

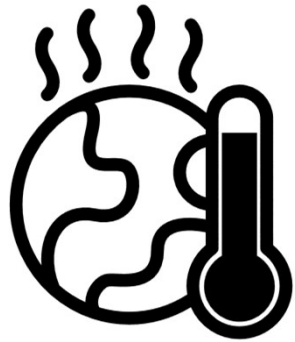
Global Experience with Electric Vehicles

Andrew Campbell

Agenda:

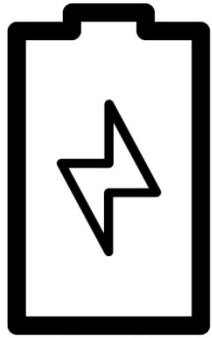
- Introductions
- Presentation by Andrew
- Questions

Backgrounder on Electric Vehicles

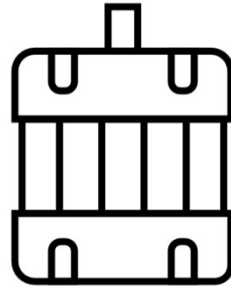


Drivers for change

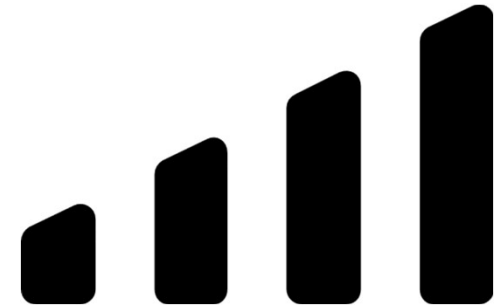
- Climate Change
- Cost of fuel imports
- Air quality
- Congestion
- Pedestrians first



Batteries



Motors



Networks/comms



Smartphones



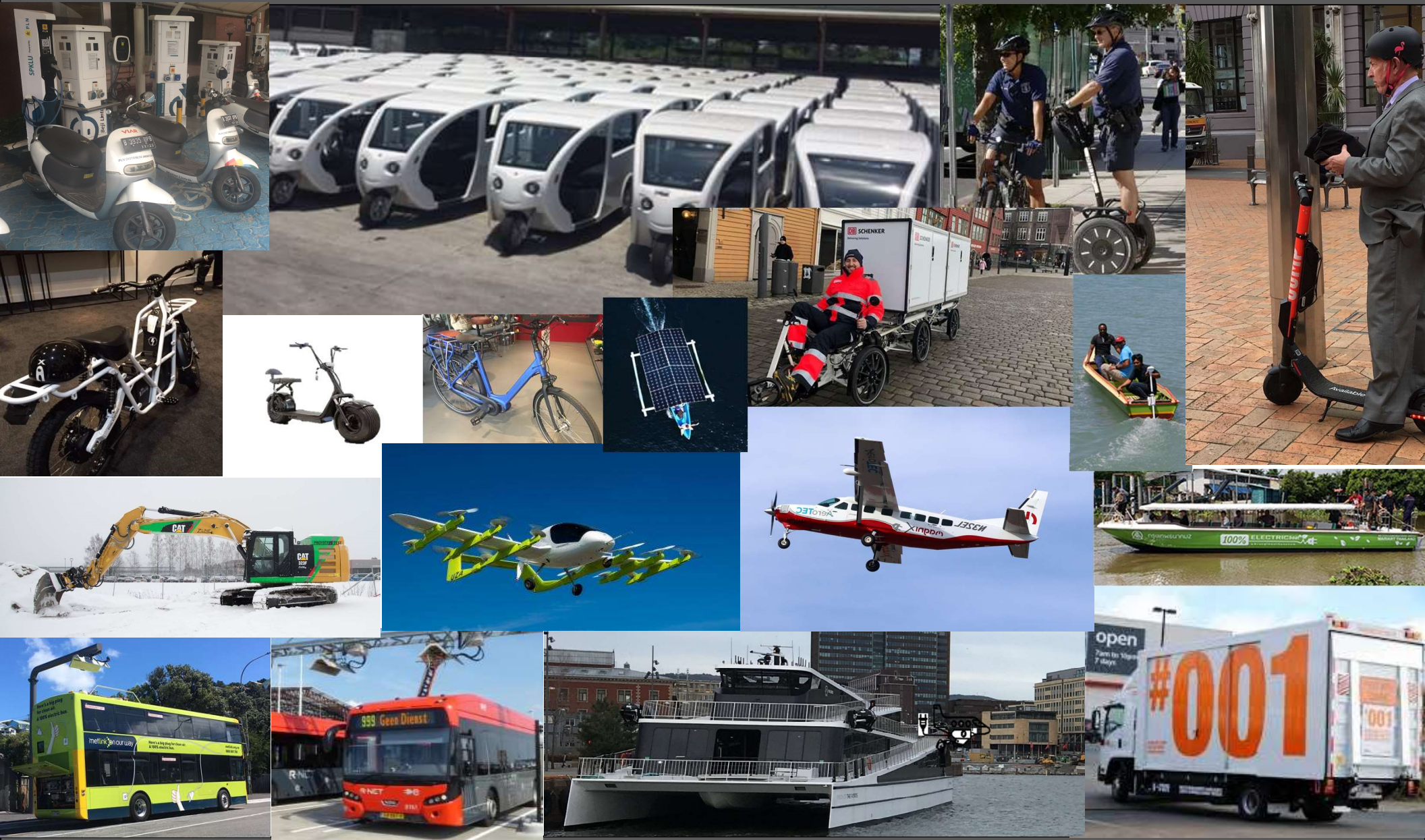
GPS/satellite tech

Enablers of change:

Technologies are developing rapidly →

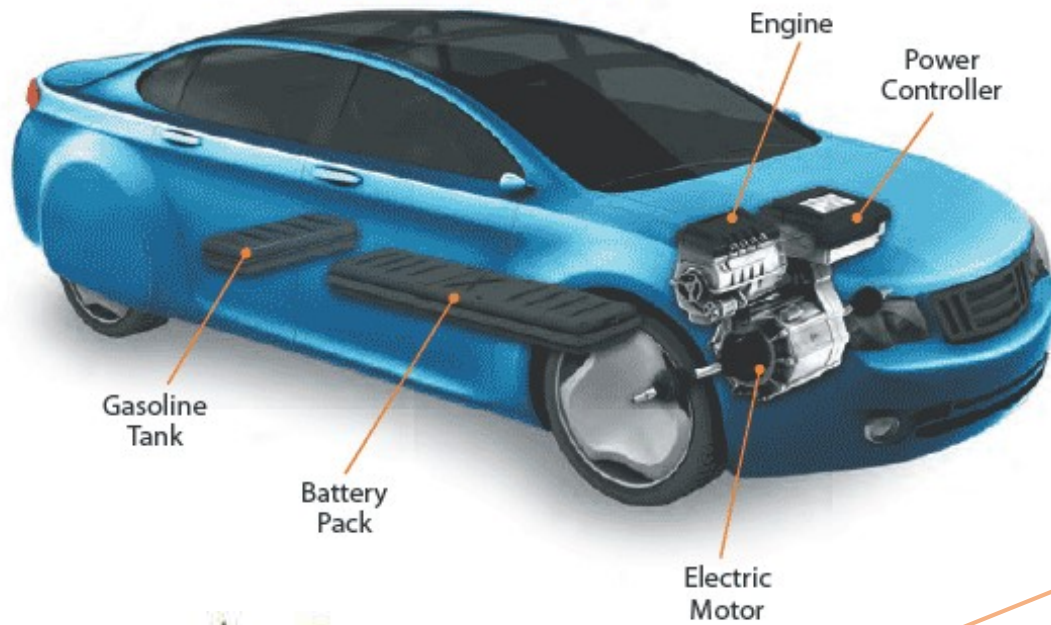
- **Falling costs**
- **Rapidly increasing capability of technology**
- **Clever combinations → new ways**
- **Affordability/better access**
- **Accelerated uptake of e-mobility.**

