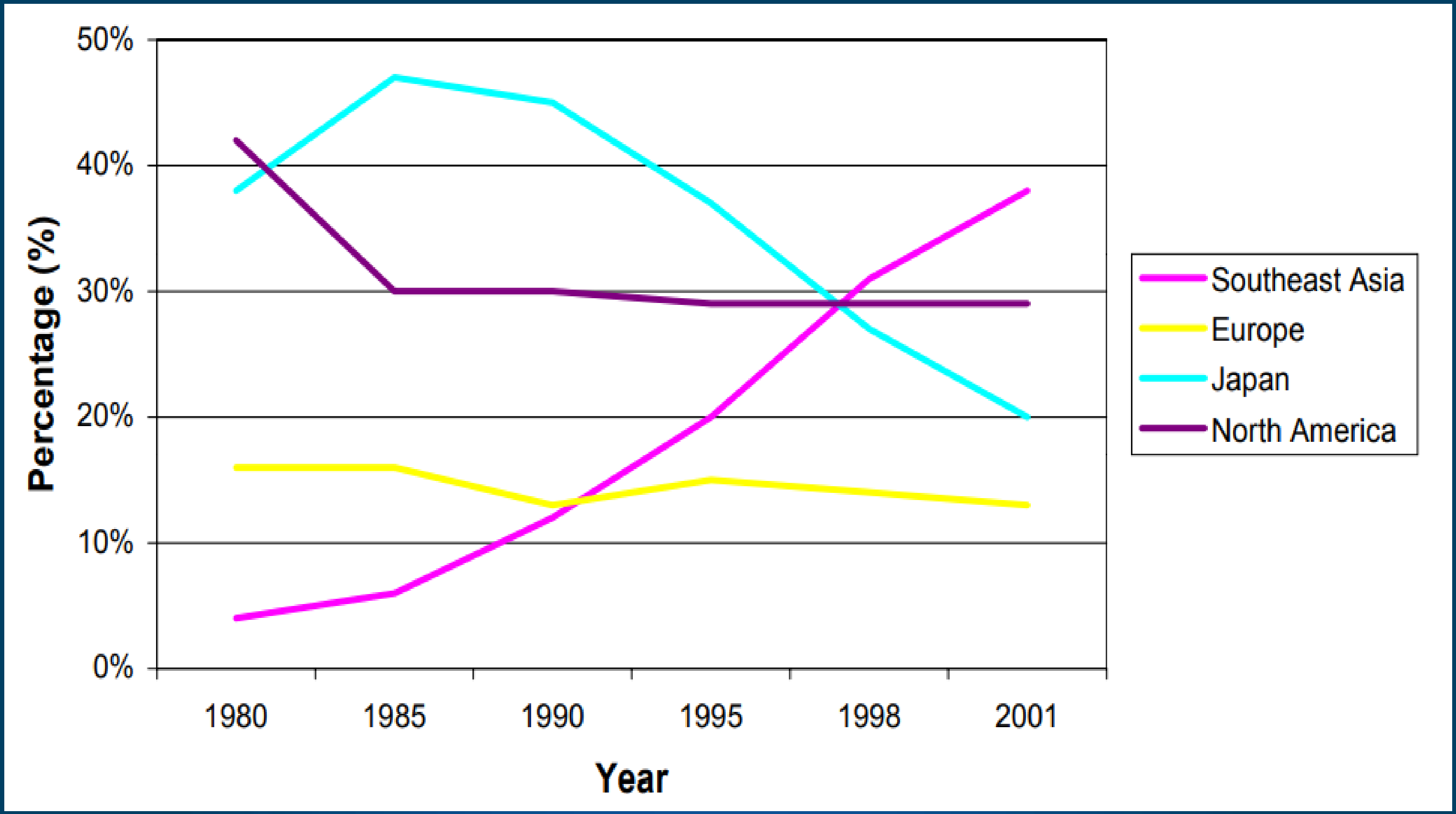
Single Board Computer

Computers

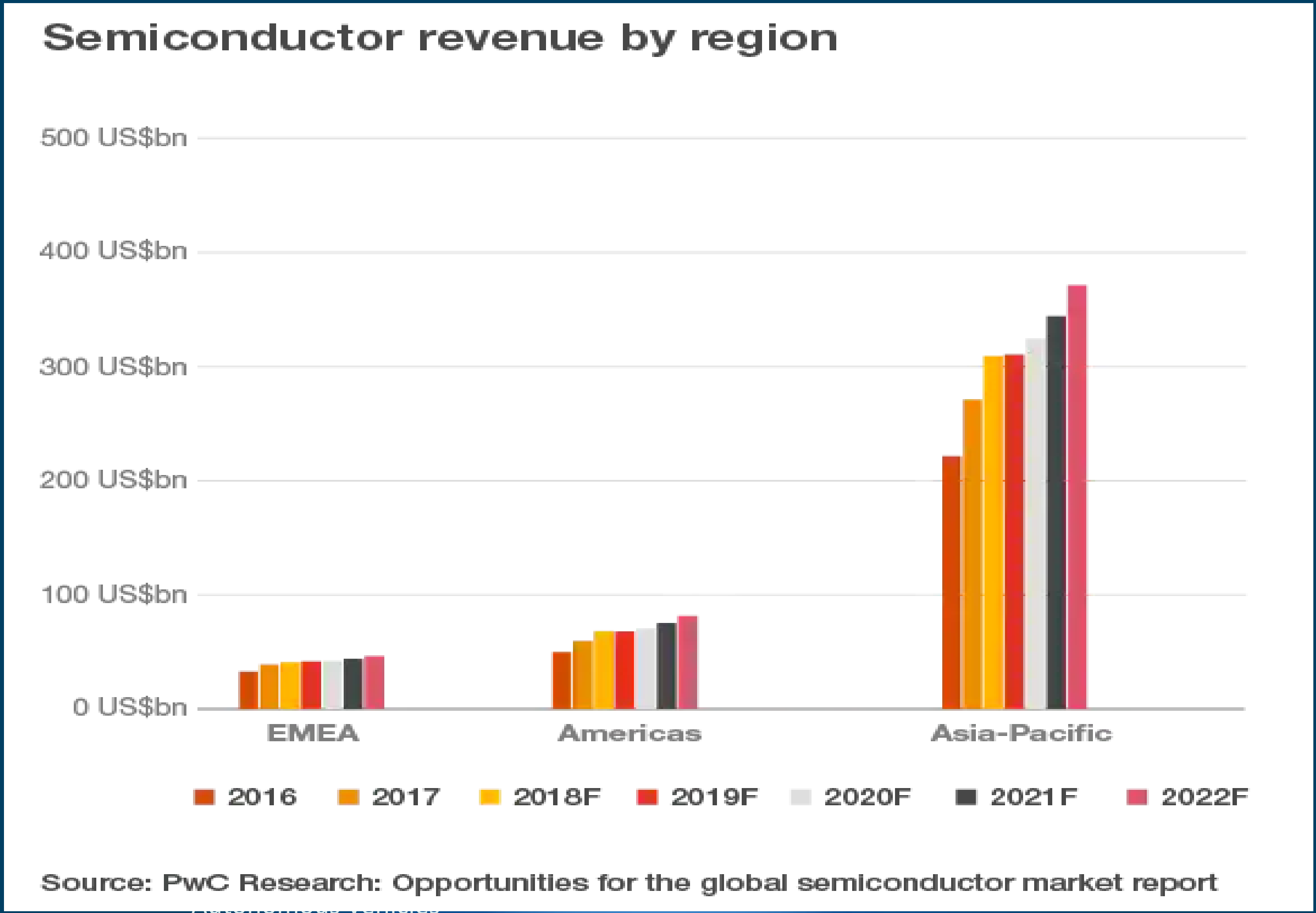
Semiconductor Regions/Countries

- Malysia: electronic exports $30bn in 2013
- Thailand: Electronic industry is valued at $100bn mainly automotive electronic parts
- The Philippines: Electronics shipments totalled $37.57bn in 2018
- Singapore: Electronic industry is valued at $37.4bn in 2017
- Israel: 5 Fabs and more than 15 fabless companies; 20,000 employees with annual revenues of $5bn
- Brazil: Semi Revenues $552.8m in 2019

Semiconductor Regions/Countries



Semiconductor Regions/Countries



The Middle East

- Silicon Oasis was established in Dubai started Pilot Design Environment to establish the Dubai Circuit Design (DCD) centre in 2001
- Abu Dhabi established Advanced Technology Investment Company (ATIC) in 2008 which invested in AMD to create Global Foundry which is 100% owned by Abu Dhabi since 2012
- Masdar Institute of Science and Technology in Abu Dhabi collaborated with Global Foundry on 28nm SLP low-power bulk CMOS technology in 2014
- Egypt started tech start-up in 1993 with Anacad. In 2004, two chip design companies emerged to cater for customers in the US, Europe and Asia. Currently, 17 fab-less companies form the semiconductor sector in Egypt
- Morocco was the first Arab country to enter semiconductor industry established by ST Micro – A French company in 2003. Acquired by Sondrel 2015

Autonomous Vehicles

Properties

- An autonomous car is a vehicle capable of sensing its environment and operating without human involvement.
- Autonomous cars rely on sensors, actuators, complex algorithms, machine learning systems, and powerful processors to execute software.
- Autonomous cars create and maintain a map of their surroundings based on a variety of sensors situated in different parts of the vehicle.

Examples

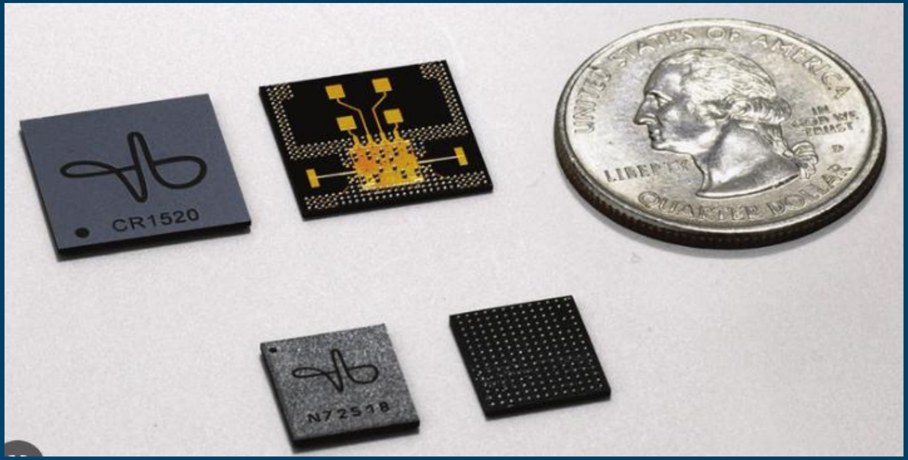
Sensors and Systems

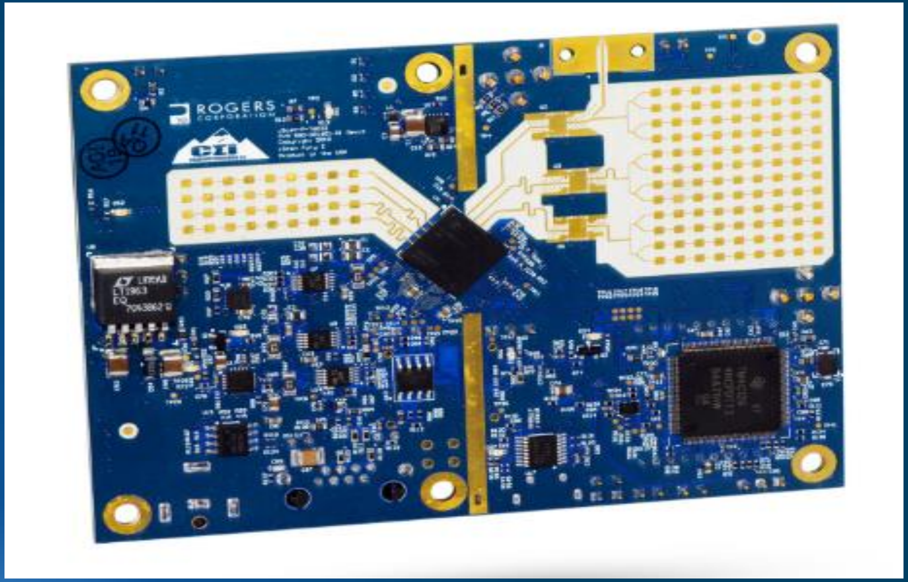
- Video Cameras:
  - detect traffic lights
  - read road signs
  - track other vehicles
  - look for pedestrians
- Radar Sensors:
  - monitor the position of nearby vehicles
- LIDAR Systems
  - measure distances
  - detect road edges
  - identify lane markings

RADAR

- Radar sensors are an integral part of advanced driver assistance systems (ADAS) in modern cars.
- They are used for:
  - blind spot detection (BSD)
  - lane change assistance (LCA)
  - collision mitigation (CM)
  - parking aid (PA)
  - rear cross traffic alert (RCTA) features
- Operate at 3 frequency bands
  - 24GHz
  - 60GHz
  - 77-79GHz

Radar chip with antennas on package

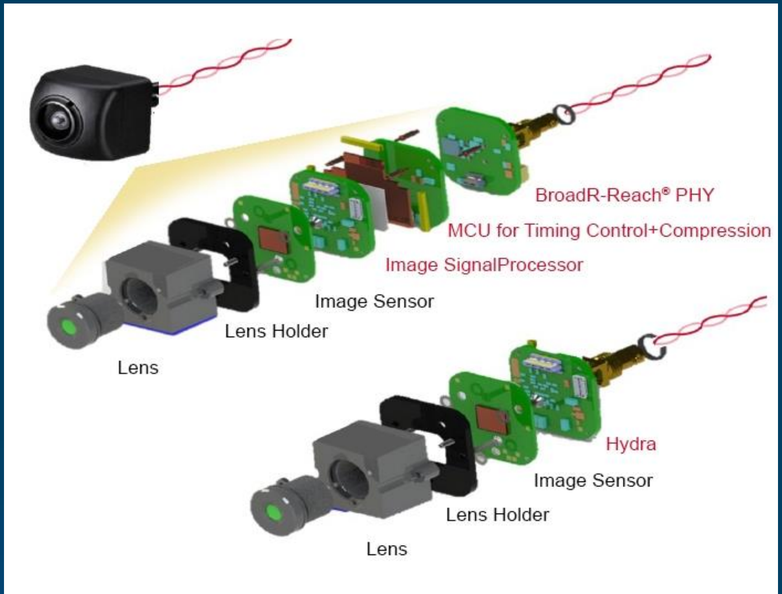




Fury radar chip by Texas Instruments

LiDAR

- LiDAR is an acronym for Light Detection and Ranging. In LiDAR, laser light is sent from a source (transmitter) and reflected from objects in the scene.
- The reflected light is detected by the system receiver and the time of flight (TOF) is used to develop a distance map of the objects in the scene.
- Implemented in a microchip of 10x10mm or smaller containing >125 million transistors

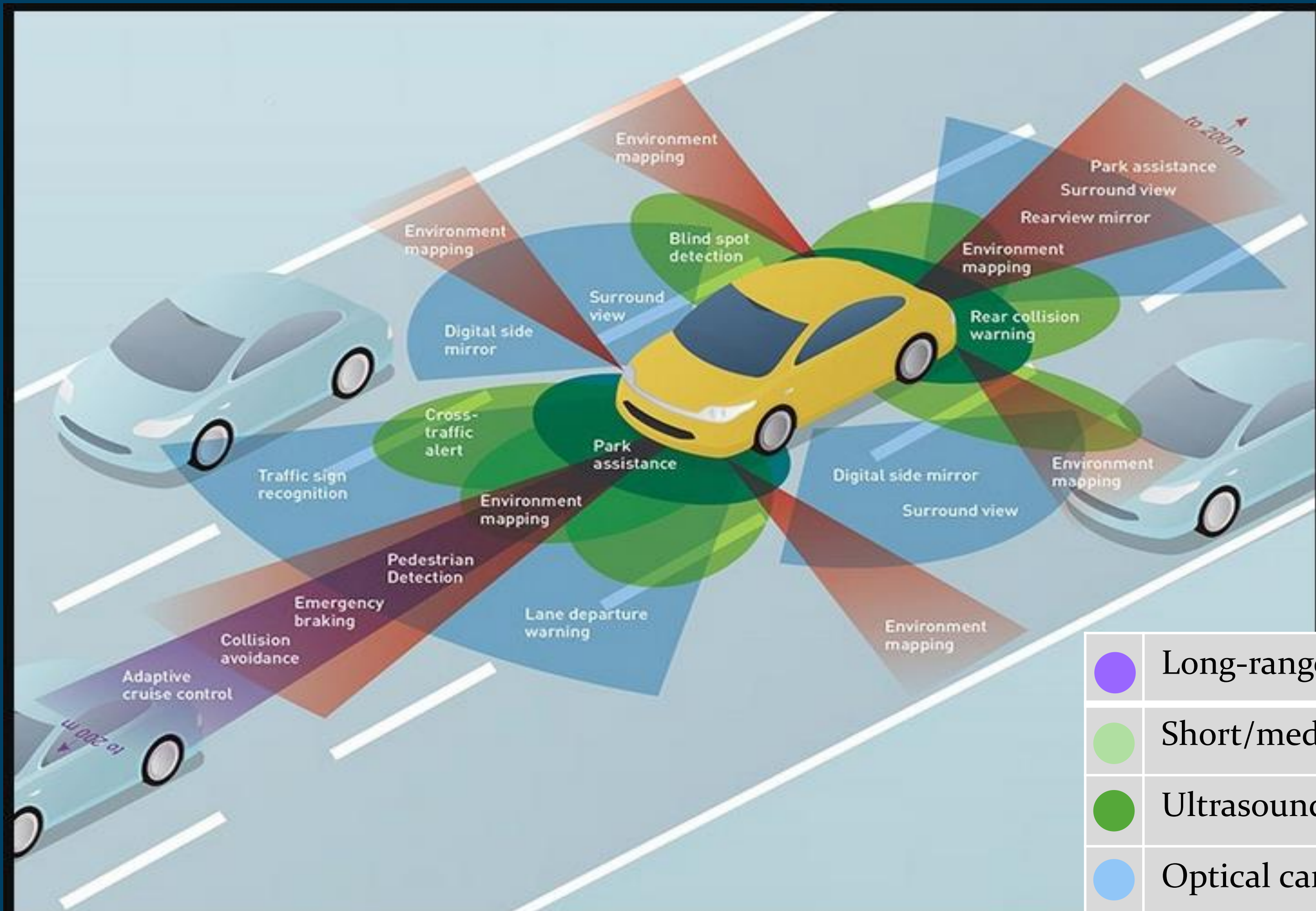


LIDAR

- Hottest topic in optics and photonics
- Spinning car-top sensors or solid-state scanners (InGaAs)
- 0.1 angular degree resolution
- Works n low-lighting conditions
- Suffers from adverse weather conditions
- Time-of-flight versus FMCW
  - TofF: determines distance from flight time of a laser pulse
  - FMCW: extracts time and velocity from frequency shift of returning light

Performance Compared Under Specific Conditions	Camera	RADAR	LiDAR
Dark, Little to No Light	Will Not Work	Very Good (Not Effected by Light Conditions)	Very Good
Variable Lighting Condition	Blinds the Camera	Very Good (Not Effected by Light Conditions)	Very Good
Adverse Weather (Rain, Snow and Fog)	Shortens Range	Very Good	Shortens Range
Angular Resolution	Poor at Long Range	Currently (2-5 Deg) Developmental (0.5-1 Deg)	0.1 Degree
Color & Contrast	Yes	No	No Color, Limited Contrast Info
Cost of Today Technology	2 Mega Pixel Resolution (Low Cost)	24/77 GHZ RADAR (Medium Cost)	Commercialized LIDAR System (Higher Cost)

Surround Views and Detection



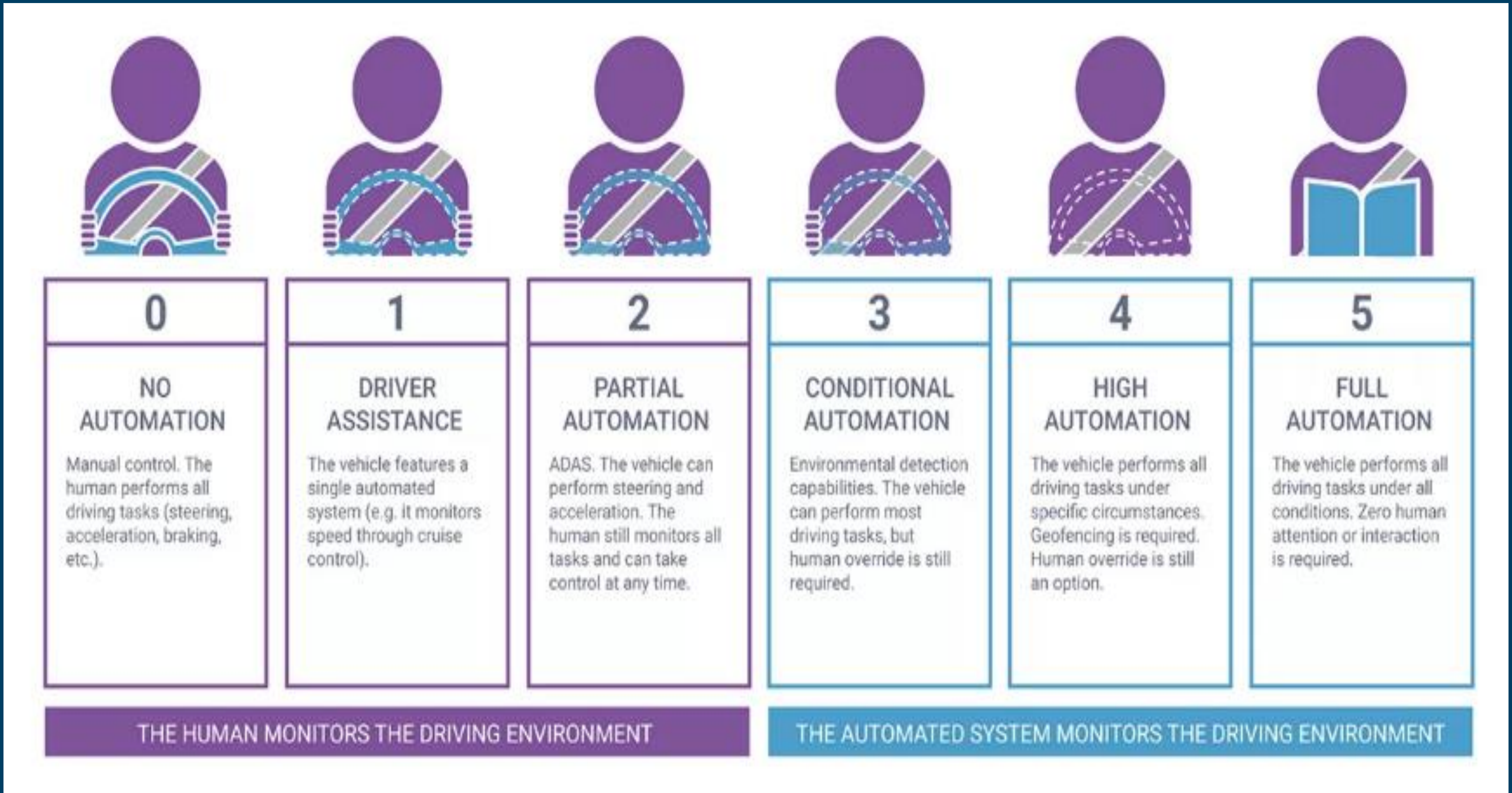
- Long-range radar
- Short/medium-range radar
- Ultrasound
- Optical cameras
- Lidar

Challenges

- **Lidar and Radar: High complexity and cost**
- **Weather Conditions**
- **Traffic Conditions and Laws**
- **Country Regulation**
- **Accident Liability**
- **Artificial vs. Emotional Intelligence**

- https://www.synopsys.com/automotive/what-is-autonomous-car.html

Levels of Driving Automation



Summary

- Modern cars increasingly rely on electronics
- Semiconductor chips are used in cars for safety, security, access, comfort, infotainment and connectivity
- Sensors are classified into three systems: cameras, Radars and Lidars all work in synergy
- Tremendous efforts are being made to overcome challenges and reduce risk
- Future cars will have higher levels of driving automation

Thank You

Notes

- Two optical challenges in particular:
  - One is the need for compact, economical, high-peak-power light sources capable of producing nanosecond pulses.
  - Equally demanding requirement is for effective collection optics and detectors that can deal with extremely low photon budgets. “Only a small fraction of emitted photons will return to the detector” even in the best case.
- On the light-source side, the most familiar distinction is between 1550-nm sources, which can operate at higher power (and, thus, longer ranges) without compromising eye safety, and more economical 905-nm systems, which “have been there forever” but must operate at lower power and ranges for eye safety.
- As with lasers, each detector type—from avalanche photodiodes to silicon-based single-photon avalanche detectors—has its weaknesses and strengths. “There’s not a ‘perfect’ detector”. “There are a lot of choices out there, and we’re still making choices today.”

Hydrogen Powered Combustion Engine as a Range Extender for Electric Vehicles

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UKRI Future Leaders Fellow

Centre for Advanced Powertrain and Fuels

Research interests:

- Advanced combustion technologies
- Dedicated zero/low carbon fuel engines
- Novel fuel designs
- Advanced hybrid electric engine systems

Research grants (£1.9m):

- UKRI Future Leaders Fellowship on novel engine and fuels
- EPSRC on ammonia/hydrogen combustion
- Industrial project on hydrogen engines

Contents

1. Challenges and opportunities of moving towards net zero transport
2. Propulsion and fuel technologies driving the net zero transition
3. Summary

Brunel University London

Contents

1. Challenges and opportunities of moving towards net zero transport
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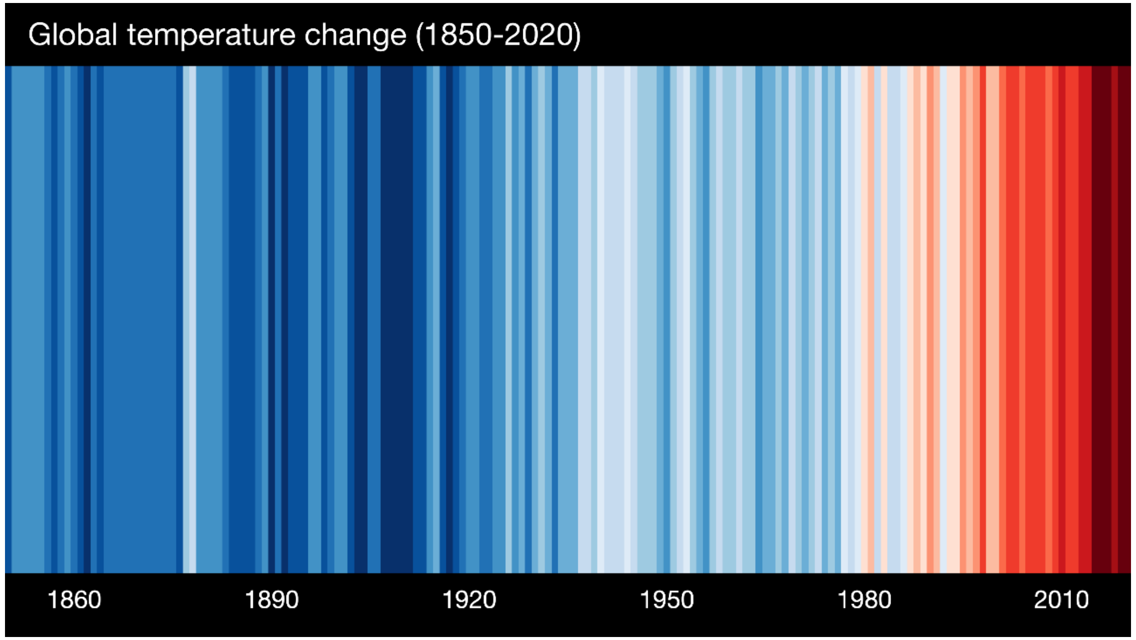
Challenges and opportunities of moving towards net zero

❑ Net zero targets drive the future development of all sectors



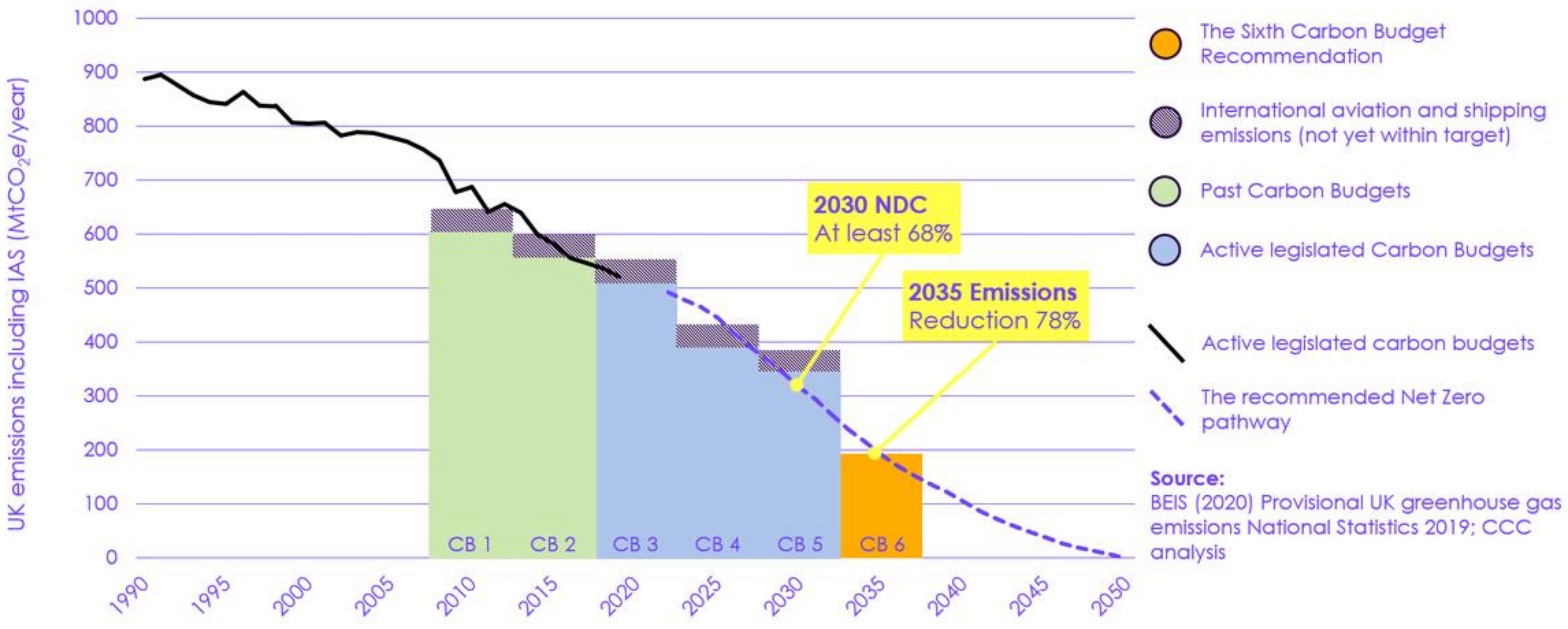
Carbon emissions

Source: University of Reading; http://www.daoxinhe.com/a/xinwendongtai/xingyedongtai/72.html

Challenges and opportunities of moving towards net zero

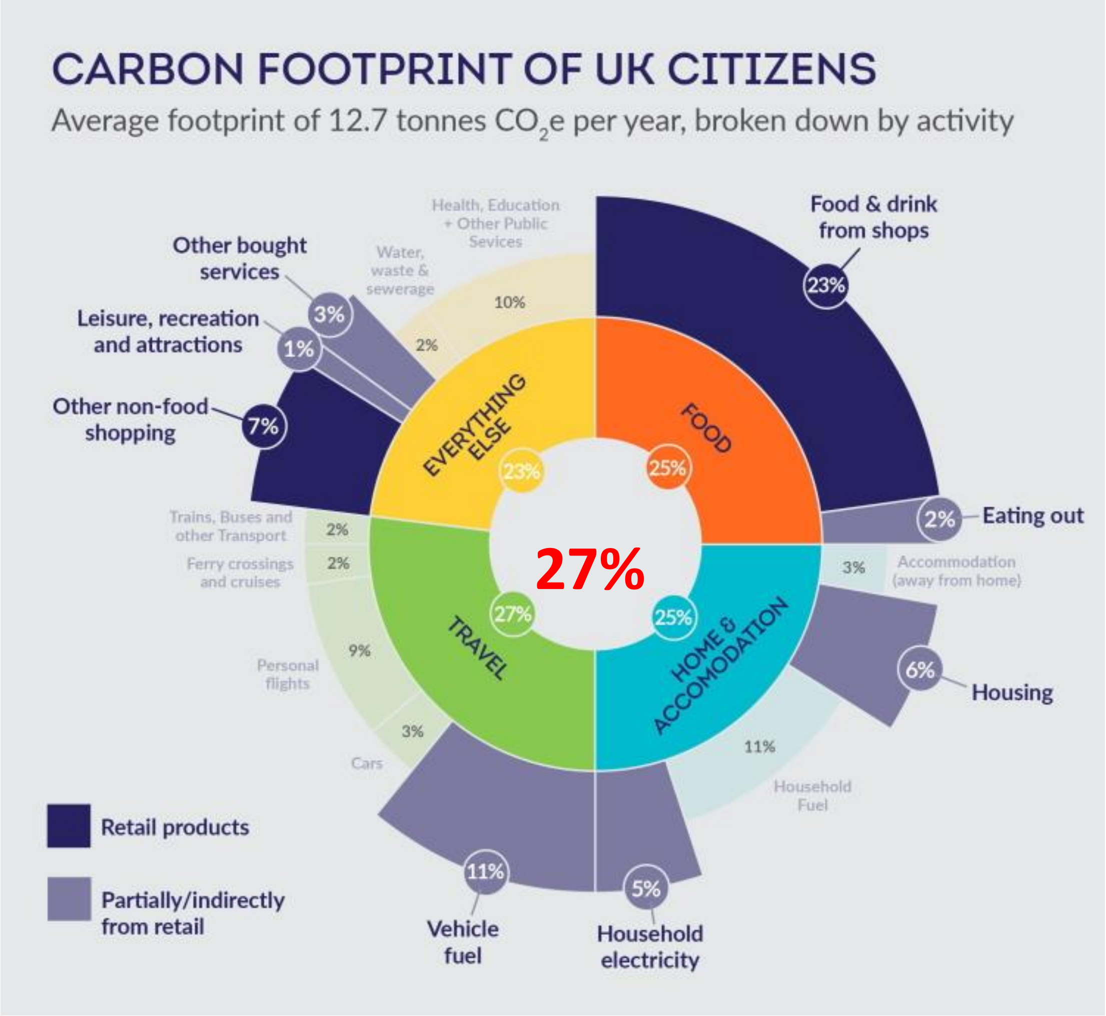
- Net zero targets drive the future development of all sectors

UK carbon budgets

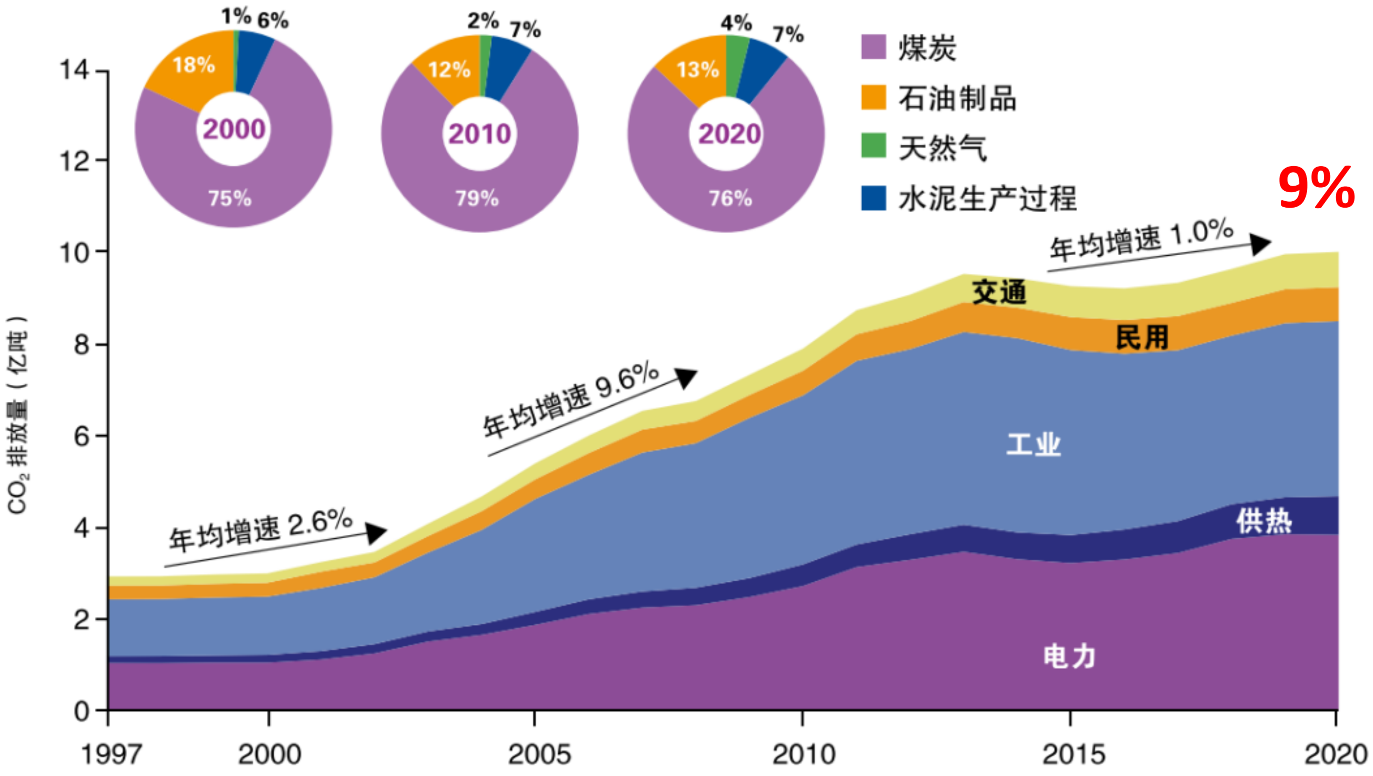


Challenges and opportunities of moving towards net zero

- Transport is an important but challenging area for decarbonisation



China

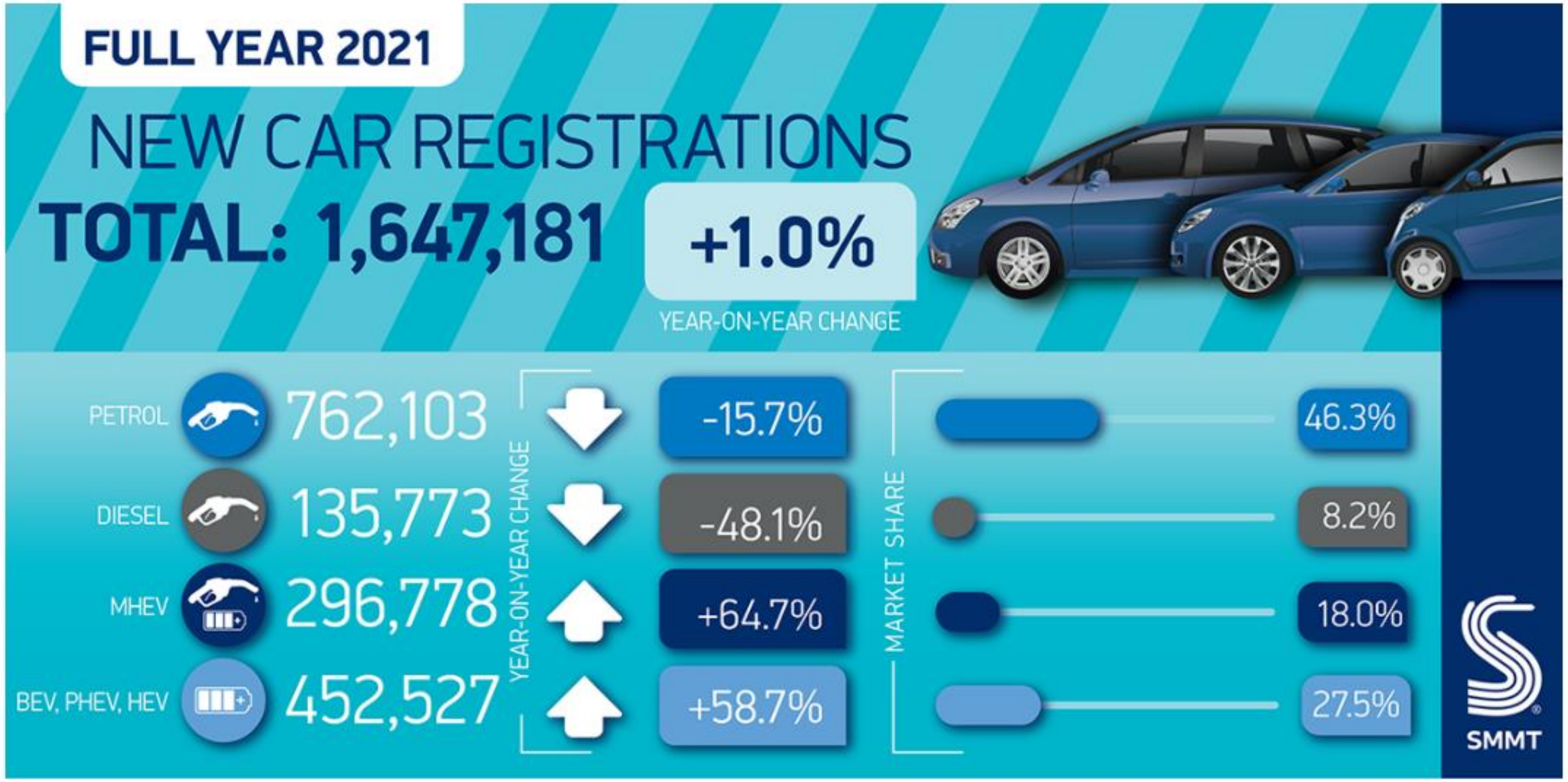


Source: Lancaster University & Small World Consulting; http://finance.sina.com.cn/esg/ep/2021-11-30/doc-ikyakumx1025810.shtml

Challenges and opportunities of moving towards net zero

- Transport is an important but challenging area for decarbonisation

UK new car sale



Challenges and opportunities of moving towards net zero

❑ Transport is an important but challenging area for decarbonisation

UK new car sale

Year to date

	YTD 2021	YTD 2020	% change	Mkt share -21	Mkt share -20
Diesel	135,773	261,772	-48.1%	8.2%	16.0%
MHEV diesel	98,753	60,953	62.0%	6.0%	3.7%
Petrol	762,103	903,961	-15.7%	46.3%	55.4%
MHEV petrol	198,025	119,179	66.2%	12.0%	7.3%
BEV	190,727	108,205	76.3%	11.6%	6.6%
PHEV	114,554	67,134	70.6%	7.0%	4.1%
HEV	147,246	109,860	34.0%	8.9%	6.7%
TOTAL	**1,647,181**	**1,631,064**	**1.0%**		

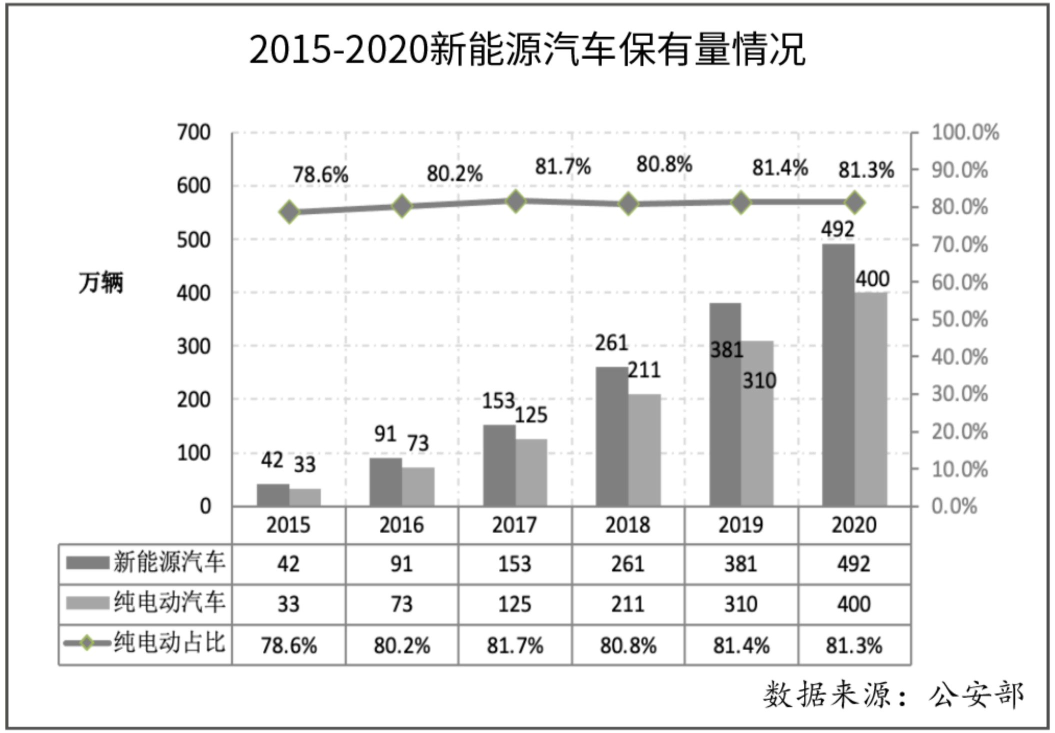
BEV - Battery Electric Vehicle; **PHEV** - Plug-in Hybrid Electric Vehicle; **HEV** - Hybrid Electric Vehicle, **MHEV** - Mild Hybrid Electric Vehicle

- The market share of hybrid increase faster than BEV.
- Petrol-powered vehicles, including mild hybrids (MHEVs), remain Britain's most popular powertrain, accounting for 58.3% of all new cars registered in 2021, with diesel-powered cars including MHEVs making up 14.2% of the market, followed by BEVs at 11.6%, HEVs at 8.9% and PHEVs at 7.0%.
- 88.4% of new vehicles still have ICEs

Challenges and opportunities of moving towards net zero

❑ Transport is an important but challenging area for decarbonisation

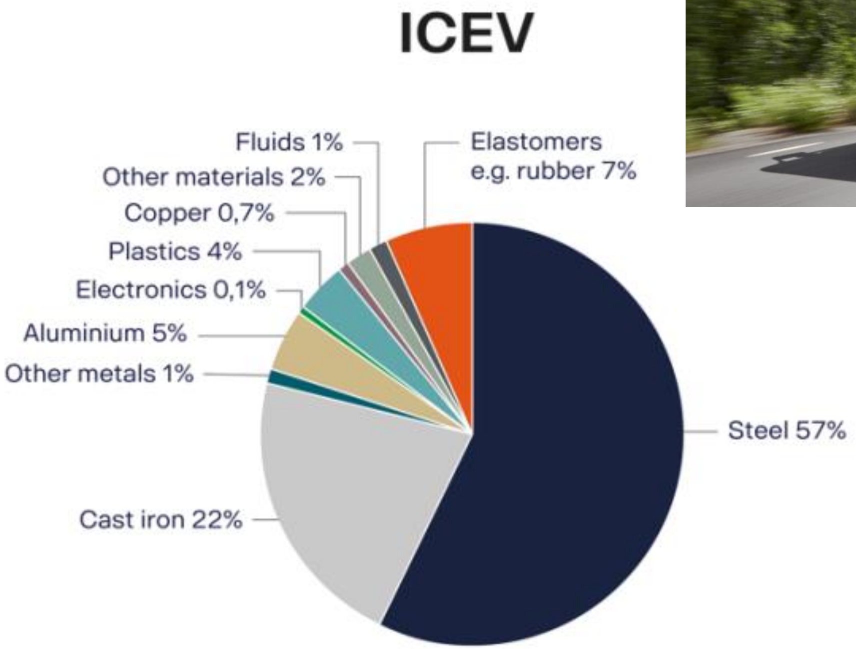
China: New Energy vehicle market is dominated by pure electric vehicles

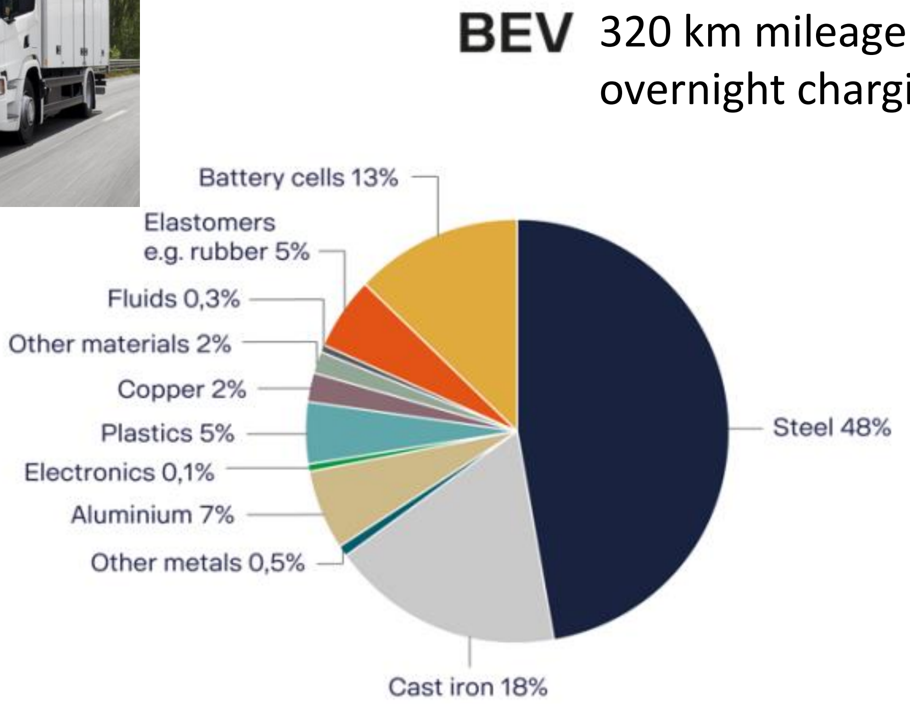


Challenges and opportunities of moving towards net zero

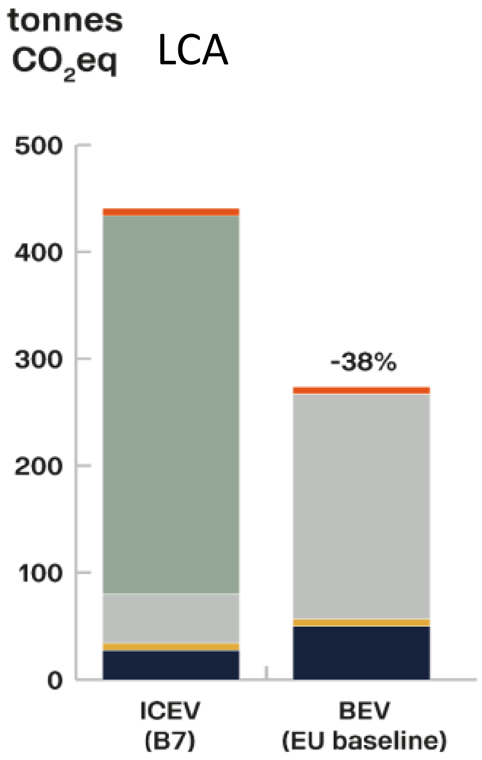
❑ Transport is an important but challenging area for decarbonisation

Heavy Good Vehicles?





320 km mileage
overnight charging

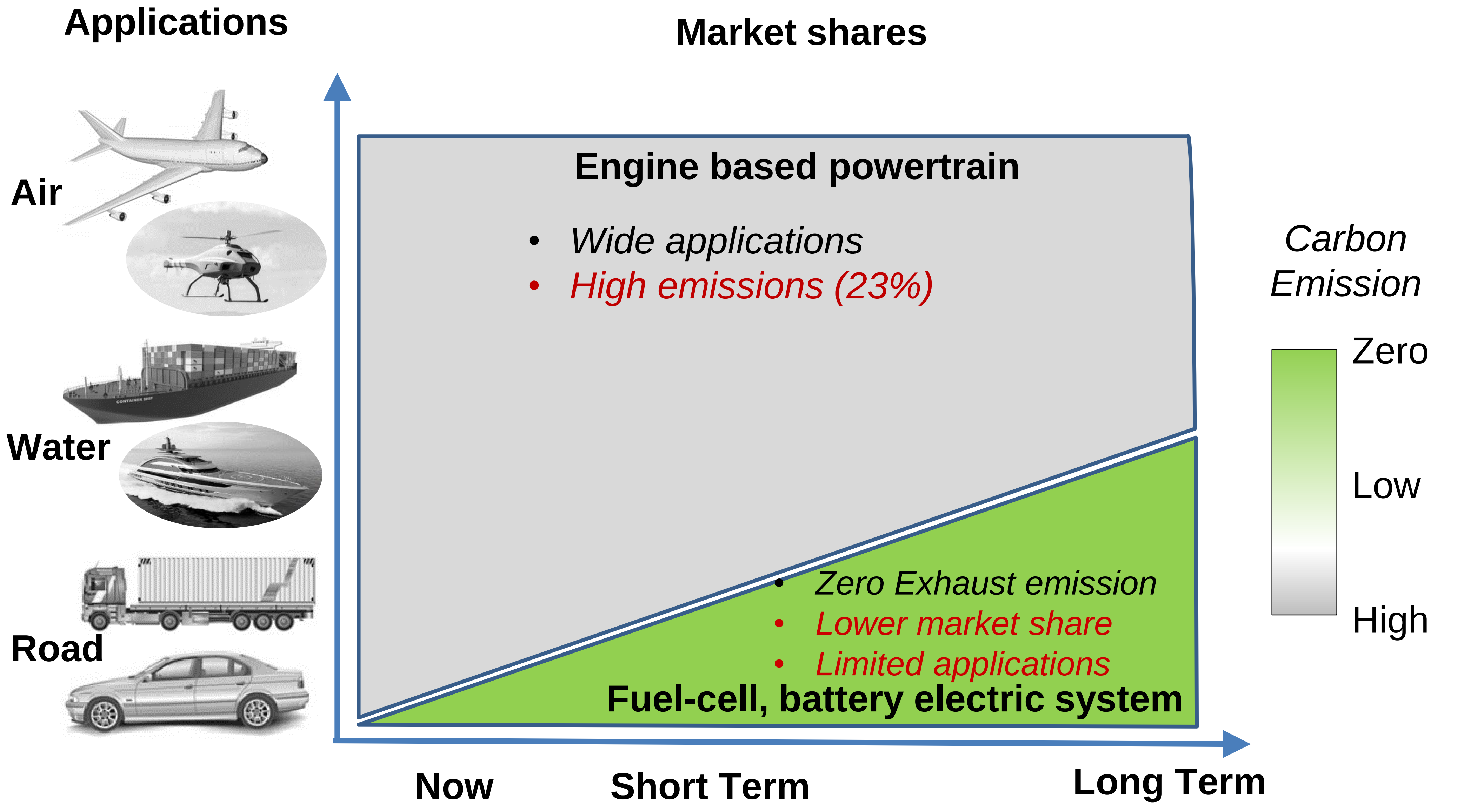


Challenges and opportunities of moving towards net zero

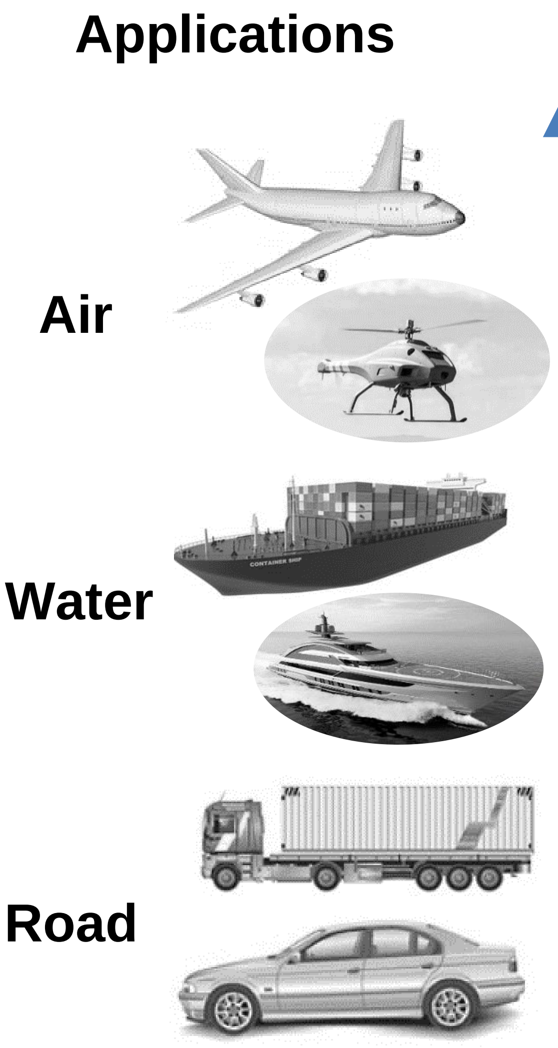
❑ Transport is an important but challenging area for decarbonisation

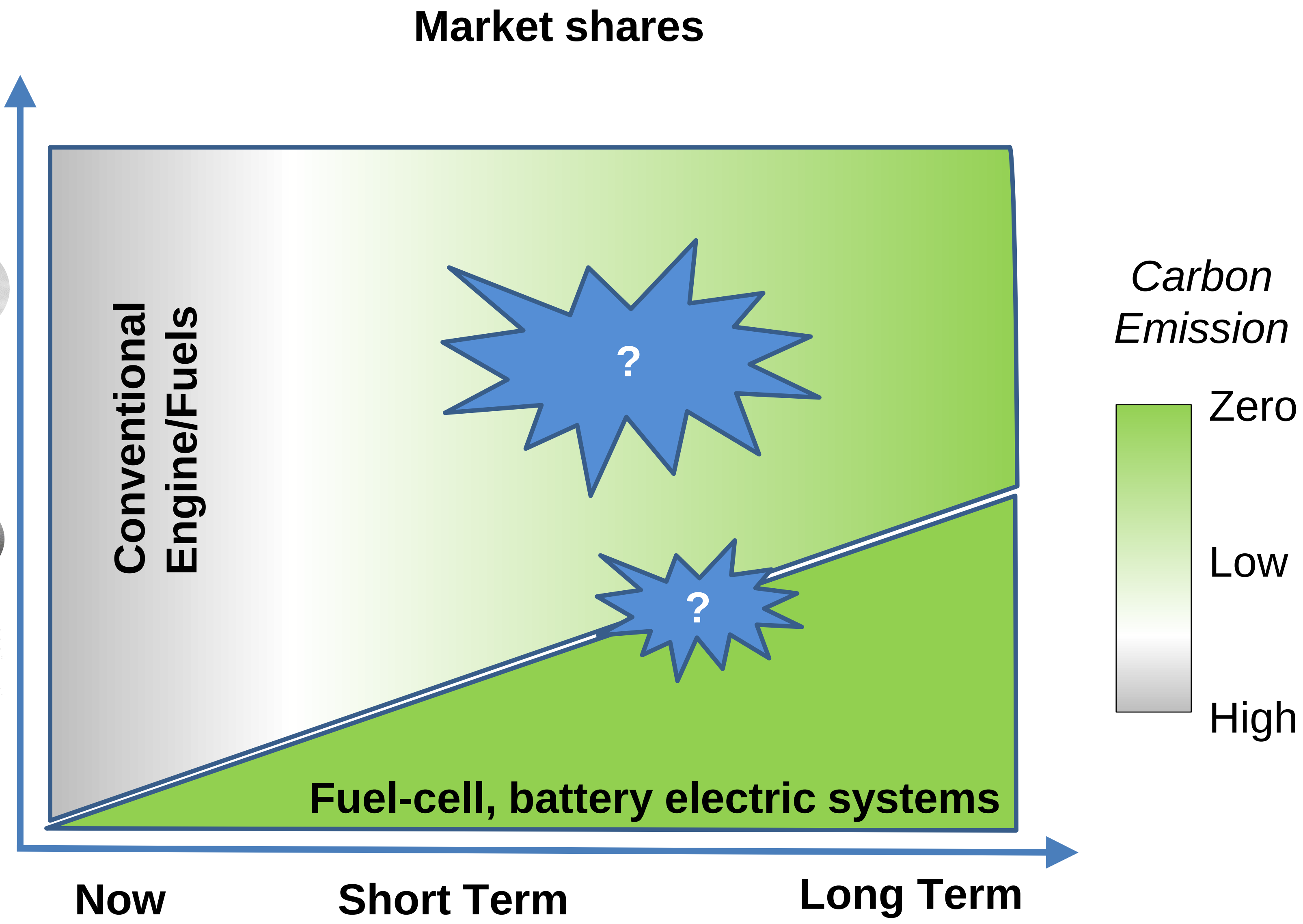
What about these?

