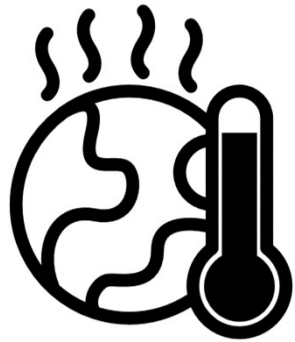


Global Experience with EVs

Andrew Campbell

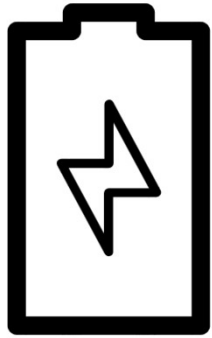
30 August 2022



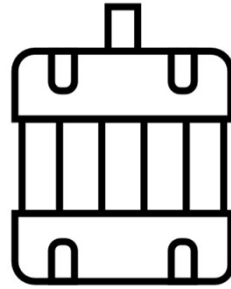
We need urgent and significant change



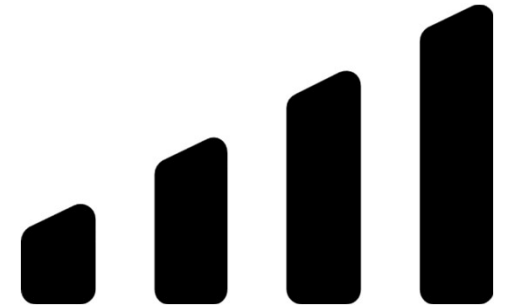
- Climate Change
- Cost of fuel imports
- Local air quality
- (Congestion)



Batteries



Motors



Networks/comms



Smartphones



GPS/satellite tech

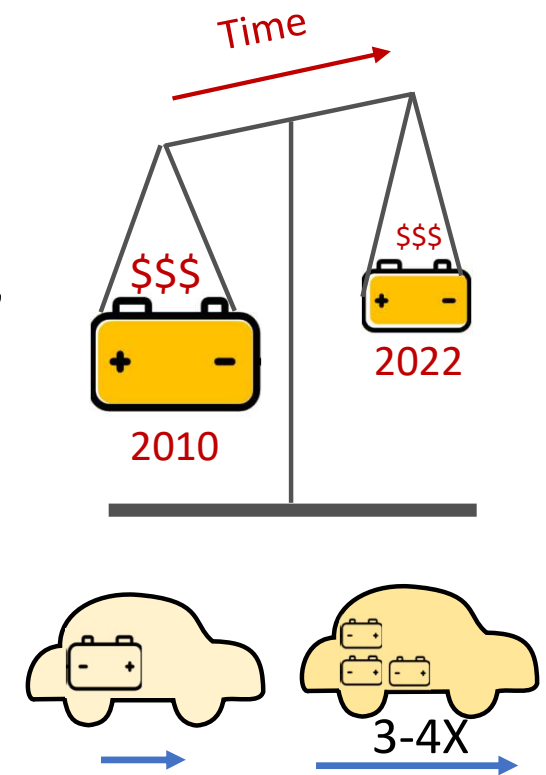
Enablers of change:

Technologies are developing rapidly →

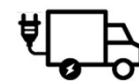
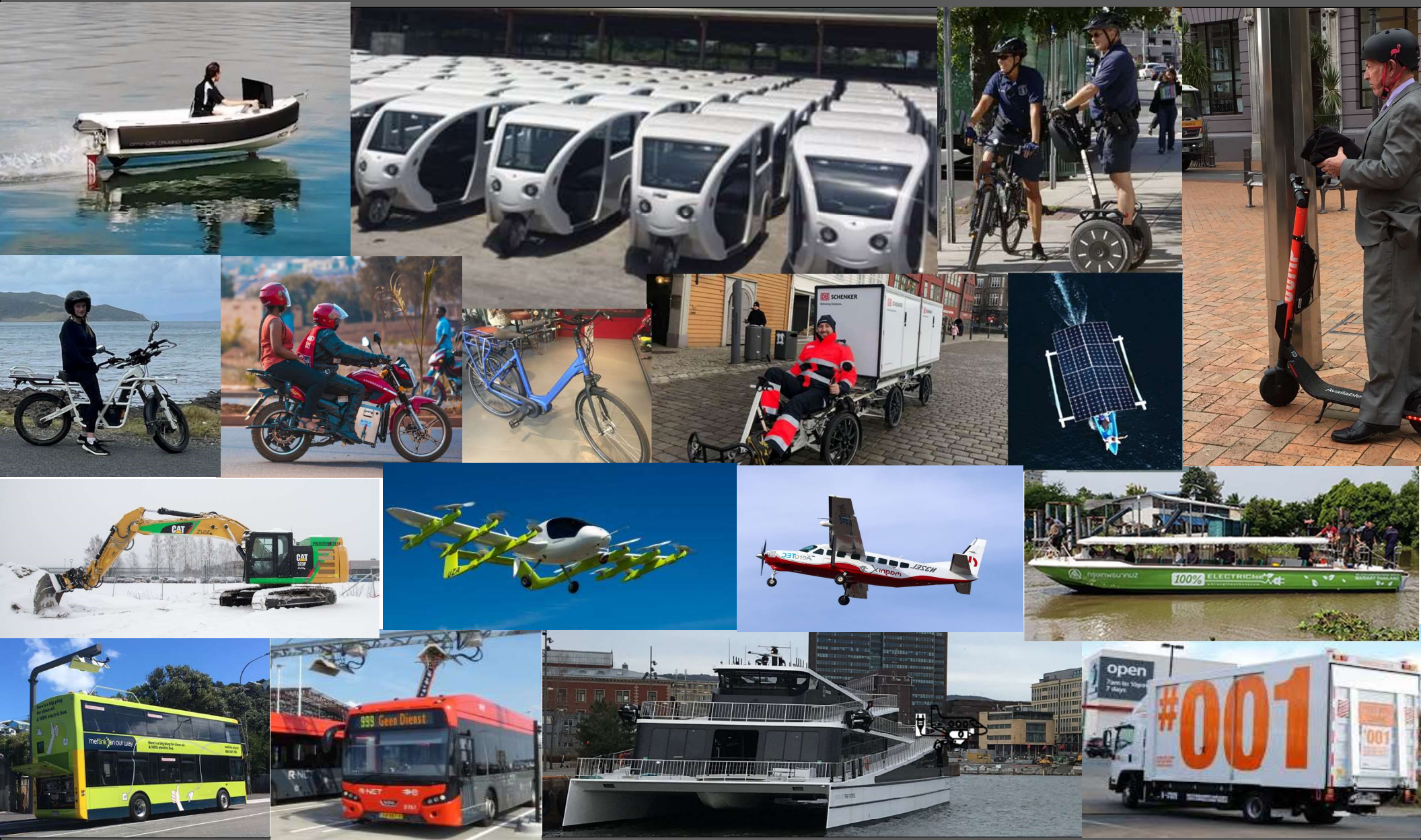
- Falling costs
- Rapidly increasing capability of technology
- Clever combinations = new ways, providing more affordable and accessible transport
 - accelerated uptake of e-mobility
 - micro- and small-format mobility
 - shared vehicles
 - connected, on demand services
 - i.e., mobility as a service (MAAS).

