

工業技術研究院

Industrial Technology
Research Institute

Taiwan Electric Vehicle Technology Development and Industrial Ecosystem

Dr. Jwu-Sheng Hu

Chairman

Mobility-Taiwan Automotive Research Consortium (mTARC)

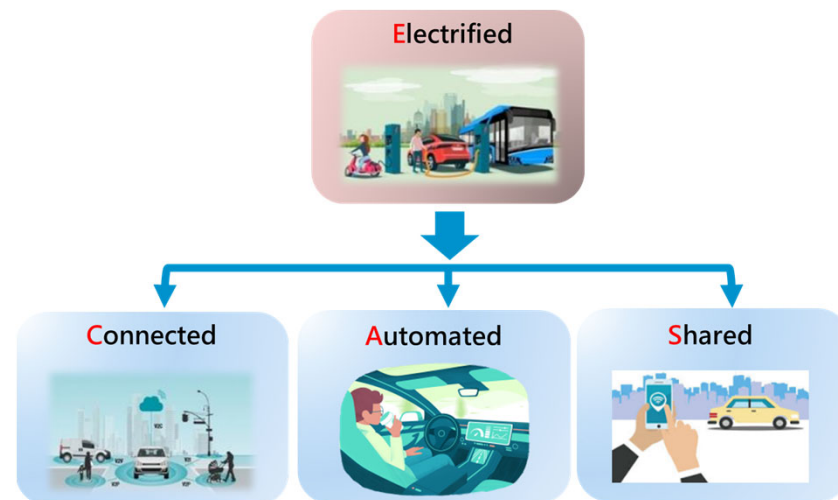
VP & General Director

Mechanical & Mechatronics Systems Research Laboratories

Industrial Technology Research Institute, Taiwan

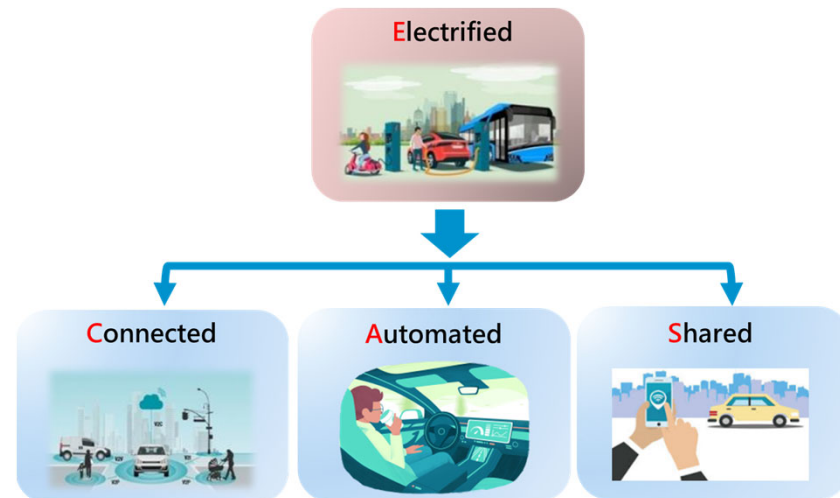
Agenda

- Global Trend
- EV Technology and Taiwan Industrial Status
- Policy, Alliance, and Consortium



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- Global Trend
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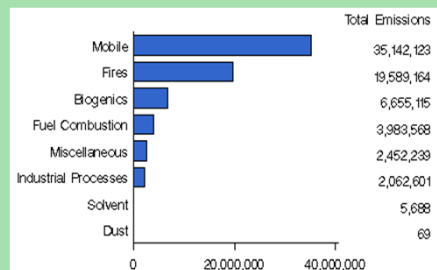
The era of EV

Global warming, carbon emission targets, government policy

- The Paris Convention is a binding EU target to reduce greenhouse gas emissions by **40% by 2030, compared to 1990**.

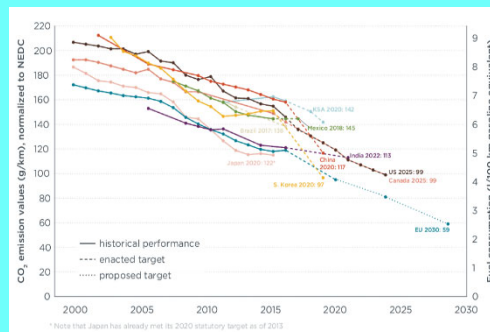
1. Global warming

- 171 countries signed the Paris Convention in 2015
- According to EPA survey, **more than 50%** of CO₂ emissions in US come from mobile pollution sources



2. carbon emission targets

- From 2015 to 2025, the average emission reduction target is **40%**
- the EU fleet-wide average emission target for new cars will be **59 g CO₂/km** in 2030.



3. government policy

- The 2020 top 3 countries in the global EV market (BEV + PHEV): **China, Germany** and **the United States**

Country	Year	Policy
China	2035	50% BEV, 50% PHEV
Germany	2030	New license for ZEV only
USA (CA)	2035	ZEV for new cars
Norway	2025	ZEV for new cars
UK	2030	No new fossil fuel vehicles
Japan	2035	BEV or HEV for new cars
France	2040	No new fossil fuel vehicles

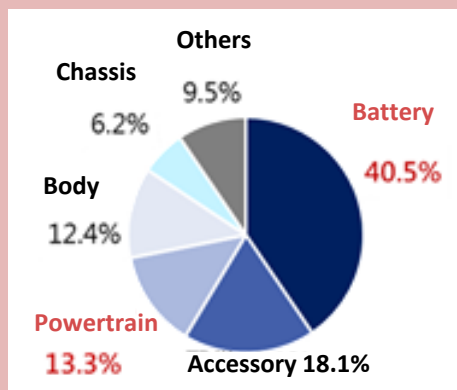
Key components: batteries, motors and electronic control

- Batteries occupy the most expensive cost.
- eAxles can be easier for the OEM to integrate due to the reduced number of parts, increasing serviceability for fleets.
- Wide bandgap semiconductors become a hot topic in electronic control products.