Challenges and opportunities of moving towards net zero



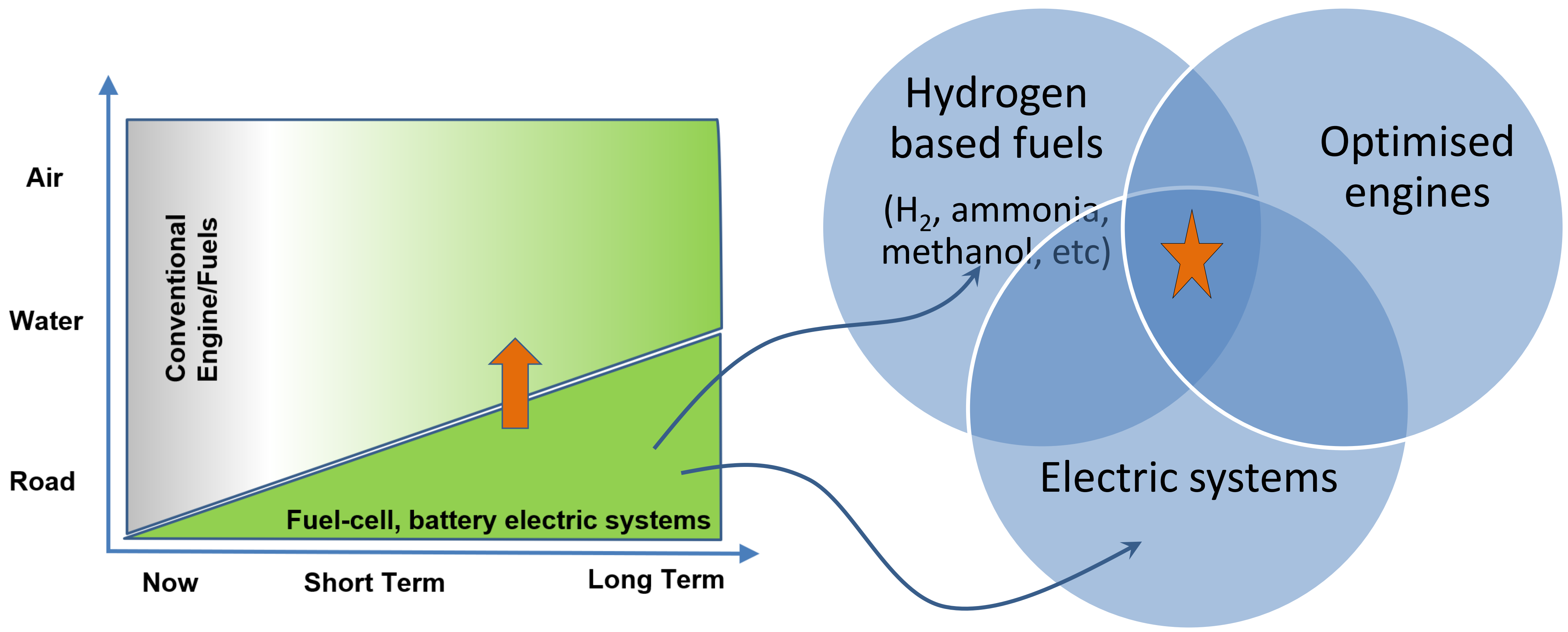
Challenges and opportunities of moving towards net zero





Challenges and opportunities of moving towards net zero

❑ What are the opportunities



Contents

1. Challenges and opportunities of moving towards net zero transport
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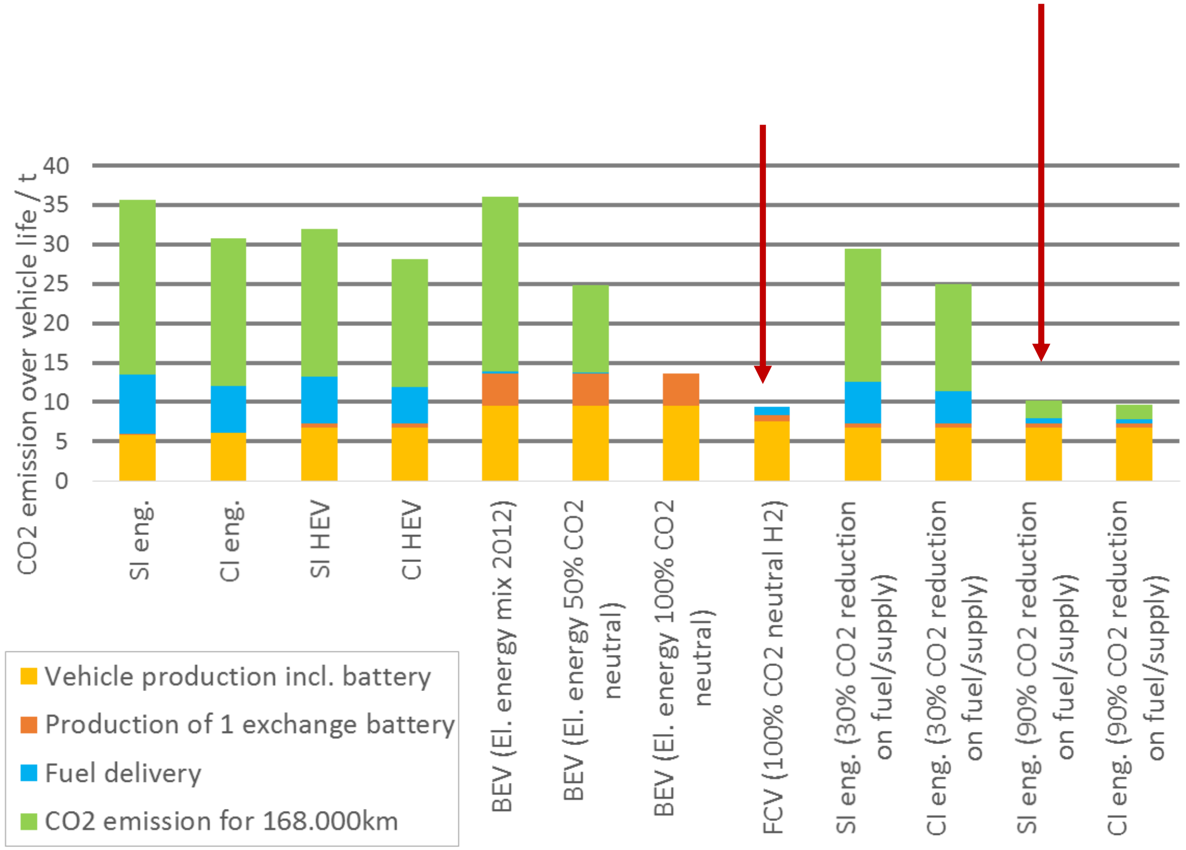
Propulsion and fuel technologies driving the net zero transition

❑ Low/zero carbon fuels

Life cycle analysis (LCA) of carbon emissions



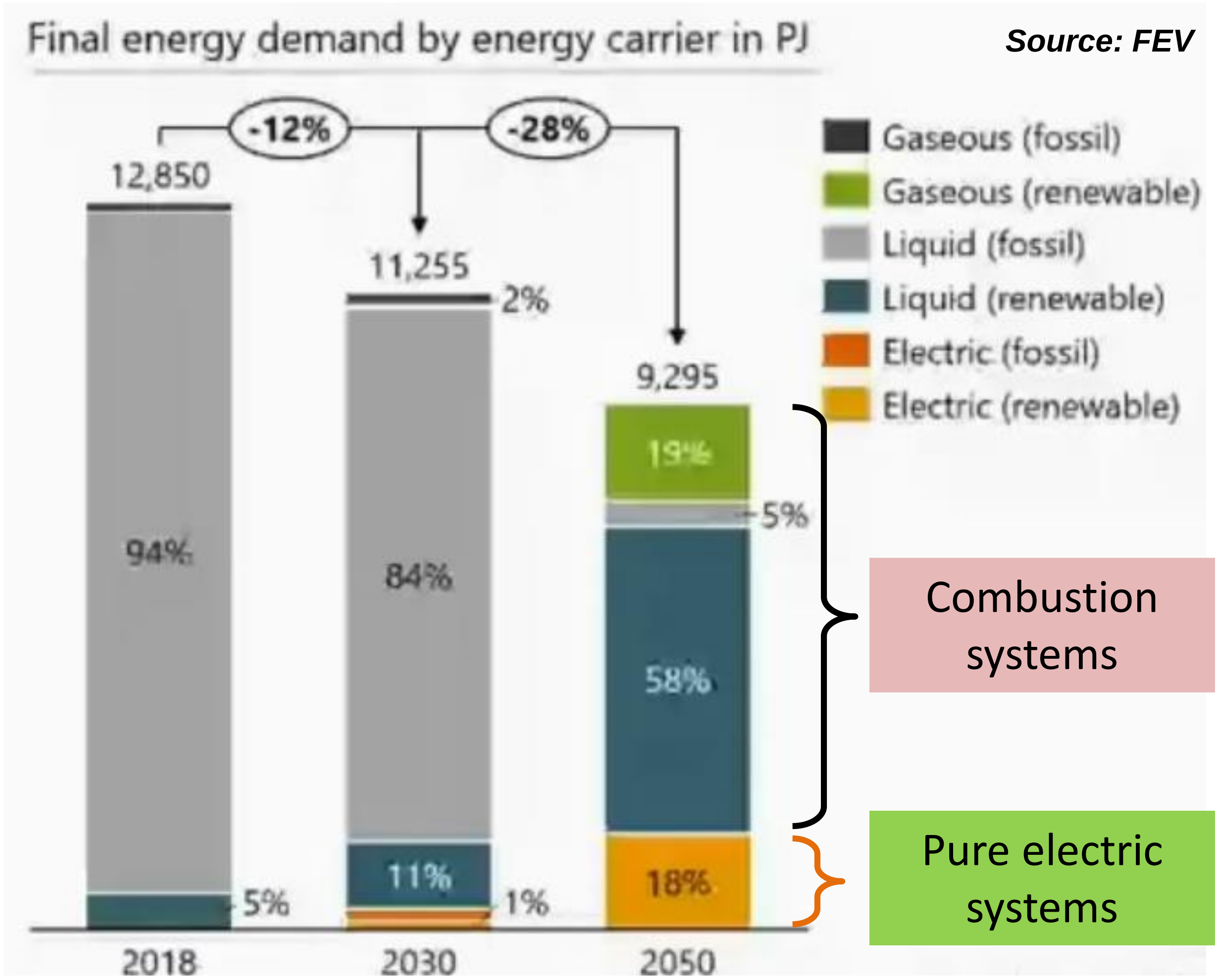
*) Total lifetime: 168 000 km

Source: FEV 2018

Brunel University London

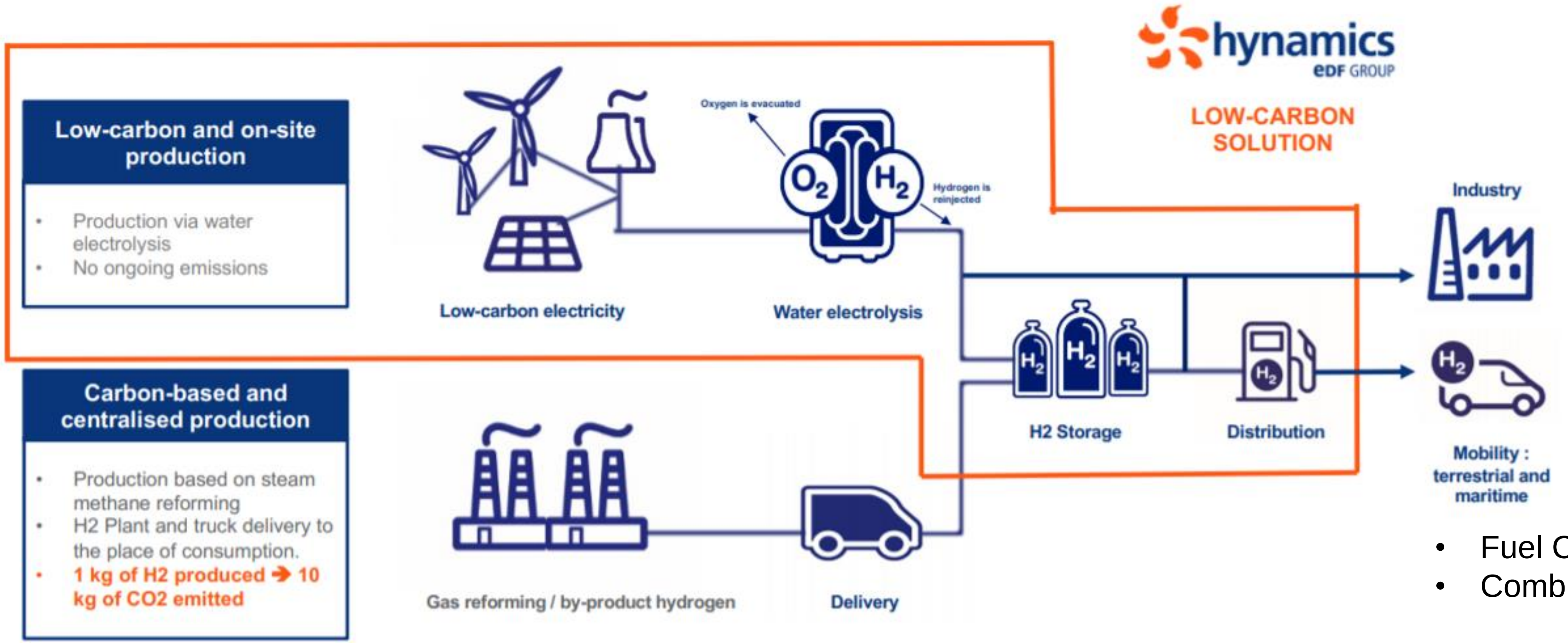
Propulsion and fuel technologies driving the net zero transition

❑ Low/zero carbon fuels



❑ Low/zero carbon fuels

Hydrogen

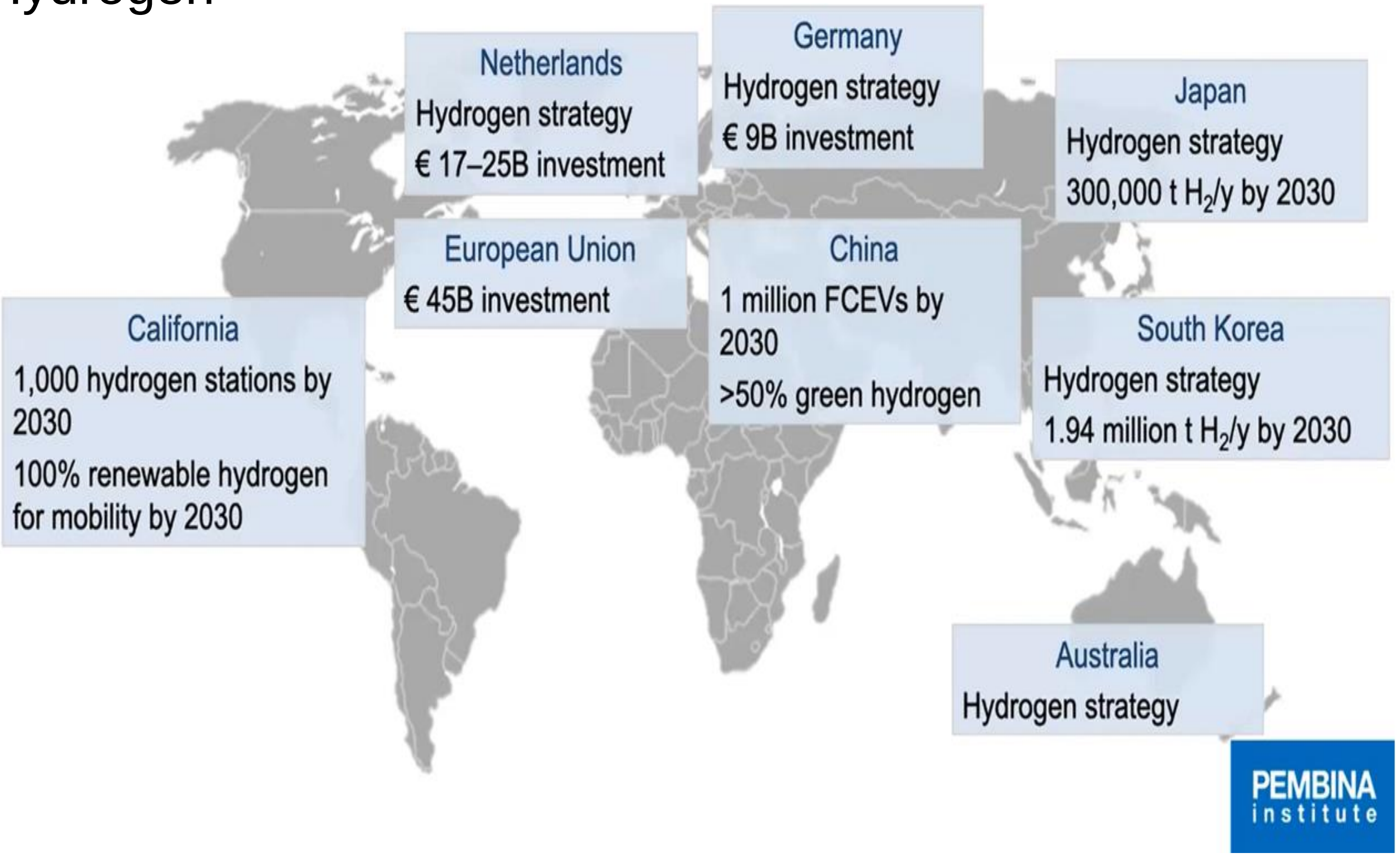


- Fuel Cells
- Combustion systems

Propulsion and fuel technologies driving the net zero transition

❑ Low/zero carbon fuels

Hydrogen



Low/zero carbon fuels

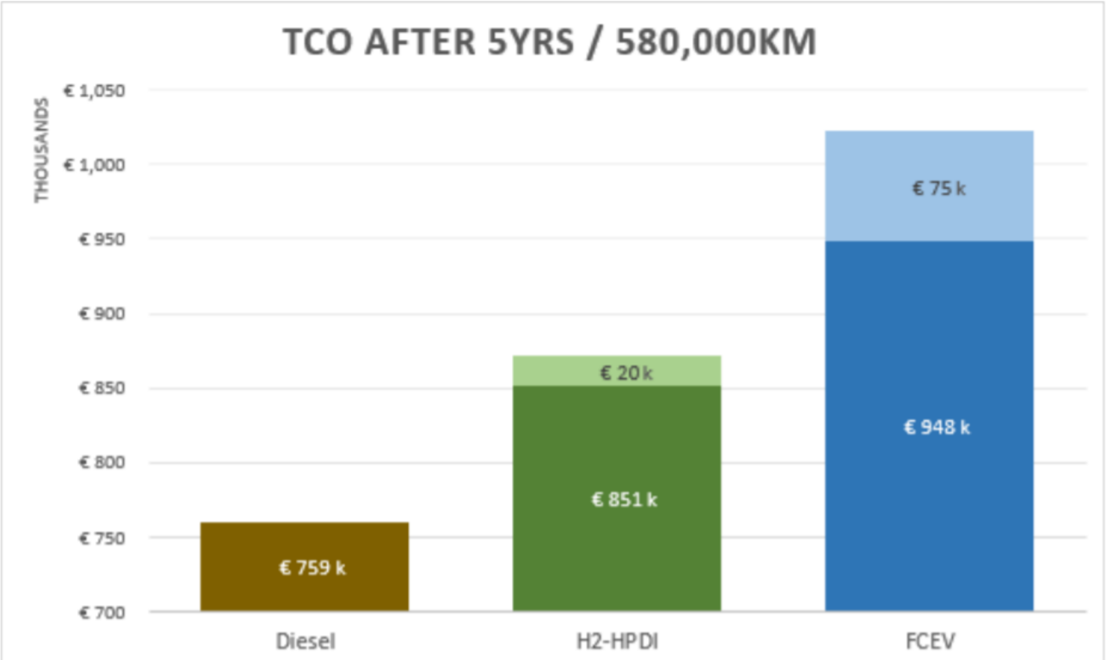
Hydrogen

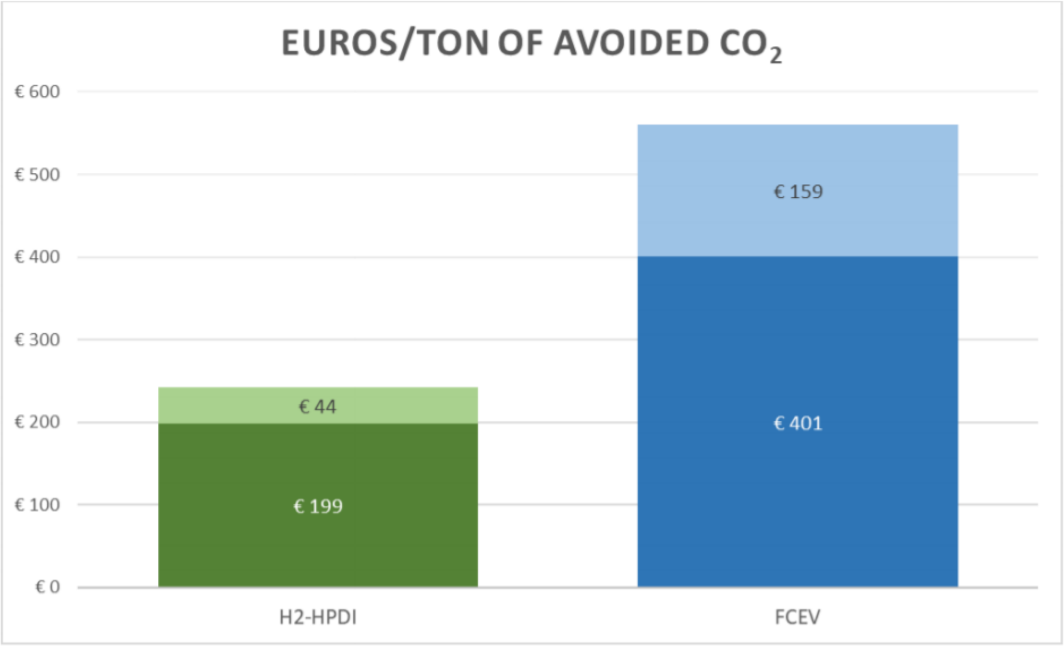
Attributes	H2 Engine	H2 Fuel Cell (FC)
CO2 emission	zero	zero
Hydrogen quality	Low purity	High purity
Powertrain system	Engine, Hybrid Electric	FC+ batteries
Cost	Similar to Diesel/NG engines	Substantially expensive
Overall efficiency	Baseline(42%), Advanced (45%), Dedicated (50%)	FC –battery-motor (55% x 80%x 80%) FC-motor (55%x 80%)
Performance	Instant cold-start and shut-down	Warm-up period, slow response
Pollutant Emission	Zero Impact NOx (< 0.5 μg/m^3 vs 18μg/m^3 ambient)	Zero
Durability	Similar to NG engines	PEM (6000 vs 30000 hours for HDV)
Social /Economic impacts	Protect Existing infrastructure and employment	New manufacturing, precious metals

Propulsion and fuel technologies driving the net zero transition

❑ Low/zero carbon fuels

Hydrogen





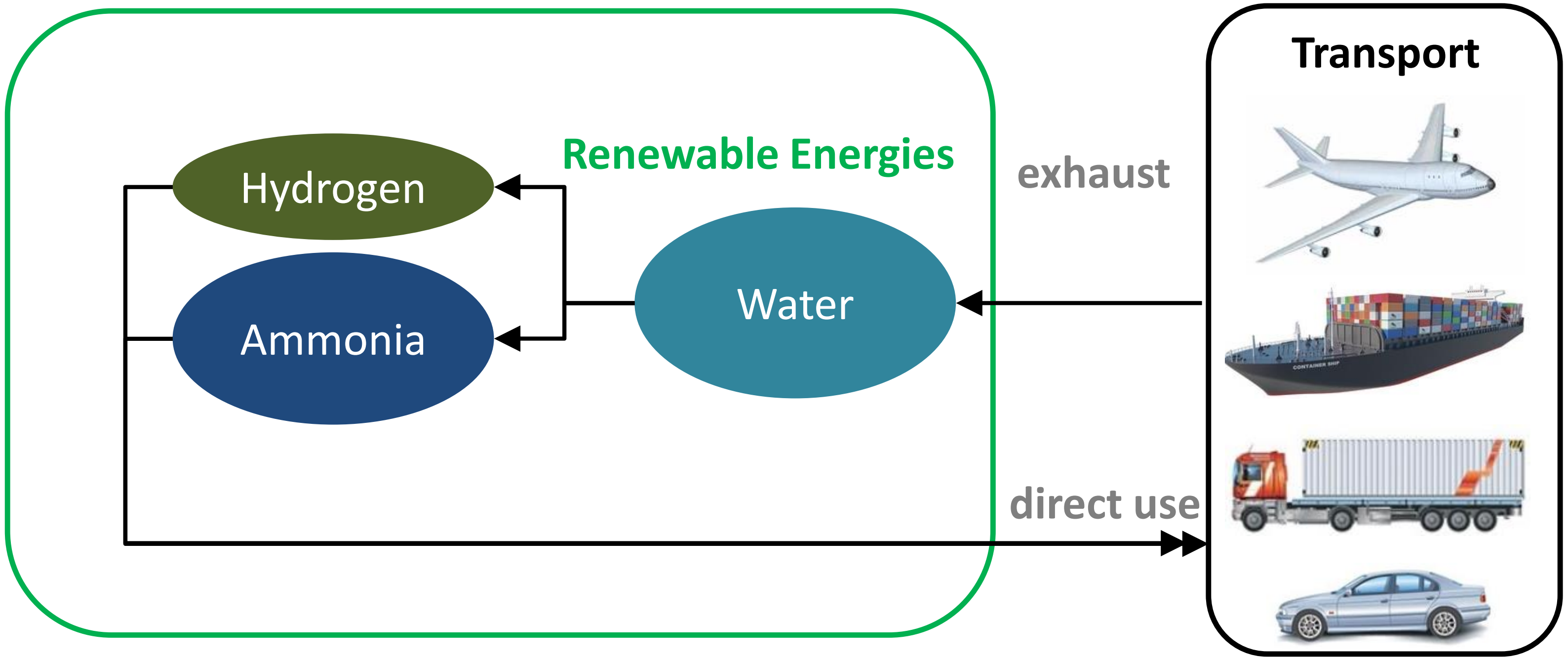
Source: AVL

Propulsion and fuel technologies driving the net zero transition

❑ Low/zero carbon fuels

Ammonia: an excellent hydrogen carrier

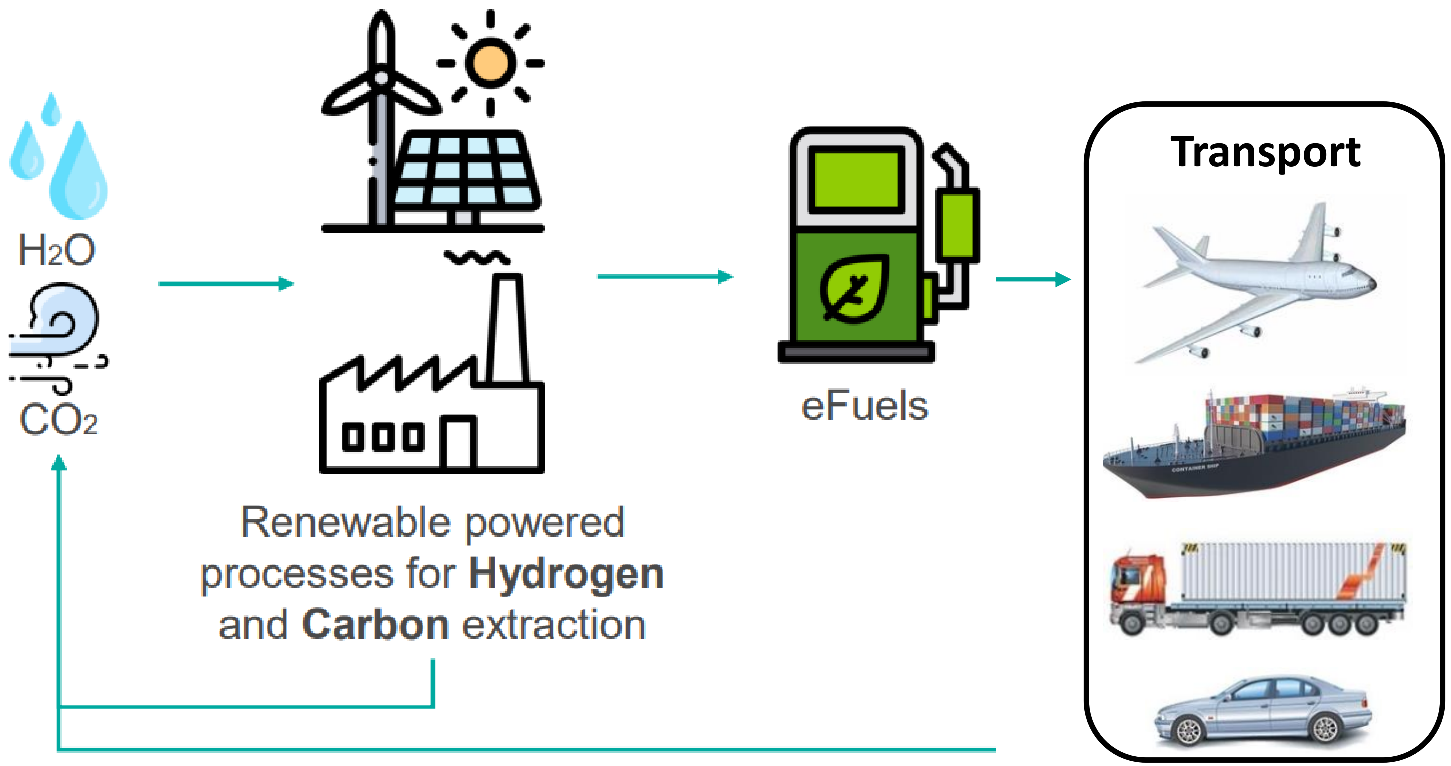
	Advantages	Disadvantages
Hydrogen	- Zero carbon - Optimal combustion + high calorific value	- Huge investment in storage - Long time to set up infrastructure
Ammonia	- Zero carbon - Existing infrastructure	- Poor combustion, low efficiency



- Carbon-free
- Optimised combustion
- Higher efficiency (with H_2)
- Using existing infrastructure
- Faster implementation
- Applicable for other sectors

❑ Low/zero carbon fuels

E-fuels (e-methanol, e-methane, etc.)



Sources: Marco Chiodi, FKFS

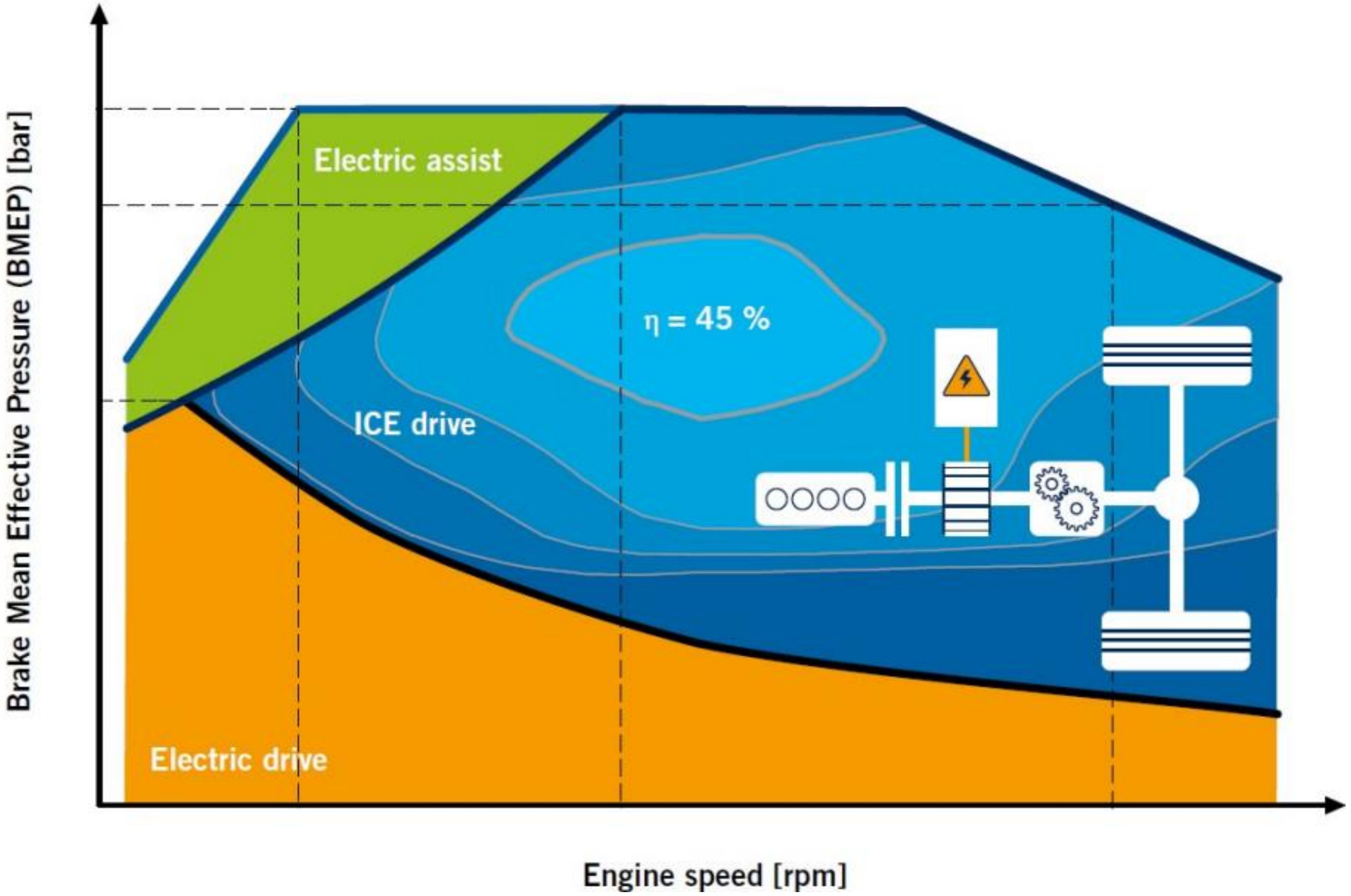
❑ Electric techniques to improve ICEs further

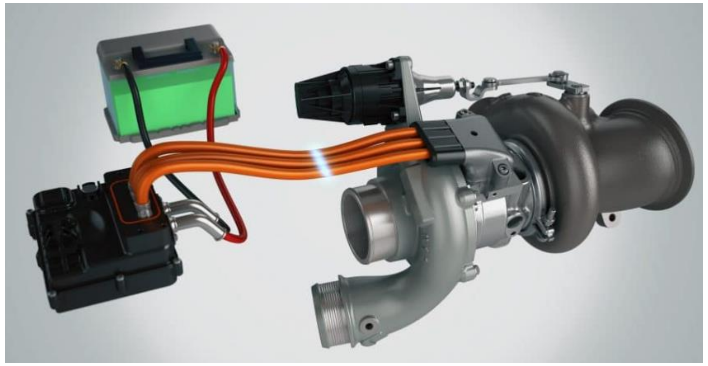
Hybrid and range extender systems

- High energy density of fuels – long range
- Eliminate/reduce external charging – increased flexibility
- Load leveller – improved ICE efficiency
- Usage of electric machine – improved efficiency and torque characteristics
- Regeneration ability – improved overall efficiency
- Start-stop function - reduced emissions and fuel consumption
- (Plug-in hybrid – used external electricity supply with lower running cost)

❑ Electric techniques to improve ICEs further

Hybrid and range extender systems

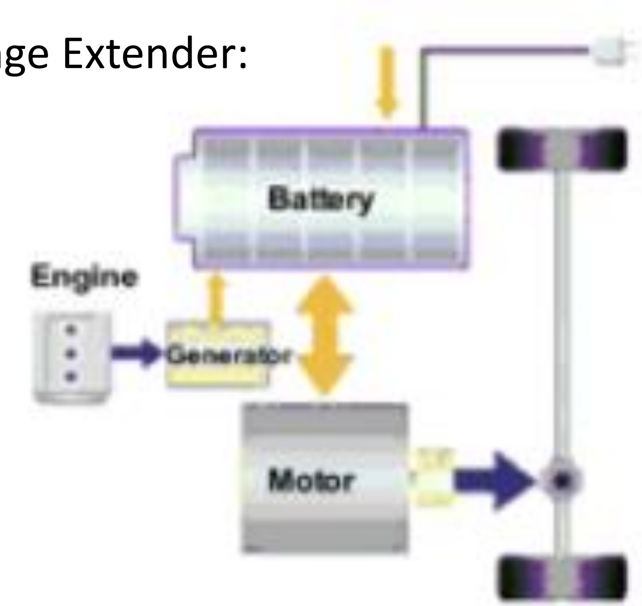


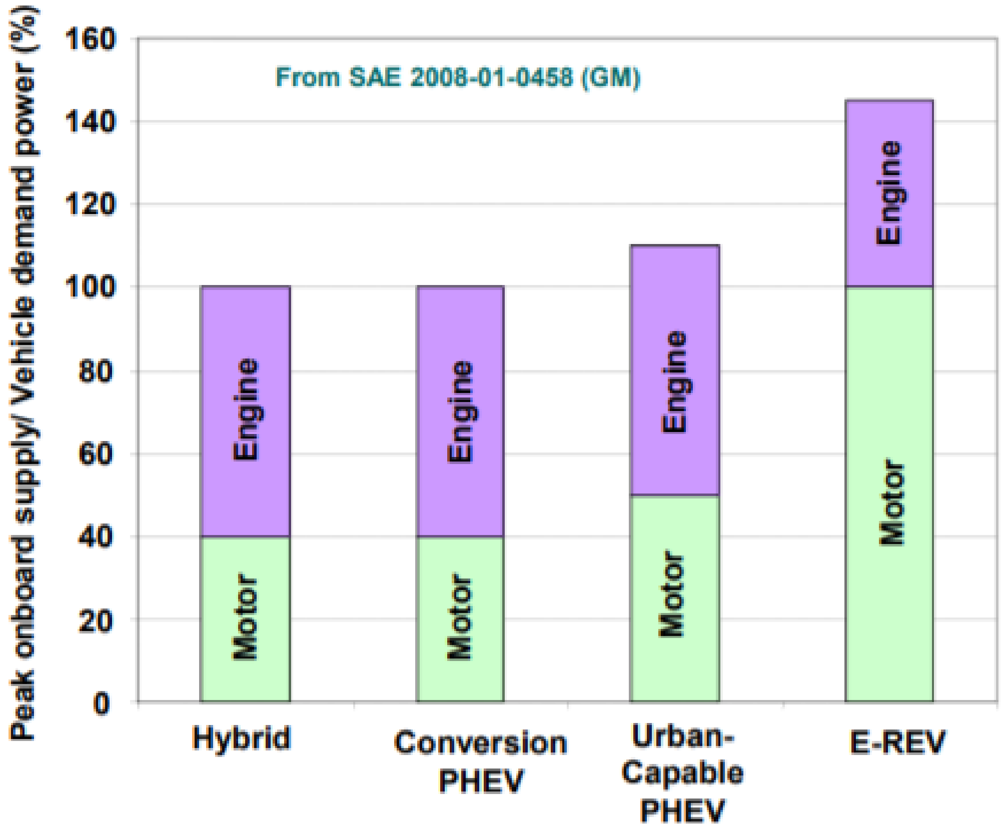


❑ Electric techniques to improve ICEs further

Hybrid and range extender systems

Range Extender:



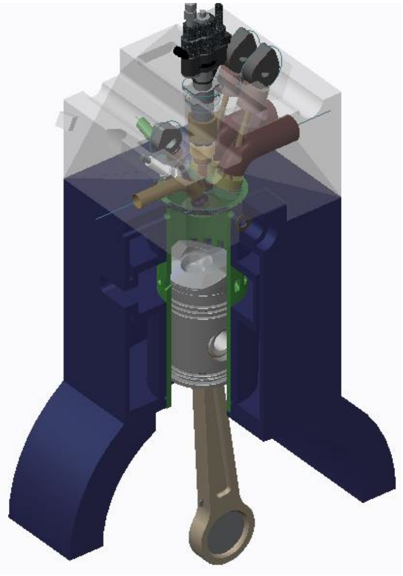


Challenges of moving towards net zero

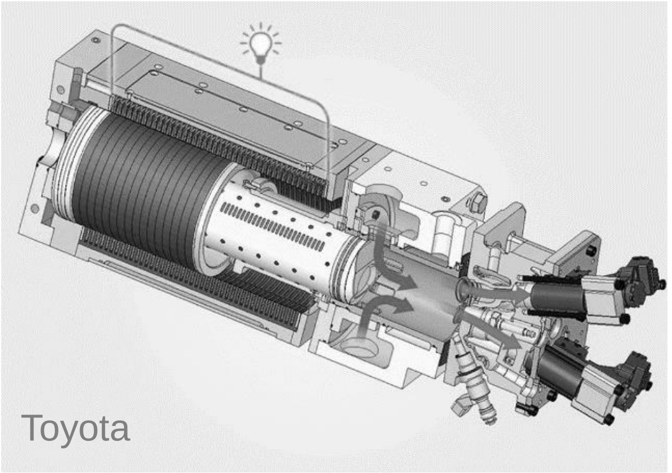
❑ Electric techniques to improve ICEs further

Dedicated range extender (Compact 2-stroke engine)

Fuel-Flexible Engine:
by adapting to hydrogen fuel.



Dedicated Engine Generator:
by integrating electric generator.



Transport

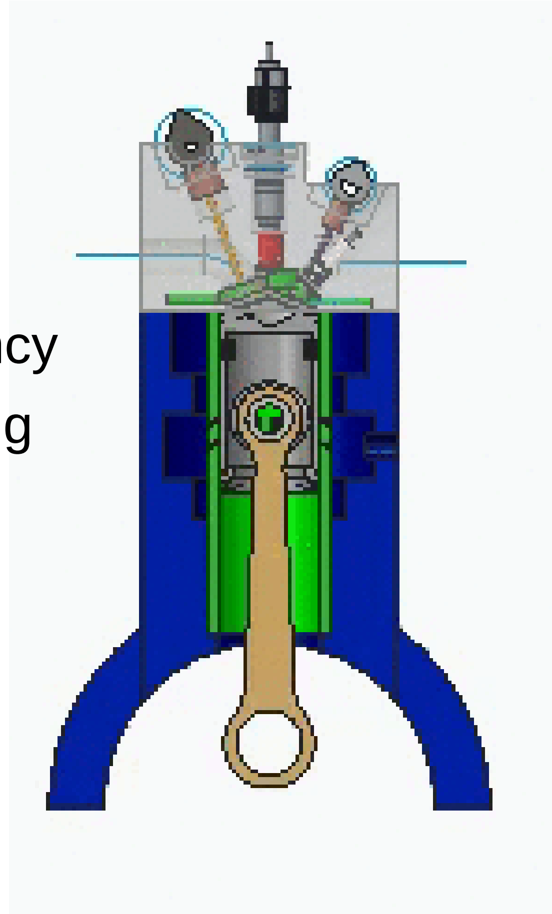
Challenges of moving towards net zero

❑ Electric techniques to improve ICEs further

Dedicated engine generator (Compact 2-stroke engine)

Key Features:

- 2-stroke operation
- Uniflow scavenging
  - Best scavenging efficiency
  - Minimised short-circuiting
  - Even thermal load
- Overhead exhaust valves
- VVA compatibility
- Direct injection
- Boosted operation

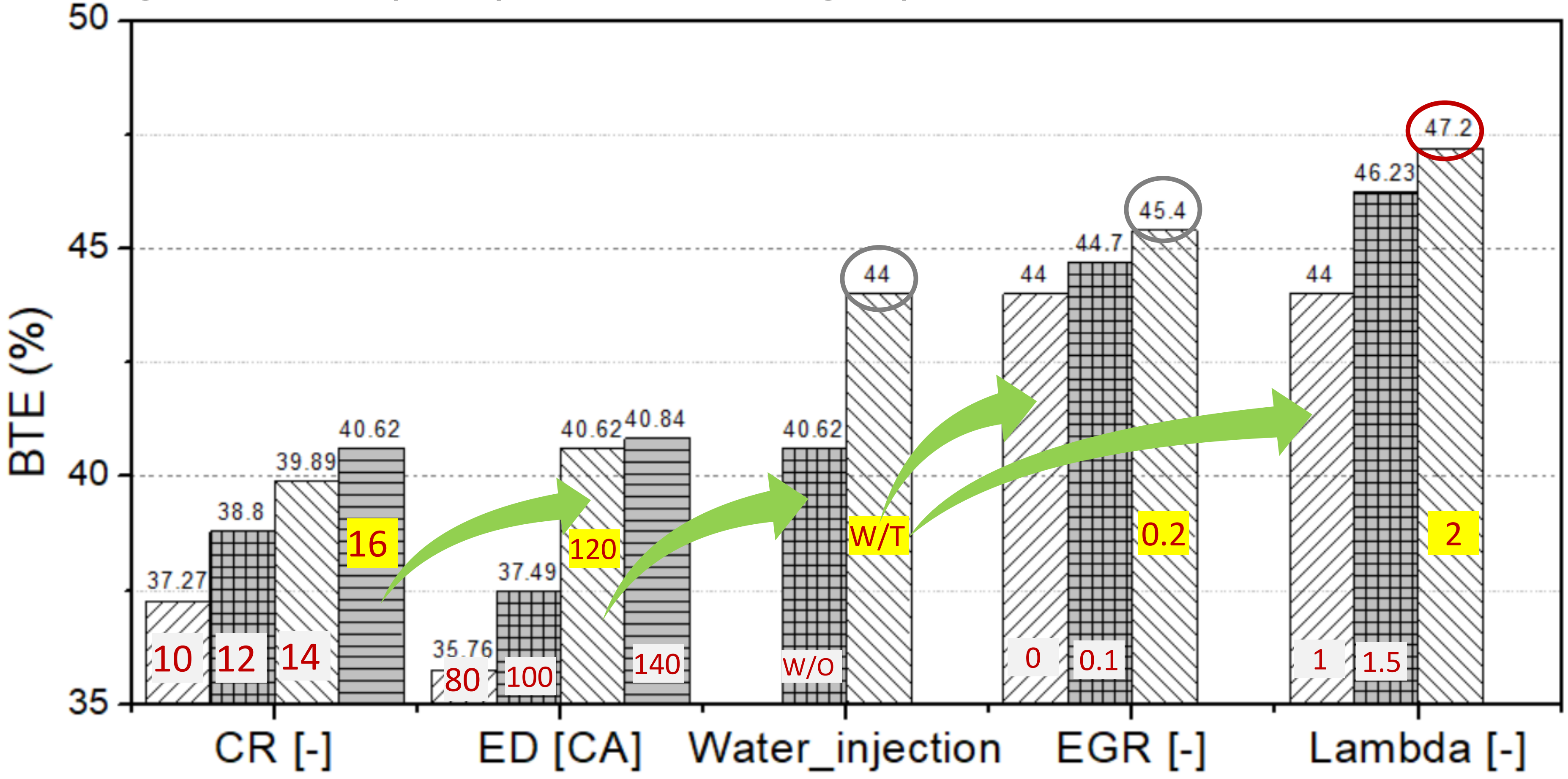


R&D work:

- **Determination of B/S ratio** , Journal of Automobile Engineering, 2017.
- **Scavenge port designs**, SAE 2016-01-1049
- **Scavenge plenum** designs, SAE 2017-01-1031
- **VVA optimization**, International Journal of Engine Research, 2017; IMechE: ICE conference 2017
- **Fuel injection strategies**, International Journal of Engine Research, 2017; SAE 2018-01-0272.
- **Combustion chamber design**, International Journal of Engine Research, 2020.
- **Boosting system optimisation**, SAE 2020-01-2007
- **Review and potential analysis**, Engineering, 2019.

❑ Electric techniques to improve ICEs further

Dedicated range extender (Compact 2-stroke engine)



X. Wang and H. Zhao (2019). "A High-Efficiency Two-Stroke Engine Concept: The Boosted Uniflow Scavenged Direct-Injection Gasoline (BUSDIG) Engine with Air Hybrid Operation." Engineering **5** (3): 535-547.

Advanced combustion techniques for low/zero carbon fuels

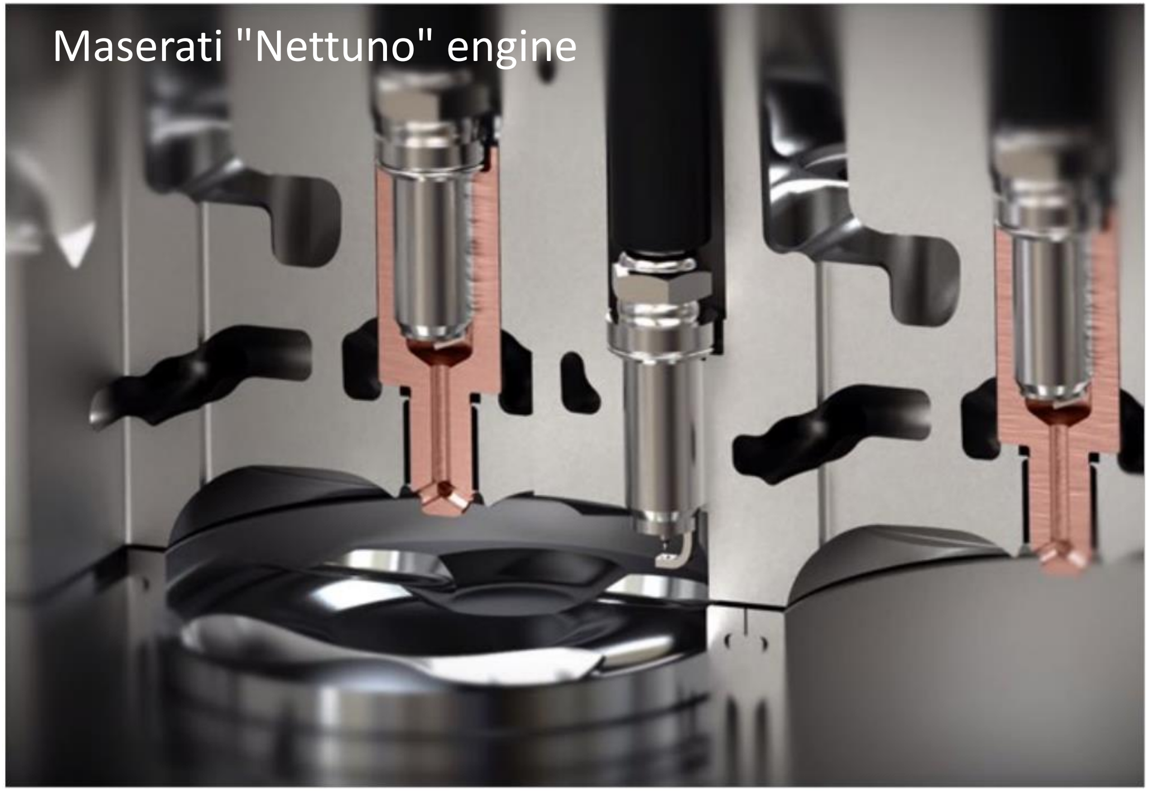
Differences in fuel properties require advanced combustion techniques to improve hydrogen engine efficiency

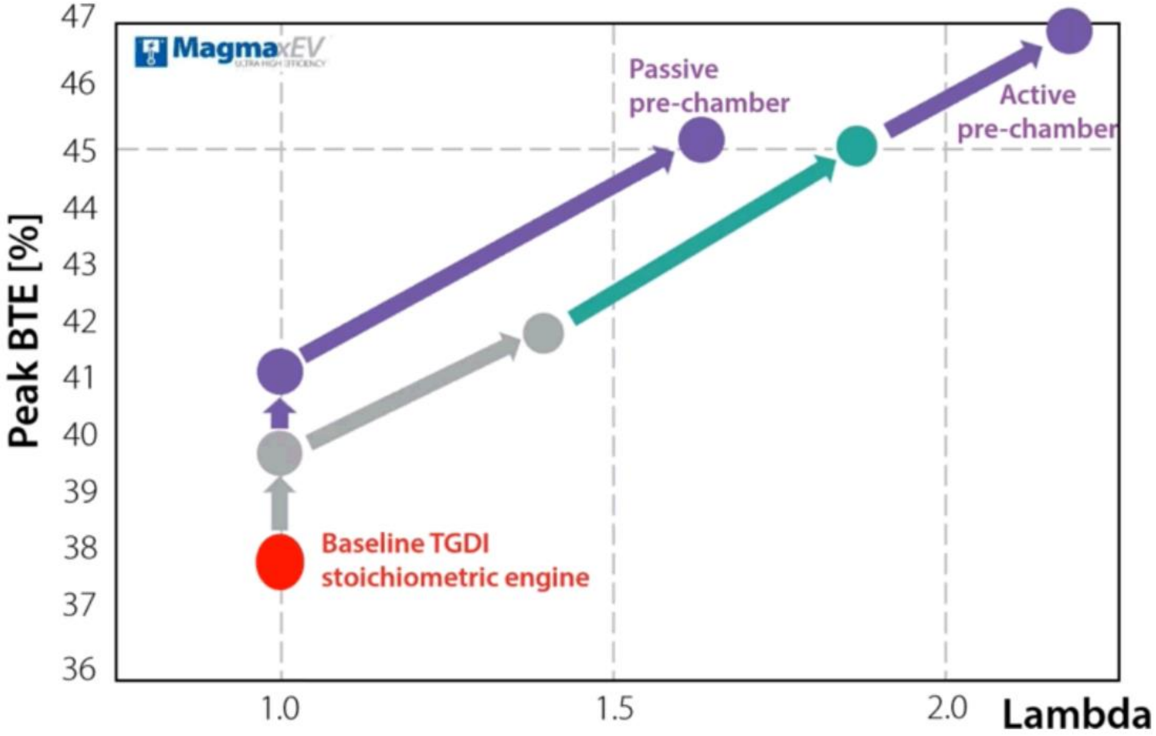
Fuel properties	Hydrogen	Ammonia	Methane
Laminar flame speed (cm/s)	291	7	37
Flammable range (f/a ER)	0.1-7.1	0.63-1.4	0.5-1.7

- Pre-chamber ignition
- Dual fuel combustion
- Low temperature combustion

Advanced combustion techniques for low/zero carbon fuels

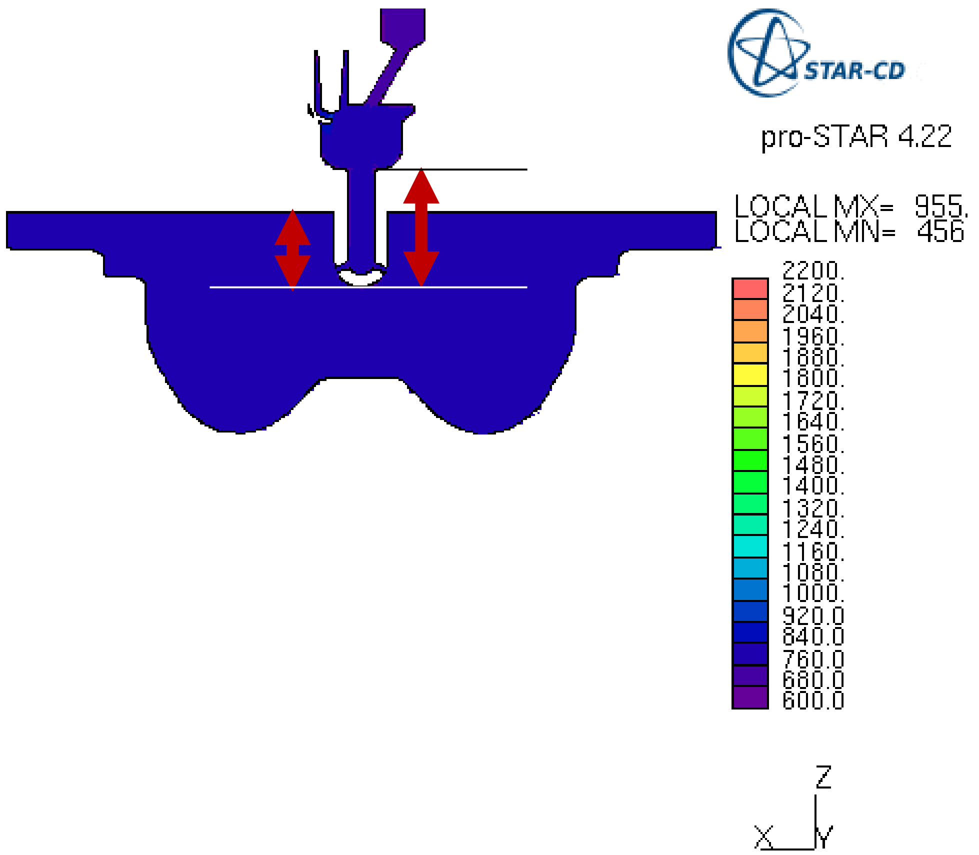
Pre-chamber ignition

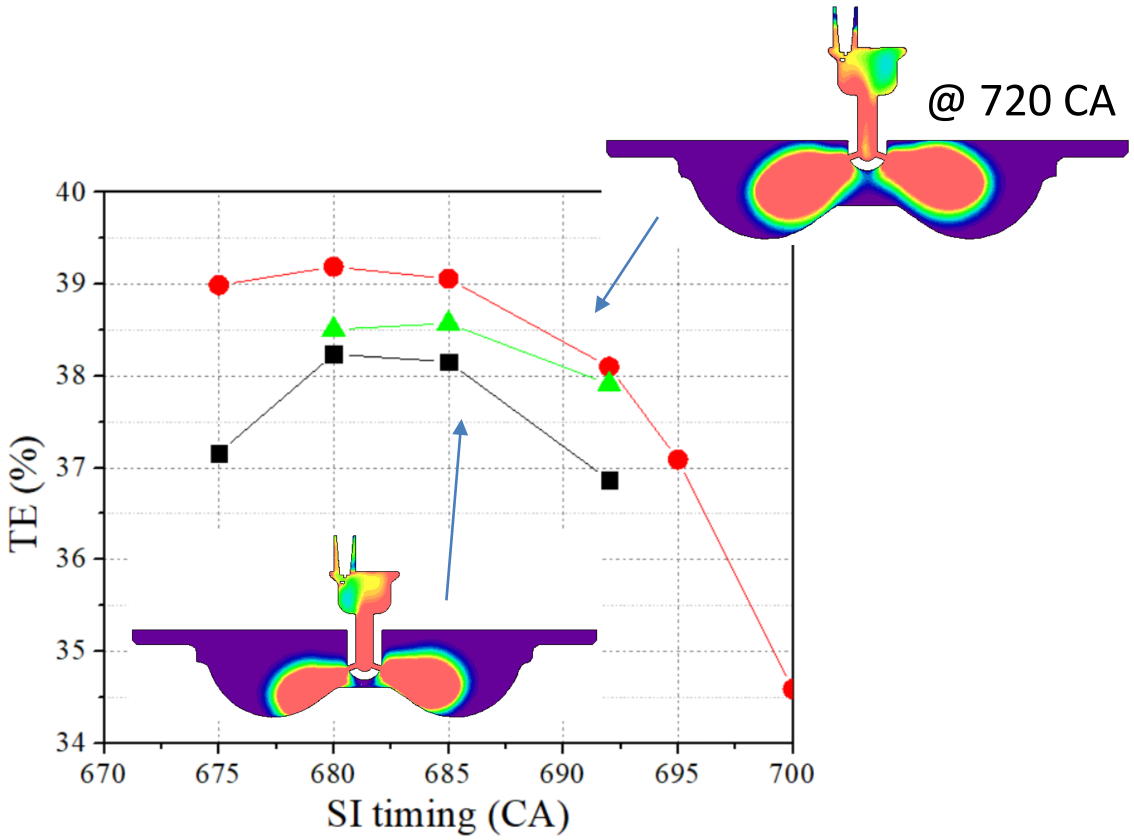




❑ Advanced combustion techniques for low/zero carbon fuels

Pre-chamber ignition





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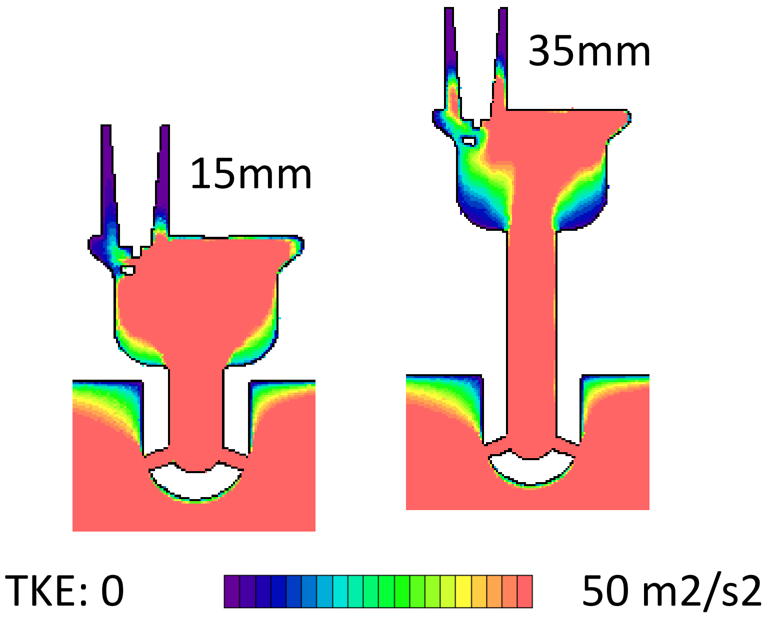
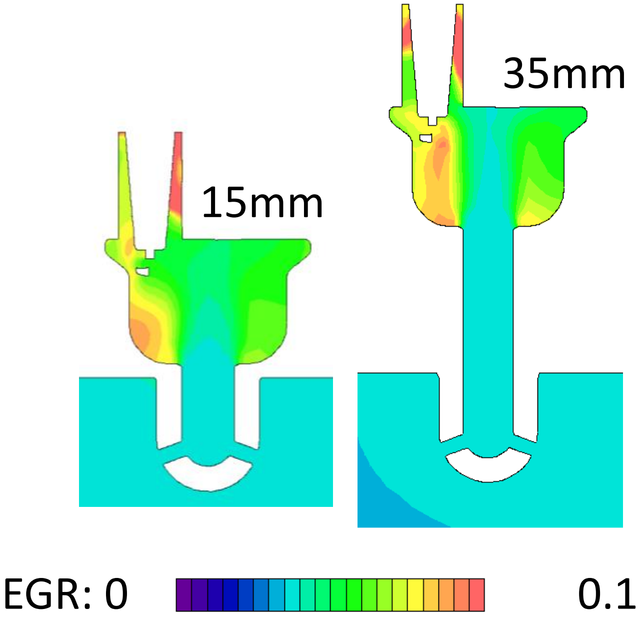
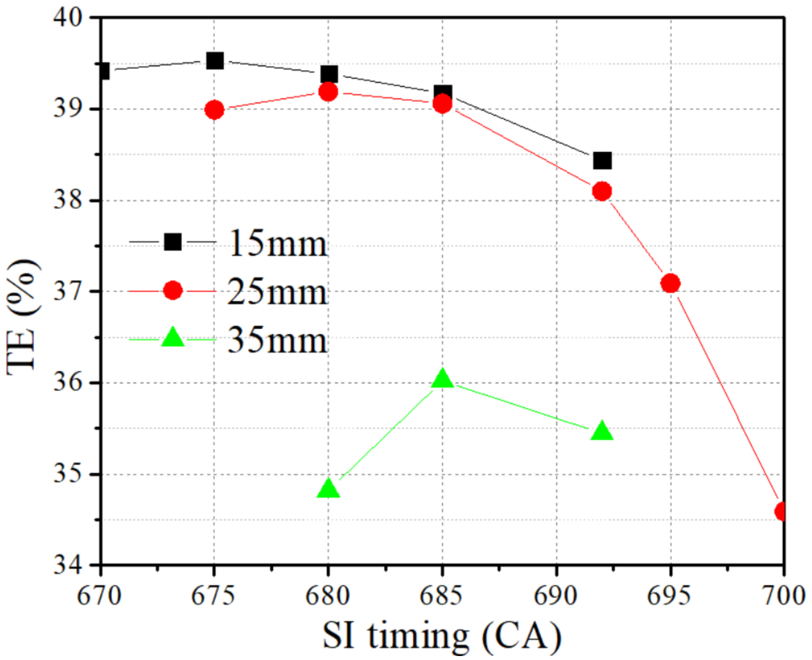
Propulsion and fuel technologies driving the net zero transition

❑ Advanced combustion techniques for low/zero carbon fuels

Pre-chamber ignition





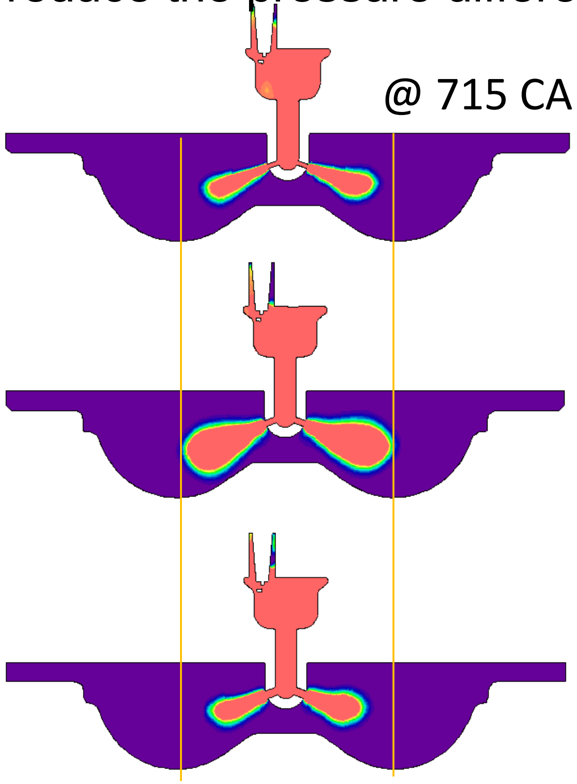


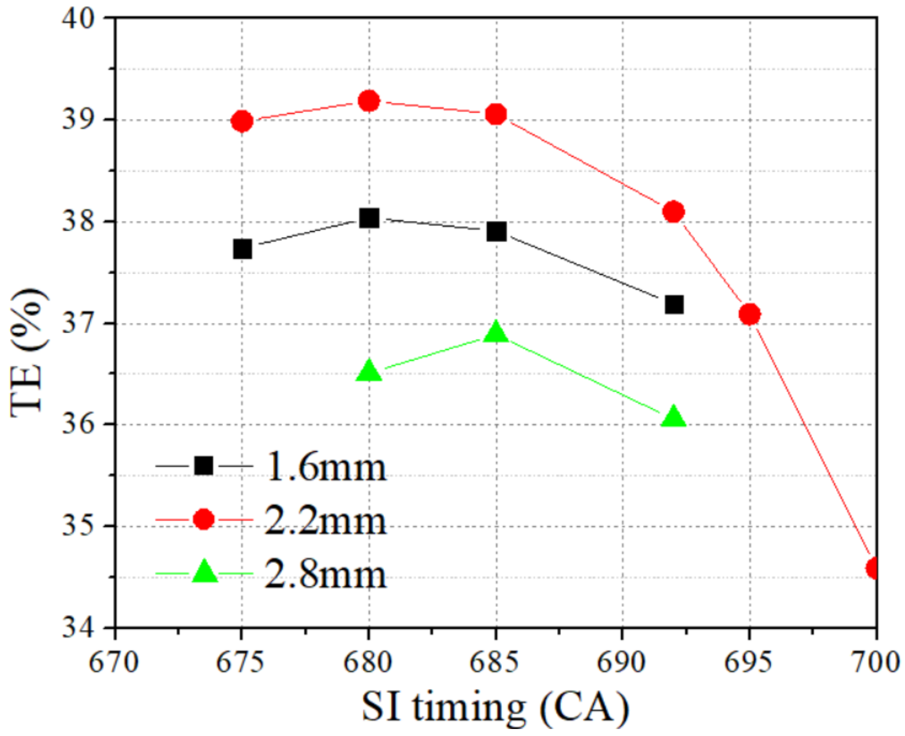
Propulsion and fuel technologies driving the net zero transition

❑ Advanced combustion techniques for low/zero carbon fuels

Pre-chamber ignition

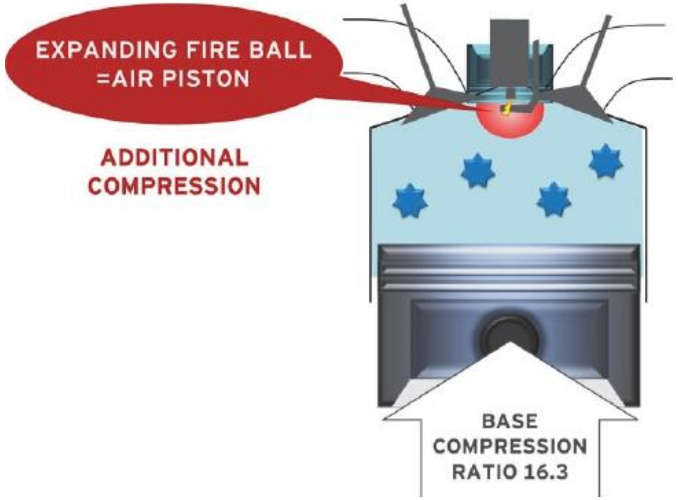
The nozzle needs to be carefully designed, as small nozzle design restrict the gas exchange, while large nozzle reduce the pressure difference.