An example ... improvements in battery technology

- For 10 years of battery development (2010-2020)
 - 1/10th cost for same kWh
 - 1/3rd weight for same kWh
 - 1/3rd size for same kWh
- Range 120km (2010)
→ 300-400km (2020)
- 50kW “fast” charging (100km in 20 mins, 2010)
→ ‘supercharging’ at 250kW (350km in 20 mins, 2020)
- Potential to use spare capacity of new EV models with electricity supply, but not yet ...
- Expect far greater battery performance in the future.
- Small and light-weight batteries → advances/new micro/small mobility

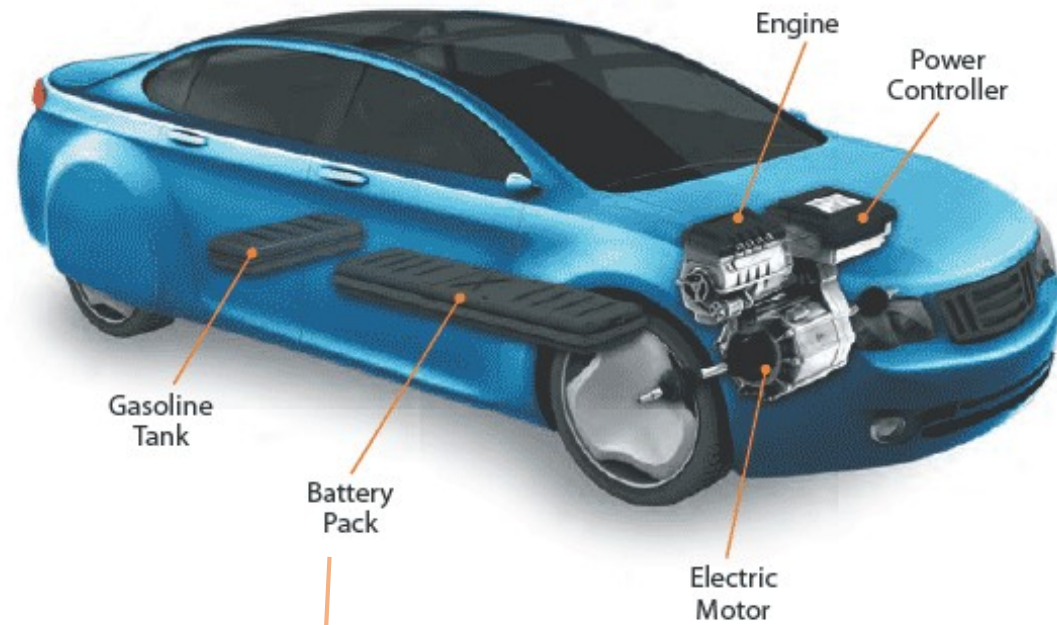


One of many results → expanding e-mobility solutions

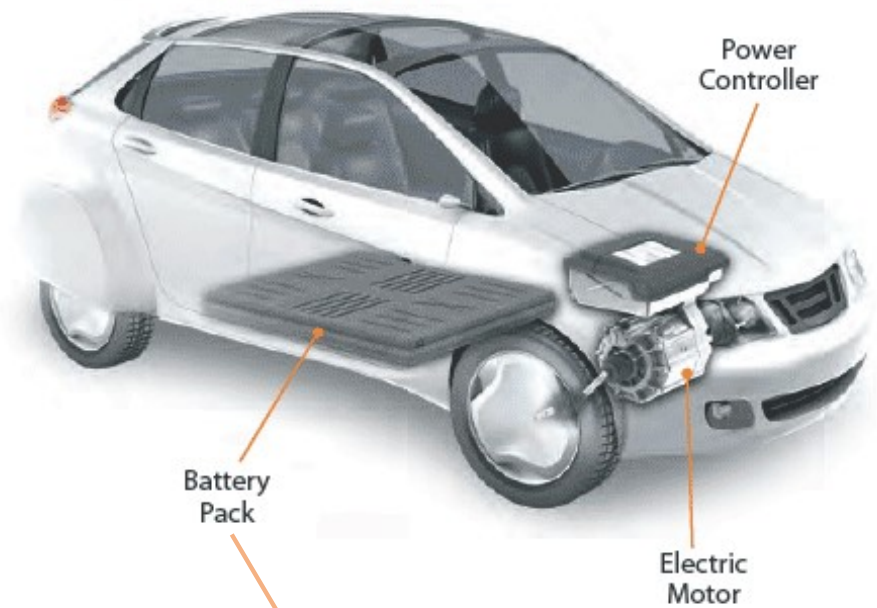


Interest is in plug-in e-mobility

Plug-in Hybrid Electric Vehicle (PHEV)



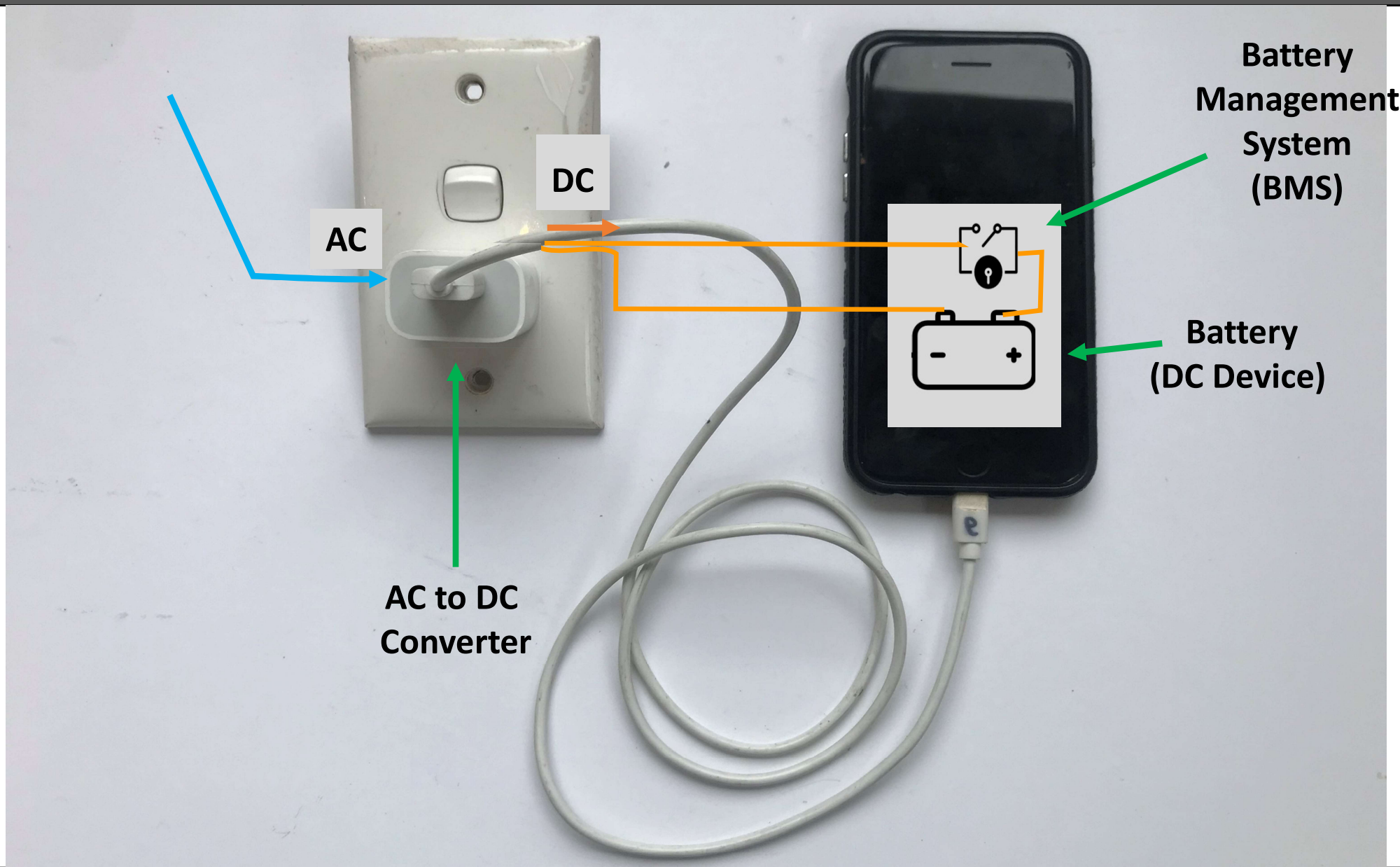
Battery Electric Vehicle (BEV)



- In common: have an onboard battery charged by an external power source
- Note: an ordinary hybrid (HEV) does not plug in and is often not counted as an EV.