Batteries

- Battery packs account for **40%** of the total cost of electric vehicles, which is the key to narrowing the cost difference to fuel vehicles



Cost structure of pure EV



motors

- Electric vehicle powertrain:
 - Motor, inverter, reduction gear, gearbox
 - eAxle is the key to development of motors
- Bosch 、 GKN 、 Denso 、 BorgWarner and Nidec Corporation

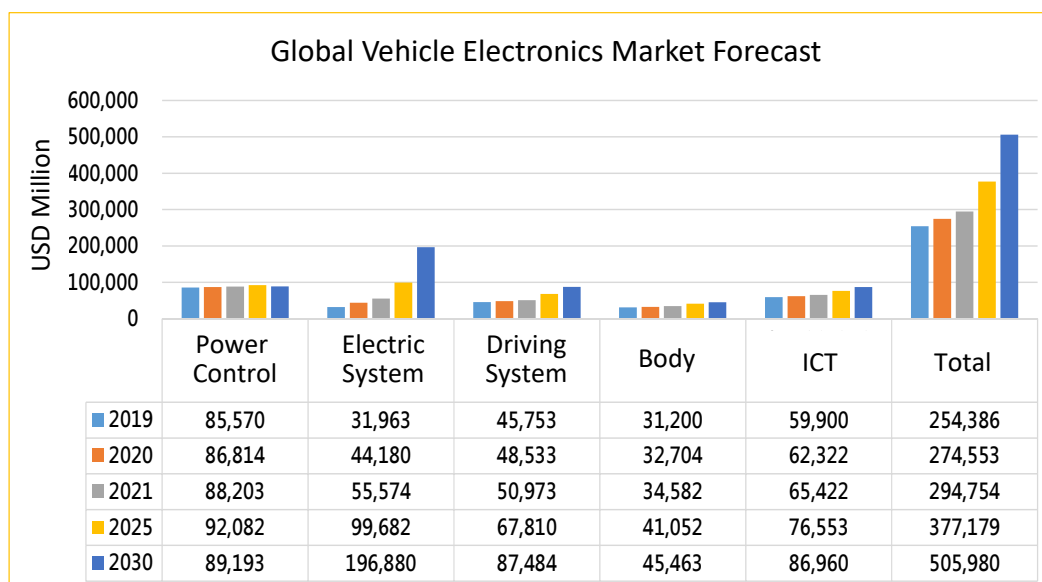


Electronic control

- The master controllers of the EV determine energy consumption, power, control, comfort and other performance
 - VCU
 - MCU
 - BMS
- Wide bandgap semiconductors such as GaN and SiC allow for greater power efficiency, smaller size, and lighter weight.

Global strong demand of power modules for EV

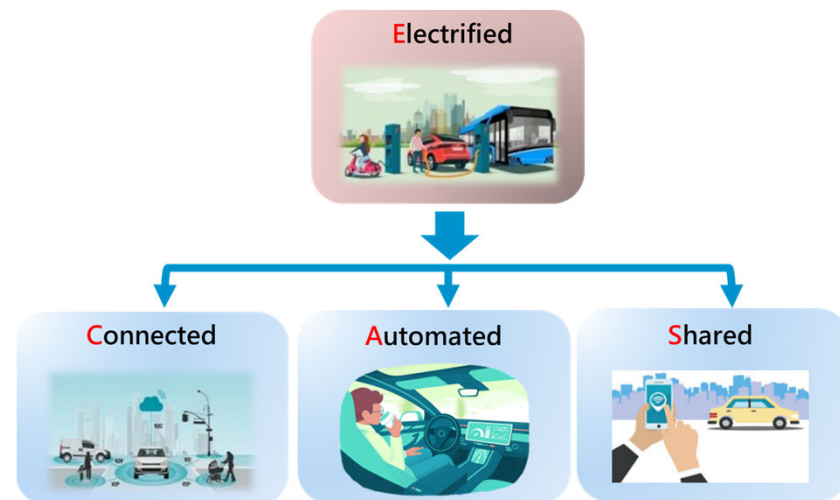
- With the increase in sales of electric vehicles (HV/PHV/EV/FCV), the demand for power modules has grown significantly.
- In 2030, the global output of electric vehicles will be 23.58 million, an increase of 10.7 times compared with 2019, and the sale of related power modules will increased by 6-12 times depending on the product.
- SiC power semiconductor devices can be applied in inverters, DC converters, on-board chargers and DC fast chargers.



Sales of Vehicles and Power Modules			
Item	2019	2030F	Growth Rate
All	90.3M	105.8M	1.2
Non-EV	88.09M	82.22M	0.9
EV	2.21M	23.58M	10.7
Inverter	5,713K	34,310K	6.0
Converter	7,891K	56,890K	7.1
Charger	2,960K	26,260K	8.8
Fast Charger	50K	600K	12.0

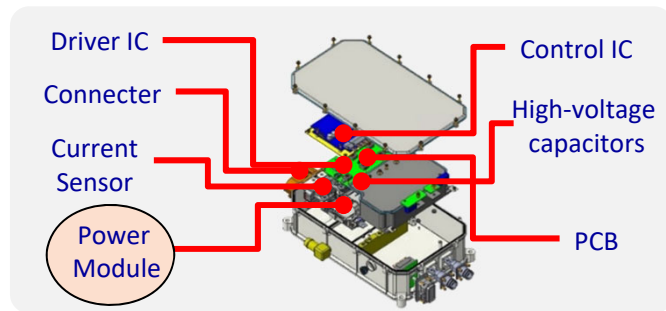
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High Efficiency Power Electronics

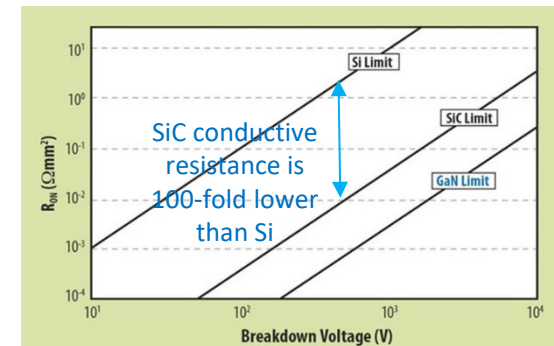
- High bandgap semiconductor
- Control chips and controller
- High voltage capacitors
- Packaging and heat dissipation



ITRI SiC Traction Motor Drive

- High power density 40kW/L
(current spec. $\sim 10\text{kW/L}$)
- High efficiency 99% (current spec. 96%)