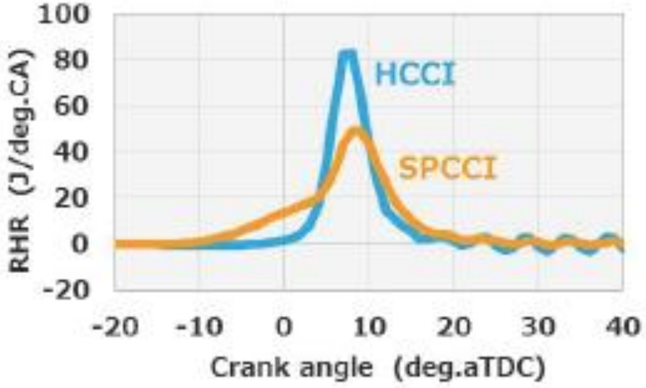




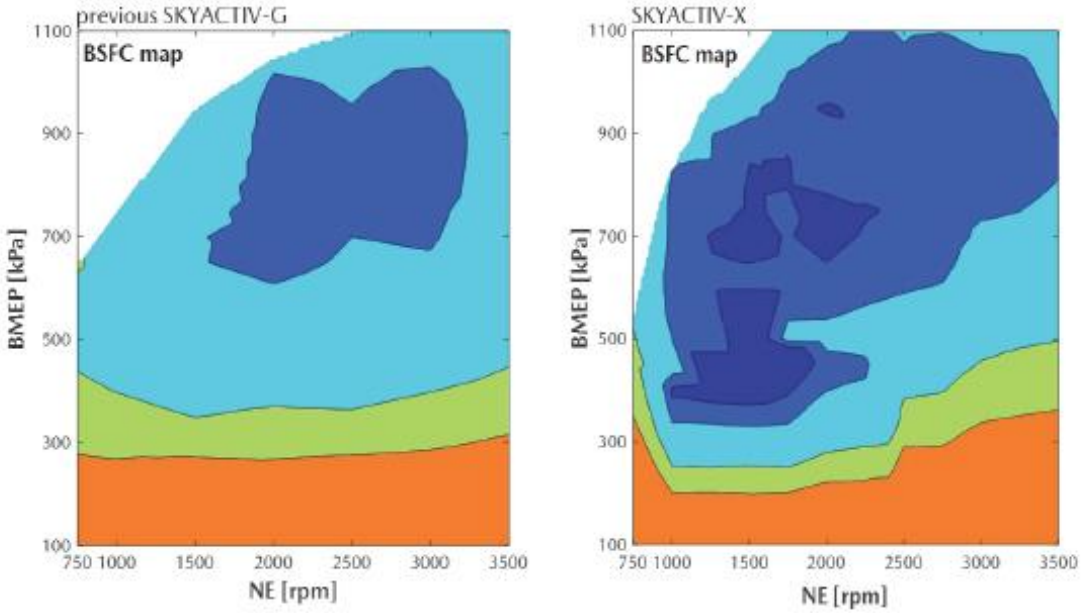
❑ Advanced combustion techniques for low/zero carbon fuels

Low temperature combustion





MAZDA Spark controlled compression ignition (SPCC)



28th Aachen Colloquium Automobile and Engine Technology 2019 55

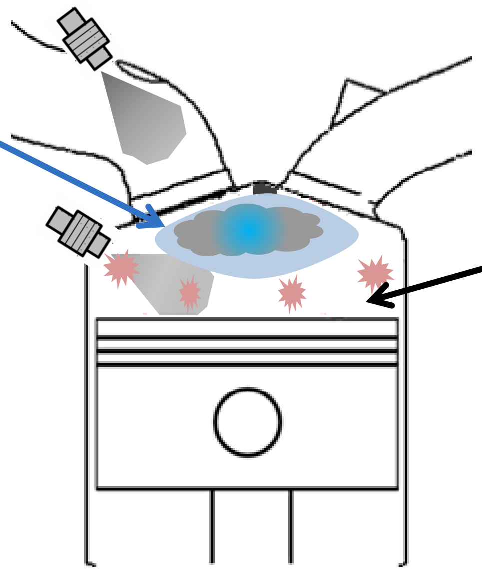
MAZDA SKYACTIV-X 2.0L Gasoline Engine

Eiji **Nakai**, Tsuyoshi **Goto**, Keitaro **Ezumi**, Yuichro **Tsumura**, Kouji **Endou**, Yasunori **Kanda**, Tomonori **Urushihara**, Masanari **Sueoka**, Mitsuo **Hitomi**
Mazda Motor Corporation, Hiroshima, Japan

❑ Advanced combustion techniques for low/zero carbon fuels

Low temperature combustion (SI-CAI hybrid combustion)

- Richer mixture around spark plug to induce flame propagation
- DI is used to optimise the fuel stratification



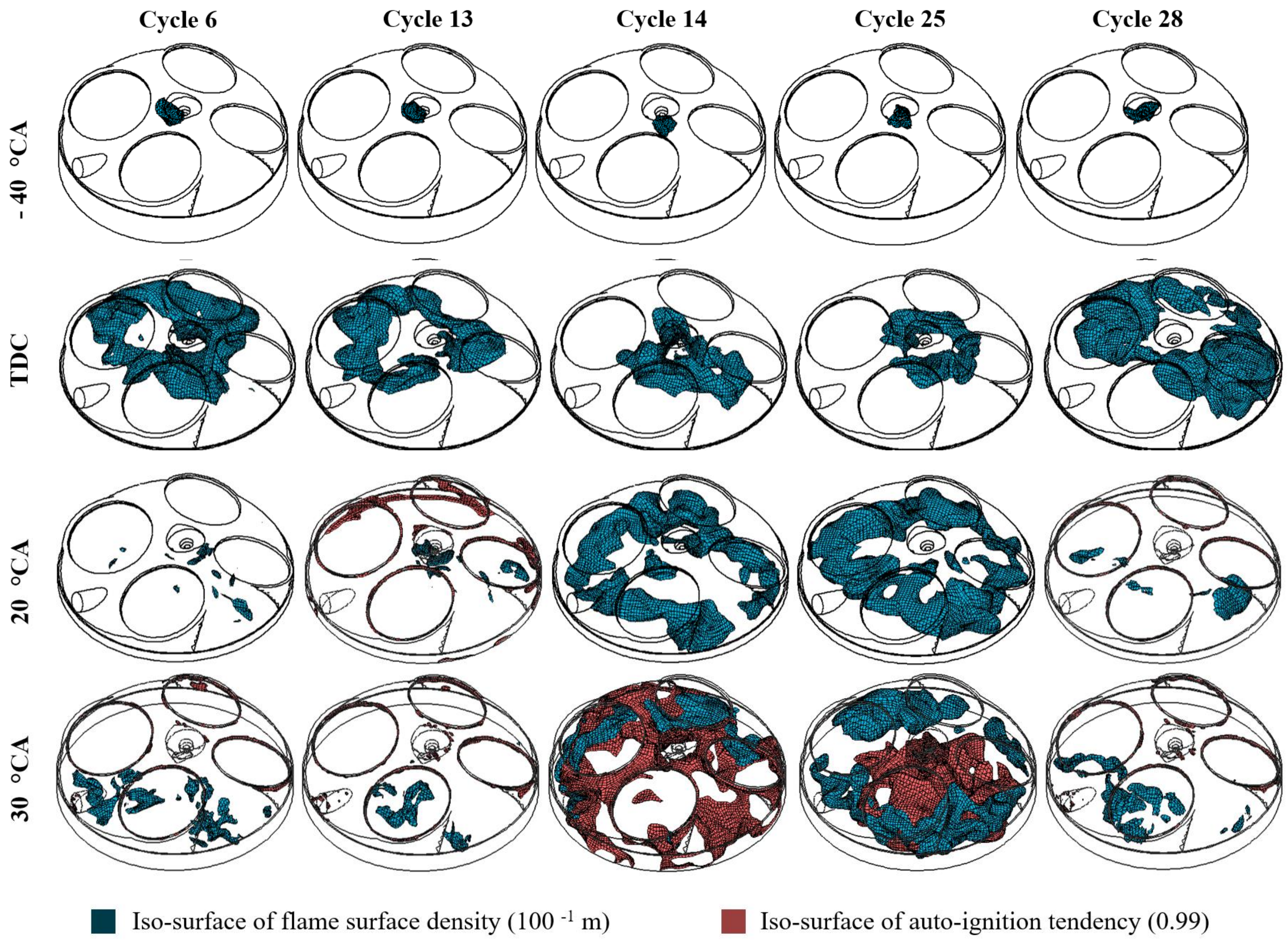
- Lean mixture around the chamber with auto-ignition mode
- PFI is used to provide lean homogeneous mixture.

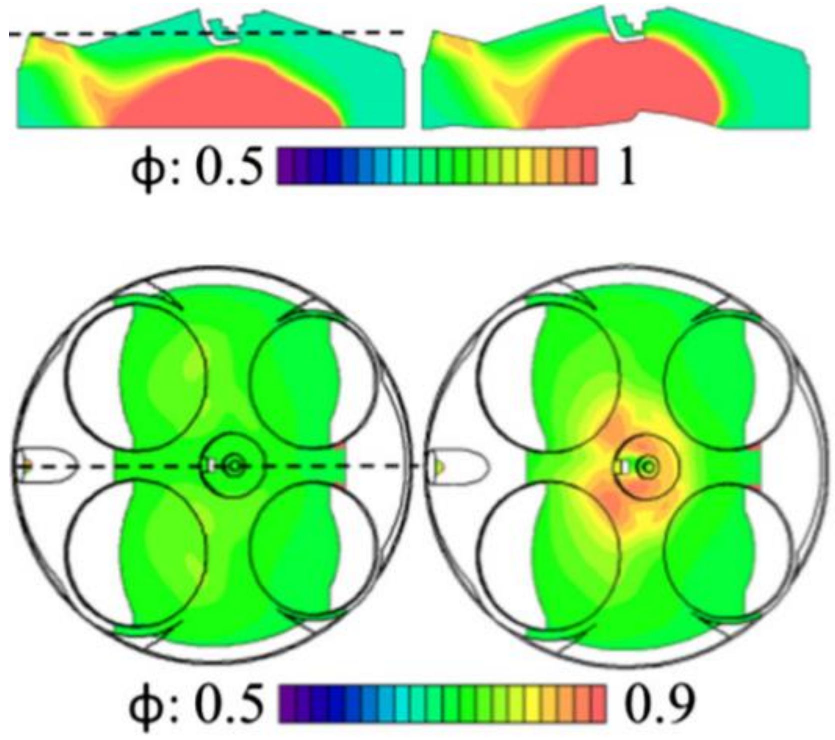
- Stabilize the flame propagation
- Reduce the PRR by subsequent auto-ignition
- Additional control methods offered by PFI/DI strategy

Wang, X., Zhao, H. and Xie, H., 2016. Effect of dilution strategies and direct injection ratios on stratified flame ignition (SFI) hybrid combustion in a PFI/DI gasoline engine. *Applied Energy*, *165*, pp.801-814. Wang, X., Zhao, H. and Xie, H., 2015. Effect of piston shapes and fuel injection strategies on stoichiometric stratified flame ignition (SFI) hybrid combustion in a PFI/DI gasoline engine by numerical simulations. Energy Conversion and Management, 98, pp.387-400.

Advanced combustion techniques for low/zero carbon fuels

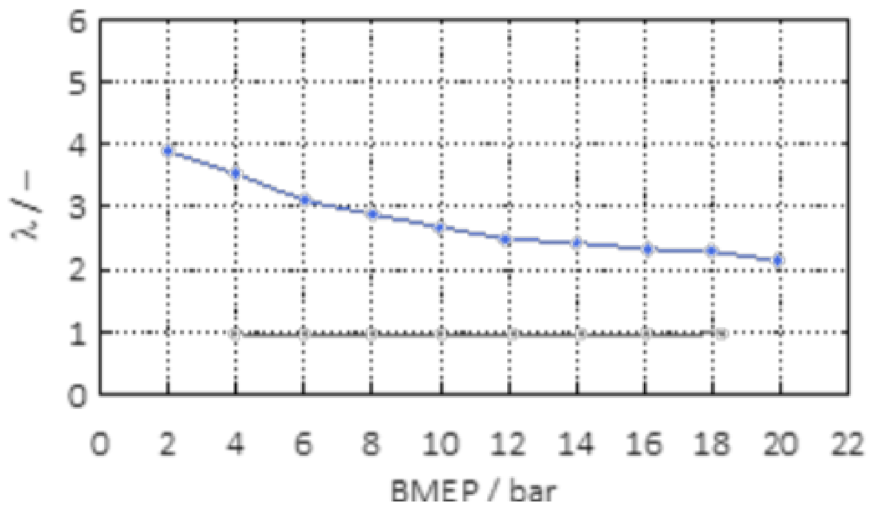
Low temperature combustion (SI-CAI hybrid combustion)



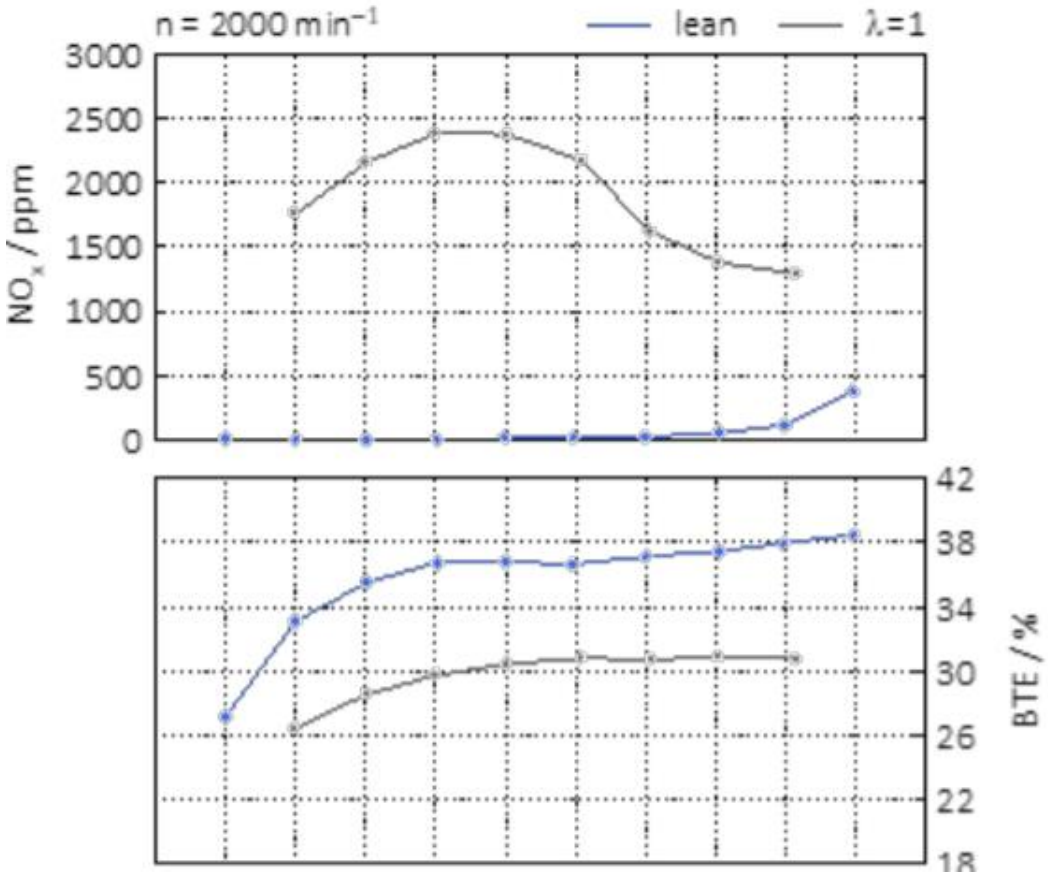


❑ Advanced combustion techniques for low/zero carbon fuels

Low temperature combustion



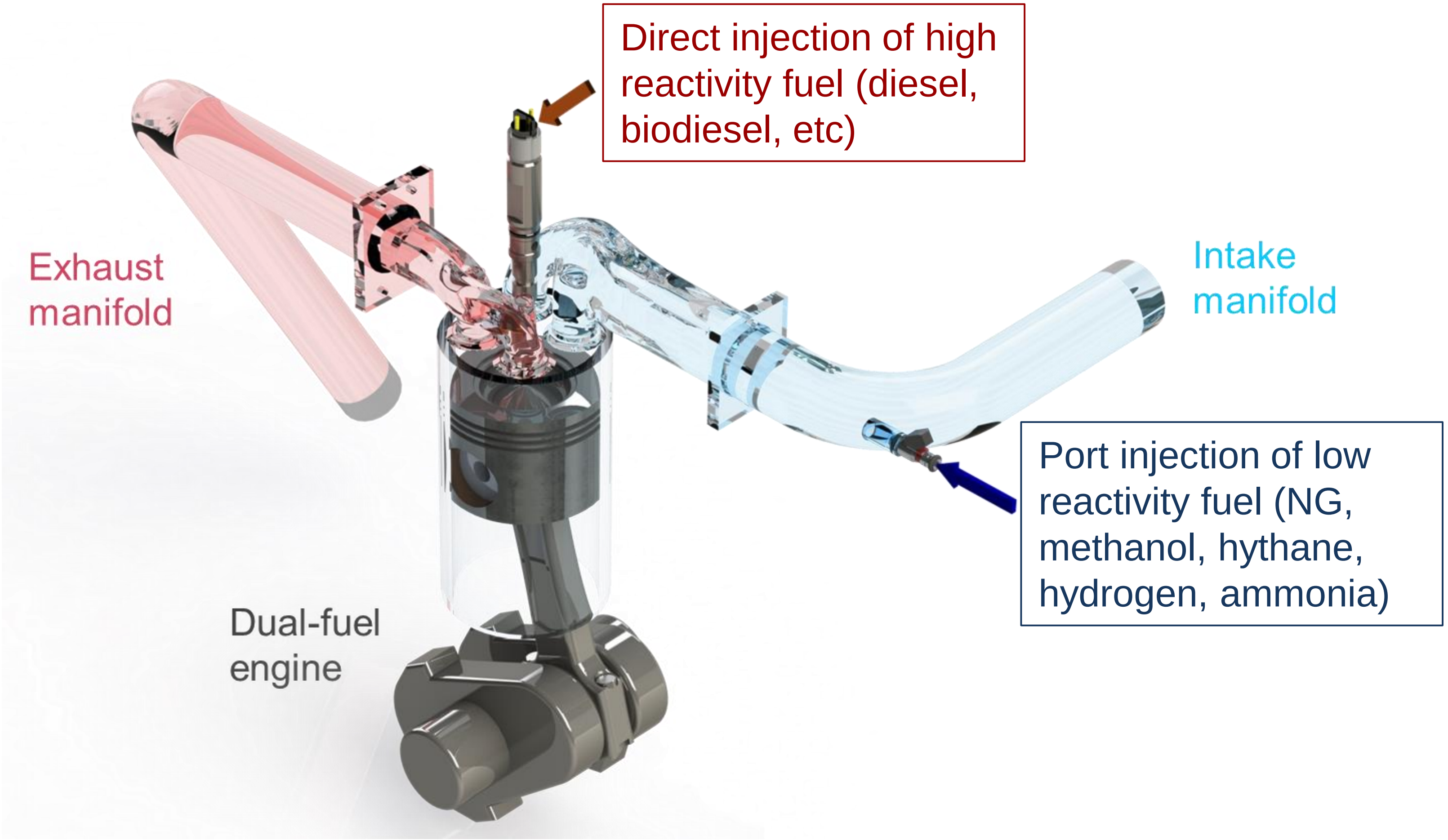
Source: Bosch

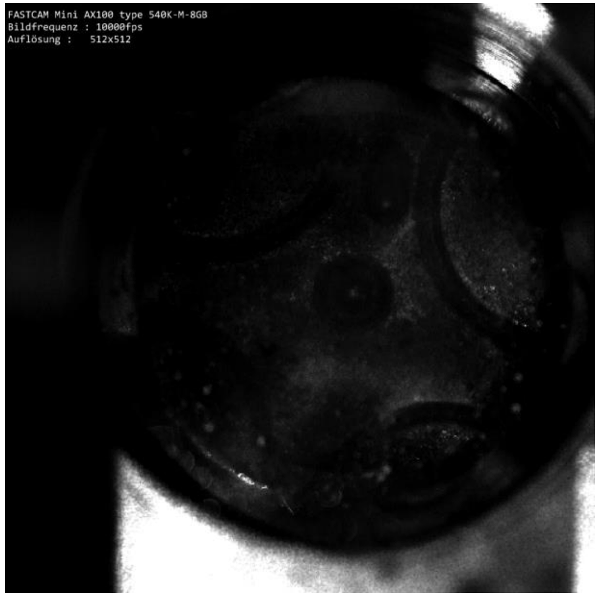


Lean burn hydrogen engine produce near zero Nox.

❑ Advanced combustion techniques for low/zero carbon fuels

Dual fuel combustion

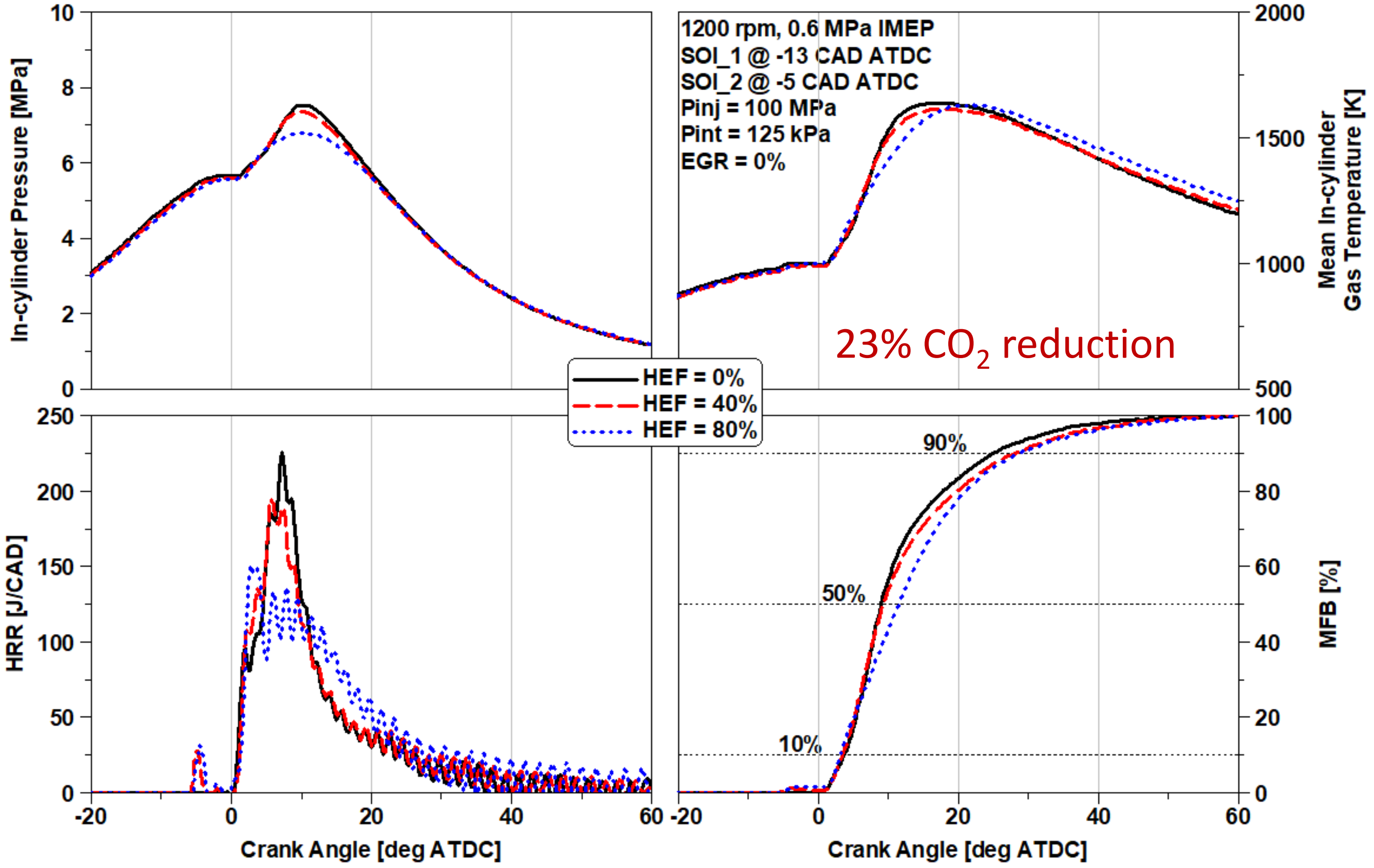




Propulsion and fuel technologies driving the net zero transition

Advanced combustion techniques for low/zero carbon fuels

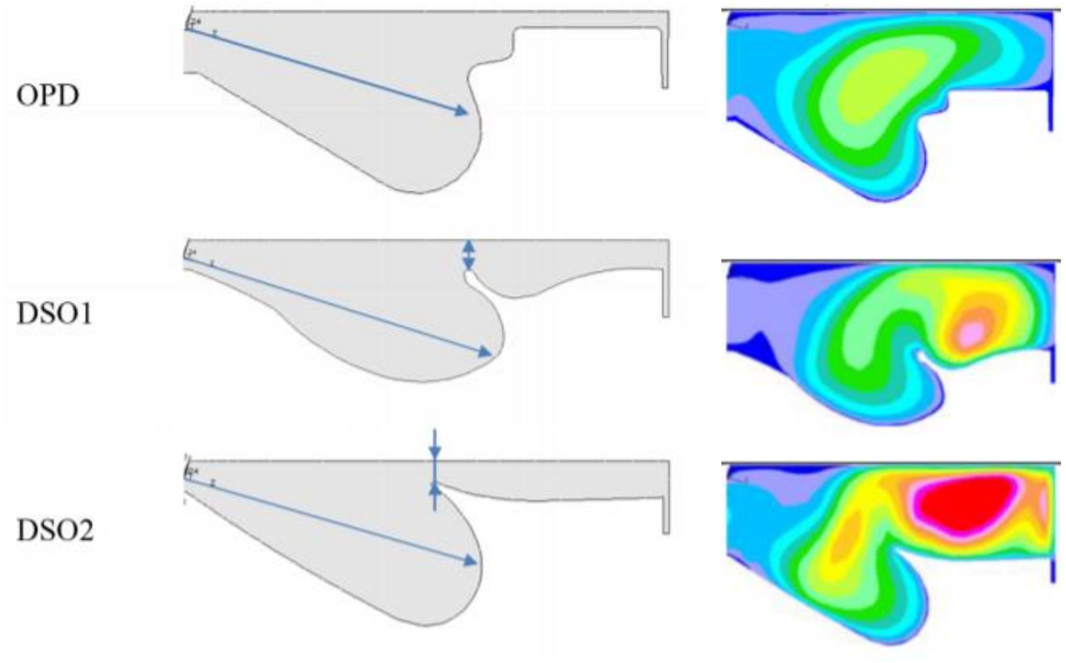
Dual fuel combustion (diesel + methane with 20% hydrogen)



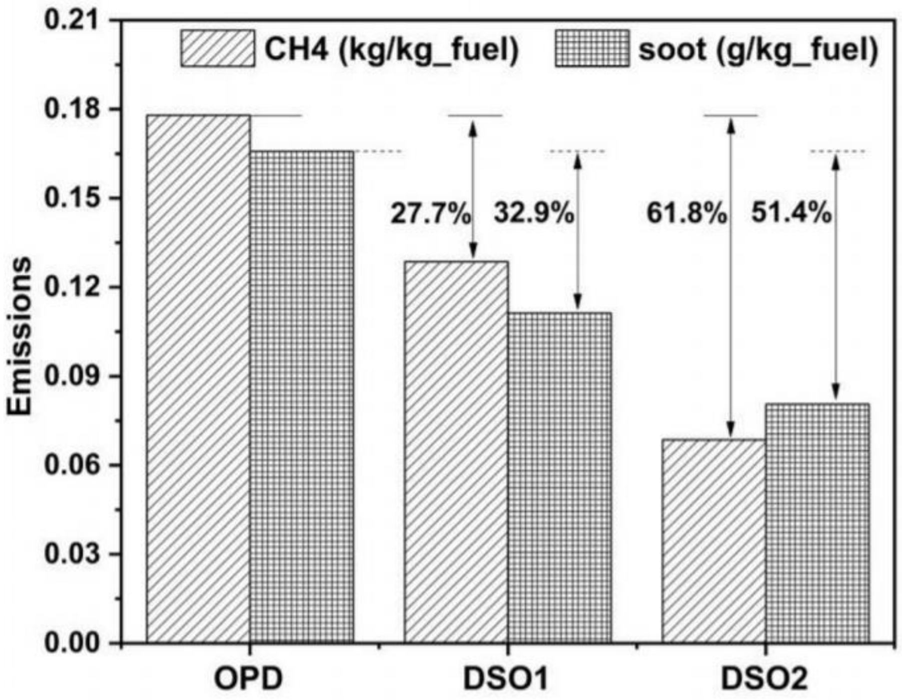
K. Longo, X. Wang , H. Zhao. The impact of Diesel-hythane dual-fuel combustion on engine performance and emissions in a heavy-duty engine at low-load condition. THIESEL Conference on Thermo-and Fluid Dynamics of Clean Propulsion Powerplants. 13-16 Sep 2022. Valencia Spain.

❑ Advanced combustion techniques for low/zero carbon fuels

Dual fuel combustion (diesel + methane)



Piston design TKE



Shen, Z., et al., Numerical investigation of natural gas-diesel dual-fuel engine with different piston geometries and radial clearances. ***Energy***, 2021. 220: p. 119706. Shen, Z., et al. Numerical Investigation of Diesel-Spray-Orientated Piston Bowls on Natural Gas and Diesel Dual Fuel Combustion Engine. 2020. ***SAE Technical Paper*** 2020-01-0311.

Contents

1. Challenges and opportunities of moving towards net zero transport

2. Propulsion and fuel technologies driving the net zero transition

3. Summary

Summary

- The combustion system represented by the internal combustion engine is a technology that is inclusive and keeps pace with the times. It does not exclude any emerging technologies, but can absorb their advantages and integrate them into technologies that are more in line with the requirements of the times and serve the public.
- The hydrogen range extender can make use of existing engine and battery technologies while addressing problems of both, showing great potential.
- The emission reduction of the transportation system cannot be solved by the transportation system itself. It also needs to coordinate with other related fields, such as power generation, clean energy acquisition, low-carbon and zero-carbon fuel production and other fields.

Thank you very much.

Q&A

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Email: Xinyan.Wang@brunel.ac.uk

Tel: +44 (0)1895 265903

Research-Led Teaching in Electric Vehicle Systems

Dr Chun Sing Lai

Lecturer, Department of Electronic and Electrical Engineering
chunsing.lai@brunel.ac.uk

"UK-Saudi Electric Vehicles Enhanced Education and Research Network" Workshop
24th-30th November 2022

Content

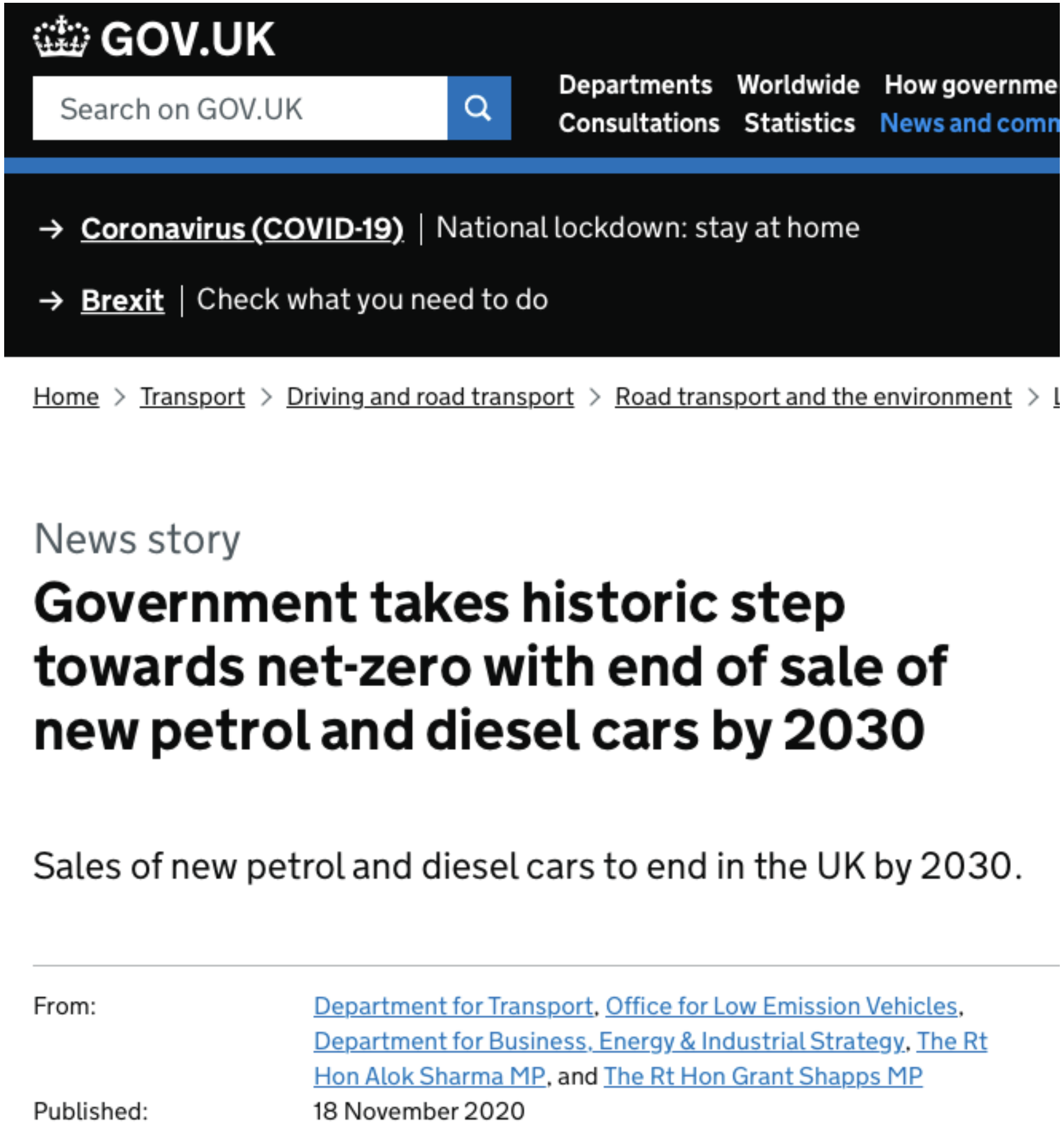
- Background
- MSc Electric Vehicle Systems
- Research Projects in EV Systems
- Doctoral Research Projects

Background

- Joined Brunel in Jan 2020 as a Lecturer
- Module Leader for EE1618 Devices and Circuits, taught at Chongqing University of Posts and Telecommunication (CQUPT)
- **Course Director for MSc Electric Vehicle Systems**
- Member of Brunel Interdisciplinary Power Systems (BIPS) Research Centre
- His current interests are in power system optimisation, energy system modeling, data analytics, electric vehicle systems, hybrid powertrains optimisation, and energy economics for renewable energy and storage systems

Motivation of Transport Electrification in the UK

- Transport accounts for around 20% of global CO_2 emissions
- Electric vehicles can be powered by green electricity
- Gov.UK Ref: www.gov.uk/government/news/government-takes-historic-step-towards-net-zero-with-end-of-sale-of-new-petrol-and-diesel-cars-by-2030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→ Brexit | Check what you need to do

Home > Transport > Driving and road transport > Road transport and the environment >

News story

Government takes historic step towards net-zero with end of sale of new petrol and diesel cars by 2030

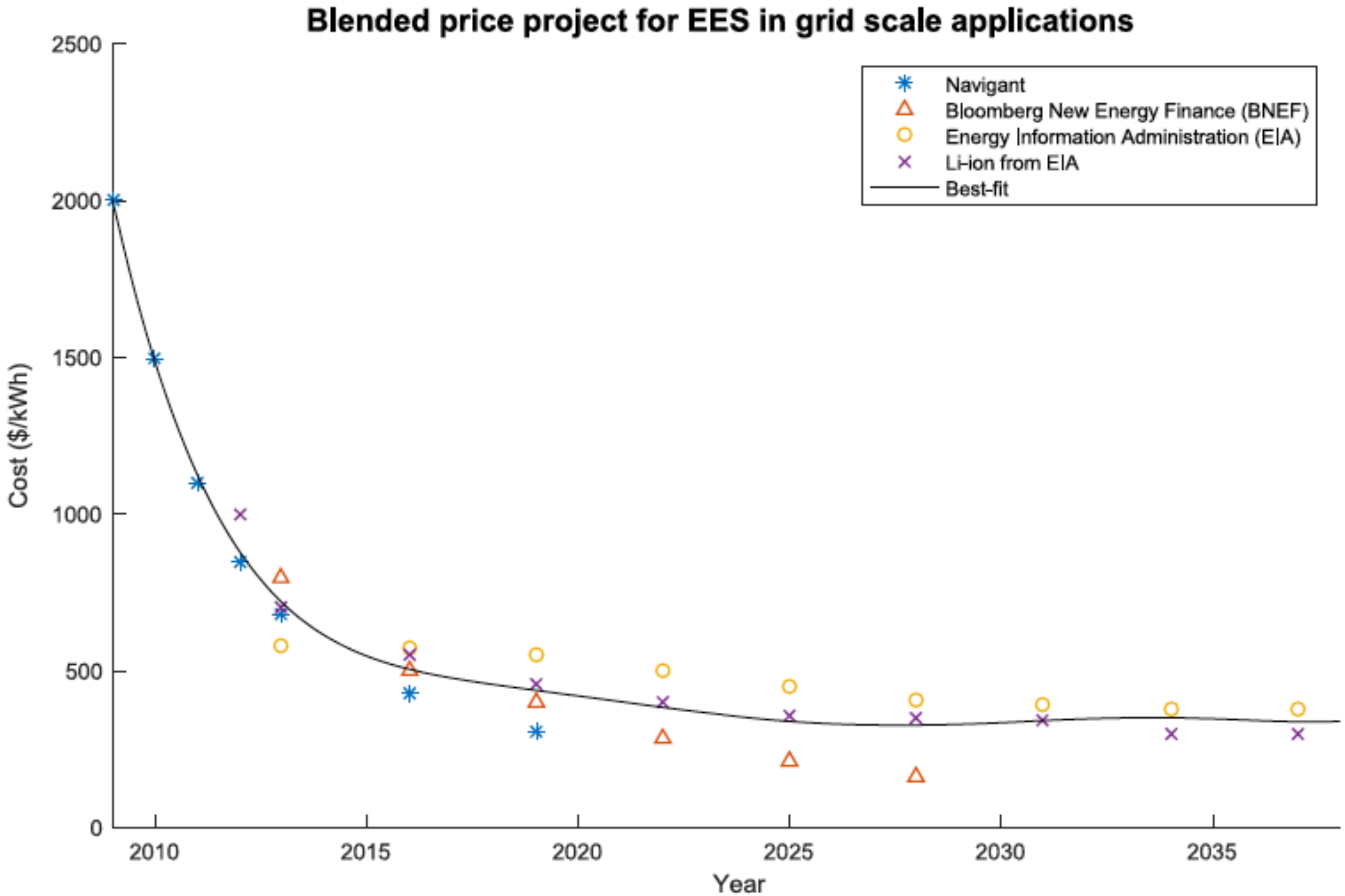
Sales of new petrol and diesel cars to end in the UK by 2030.

From: Department for Transport, Office for Low Emission Vehicles, Department for Business, Energy & Industrial Strategy, The Rt Hon Alok Sharma MP, and The Rt Hon Grant Shapps MP

Published: 18 November 2020

Key Technology Enabler: Electrical Energy Storage and Batteries

- Large-scale energy storage cost is plummeting



Lai, C.S. et al., 2017. A comprehensive review on large-scale photovoltaic system with applications of electrical energy storage. *Renewable and Sustainable Energy Reviews*, *78*, pp.439-451.

MSc EVS Programme Aim

- Aim of this MSc programme is to produce postgraduates with advanced and targeted knowledge and skills relevant to **growing sector of electric vehicle engineering**
- The graduate will have **specific knowledge and expertise in electronic and electrical engineering** subjects:

- Power electronics and drives
- Data communication systems
- Electrical power systems
- Sensors and instrumentation
- Control and intelligent systems
- Embedded systems

Current status update

- Programme approved by Senate on 19th May 2022
- Programme web page available to public in end-June 2022
- 8 applicants for the programme in Sept 2022 intake
- 2 students are enrolled (1 UK and 1 Chinese student)
- 2nd Industry Advisory Panel meeting: 17th November 2022
- 10 applicants to date for the programme in Sept 2023 intake

Current Modules

Compulsory Modules	Term	Programme Team/ Module Leader
EE5631 Advanced Vehicular Systems Technology	Autumn	Dr C S Lai
EE5630 Advanced Embedded Systems Engineering	Autumn	Dr H Meng
EE5633 Smart Grid Operation and Management	Spring	Prof G Taylor
EE5632 Power Electronics and Drives	Spring	Dr M Darwish
EE5625 Engineering Ethics and Sustainability	Spring	Dr D Smith
EE5518 Energy Economics and Power Markets	Autumn	Prof G Taylor
EE5500 Project / Dissertation – 60 Credits	Throughout	Dr T Itagaki

Optional Modules (select 2)	Term	Programme Team/ Module Leader
EE5622 Communication Network Technologies	Autumn	Prof H Al-Raweshidy
EE5623 Design for Internet of Things	Autumn	Dr L Gan
EE5624 Applied Sensors, Instrumentation and Control	Autumn	Dr I Pisica
EE5627 Artificial Intelligence System Techniques	Autumn	Prof M Abbod

- All modules are 15-credits unless stated

Modules in 2023/24

Compulsory Modules	Term	Programme Team/ Module Leader
EE5631 Advanced Vehicular Systems Technology	Autumn	Dr C S Lai
EE5518 Energy Economics and Power Markets	Autumn	Prof G Taylor
EE5633 Smart Grid Operation and Management	Spring	Prof G Taylor
EE5632 Power Electronics and Drives	Spring	Dr M Darwish
EE5625 Engineering Ethics and Sustainability	Spring	Dr D Smith
EE5500 Project / Dissertation – 60 Credits	Throughout	Dr T Itagaki

Optional Modules (select 2)	Term	Programme Team/ Module Leader
EE5628 Embedded DSP for Communications	Spring	Dr N Boulgouris
EE5612 Communication Networks Security	Spring	Dr T Itagaki
EE5622 Communication Network Technologies	Autumn	Prof H Al-Raweshidy
EE5630 Advanced Embedded Systems Engineering	Autumn	Dr H Meng
EE5623 Design for Internet of Things	Autumn	Dr L Gan
EE5624 Applied Sensors, Instrumentation and Control	Autumn	Dr I Pisica

- All modules are 15-credits unless stated

EE5631 Advanced Vehicular Systems Technology

INDICATIVE CONTENT

- Electric vehicle architecture including battery electric vehicles and solar-powered vehicles
- Driving cycles and range modelling of electric vehicles
- Local Interconnect Network, Media Oriented Systems Transport, and Flexray
- Controller Area Network bus topology and architecture (ISO 11898-2, ISO 11898-3 and CAN frames)
- Vehicular Ad-Hoc Networks (VANET): Architecture, Applications, Requirements, and Routing
- Dedicated short Range Communication (DSRC) and Wireless Access for Vehicular Environment (WAVE): Spectrum, Protocol Components, V2X technologies/standards: IEEE 802.11p and Cellular V2X
- Policy strategies for vehicle electrification
- Battery technologies including Lithium-ion, valve-regulated lead acid, nickel-metal hydride for electric vehicles
- Battery management systems for electric vehicles: topologies and principle of operations
- Battery charging technology including inductive and capacitive coupling wireless charging
- Electromagnetic compatibility in the vehicle environment
- Charging infrastructure and standards

ASSESSMENT NUMBER	SUMMATIVE ASSESSMENT METHODS WHICH ENABLE STUDENT TO DEMONSTRATE THE LEARNING OUTCOMES (please provide the length/duration of each assessment listed):	WEIGHTING
1	1 assignment: Design and simulation of electric vehicle communication systems. (Assesses LOs 1, 2, and 3). (10-15 pages technical report)	50%
Final Assessment	1 assignment: Design of Battery Management System for electric vehicles (practical and simulation). (Assesses LOs 1, 2, 4, and 5). (10-15 pages technical report)	50%

EE5632 Power Electronics and Drives

INDICATIVE CONTENT

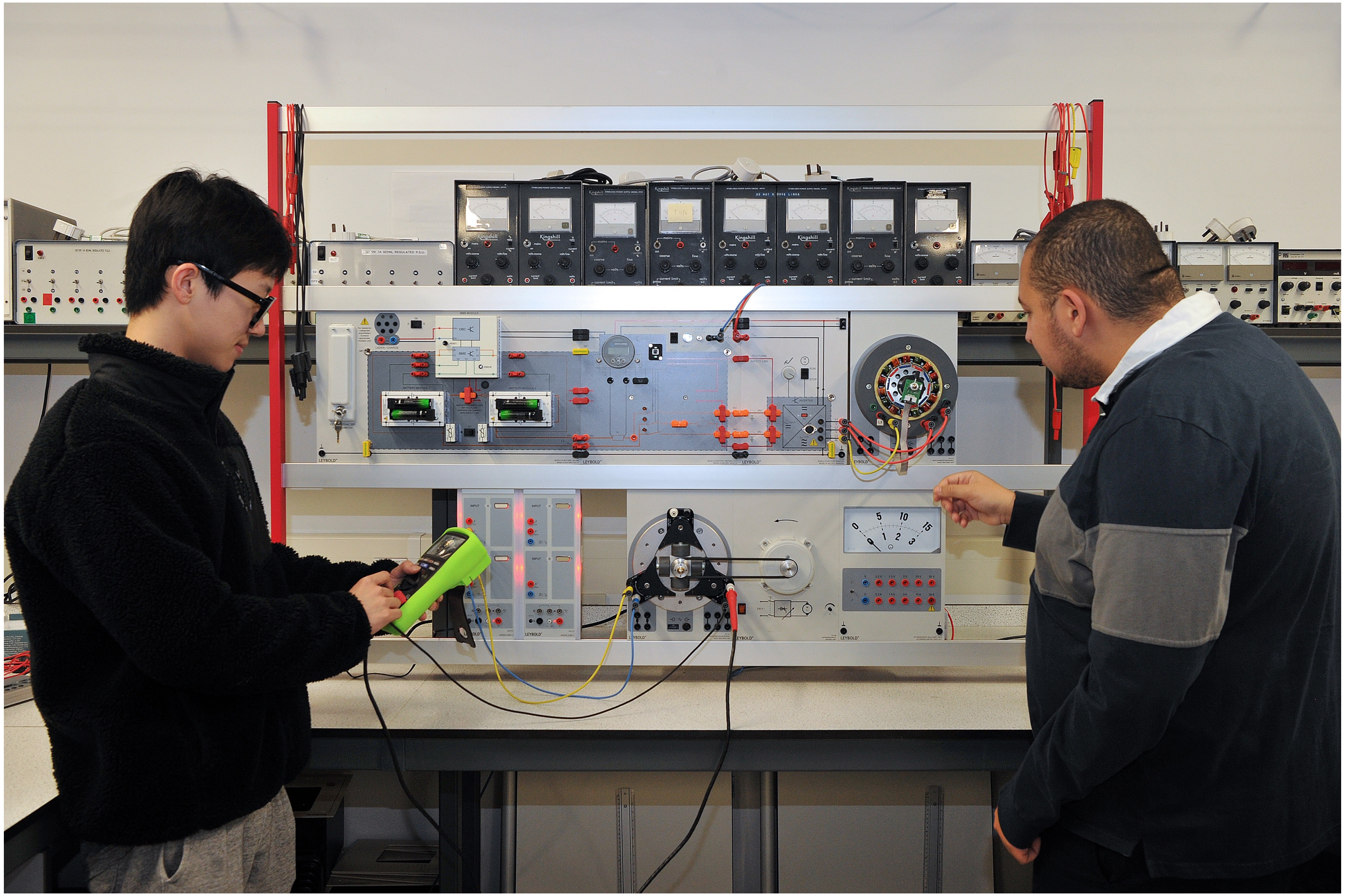
- State-of-the-art power semiconductor devices; MOSFET, IGBTs; Protection mechanisms; Wide band-gap semiconductors.
- Voltage-sourced and current-sourced converters
- Uninterruptible Power Supplies; High frequency UPS
- Active Power Filters; Inverter-based; Retrofit
- Electrical machines for electric vehicles including commutator (series DC, shunt DC, separately excited DC, and permanent magnet DC) and commutator-less (cage-rotor induction, permanent magnet brushless AC, and permanent magnet brushless DC) machines
- Drive systems for DC, induction, and permanent magnet brushless motors
- Design criteria of motor drives for electric vehicles
- DC/DC converter analysis
- Modulation schemes for inverters
- Overall power system of a vehicle, including the drive train
- Control theory for power electronics
    - AC analysis of converters
    - Linearisation of the plant (converter)
    - Controller design using bode plot analysis

1	1 group assignment: Design of Power Train System (practical and simulation) (Assesses LOs 3 and 4) ((20 pages (±10%) technical report per each student in the group to cover his/her part of the design work plus 2 pages per each student to reflect how was he/she worked as a team member within the group)	40%
Final assessment	Written open book examination (2 hours) (Assesses LOs 1, 2 and 4)	60%

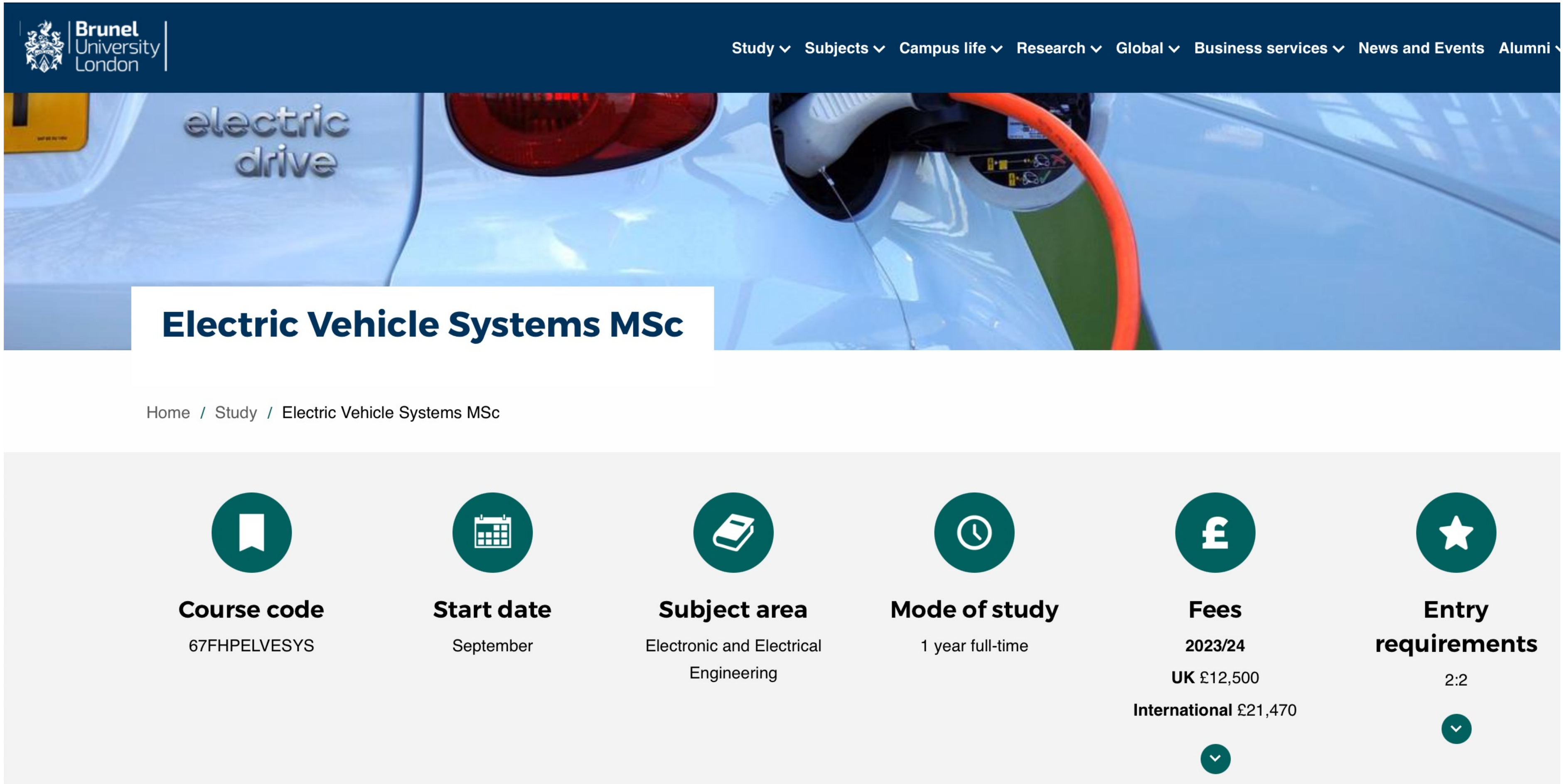
Dedicated Laboratory Equipment

Battery Management System

Electrical Machines and Drives



MSc Electric Vehicle Systems



https://www.brunel.ac.uk/study/postgraduate/electric-vehicle-systems-msc

Industry Advisory Panel

Sector	Organisation	Contact Person
Vehicle Manufactures	Renault Group	Dr Javier Ibanez-Guzman
	Toyota	Dr Pujitha Gunaratne
BMS Manufacturer	Brill Power Ltd	Dr Damien Frost
Substation/DNOs/Others	eClassics	Mr Joseph Salama
	HVSS High Voltage Substation Services Ltd	Mr Sina Etminan
	National Grid ESO	Mr Benjamin Bonjesi
	Scottish and Southern Electricity Networks	Mr Maciej Fila
	UK Power Networks	Mr Tim Manandha

IAP Individual Commitment

- Two meetings per annum: online (first term, Nov) and in person (third term, July)
- Poster presentation in July (combined with SEP this academic year)
- Field trips
- Industry led projects
- Awards and bursaries

Project: Data-driven Approach for Optimal Distribution Network Operation With Rapid Charging Infrastructure and Large-scale Battery

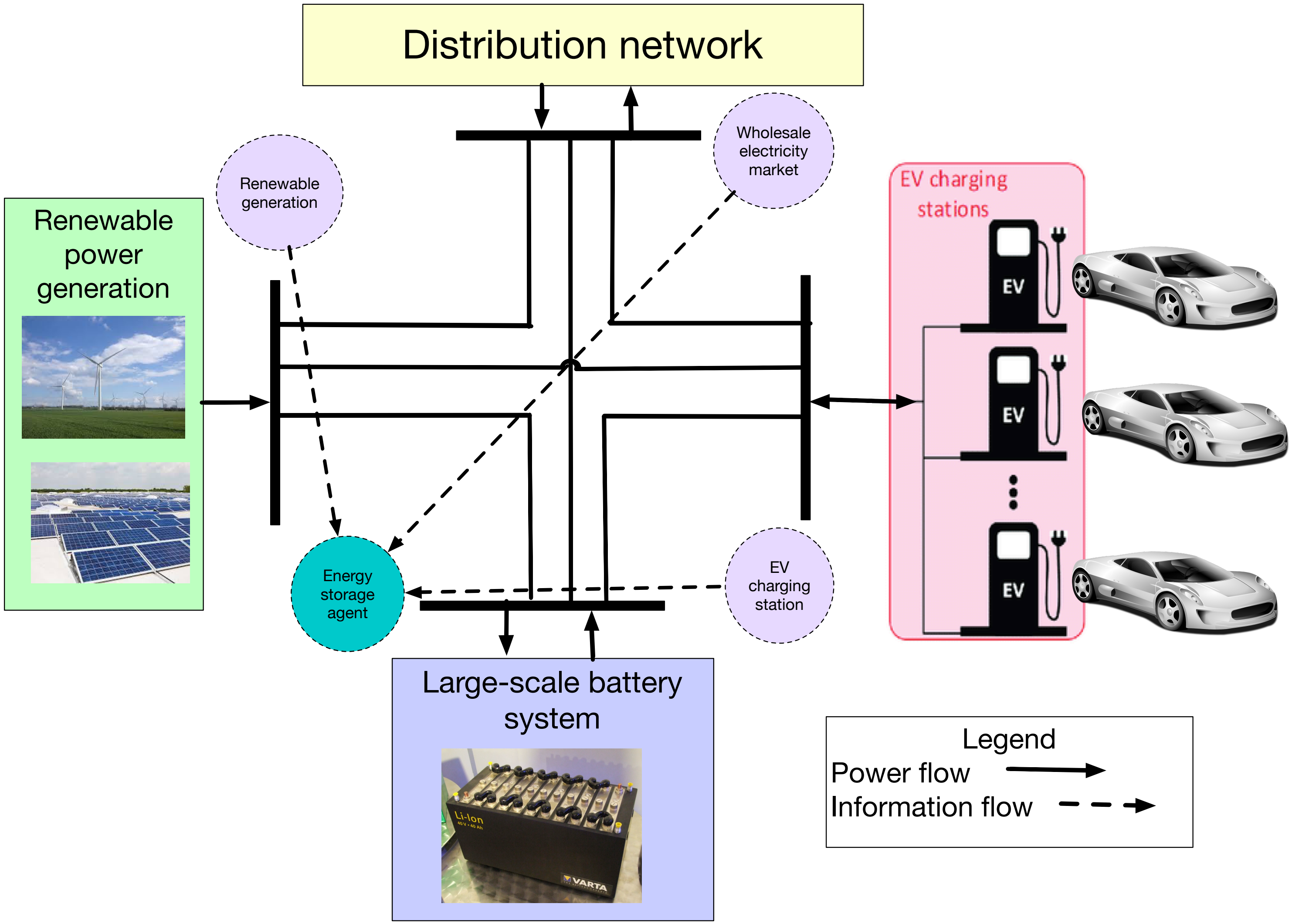
- Develop an innovative toolkit to enable **active management of distribution networks**
- To maximise and examine the **profitability of large-scale battery** in distribution networks
- Project duration: 1st Feb 2021 - 31st March 2022
- PI: Dr C S Lai; Co-I: Prof G A Taylor

DTE Network
Decarbonising Transport Through Electrification

EPSRC
Pioneering research and skills

Brunel University London

Project: Data-driven Approach for Optimal Distribution Network Operation With Rapid Charging Infrastructure and Large-scale Battery



Project: Data-driven Approach for Optimal Distribution Network Operation With Rapid Charging Infrastructure and Large-scale Battery

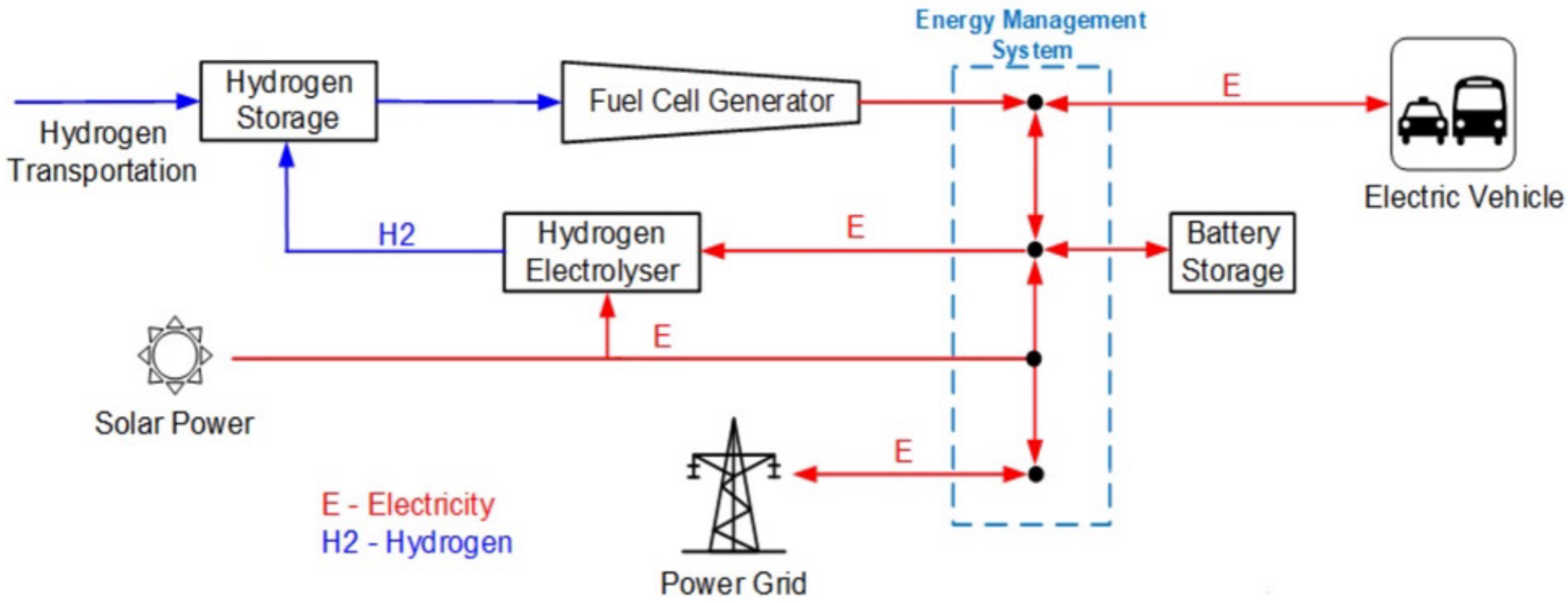
1. Lai, C.S., et al. 2021, July. Operational challenges to accommodate high penetration of electric vehicles: a comparison between UK and China. In 2021 IEEE 15th International Conference on Compatibility, Power Electronics and Power Engineering (CPE-POWERENG).
2. Lai, C.S., et al. 2021, April. A distributed transaction method for mitigating three-phase imbalance by scheduling electric vehicle charging. In 2021 6th Asia Conference on Power and Electrical Engineering (ACPEE).
3. Huang, L. et al. A distributed optimization model for mitigating three-phase imbalance with electric vehicles and grid battery. Accepted on 7th May 2022 by *Electric Power Systems Research* (IF: 3.414)
4. Lai C.S. et al. “Profit maximization for large-scale energy storage systems to enable fast EV charging infrastructure in distribution networks”, Major revision, *Energy* (IF:7.147)

Doctoral Research Projects Supervisions

1. Ms L Duan, **Solar-Hydrogen-Storage Integrated EV Charging Station.** 01/10/21-now. Second Supervisor: Dr X Zhang
2. Mr MME Farrag, **EV Powertrain Optimisation with Supercapacitor and Battery Systems.** 01/10/21-now. Second Supervisor: Dr M Darwish
3. Mr X Ren, **Design and Implementation of Intelligent Energy Management Systems for Autonomous EVs.** 09/2022-now. Second Supervisor: Prof G Taylor
4. Mr GA Blankson, **Interoperable High Frequency and Low Frequency Impedance Matching for EV Wireless Power Transfer.** 01/01/22-now. Principal Supervisor: Dr M Darwish
5. MEng Group Project, **ICE to EV conversion: A Feasibility Study.** 2021/22. Principal Supervisor: Dr M Darwish

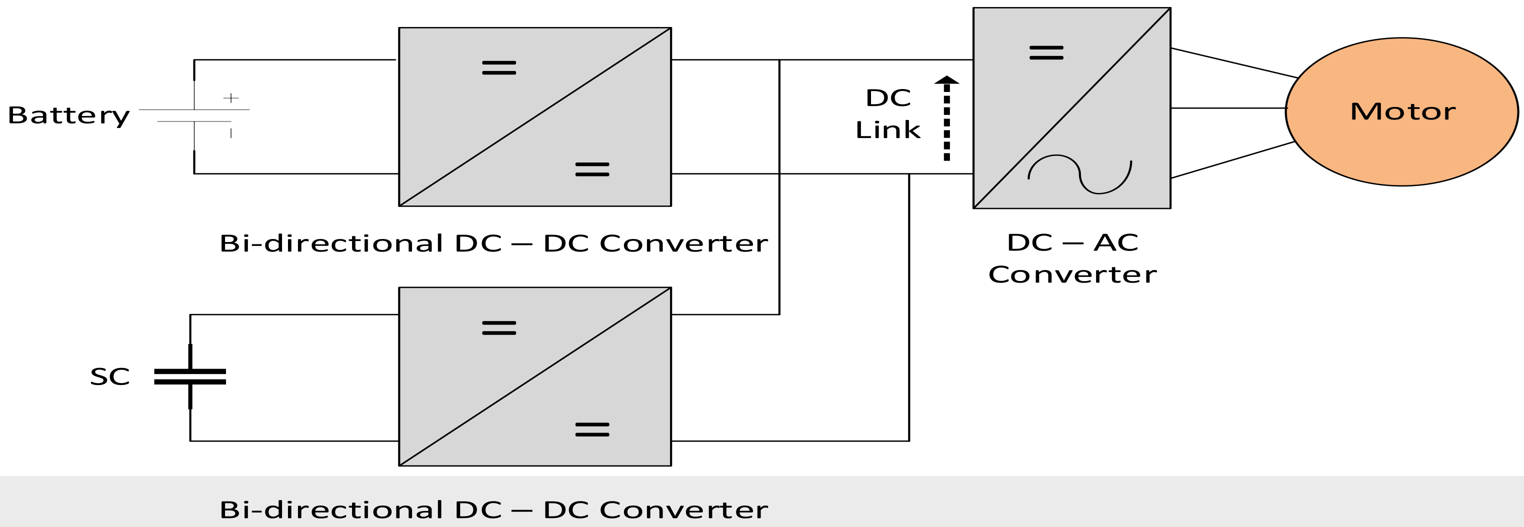
Solar-Hydrogen-Storage Integrated Electric Vehicle Charging Station

Minimise the CAPEX and OPEX of EV charging station.



EV Powertrain Optimisation with Supercapacitor and Battery Systems

- To study the technical and economic viability of a hybrid energy storage system for EVs comprising of the battery pack and a super-capacitor.
- To examine the electrical and thermal characteristic of BMS.
- Increase the lifetime of the EVs battery and reduce the stress on its materials.



Design and implementation of intelligent energy management systems for autonomous vehicle electrification

- Inter-vehicle communication model in eco-driving based EMS scenario and explore how much each type of data error from GPS and V2X will affect the agent's decision-making
- Distributed Federated Reinforcement Learning-based eco-driving strategy so that solve the problem of privacy problem when collecting massive data from reality.
- Eco-Driving based EMS from a most economical view in variation price scenario rather than energy consumption.

Summary

- Teaching of Electric Vehicle Systems is challenging

1. Multi-disciplinary
2. Teaching content
3. Emerging area

- MSc dissertation projects can be based on real-life scenarios/challenges

Thank You

Q/A

Power Converters and Drives

ELECTRIC BRAKING OF DC MOTORS

Why Braking

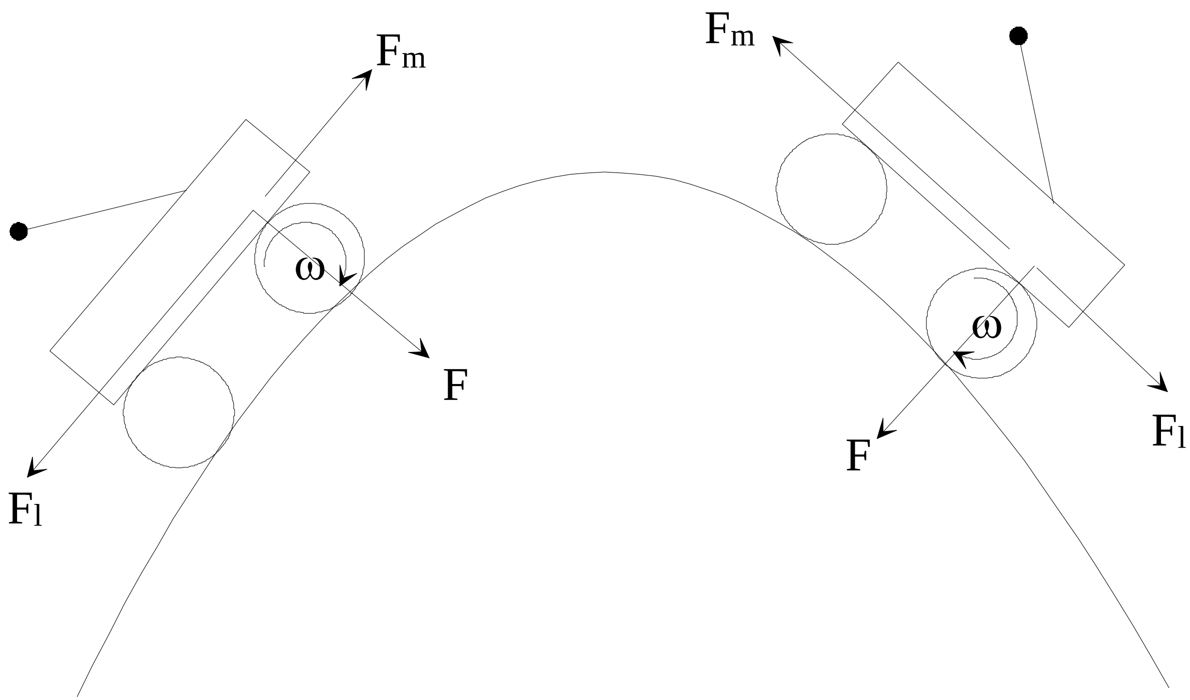
- To stop the electric motor.
- To sustain the speed of the drive system at the desired value.
- To prevent the motor from over-speeding.
- To hold the motor shaft at a certain position regardless to the applied load torque.