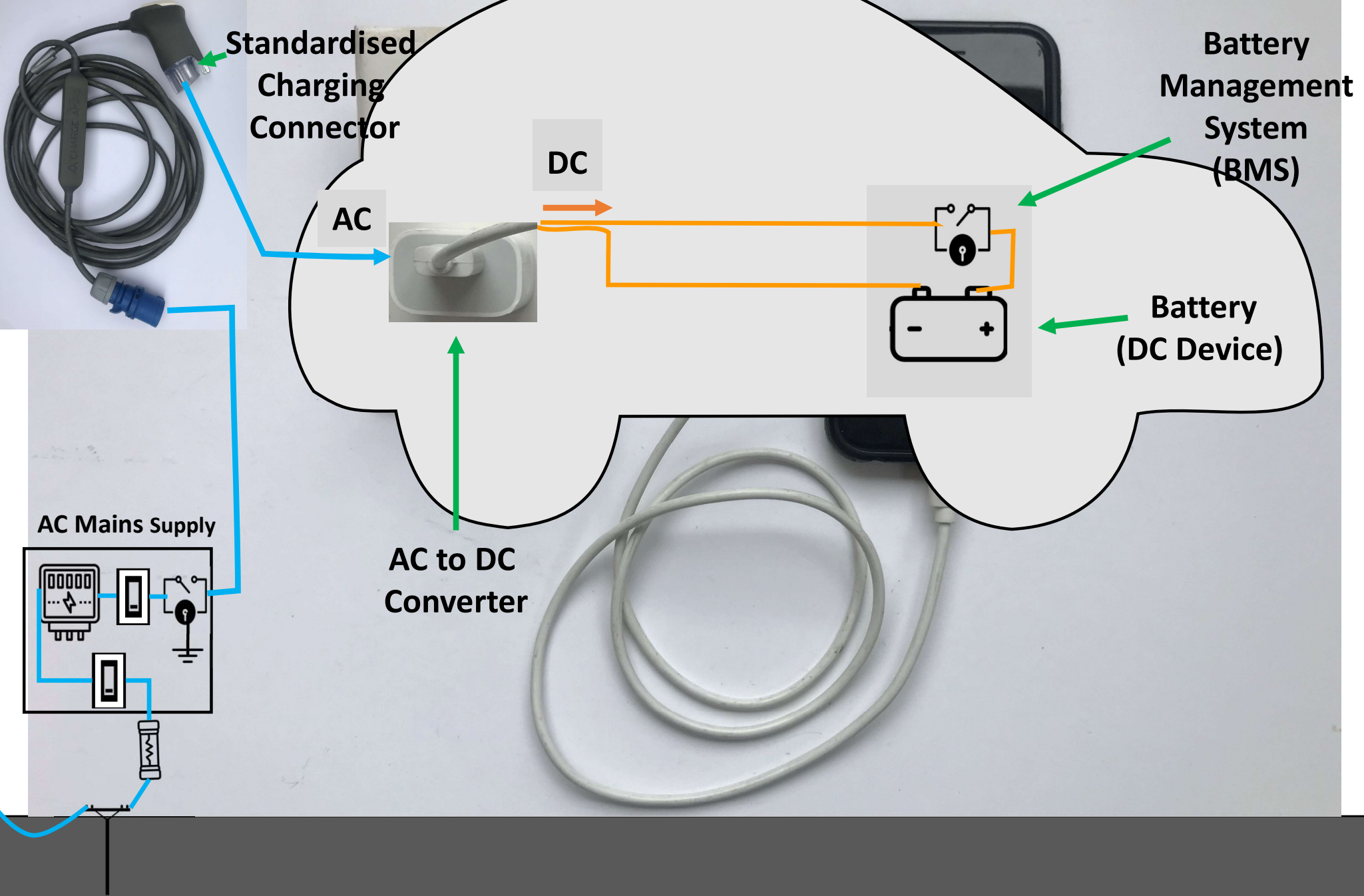
Charging basics ...

'AC Charging'



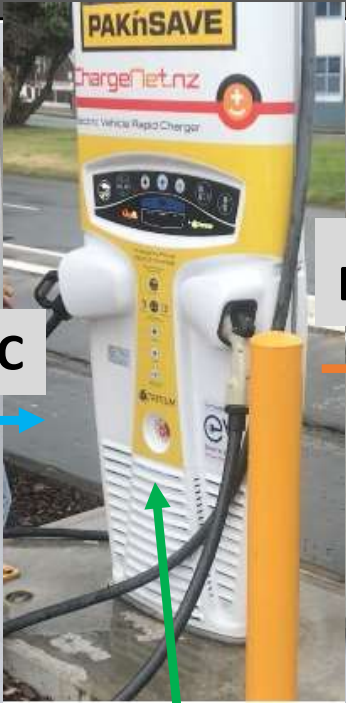
Charging basics ...

'AC Charging'



Charging basics ...

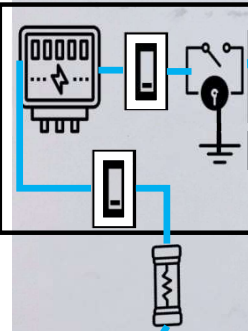
'DC Charging'



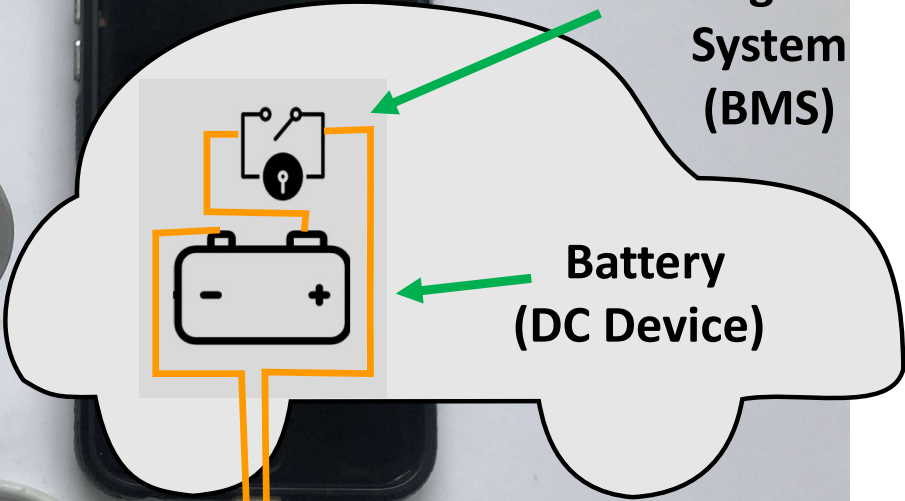
AC

DC

AC Mains Supply



AC to DC Converter



Battery Management System (BMS)

Battery (DC Device)

Charging Cable (DC)



CCS

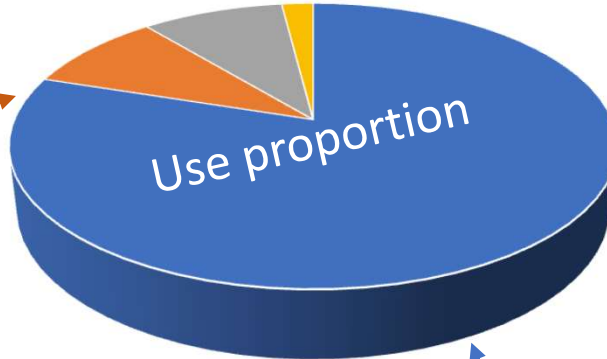
Standardised Charging Connector

Destination



Types of Charging

On the go/journey (and 'oops')



At home



At work



and in neighbourhood

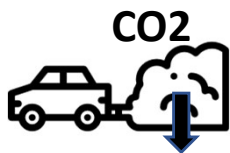
Battery-swap stations and vehicles ...



Global incentive schemes for EV car uptake



- **Purchase price subsidies** and/or purchase/regro tax rebates to reduce price gap.



- **Tailpipe CO₂ mandates** → EVs cheaper option for EU manufacturers to meet them.



- **Mandatory EV sales targets** (e.g., California and China).



- **Low- and zero-emission zones** (Oslo, China).



- **Full phase out of ICEs** over next 10-30 years (20 countries).