Materials Property	Si	SiC-4H	GaN	CVD Diamond
Band Gap (eV)	1.1	3.2	3.4	5.47
Breakdown Field (10^6 V/cm)	0.3	3	3.5	10
Electron Mobility ($\text{cm}^2/\text{V}\cdot\text{sec}$)	1450	900	2000	4500
Electron Saturation Velocity (10^6 cm/sec)	10	22	25	20
Thermal Conductivity ($\text{Watts}/\text{cm}^2\text{ K}$)	1.5	5	1.3	24



EV Motor Power Density and Rare Earth Material

- Motor cost and power density demand
 - U.S. Drive Electrical and Electronics Technical Team 2025 target
 - Cost \$6/kW · power density 33 kW/L (@ 100 kW peak power)
- Dependency of high performance motor on rare earth materials
 - Presently most EV motors are PMSM
 - Most speed under 20,000rpm · rare earth material occupies 15~30% motor cost
 - Rare earth material price increased 200% in a year · high magnetic energy capacity (> 42 MGOe) and high temperature endurance (UH/EH) such as neodymium and boron become strategic material among nations.

表. 國際主要電動車款馬達類型

車廠	永磁馬達	感應馬達
Tesla	Model 3	Model S、Model X
Nissan	Leaf	無
Toyota	Prius	無
BMW	Active Hybrid、i3	Mini-E
Volkswagen	ID.3	無
Benz	無	EQC
Chevrolet	Volt	無
比亞迪	秦、宋	無
吉利	帝豪車系、幾何 A	無
北汽	EC 車系	無
上汽	榮威車系	無

資料來源：各車廠、車輛中心整理(2020/01)

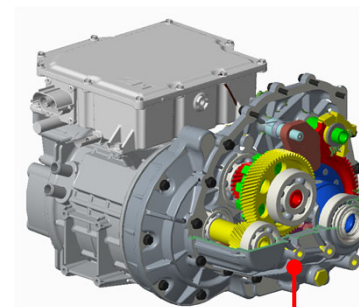
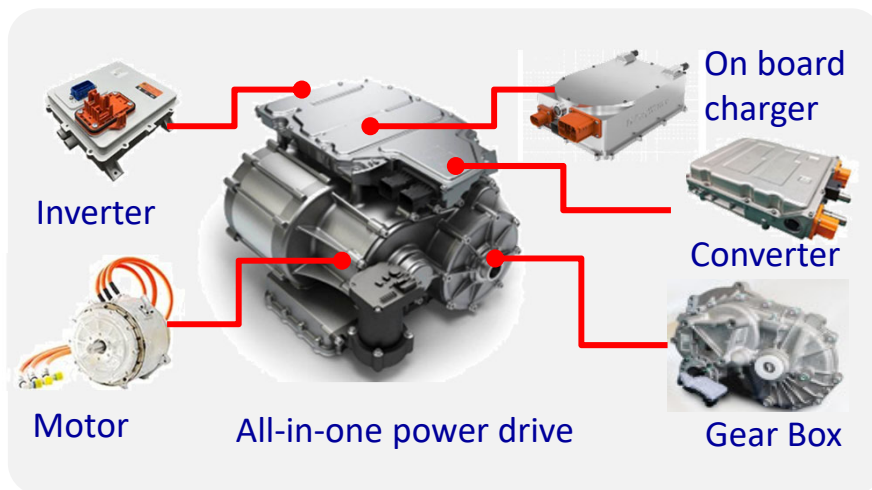
Dependency of high performance motor on rare earth materials



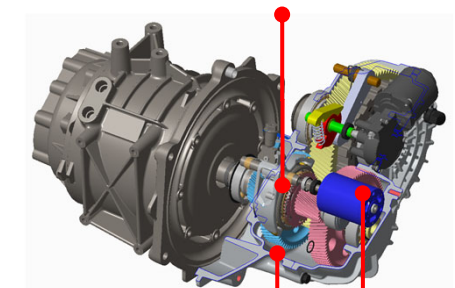
Rare earth material price increased 200% in a year

Integrated power drive

- Power drive unit integration
 - Cost reduction for massive manufacturing, weight reduction, compact design, less wire harness and efficient cooling.
- Leading mechatronic companies in Taiwan with strong support from local motor, gear, and power electronic supply chain.
- Innovation
 - Efficiency optimization for high gear reduction ratio and gear shift mechanism.
 - Novel motor design for zero rare earth material, high speed (> 20000 rpm) and high voltage ($> 1000V$).



Synchronizer/Shift mechanism



Gear Shift actuator/controller

All-in-one power drive

Taiwan's supply chain

Supply Chain

Potential System Integrated Maker
(Delta/Teco/Fukuta/Tatung)

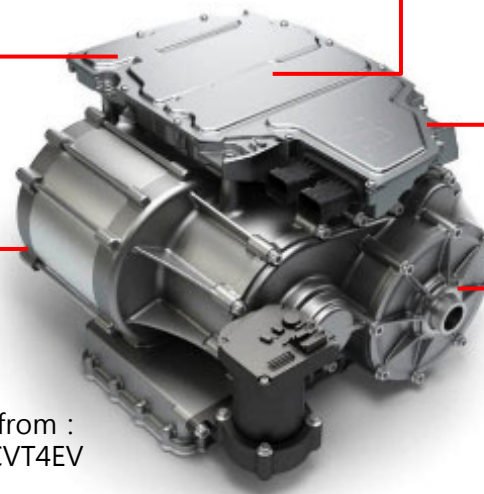
- Inverter : Delta/Teco/Chroma
- IGBT : Actron 、 Panjit 、 Santec