Regenerative Braking

1. Regenerative Braking

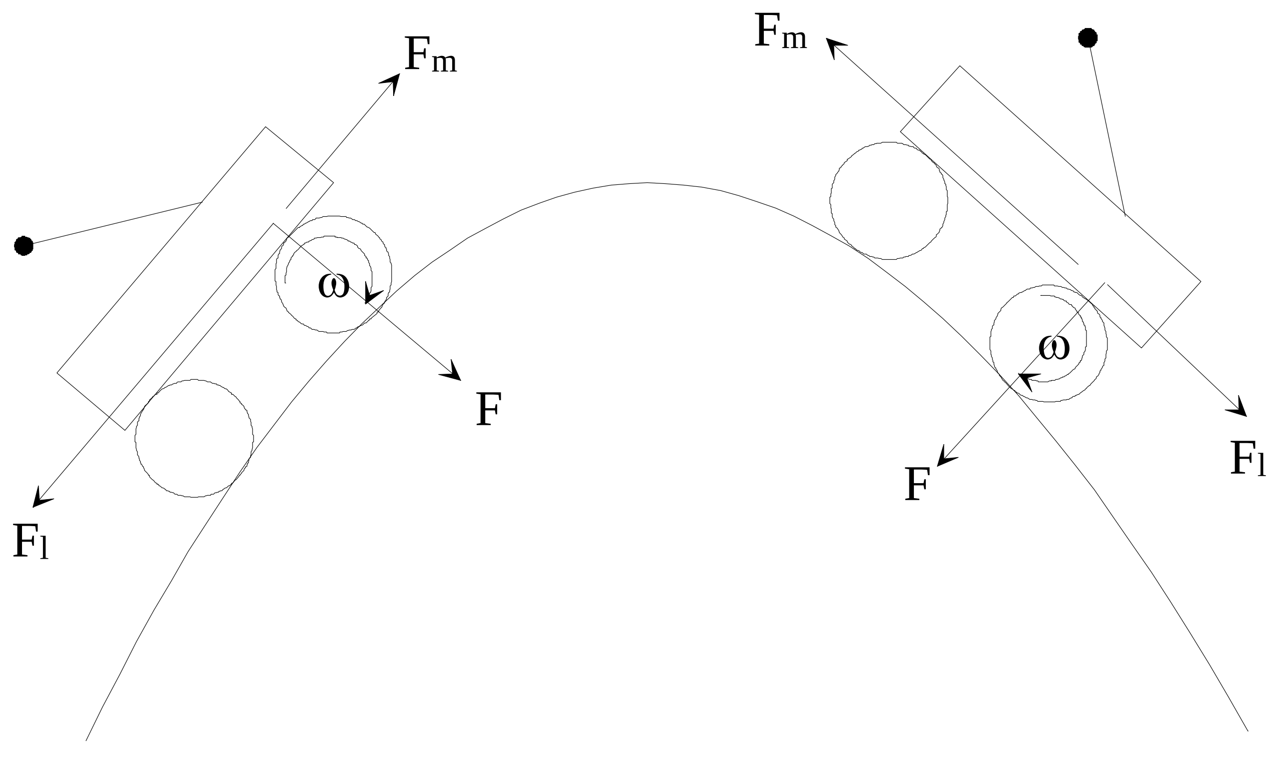
This method is used when the load on the motor has over-hauling characteristic as in

1) the lowering of the cage of a hoist or
2) the downgrade motion of an electric train



1. Regenerative Braking

- When the motor torque causes the machine to run at a ***speed > no-load speed***, but ***without changing its direction of rotation***, the motor is in regenerative braking.

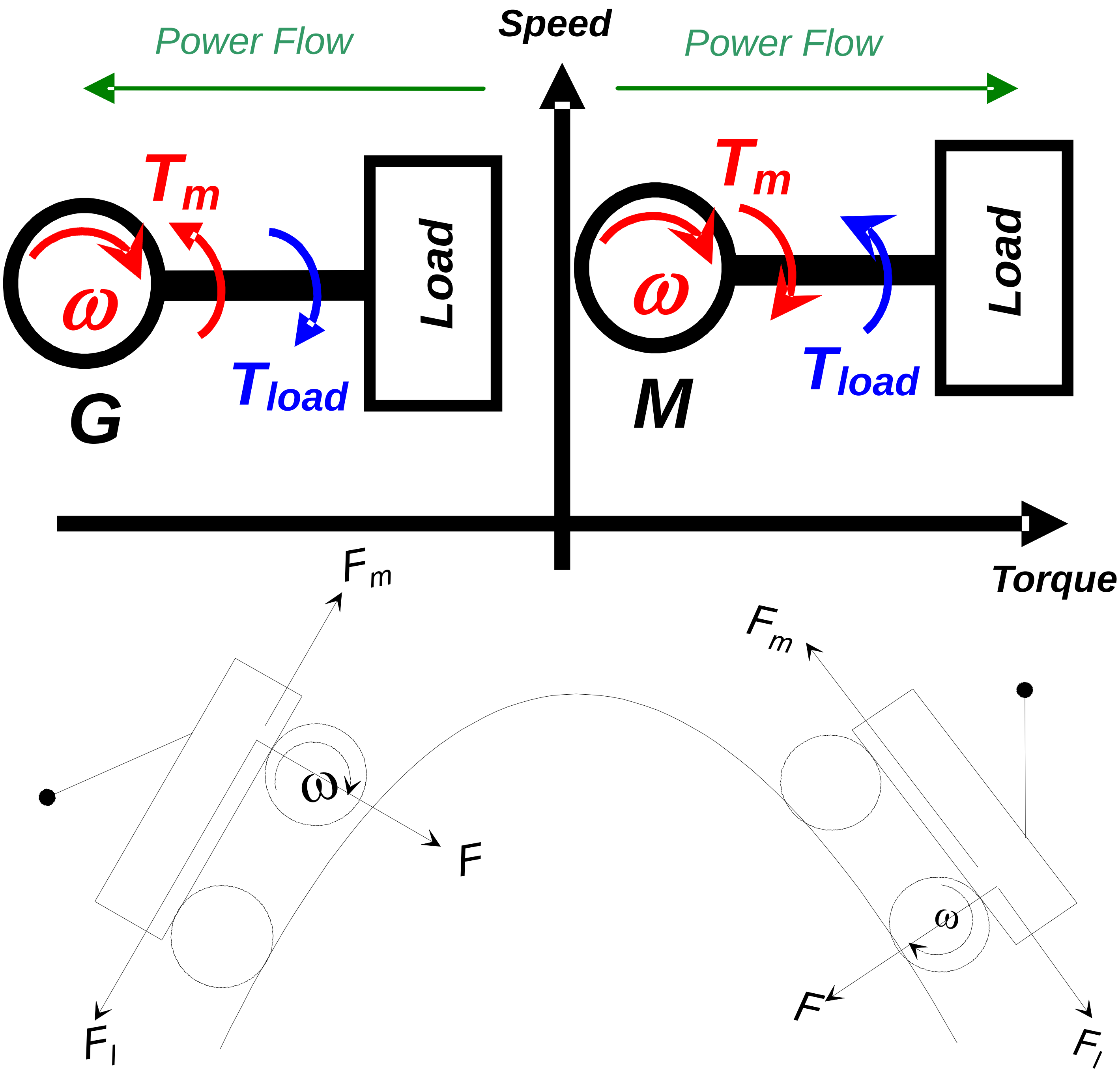


1. Regenerative Braking

- Regeneration takes place when the back EMF of the machine (E_a) becomes grater than the applied voltage V_a.
- This happens when the overhauling load acts as a prime mover and so drives the machine as a generator.
- Consequently, direction of I_a and hence of armature torque is reversed and speed falls until E becomes lower than V.

1. Regenerative Braking

- It is obvious that during the slowing down of the motor, power is returned to the line which may be used for supplying another train on an upgrade, thereby relieving the powerhouse of part of its load.



Power Flow
Speed
Power Flow
Tm
ω
Tload
Load
G
Tm
ω
Tload
Load
M
Torque
Fm
ω
F
Fl
Fm
ω
F
Fl

$$\omega_3 = \frac{V_t}{K\phi} - \frac{R_a}{(K\phi)^2} T_{l3}$$

$$I_{a3} = \frac{V_t - E_{a3}}{R_a} = \frac{T_{l3}}{K\phi}$$

$$V_t < E_{a3}$$

$$\omega_2 = \frac{V_t}{K\phi}$$

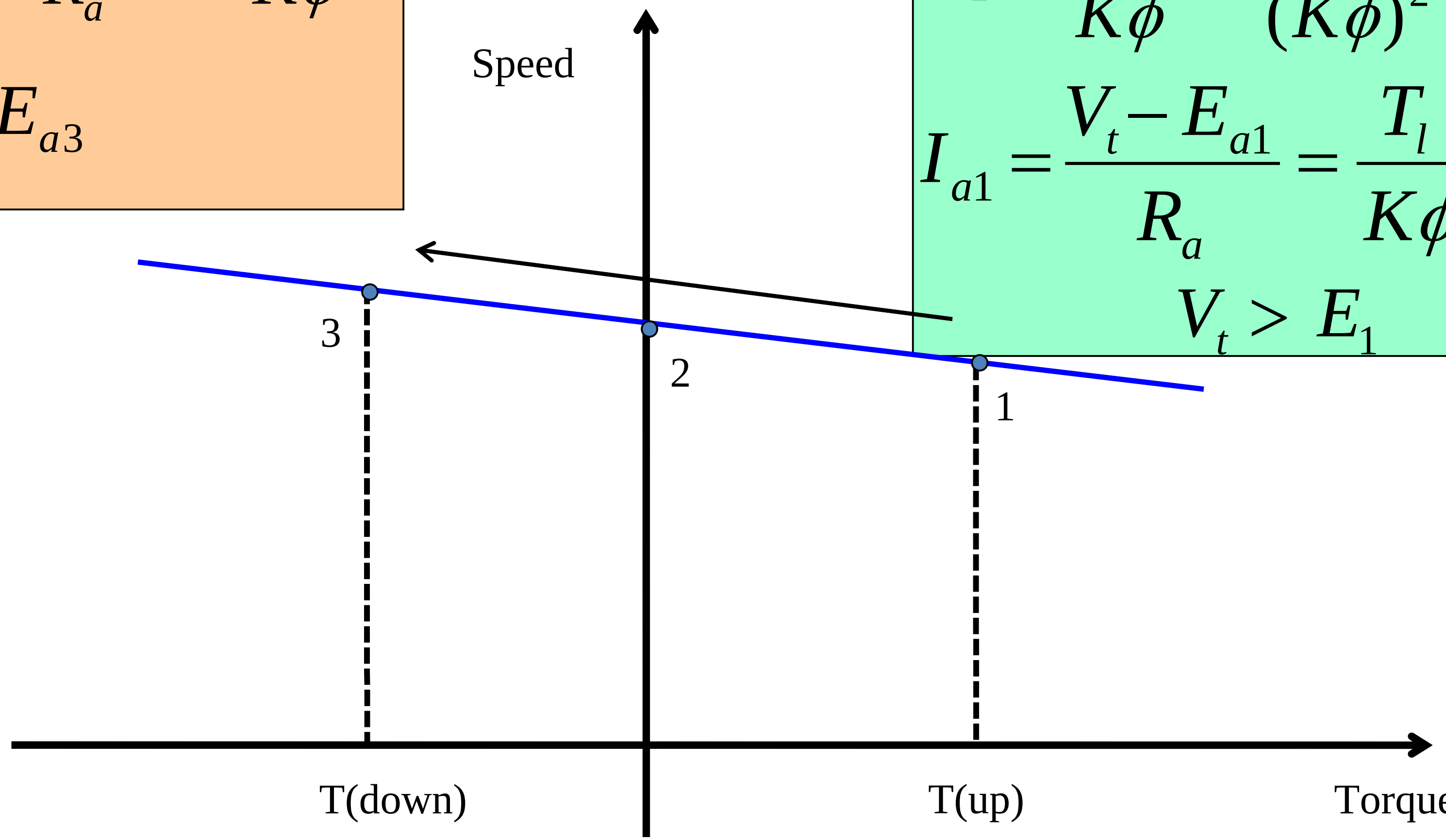
$$I_{a2} = \frac{V_t - E_{a2}}{R_a} = \frac{T_{l2}}{K\phi} = 0$$

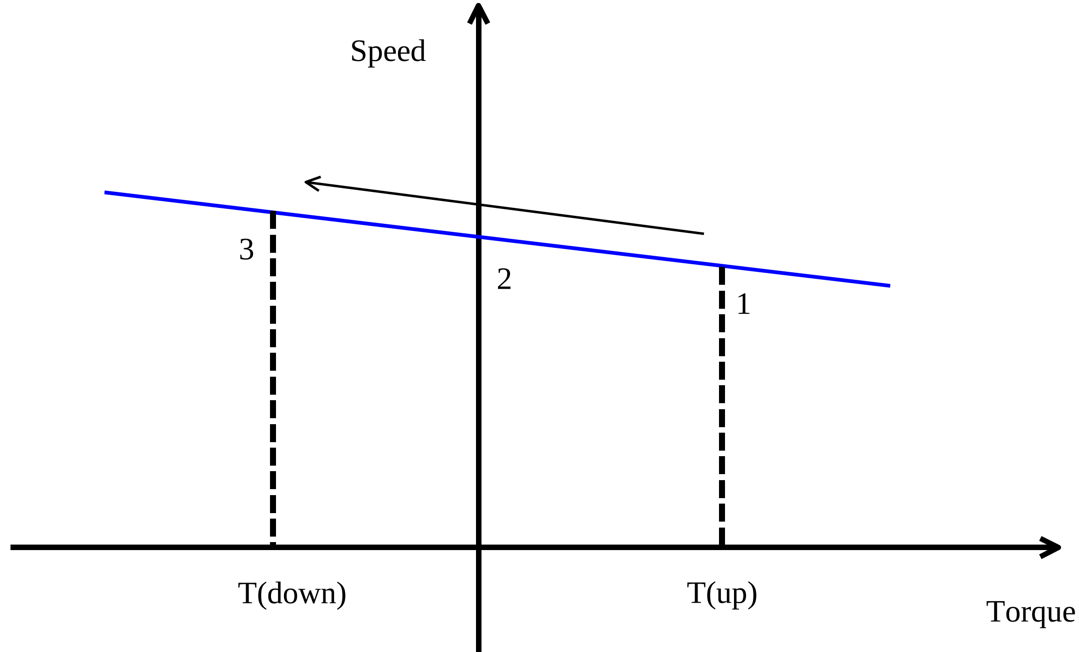
$$V_t = E_{a2}$$

$$\omega_1 = \frac{V_t}{K\phi} - \frac{R_a}{(K\phi)^2} T_{l1}$$

$$I_{a1} = \frac{V_t - E_{a1}}{R_a} = \frac{T_l}{K\phi}$$

$$V_t > E_1$$





Operating point	Load Torque	Terminal Voltage	Armature current	Speed	Field	E_a	Comments
1	→	→	→	→ $\omega_1 < \omega_o$	→	→ $E_{a1} < V_t$	Motor
2	0	→	0	→ $\omega_2 = \omega_o$	→	$E_{a2} = V_t$	No Load
3	←	→	←	→ $\omega_3 > \omega_o$	→	→ $E_{a3} > V_t$	Generator

ADVANCED ELECTRICAL MACHINES AND ENERGY CONVERTERS

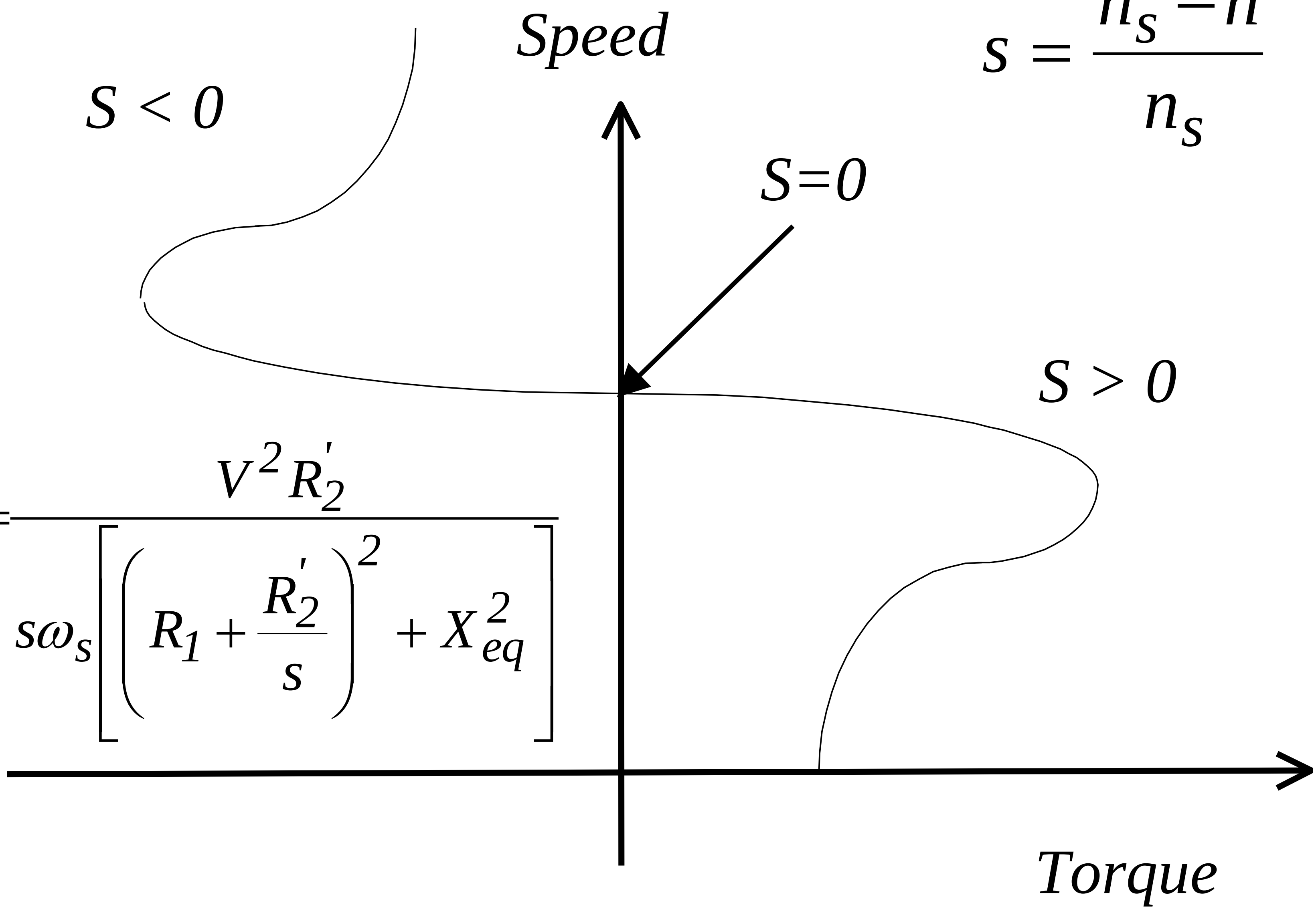
INDUCTION MOTOR BRAKING

Regenerative Braking

Regenerative Braking

- Regenerative braking occurs when the motor speed exceeds the synchronous speed.
- This may happen when the load torque drives the electric motor beyond it synchronous speed.
- In this case, the load is the source of the energy and the induction machine is converting the mechanical power into electrical power which is delivered back to the electrical system.
- The maximum torque developed by the induction motor on generating operation (regenerative braking) will reach a higher value than that on motoring operation

$$s = \frac{n_s - n}{n_s}$$



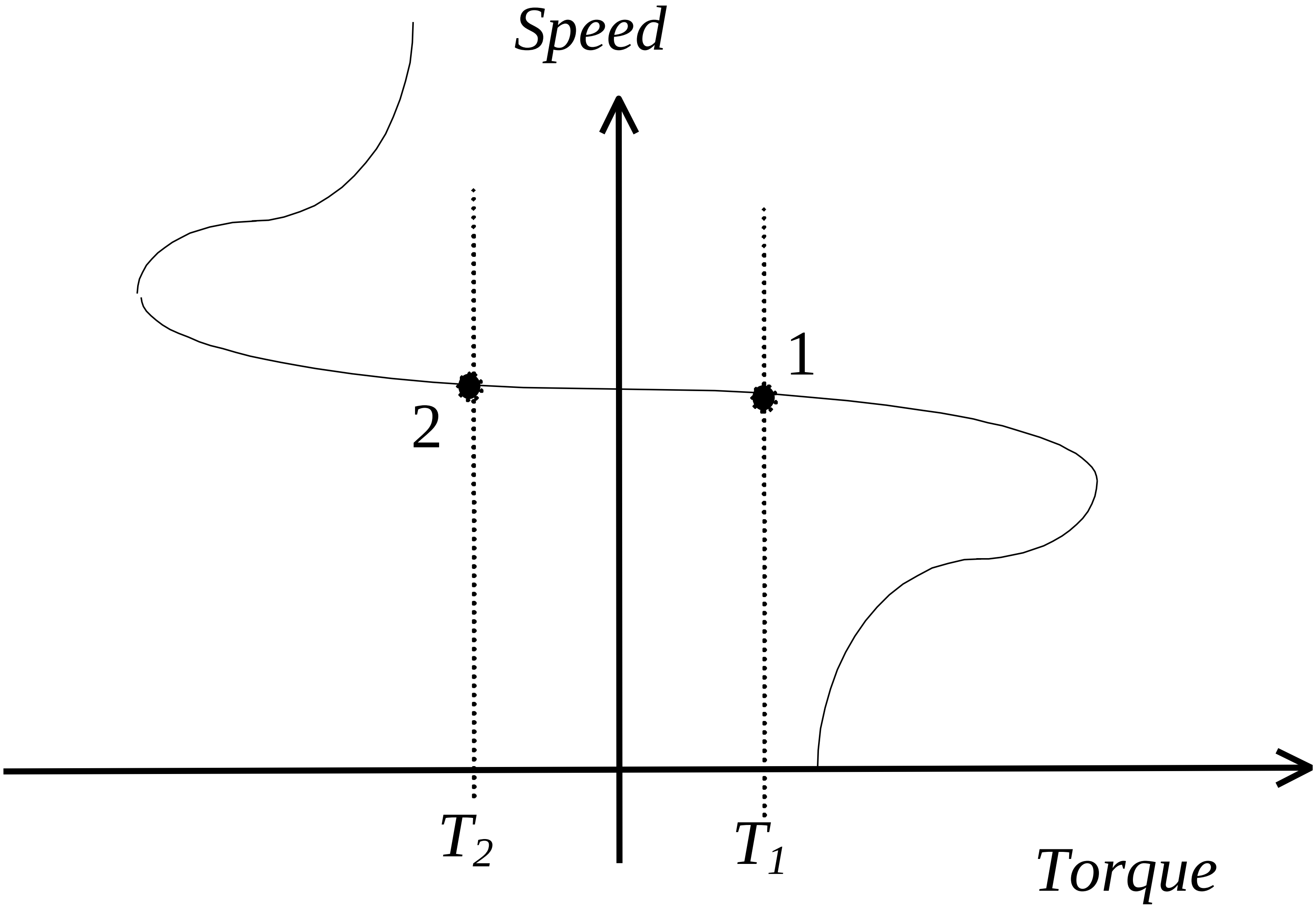
$$T_d = \frac{V^2 R_2'}{s\omega_s\left[\left(R_1 + \frac{R_2'}{s}\right)^2 + X_{eq}^2\right]}$$

Since the torque of the machine is negative during regenerative braking, but the direction of rotation of the machine is the same as that in the first quadrant, the flow of power is reversed. The mechanical power is the source of energy and is converted to electrical power by the machine. This electrical power is delivered to the electrical system, and the machine is acting as generator.

The induction machine of the wind system is designed to operate at regenerative braking only (second quadrant). When the wind speed is low so that the rotor speed is near or below the synchronous speed, the blades are locked and the motor is disconnected from the electrical supply to prevent the machine from running as a motor.

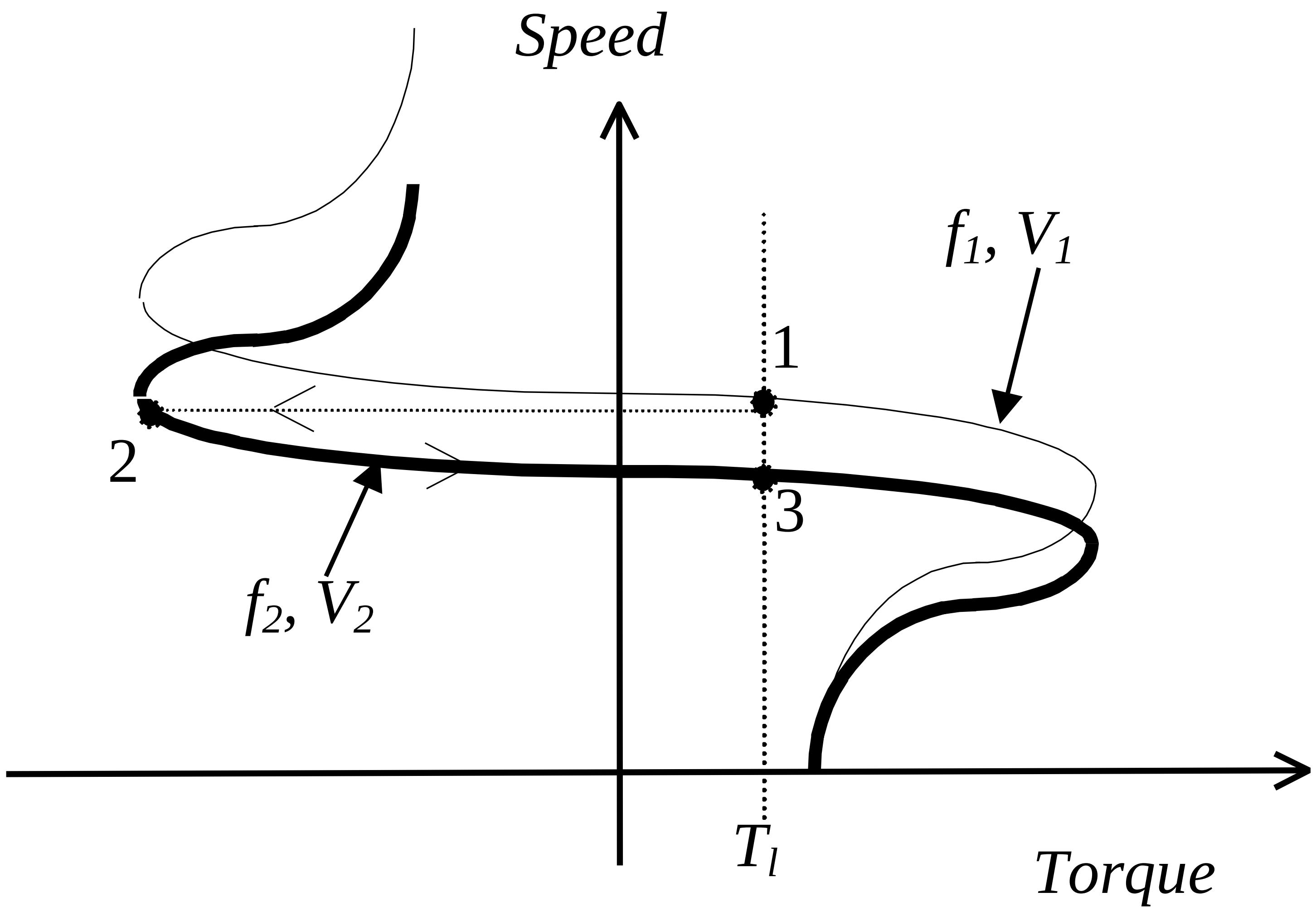
- In more general drive systems, the induction machines may operate in the first or second quadrant (as motor or generator).
- An example is shown in the following figure, the load torque is considered constant but reversible.
- The reference operating point represents a motor operation where the motor speed is less than the synchronous speed.
- When the load torque changes its direction from T1 to T2, the motor operates in the second quadrant and the speed of the motor exceeds its synchronous speed.
- Keep in mind that the motor still rotates in the original direction.

Regenerative braking



- Another example of regenerative braking is shown in the following figure:
- The figure shows two characteristics for two different values of *v/f* control
- The load torque is assumed to be constant and unidirectional, and the operating point is 1
- If v/f control is applied to reduce the speed of the motor, the operating point moves to 2, and eventually settles at point 3 in the first quadrant.
- However, during the transition from point 2 to point 3, the motor operates in the second quadrant under regenerative barking.

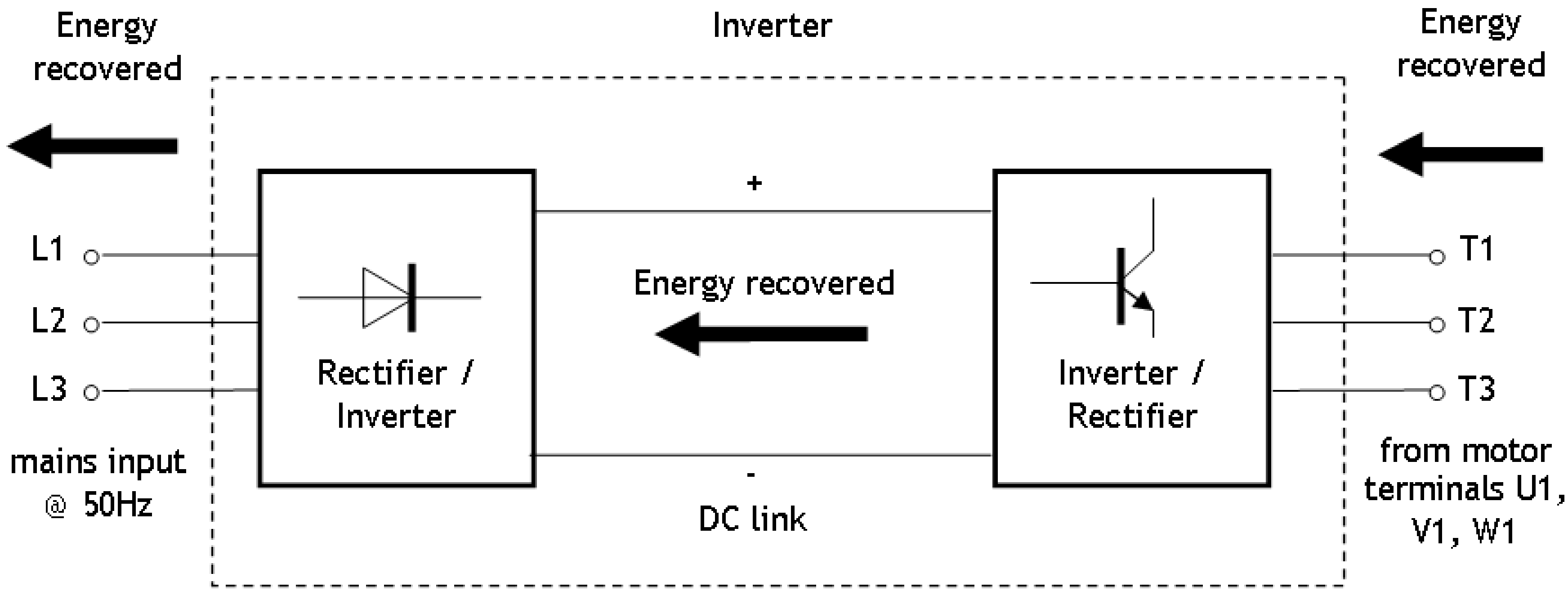
Regenerative braking during speed reduction



INDUCTION GENERATORS

- The induction generator is nothing more than an induction motor driven above its synchronous speed by an amount not exceeding the full load slip the unit would have as a motor.
- Assuming a full load slip of 3%, a motor with a synchronous speed of 1200 rpm would have a full load speed of 1164 rpm. This unit could also be driven by an external prime mover at 1236 rpm for use as an induction generator.

Regenerative Braking with Inverter



GRIDSERVE: Sun-to-Wheel

UK-Saudi EV Enhanced Education and Research Network

November 2022

GRIDSERVE


GRIDSERVE’s purpose is to #deliver sustainable energy and move the needle on climate change

GRIDSERVE Sun-to-Wheel Eco-system

Feedstock
(Sunlight)

Refining
(Battery Storage)

Transport
(Electricity Grids)

Charging
(Electric Forecourts & Hubs)

Wheel
(Electric Vehicles)

Sun-to-Wheel

1 Acre of Solar generates enough energy <u>every</u> year to drive an EV 1,000,000 miles.

Providing Energy Security, Fighting Climate Change, Improving Air Quality

GRIDSERVE®
sustainable energy

YORK HYBRID SOLAR FARM

SOLAR:

35 MWp

STORAGE:

30 MWh

After years of research, design and innovation we decided to build the world’s most technically advanced solar farm.

In just five months, we made it happen. Welcome to York, the first of its type, a truly subsidy free hybrid solar farm.

HULL HYBRID SOLAR FARM

SOLAR:

26 MWp

STORAGE:

10 MWh

Similar to York, Hull uses a single axis tracking system with bifacial modules and energy storage. It supplies all of the council's electricity needs and will save them more than £2 million a year.

CLAY HILL HYBRID SOLAR FARM

SOLAR:

10 MWp

STORAGE:

6 MWh

Clayhill, located near Flitwick in Bedfordshire, was acquired to #deliver our Sun to Wheel model, a net zero carbon, completely sustainable electric vehicle charging ecosystem.

This project is the beginning of our ambition to provide UK drivers dependable, low cost, clean energy from solar power. The good news? It can be replicated.

GRIDSERVE Sun-to-Wheel Eco-system

Feedstock
(Sunlight)

Refining
(Battery Storage)

Transport
(Electricity Grids)

Charging
(Electric Forecourts & Hubs)

Wheel
(Electric Vehicles)

Sun-to-Wheel

1 Acre of Solar generates enough energy every year to drive an EV 1,000,000 miles.

Providing Energy Security, Fighting Climate Change, Improving Air Quality

GRIDSERVE®
sustainable energy

GRIDSERVE® ELECTRIC HIGHWAY

Network Highlights

- 130,000 charging sessions per month
- Net Zero Carbon EV Charging
- Flexible charging solutions addressing different customer charging needs: DC / AC, CCS / CHAdeMO
- More than 160 state-of-the-art Motorway Network & Electric Hub sites operational
- Ease of use: Contactless payment, open easy access for all with no membership, no App, no RFID card
- Convenient, dependable, reliable using leading ABB chargers backed by AA and in-house customer support 24/7/265
- Fast DC charging: all chargers 50kW to 350kW

GRIDSERVE Electric Hubs

- Motorway Electric Hubs

Backbone of the GRIDSERVE Electric Highway, serving the UK's motorways and Strategic Road Network (SRN)

- Destination Electric Hubs

Maximizes regional & local network coverage through partnerships with leading retailers and site owners in convenient destination locations

GRIDSERVE Electric Forecourts

State of the art community-based charging infrastructure to primarily serve local areas, in particular people who do not have access to home charging. Includes an integrated retail convenience experience, wi-fi and site dependent facilities including convenience supermarket, coffee, hot food, meeting rooms, fitness facilities

GRIDSERVE Electric Super Hubs 2022

Super Hubs

Between 6 and 12 x 350kW Chargers

Easy to use and reliable

All with Contactless payment

Can add over 100 miles range in 15 minutes

Co-located with full range of services – food, coffee, washrooms, rest area

The first phase of a UK-wide network of Ultra-fast chargers

Already providing a fast and reliable network for high mileage, long-distance EV drivers in addition to the GRIDSERVE Medium Power chargers located across the UK motorway network

Located on roads and routes with exceptional traffic flow

MANY MORE to be installed in 2023 and beyond!

GRIDSERVE Sun-to-Wheel Eco-system

EXETER
12 x 350kW chargers

RUGBY
12 x 350kW chargers

Note: Photos taken during the commissioning phase and prior to opening to the public – these are exceptionally busy sites!

GRIDSERVE® sustainable energy

GRIDSERVE Braintree Electric Forecourt®

Source: Company information.

GRIDSERVE Norwich Electric Forecourt®

The Next GRIDSERVE Electric Forecourts®

Gatwick Airport

Nevendon

Bromborough

Liverpool – Edge Lane

Stevenage

Plymouth

Next-gen High Power Charging

Within the last 12 months we have seen a surge in light commercial electric vehicles regularly charging at our Braintree and Norwich Electric Forecourts® . Vehicles like the Ford E-Transit pictured. The main reason is that the economics today are more than favourable: electric light commercial vehicles are now fundamentally better than their diesel-powered counterparts on price, performance and practicality.

The new charger is able to offer dynamic dual-charging meaning that two vehicles will be able to plug in and charge simultaneously, and the EV charger will dynamically distribute the power between both vehicles.

The chargerl design is more user-friendly. LED lighting will now reveal when a charger is available or in use, a new pulley system ensures the retractable 5m charging cable is manoeuvrable and keeps pathways clear, while enlarged digital screens will provide all your EV charging information. The addition of a second, portrait-shaped screen means additional interactivity is possible.

GRIDSERVE

GRIDSERVE Sun-to-Wheel Eco-system

Feedstock	Refining	Transport	Charging	Wheel
(Sunlight)	(Battery Storage)	(Electricity Grids)	(Electric Forecourts & Hubs)	(Electric Vehicles)

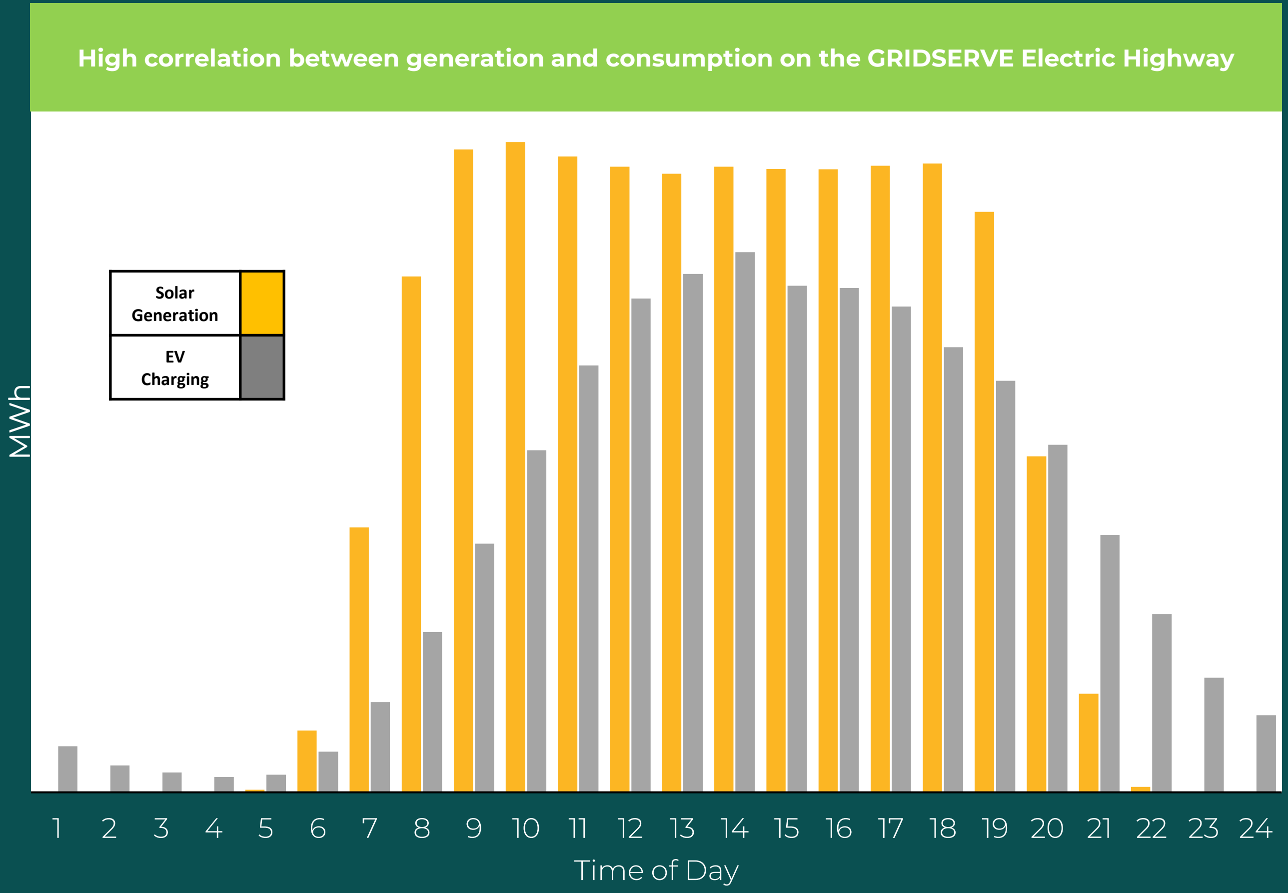
Sun-to-Wheel

1 Acre of Solar generates enough energy <u>every</u> year to drive an EV 1,000,000 miles.

Providing Energy Security, Fighting Climate Change, Improving Air Quality

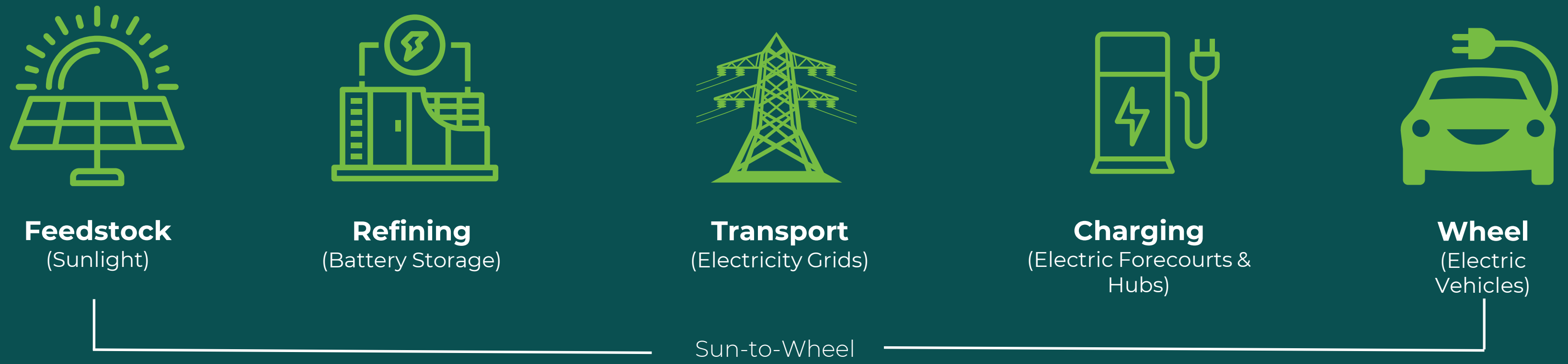
GRIDSERVE® sustainable energy

GRIDSERVE Sun-to-Wheel Eco-system



GRIDSERVE sustainable energy

GRIDSERVE Sun-to-Wheel Eco-system



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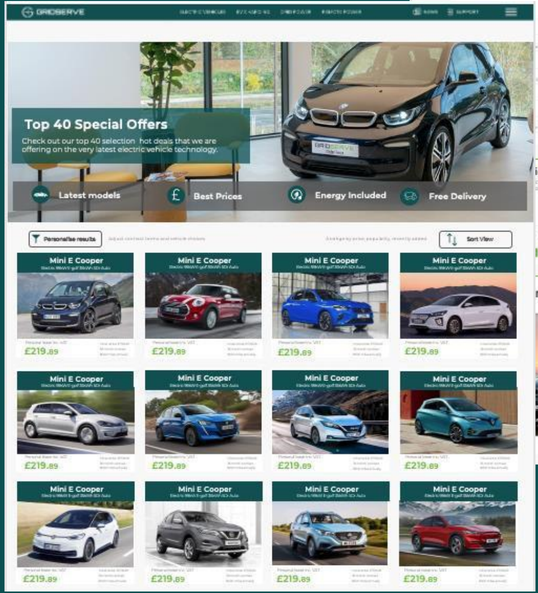
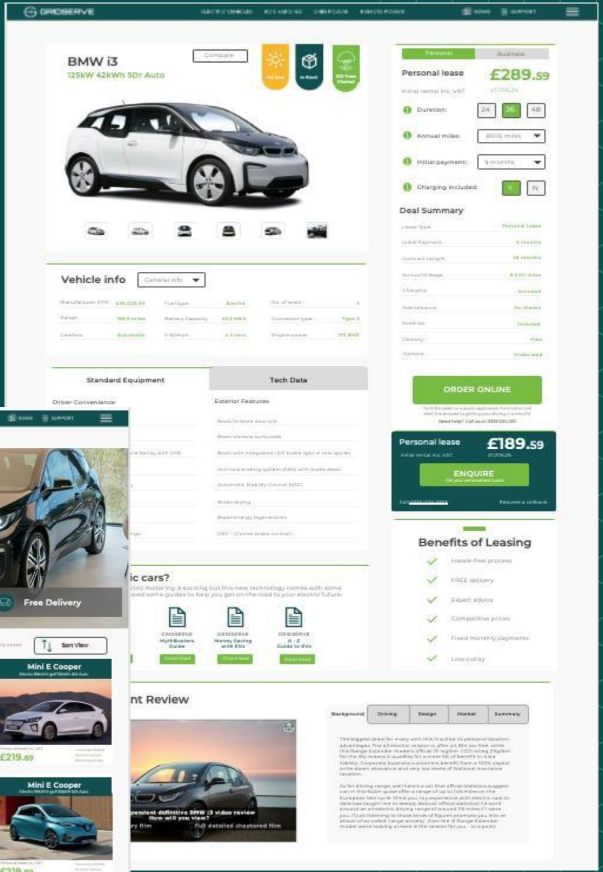
Providing Energy Security, Fighting Climate Change, Improving Air Quality

GRIDSERVE® sustainable energy

Electric Vehicle Leasing

GRIDSERVE offers electric vehicle leasing packages to customers that can include charging and other benefits.





GRIDSERVE

GRIDSERVE Sun-to-Wheel Eco-system

Feedstock
(Sunlight)

Refining
(Battery Storage)

Transport
(Electricity Grids)

Charging
(Electric Forecourts & Hubs)

Wheel
(Electric Vehicles)

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Providing Energy Security, Fighting Climate Change, Improving Air Quality

GRIDSERVE sustainable energy

Sun-to-Wheel
As a Service (SWaaS)

The GRIDSERVE Partner Network

Maximising success & scale-up capabilities,
Providing GRIDSERVE world class tech ecosystem to partners
'Sun-to-Wheel-as-a-Service' (SWaaS)

Partner Program offerings include:

- Network Creation
- All Products & Systems
- Infrastructure Delivery
- Financing Options
- Knowledge & Training
- Turn-key Technical Support
- Sales & Marketing
- Competitive Advantages
- Grow with GRIDSERVE

GRIDSERVE
Partner Network

Our Partner Network program offers full DEPCOMM access to our product suite allowing third-party partners to capitalise on GRIDSERVE's market leading net zero charging solutions and technology platforms within their own networks and geographies. This approach also turns would-be competitors, into revenue generating committed partners.

Market Leading Flexible Solutions

Latest Technology

We are a leading technology integrator working primarily with ABB and Tritium. We integrate our additional software, components and technology to deliver a superior customer experience, evidenced by our 5-star ratings.

Best Service Levels

EV charging technology is still in its infancy and needs constant support. We are obsessed with customer satisfaction and service levels. We have our own operation & maintenance teams continuously analysing data, monitoring equipment, diagnosing and fixing issues, and delivering 24x7 support.

Sustainable Energy

We are technology leaders in integrating solar PV energy and energy storage, providing complementary benefits including lower cost net zero carbon energy, buffering grid connections and generating additional income through grid services. These are available through our Sun-to-Wheel service.

Additional Customers

In addition to delivering, operating and maintaining the chargers, we focus on maximising utilisation. We promote the chargers on our rapidly growing, EV Charging Network, and we sell electric vehicle deals to people in the vicinity of each charger, particularly those who can't charge at home.

International Partner

GRIDSERVE are interested in partnering with like-minded companies globally. Our principal objective is to #deliver EV charging networks powered by renewable energy to help move the needle on climate change for the benefit of all.

Culture

GRIDSERVE's businesses are hugely ambitious and highly adaptive market leaders, with a strong family heritage. With partners who share these values we can scale quickly and successfully together.

GRIDSERVE Sun-to-Wheel Eco-system

Feedstock	**Refining**	**Transport**	**Charging**	**Wheel**
(Sunlight)	(Battery Storage)	(Electricity Grids)	(Electric Forecourts & Hubs)	(Electric Vehicles)

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1 Acre of Solar generates enough energy every year to drive an EV 1,000,000 miles.

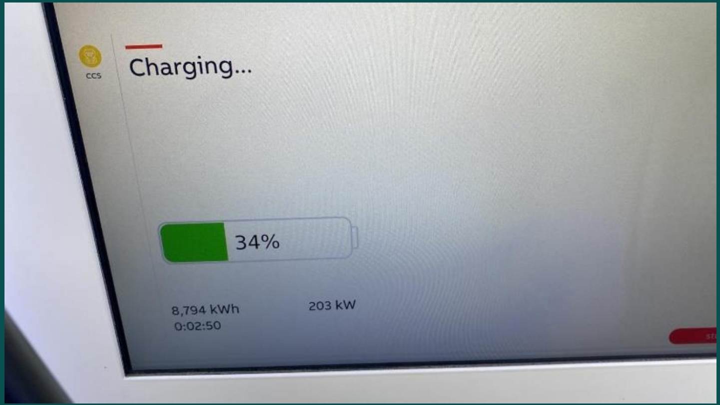
Providing Energy Security, Fighting Climate Change, Improving Air Quality

GRIDSERVE®
sustainable energy

Norwich Electric Forecourt®: Interesting Visitor

GRIDSERVE®
sustainable energy

Braintree Electric Forecourt®: Interesting Visitors



GRIDSERVE®
sustainable energy

GRIDSERVE – Leading the Charge

EVIES awards

Charge Point Network of the Year

IJ Global-ESG Europe Awards

Best sustainable transport transaction

Forecourt Trader Awards

Best Alternate Fuel Provider

Best Forecourt Innovation

GRIDSERVE sustainable energy

GRIDSERVE®
sustainable energy

Let’s work together to #deliver sustainable energy and move the needle on climate change.

Distributed conversion and EV Projects

Damien Frost, CTO & Co-Founder

UK-Saudi Electric Vehicles Enhanced Education and Research Network

25 November 2022

Who?

Who we are

Oxford spin-out developing intelligent battery management, monitoring, and *control* technology.

- Founded in 2016
- HQ in Oxford, UK
- 32 FTEs
- Markets: energy storage and electromobility

Founding Team

Christoph Birkl, DPhil, CEO, Director

Carolyn Hicks, MASc, MBA, CFO, Director

Damien Frost, DPhil, CTO

Adrien Bizeray, DPhil, Chief Data Scientist

OUR STORY

The founding members met whilst pursuing their PHD's in battery degradation, battery modelling and power electronics at the University of Oxford. It started with a goal of reducing battery waste by means of innovating BMS design to accurately study and predict battery degradation over time.

The rigidity of conventional BMS designs became an obstacle and our vision developed to, not only include and solve the battery waste issue but also to introduce the means so that every cell is used to its full potential.

Simply put, in a few short years, Brill Power changed the landscape of BMS technology and innovation.

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Simply put, in a few short years, Brill Power changed the landscape of BMS technology and innovation.

Brill Power Timeline

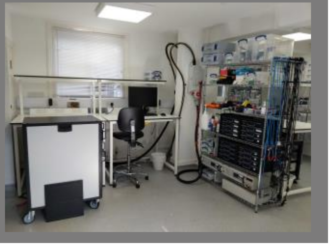
BrillPower

Oxford Uni Innovation Fund
Climate KIC accelerator
2nd patent application

Prototype complete
3rd patent application
Shell New Energy Challenge
Pre-seed round
IUK Investment Acc. grant
Faraday Challenge grant

EEF 7 grant
2 Faraday Challenge Grants
3rd prize in LG Chem Competition
TDAP Admission
Pilot delivery
Team grown to 8
1st Patent Grant

Team grown to 24
Expanded office space.
Product launched.
12 R&D projects completed



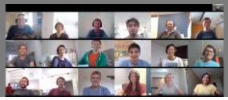
2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022

1st patent application
Presentation at IEEE GHTC, US
Greenhouse pre-accelerator

Incorporation of Brill Power Ltd
Proof of concept
GHTC grant

First Pilot project agreed
2nd iteration of BrillMS
2 new employees

Team grown to 15
Seed Round
8 Projects Underway
Over £4 million in funding committed (private and government grant)
Adapting to Covid 19



Team grown to 30+
£8.6million Series A
Ongoing product development

Integrate power electronics

into battery packs to

increase their performance

The Problem

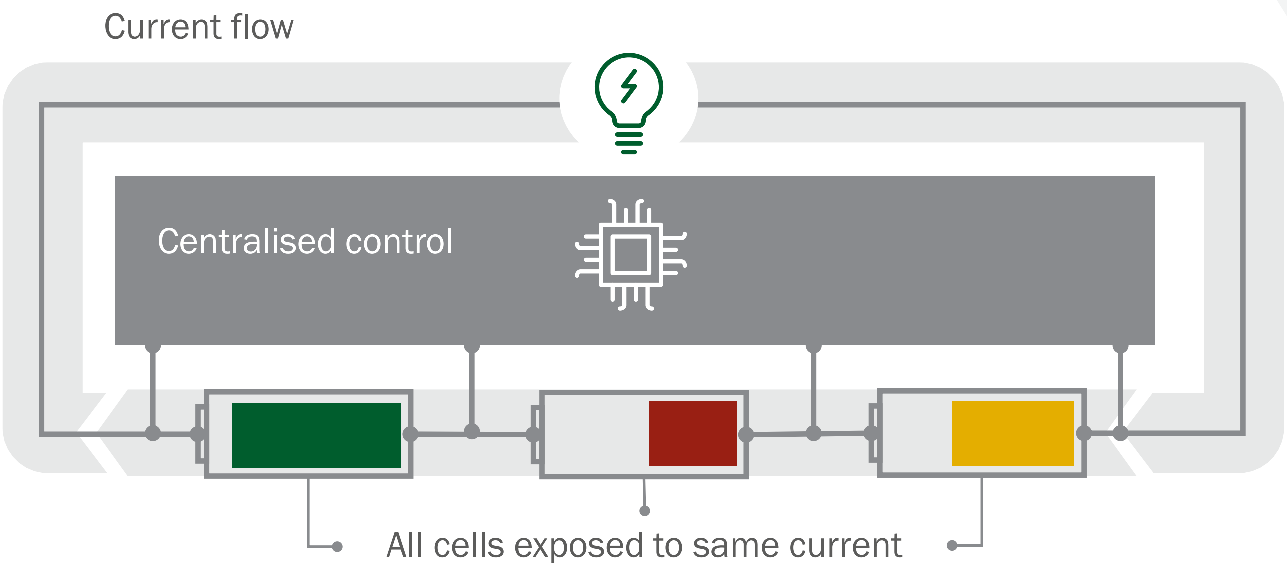
The weakest link issue: batteries are only as good as their weakest cells

Performance:
Limited by weakest cell

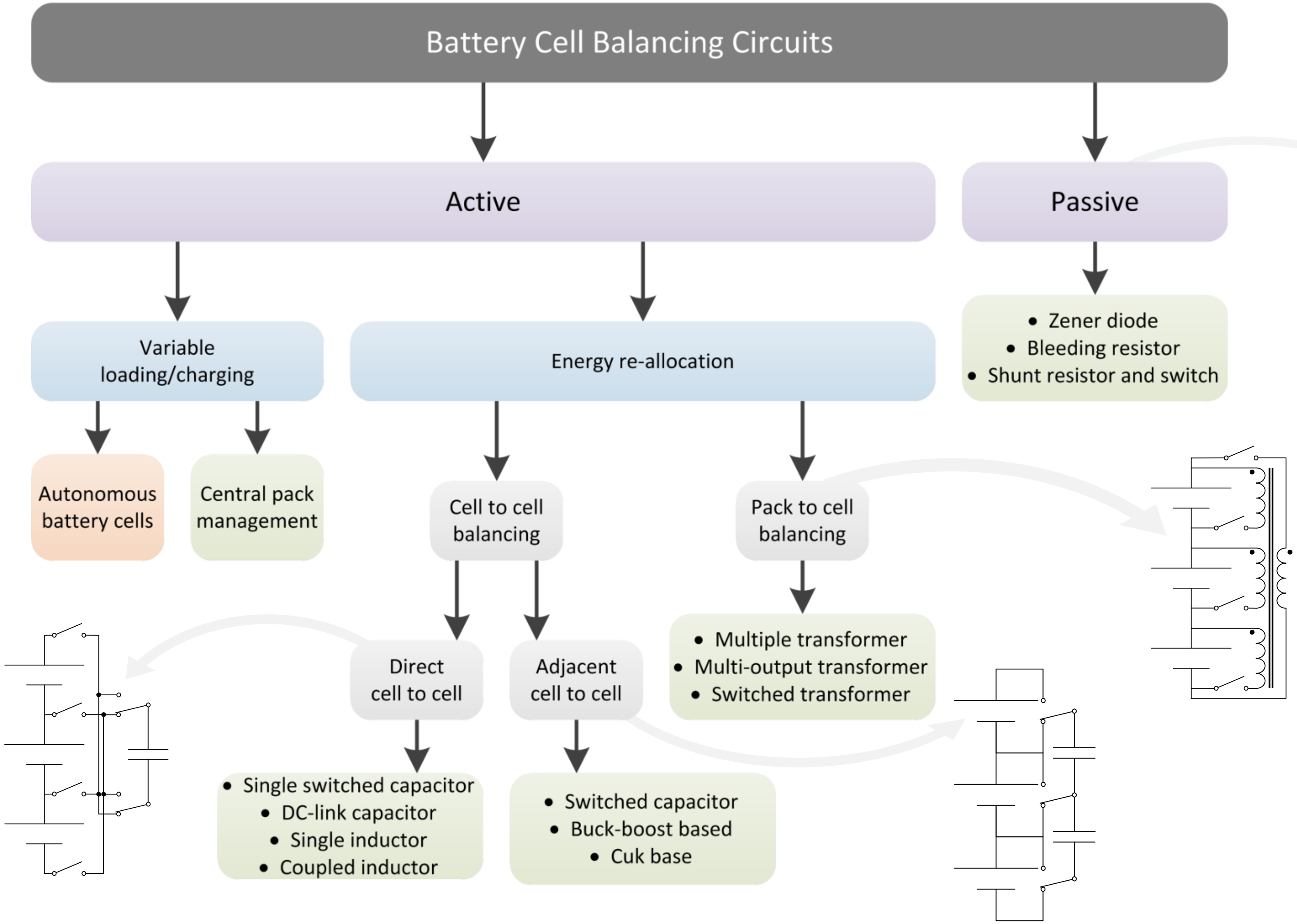
Lifetime:
Limited by weakest cell

Cost:
High due to replacements/oversizing

Sustainability:
Low due to battery waste from replacements

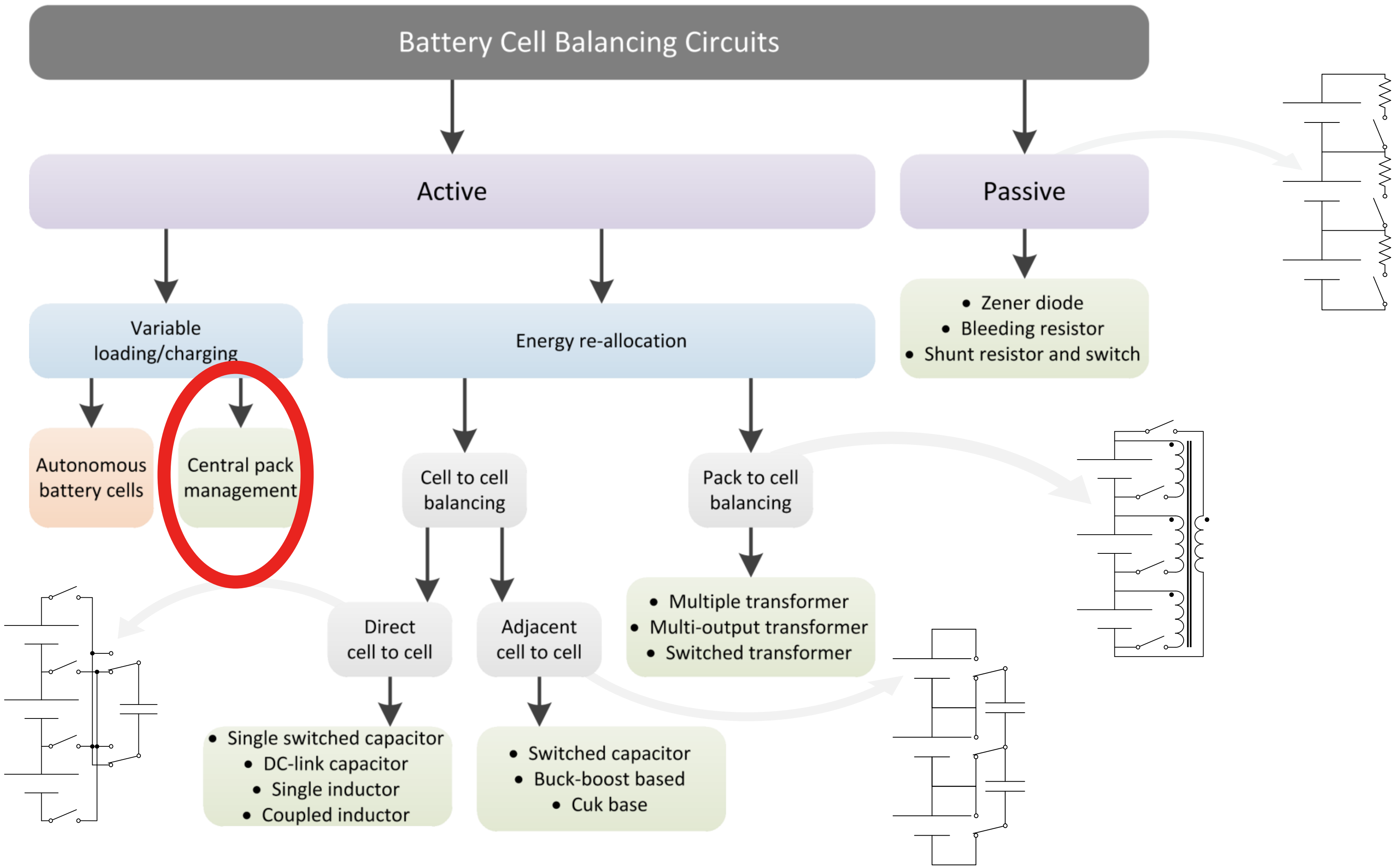


Balancing Options



The Problem

Balancing Options



The Solution

BrillPower

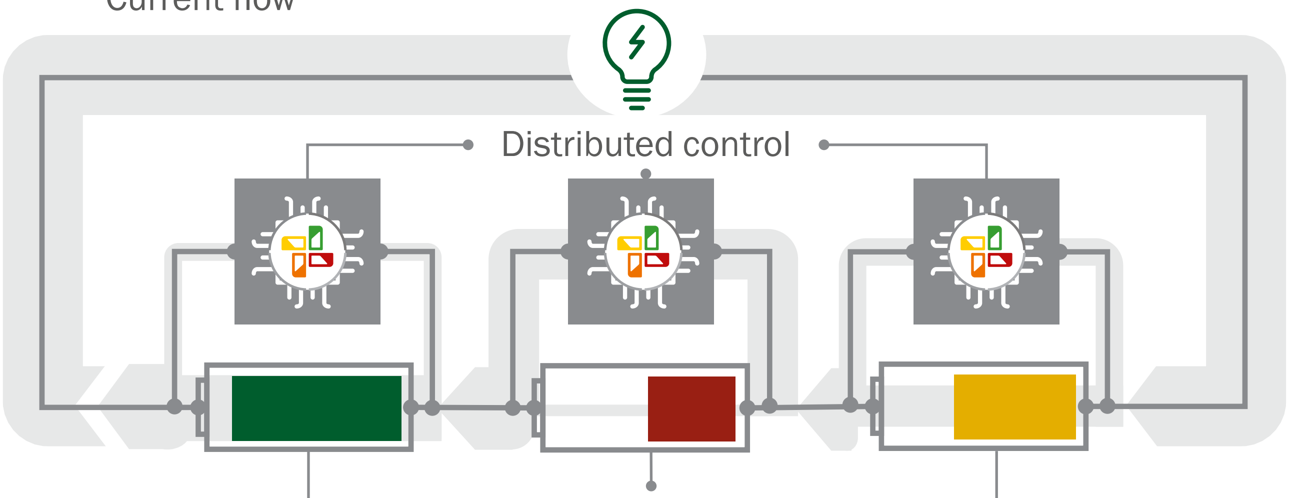
The BrillMS: intelligent control for maximal lifetime, performance and safety

Performance:
Up to 46% more energy

Lifetime:
Up to 60% longer lifetime

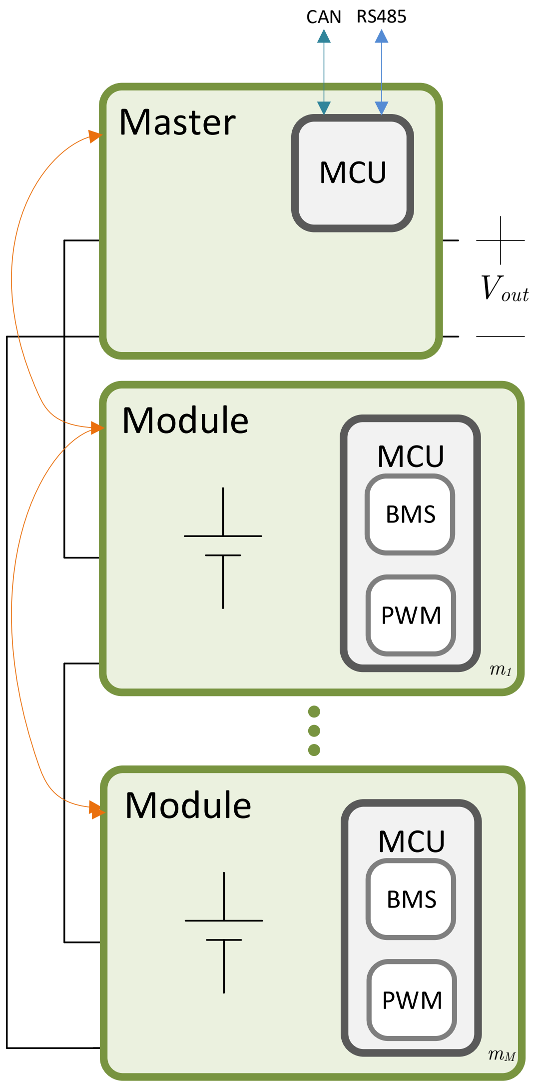
Cost:
Low - no replacements/oversizing

Sustainability:
High – no unnecessary battery waste



The BrillMS: intelligent control for maximal lifetime, performance and safety

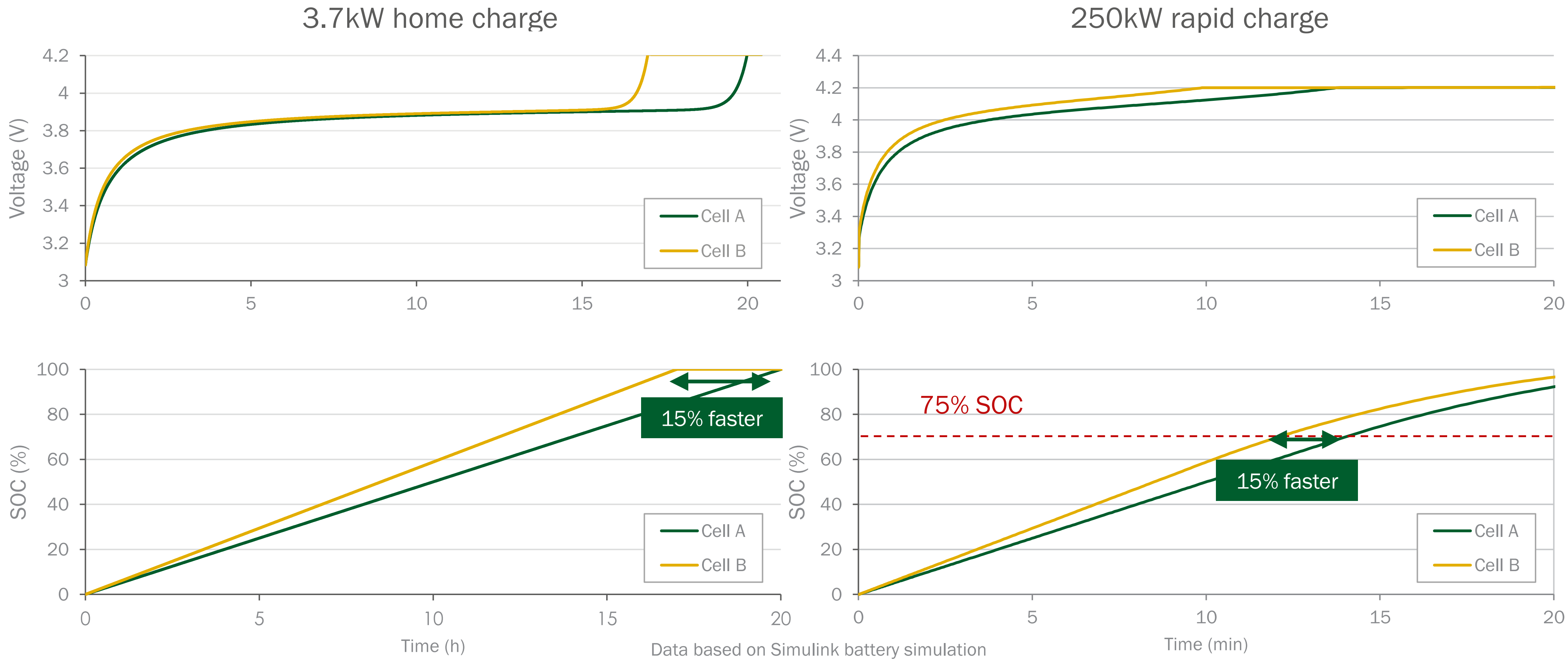
- Each Module contains power electronics
  - The outputs of the Modules are connected in series
  - Each module is responsible for the control of the power electronics and ensuring the safety of the electrochemical energy storage elements
- The output of the pack has voltage and current regulation
- The master is the gateway to the pack and controller of electrical distribution system (EDS).