Global incentive schemes for EV car uptake



- Purchase price subsidies and/or rebates to encourage EV uptake



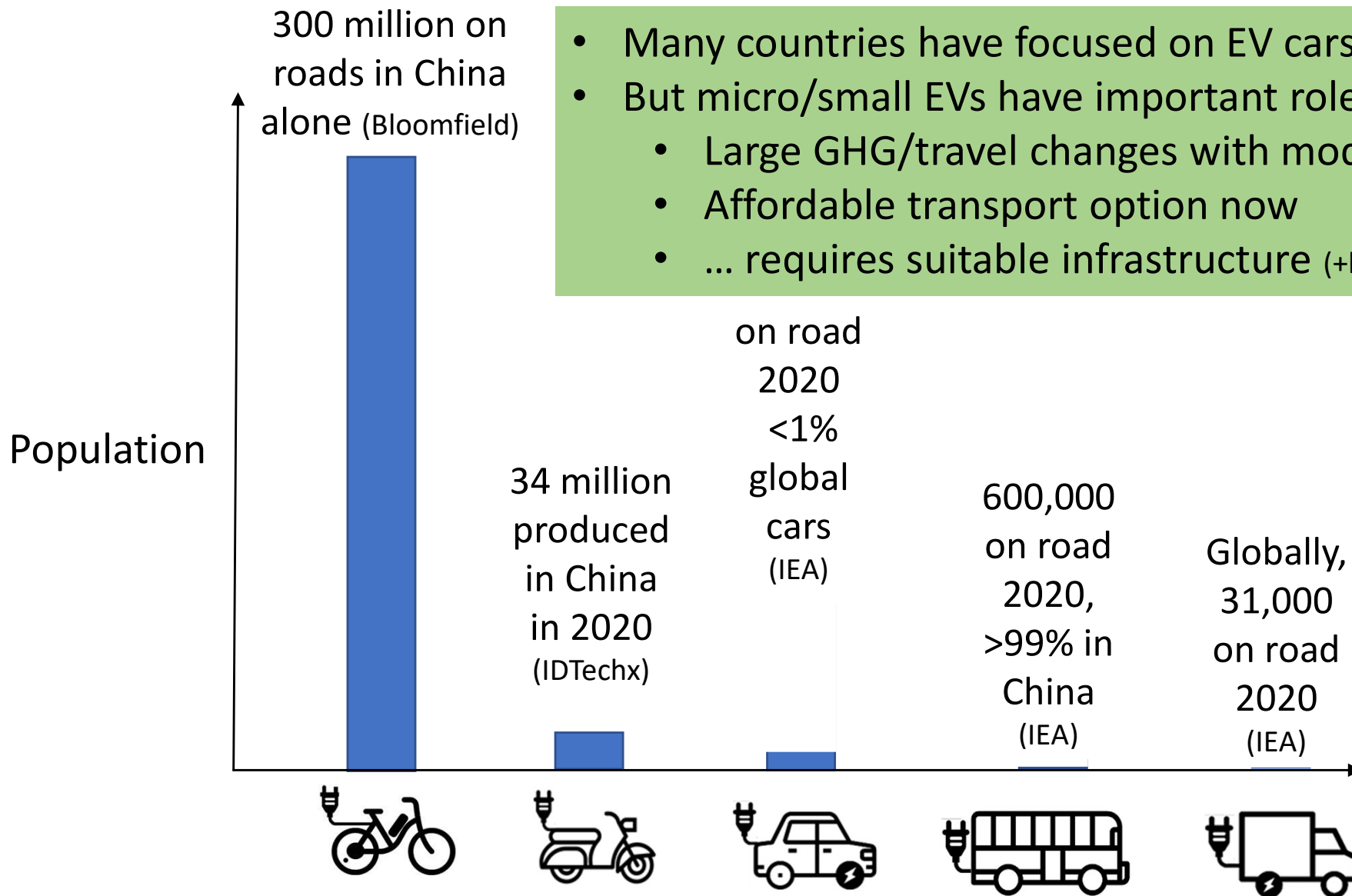
With these signals from governments:

- Audi Europe now putting all R&D spend into EVs (NZ Audi Agent)
- Audi Europe stopping internal combustion engine (ICE) builds in 2027 (NZ Audi Agent)
 - starts a process where ICEs will not be supported in the future

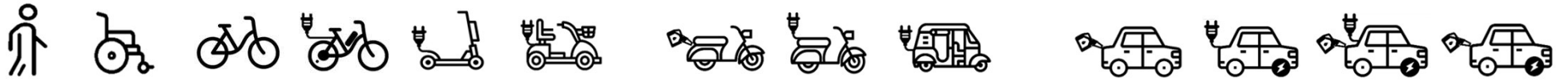


...ICEs over next 10-30 years (20 countries).

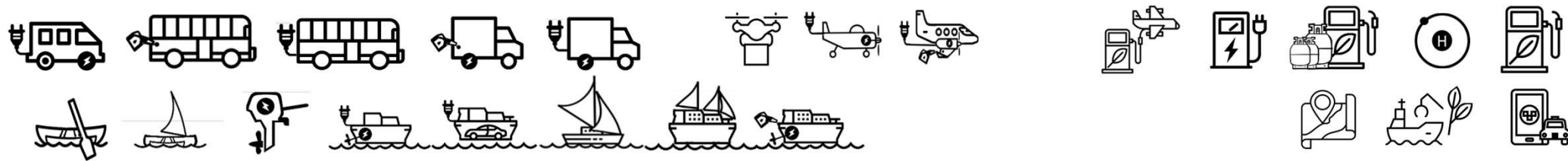
EV Global status



- Many countries have focused on EV cars
- But micro/small EVs have important role:
 - Large GHG/travel changes with mode shift
 - Affordable transport option now
 - ... requires suitable infrastructure (+beyond roads).



Lets look wider across the
‘Technology Catalogue’
of transport options



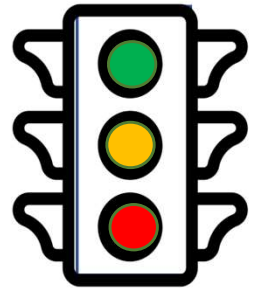


37 Technologies

15 Assessment Dimensions

- Type of journey/ service
- Overall suitability (horizons H1/H2/H3)
- Global tech outlook (feasibility/ availability)
- Affordability/ cost
- Supply/ availability
- Carbon footprint
- Energy security
- Convenience, comfort, safety and accessibility
- Infrastructure & refuelling requirements
- Operation & maintenance requirements
- Waste/ end-of-life disposal
- Environmental & social impact
- Local value chain/ economic opportunity
- Required complementary measures
- Other considerations




















Vehicle/transport option	Walking	Wheelchairs	Bicycles	E-Bikes	E-Push Scooters	Mobility Scooters	Petroleum Two Wheelers	Two Wheelers	E-Trikes	ICE	Electric	Petroleum	Electric	Hybrid	Electric				
Type of journey/ service	Very short distance, single passenger.	Short distance, single passenger	Short distance, single passenger.	Short distance, single passenger	Short distance, single passenger.	Walking-speed, short distance, single passenger.	Short- and medium-distance, 1-	Short- and medium-distance, 1-	Short- and medium-distance, multi-	several	several	several	several	Charging of EVs	distance, multi-	distance, multi-	distance, multi-	long-distance	distance urban
Overall suitability	H1: 5	5	4	4	3														
	H2: 5	5	5	5	5														
	H3: 5	5	5	5	5														
Global technology outlook (feasibility/ availability)	Mature	Mature	Mature	Mature and developing	Early adoption.	Mature													
Affordability/ cost	Whole of Life: \$	\$	\$	\$\$	\$\$														
	Purchase: \$	\$	\$	\$\$	\$\$														
	Ongoing: \$	\$	\$	\$\$	\$\$														
	Future TCO: \$	\$	\$	\$	\$														
Supply/ availability	5		5	5	5														
Carbon footprint	5		5	5	5														
Energy security				5	5														
Convenience, comfort, safety and accessibility						3													
Infrastructure & refuelling requirements																			
Operation & maintenance requirements																			
Waste/ end of life disposal																			
Environmental & social impact																			
Local value chain/ economic opportunity																			
Required complementary measures																			
Other considerations																			