Result → variety of e-mobility solutions expanding

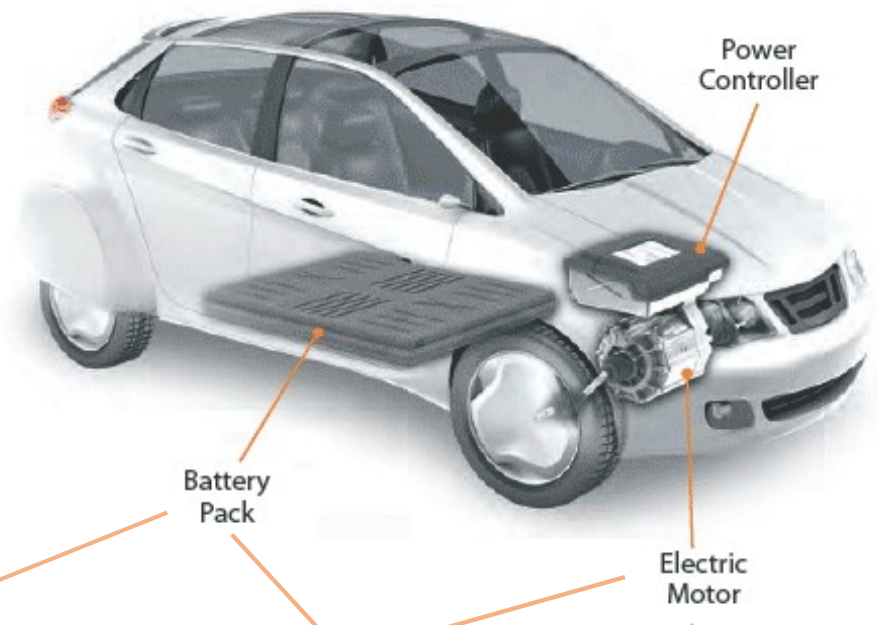


Interest is in plug-in e-mobility

Plug-in Hybrid Electric Vehicle (PHEV)



Battery Electric Vehicle (BEV)




- In common: have an onboard battery charged by an external power source
- Note: a non-plug-in hybrid (HEV) is always dependent on fuel (and often not counted)

The vehicle is only one component of the “EV solution” ...



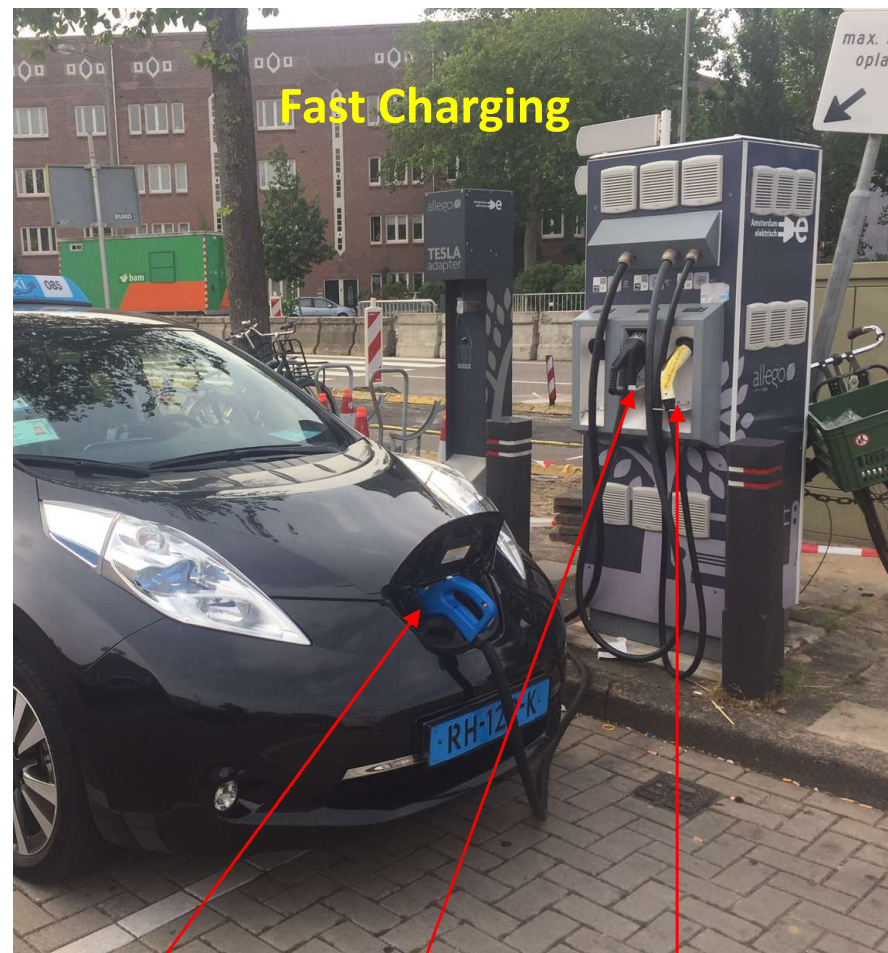
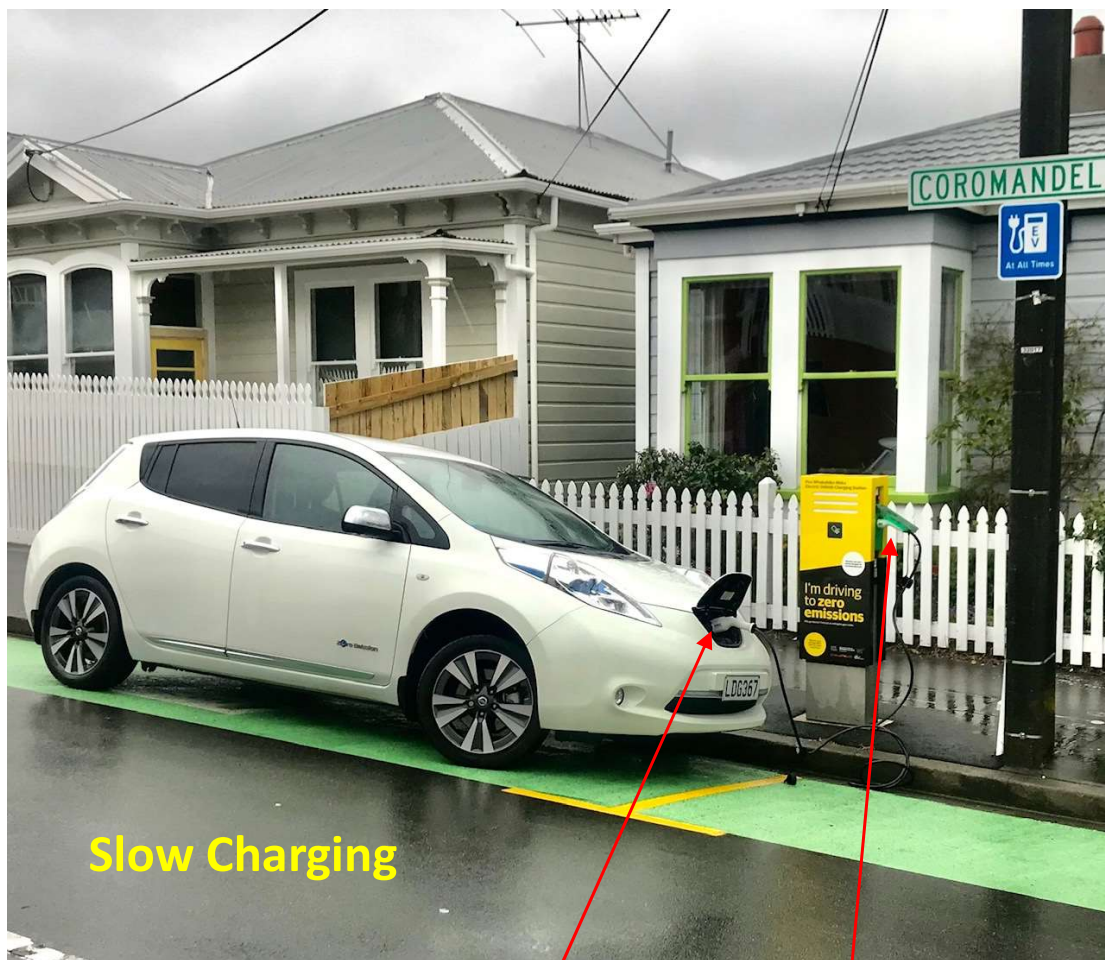
Many charging connector options. Important to guide industry to a few

	Name	AC/DC	Rate	Vehicle
	"Type 1" (SAE J1772)	AC	1-20kW	Japan, US origin, Some EU
	European Mennekes "Type 2"	AC	3-22kW AC BYD/Tesla up to 400kW DC)	EU-sourced
	CHAdeMO (China High Power Charging)	DC	400kW DC)	mainly Japan origin
	Combo or CSS (Combined Charging System, Type 1 and 2)	AC and DC	50-350kW DC	EU-sourced
	Tesla Super-charger	DC	Up to 250kW	Tesla