Charge rates

Faster charge rates with Brill Power BMS

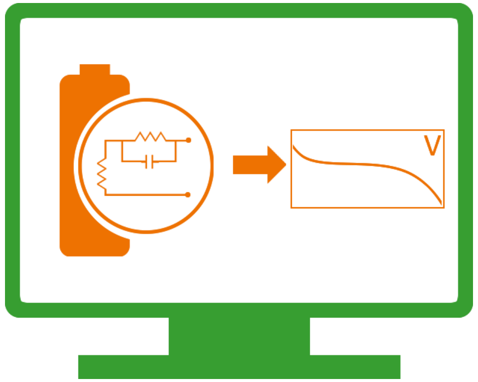
Charge rates are accelerated by compensating for differences in cell capacities (example: 15% difference between weakest and average cell)



Data based on Simulink battery simulation

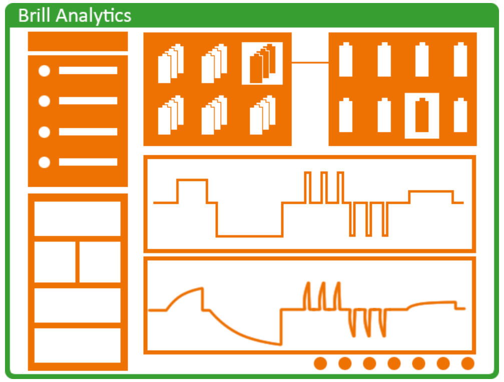
Brill Power battery software

Software solutions for various battery management functions



- High-accuracy state estimation algorithms:
  - state of charge
  - state of health
  - power capability
- Unique real-time resistance measurement

- State of health and end of life prediction models
- Full access to low-level cell data for improved warranty and insurance



- Cloud based battery intelligence platform:
  - Real-time display of battery status and key operating metrics across asset portfolio
  - Access to historic battery data
  - Prediction of performance and expected EoL
  - IoT communication and security based on Microsoft Azure

Brill Power battery analytics

Cloud-based battery analytics platform

IoT communication and Cloud Infrastructure

- Reliable IoT communication, networking and provisioning supported by Microsoft Azure services
- Secure user identification based on Microsoft Azure Active Directory

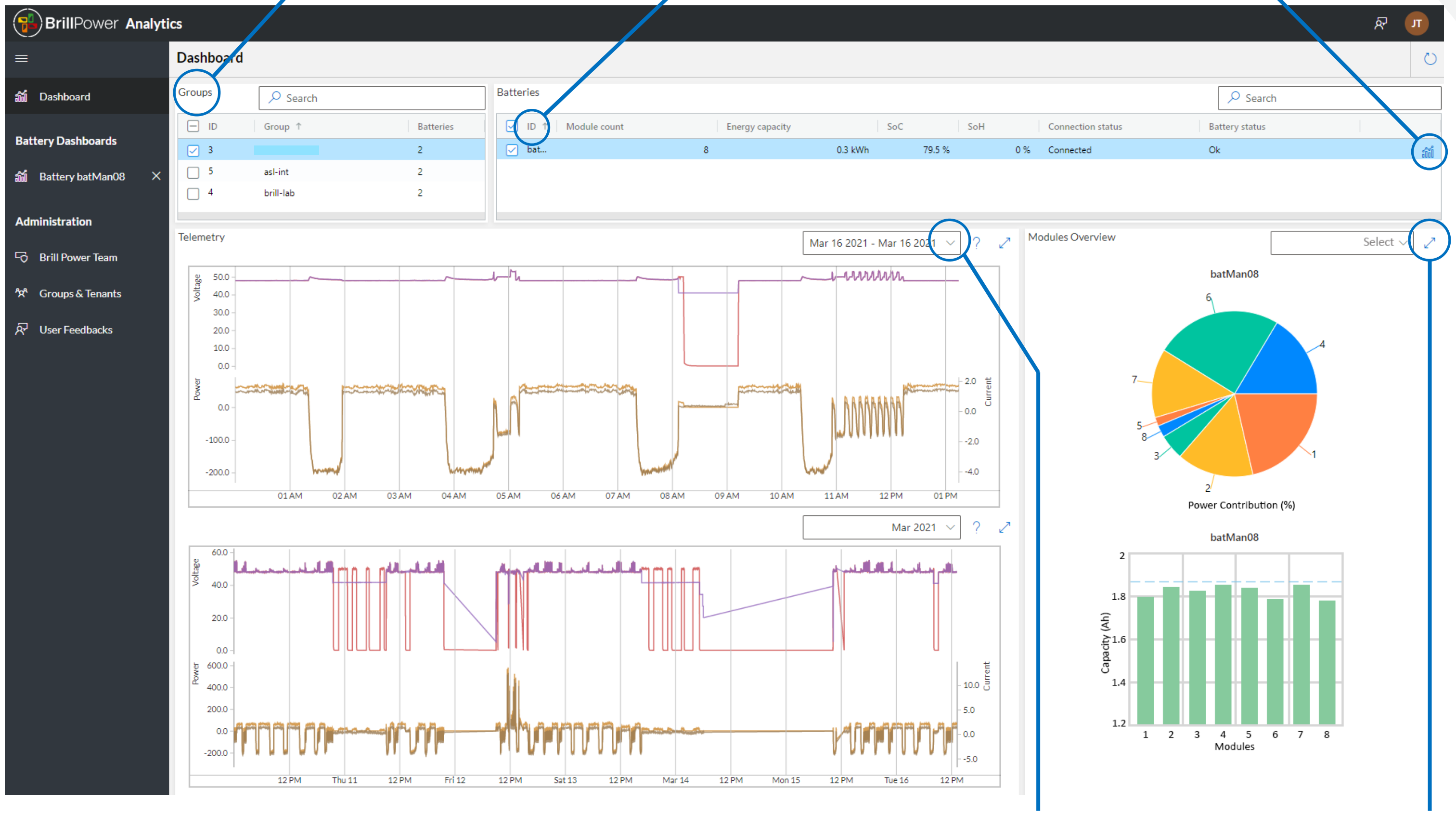
Dashboard view

- Battery pack status and key metrics across a portfolio of battery assets
- Comparison of high-level current and historical telemetry data across different battery assets

List of asset groups

List of batteries

Module level details explorer



Data viewer – Real Time and Long term

Performance Metrics viewer

Challenges and Motivation

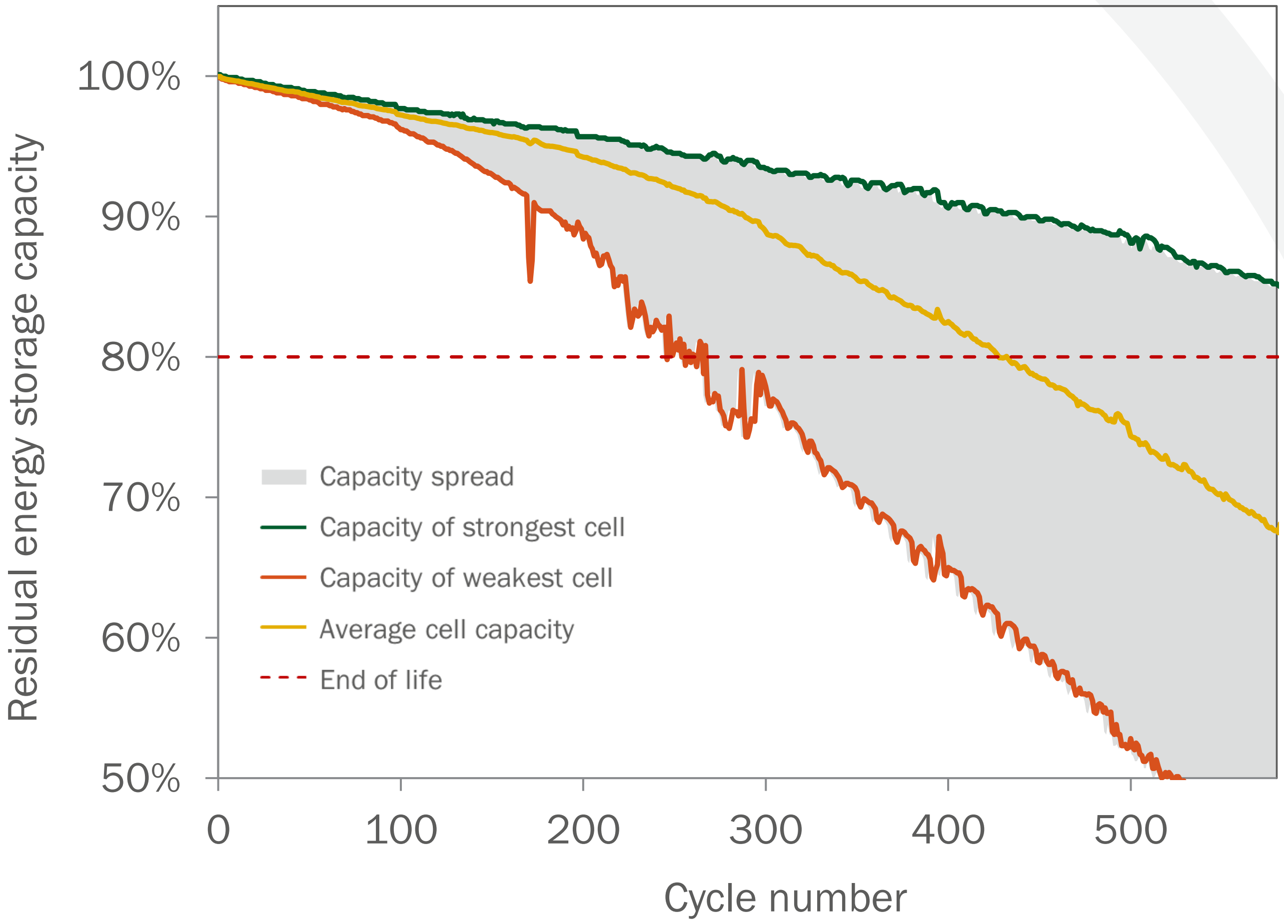
1. Electrochemical Cells are Small

Challenges and Motivation

2. 454 Wh per 1 Wh of Li-ion energy storage[1]

- Take any cradle to grave study with a pinch of salt
  - This one if from 2013
- Need 500 cycles just to break even
- Now getting 10x return

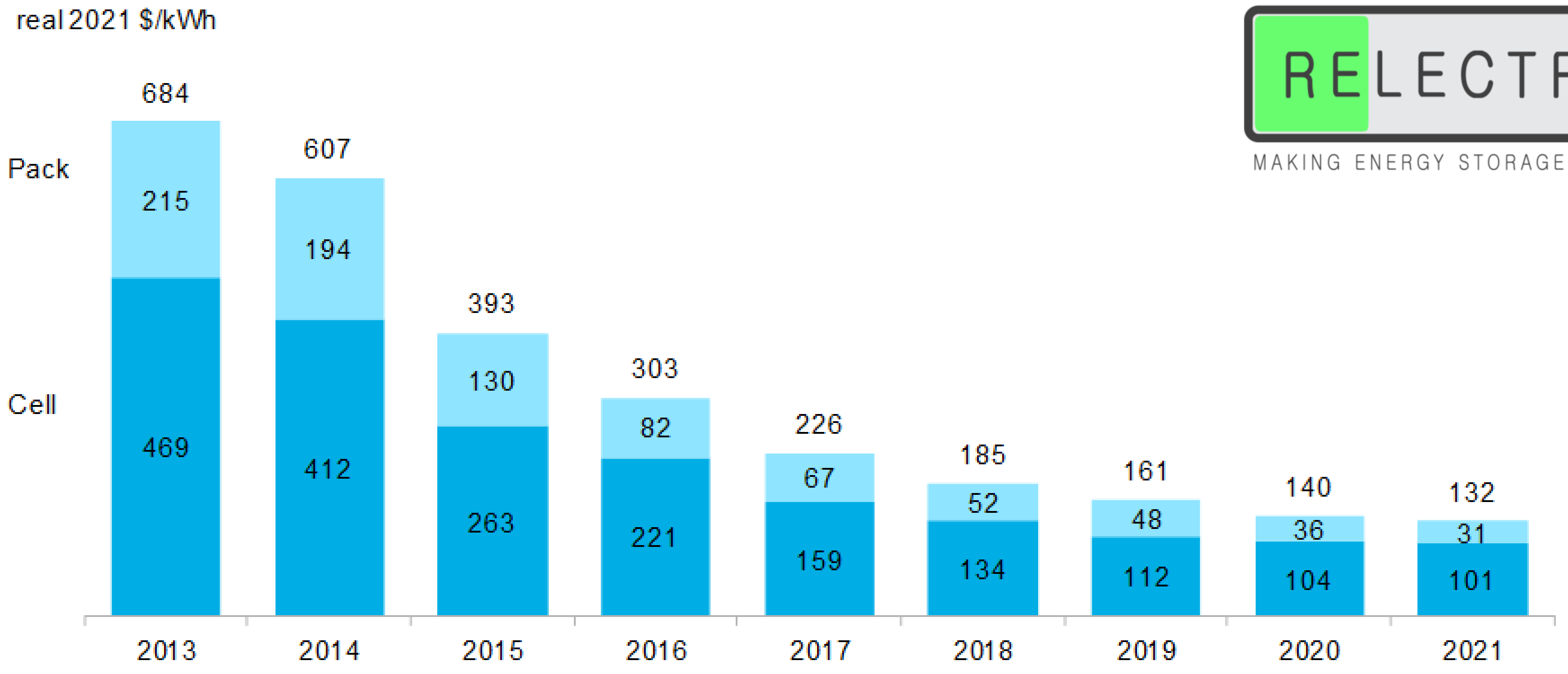
*We must use each cell until it is **completely** depleted*



1. C. J. Barnhart and S. M. Benson, "On the importance of reducing the energetic and material demands of electrical energy storage," *Energy Environ. Sci.*, vol. 6, pp. 1083–1092, 2013. [Online]. Available: http://dx.doi.org/10.1039/C3EE24040A

3. Adding cost to an expensive component

Figure 1: Volume-weighted average pack and cell price split



Source: BloombergNEF.

RELECTRIFY

MAKING ENERGY STORAGE AFFORDABLE

TESVOLT

THE ENERGY STORAGE EXPERTS

…but there are many active players in the market

BrillPower

4. BABE* Project (Not our name...)

Warranties	Size	Range (km)	Mileage Guarantee	Age Guarantee	SoH Guarantee	Est. Replacement Cost
Nissan Leaf	24 kWh	135	60,000	5	70%	£5k
Nissan Leaf	30 kWh	172	100,000	8	70%	£6k
Chevrolet Bolt	60 kWh	520	100,000	8	60%	£12k
Renault ZOE	22 KWh	240	60,000	5	70%	£5k
Renault ZOE	41 KWh	400	60,000	5	70%	£6k

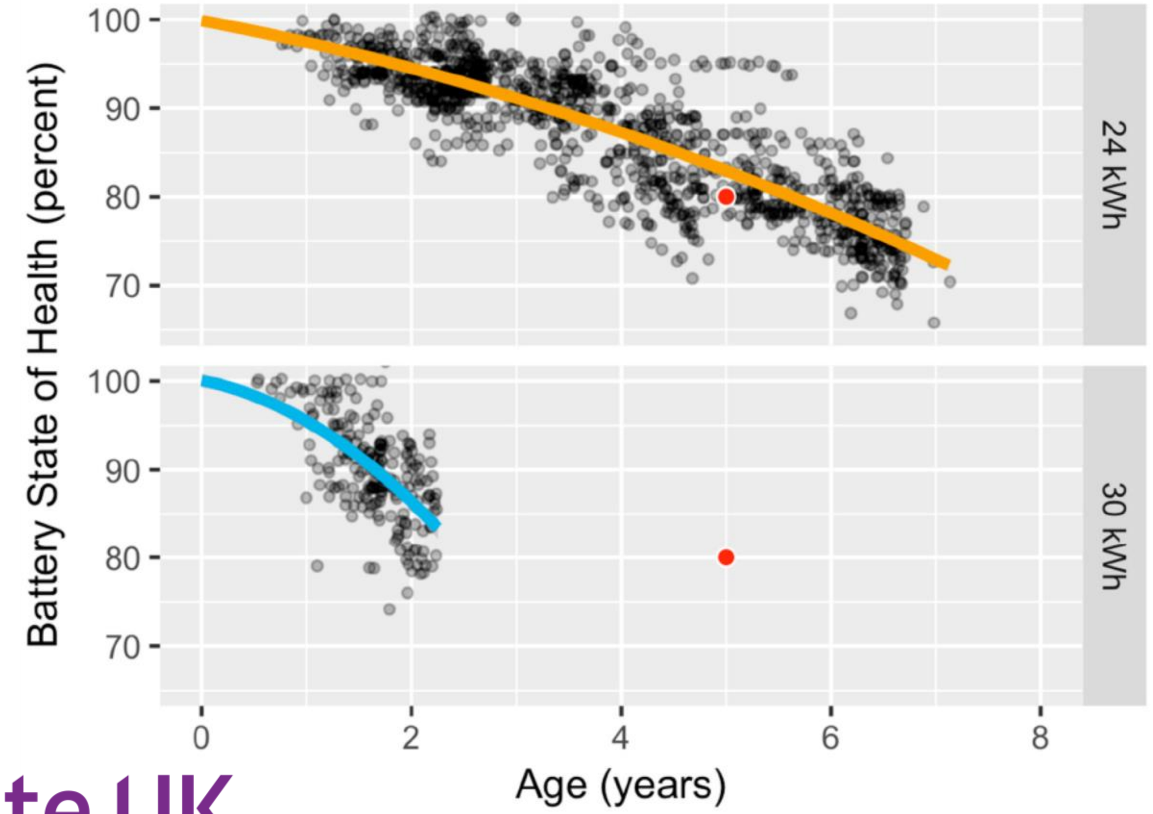
Data from 2018

*Battery management control system for Advanced Battery Engineering ☹

Challenges and Motivation

4. BABE* Project (Not our name...)

- Nissan Leaf Study 2018
  - User submitted, publicly available data
  - 201x 24 kWh Nissan Leafs
  - 82x 30 kWh Nissan Leafs (newer model)
  - 1,302 SoH data points
- Red dot is the warranty
  - Older model performed as designed
  - Newer model was not
- Distance travelled not recorded, which will play a factor.



Projects

Brill Power technology demonstration

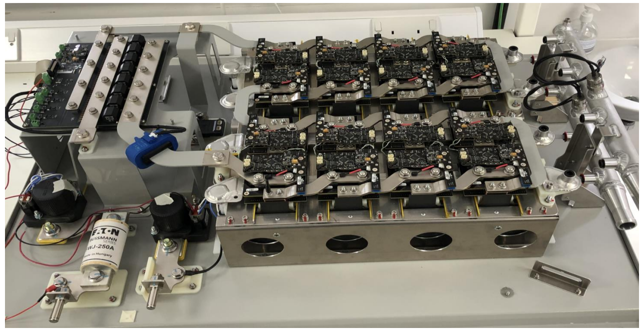
BrillPower

Various EV demo projects completed

Projects

Hybrid Vehicle battery Optimisation (HBO)

Dual chemistry EV demo system using high-energy/high-power Li-ion cells. Specifications: 48 V, 850 A, 6.5 kWh



Pozibot

EV demo system. Specifications: 48 V, 500 A

Retrofitting Electric Vehicles for Extended Lifetime (REVEL)

EV demo system with AMTE Power li-ion cells and Brill Power BMS
Specifications: 48 V, 192 A, 5.5 kWh

Project Partners

ASTON MARTIN

Imperial College London

delta A Cosworth Company

Altelium

Lancaster University

amte power

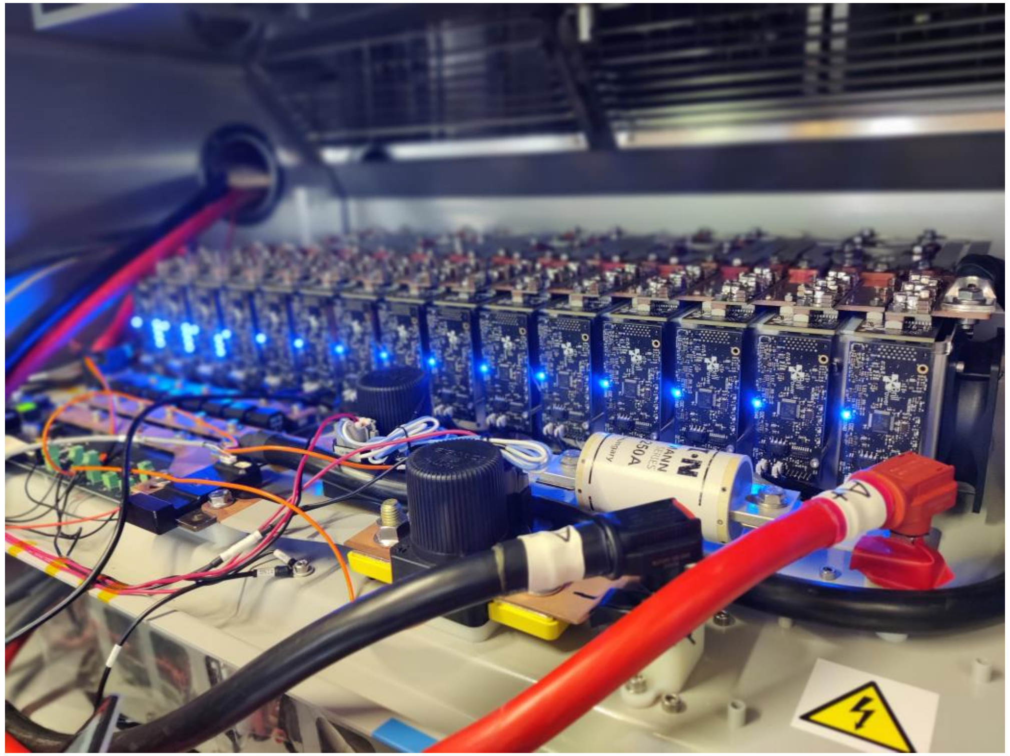
Project 1: Pozibot

Pozibot

BrillPower

Goals

- Business
  - How to insure batteries?
    - Transforming accountancy, insurance and legal services with AI and data
- Hardware
  - Create a high current pack
    - 25 A packs to date
    - 500 A pack for Pozibot
  - Interface with an ECU
    - Learn about automotive CAN and its requirements
    - Implement on our hardware
- Working with external hardware partner, Delta Motorsports



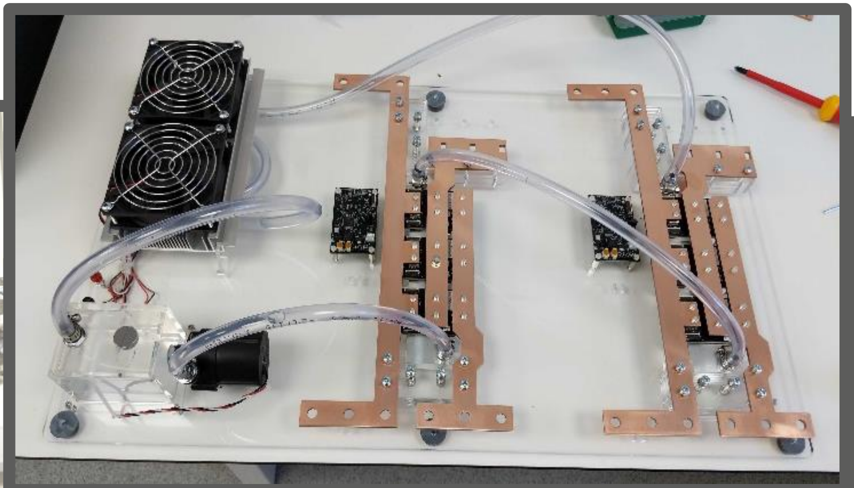
delta A Cosworth Company

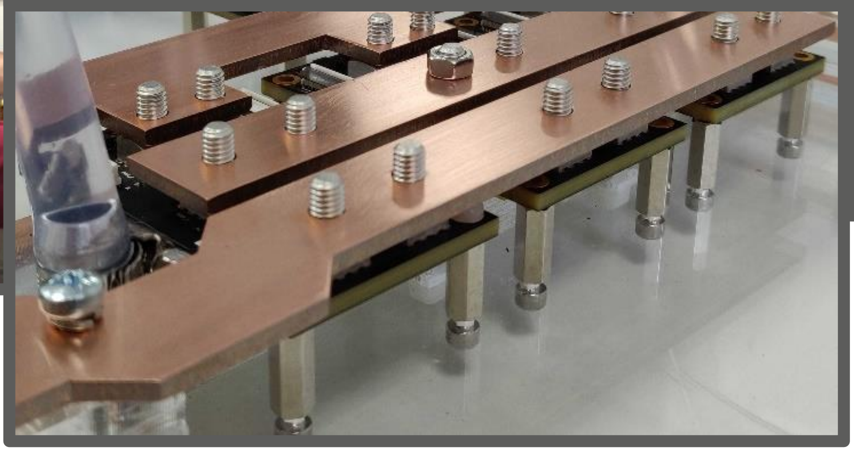
Altelium

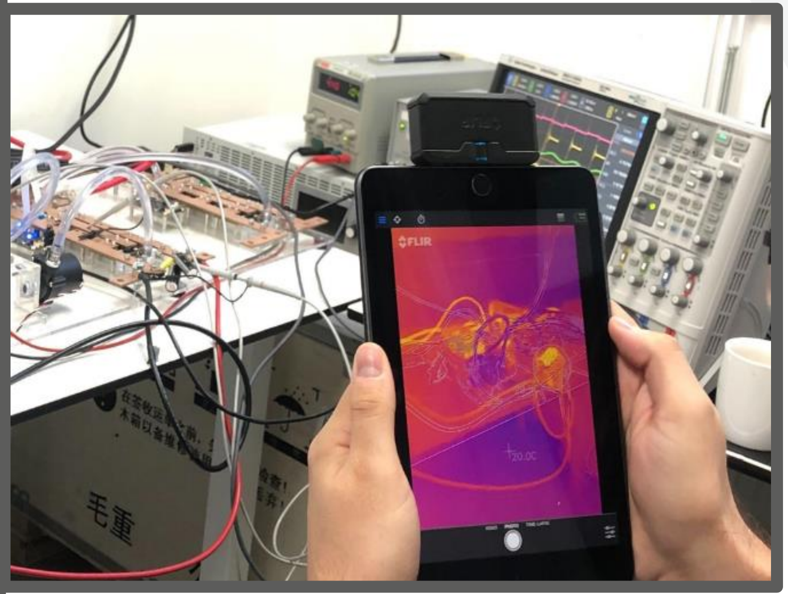
Lancaster University

Pozibot

Road to 500 A

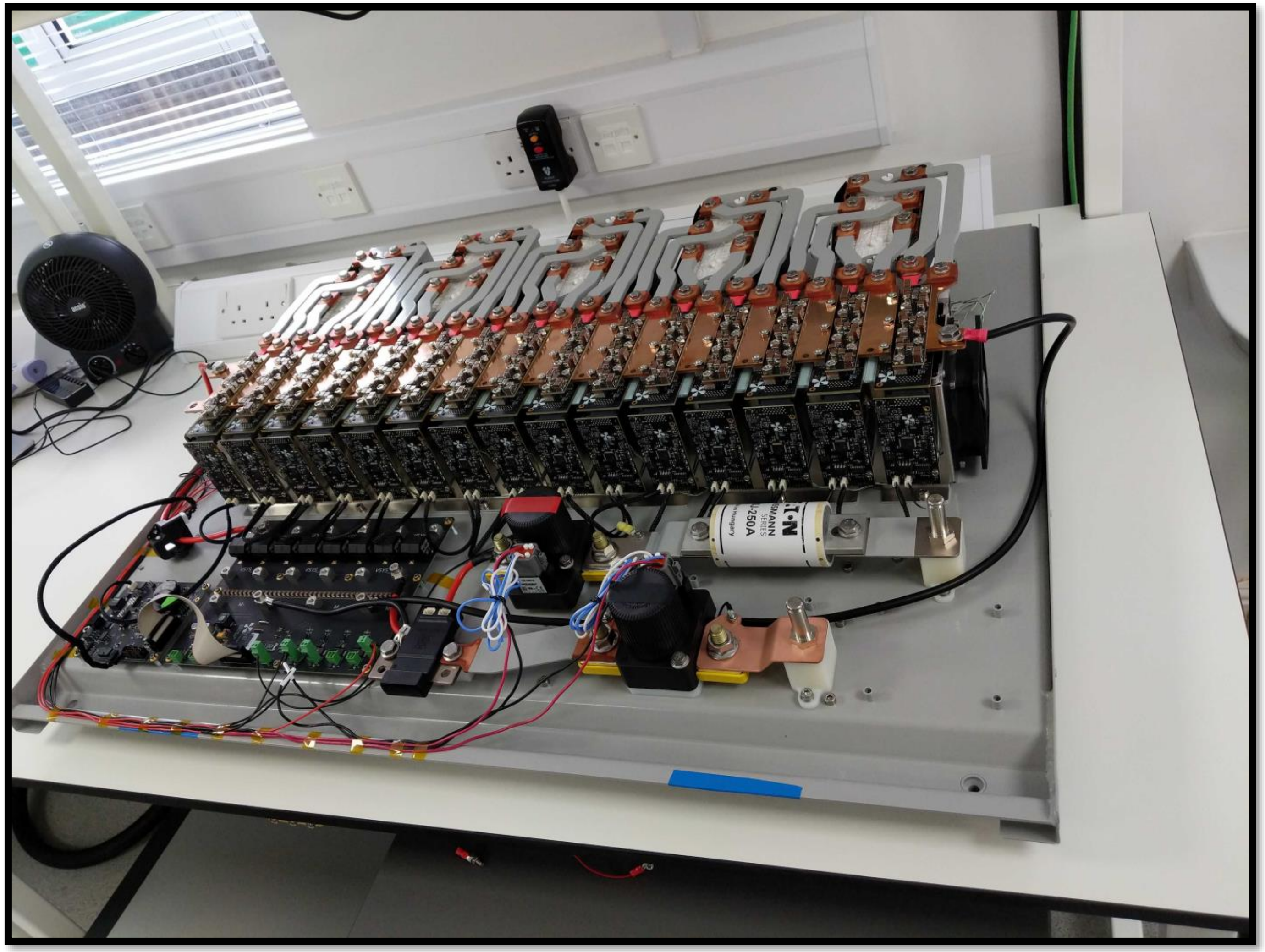






Pozibot

The completed pack



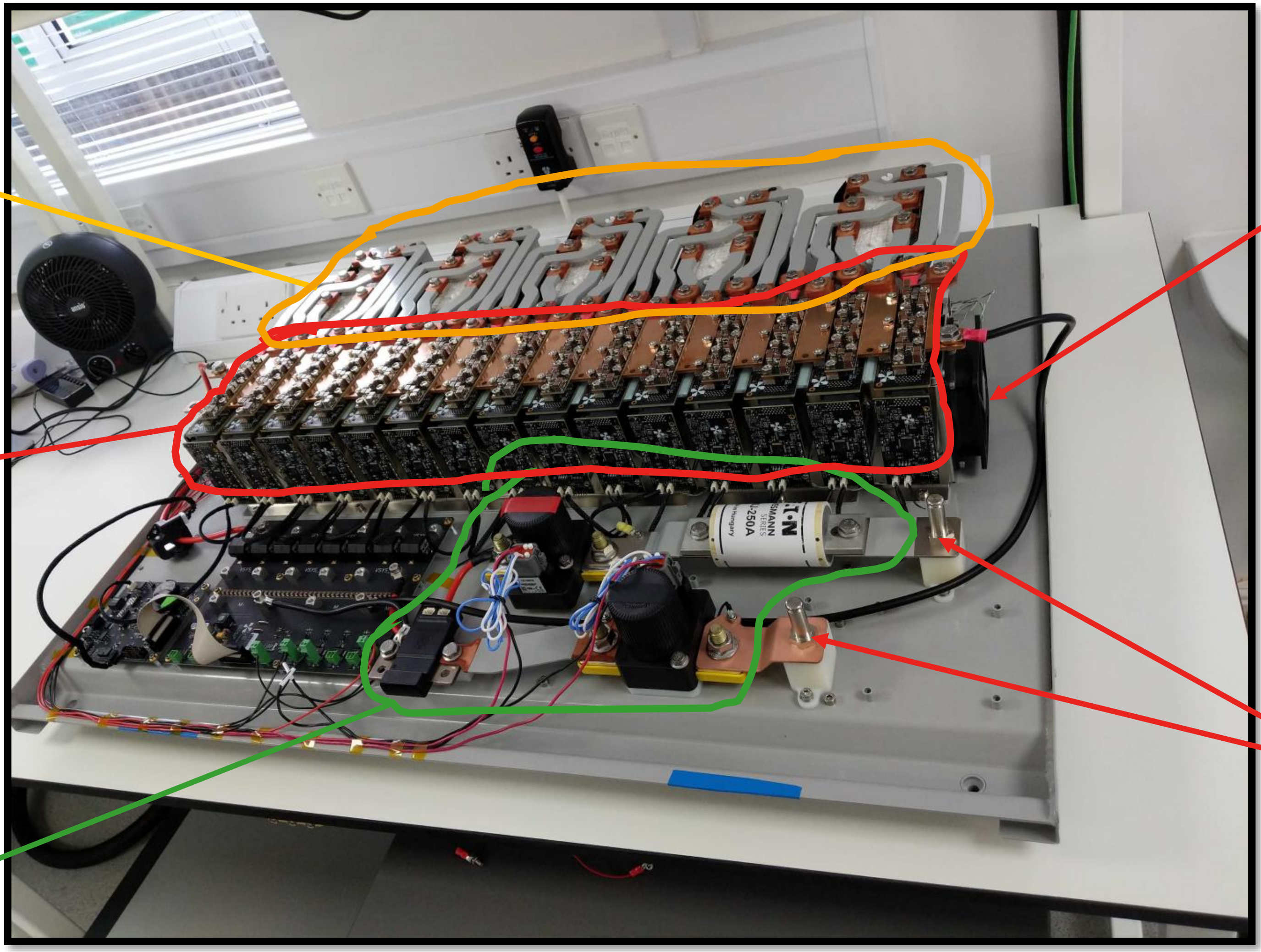
Pozibot

The completed pack

Liquid cooled Cells

Air cooled modules

Electrical Distribution System

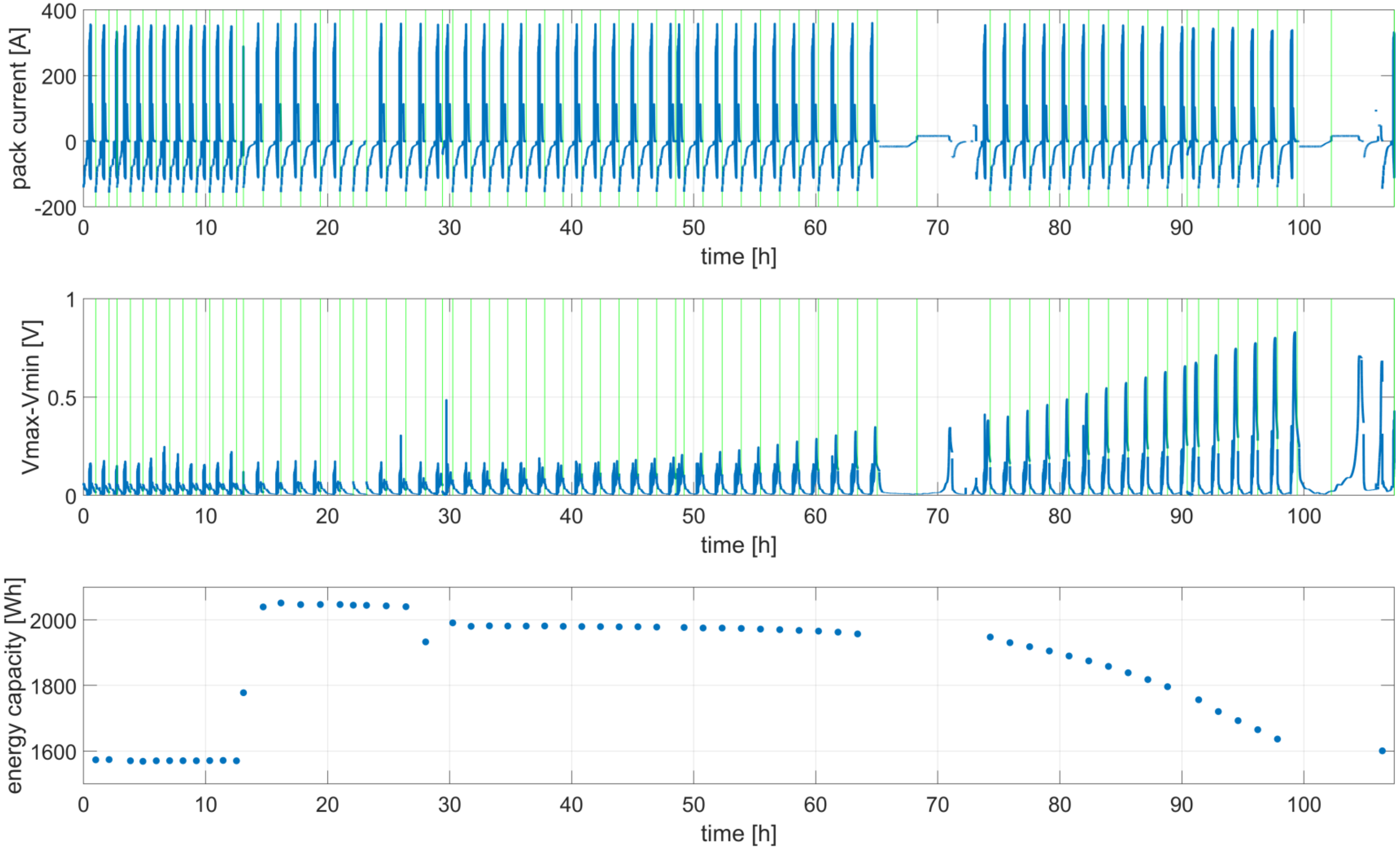


Fan for Module cooling

Pack terminals

Life Analysis

Conventional Battery Pack



Project 2: HBO

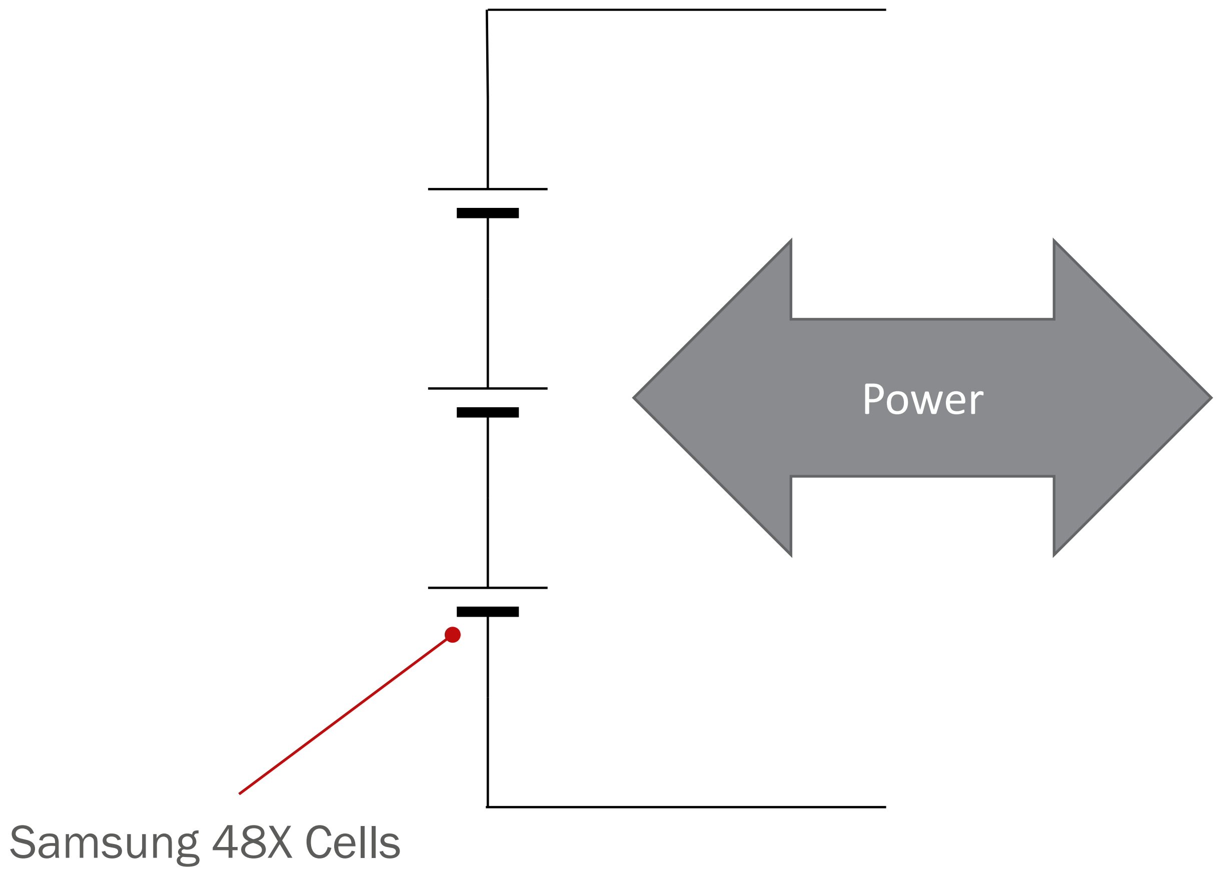
Hybrid Battery Optimisation

Goals

- Maximise the performance of an EV battery pack over its SoC range
- Main problem: battery packs are de-rated at low SoC
  - Lower SoC -> Lower voltages on cells
  - Lower voltages on cells -> high currents are required
  - Higher currents -> larger voltage drop on cells
  - Voltage drop on cells -> hit lower voltage limit sooner.

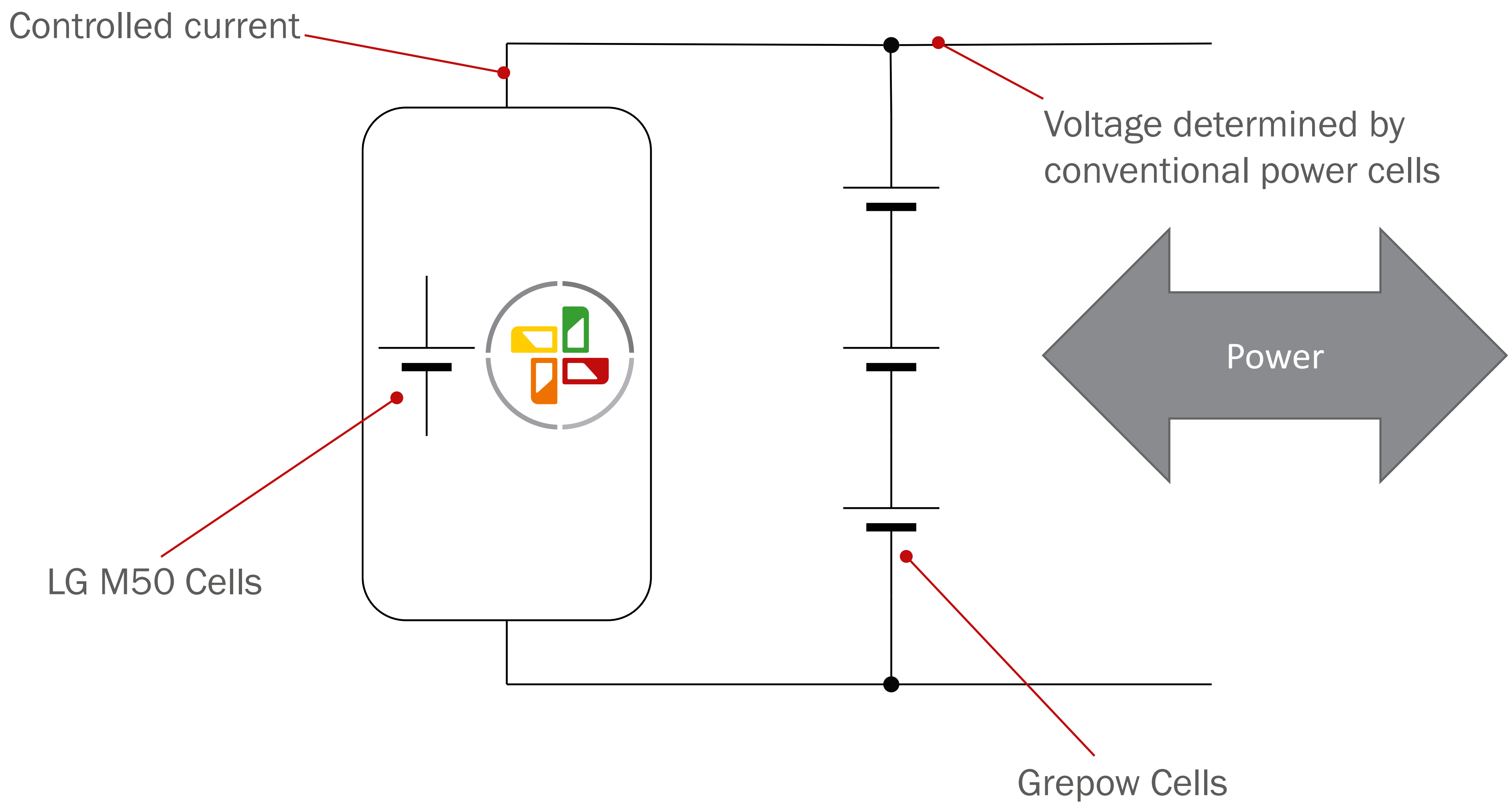
Hybrid Battery Optimisation

Conventional pack



BrillPower

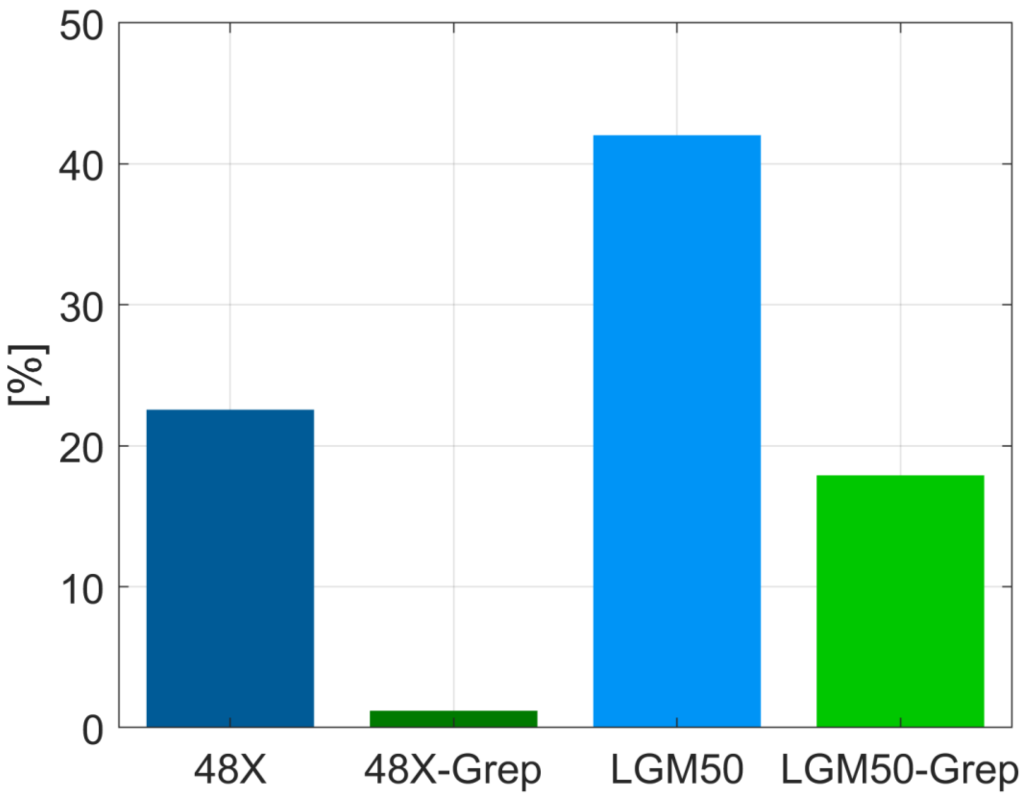
Hybrid Battery Pack



Hybrid packs can reduce the amount of derating

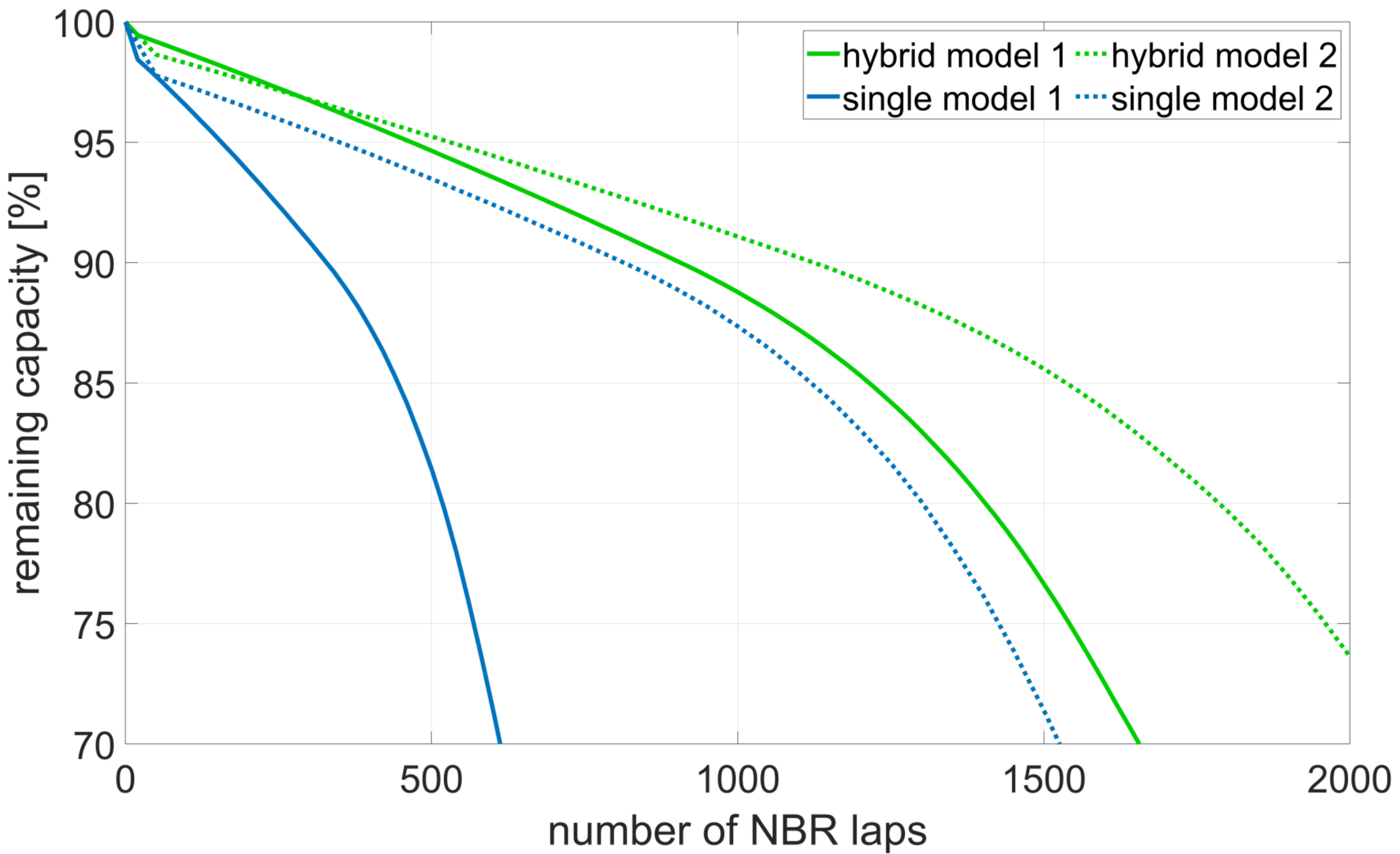
Hybridisation reduces average power de-rating in all cases.

A 55kW LGM50-Grepow hybrid system out-performs a single chem 55kW 48X system.



Estimated degradation

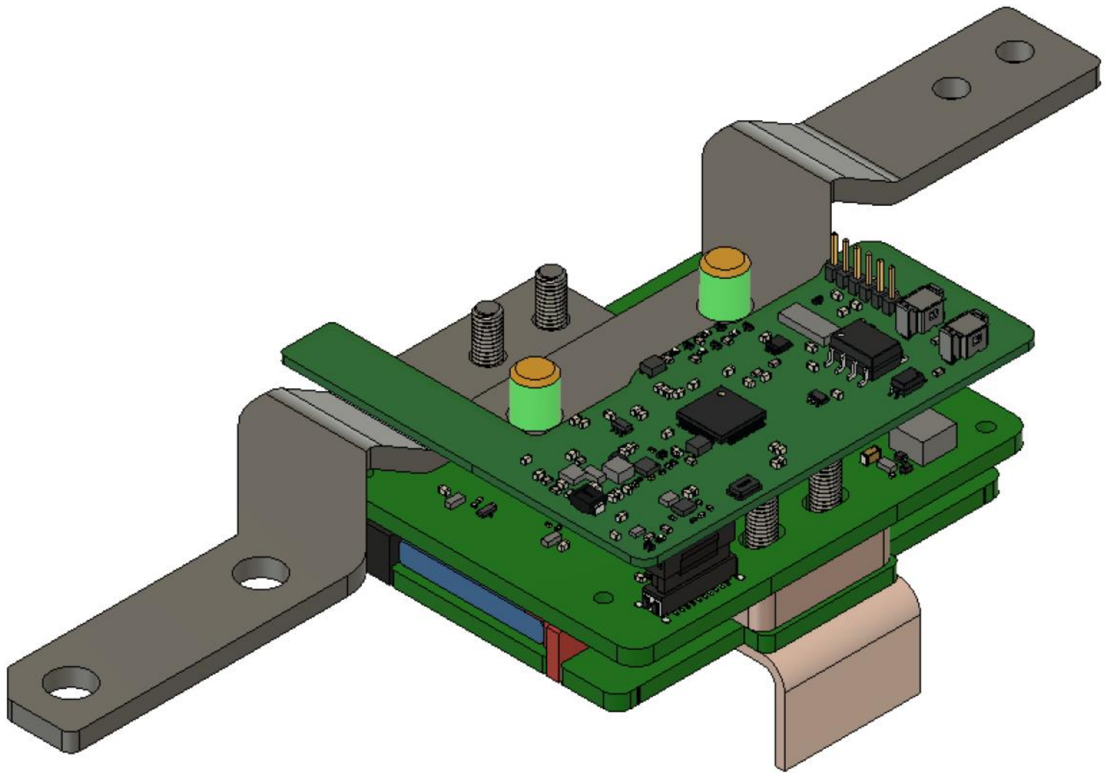
Estimation of the degradation of 48X cells in a single-chem pack vs 48X cells in a hybrid (48X – Grepow) according to two degradation models.



Hybrid Battery Optimisation

Pack Integration

- Take the learnings from the Pozibot Project and create a more integrated design
- Liquid cooled electronics
  - Cooling circuit integrated with cells
- Electronics more integrated into the pack
- Vertical stack-up for manufacturability



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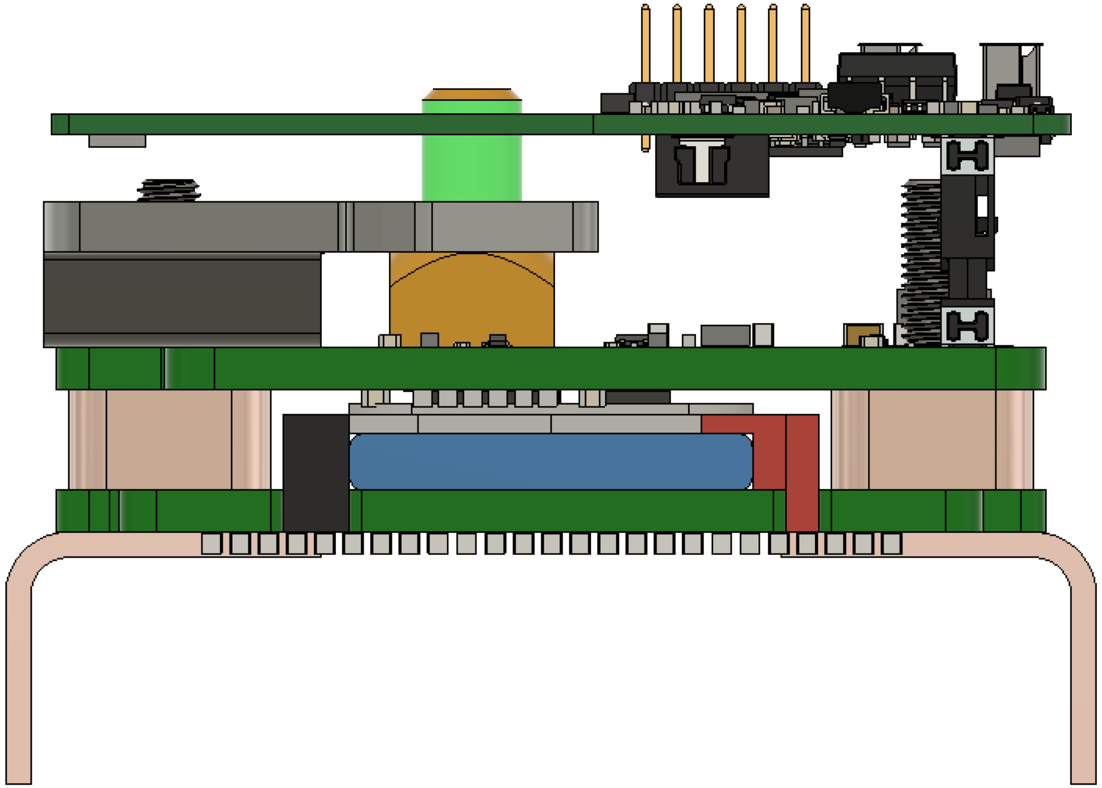

Hybrid Battery Optimisation

BrillPower

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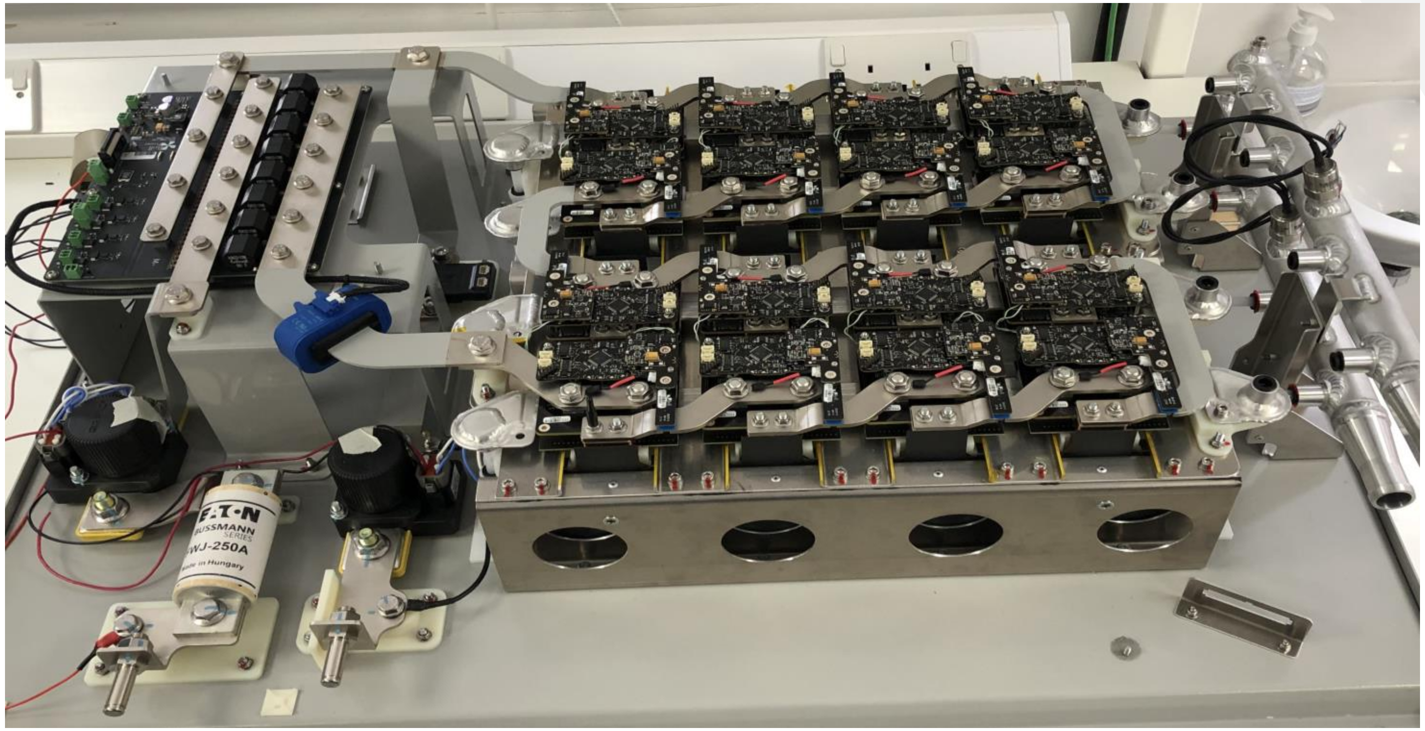
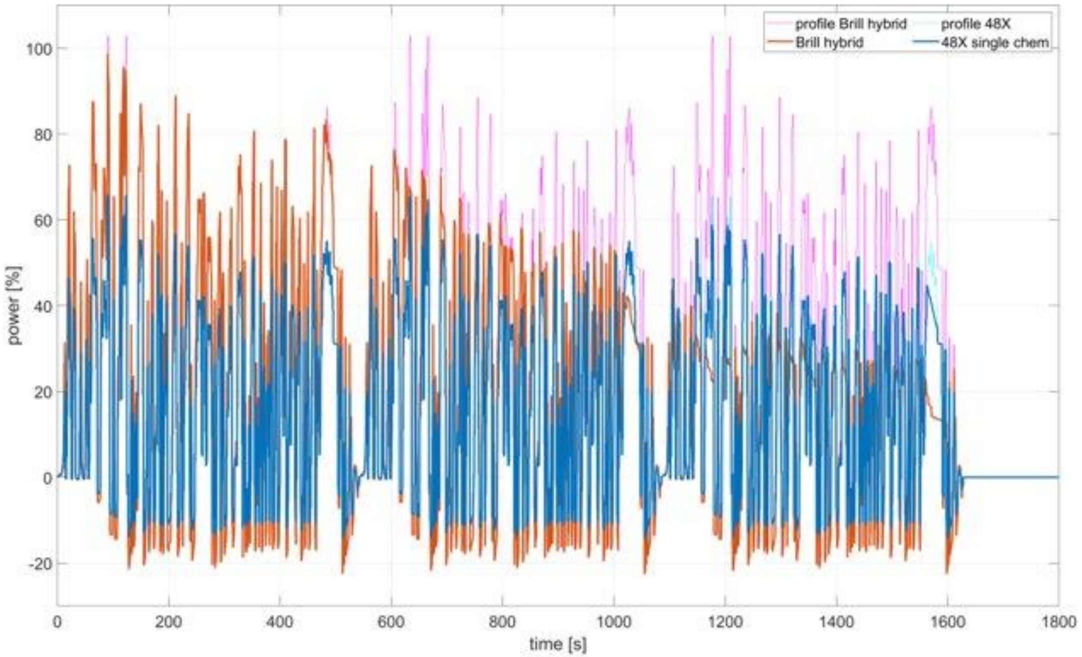
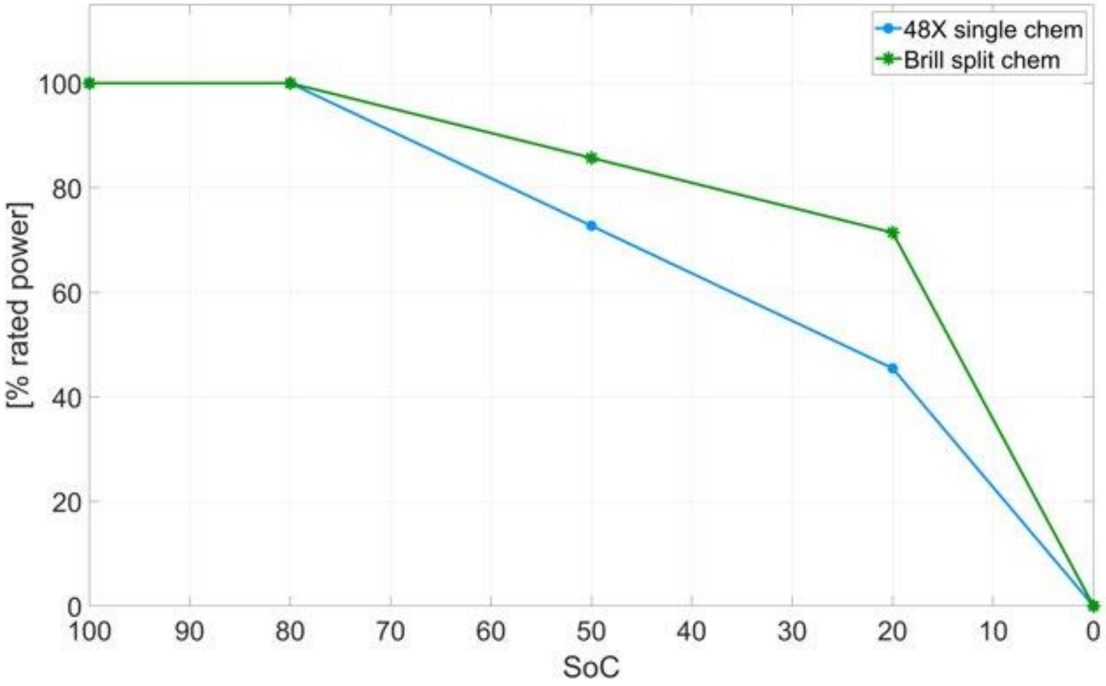


Hybrid Battery Optimisation

HESS Performance Testing





- Hybridisation allows packs to keep delivering high powers even at low state of charge.
- System design and testing were subject to constraints on component availability and development/test time. Removing these constraints, the performance of the hybrid system can be significantly improved.