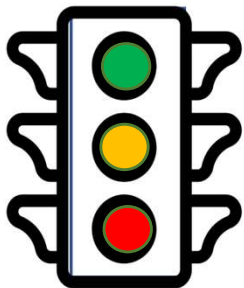


Work Commissioned by NZ Ministry of Foreign Affairs and Trade (MFAT)



















Vehicle/transport option	Non-H2 and Biodiesel Alternative Fuels
Type of journey/ service	Fuel alternative.
Overall suitability	H1: 1
	H2: 1
	H3: 3
Global technology outlook (feasibility/ availability)	Demonstration.
Affordability/ cost	Whole of Life: \$\$\$
	Purchase: \$\$\$
	Ongoing: \$\$\$
	Future TCO: \$\$\$
Supply/ availability	2
Carbon footprint	3
Energy security	3
Convenience, comfort, safety and accessibility	2
Infrastructure & refuelling requirements	2
Operation & maintenance requirements	2
Waste/ end of life disposal	3
Environmental & social impact	4
Local value chain/ economic opportunity	3
Required complementary measures	3
Other considerations	3

	2	4	3	5	3	2	2	3	3	2	2	4	4	2	4	4	2	4	4	2
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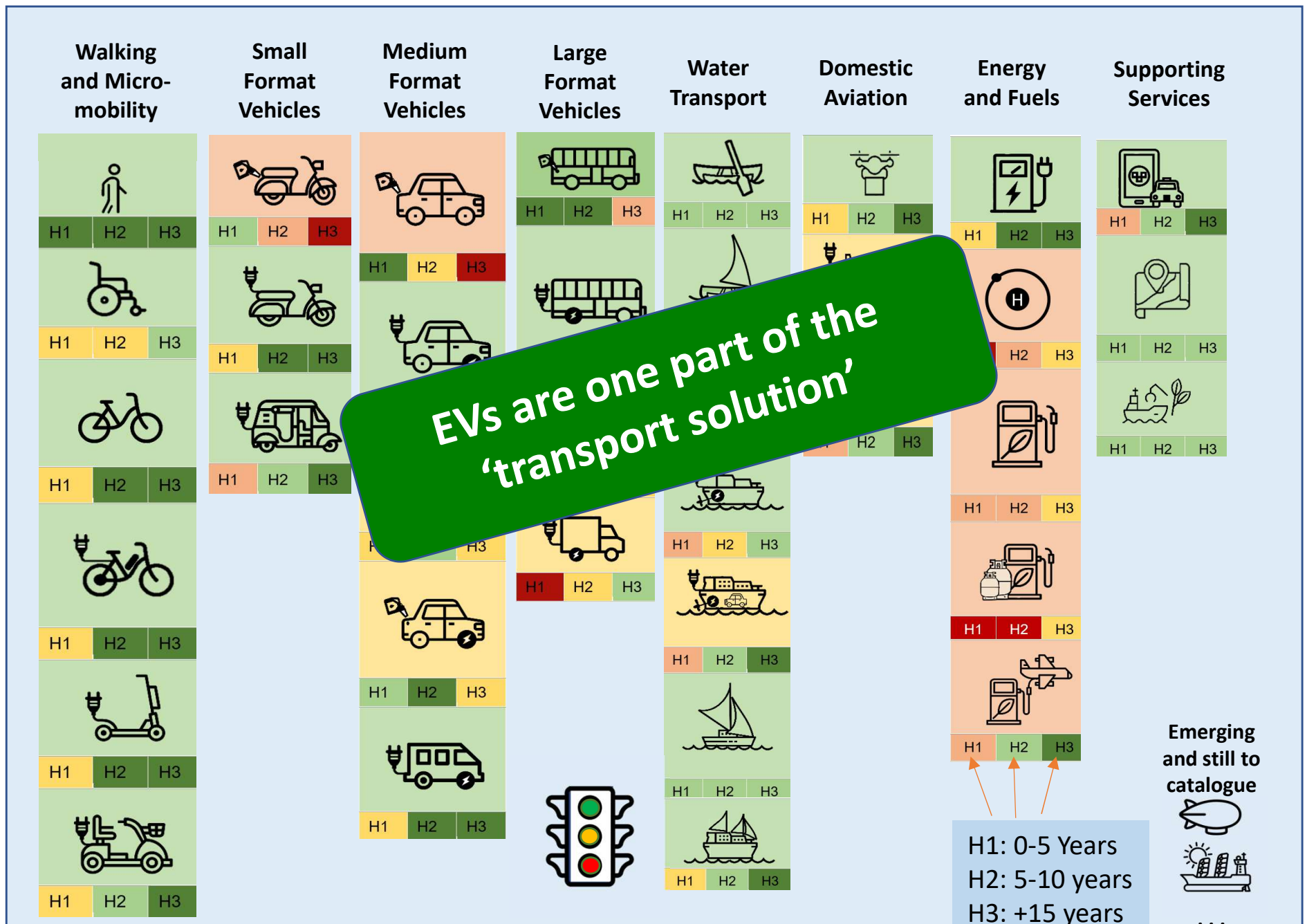
																				
Vehicle/transport option		Walking	Wheelchairs	Bicycles	E-Bikes	E-Push Scooters	Mobility Scooters	Petroleum Two Wheelers	Electric Two Wheelers	E-Trikes et al.	ICE Passenger Car	BEVs	PHEVs	HEVs	EV Charging	Electric Minibuses	Petroleum Fuelled Buses	Electric Buses	Hybrid Truck	Electric Truck
Type of journey/ service		Very short distance, single passenger.	Short-distance, single passenger	Short distance, single passenger.	Short distance, single passenger	Short distance, single passenger.	Walking-speed, short distance, single passenger	Short- and medium-distance, 1-2 passenger	Short- and medium-distance, 1-2 passenger	Short-to-medium-distance, multi-passenger and goods	Short-to long-distance, 1-several passenger and goods transport	Short-to long-distance, 1-several passenger and goods transport	Short-to long-distance, 1-several passenger and goods transport	Short-to long-distance, 1-several passenger and goods transport	Charging of EVs	Short-to medium-distance, multi-passenger transport	Short-to long-distance, multi-passenger transport	Short-to medium-distance, multi-passenger transport	Short-to long-distance freight	Short-to medium-distance urban freight transport
Overall suitability	H1	5	5	4	4	3	3	4	3	2	5	3	3	4	3	3	5	2	3	1
	H2	5	5	5	5	5	4	2	5	4	3	4	4	5	5	5	5	4	4	3
	H3	5	5	5	5	5	5	1	5	5	1	5	3	3	5	5	2	5	3	4
Global technology outlook (feasibility/ availability)		Mature	Mature	Mature	Mature and developing	Early adoption.	Mature and developing.	Mature	Mature and developing	Early adoption	Mature and developing	Mature and developing	Mature and developing	Mature	Mature and developing	Mature and developing	Mature	Mature and developing	Mature and developing	Demonstration
Affordability/ cost	Whole of Life	\$	\$	\$	\$\$	\$\$	\$\$	\$\$	\$	\$\$	\$\$	\$\$	\$\$	\$\$	\$	\$\$	\$\$\$	\$\$\$\$	\$\$	\$\$\$\$
	Purchase	\$	\$	\$	\$\$	\$\$	\$\$	\$\$	\$\$	\$\$	\$\$	\$\$	\$\$	\$\$	-\$	\$\$	\$\$\$	\$\$\$\$	\$\$\$	\$\$\$\$
	Ongoing	\$	\$	\$	\$\$	\$\$	\$	\$\$	\$	\$	\$\$	\$	\$\$	\$\$	\$	\$\$	\$\$\$	\$\$\$	\$\$	\$\$
	Future TCO	\$	\$	\$	\$	\$	\$\$	\$\$	\$	\$\$	\$\$	\$\$	\$\$	\$\$	\$	\$\$	\$\$\$	\$\$	\$\$	\$\$
Supply/ availability	5	4	5	5	5	4	5	3	3	5	3	3	5	4	3	4	3	3	2	
Carbon footprint	5	5	5	5	5	4	5	5	3	4	4	4	4	5	4	4	3	4	4	
Energy security	5	5	5	5	5	5	4	5	5	3	4	4	4	5	4	2	4	4	4	
Convenience, comfort, safety and accessibility	3	3	3	3	3	3	3	3	3	5	5	5	5	4	4	3	4	5	5	
Infrastructure & refuelling requirements	4	2	5	4	4	3	4	4	5	4	3	5	3	3	3	4	2	4	2	
Operation & maintenance requirements	5	5	5	4	4	4	4	4	4	4	3	3	4	3	3	4	2	3	2	
Waste/ end of life disposal	5	5	5	4	4	4	4	4	4	3	3	3	2	4	3	3	3	3	3	
Environmental & social impact	5	5	5	5	5	5	4	5	5	3	4	3	4	5	4	3	5	4	4	
Local value chain/ economic opportunity	4	4	5	5	4	5	5	5	4	4	4	3	4	4	4	4	4	4	2	
Required complementary measures	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
Other considerations				3			3		3	5	4	3	4							