Commonly referred to in guidelines

Charging in practice ... providing for different vehicle connectors

Examples of public roadside charging

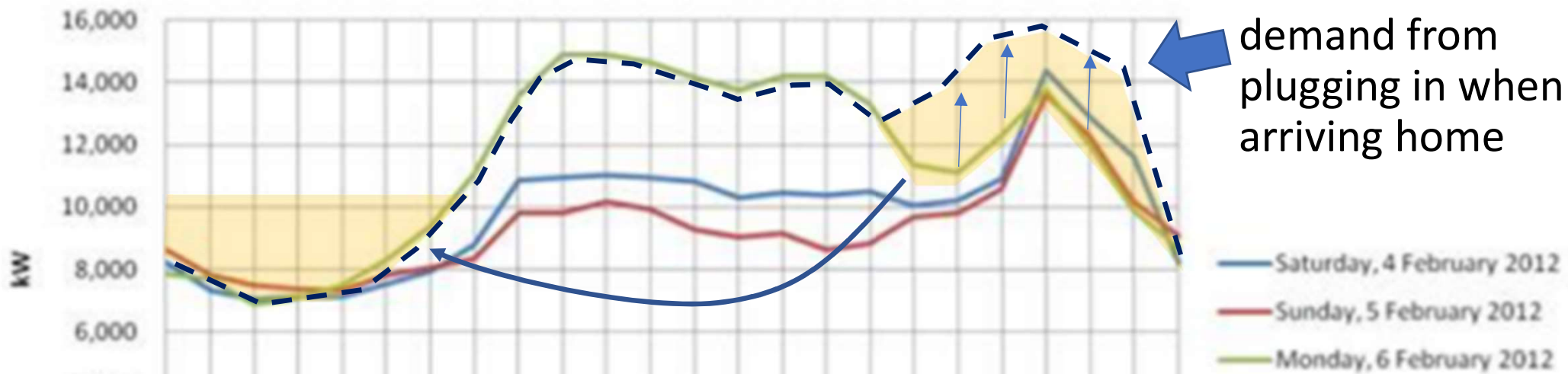


Portable cable with: Type 1 at EV and Type 2 charger

CHAdEMO CCS Type 2 Type 2

Effect charging may have on electricity demand:

Demand Profile, Upolu - February 2012



- What would it take to change the time of charging?
- Time of Use (TOU) pricing and timers on chargers among the tools available.
- At some stage, batteries of in-service EVs may be used to support electricity supply (e.g., capture solar and deliver energy when required ... V2G ... but some time off).

(from IRENA 2013).

IDTechEx Research – six future mobility trends (report Jan 2022)



Electrification is global and happening in all sectors.



Autonomous vehicles will transform the automotive industry
→ declining vehicle ownership, declining vehicle manufacture.



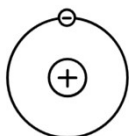
Lithium-based batteries will continue to be the great enabler for electrification over the next decade, but new technologies developing.



Powertrain safety via thermal management will be critical as the market matures.



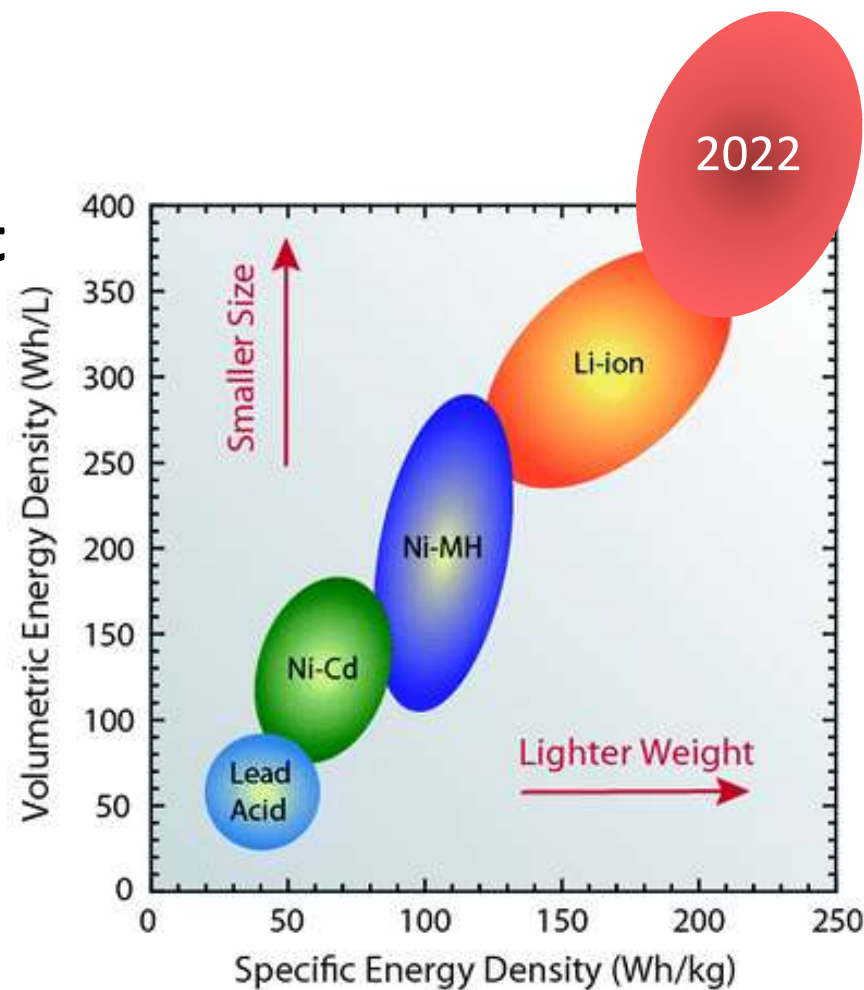
Advanced motors and power electronics are key to lowering cost and increasing range (Mercedes have showcased a 1000km EV).



Hydrogen fuel cells are the last piece of the puzzle to decarbonize land transport ... many weakness but potential to fill some gaps.

Example: battery technology

- Last 10 years of battery development
 - 1/10th cost for same kWh
 - 1/3rd weight for same kWh
 - 1/3rd size for same kWh
- Range 100km (2010)
→ 300KM (2020)
- 50kW “fast” charging (2010)
→ ‘supercharging’ at 250kW (2020)
→ +400kW commercial EVs
- And technology still advancing



EV Global status



300 million on roads in China alone (Bloomfield)



34 million produced in China in 2020 (IDTechx)



Globally, 10 million on road 2020 (IEA, 145m by 2030)



600,000 on road 2020, >99% in China (IEA)

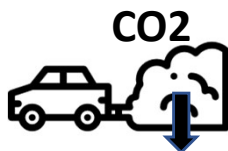


Globally, 31,000 on road 2020 (IEA)

Global incentive schemes



- **Purchase price subsidies** and/or purchase/regio 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).