- Motor : Fukuta/Teco/
Delta/Tatung/Shihlin



Source from :
Bosch CVT4EV



- OBC : Delta/Acbel



- DCDC :
Delta/Acbel



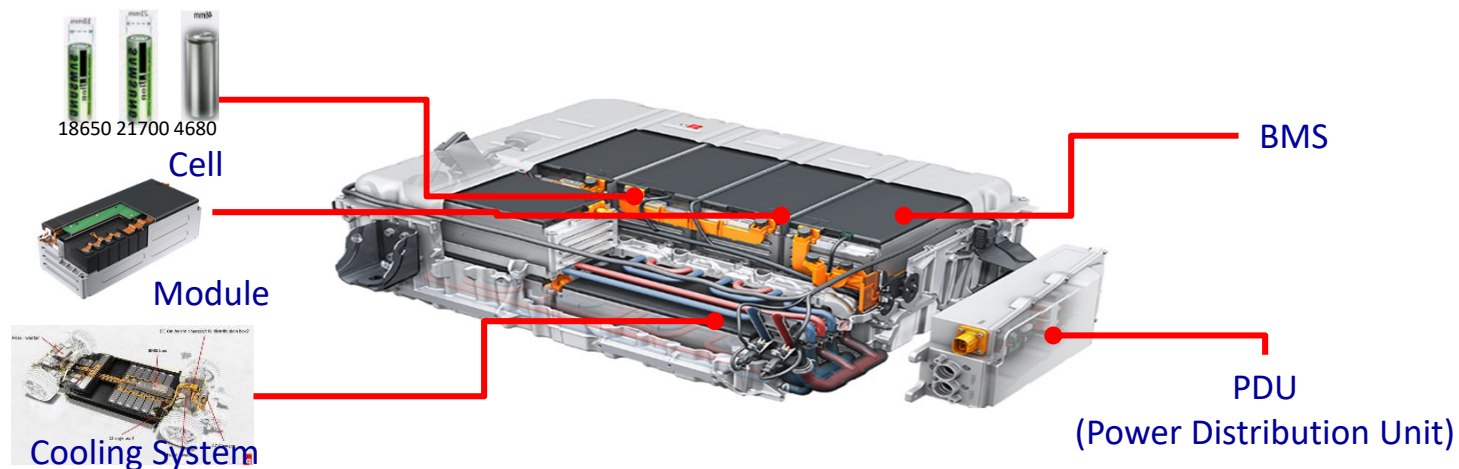
- Gear Box : Hota /Roc-
spicer/ Batom



Validation & Certification
UTAC/Chroma

Battery and Battery Pack

- Battery supply chain in Taiwan consists of a variety of companies in material (e.g., cathode, anode), electronics and mechanical components
- Development in progress for higher energy density lithium batteries, e.g., 21700 battery energy density 260Wh/kg, life > 1,000 times
- On-going research on next generation solid-state batteries.



Battery System

Taiwan's supply chain

Supply Chain

Battery Pack: Foxtron/ Delta/ Mobiletron

Cell: Molicel 、Amita 、
Delta 、PROLOGIUM 、
Phoenix battery 、Gus

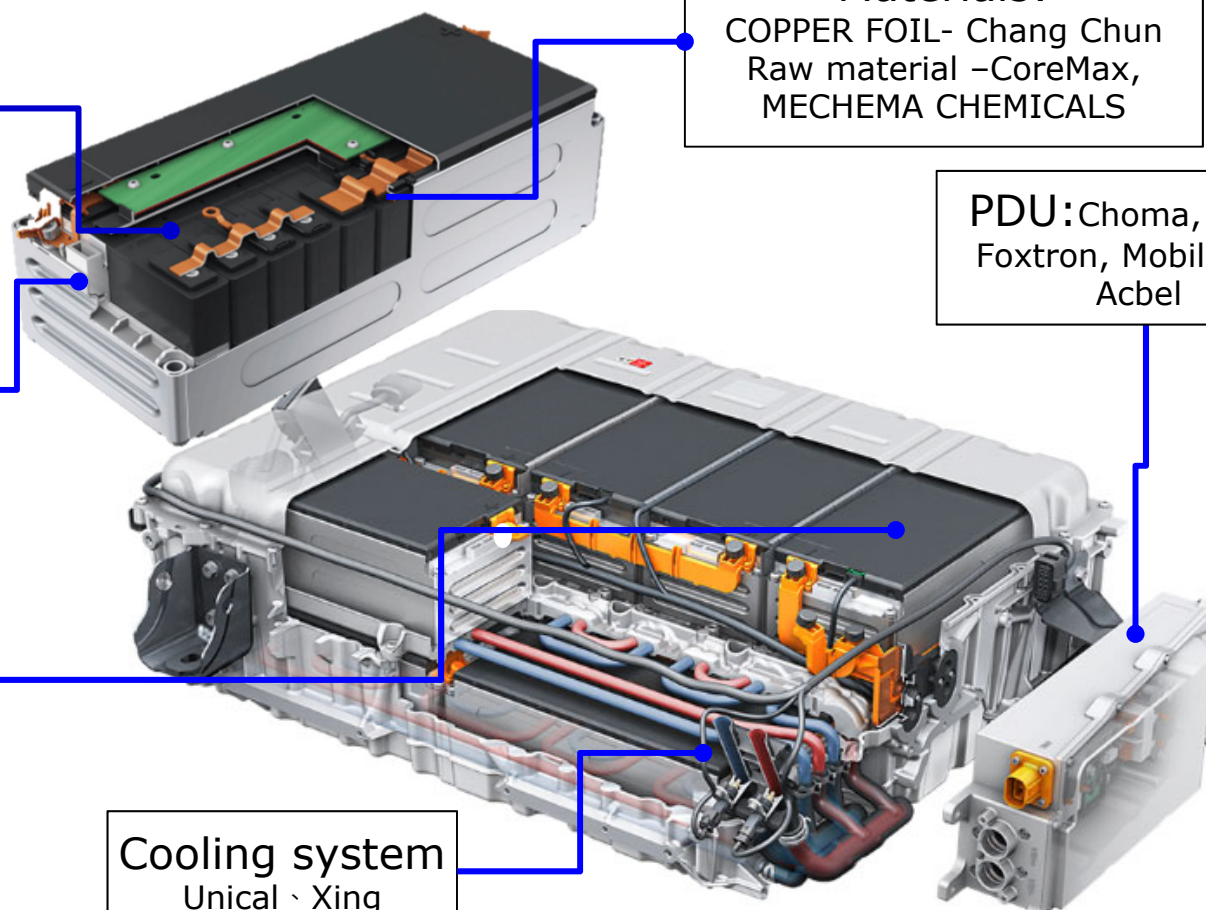
Module:
Simplo, Delta, Sti-
tech, Celxpert