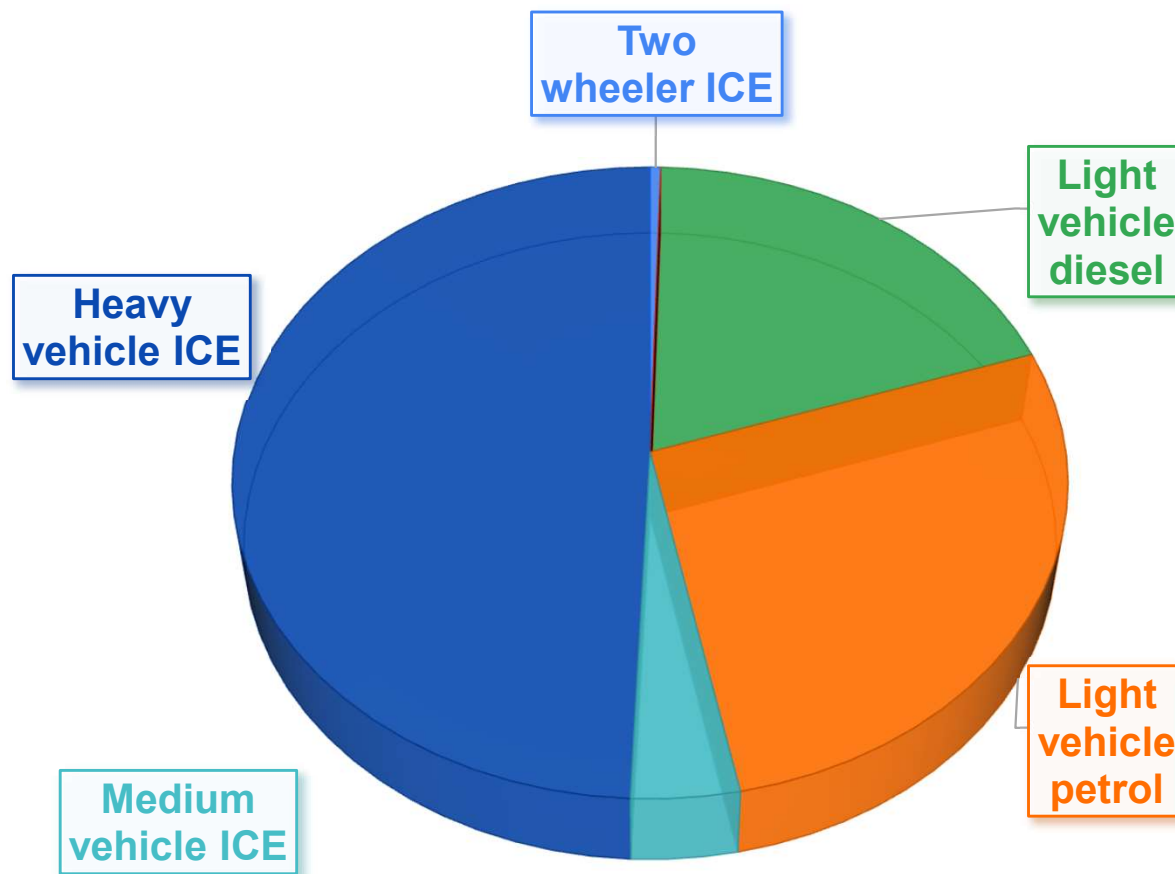
Work
Commissioned
by NZ Ministry
of Foreign
Affairs and
Trade (MFAT)

																			
Vehicle/transport option		Non-H2 and Biodiesel Alternative Fuels	Hydrogen	Biodiesel	Personal Paddling Watercraft	Personal Sailing Watercraft	Small battery-electric propulsion	Electric Small-Med Boats	Electric Ferries	Sailing Vessels	Wind-Assisted Propulsion	Hybrid Vessels	Energy Efficiency Measures	Green Ports	Drone Delivery	SAFs	Battery Electric Light Aircraft	Hybrid Electric Aircraft	Software Services
Type of journey/ service		Fuel alternative.	Provides an alternative to traditional fuel systems	Alternative fuel	Short inshore personal transport	Short and medium distance, personal transport	Short range and slow speed personal and goods water transport	Short range and/or slow speed	Short-distance, multi-passenger and freight marine transport	Short-distance, multi-passenger and freight marine transport	Provide assisted propulsion on existing/new-build vessels.	Short-distance, multi-passenger and freight marine transport	Improvements to existing operations	Improvement to current operations and infrastructure.	Wide ranging, from parcel delivery to potentially passenger transport.	Fuel alternative	Fast, short-distance small number passenger travel.	An alternative propulsion system for wide range of aircraft.	Managed logistics of transport services.
Overall suitability	H1	1	1	3	5	5	3	2	2	4	3	2	4	4	3	2	2	1	4
	H2	1	2	2	5	5	4	3	3	4	4	3	4	4	4	2	2	1	5
	H3	3	3	2	5	5	5	4	4	4	5	4	4	4	5	3	4	4	5
Global technology outlook (feasibility/ availability)		Demonstration.	Demonstration.	Mature	Mature	Mature	Demonstration	Demonstration	Demonstration	Demo for modern	Demonstration	Demonstration	Mature and developing	Individual mechanisms	Demonstration	Prototype	Demonstration	Prototype	Mature and developing
Affordability/ cost	Whole of Life	\$\$\$	\$\$\$\$	\$\$\$	\$	\$	\$	\$\$\$	\$\$\$	\$	\$\$\$	\$\$\$	\$	\$\$	\$	-	\$\$	\$\$	\$
	Purchase	\$\$\$	\$\$\$\$	\$\$\$	\$	\$	\$	\$\$\$	\$\$\$	\$	\$\$\$	\$\$\$	\$	\$\$	\$	-\$	\$\$	\$\$	\$
	Ongoing	\$\$\$	\$\$\$	\$\$\$	\$	\$	\$	\$	\$\$	\$	\$	\$\$	\$	\$\$	\$	-	\$	\$	\$
	Future TCO	\$\$\$	\$\$\$	\$\$\$	\$	\$	\$	\$	\$\$\$	\$\$	\$\$	\$\$	\$	\$	\$	\$\$\$	\$	\$\$	\$
Supply/ availability	2	2	2	5	4	3	2	1	3	3	1	4	2	2	1	1	1	4	
Carbon footprint	3	4	4	5	5	5	4	4	4	5	4	4	4	4	5	4	4	4	
Energy security	3	4	4	5	5	5	4	4	3	5	4	3	4	4	5	3	4	4	
Convenience, comfort, safety and accessibility	2	2	3	2	3	3	4	5	2	3	5	4	4	5	2	4	4	4	
Infrastructure & refuelling requirements	2	1	2	5	5	4	2	2	4	5	2	5	4	5	2	4	4	3	
Operation & maintenance requirements	2	2	4	5	4	4	3	3	4	3	3	4	4	4	2	4	4	5	
Waste/ end of life disposal	3	3	3	5	4	4	2	2	4	5	2	5	4	4	5	3	3	5	
Environmental & social impact	4	5	3	5	5	5	4	4	4	5	4	4	4	4	5	4	4	4	
Local value chain/ economic opportunity	3	2	4	5	5	5	2	2	4	4	2	5	4	4	3	4	4	4	
Required complementary measures	3	2	4	5	5	5	2	2	4	4	2	5	4	4	3	4	4	4	
Other considerations	3	2	4	3	5	3	2	2	3	3	2	2	4	4	2	4	4	2	

The current catalogue ...