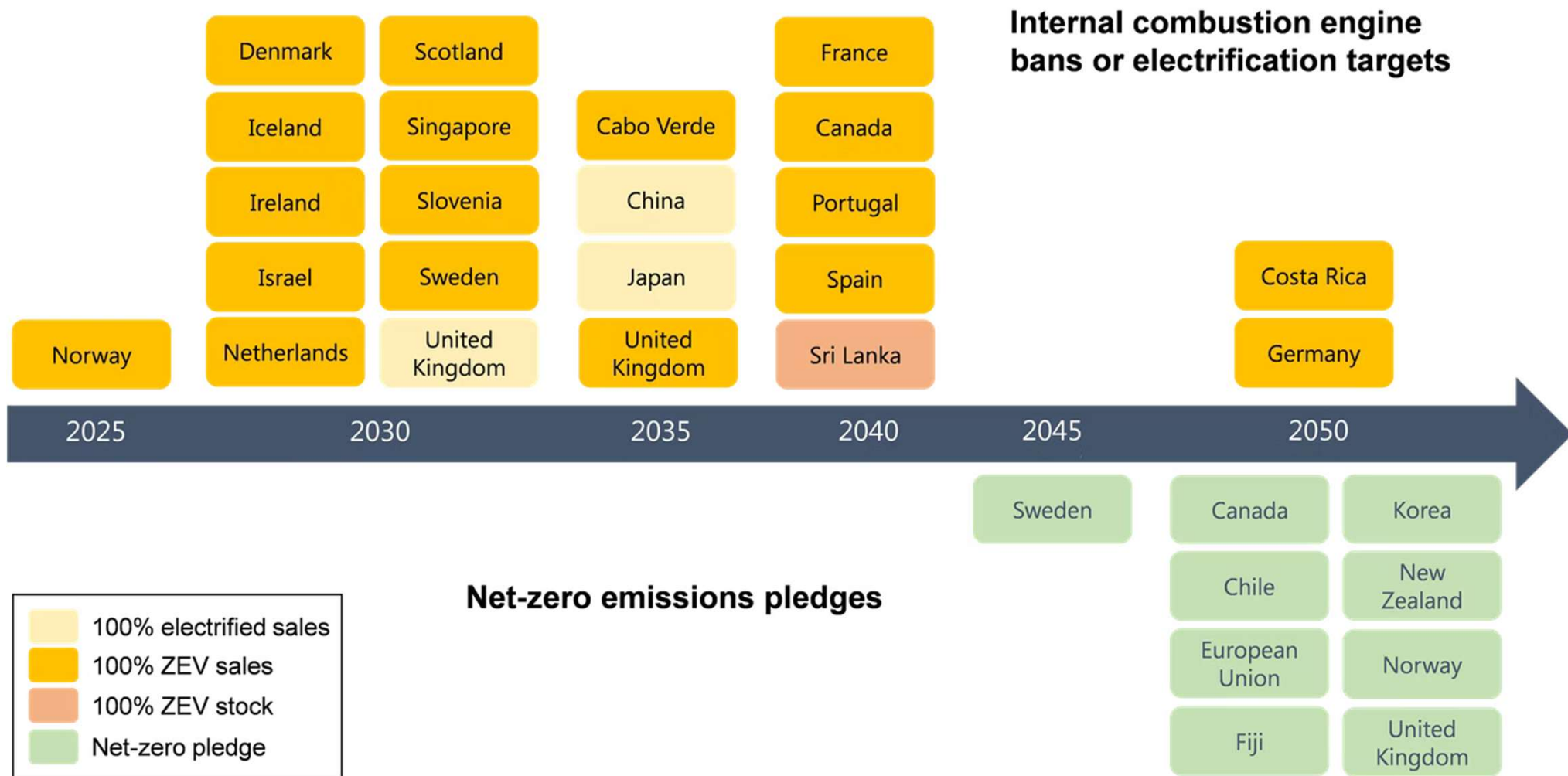


- **Low- and zero-emission zones** (Oslo, China).



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

Global incentive schemes



Examples of countries starting EV programs: Thailand



- National Electric Vehicle Policy Committee formed.
- Electric Vehicle Association of Thailand (EVAT) formed.



- Extensive roadmap in place (EV manufacture, battery manufacture, supporting infrastructure (charging stations and power grid management), safety standards, supporting regulations/policy).

- EV targets:









- EVs 30% of all car sales in Thailand by 2030
- Targets 1 million EVs on its road by 2025 and 15 million by 2035.
- All vehicles produced/registered ZEVs by 2035.
- Government leadership: all govt purchases ZEVs by 2025, all govt vehicles ZEVs by 2030.

- Charging targets:

- 10,000 public charging stations by 2025, 80,000 by 2035 (e2W and e4W).
- Develop smart grid and smart EV charging system, including V2G, TOU, facilitating rooftop RE.
- Regulated charging rates



Thailand continued:

-  • Extensive tax exemption/reductions for e2Ws to e-vessels including R&D.
-  • Incentives on land ownership and work/visa facilitation.
-  • Min of Industry and Thailand Automotive Institute (TAI) establishing a battery test centre near Bangkok ... expected to be the largest in ASEAN.
-  • Battery production already begun and expected to grow.
-  • Min of Industry working with research institutes on managing end-of-life battery system.
-  • Wide range of regional and domestic fairs/trade shows.
-  • Investment in digital infrastructure encouraged – to support cloud-based/IOT.
-  • Customer surveys.

Vietnam



- EV market at an emerging stage.
- No explicit government policy and incentives (despite 15%-70% taxes on imported vehicles).
- Draft decree halving registration fee for EVs (currently +10-15% for 9 or less seats).



- Vietnam Automobile Manufacturing Association (VAMA) plans to develop roadmap.
- Private company Vinfast:



- Has been selling e2Ws
- Started production of EVs in Hai Phong factory (Dec 2021). Has established 200 public charging stations (at Aug 2021). Also offering a battery rental plan.



- Looking at e-bus manufacture.



- Modmo: e-bike manufacture and export from Ho Chi Minh City.



- Potential: has nickel and cobalt ore reserves.

Malaysia


-  • Government Agency responsible for managing EV promotion.

-  • Roadmap in development. Proposing EV and charger targets

-  • Proposed EVs exempt from import, excise and sales tax until end 2023 for completely built up (CBU) EVs, and end 2025 for completely knocked down (CKD) EVs.

- Also proposed exemption from road taxes, and tax relief.

-  • EV demonstration on Mactan Island (tourist destination).

-  • Target of 30% RE grid electricity by 2025.

Indonesia



- **Presidential Regulation 55/2019 setting legal framework for promoting EVs.**



- **Developing extensive roadmap**



- **Initial focus on EV cars but now looking far broader including e2Ws, bus rapid transport (BRT) and e-vessels.**

- **Targets for:**

- **EV uptake, EV production and export.**
- **Charging infrastructure, type and coverage.**
- **Motorbikes sales to be restricted to electric from 2040. Cars from 2050**



- **Subsidies and tax incentives to support industry (politically difficult to apply to individuals).**



- **Non-fiscal measures such as exemption from odd/even plate restrictions.**



- **Possess cobalt resources. Have stopped export of ore and looking to setup battery manufacture.**



- **High coal use in electricity generation, using older technology.**

Singapore



- **Government vision: to phase out internal combustion engine (ICE) vehicles by 2040.**



- **National Electric Vehicle Centre (NEVC) driving promotion of EVs.**
- **Extensive EV roadmap within Singapore Green Plan 2030 (SGP2030), focusing on:**



- **Becoming “EV Ready”.**
- **Use of vehicle taxes and incentives.**
- **Regulations and standards.**
- **EV charger deployment.**



- **Target 40,000 public charging stations and 20,000 at-home and at-work private charging points by 2030 (5:1).**



- **Target 100% cleaner energy bus fleet by 2040 (60 electric buses to date).**



- **EV Charging Operators such as Shell, Greenlots and SP are already providing fast charging services island-wide, in places such as petrol stations, shopping malls, office buildings and industrial estates.**



- **Electricity generated from NG. Claim EVs → 50% GHG reduction.**

Common success themes (also for countries with developed EV sectors):



- 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.



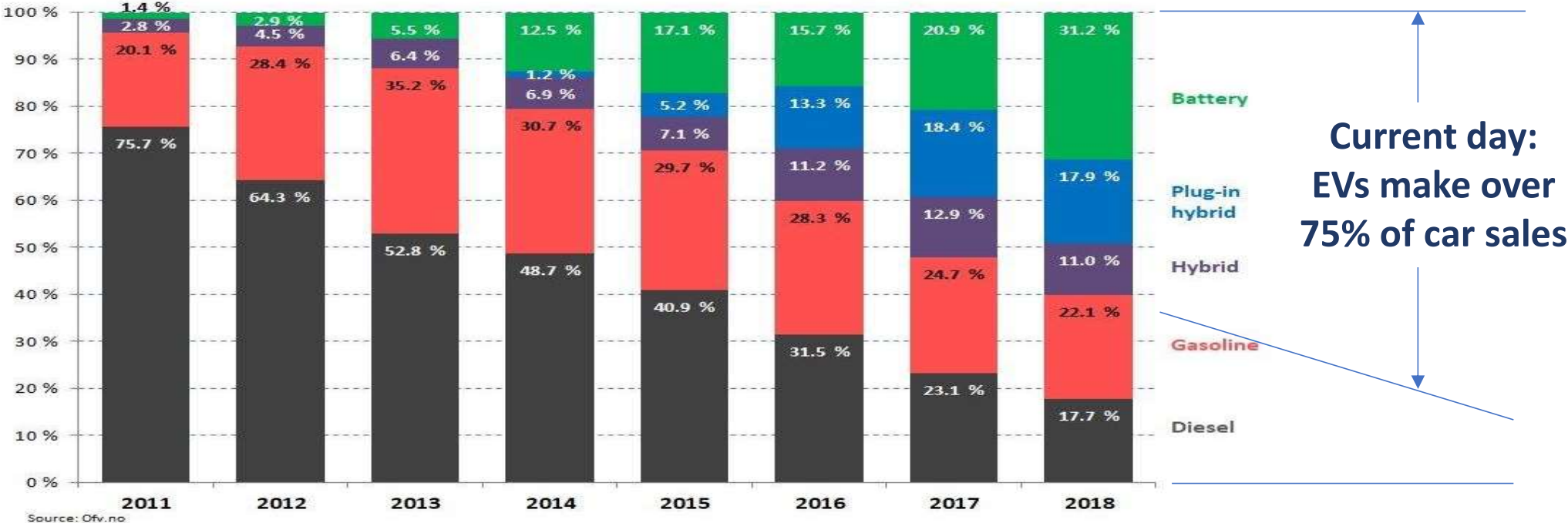
- Quality, dependable information ... and quality marketing/public management.