BMS:
Delta, Molcel,
Amita, Mobiletron,,
Foxtron, Xing

Cooling system
Unical 、Xing

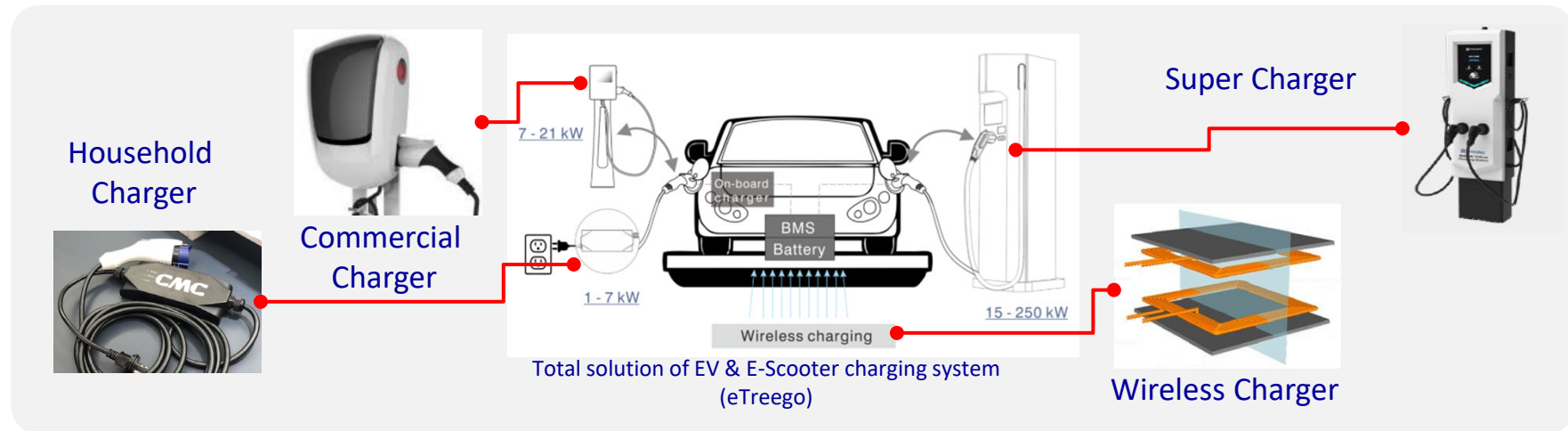
Materials:
COPPER FOIL- Chang Chun
Raw material –CoreMax,
MECHEMA CHEMICALS

PDU: Choma, Delta,
Foxtron, Mobiletron,
Acbel



Source from : Audi Q7 e-tron 2.0 TFSI
quattro

EV energy equipment and service



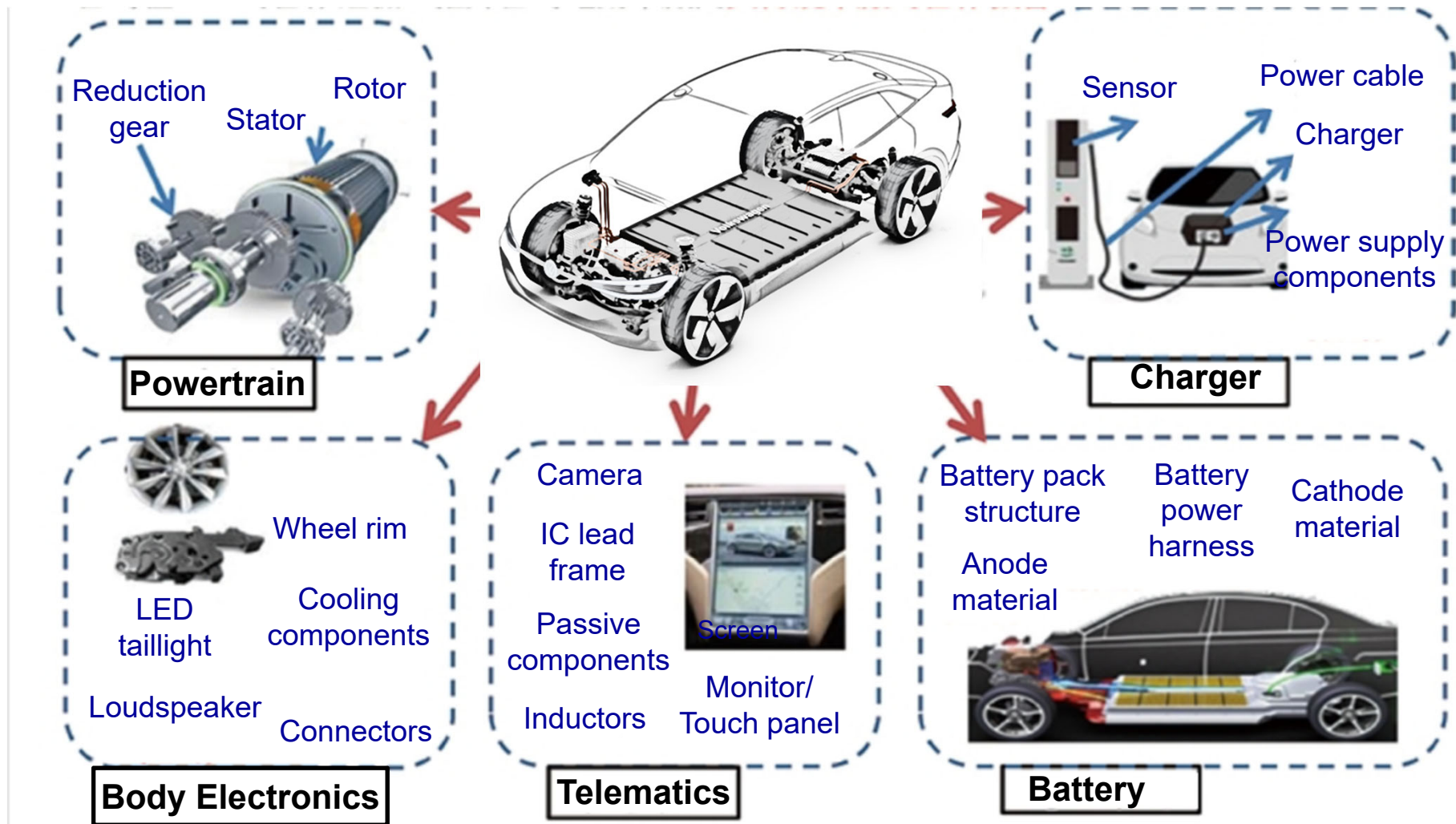
- Well-established and proven technology in charging equipment design and manufacturing in Taiwan (leading company: Delta, Pihong, Etreego)
- Deployment in progress for charging facility in gas station, highway rest area and public parking lots etc.
- Future subjects
 - V2G standards and business models
 - Green energy supply to EV



Charging integration with mechanical parking

Taiwan Products to Global EV Makers

- Taiwan laid the successful groundwork for the EV supply chain.