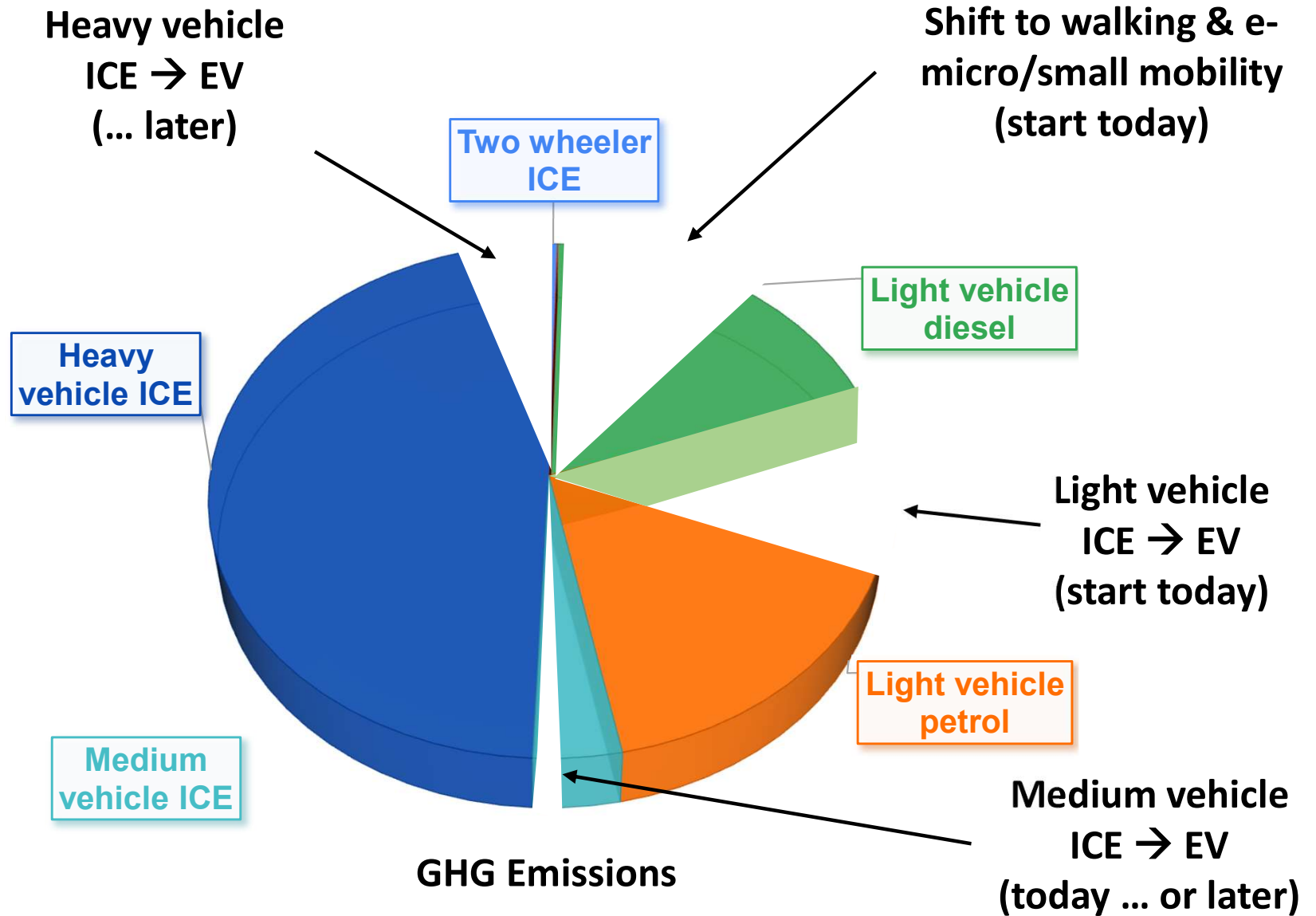


Why multiple GHG reduction pathways are required ...



GHG Emissions

Why multiple GHG reduction pathways are required ...



Key points:

- Require alternatives to the use of non-renewable fuels.
- ‘Pedestrians first’.
- Target: to **become ‘EV-ready’**:
 - Manage **barriers**.
 - Support **capacity building**.
 - Familiarisation with technology important → **early demonstration**.
 - → Work towards ‘**normalisation**’ (required for national-scale change).
 - **Marketing** and **quality information**.
- **Small-format mobility important** – e.g., makes public transport more accessible. Current roading may require change to be fit for small-format mobility.
- **EVs only make sense if high proportion of renewable electricity**.
- Avoid import of low-performance/low quality goods.
- Network communications systems an enabler of many smart transport options (and therefore an important new technology enabler).

Key points:

- Require alternatives to the use of non-renewable fuels.
- 'Pedestrians first'.
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 - → Work towards **EV demonstration**.
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- **EVs only make sense if high proportion of renewable electricity.**
- Avoid import of low-performance/low quality goods.
- Network communications systems an enabler of many smart transport options (and therefore an important new technology enabler).

**Develop a plan
→ EV Roadmap
(and consider electricity demand)**

Common success themes of EV Roadmaps (from looking across many countries)



- Have a vision of what future is wanted.



- A specific government group and a specific industry/public group responsible for developing EV sector.



- An agreed roadmap across all parties.



- Targets.



- Well thought out incentives.

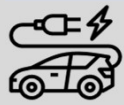


- Quality, dependable information ... and quality marketing/public management.



- Supporting policy.

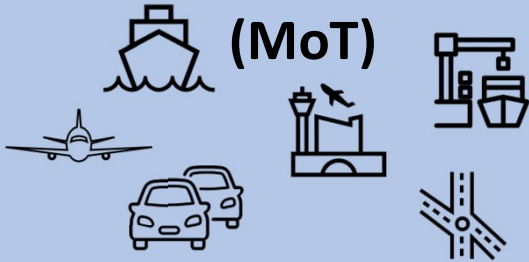
Possible Government Structure ... example from New Zealand:



Vehicle/Roadside-Related

Ministry of Transport

(MoT)



Vehicles and Infrastructure

- EV uptake modelling and targets.
- Standards for EVs.
- Registration of EVs.
 - Including monitoring.
- Public charging:
 - Connectors for public CSs.
 - Roadside access for charging.

Cabinet Office

Execution



Energy Efficiency and Conservation Authority

(reporting to both MoT and MBIE)



Connection with business and community

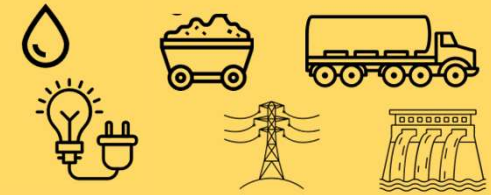
- Monitoring.
- EV marketing campaign.
 - Develop/deliver campaign
 - Develop/deliver quality information.
 - Market surveys.
- Administration of govt fund for supporting EV & public charging uptake.



Electricity Supply and Charging

Minister of Energy and Resources

(Dept: Ministry of Business Innovation and Employment, MBIE)




Energy and Infrastructure

- Safety standards for charging equipment and installations.
- Safety guidelines for charging.
- Modelling and planning supply of electricity.