- Supporting policy.

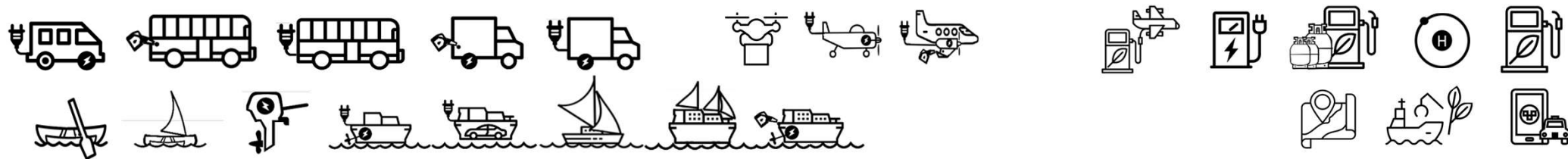
What can be achieved ... example from Norway

Proportion of EVs in new vehicle registrations in Norway





Lets also look at the 'Technology Catalogue' of Transport Options



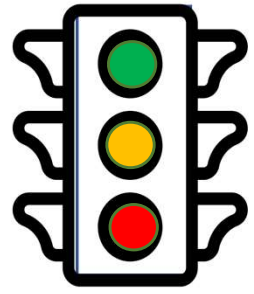


37 Technologies

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	5																		
Waste/ end of life disposal	5																		
Environmental & social impact	5																		
Local value chain/ economic opportunity	4																		
Required complementary measures	3			3	3														
Other considerations					3														

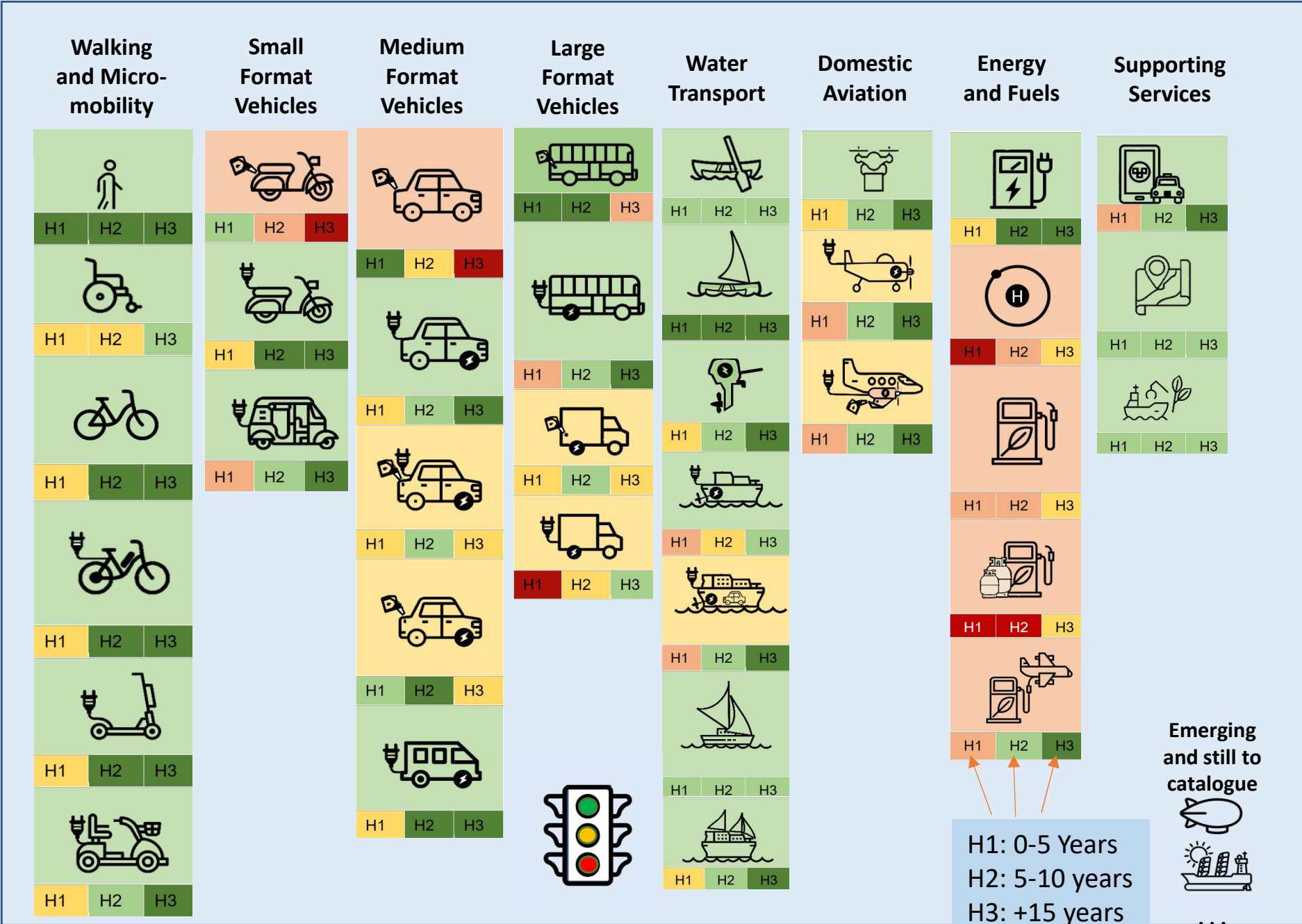


Work Commissioned by NZ Ministry of Foreign Affairs and Trade (MFAT)

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	2
Environmental & social impact	3
Local value chain/ economic opportunity	4
Required complementary measures	3
Other considerations	3

	2	4	3	5	3	2	2	3	3	2	2	4	4	2	4	4	2
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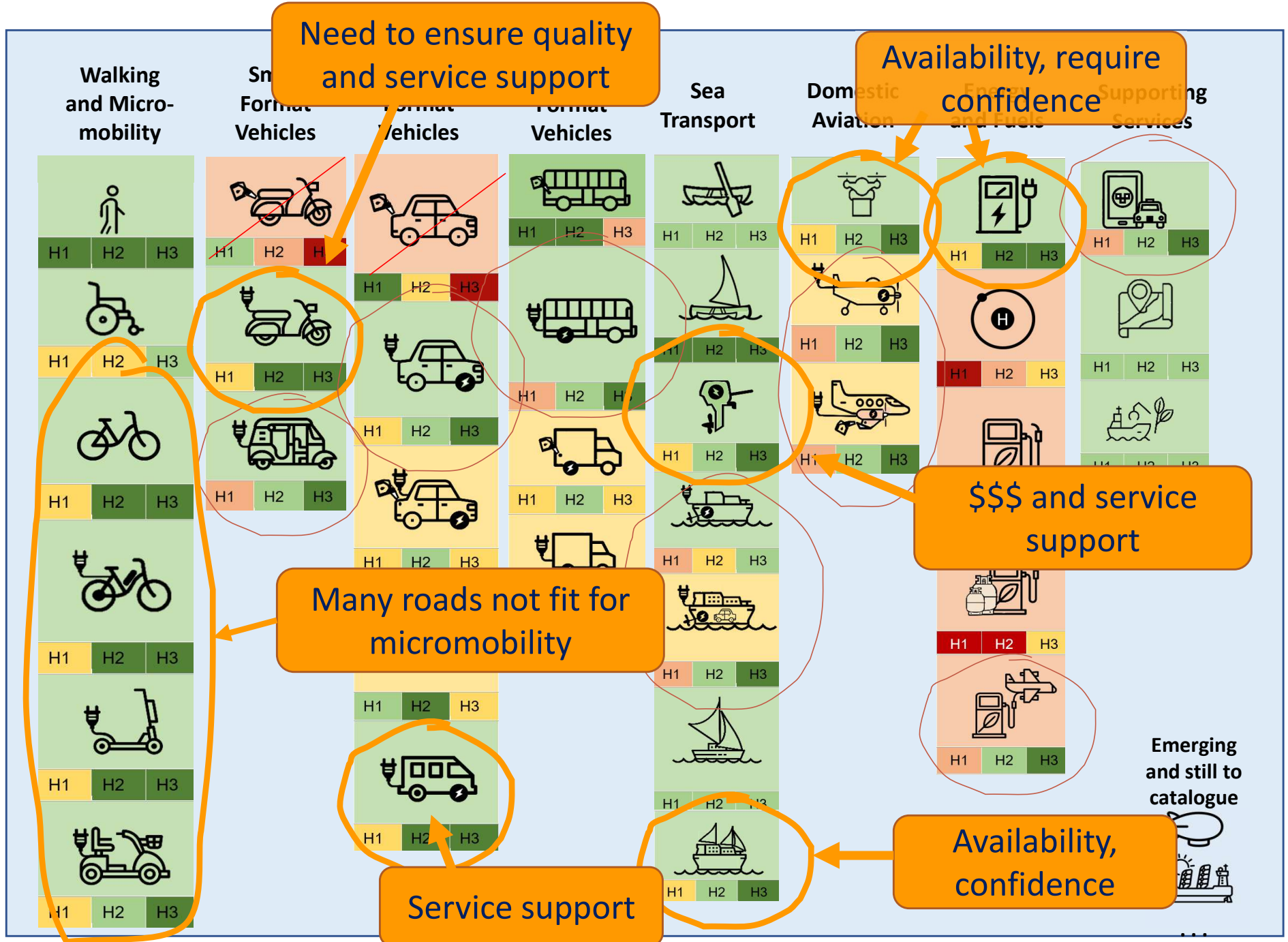
The current catalogue ...