Taiwan ICT industry strength in EV supply chain

Vehicle Cabin Electronics

- Driver monitoring
- AR/VR
- Panel display
- Entertainment
- HMI & Telematics

Communication

- 5G modem
- LTE, WIFI
- OBU
- T-box

Sensors

- Camera
- Radar
- Lidar
- Ultrasonic
- GPS/GNSS

Autonomy

- Lane keeping system (LKS)
- Automatic emergency brake (AEB)
- Adaptive cruise control (ACC)
- Automatic parking assist (APA)
- Level 3-5 autonomous driving

Lighting system

- Light source (LED)
- Adaptive driving beam
- Optics
- Lighting controller

IC & Electronic Components

- Microcontrollers
- RISC CPU
- Power Electronics
- Passive components
- PCB
- Embedded computer

ADAS (perception)

- Blind spot detection (BSD)
- Lane departure warning (LDW)
- Around view monitor (AVM)
- Forward collision warning (FCW)

Taiwan EV Manufacturing

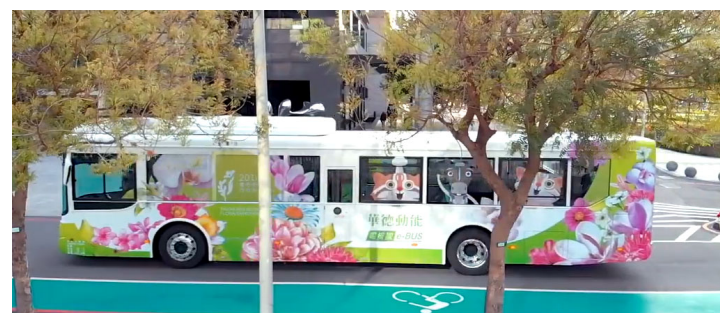
- Domestic and OEM automotive manufacturing facility
 - Small volume and mixed model production experience
 - Leveraging local supply chain for production efficiency and cost reduction



Taiwan automotive manufacturing

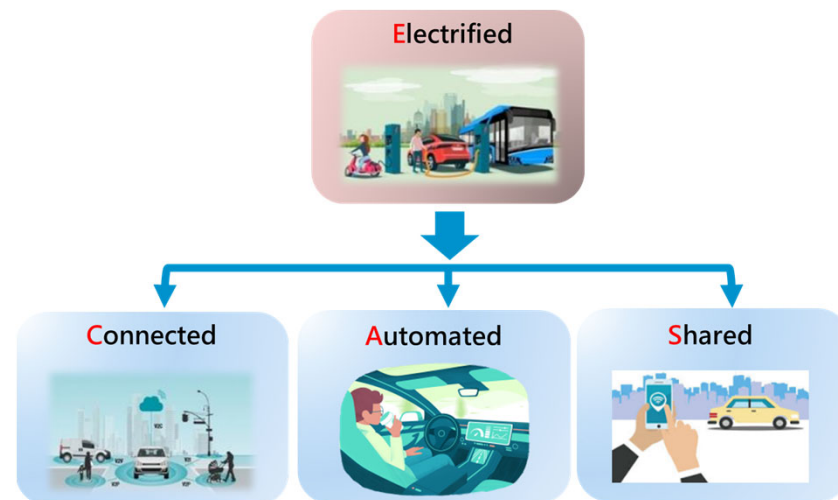


Taiwan Electric Bus Manufacturers



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Milestones for Electric Vehicles in Taiwan

➤ Policy Twins

- Electric Vehicles
- Autonomous Vehicles

➤ EV milestones

2030 Public buses and government owned vehicles

2035 Motorcycles

2040 Passenger cars



E-Bus Industry in Taiwan

Top-down Policy

- Taiwan government announced till **2030**, the **official vehicles** and **buses** should be **all electric powered**.

Key Driving Factors

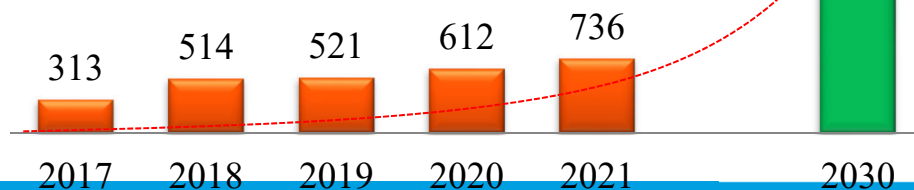
- Subsidies
 - Replace the old for new
 - New route
 - Battery purchase or lease
 - Charging station **infrastructure** settings