Conclusions

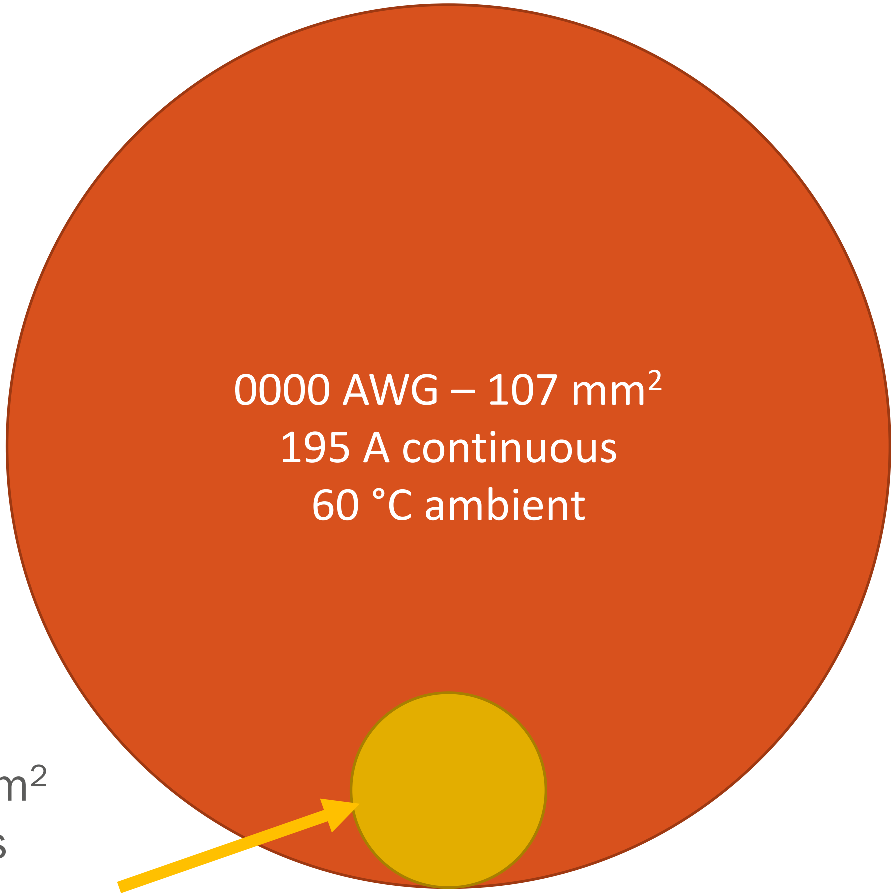
- City driving
  - Hybrid packs not advantageous
  - No high performance needed
  - lower efficiency reduces range
- Premium EVs & highway driving
  - Low-end single-chem battery packs do not have enough power
  - High-end single-chem battery packs have to derate peaks due to low SoC but can meet demand
  - Hybrid packs can meet power pulses longer, but reduced range
- Conclusion:
  - Hybrids not useful for low-end use
  - Hybrids can improve acceleration at mid-SoC
  - Hybrids can be good cost-compromise to use cheaper cells while getting similar performance
  - Keep an eye on efficiency or range is compromised
    - Could use high-end 48X-Grepow hybrid but then the cost advantage goes away

Future of Automotive

Current

You need a lot

- EVs require a lot of current
  - BMW i3
    - 125 kW peak
    - 350 V Battery pack
    - **357 A**
  - Tesla Model S
    - 750 kW peak
    - 407 V Battery pack
    - **1,843 A**
      - Ouch
- Solutions?
  - $V=I^2R$
    - Make V bigger



Current

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- EVs require a lot of current
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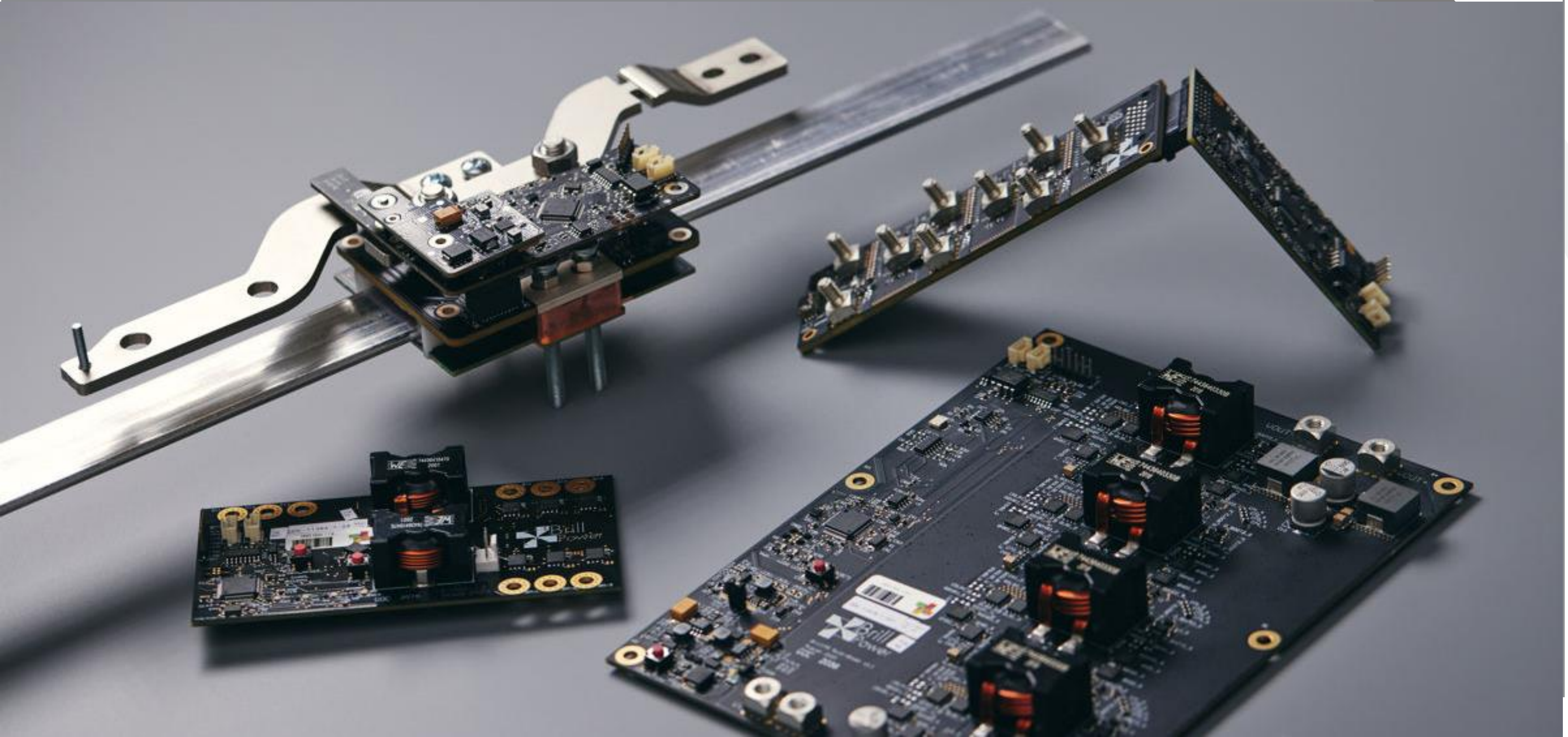
      - Ouch
- Solutions?
  - $V=I^2R$
    - Make V bigger
- Challenges with existing infrastructure

560 kW peak; 800 V Battery pack; 700 A

Distributed Power Electronics?

Will distributed power electronics be main stream?



Interesting Resources

BrillPower

Tear down videos of vehicles

- Weber Auto
  - https://www.youtube.com/@WeberAuto

- Munro Live
  - https://www.youtube.com/c/MunroLive

BrillPower

Thank you!

Get in touch: damien.frost@brillpower.com

Industry 4.0, Drive and Fly by Wire: Towards Connected Autonomous Vehicles Technology for Future Smart Cities Applications

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Professor AC in Intelligent Mechatronics Engineering and Digital Technology
Principal Investigator
Editor-In-Chief of International Journal of Robotics and Mechatronics
Website: http://ojs.unsysdigital.com/index.php/ijrm
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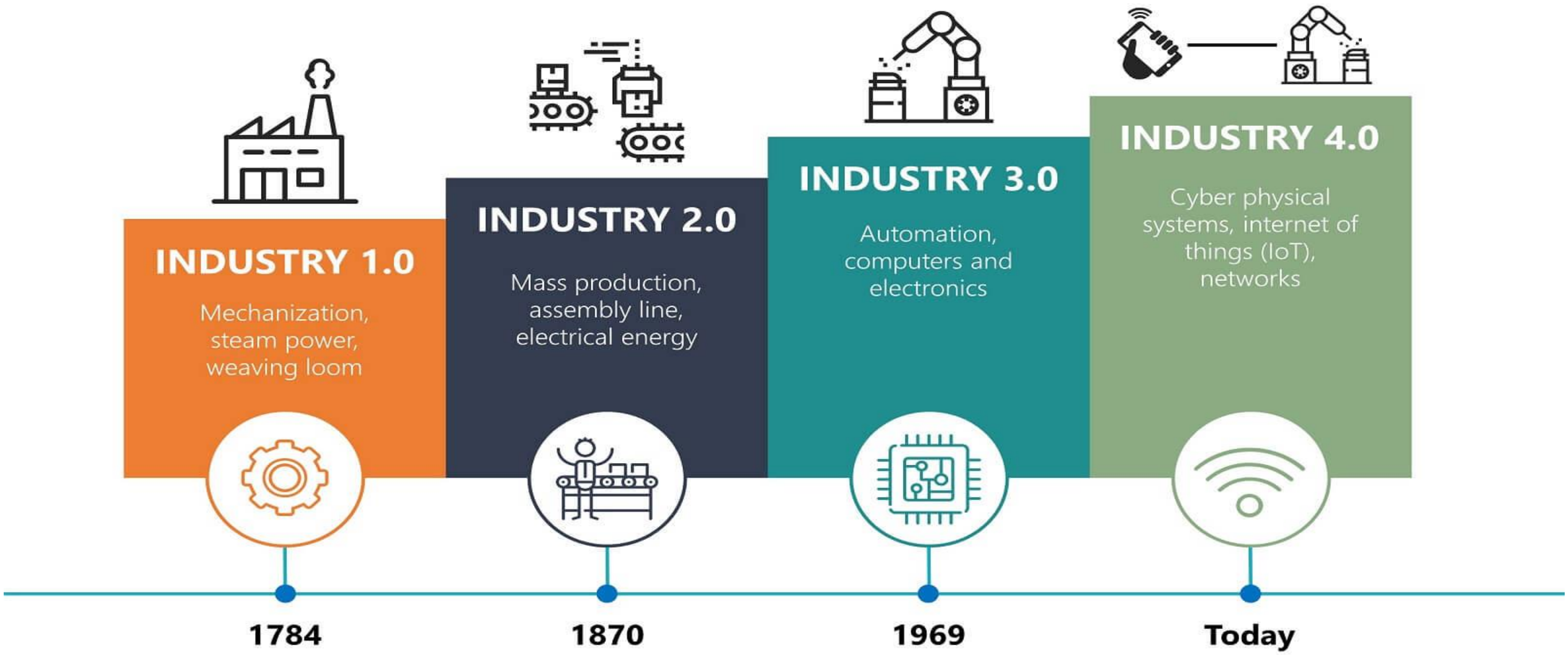
Overview

- **Introduction**
  - **Challenges and Barriers to SME's Growth!**
  - **Industry 4.0 & IoE & Big Data & 5G and AI!**
- **Drive and Fly by Wire**
  - **Safety, Reliability, and Battery Technology!**
- **Connected Vehicles**
  - **Autonomous and Hover Vehicles**
  - **Data Security and Cybersecurity!**
- **Snapshots of ongoing Research Programmes!**
- **Summary and Discussions!**

Challenges and Barriers to SME's Growth

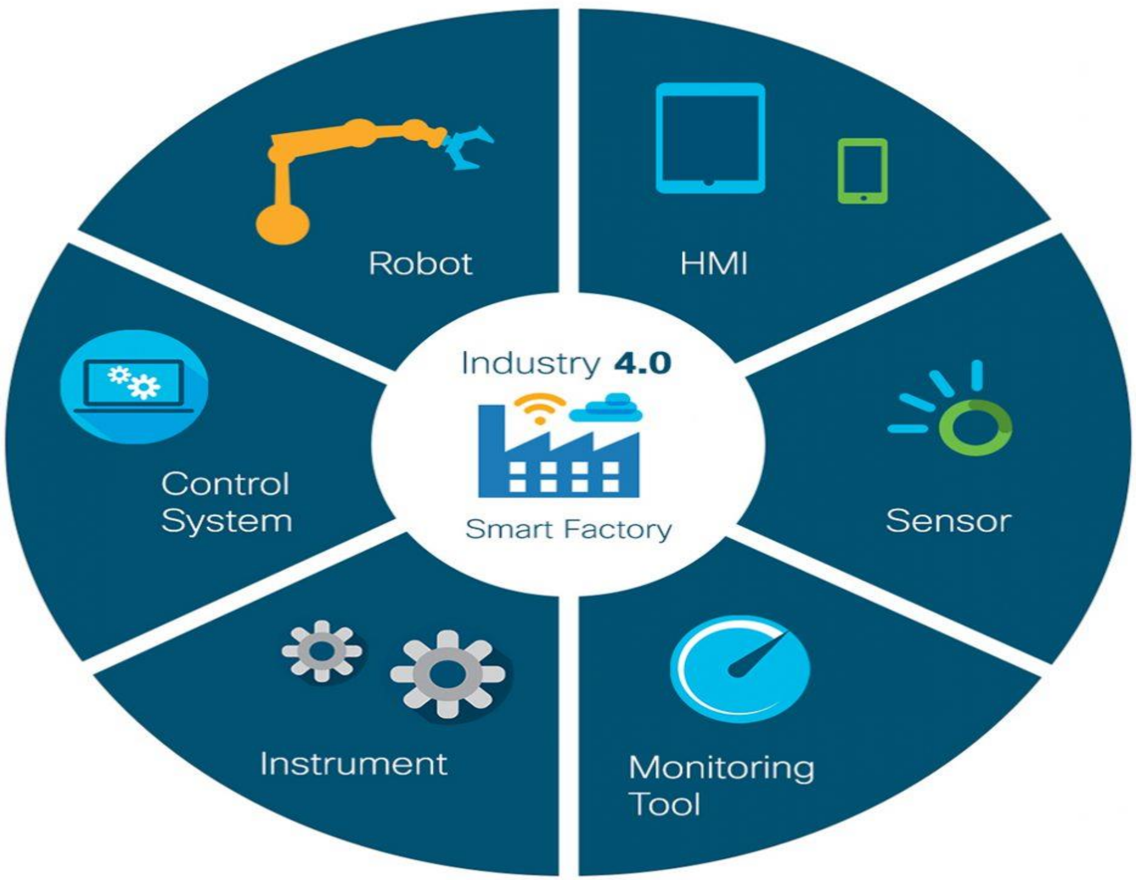
- Take Up of New Technologies
- Innovation and Knowledge Transfer
- Accessing Skills and Training
- Access to Finance
- Exporting
- Regulatory Issues
- Energy Cost and Security of Supply!
- COVID-19
- … etc.

Industry 4.0



https://lvivity.com/what-is-industry-4-0

Industry 4.0



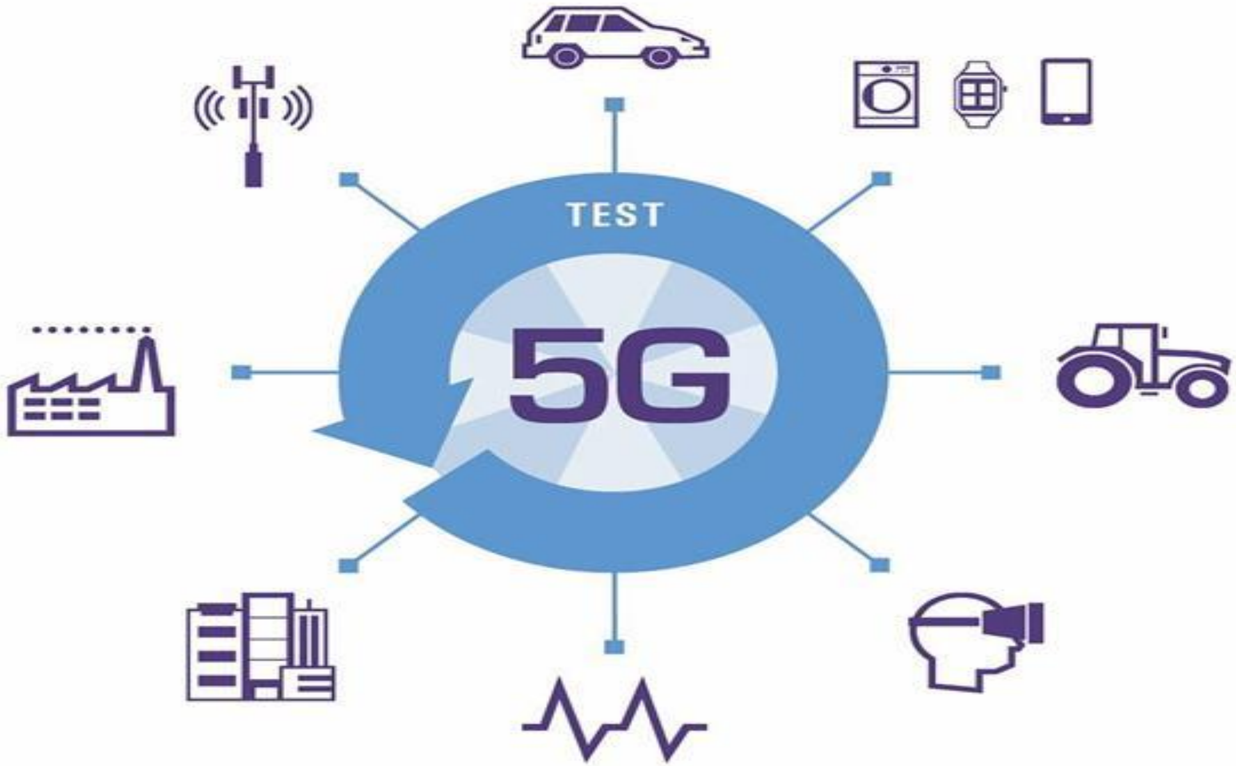
Smart Manufacturing!

Industry 4.0 Revolution

Shifting our Thinking!!!

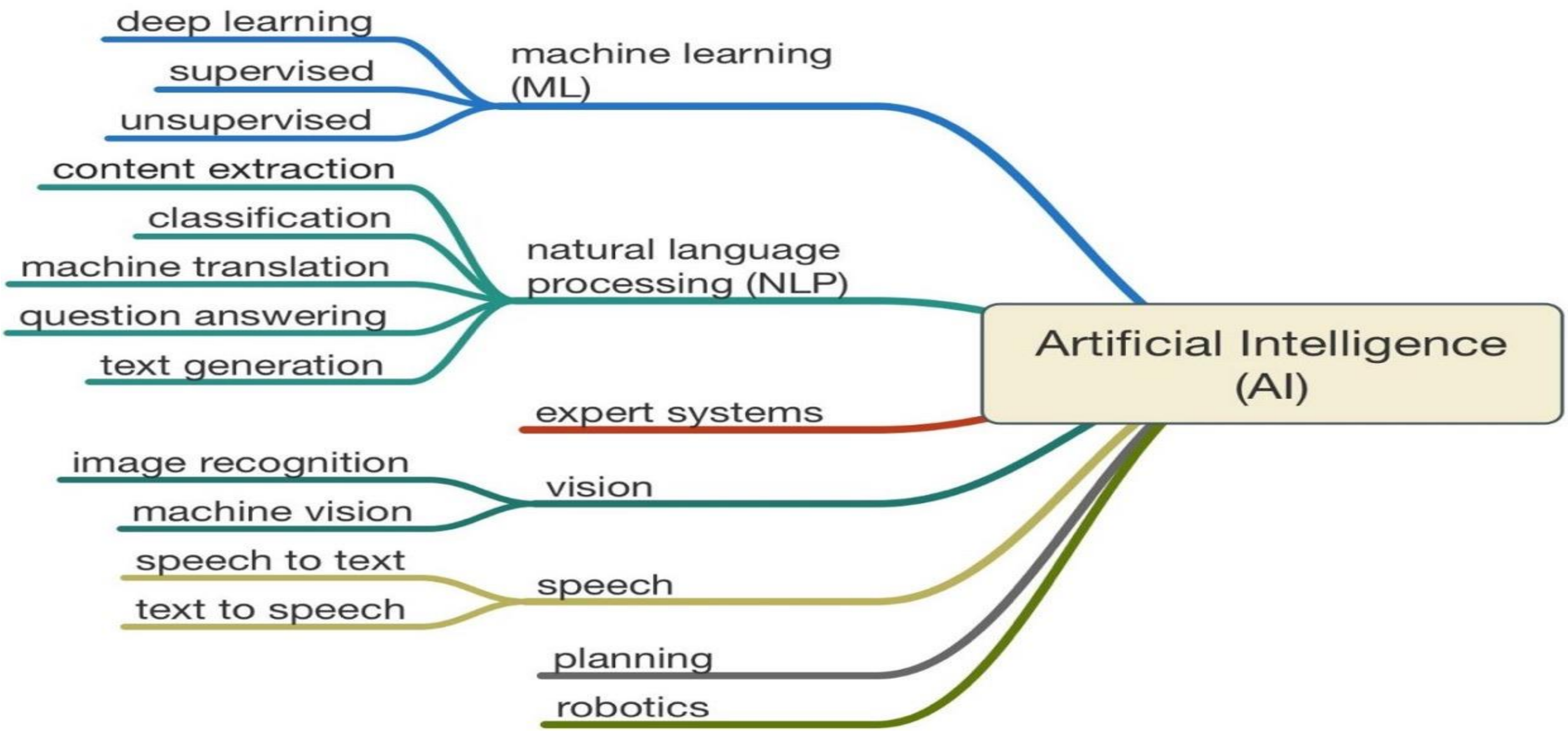
Transform Industry and Business into New Era!

Big Data & IoT & IoE & 5G & ICT and Beyond!



ICT Generation Helps to Transform Lives into Digital Era!

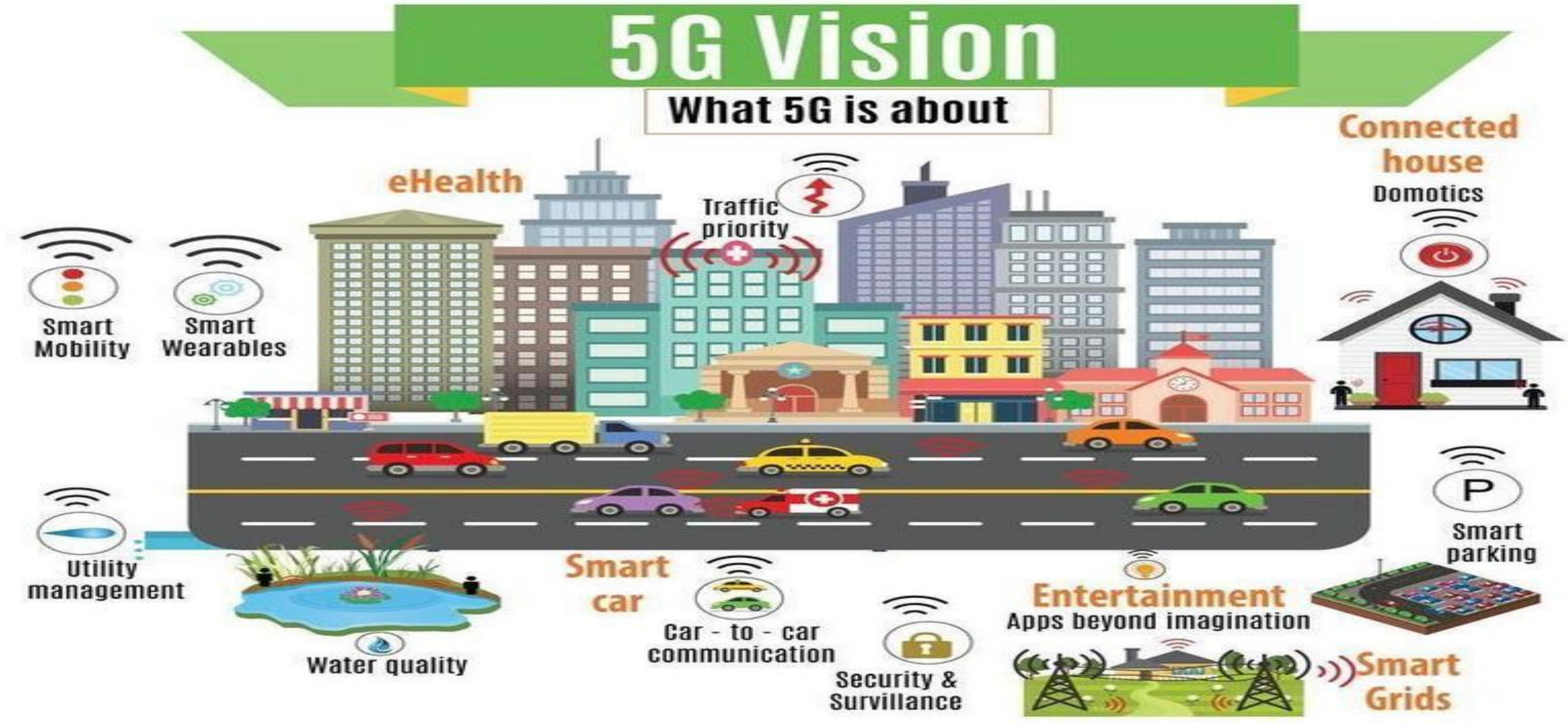
Artificial Intelligence!



Intelligent Systems and Self-learning Machinery!

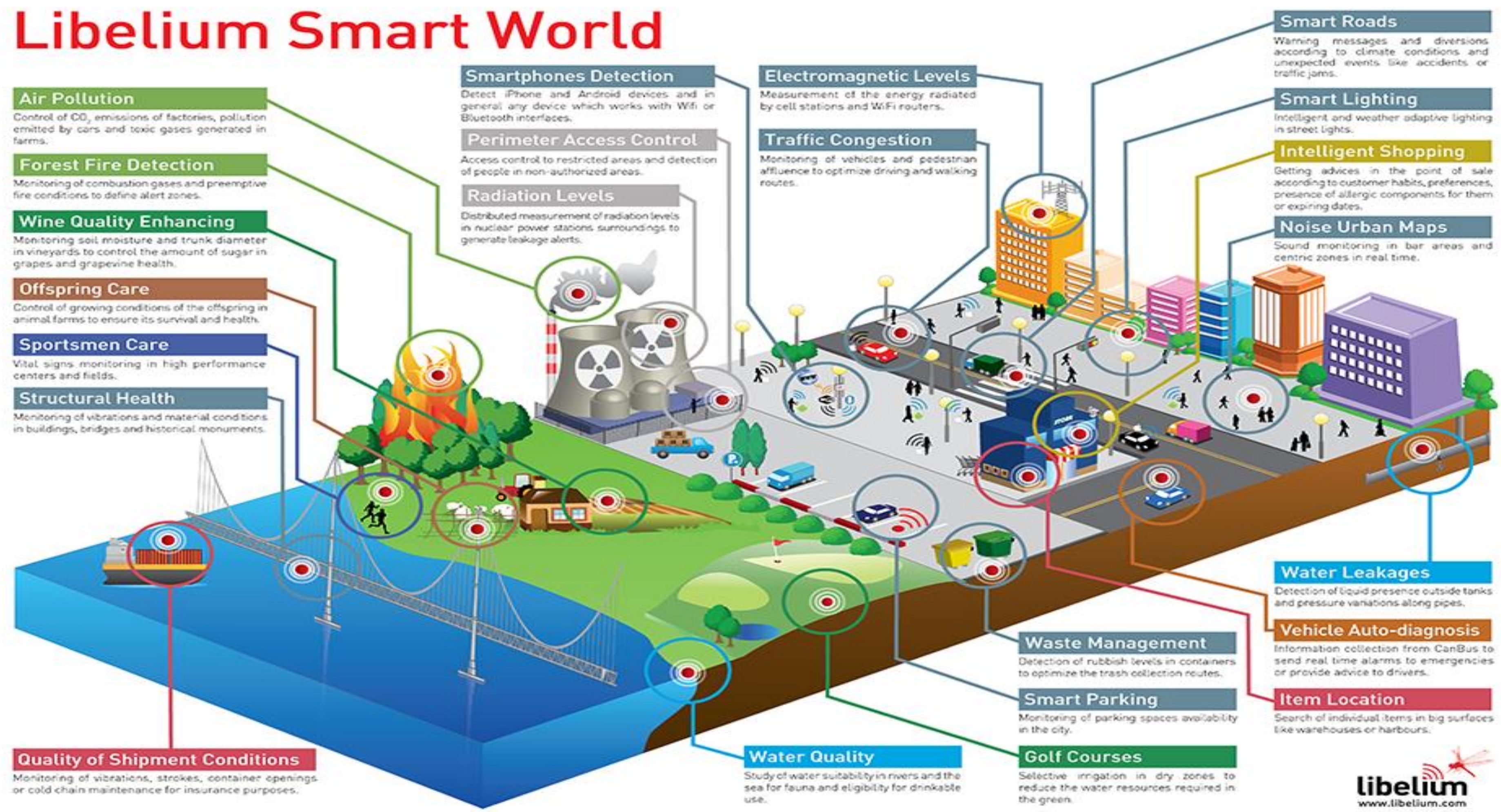
https://wiredelta.com/simple-guide-to-machine-learning-and-ai/

Industry 4.0, 5G and Beyond!



Transform Lives into Digital Era - Connected Devices & Self-learning Machinery!

Industry 4.0, 5G and Beyond!



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•https://www.libelium.com/libeliumworld/top_50_iot_sensor_applications_ranking/

Sensitivity: Internal

Drive and Fly by Wire:

Towards Connected Autonomous Vehicles Technology for Future Smart Cities Applications

Drive and Fly by Wire: Electric and Autonomous Vehicles!

The global market of drive by wire was valued at USD 23.99 billion in 2020 and is projected to reach USD 37.66 billion by 2028, growing at a compound annual growth rate (CAGR) of 5.8% from 2022 to 2031.

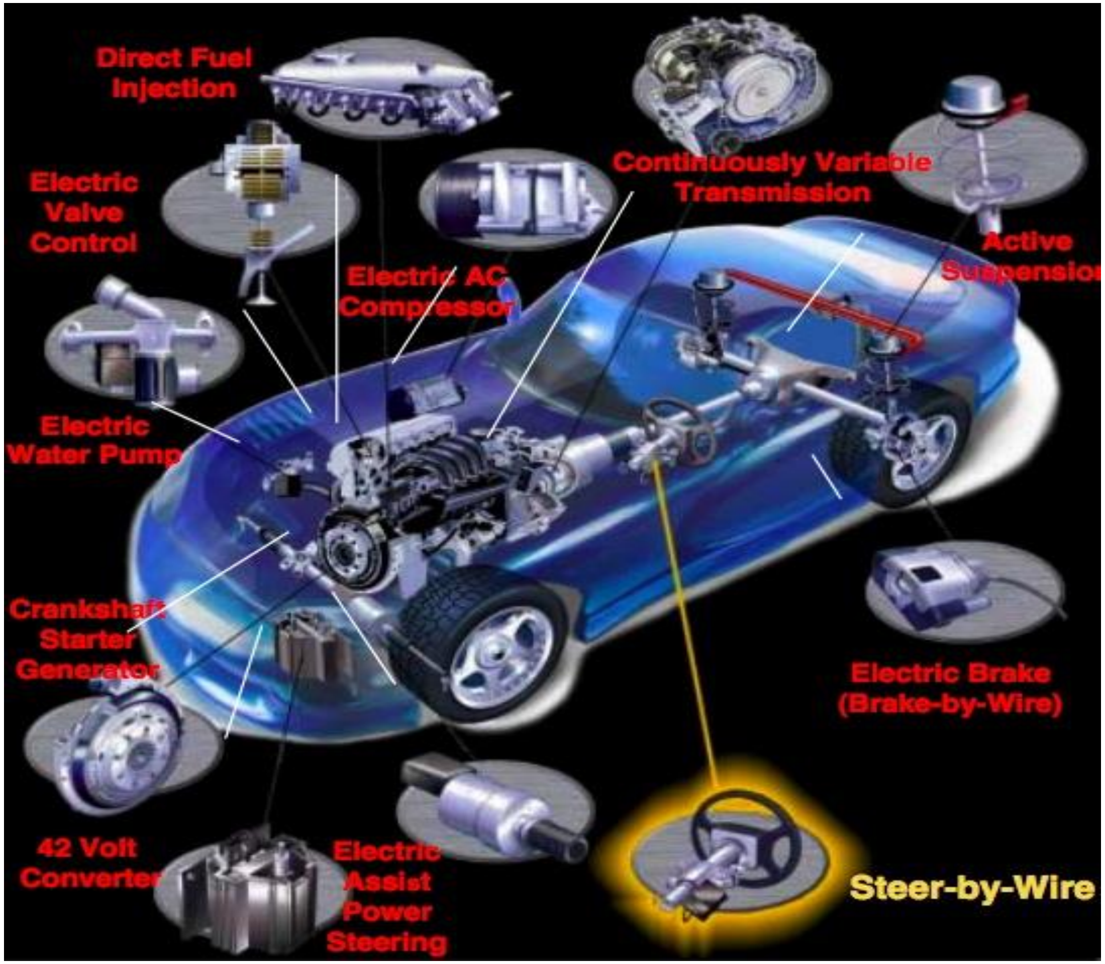
Global Market Drive by Wire 2021 – 2028!

Drive and Fly by Wire: Electric and Autonomous Vehicles!

Typical Applications:

- Steer-By-Wire
- Brake-by-Wire
- Park-by-wire
- Integrated vehicle dynamics
- Cam-less engines
- Integrated starter alternator

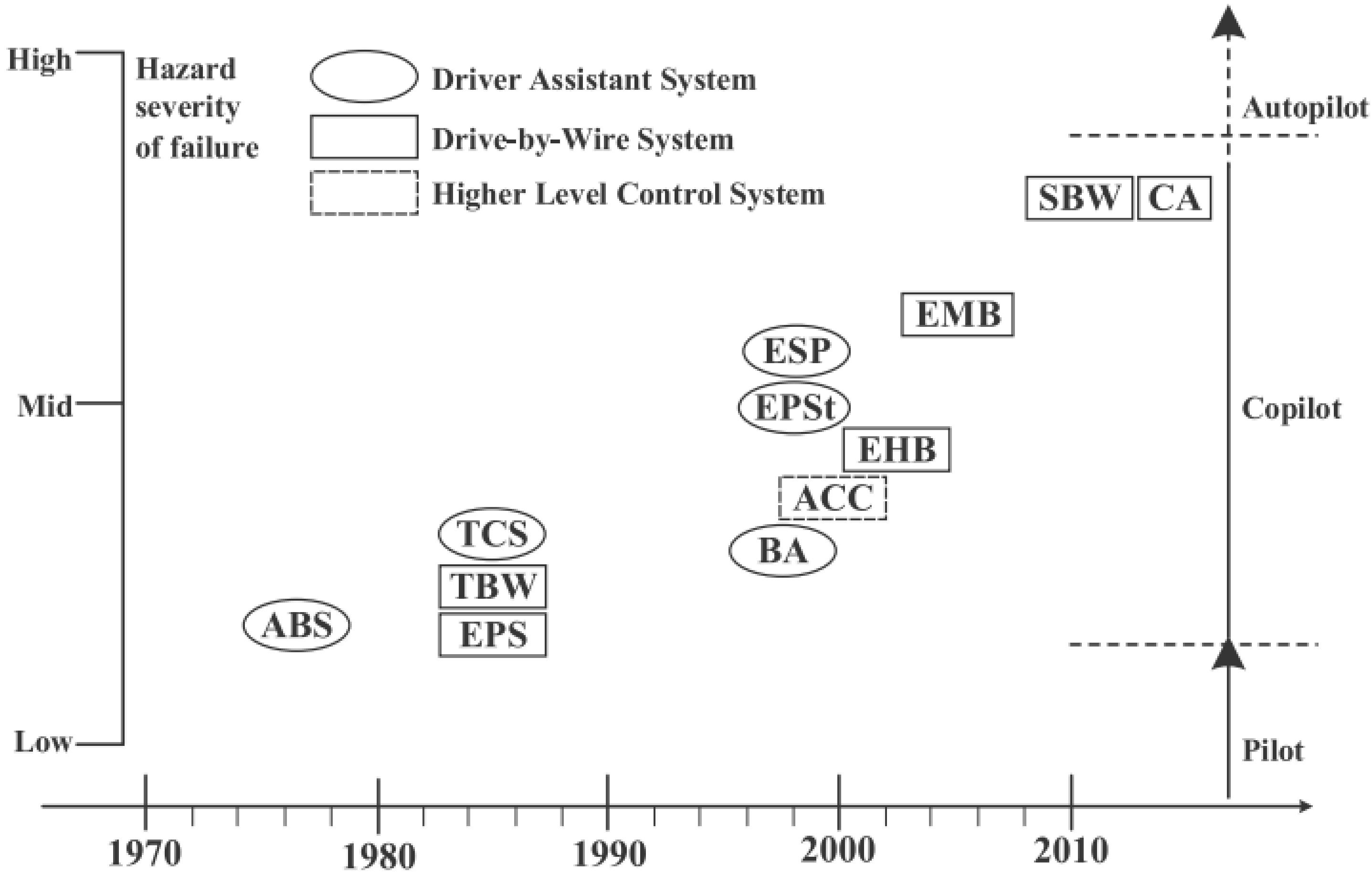
…etc.



OEM Driven:

- Advanced safety features
- Reliability
- Fuel economy
- Manufacturing flexibility
- Design freedom
- Cost
- …etc.

Steer and Fly by Wire: Electric and Autonomous Vehicles!



https://www.sciencedirect.com/science/article/pii/S0951832019305034

ABS	Antilock Braking System	TBW	Throttle By Wire
TCS	Tacktion Control System	EPS	Electropneumatic Shifting
ESP	Electronic Stability Program	EHB	Electrohydraulic Brake System
ESPt	Electrical Power Steering	EMB	Electromechanical Brake System
BA	Brake Assistance	SBW	Steer By Wire
ACC	Adaptive Cruise Control	CA	Collision Avoidance

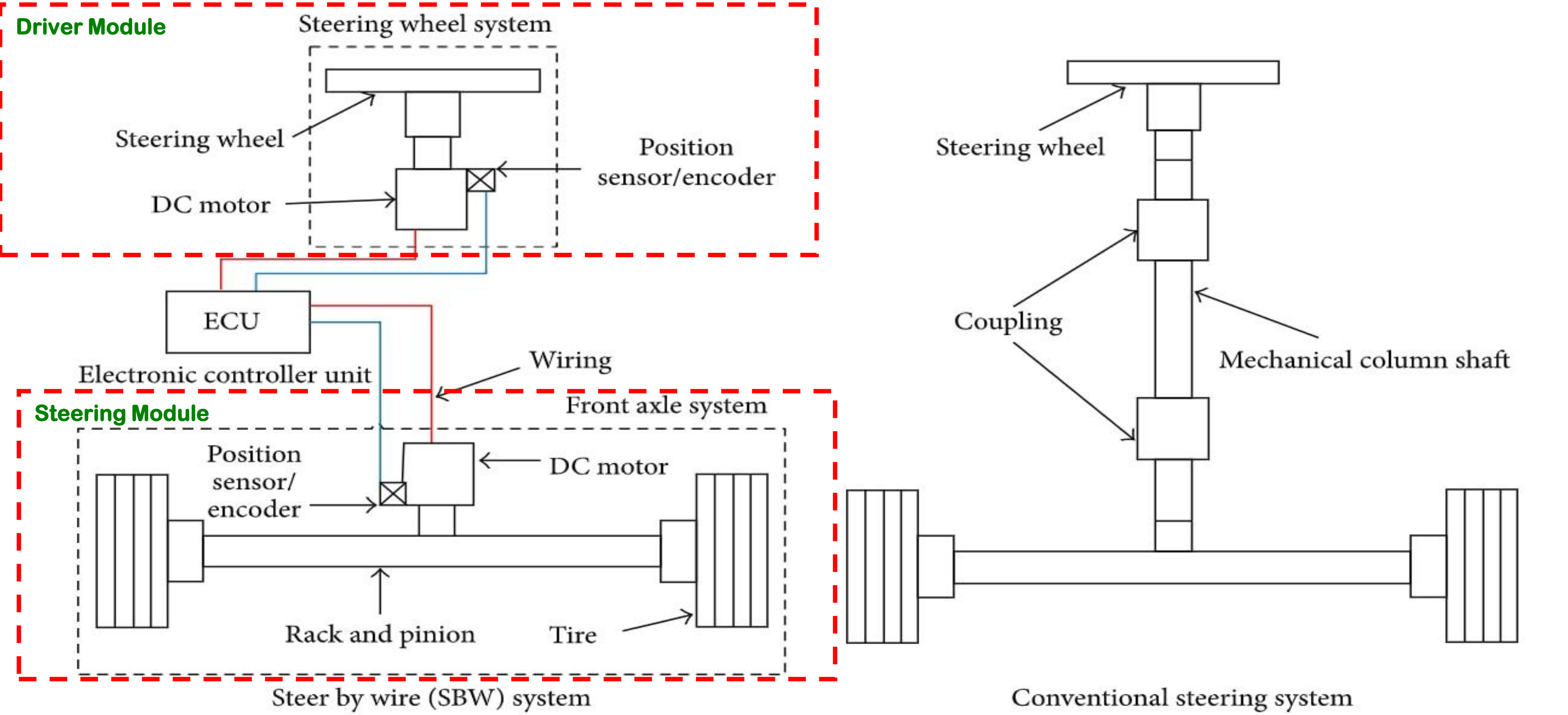
Steer and Fly by Wire: Electric and Autonomous Vehicles!

High Integrity Actuation with Embedded Intelligence for Steer-by-Wire!

Programme was aiming to:

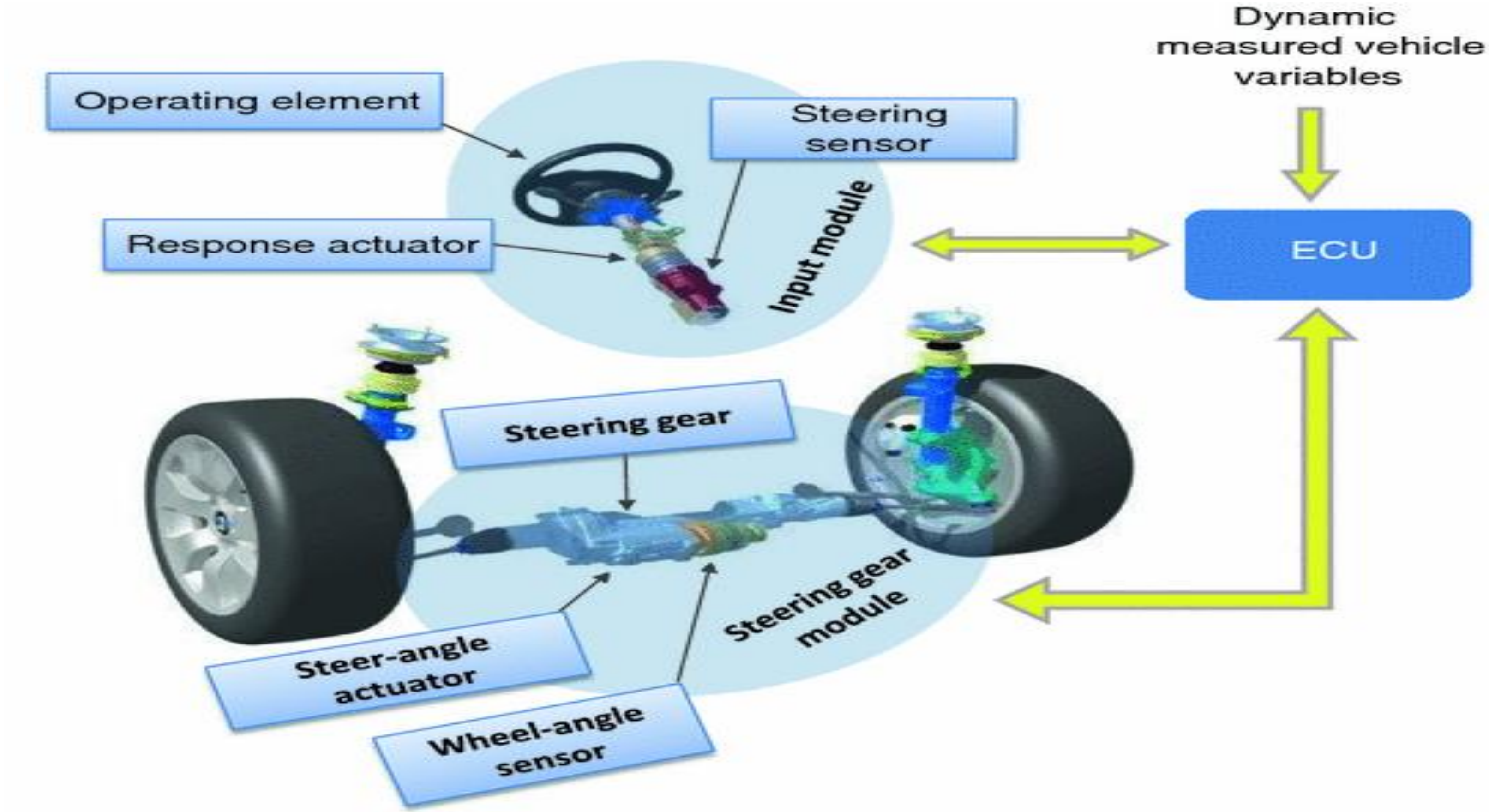
develop a fault-tolerance actuation system to meet the key safety requirements, and at the same time improve the reliability at reduced cost!

Steer and Fly by Wire: Electric and Autonomous Vehicles!



System Architecture of Steer – by - Wire for EV and AV Technology

Steer and Fly by Wire: Electric and Autonomous Vehicles!



System Architecture of Steer – by - Wire for EV and AV Technology

Steer and Fly by Wire: Electric and Autonomous Vehicles!

- Subsystem Level Vs. Component level
  - Advanced Safety Features
  - Reliability
  - Redundancy Level
  - ISO
  - Cost
  - … etc.

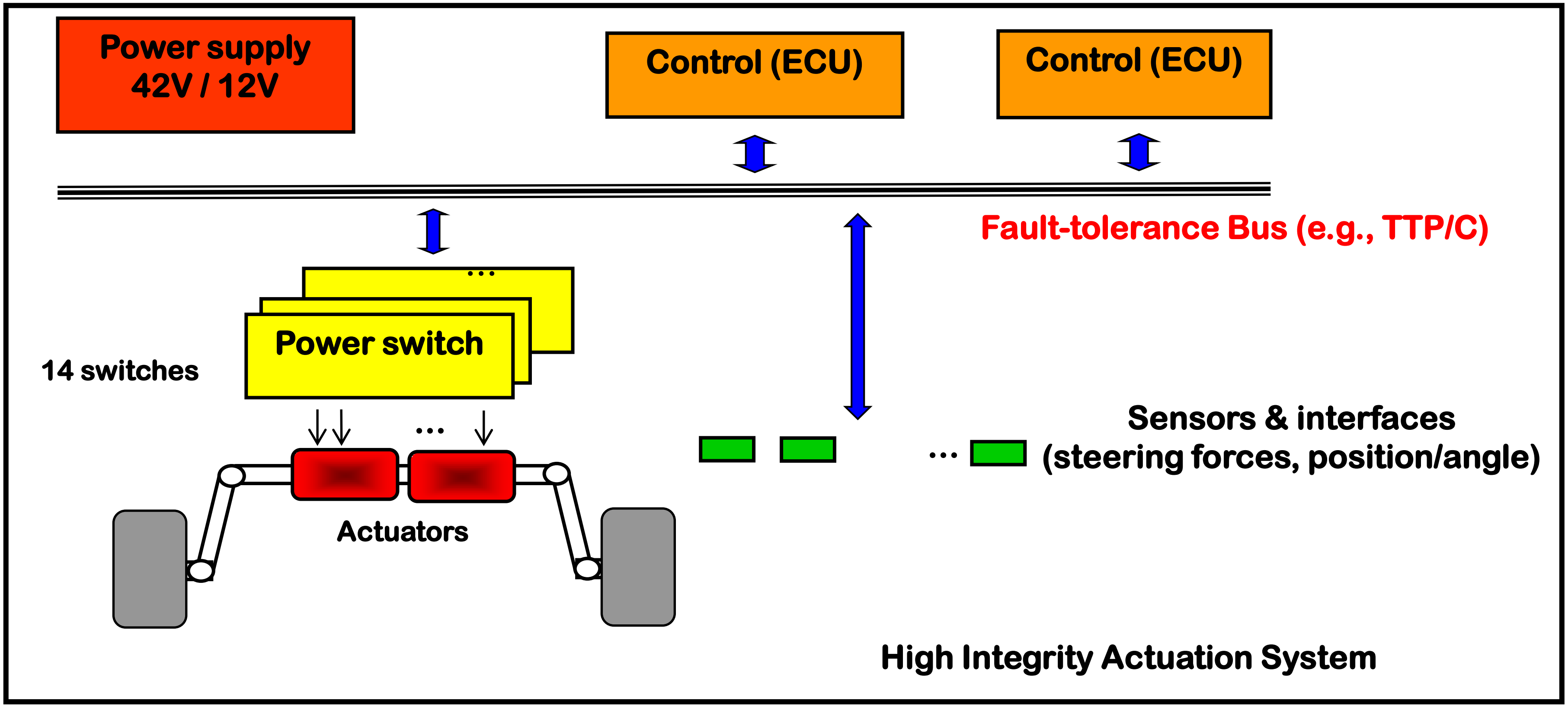
Steer and Fly by Wire: Electric and Autonomous Vehicles!

Programme key innovation:

New power control configuration and integrated control method to enable the independent control of individual motor phases so that remaining phases will not be affected if any one (or more) phase fails to function (e.g., due to failure of power switch, motor winding … etc)

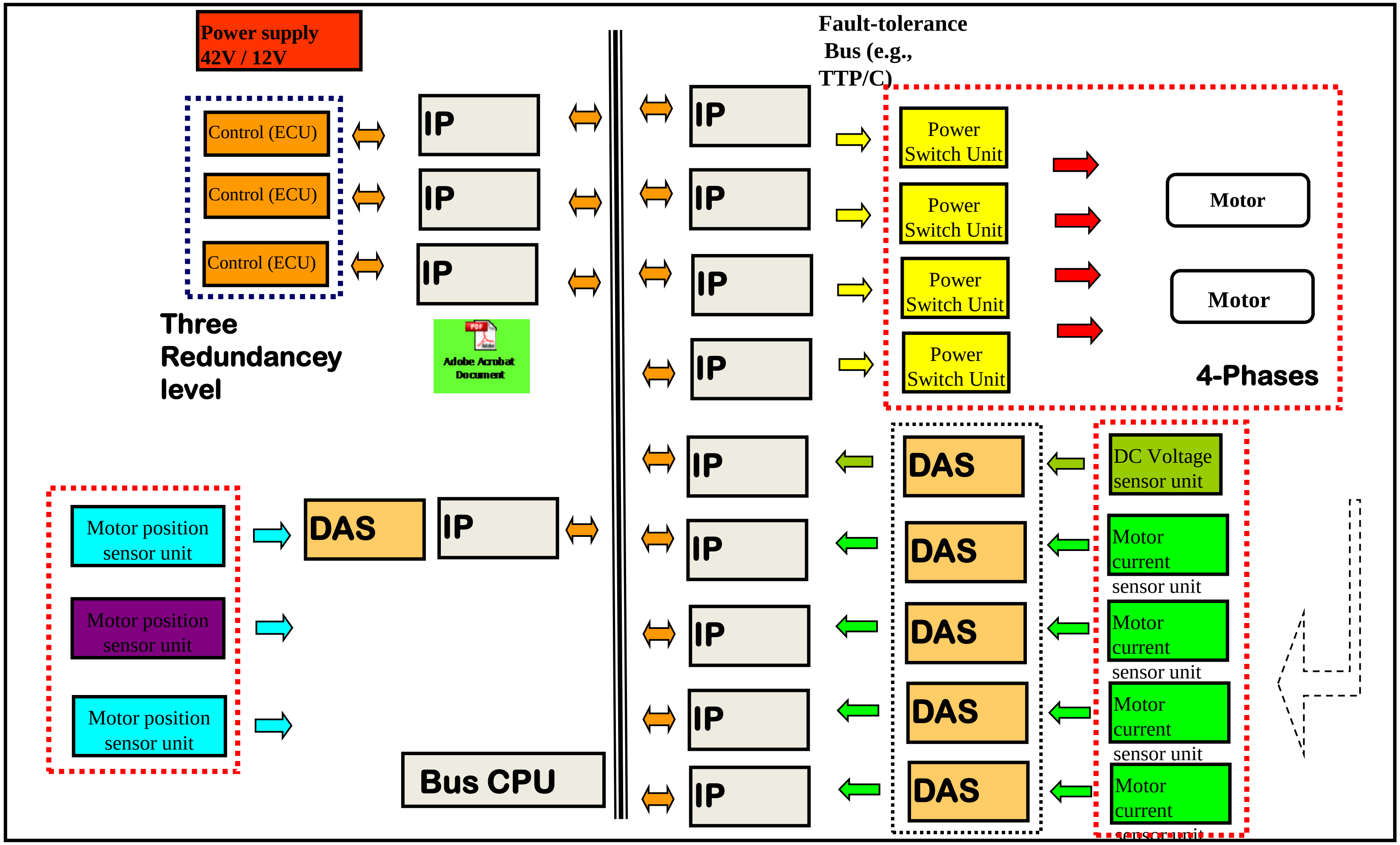
A robust and effective method to detect critical faults in the system, taking full advantage of the symmetrical structure of electrical motors.

Steer and Fly by Wire: Electric and Autonomous Vehicles!



System architecture showing the interface of each module to the TTP/C and actual road wheel Steer (X)-BY-Wire

Steer and Fly by Wire: Safety and Reliability



System architecture showing the interface of each module to the TTP/C and actual road wheel Steer (X)-BY-Wire

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Society of Automotive Engineers (SAE) Communication Classes

Three communication system classes

- Class A
  - System with low speed networks
  - Soft Real Time Systems
- Class B
  - System with high speed networks, but without safety-Critical requirements
- Class C
  - System with safety critical requirements $[125-200C^{o}]$
  - Hard real-time system!

Steer and Fly by Wire: Electric and Autonomous Vehicles!

- **Subsystem Level Vs. Component level**
  - Advanced Safety Features
  - Reliability
  - Redundancy Level
  - Cost … etc.
- **TTP/C Vs FlexRay Data Bus**
  - Data rate
  - Fault tolerant
  - Safety
  - Cost …etc.

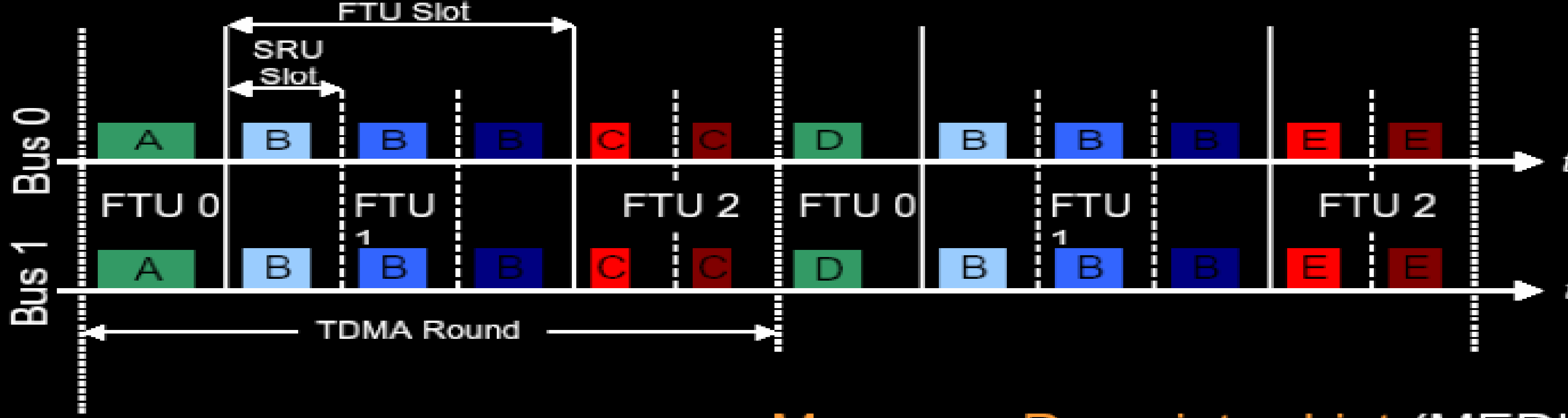
TTP – Principles and Mechanism

TTP/C –Time Triggered Protocol

- Developed by TTTech which was formed from University of Vienna
- TTP involves a **continuous communication** of all connected nodes via **a redundant bus**
- Operates according to Time Division Multiple Access (**TDMA**) standard
- Each node connected has a **pre-allocated time slot** that is used to send a message on the bus.
- Each node consists of a **TTP/C controller**, **Controller Network Interface** and a **Host CPU**

TTP – Principles and Mechanism

Time Division Multiple Access
- Fixed assignment of slots to nodes
- Every node periodically



Message Descriptor List (MEDL):
- Static data structure
- Message dispatching table
- FTU: Fault Tolerant Unit

Source: Motorola, 1999

TTP/C Message data static structure and message dispatching table

TTP – Principles and Mechanism

- **On the cluster level, node failures and communication failures can be masked by replicating the nodes and grouping them into Fault-Tolerant Units (FTUs)**
- **Message transmission is replicated in both the space domain, by using two buses, and the time domain, by sending the messages twice on each bus**
- **Each node is considered to fail silent!**
- **Features:**
  - **25 Mbits/Sec per channel**
  - **Redundancy**
  - **Safety and**
  - **Fault Tolerance!**

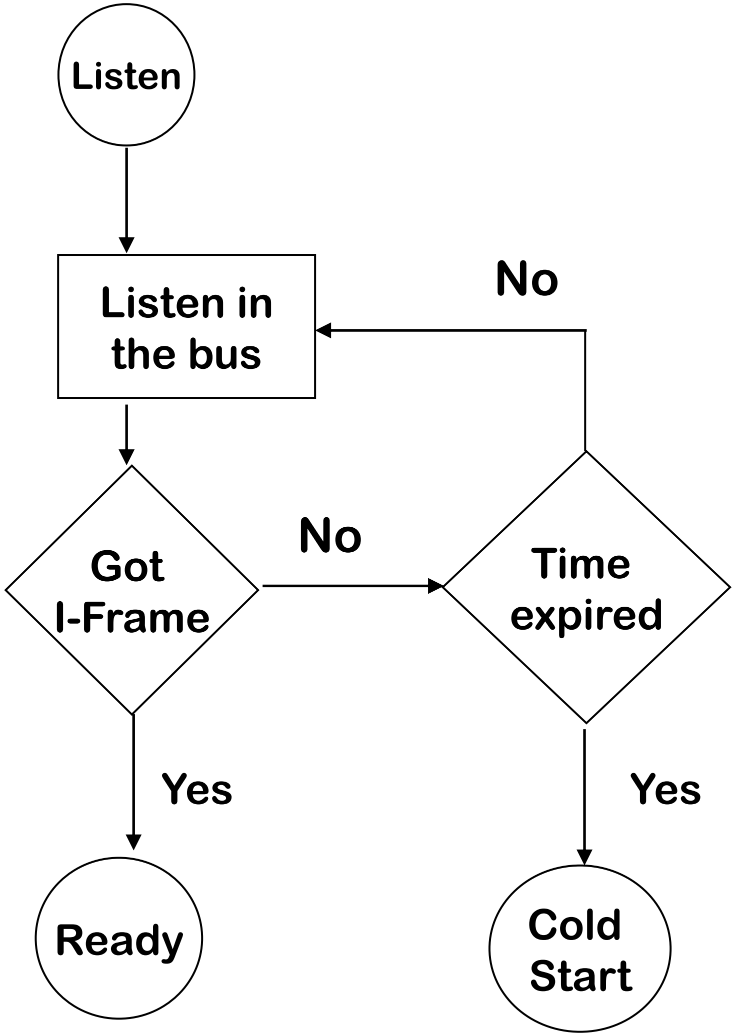
TTP IP Power Node

- **Communication Start-up**

How it all begins…..