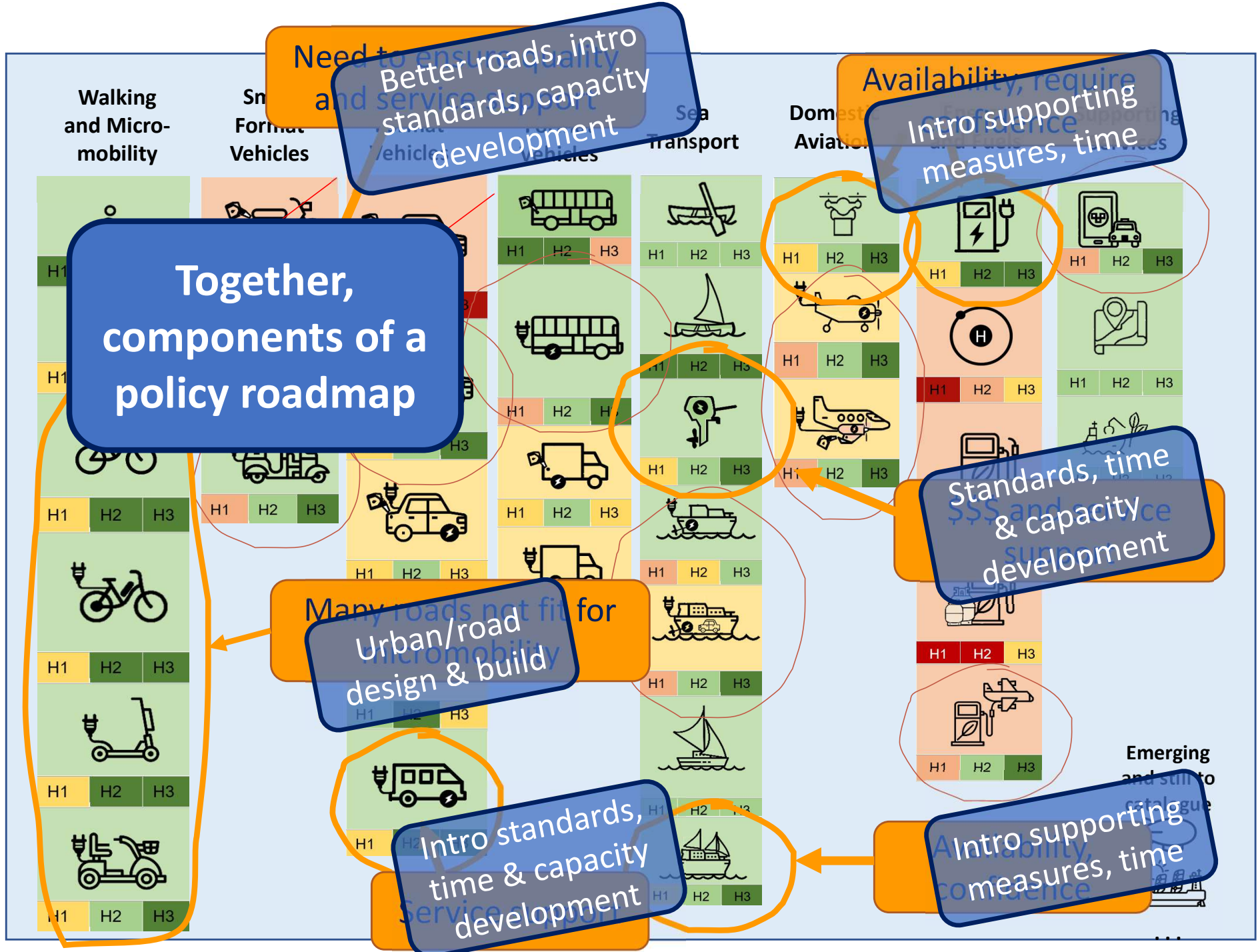
Key points when looking across the easy- to difficult-options:

- 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.
- 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).

For example: consider the barriers to promising technology ...