Key Market Players

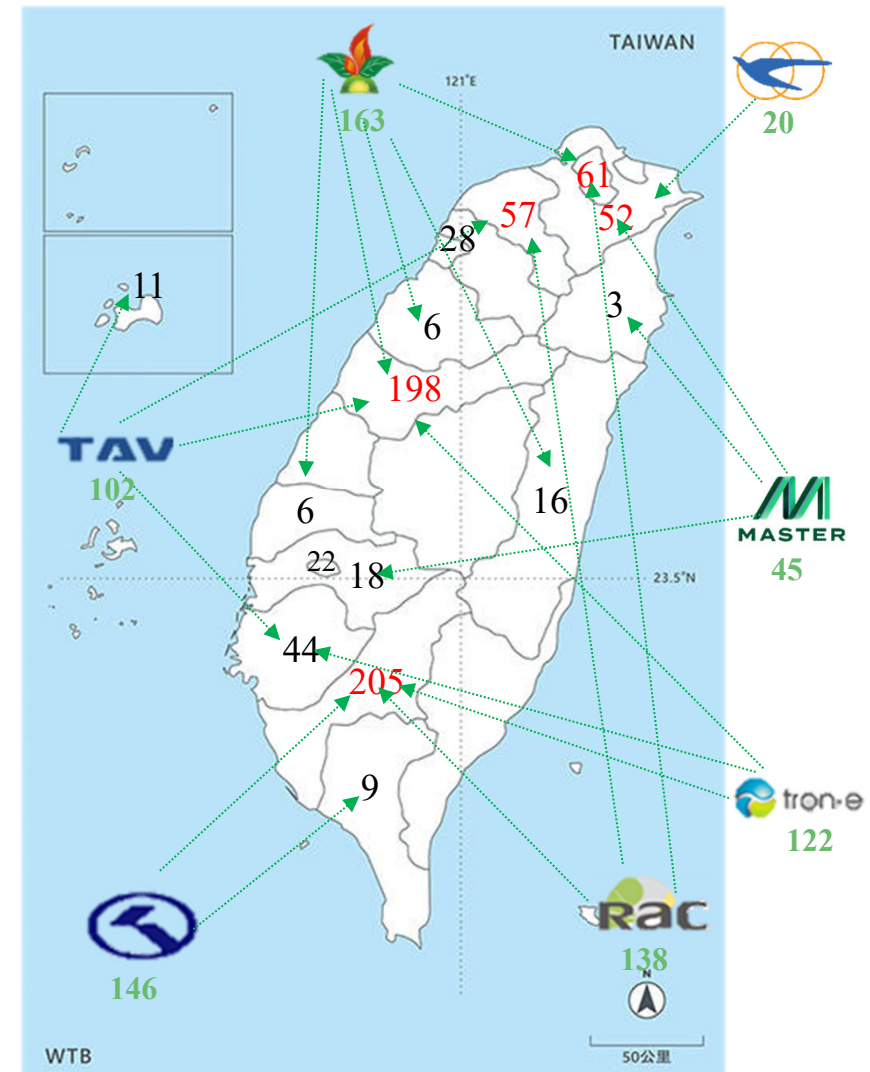
- E-Bus DMIT pilot project by the government in 2021



KGET Tong Ying Tang Eng Tronetek KING LONG



2021 : Around 736 E-Bus were registered



Source: ARTC(2021) ; MOTC(2021) ; ITRI-ISTI (2019/2)

Autonomous Driving Test/ Demonstration Fields

Vision: To Be Asian Autonomous Driving R&D and Manufacturing Center

2020 Goal : to Build up the manufacturing capability of autonomous driving in supply chain

2025 Goal : to Build up the innovation applications in autonomous driving under social needs

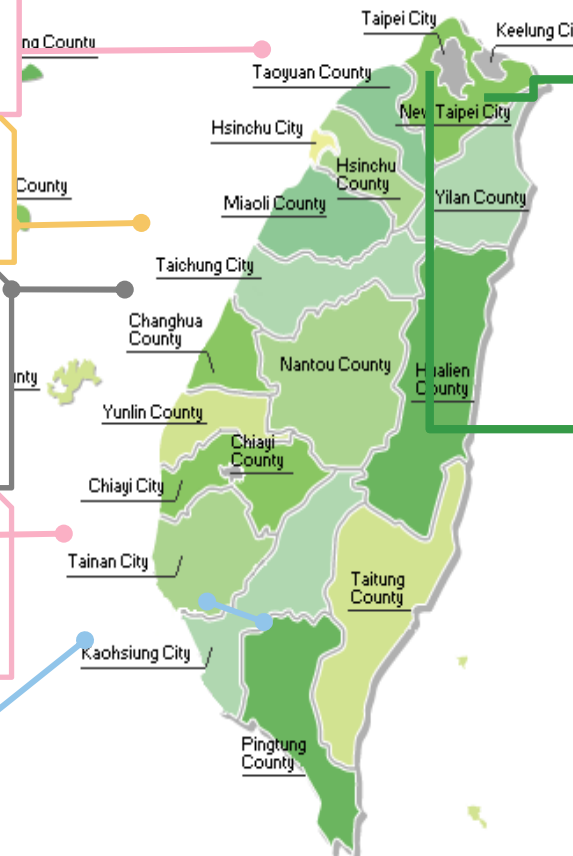
- ▶ Year: 2018
- ▶ Field Area: 5.8 Acres. (1.7 Ar. First phase)
- ▶ Type: Closed Area
- ▶ Applications: Domestic autonomous vehicles demonstration
- ▶ Applicants: nVidia, Kingway, Whetron, Turinig-Drive, etc

- ▶ Year: 2018
- ▶ Field Area: International Flower Exhibition Place
- ▶ Type: Closed Areas
- ▶ Applicants: ITRI, iAuto, Mobiletron, Racev, Gbus, LiLEE, Unex, etc

- ▶ Year: 2019~2022
- ▶ Type: Semi Open Roads
- ▶ Applications: Autonomous Shuttle Bus, Speed limit <50kph
- ▶ Test Items: Test for driving on merging roads, traffic signs, signals, mix with motorcycle, bikes, pedestrians, buses and cars

- ▶ Year: 2019
- ▶ Field Area: 2.2 Acres
- ▶ Type: Closed Roads
- ▶ Test Items:
- ▶ Applications: more than 15 scenarios for low speed shuttle buses, pods, cars,

- ▶ Year: 2017
- ▶ Field: Hamastar Yart, Pier 2, KHCC
- ▶ Test Items: Autonomous Fields Trial



- ▶ Year: 2018
- ▶ Type: Proposal for Ideas collections
- ▶ Year: 2019 RFP (Planning)
- ▶ Applicants: Domestic and International Companies
- ▶ Road Type: Semi Open Roads
- ▶ Test Items: Last Mile Public/ Private Transportation from subway to exhibition entrance)



- ▶ Year: 2018:
- ▶ Field Area :10 Acres
- ▶ Type: Closed Area
- ▶ Simulation: Real Roads
- ▶ Test Items: Technology feasibility
- ▶ Applications: Connected Vehicle(V2R), Autonomous driving in cross roads, Smart infrastructure on roads
- ▶ Users: Acer, EZ Mile, ITRI, iAuto, ITRI, ARTC, Forward, III, NTU, etc.