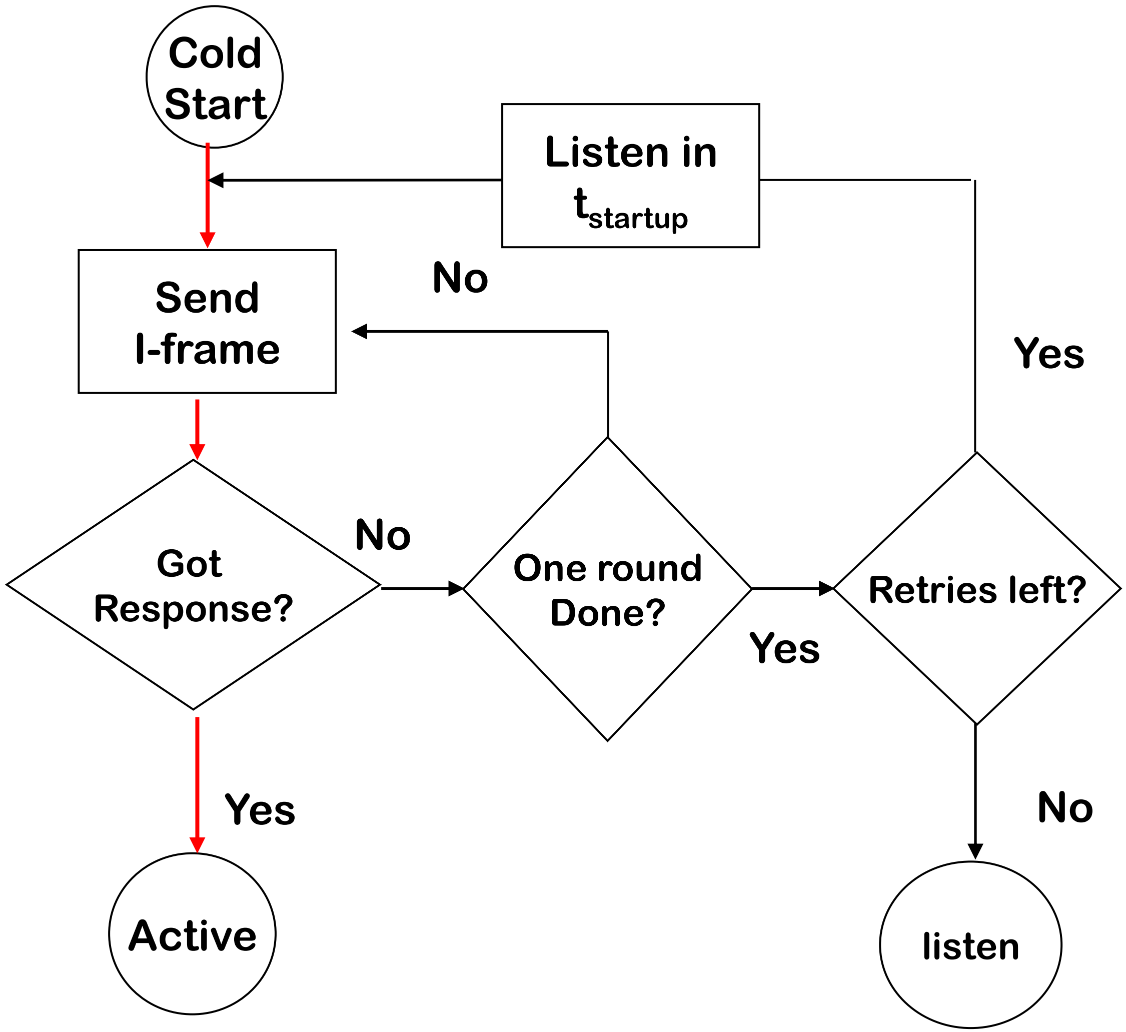
TTP IP Power Node

- **After initialisation, the controller starts to listen on the network to establish if there is any communication.**
- **If communication is available it integrates into network,**
- **if not it goes into “cold-start”**



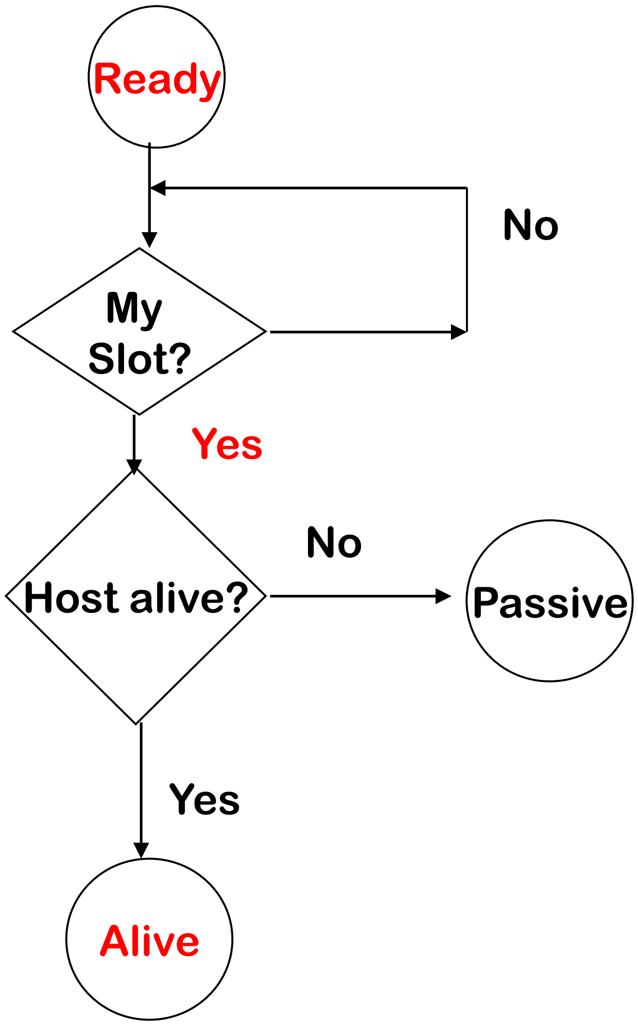
TTP IP Power Node

- In cold start controller sends an I-frame, then tries to receive a response for one TDMA round.
- If that fails, it retries until it either gets a response or runs out of tries.



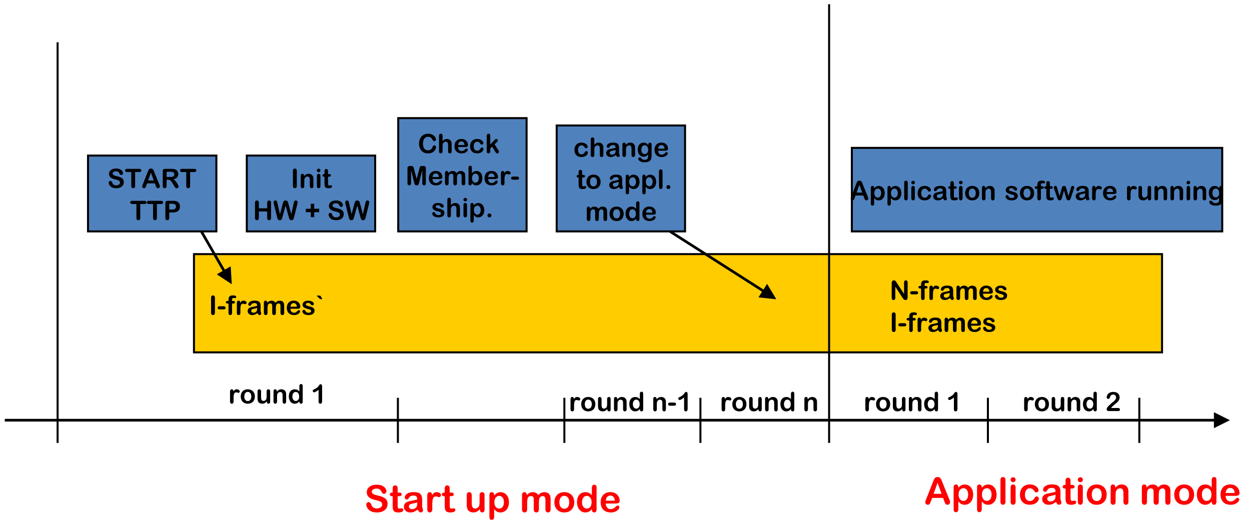
TTP IP Power Node

- Once a controller is ready, it waits for its next sending slot and
- if the host is alive, it becomes active.



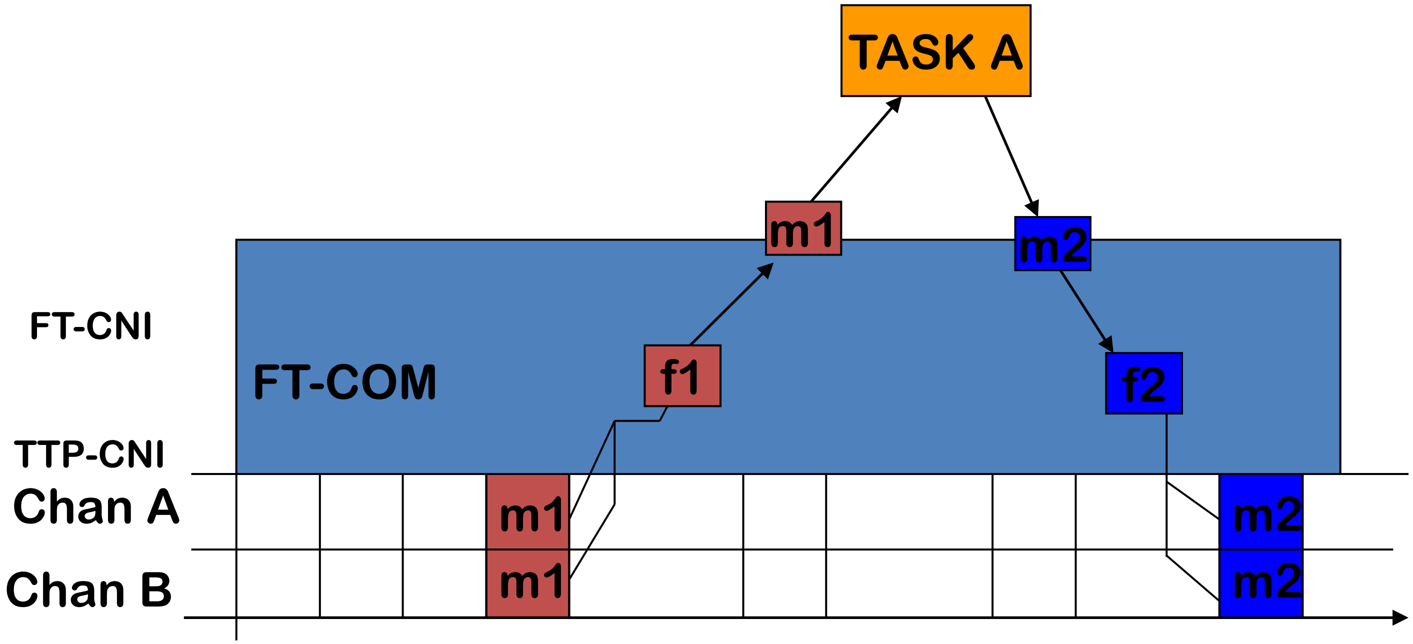
TTP IP Power Node

- **Start up mode: start-up of cluster communication and application SW**
- **Application mode: normal operation of cluster**

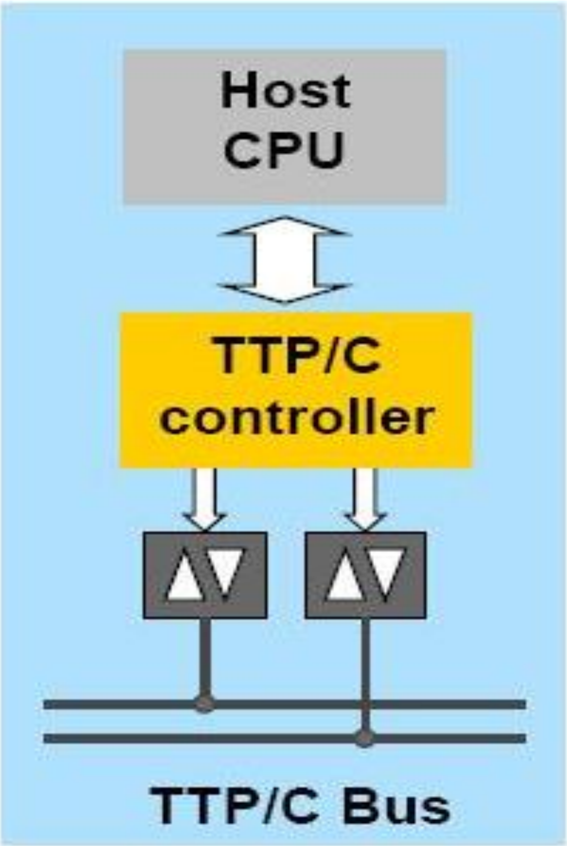


TTP IP Power Node

- **Message Transfer**



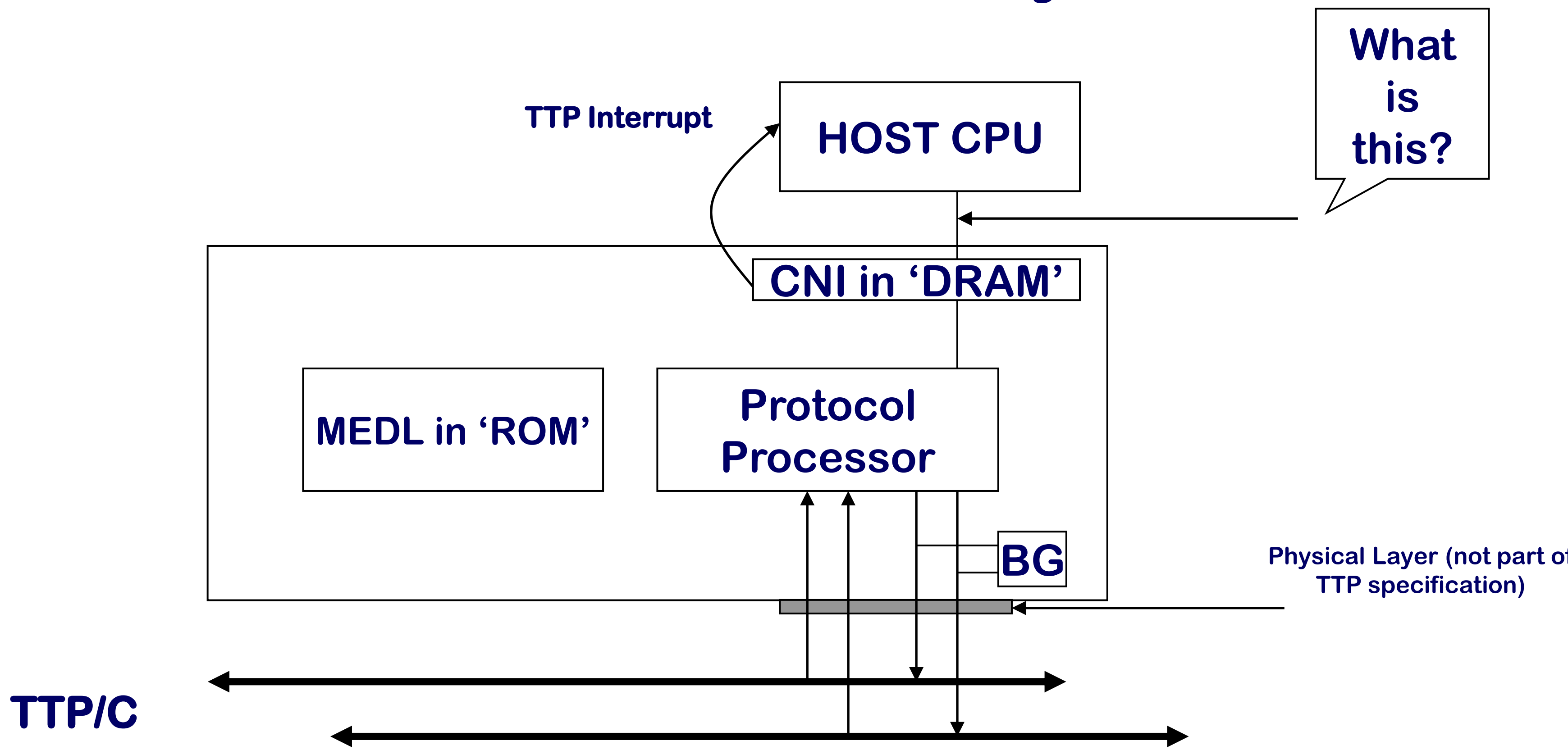
TTP Controller and Interface



TTP/C communication interface and TTP/C communication structure

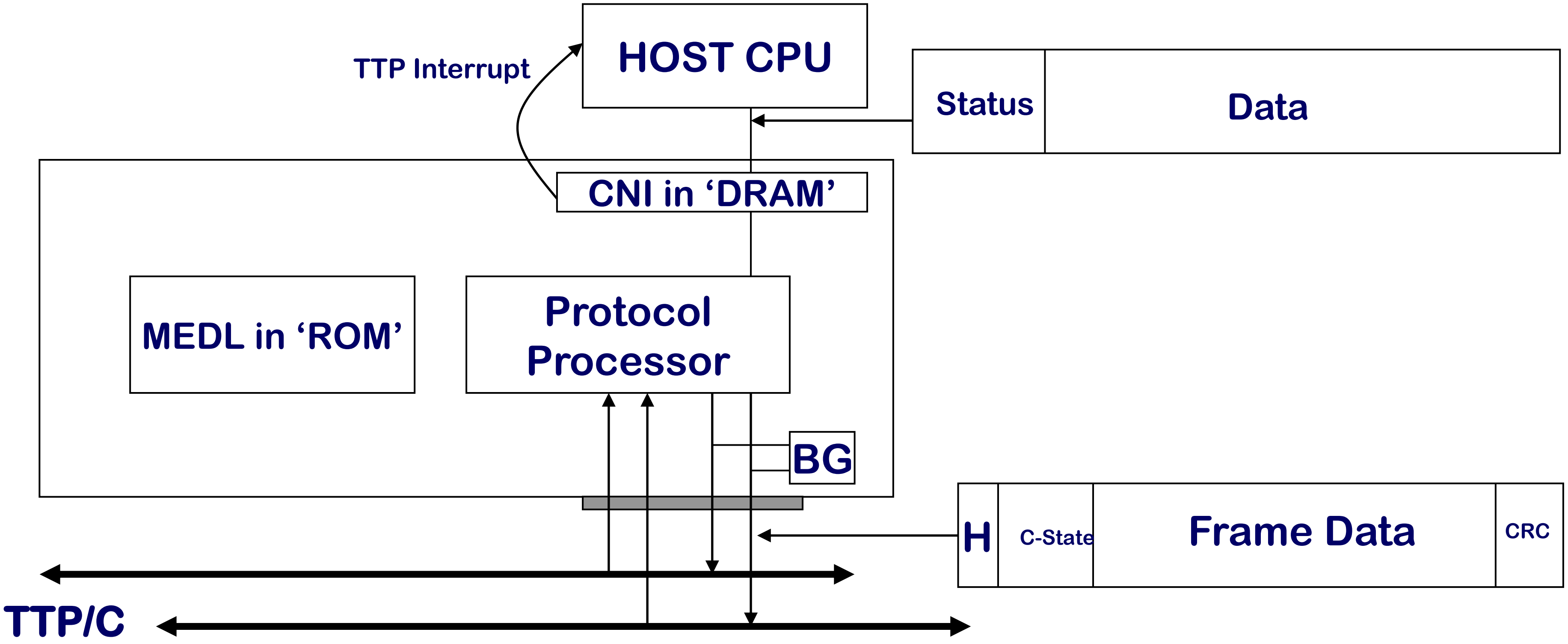
TTP Controller and Interface

- **TTP Controller – Schematic Layout**



MEDL – Message Description List
CNI – Communication Network Interface
BG – Bus Guardian

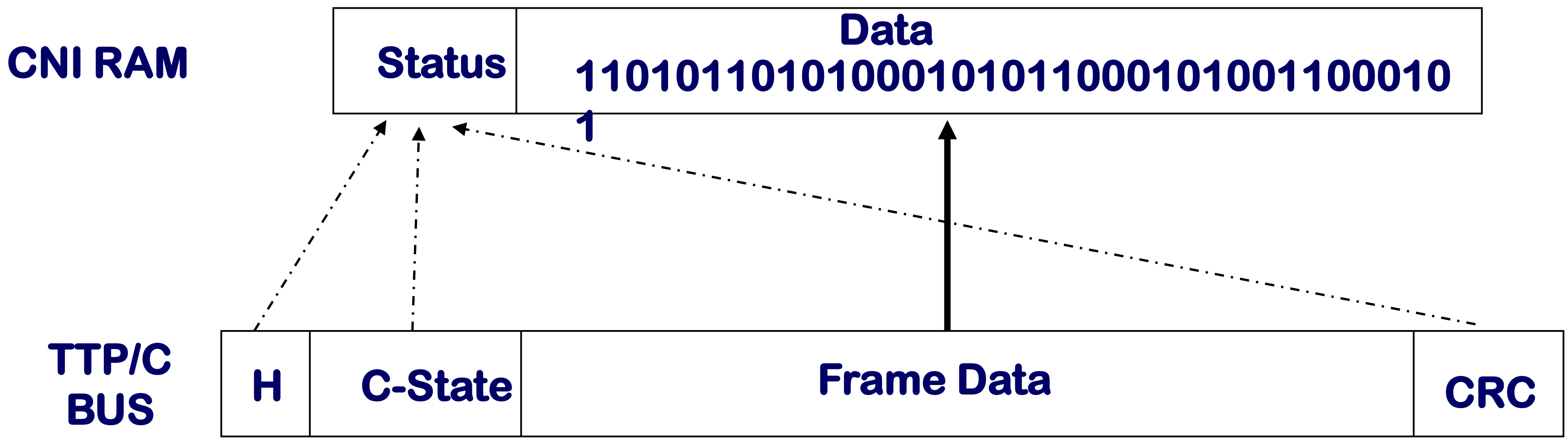
TTP Controller and Interface



MEDL – Message Description List
CNI – Communication Network Interface
BG – Bus Guardian

TTP Controller and Interface

In detail….



The frame-to-memory mapping is done in the MEDL

TTA Application Design

FT – COM Layer:

Responsible for transmitting information from between the application and the Communication Network Interface (CNI) and is the interface between TTP-OS and the CNI.

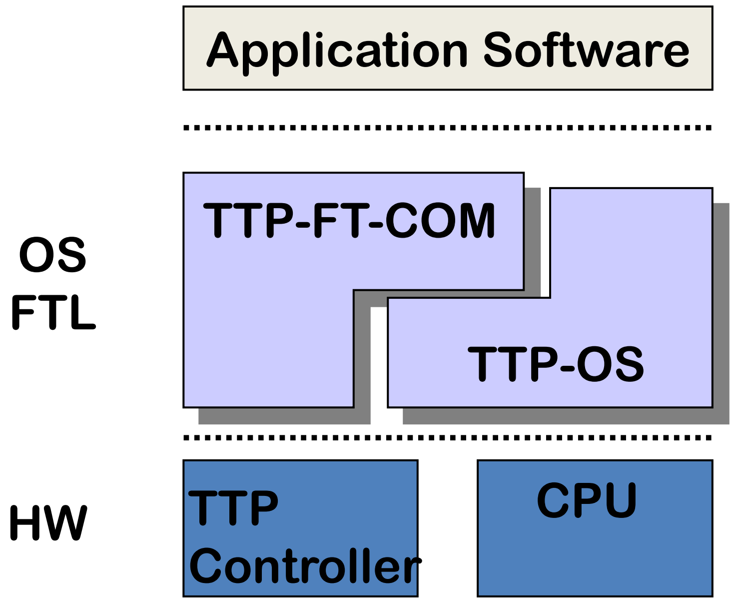
It packs and unpacks messages into frames and does all demanding work necessary to handle things like:

- **Message packing and unpacking**
- **Message compression and decompression of bit messages**
- **Redundancy management for two comms. Channels**
- **Message stability handling**
- **Replica-deterministic agreement**
- **Byte order**
- **Synchronisation of CNI access, and**
- **Message status handling**

TTA Application Design

TTP-OS

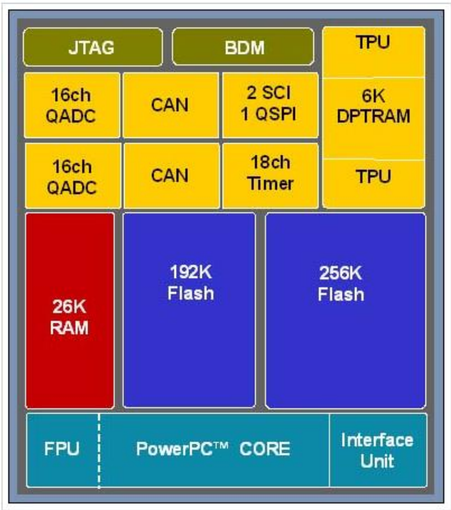
- **Interface between the hardware of the host controller and the applications Running on the host.**

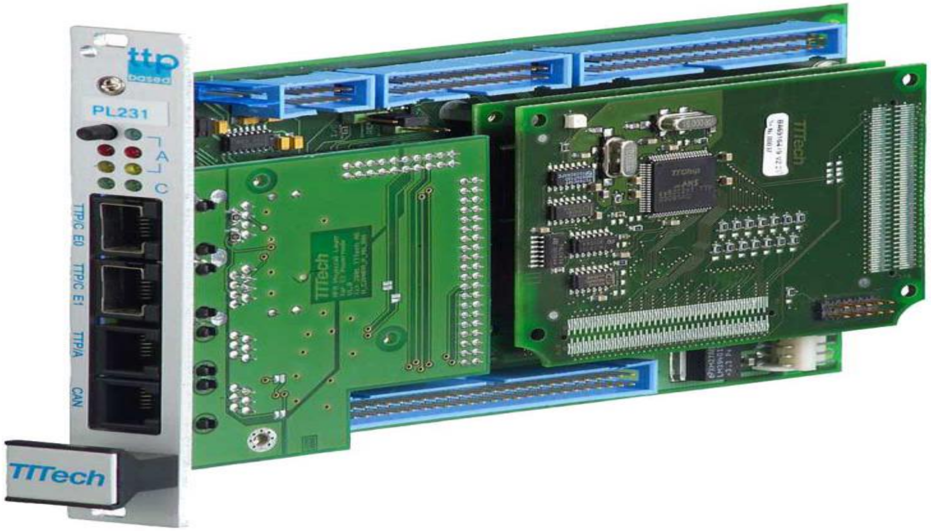


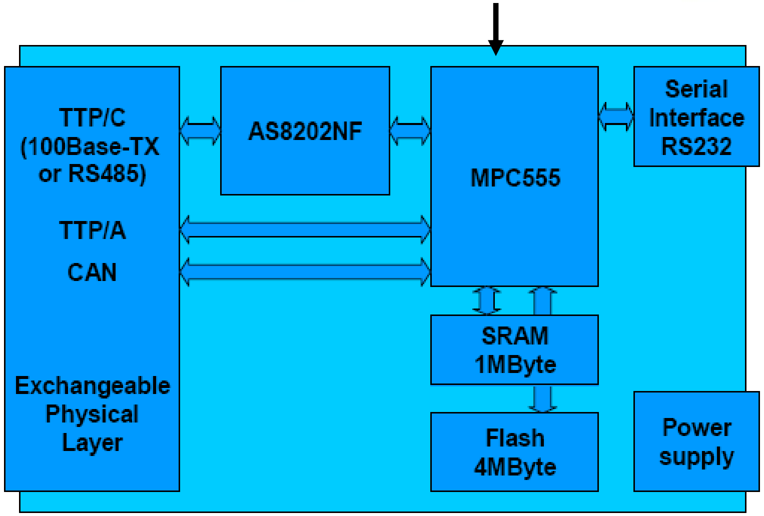
TTP Cluster Tools Interface

The cluster nodes contain an MPC 555 CPU that has the following interfaces:

- **PWM output**
- **Digital input & output, and**
- **ADC input**







TTP/C Data Bus

There are two approaches:

- Off-Shelf System [TTECH Vienna-Austria]
  - Development life cycle
  - Cost!
- Develop our own TTP/C
  - Hardware
    - Components
  - Software
    - Algorithm
    - Features & Criteria
  - Modules

Adobe Acrobat Document

Adobe Acrobat Document

Adobe Acrobat Document

Adobe Acrobat Document

Steer and Fly by Wire: Safety, Reliability and Cost!

Facts and Statistics

Component Level:

- The total number of IP for TTP/C bus required are 14 IP's [will be more according to the redundancy level]
- The cost of each IP is approx. £25/1KU
  - TTP/C Microcontroller is approx. €8/1KU

- The number of the DAS are 6 DAS
  - STM 32 is approx. $3-4/1KU or
  - DSP C28XX is approx. $5/1KU
- The cost of each DAS is approx. £15/1KU

The total cost for system interface on this case will be approx. £410

Steer and Fly by Wire: Safety, Reliability and Cost!

Facts and Statistics

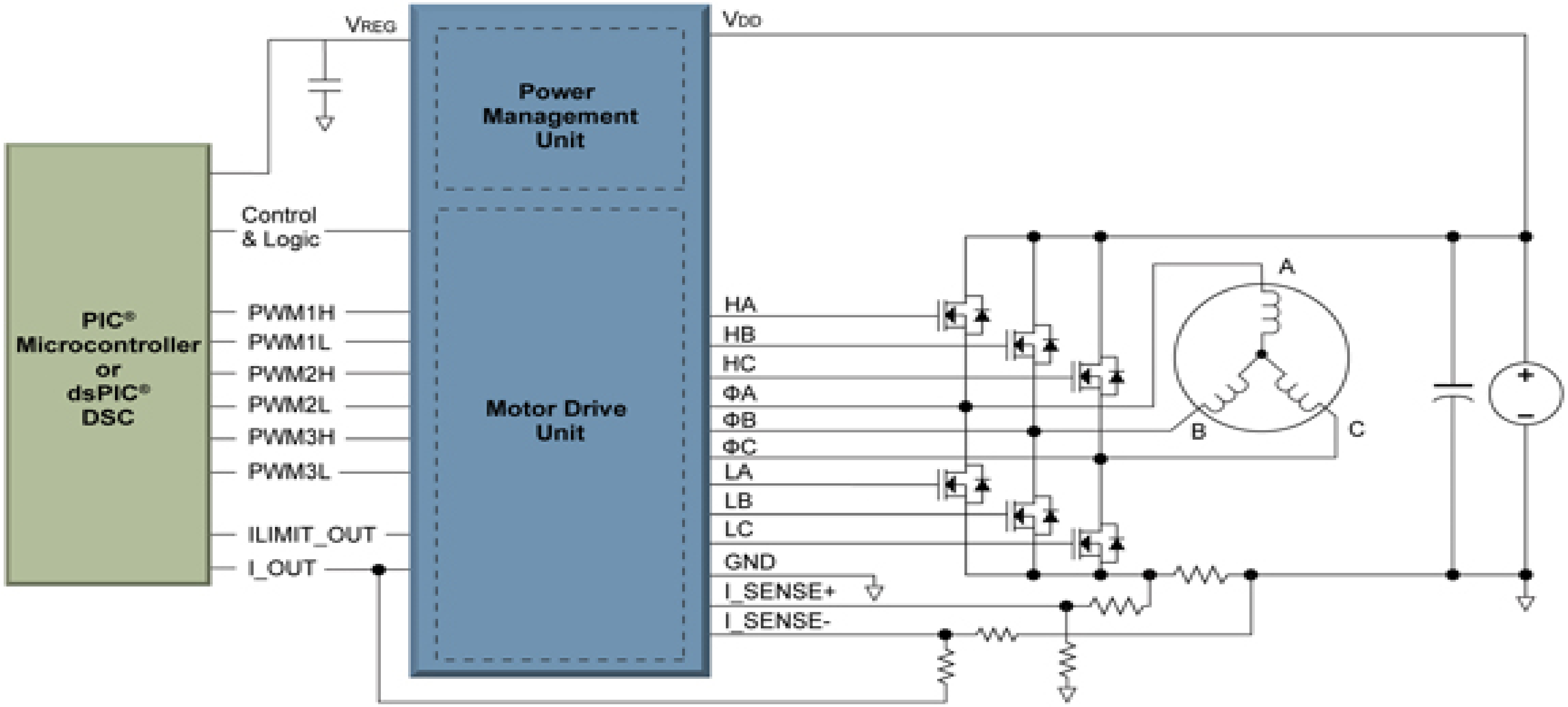
Component Level:

- The total number of IP for TTP/C bus required are **10 IP's** [will be more according to the redundancy level]
- The cost of each IP is approx. **£25/1KU**
  - TTP/C Microcontroller is approx. **€8/1KU**

- The number of the DAS are **6 DAS**
  - STM 32 is approx. **$3-4/1KU or**
  - **DSP C28XX is approx. $5/1KU**
- The cost of each DAS is approx. **£15/1KU**

The total cost for system interface on this case will be approx. £340

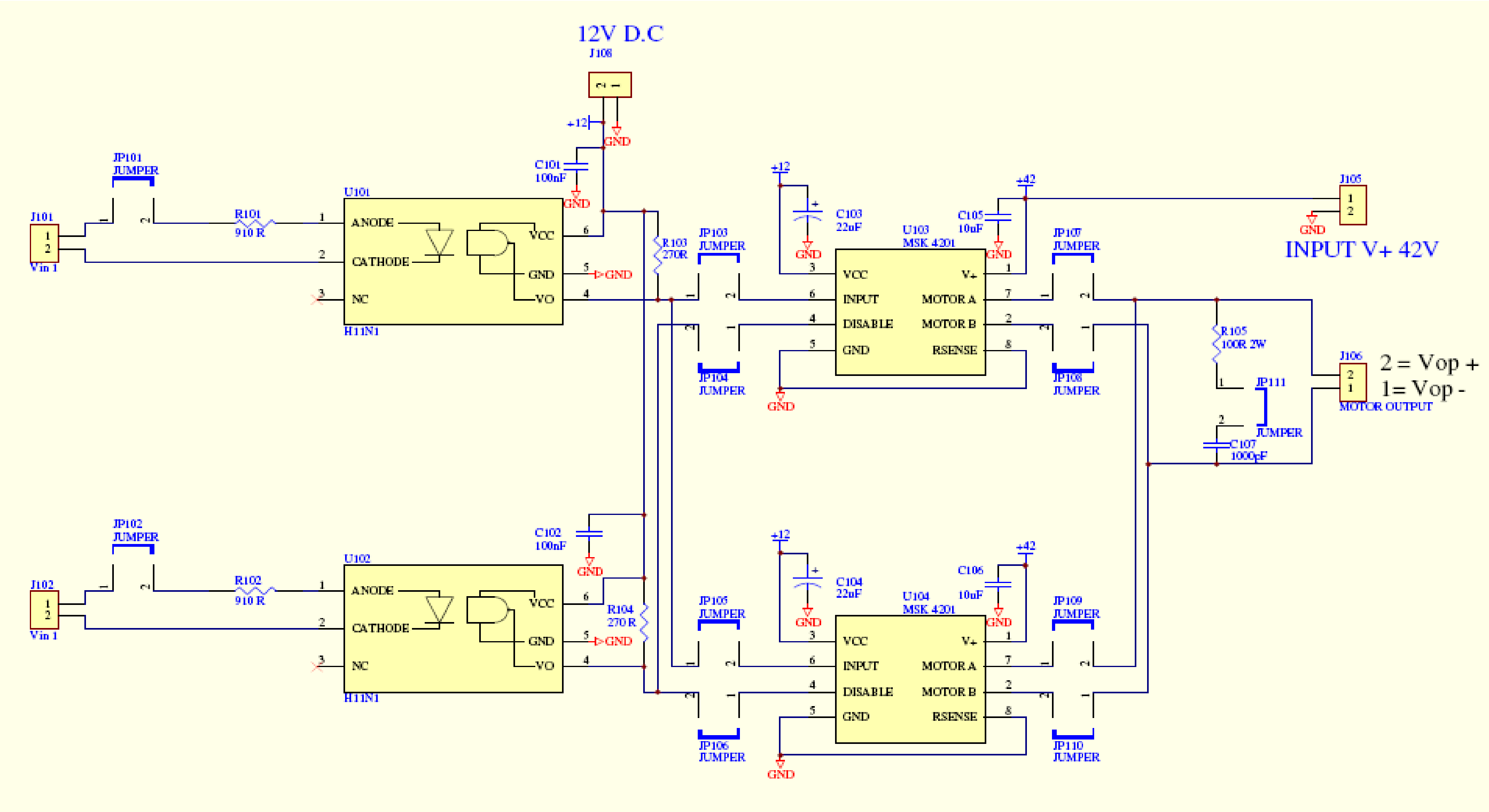
Industrial Applications: Solid State Devices MOSFET & IGBT Industrial Applications



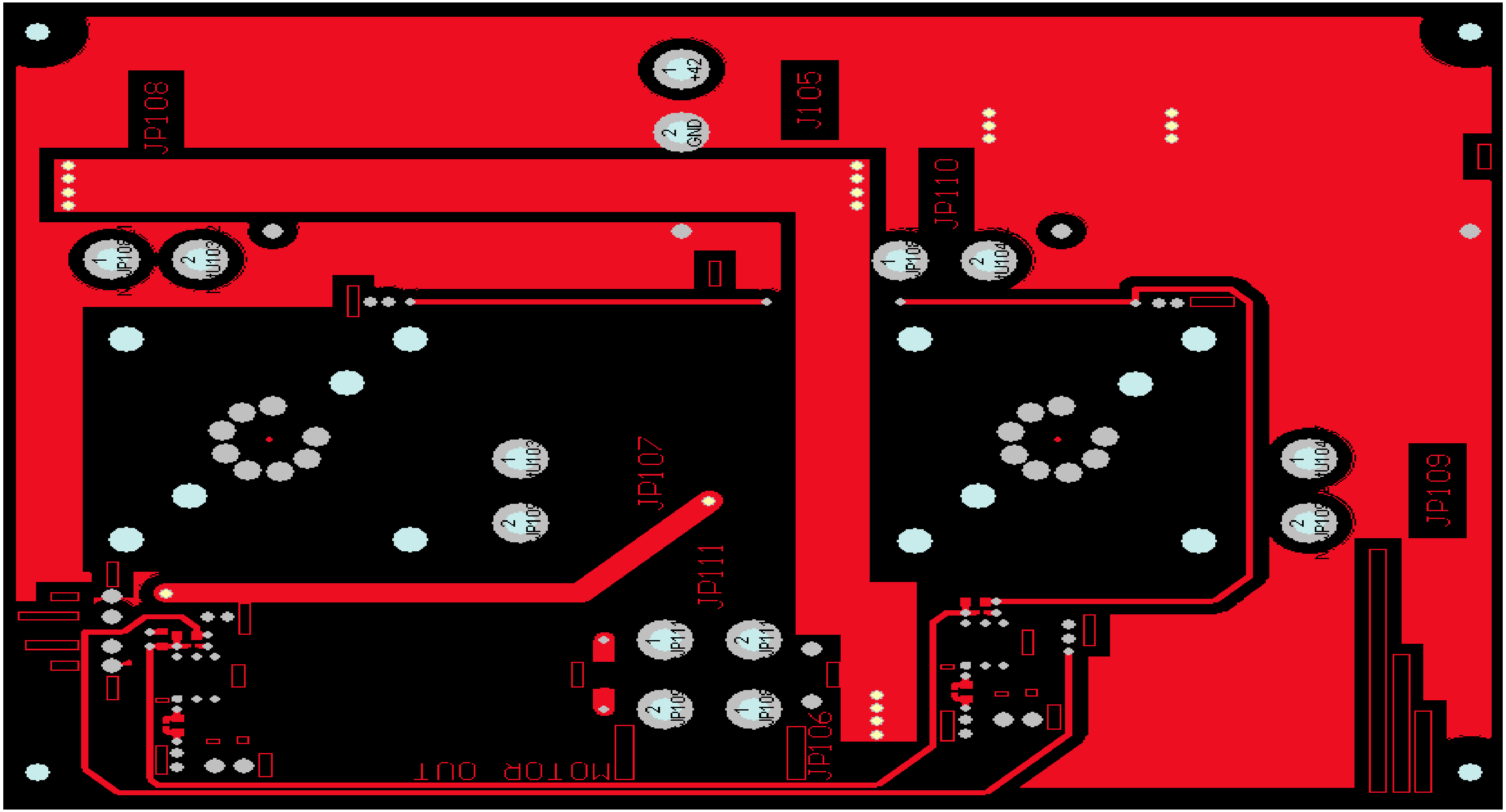
Three Main Functional Blocks are Integrated into a Single Device that Drives a Three-phase Motor

https://www.ecnmag.com/article/2012/04/selecting-best-three-phase-bldc-motor-design-technique

Power Switch Circuit Module

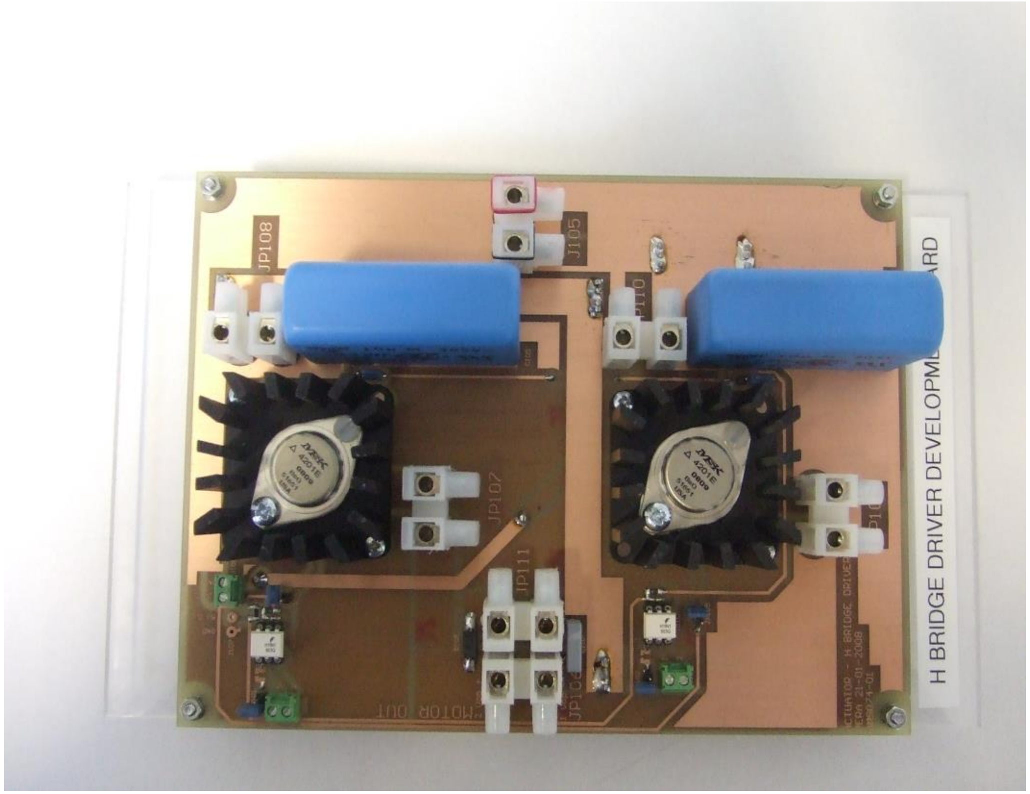


Power Switch Circuit Module



TTP/C and Power Switch Circuit Module

TTP/C Power Node

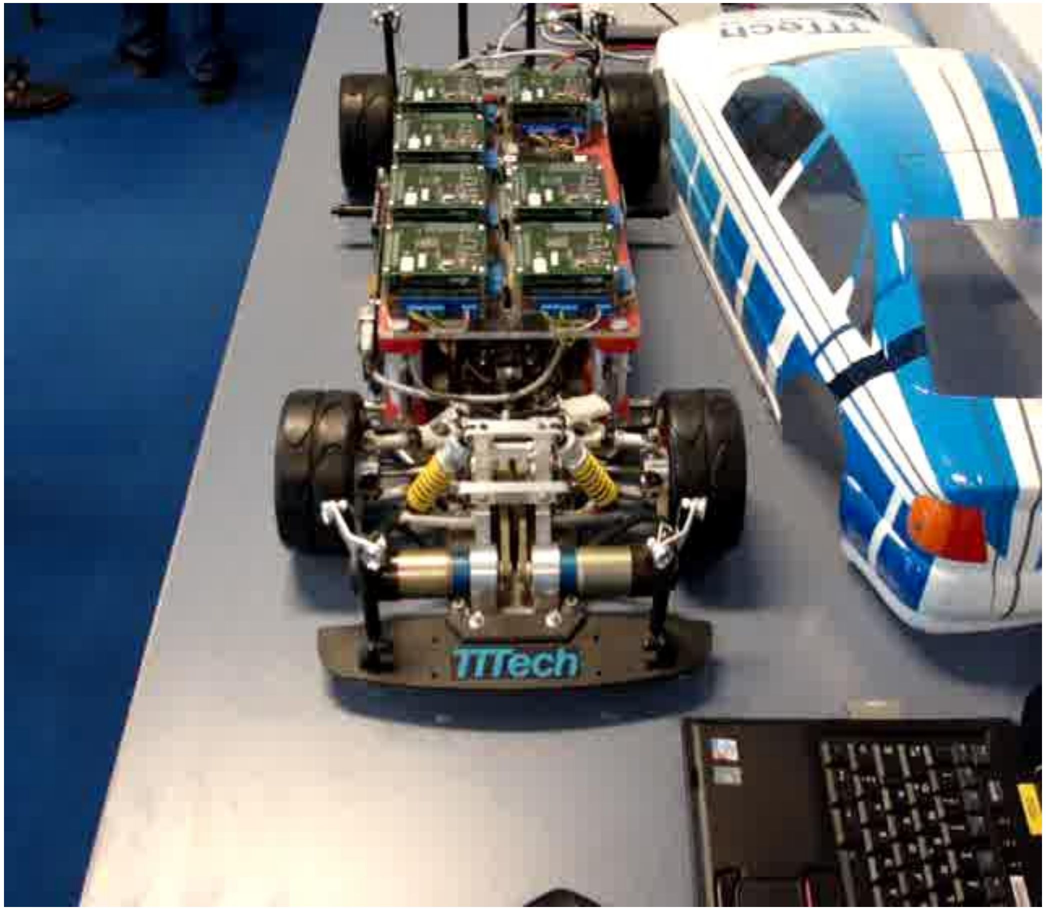


Power Switch Unit

Steer and Fly by Wire: Electric and Autonomous Vehicles!

TTP/C Power Node for whole Drive by wire Vehicle:

- 11 TTP Power Node
  - 3 Nodes for Steering system [Triple redundancy]
  - 2 Nodes for force feedback [Two redundancy]
  - 4 Nodes for the brake
  - 2 Nodes for Padel [Two redundancy]



Time Triggered Protocols

TTP/C – Present:

- **Hamilton Sundstrand has selected TTechs's TTP controller for Boeing 787 Dreamliner**

- **TTP from TTTech are used in Nord-Micros's cabin pressure control system on the Airbus A380 mega-airline**

https://www.tttech.com/wp-content/uploads/TTTech-Nord_Micro-Casestudy-A380.pdf

Time Triggered Protocols

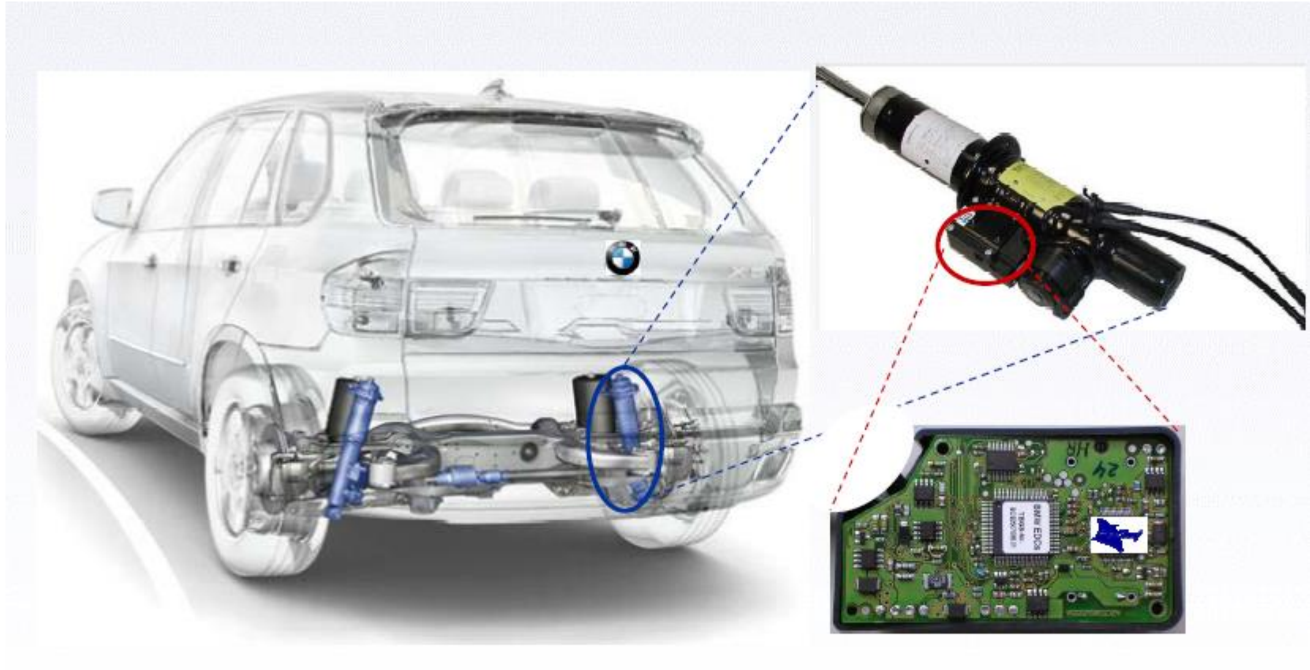
- TTP/C
  - 25 Mbits/Sec per channel
  - Redundancy, safety and fault tolerance
  - Costly
  - Supports only static mode Comms
  - …etc.
- FlexRay
  - 10 Mbits/Sec per channel
  - Redundancy, safety and fault tolerance
  - Seems to win in the automotive market
  - Cheaper
  - …etc.

Time Triggered Protocols FlexRay

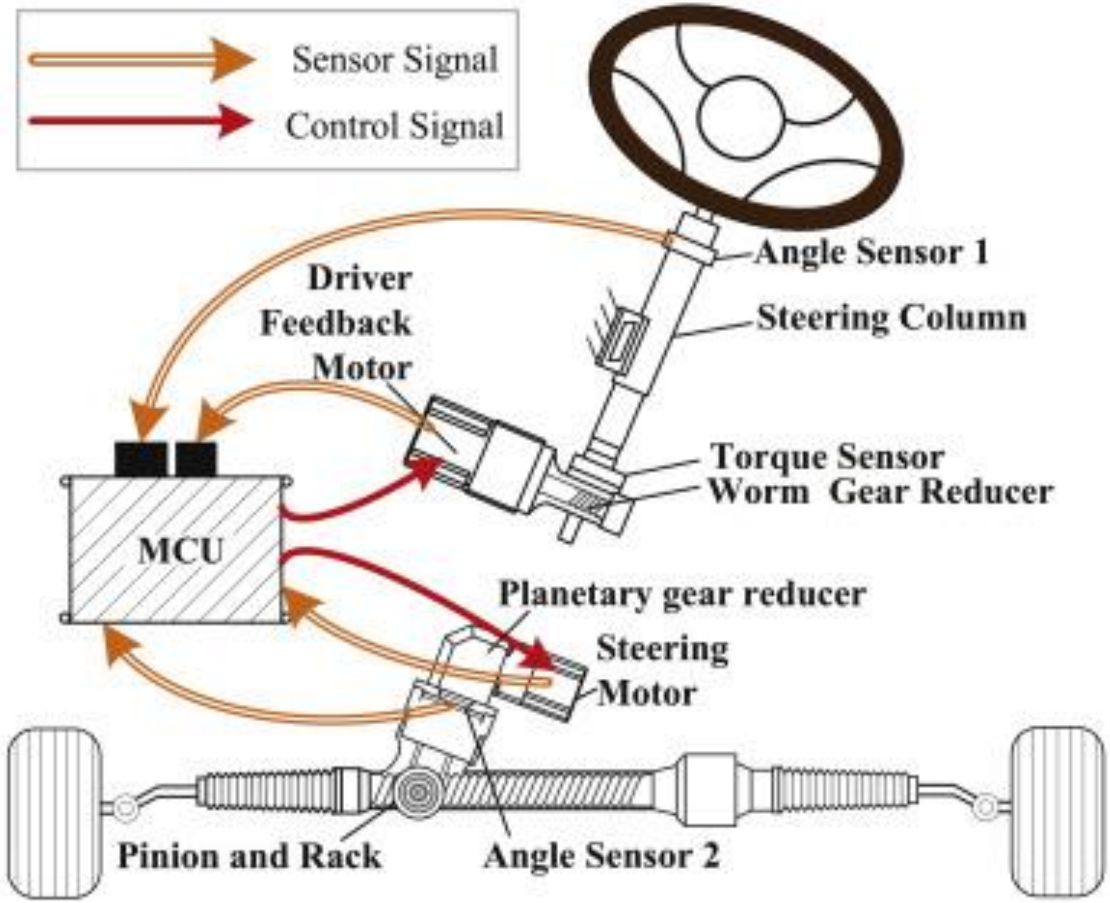
FlexRay™

Flex Ray -Current

- **Currently on the BMW X5.**

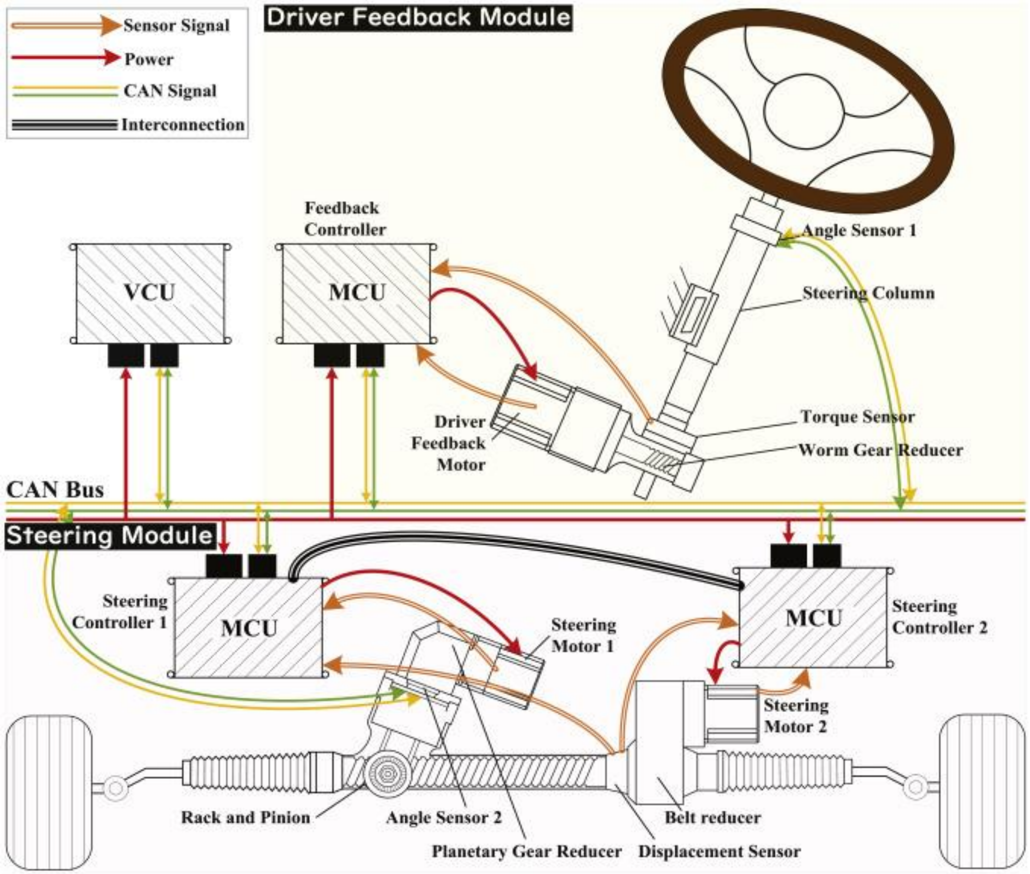


Steer and Fly by Wire: Electric and Autonomous Vehicles!



Steer – by - Wire System Architecture for EV and AV Technology

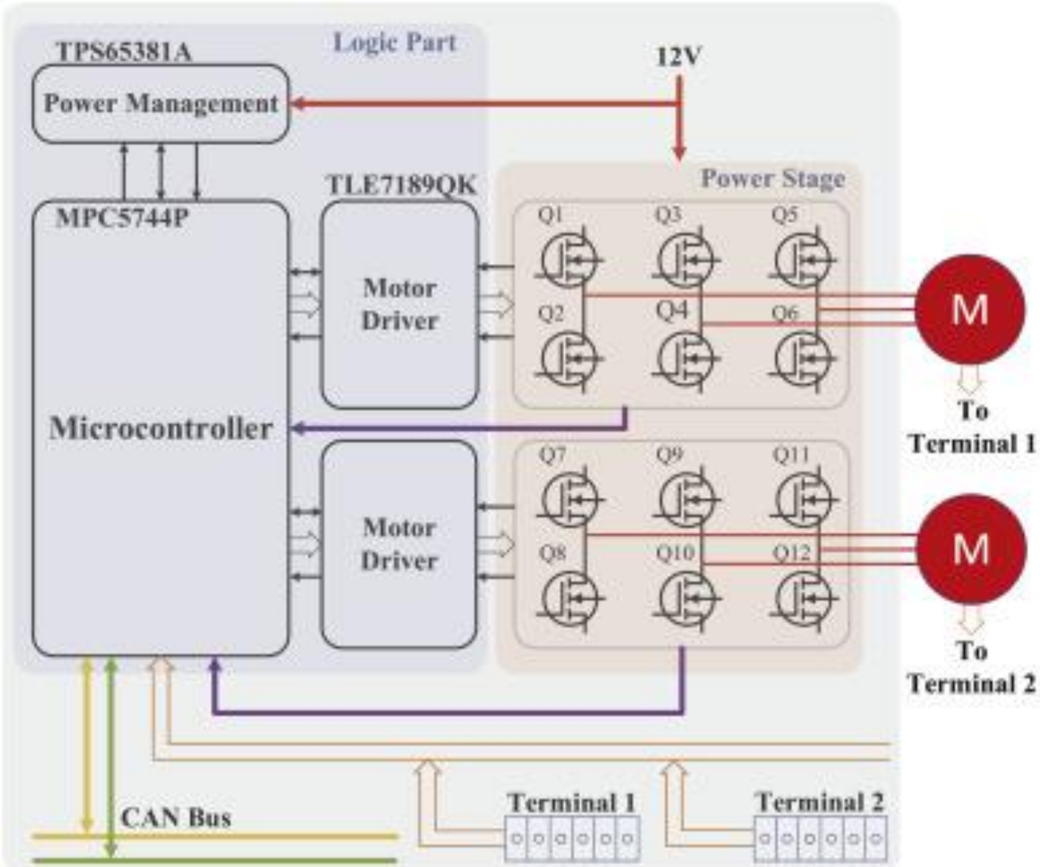
Steer and Fly by Wire: Electric and Autonomous Vehicles!



Schematic of the Fail operational Steer-by-Wire System Architecture of for EV Technology

https://www.sciencedirect.com/science/article/pii/S0951832019305034

Steer and Fly by Wire: Electric and Autonomous Vehicles!