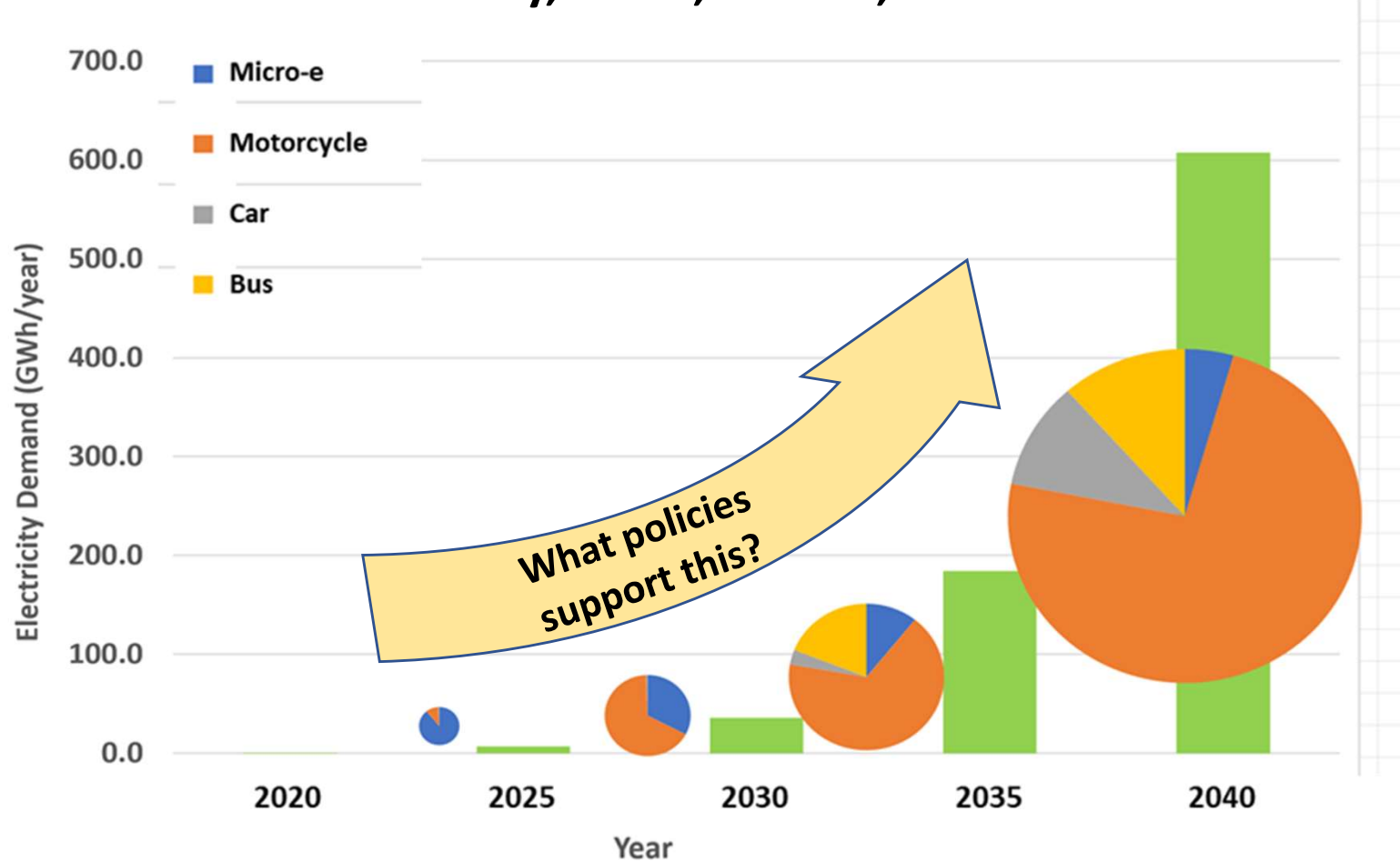


How do we best prepare for these potential futures? ...



Also, consider scale and where the EV sector might go ...

- Modelling carried out for ADB as part of understanding potential electricity demand from EVs in Cambodia.
- Considered micro-e-mobility, e2Ws, EV cars, e-buses and e-trucks.



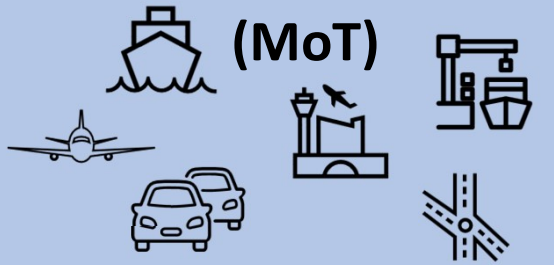
Developing an EV Roadmap

What Government Structure to Manage the Change?

Government Structure – example from New Zealand

Cabinet Office

Ministry of Transport



Vehicles and Infrastructure

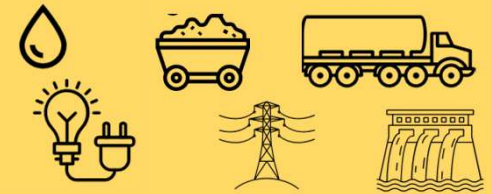
- Safe, affordable and accessible transport

It was recognised:

- Land transport responsible for high % of GHG emissions.
- NZ vulnerable to supply disruption/\$\$\$ of fuel imports.
- Has high %RE electricity.

Minister of Energy and Resources

(Dept: Ministry of Business Innovation and Employment)



Energy and Infrastructure

- Energy security/accessibility
- Energy efficiency

Ministry of Finance



- Affordability
- GDP

→ **MoT**: mandate to develop EV targets.

→ **MoE**: mandate to manage electricity supply and some charging aspects.

→ **All-of-govt**: to address identified barriers in their respective control.

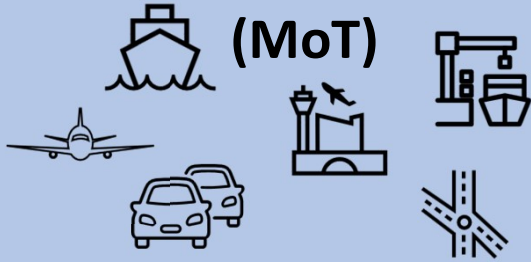
Ministry for the Environment



- GHG mandates
- Air quality

But also need a link to businesses and people:

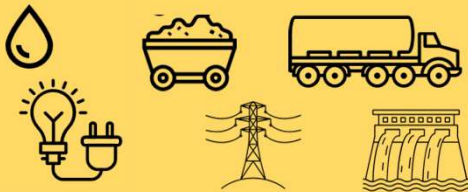
Ministry of Transport



Vehicles and Infrastructure

- Safe, affordable and accessible transport

Minister of Energy and Resources (Dept: Ministry of Business Innovation and Employment)



Energy and Infrastructure

- Energy security/accessibility
- Energy efficiency

Cabinet Office



Also recognized:

- Central government has little direct connection with people.
- EV uptake dependent on changing people's behaviour.
- Govt agency 'Energy Efficiency and Conservation Authority' (EECA), under Minister of Energy, has connection with people:
 - Already worked with industry and community groups.
 - Already provided quality information on energy efficiency.
 - Respected agency.

→ EECA provided mandate to execute MoT's EV target.

Energy Efficiency and Conservation Authority (EECA)



- Connection with industry and public
- Quality information

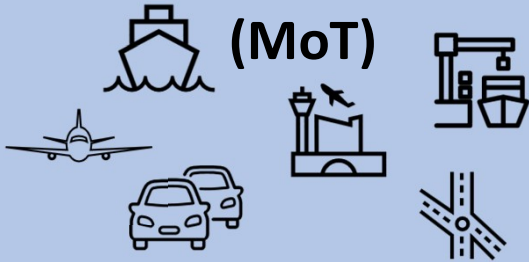
Main government players of resulting EV program:



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



EECA

(reporting to both MoT and MBIE)



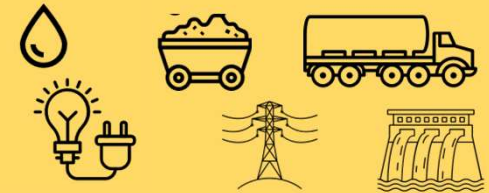
Connection with business and community

- 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.

Private sector also has an important role:

- 
- The background image shows an outdoor event, likely an electric vehicle exhibition. A large green sign with a white car icon and the word 'ELECTRIC' is visible. Several people are gathered around a white car, and a man in a suit is walking in the foreground. The scene is set in a grassy area with trees in the background.
- **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.**

Planning and Policy Development

Planning and Policy Development

Change in planning methods: the sustainable transport paradigm shift

Organic/ incremental → planned/ transformative

‘Predict and provide’ → vision-led ‘decide and provide’