Source: ISTI/ITRI(2019/02)

Mobility-Taiwan Automotive Research Consortium (mTARC)



工業技術研究院 **Industrial Technology Research Institute (ITRI)**

Mechanical & Mechatronics Systems Research Laboratories

Material and Chemical Research Laboratories

Information and Communications Research Laboratories

<https://www.itri.org.tw/>



車輛研究測試中心

Automotive Research & Testing Center (ARTC)

<https://www.itri.org.tw/>



金屬工業研究發展中心

Metal Industries Research & Development Centre (MIRDC)

<https://www.mirdc.org.tw/>



國家中山科學研究所

National Chung-Shan Institute of Science & Technology (NCSIST)

<http://www.ncsist.org.tw/>



華創車電技術中心股份有限公司

Hua-chuang Automobile Information Technical Center Co., Ltd. (HAITEC)

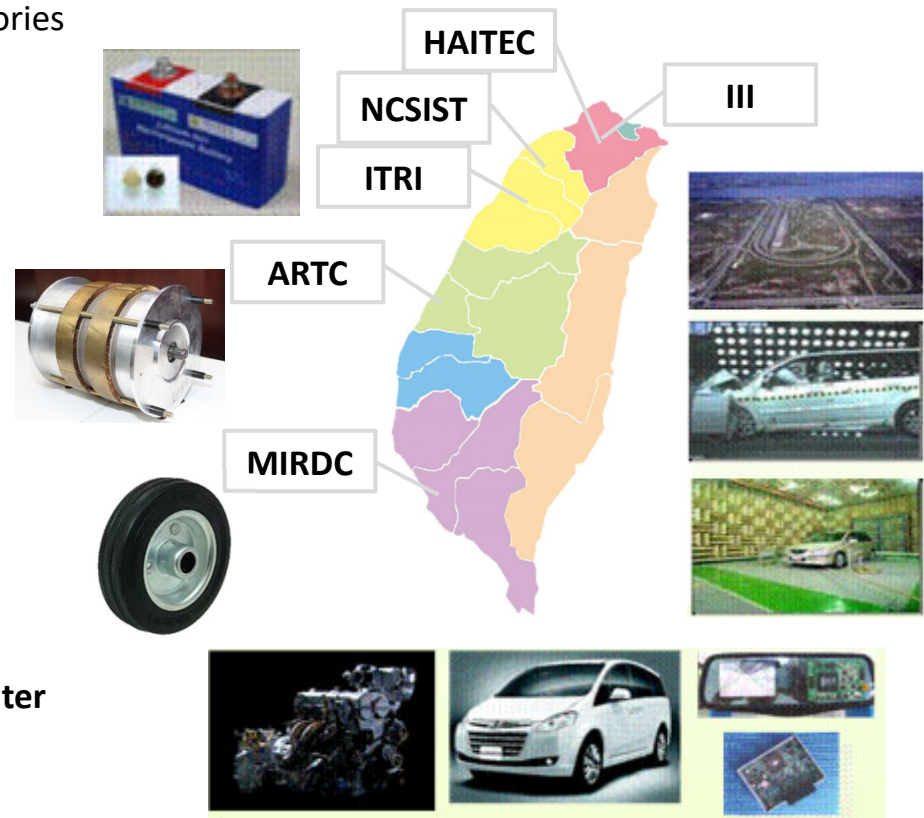
<http://www.haitec.com.tw/>



資訊工業策進會

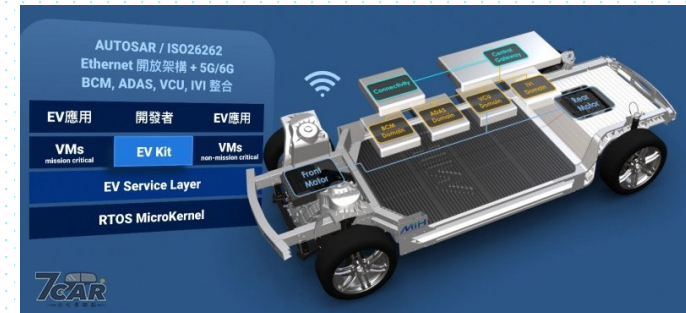
Institute for Information Industry (III)

<https://www.iii.org.tw/>



Taiwan Industrial EV Platform- MIH

- Hon Hai launched the MIH electric vehicle platform which includes more than 1600 companies.
- “EV-kit” announced in 2021 to offer a drive-by-wire platform for developers.
- New ecosystem and business model for future EV & EBus



4個級距 模組彈性客製		B+ 軸距2750	C 軸距2860	D 軸距2950	E 軸距3100
3種 驅動	前驅	●	○	●	●
	後驅	○	●	●	●
	四驅	○	●	●	●
3種 電池包	小 ~93kWh	●			
	中 ~100kWh		●	●	
	大 ~116kWh				●
電機規格	前懸吊	麥花臣	雙A臂	雙A臂	雙A臂
	後懸吊	拖曳臂	多連桿	多連桿	多連桿
	前電機單速95kW~200kW，後電機單速150kW~240kW及2速340kW				

FVT E Bus式樣與規格介紹

鴻華先進
Foxtron Vehicle Technology

簡約風尚外型

舒適科技化內裝

規格

- 尺寸(長*寬*高): 11,940 * 2,500 * 3,195 (mm)
- 軸距: 6,000 (mm)
- 座位數: 58 (28 座位 + 30 站位)
- 最大功率: 260 KW
- 最大扭矩: 3,000 N-M
- 最高速度: >90 KPH
- 續航里程: 250公里以上
- 懸吊系統: 可傾斜式電子氣壓懸吊系統
- 轉向系統: 電子液壓轉向系統(EHPS)
- 煞車系統: 防鎖死碟煞煞車系統

Taiwan EV Power Supplement Alliance

Taiwan Electric Vehicle Power Supplement Industry Technology Promotion Alliance



- Established by ITRI in September 2020.
- To reach consensus of EV charging standard (fast charging) among government, companies, industrial association and institutions.
 - More than 50 members including government agencies such as MOEA, MOI, MOTC, EPA, state-own companies such as Taiwan Power company and CPC, and private companies.
- To speed up the development of charging infrastructure and EV energy supply business in Taiwan

THANK YOU!