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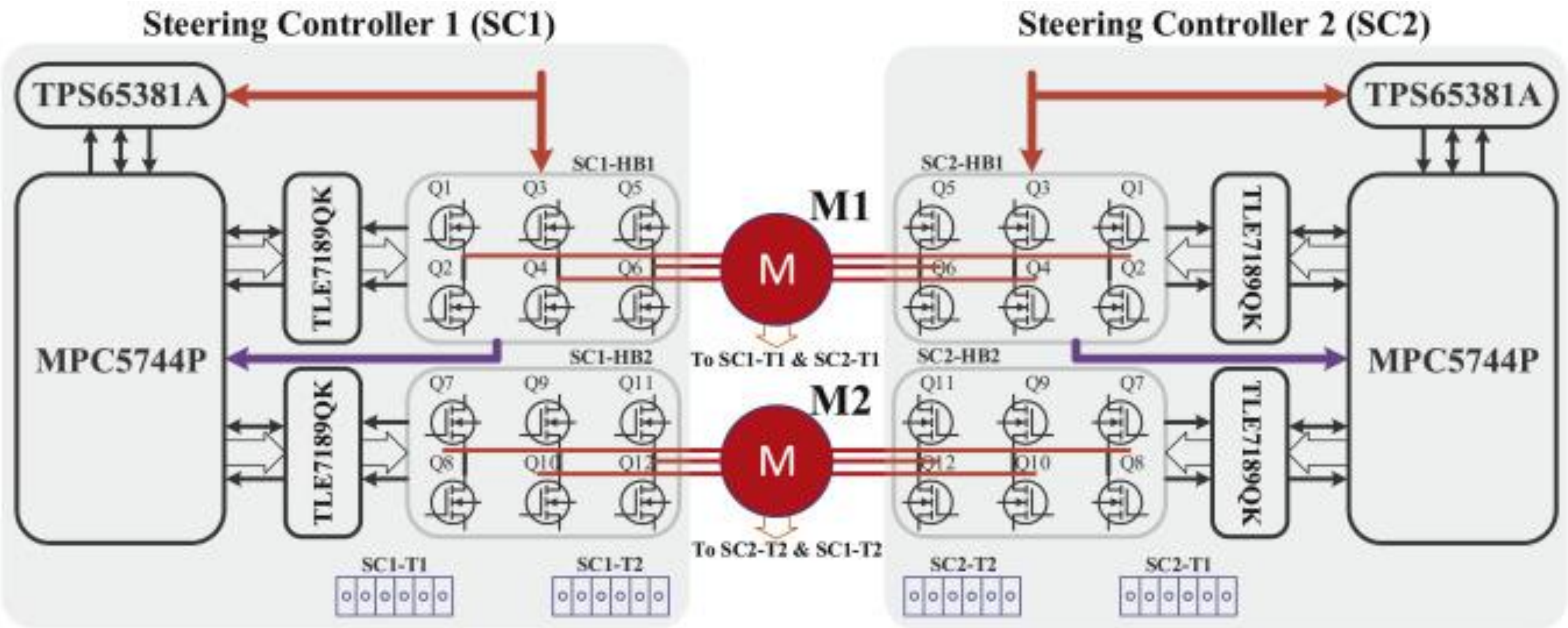
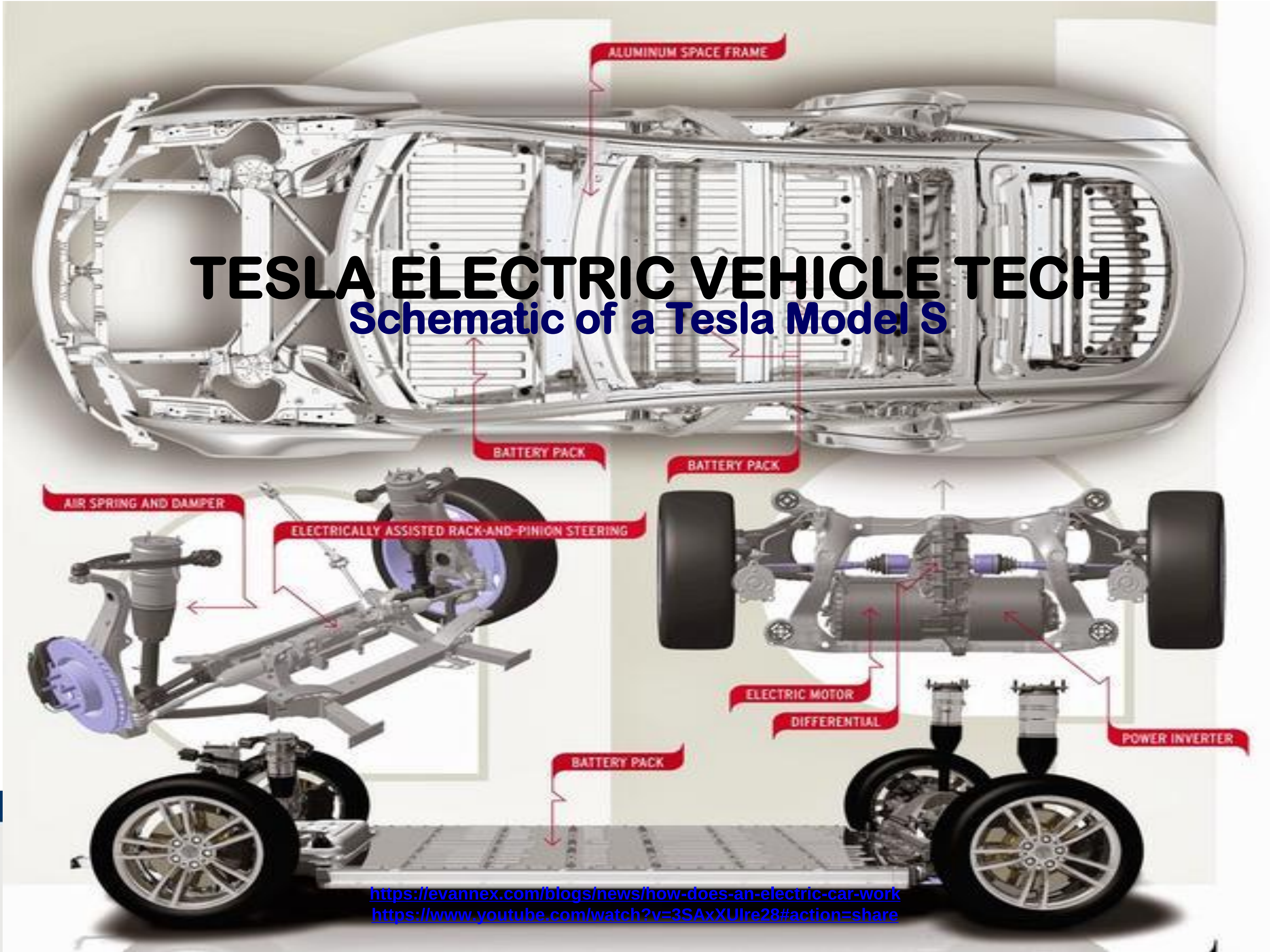


Schematic of the Fail operational Steer-by-Wire System Architecture of for EV Technology

https://www.sciencedirect.com/science/article/pii/S0951832019305034

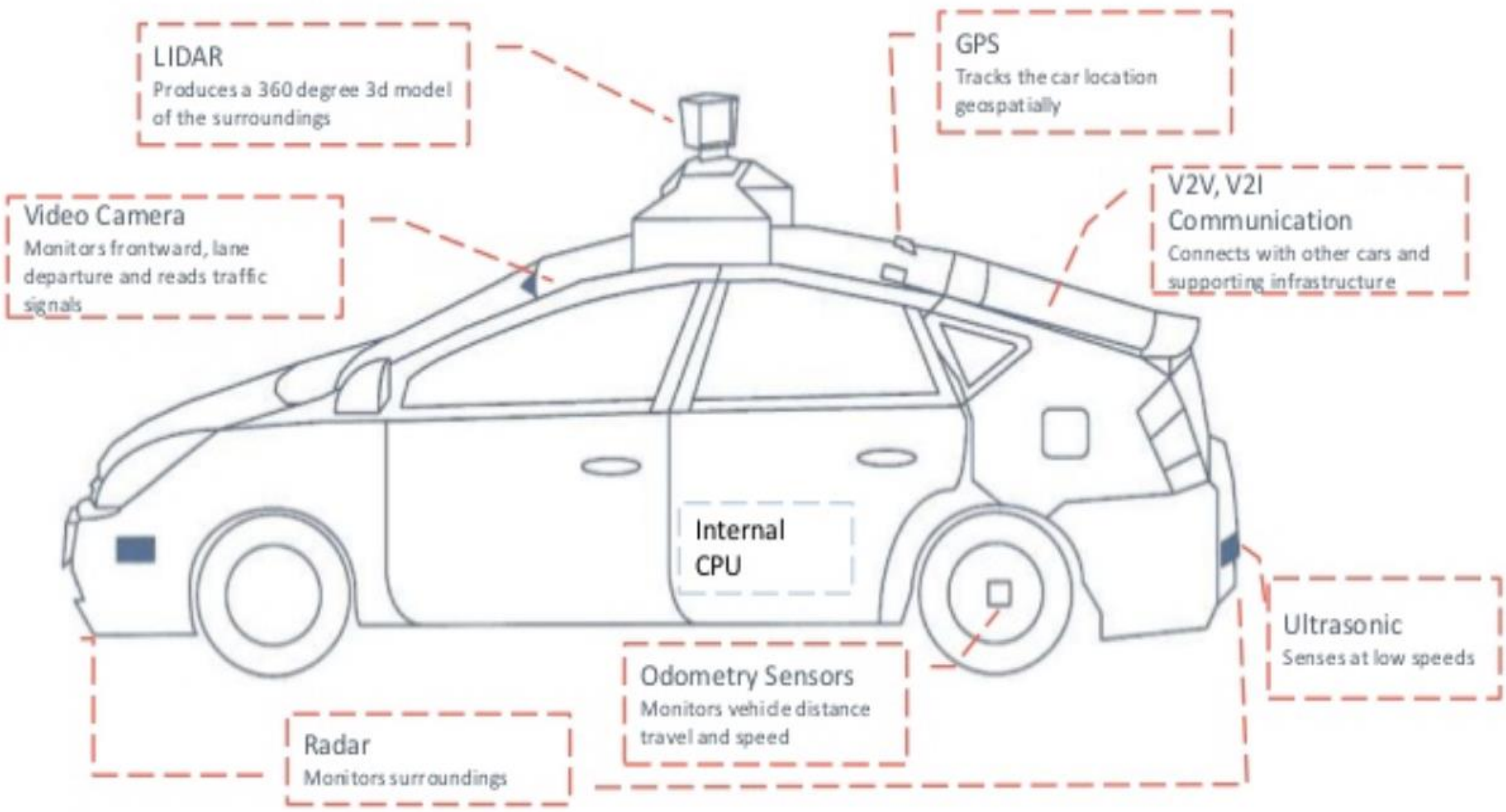
TESLA ELECTRIC VEHICLE TECH

Schematic of a Tesla Model S



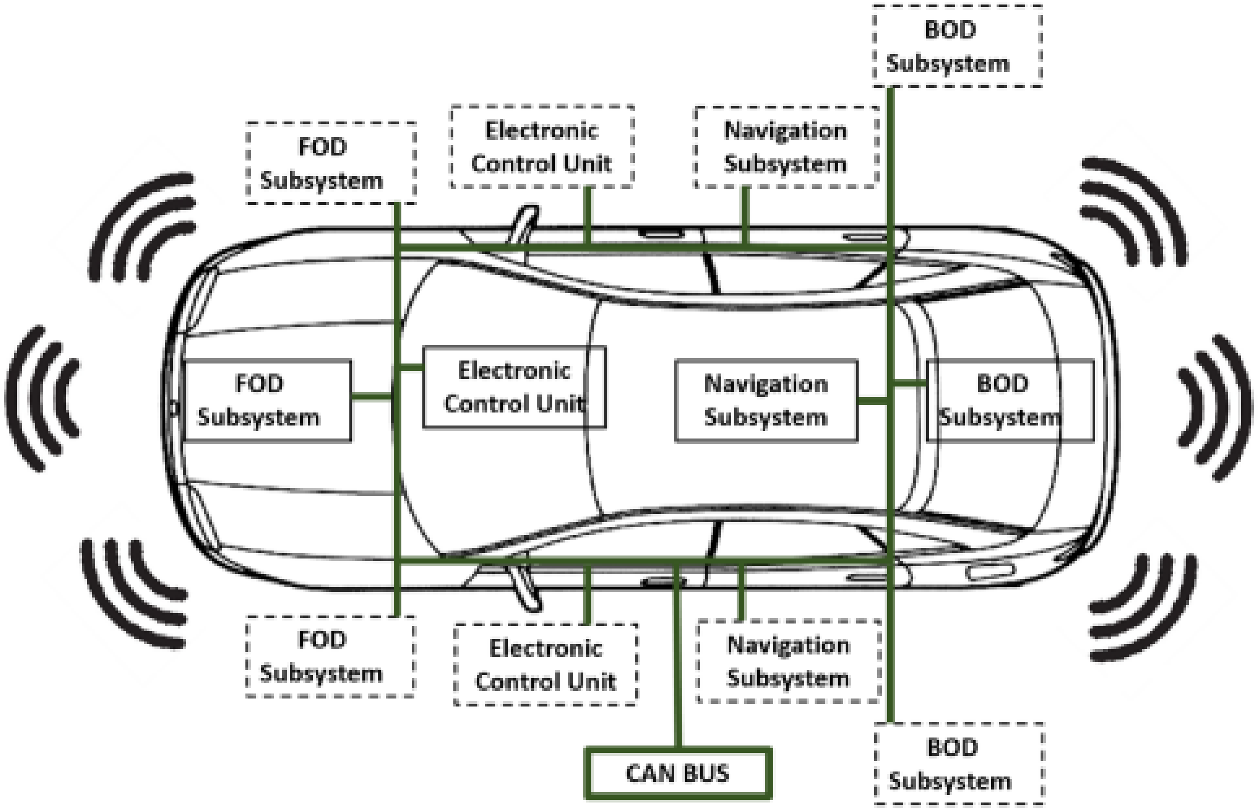
https://evannex.com/blogs/news/how-does-an-electric-car-work
https://www.youtube.com/watch?v=3SAxXUIre28#action=share

Collision Avoidance Platform Solution for Autonomous Vehicles



Autonomous Vehicles systems architecture overview and various sources of INS and GPS

Collision Avoidance Platform Solution for Autonomous Vehicles



Collision Avoidance System architecture overview of the Autonomous Vehicles prototype

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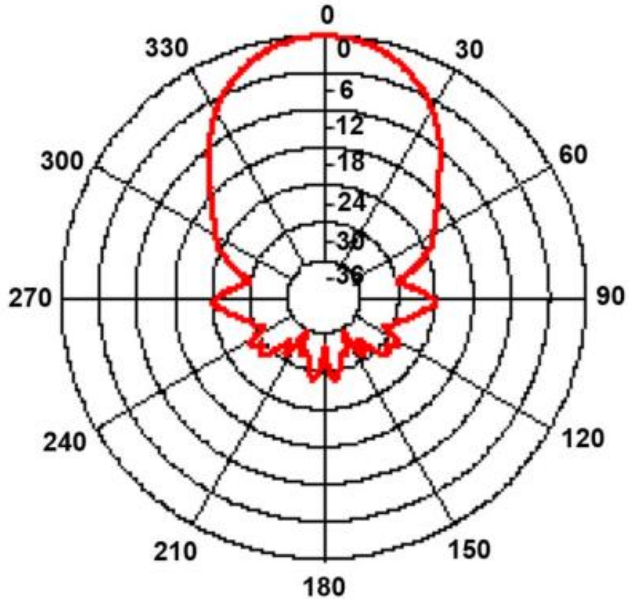
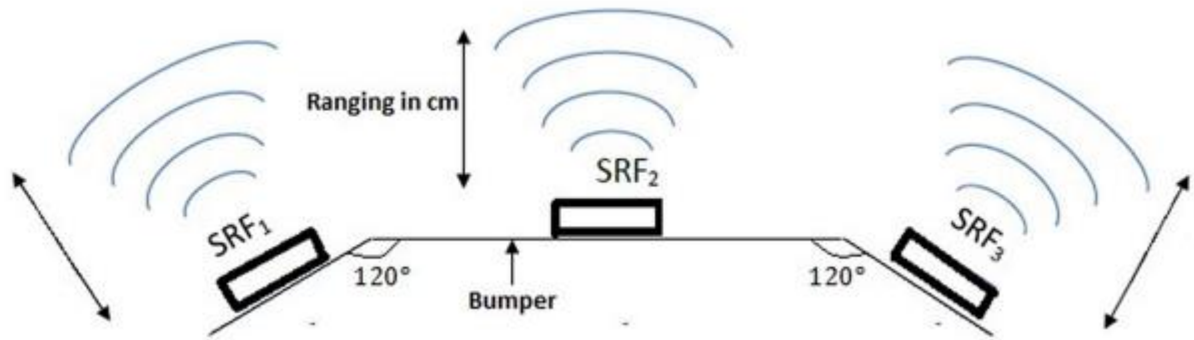
https://link.springer.com/article/10.1007/s42452-020-2383-2

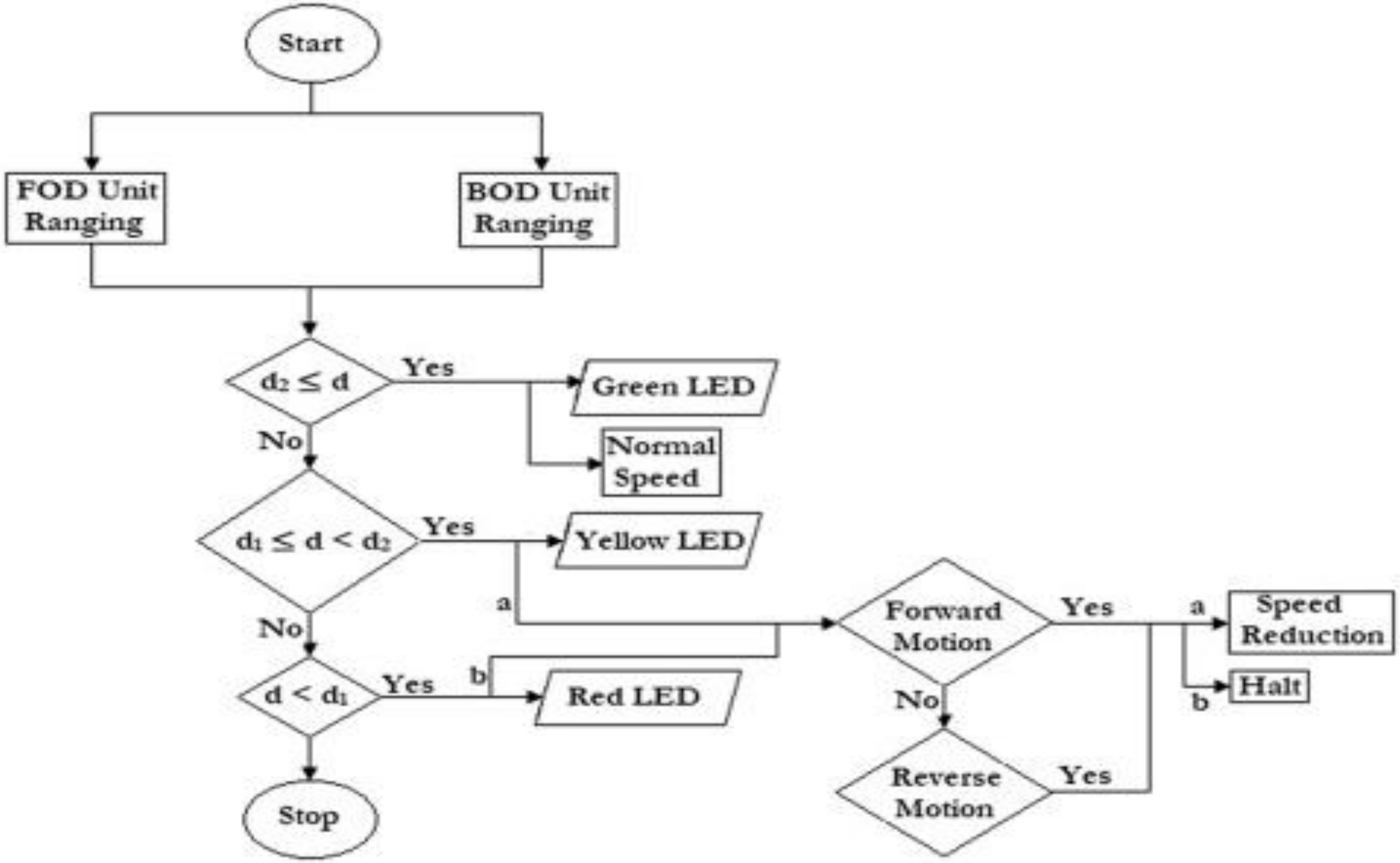
Collision Avoidance Platform Solution for Autonomous Vehicles





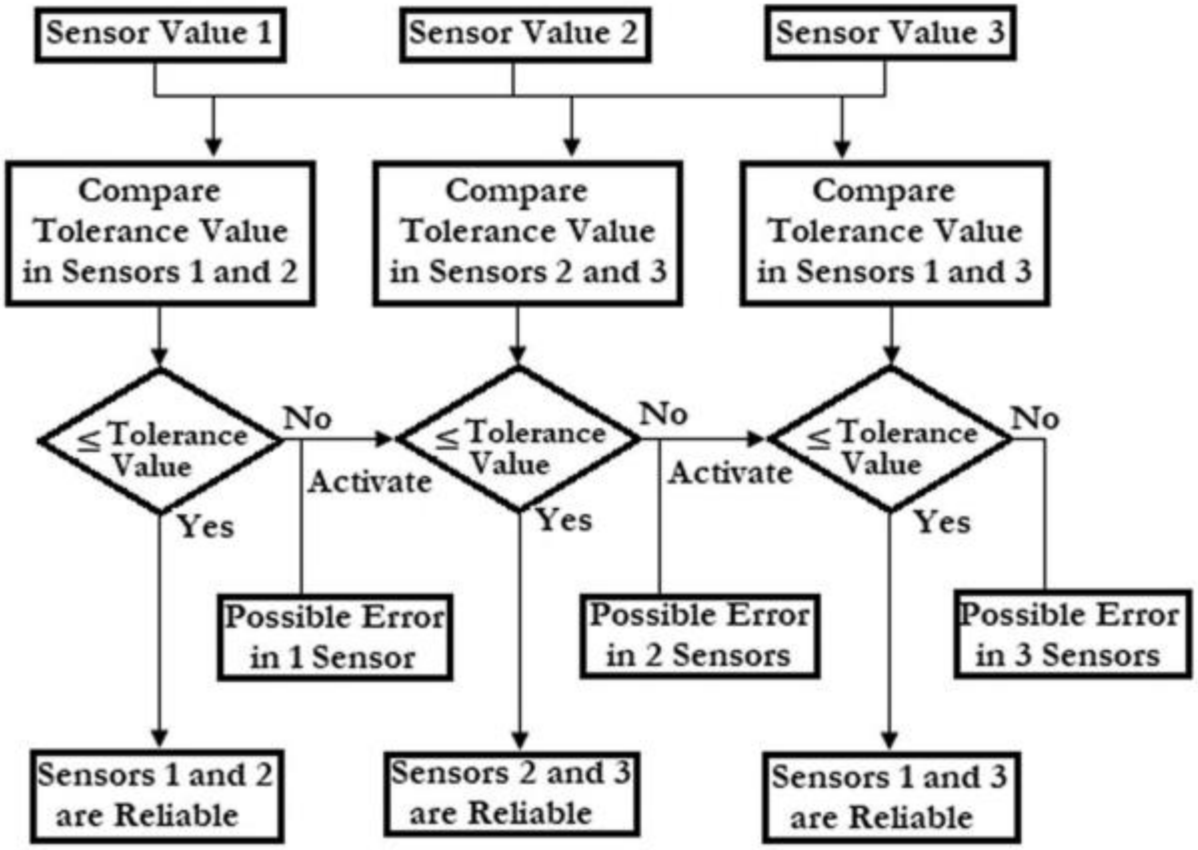
Collision Avoidance System SRF05 ultrasonic sensor beam pattern

Collision Avoidance Platform Solution for Autonomous Vehicles



Algorithm flowchart of Collision Avoidance System

Collision Avoidance Platform Solution for Autonomous Vehicles



Collision Avoidance System Voting programme flowchart

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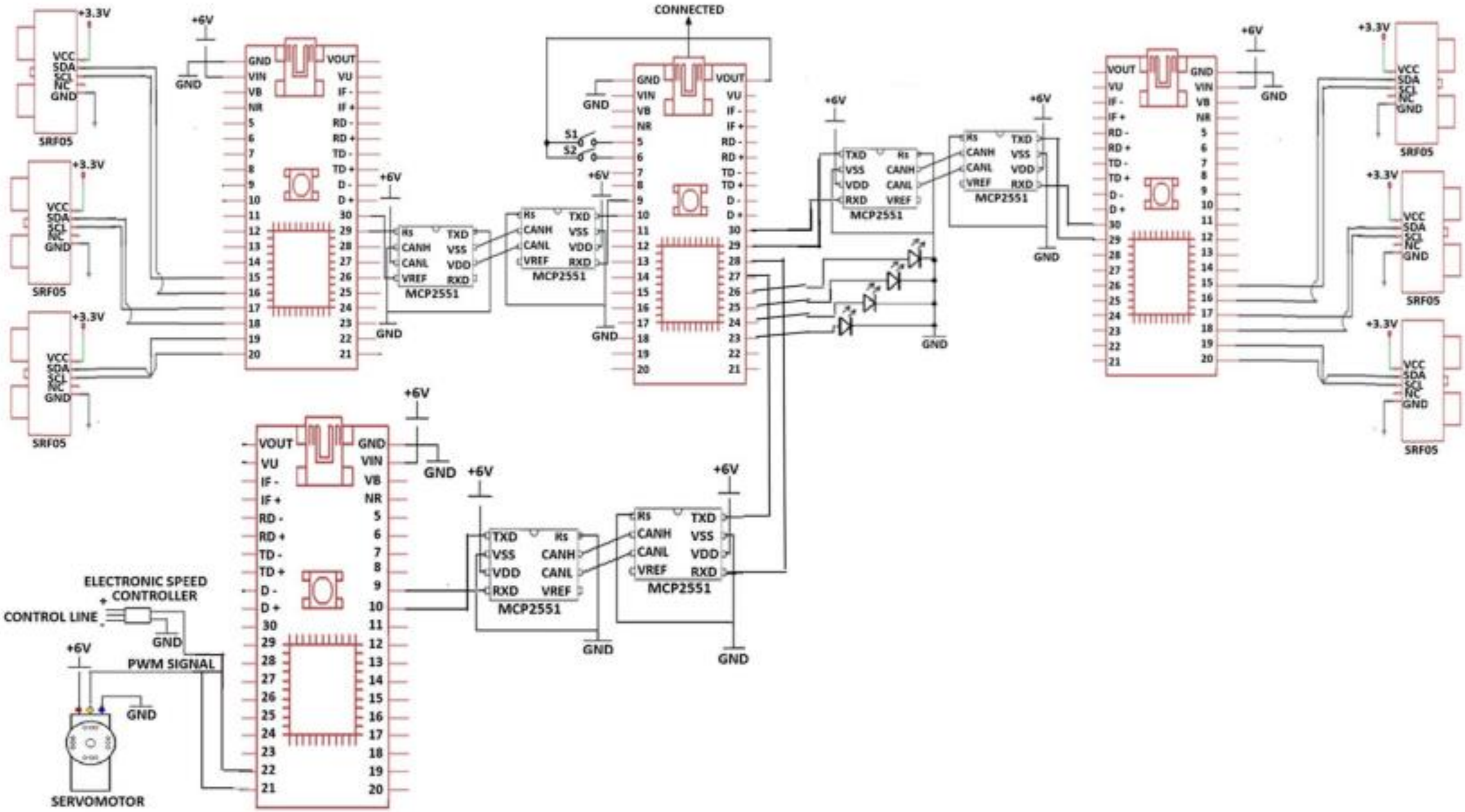
Sensitivity: Internal

Collision Avoidance Platform Solution for Autonomous Vehicles



Collision avoidance system including FOD, BOD and NV circuit diagram

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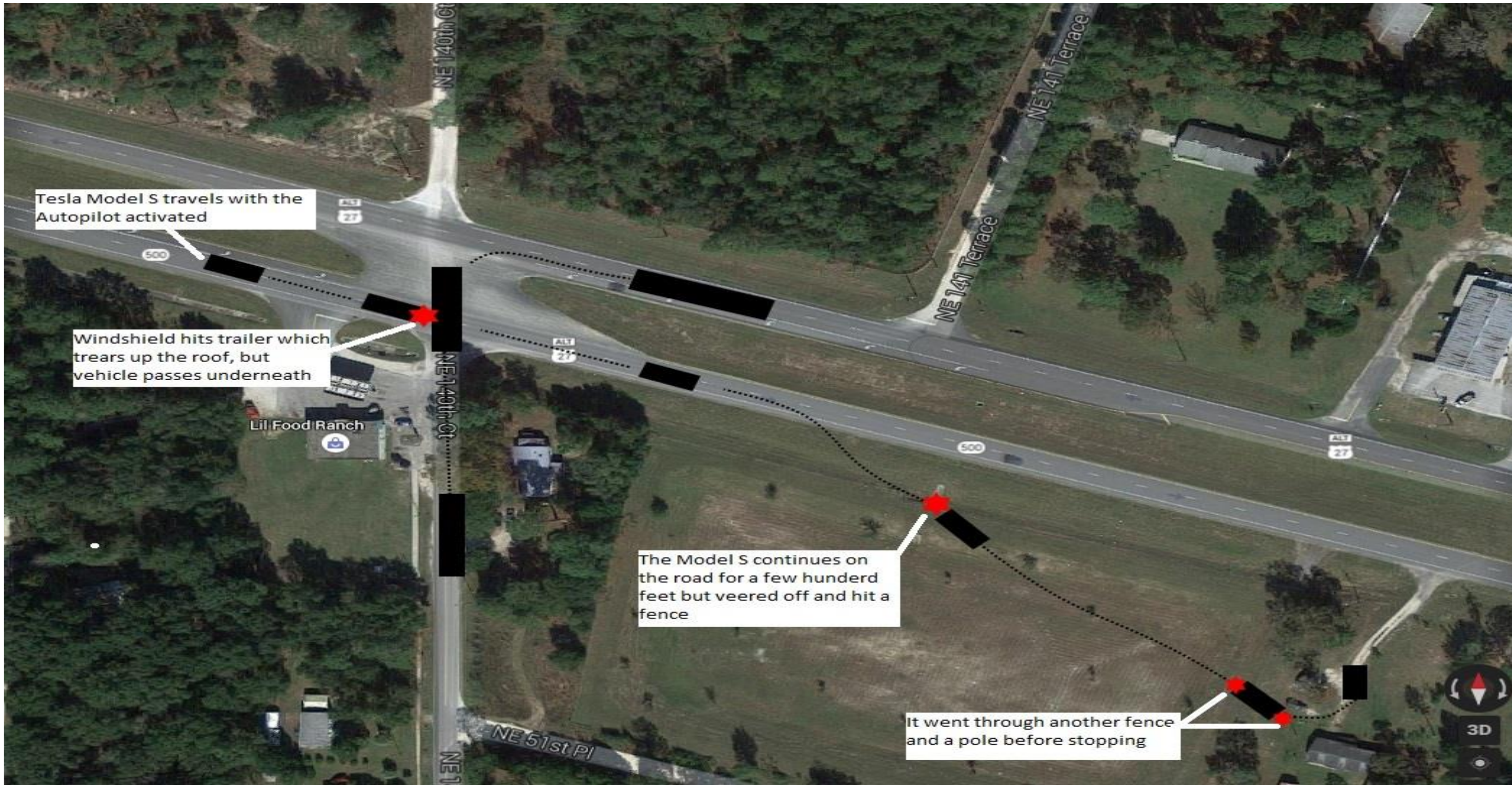
Collision Avoidance Platform Solution for Autonomous Vehicles



Tesla Collision at Road Intersection: 3D Vision systems able to perceive, reason, move in 3D, and learn from experiences at lower cost!

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https://electrek.co/2016/07/01/understanding-fatal-tesla-accident-autopilot-nhtsa-probe/

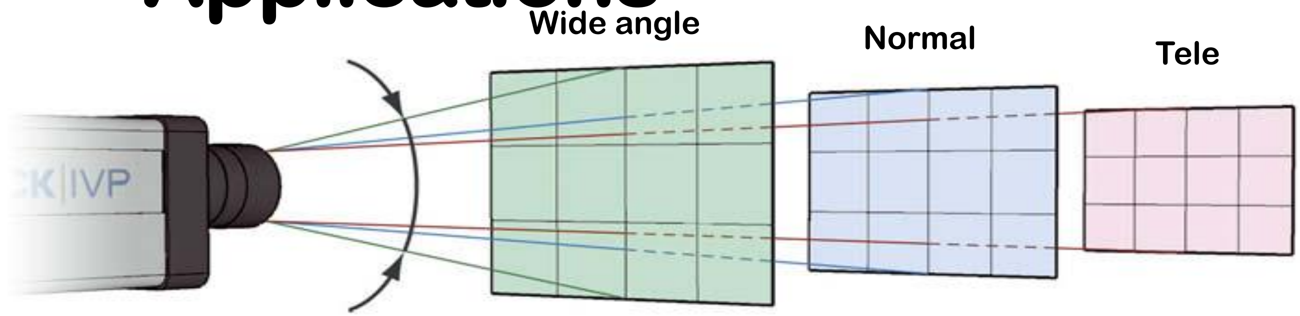
https://www.youtube.com/watch?v=X3hrKnv0dPQ

https://www.youtube.com/watch?v=zRnSmw1i_DQ – AV

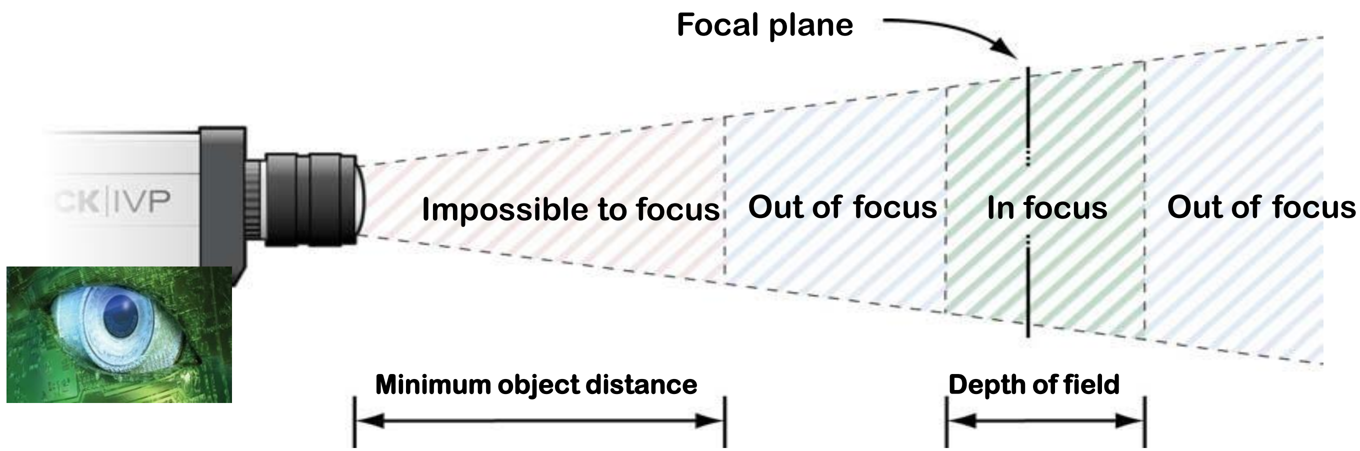
https://www.youtube.com/watch?v=7KpGIuGduLk – Prediction

3D Machine Vision System using Machine Learning for Connected Vehicles Applications

Field of View in 2D

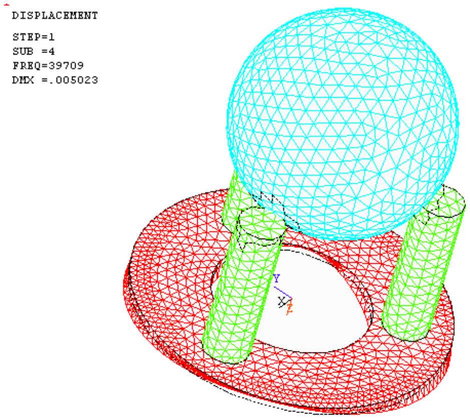


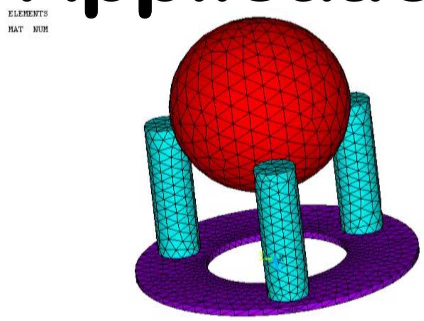
Depth of Field

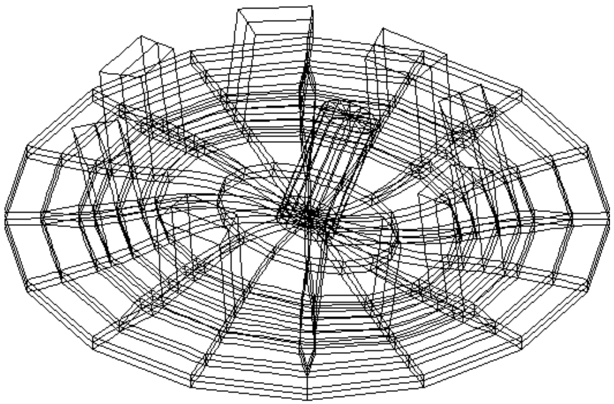


3D Vision systems able to perceive, reason, move in 3D, and learn from experiences at lower cost!

3D Machine Vision System using Machine Learning for Connected Vehicles Applications

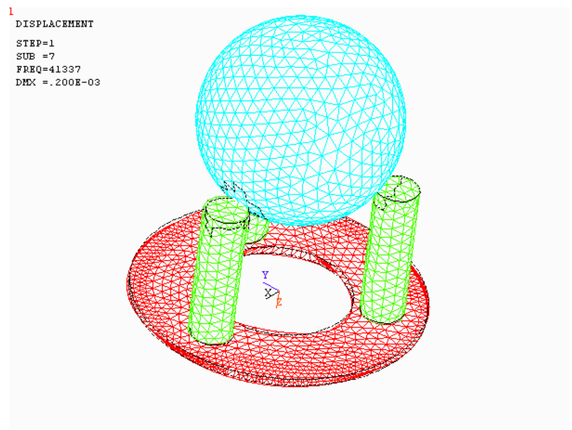


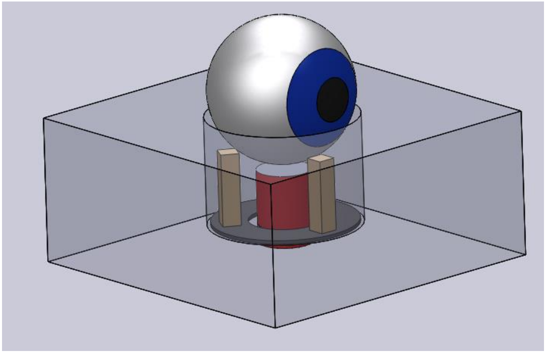




3D Actuator.wmv

3D Actuator.wmv





3D Vision systems able to perceive, reason, move in 3D, and learn from experiences at lower cost!

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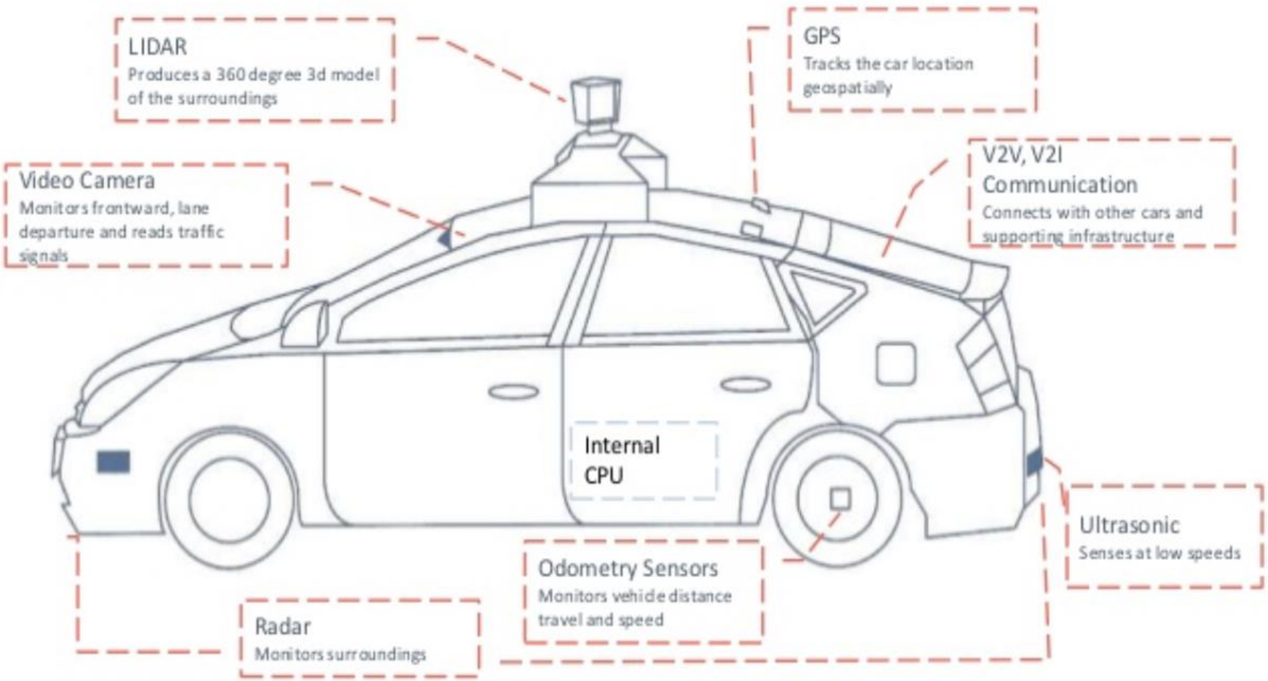
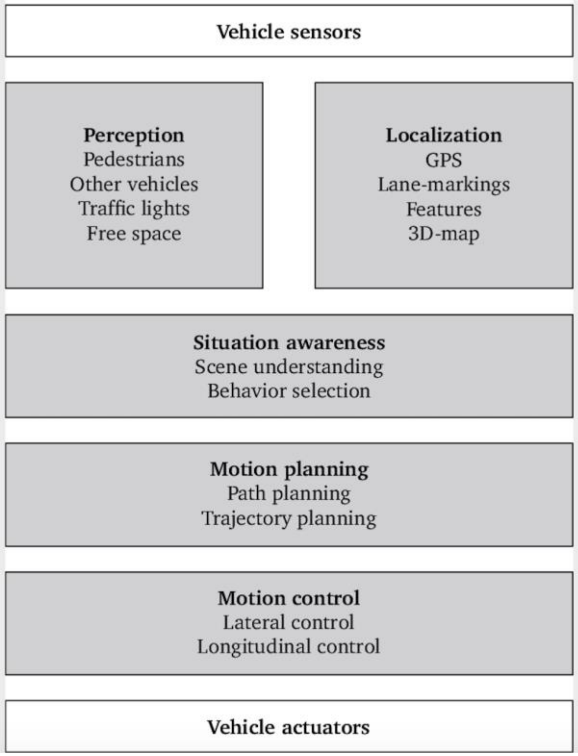
A Tracking Platform Solution for Autonomous Vehicles Localization in Smart Cities, Using Machine Learning

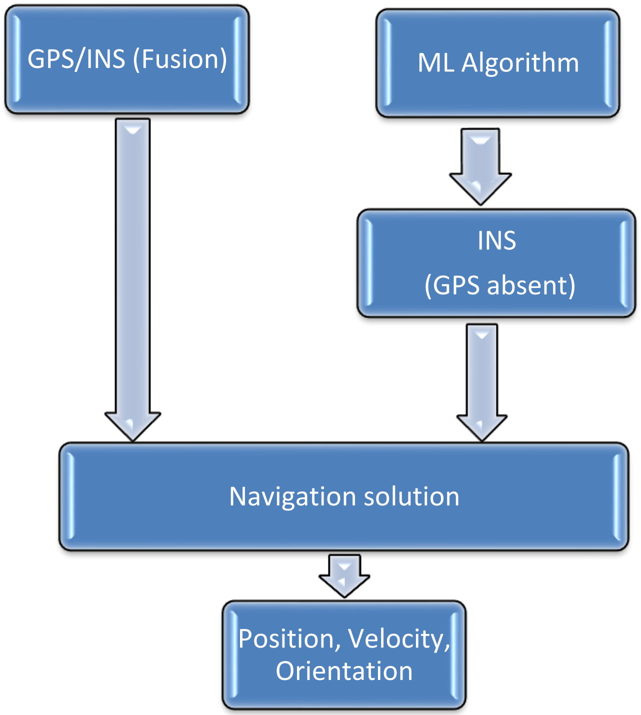




Autonomous Vehicles systems architecture overview and various sources of INS and GPS

A Tracking Platform Solution for Autonomous Vehicles Localization in Smart Cities Using Machine Learning

- **Navigation data for AV is based on information obtained from multiple sources: INS, GPS, dynamic maps, LIDAR, RADAR, vision systems …etc.**
- **Continuous and accurate localization involves is critical to safe implementation of driverless systems.**
- **GPS/INS is key in continuous localization, albeit with their unique setbacks.**
- **This programme is focused on the implementation of ML algorithm to offset the deficiencies of traditional GPS/INS fusion.**
- **This research work focuses its implementation on "*GPS shadow areas*".**



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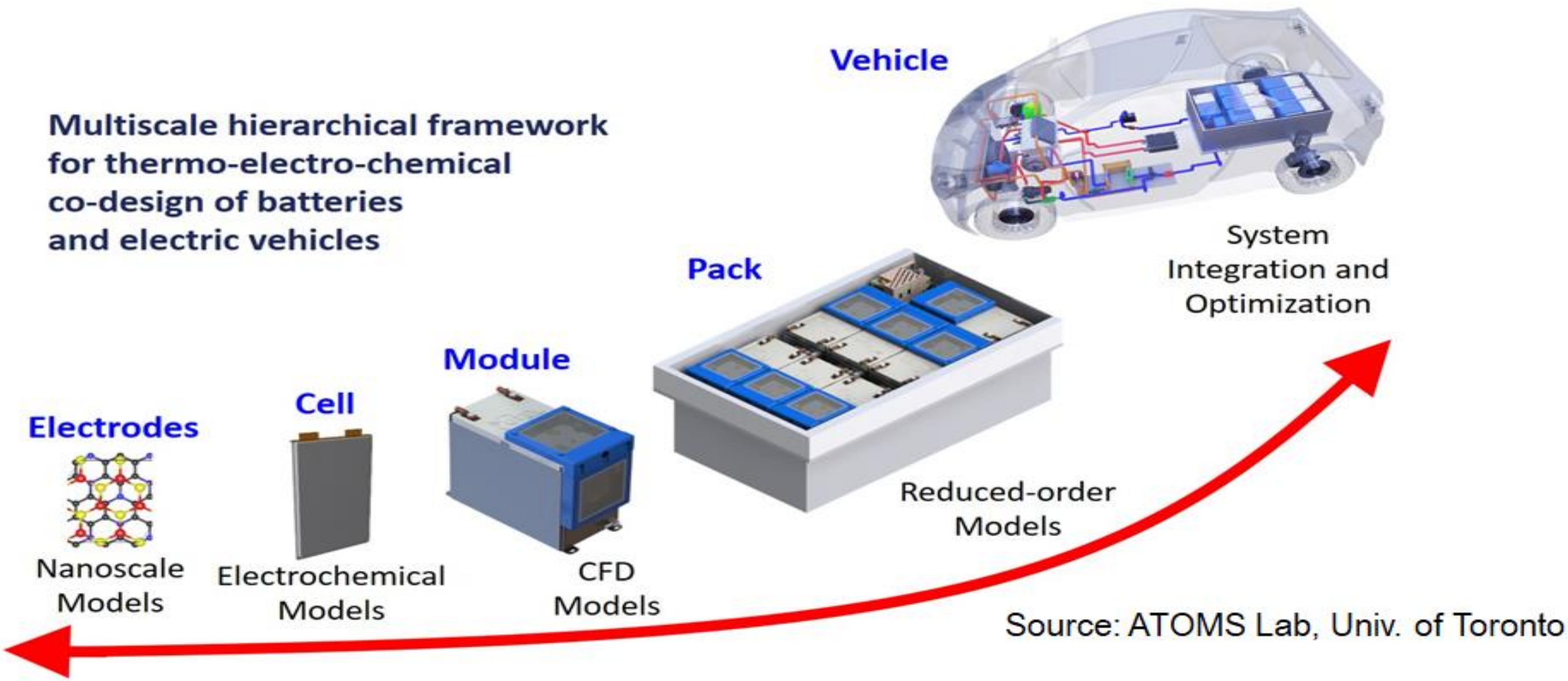
Sensitivity: Internal

Next Generation of Battery and BMS Technology for AV

Addressing Design and System Integration is a multi-scale challenge



Challenges that need to be accounted for while understanding the physics of operation and degradation of NIB

Next Generation of Battery and BMS Technology for AV

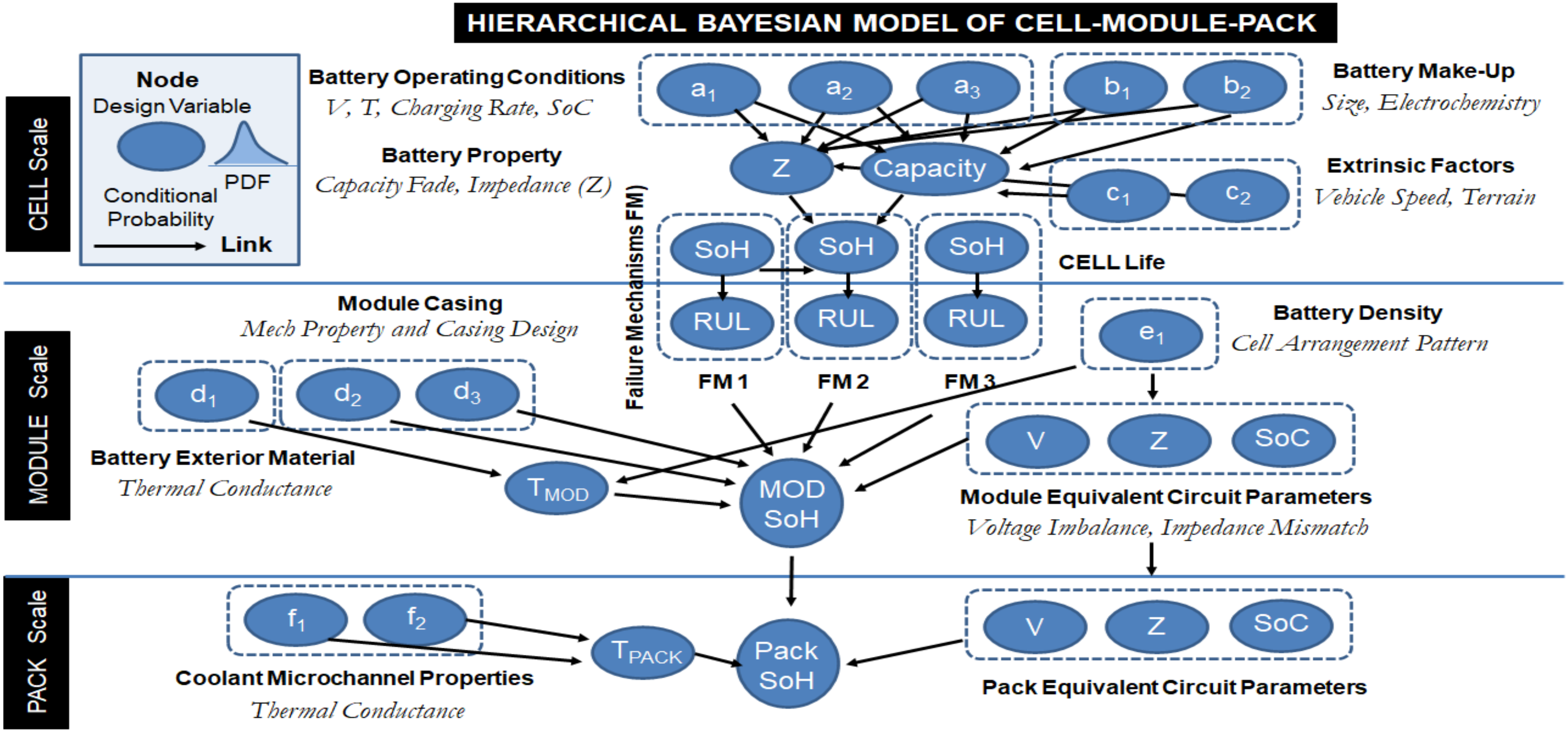


Illustration of the Hierarchical Bayesian Network that captures the ontology of degradation influencing factors at the cell, module and pack level through probabilistic knowledge graphs

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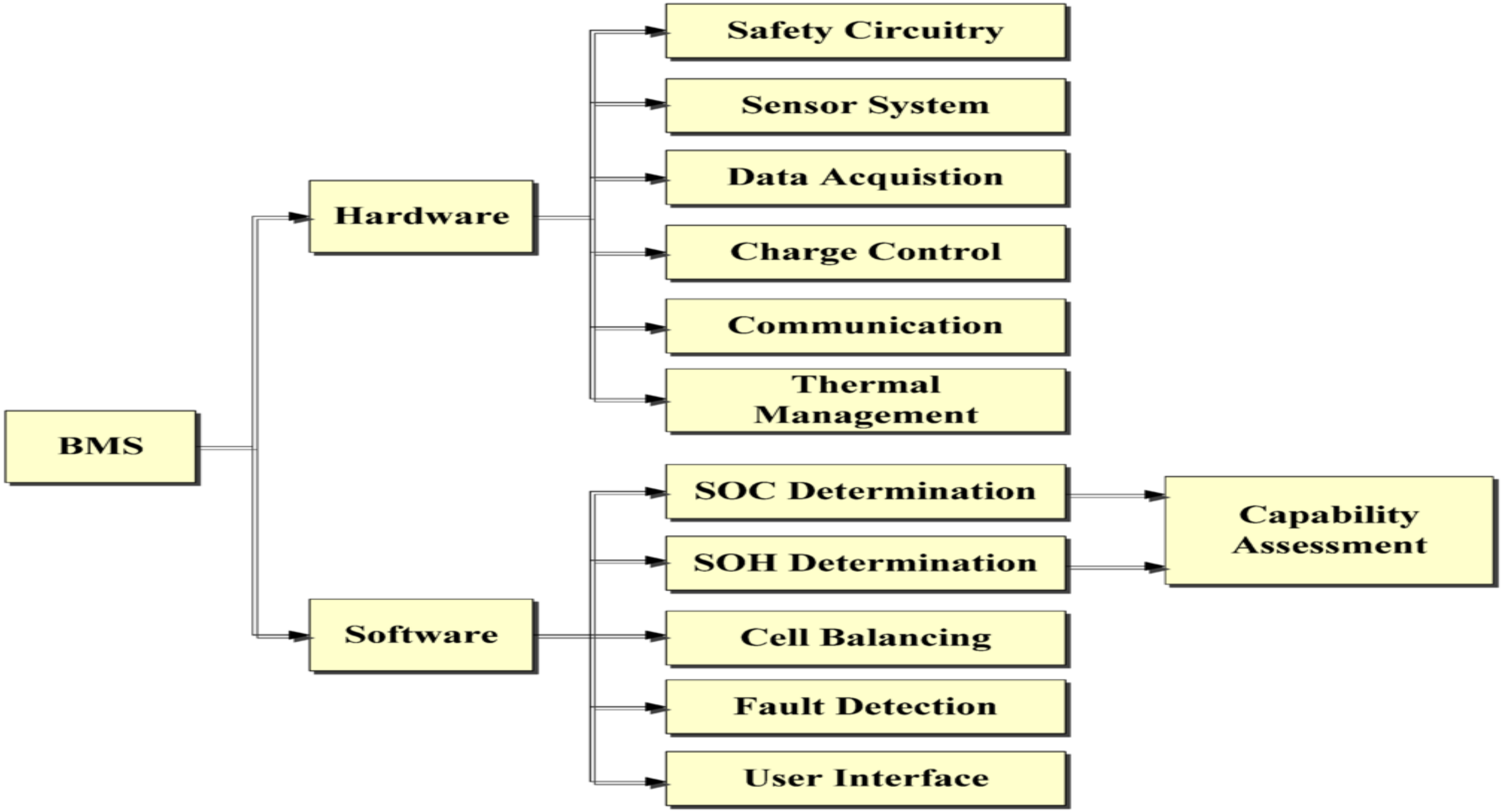
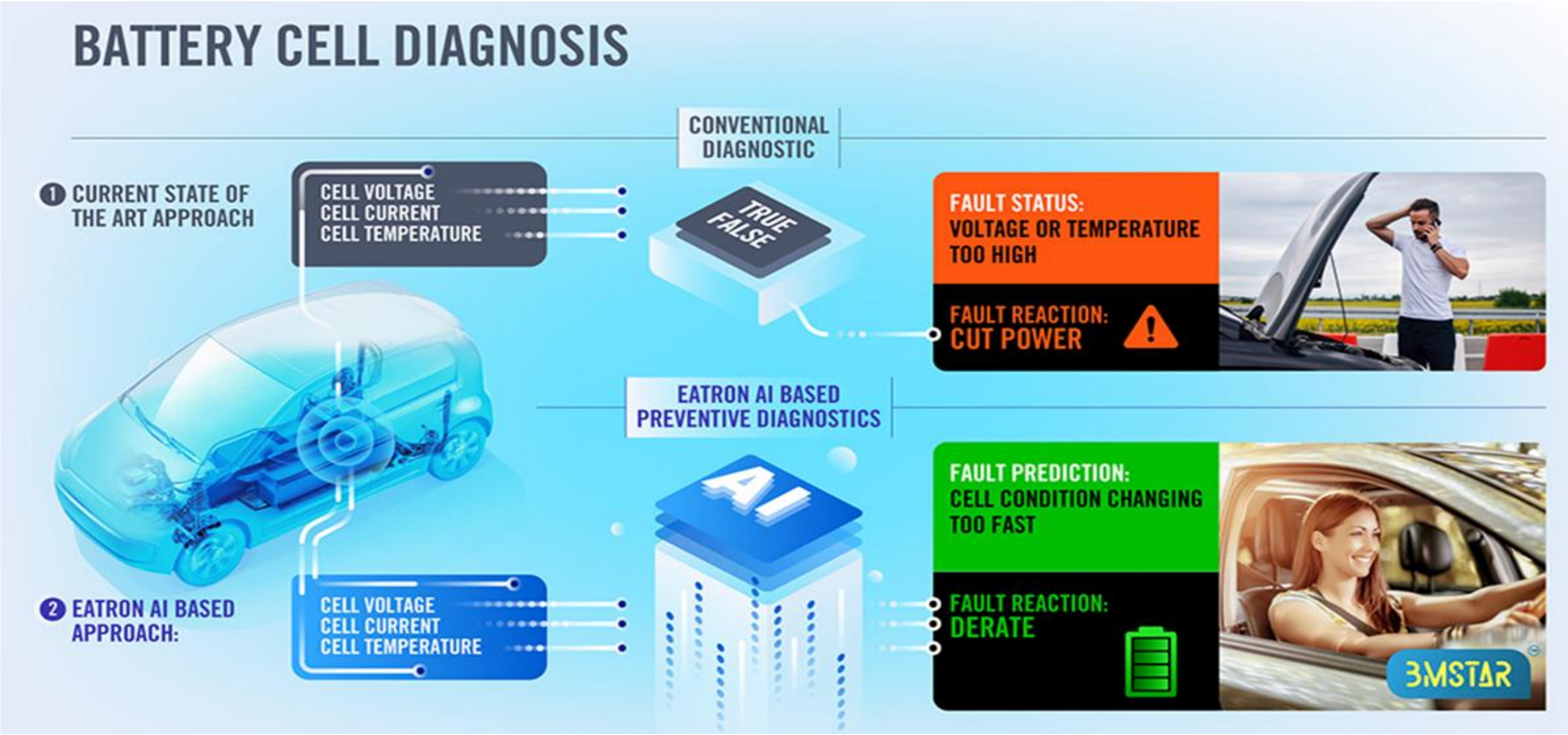
Next Generation of Battery and BMS Technology for AV



BMS Main Function Flow Diagram

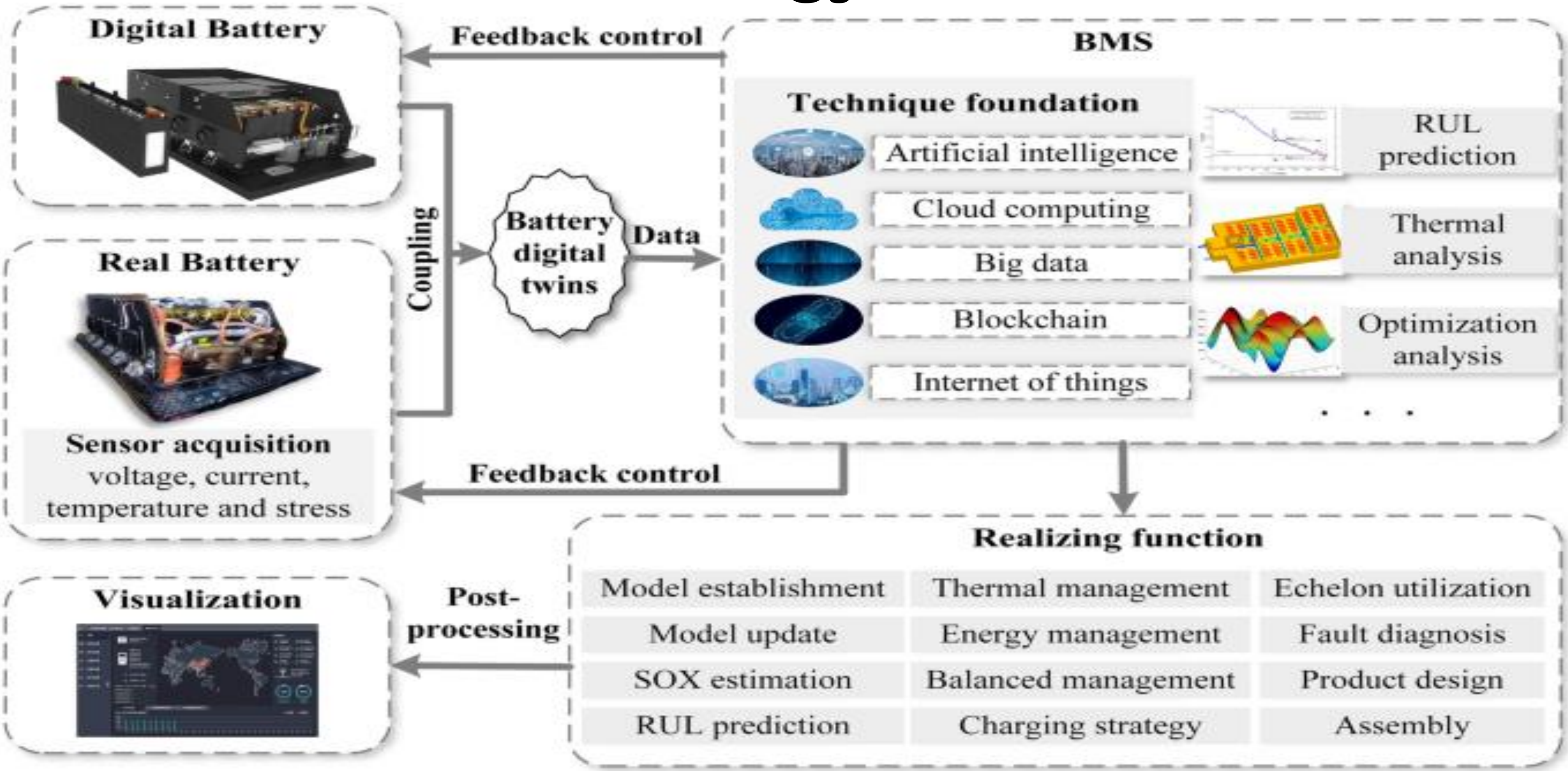
Next Generation of Battery and BMS Technology for AV



Solutions Proposed By EATRON in a R&D Stage

https://eatron.com/ai-points-the-way-to-better-ev-battery-management/

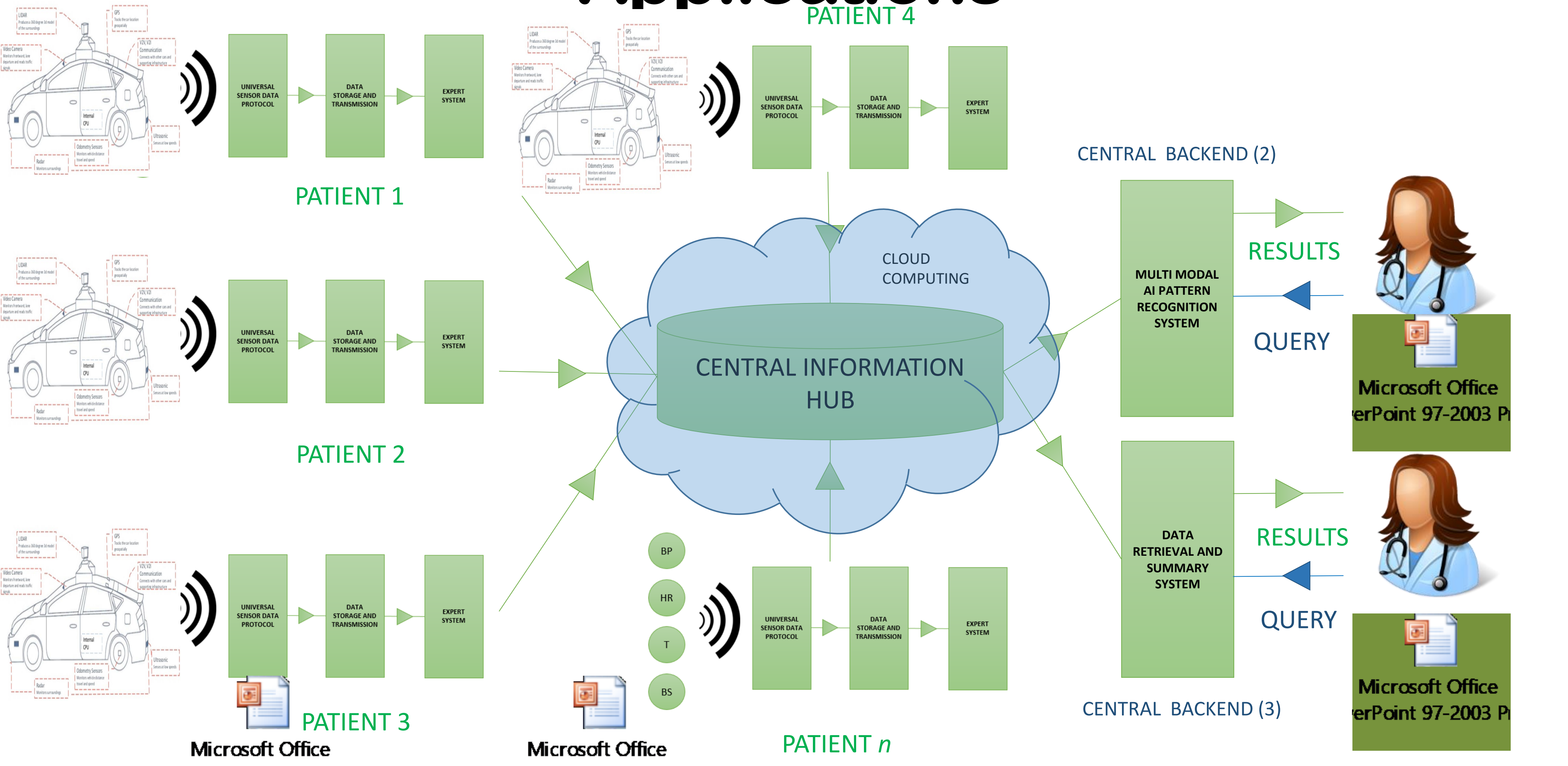
Next Generation of Battery and BMS Technology for AV



Application of Digital Twin in Smart Battery Management Systems (Wang et al.,2021)

Industry 4.0, Steer and Fly by Wire: Towards Connected Autonomous Vehicles Technology for Future Smart Cities Applications

Platform Solution for Connected Vehicles Applications



Schematic View of Connected Vehicles Network System Architecture

Platform Solution for Connected Vehicles Applications

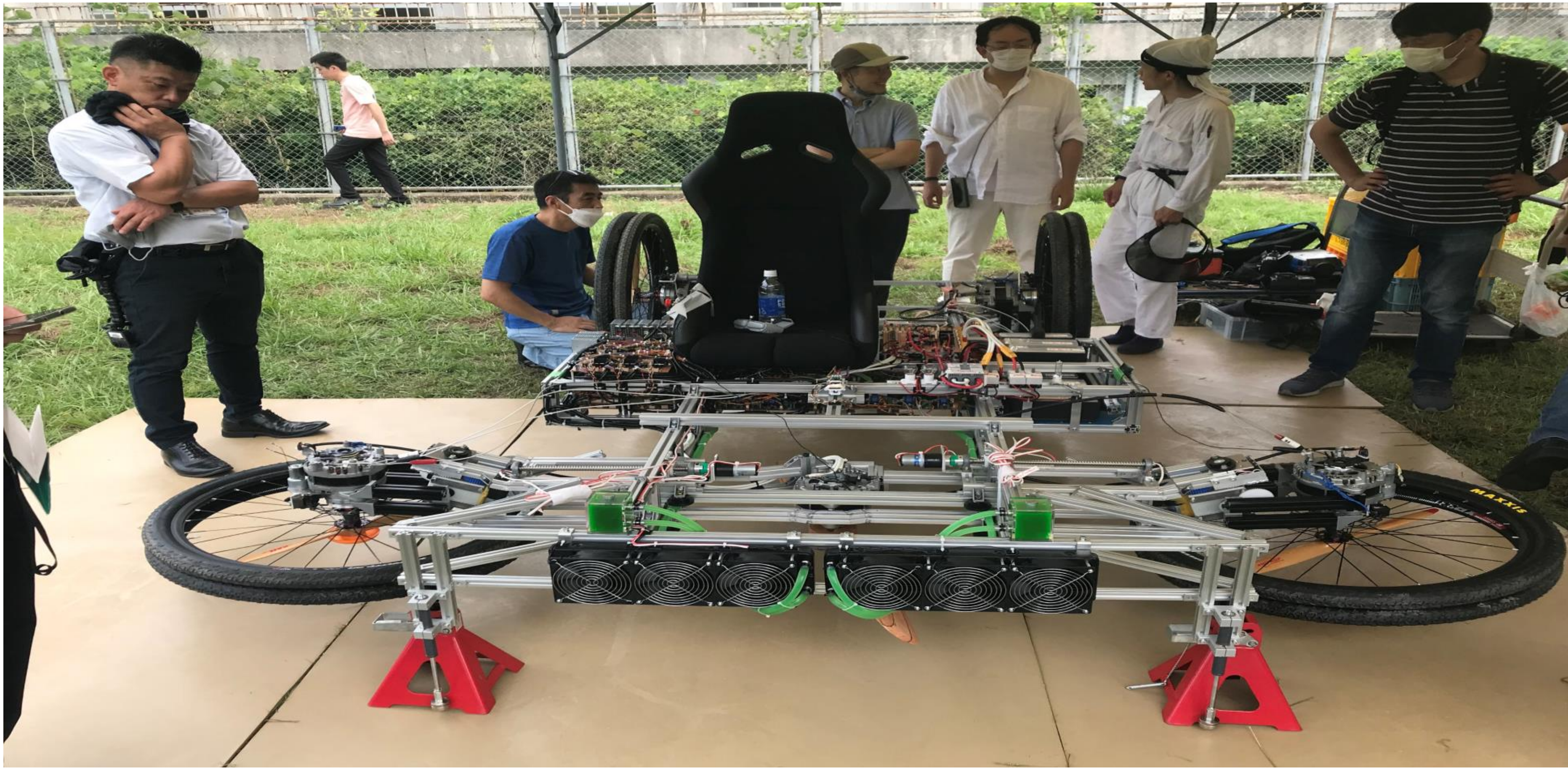
System Architecture:

1. Blockchain!!!
2. Cyber Security Platform Solution using Machine Learning, Deep Learning, and Cognitive
3. Edge Computing
4. Cloud Computing
5. Big Data & AI
6. IoT & IoE …etc.!

Industry 4.0, Steer and Fly by Wire: Towards Connected Autonomous and Hover Vehicles Technology for Future Smart Cities Applications

Sensitivity: Internal

Fly by Wire: Towards Hover Vehicles for Future Smart Cities Applications



Hover Vehicles for Future Smart Cities Applications – Tokushima University

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Sensitivity: Internal

Fly by Wire: Towards Hover Vehicles for Future Smart Cities Applications

Hover Vehicles for Future Smart Cities Applications – Tokushima University

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Boots
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David Nieper
NetworkRail
DERBYSHIRE
County Council
faurecia
BRIEFYOURMARKET.com
RATEMY PLACEMENT
npower
An RWE company
Mattioli Woods plc
graduate-jobs.com
Sainsbury's
Px tech
SNC·LAVALIN
Derby City Council
JCB
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BE THE BEST
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Putting Learning and Teaching into Practice!

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Towards Connected Autonomous and Hover Vehicles - Ways Forward!

- It is very much believed that industry 4.0 and ICT will have a great impact on future traffic and transportation services and facilities within smart cities that will be fully equipped to ensure connected vehicles and services meet the end-user needs and expectation.

- It is the use of Smart Sensors Wireless Network Technology, IoE, Big Data, 5G, and AI that will have the supreme prospective, in the coming decades to revolutionise the concept of Intelligent Traffic And Transportation Services.

Summary and Discussions!

- **Excellence and Business Growth:**
  - Innovation and Knowledge Transfer
  - Finding Pioneering Solutions
  - Skills and Training
  - Retain Clients
  - New Business
  - New Clients
  - Spin-Out Companies
  - Income Generations

Thank You!

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TRELLEBORG
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GRIDSERVE
SUSTAINABLE ENERGY
M&S
FOOD


UP TO 90 kW
UP TO 350 kW
UP TO 350 kW
UP TO 90 kW


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SMS
INDRA


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The above steps are elaborated as follows:
Task 1.1: Load the driving cycle