Fossil fuels → (net-)zero emissions

Mobility → accessibility

Cars first → pedestrians first

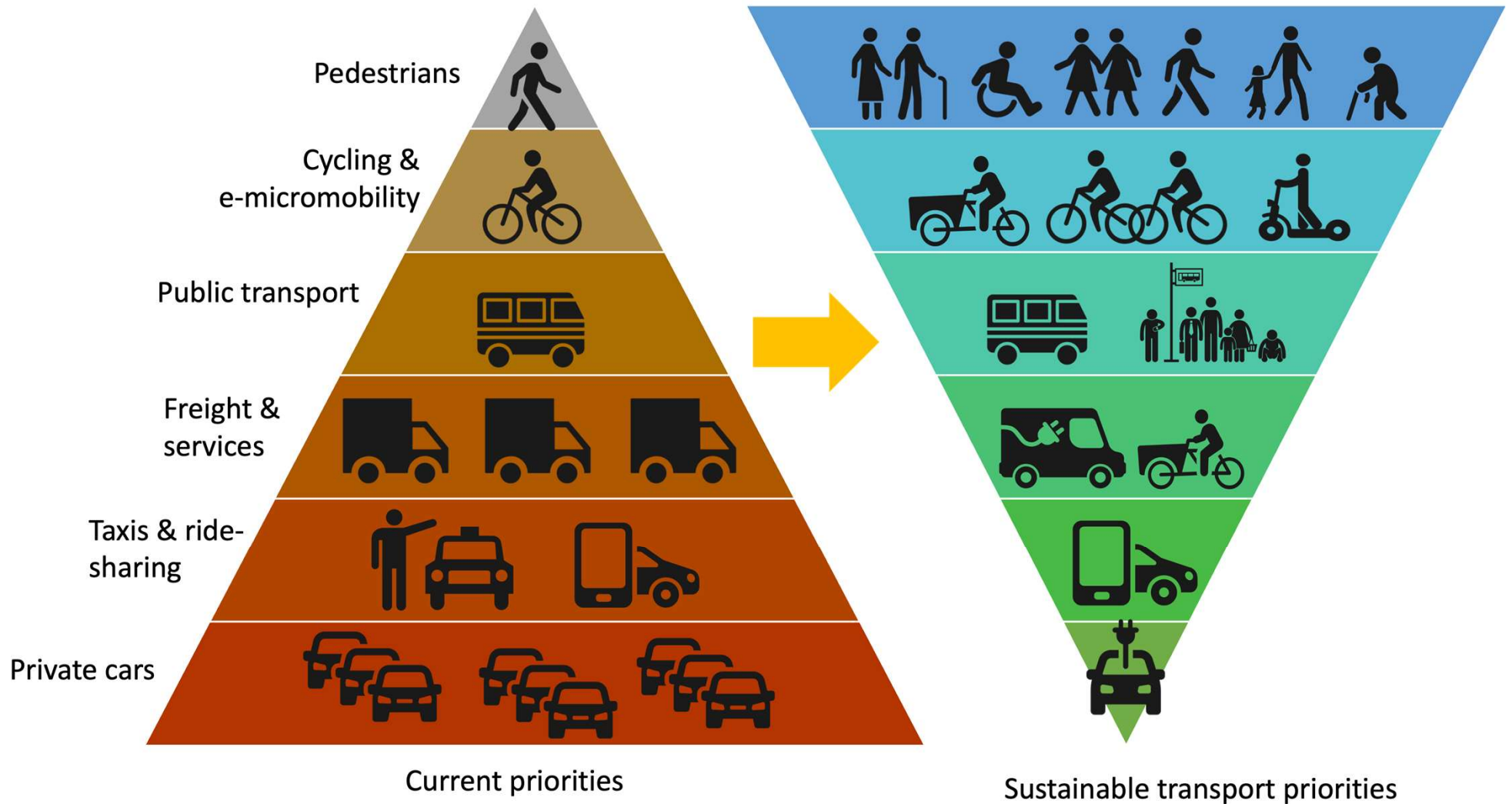
Asset based → service based

Single asset → integrated systems

Imported ideas → locally appropriate, context-specific solutions

From: Navigating Island Futures in Transport – a 21st Century approach to sustainable transport systems for SIDS, Baker and Campbell.

For example, cars first to pedestrians first ...



From: Navigating Island Futures in Transport – a 21st Century approach to sustainable transport systems for SIDS, Baker and Campbell.

Organising policy development – time-in-life of an EV

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, technology, meeting market	Standards, technology, and related hardware and software, 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, experience, 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

Standards



The New Zealand Herald

BUSINESS

Electric scooter giant Lime recalled scooters amid fears that some could catch on fire

🕒 4 minutes to read

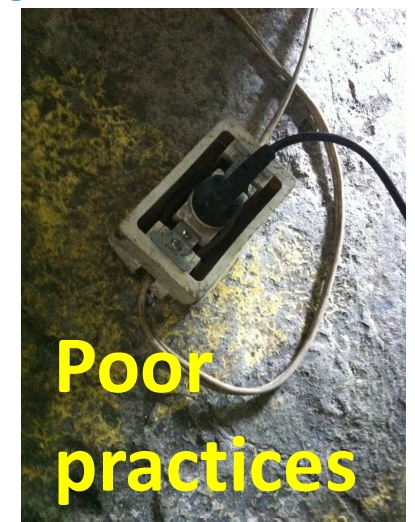
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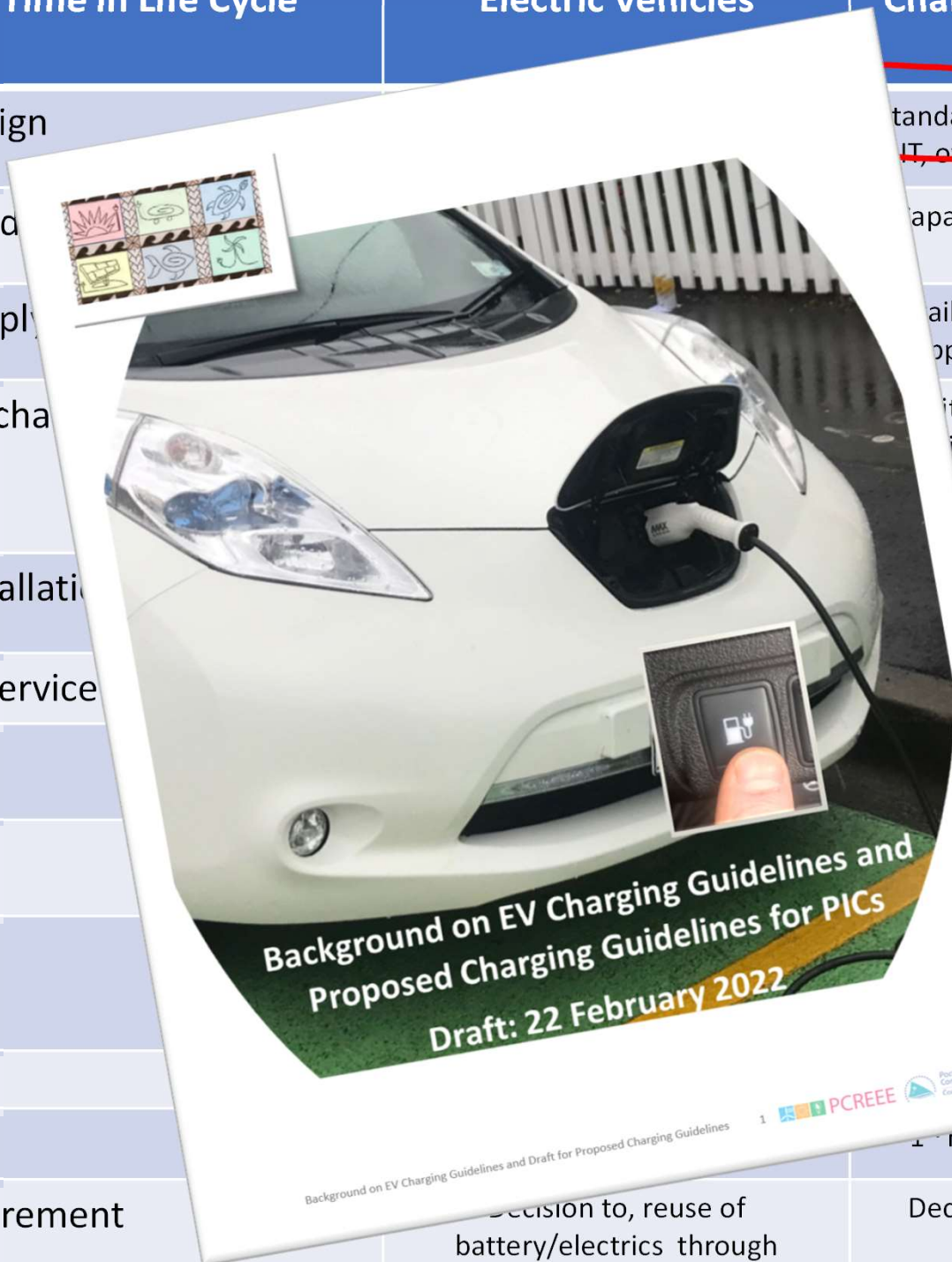
Why we have standards:



- To direct industry (e.g. connectors)
- Minimum performance
- Security and others



Time in Life Cycle	Electric Vehicles	Charging Infrastructure	Electricity to the Plug/Charger
Design		standards, related hardware and software, overall plan, compatibility.	Electricity supply system, planning
Build		capacity, demand by different type	Gen Co.s/Line Co.s
Supply		availability, meeting demand, sourcing, import, certification.	Gen Co.s/Lines Co.s, general information on
Purchase		fit-for-purpose purchase decisions, future-proofing, grid-connection, compatibility, available models	Gen/network upgrade, generation type switching ... company and country plans
Installation		approval, site works, construction, industry training.	Gen Co.s/Lines Co.s
In-service		restrictions, signage, safety, location App.	Awareness, controls (pricing and other).
		charging, connectivity, payment, charge, billing.	Connectivity, time of charging, billing
		certification, industry training.	Gen Co.s/Lines Co.s
		industry training, map.	Gen Co.s/Lines Co.s
		emergency 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
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, WoE	Approval, site works, certification, industry training.	Gen Co.s/Lines Co.s
In-service operation			
General use	Understanding, best driving practices		Awareness, controls (pricing and
Charging	Understanding of, options, best practice		
Servicing/maintenance	Understanding of, industry capability and capacity, industry training		
Breakdown	Guidelines/best practice		
Accident	1 st response, repair, fleet r		
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:



- **Lessons to be learned** 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.



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



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