Together, responsible for developing and maintaining the EV Roadmap

Private sector also has an important role:

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- **Industry groups including vehicle suppliers.**
 - **Community groups:**
 - Automobile Association
 - ‘Leading the Charge’ ... a community group connecting EV owner/enthusiasts with people looking to buy an EV.
 - **Private sector:**
 - ‘ChargeNet’ has provided 90% of public fast charging infrastructure (with government assistance in less-financial situations).
 - Shops and malls offer free access to land for charging.
 - Vehicle importers
 - Technicians

Importance of policy and government support



- Require early movers to demonstrate and begin a process of 'normalization' of the technology (... and begin capacity building across the sector).



- EV manufacturers want to see supporting government policy to warrant prioritizing supply over supply to other countries ... joint PIC message



- It is expensive for a supplier of new EVs to set up support for their first EV model(s) ... and \$\$\$ returns could be slow in coming.



- Risks with importing used EVs without suitable support ... (although risk reducing with familiarity, 'Technician YouTube' and others ...)



- Expensive for charging providers to set up commercial operation.

- **It is important for government to support these early movers, especially in 'PIC-sized' markets ... reason to join efforts across PICs.**



- **Important role of government/policy to manage/remove barriers (and assist appropriate, early moves).**
- **Government-lead information/awareness campaign and marketing critical (task too big for early mover individuals ... and some PICs).**

Organising and EV policy development

Consider the time in the life of an EV:



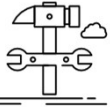
- Design

- Build



- Supply

- “Installation”



- In-service operation



- General use

- Charging



- Servicing

- Breakdown



- Accident

- Retirement, end-of-life.



Time in Life Cycle	Electric Vehicles	Charging Infrastructure	Electricity to the Plug/Charger
Design	Standards, tech development, meeting market	Standards, related hardware and IT, overall plan, compatibility.	Electricity supply system, planning
Build	Capacity, market demand by vehicle class	Capacity, demand by different type	Gen Co.s/Line Co.s
Supply	Availability, meeting demand, shipping, import, certification.	Availability, meeting demand, shipping, import, certification.	Gen Co.s/Lines Co.s, general information on
Purchase (and resell)	Awareness/information, experiences, overcoming barriers, EV performance, fit for purpose, decision, available models	Fit-for-purpose purchase decisions, future-proofing, grid-aligned, compatibility, available models	Gen/network upgrade, generation type switching ... company and country plans
Installation	Insurance, warranty, registration, identification, WoF	Approval, site works, certification, industry training.	Gen Co.s/Lines Co.s
In-service operation			
General use	Understanding, best driving practices	Access/restrictions, signage, availability, location App.	Awareness, controls (pricing and other).
Charging	Understanding of, options, costs, best practice	Understanding of, connectivity, time of charge, billing.	Connectivity, time of charging, billing
Servicing/maintenance	Understanding of, industry capability and capacity, industry training	WoF, certification, industry training.	Gen Co.s/Lines Co.s
Breakdown	Guidelines/best practice	Response, industry training, map.	Gen Co.s/Lines Co.s
Accident	1 st response, repair, fleet re-entry	1 st response, repair, re-cert.	Gen Co.s/Lines Co.s
Retirement	Decision to, reuse of battery/electrics through scrap/recycle .	Decision to, re-use/upgrade through scrap	Gen Co.s/Lines Co.s

Time in Life Cycle

Electric Vehicles

Charging Infrastructure

Electricity to the Plug/Charger

development, market

Standards, related hardware and IT, overall plan, compatibility.

Electricity supply system, planning

demand by class

Capacity, demand by different type

Gen Co.s/Line Co.s

ing demand, certification.

Availability, meeting demand, shipping, import, certification.

Gen Co.s/Lines Co.s, general information on

ation, ing barriers, r purpose, models

Fit-for-purpose purchase decisions, future-proofing, grid-aligned, compatibility, available models

Gen/network upgrade, generation type switching ... company and country plans

istration, E

Approval, site works, certification, industry training.

Gen Co.s/Lines Co.s

iv ... signage Awareness, controls (pricing and

ing or, options, best practice

Servicing/maintenance

Understanding of, industry capability and capacity, industry training

Breakdown

Guidelines/best practice

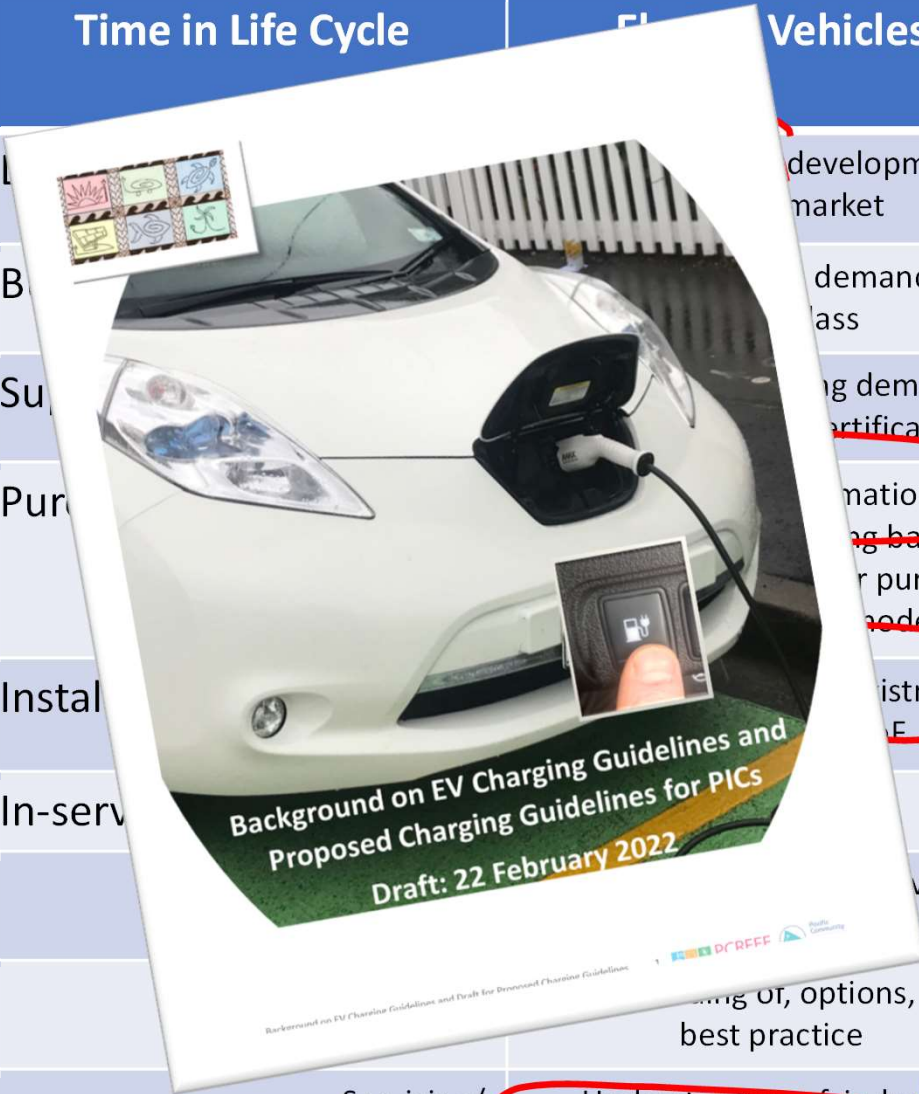
Accident

1st response, repair, fleet m

Retirement

Decision to, reuse of battery/electrics through scrap/recycle .

Decision to, through scrap



Early focus areas for EV roadmap:

- **Standards:** EVs and charging.
- **Fitting EVs into vehicle reg. systems.**
- **Awareness/information**
- **Building industry capacity**
- **→ becoming EV Ready**

Summing up:



- Many options for EVs ... they are an important part of wider transport plan ... today and tomorrow.



- **Learn from lessons** from others.



- **EV Roadmap** very important, with vision and targets. 



- Require an **across-government** solution for developing and executing policy → form a focus group to manage uptake. And private sector group.



- Look across life of vehicle/infrastructure. Identify gaps and **focus on major barriers**.



- Develop good **marketing and information** campaign.