Global Experience with Electric Vehicles

Andrew Campbell

- Backgrounder on EVs
- Global Status
- Developing EV Policy

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Backgrounder on Electric Vehicles

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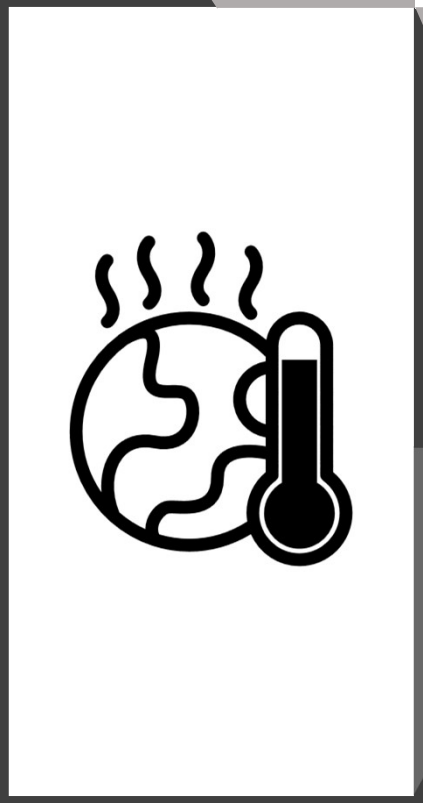

Drivers for change

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

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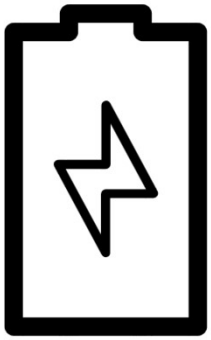
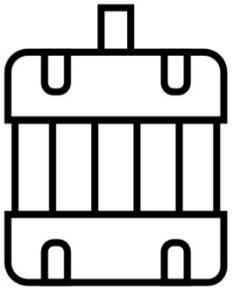
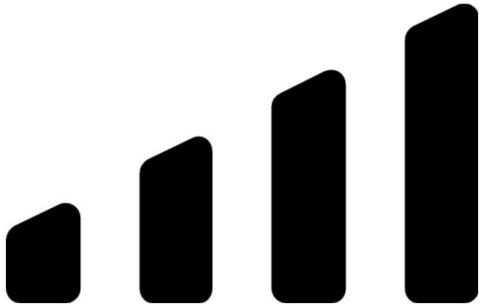


Batteries



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**
- **→ more affordable and accessible transport**
- **Accelerated uptake of e-mobility.**

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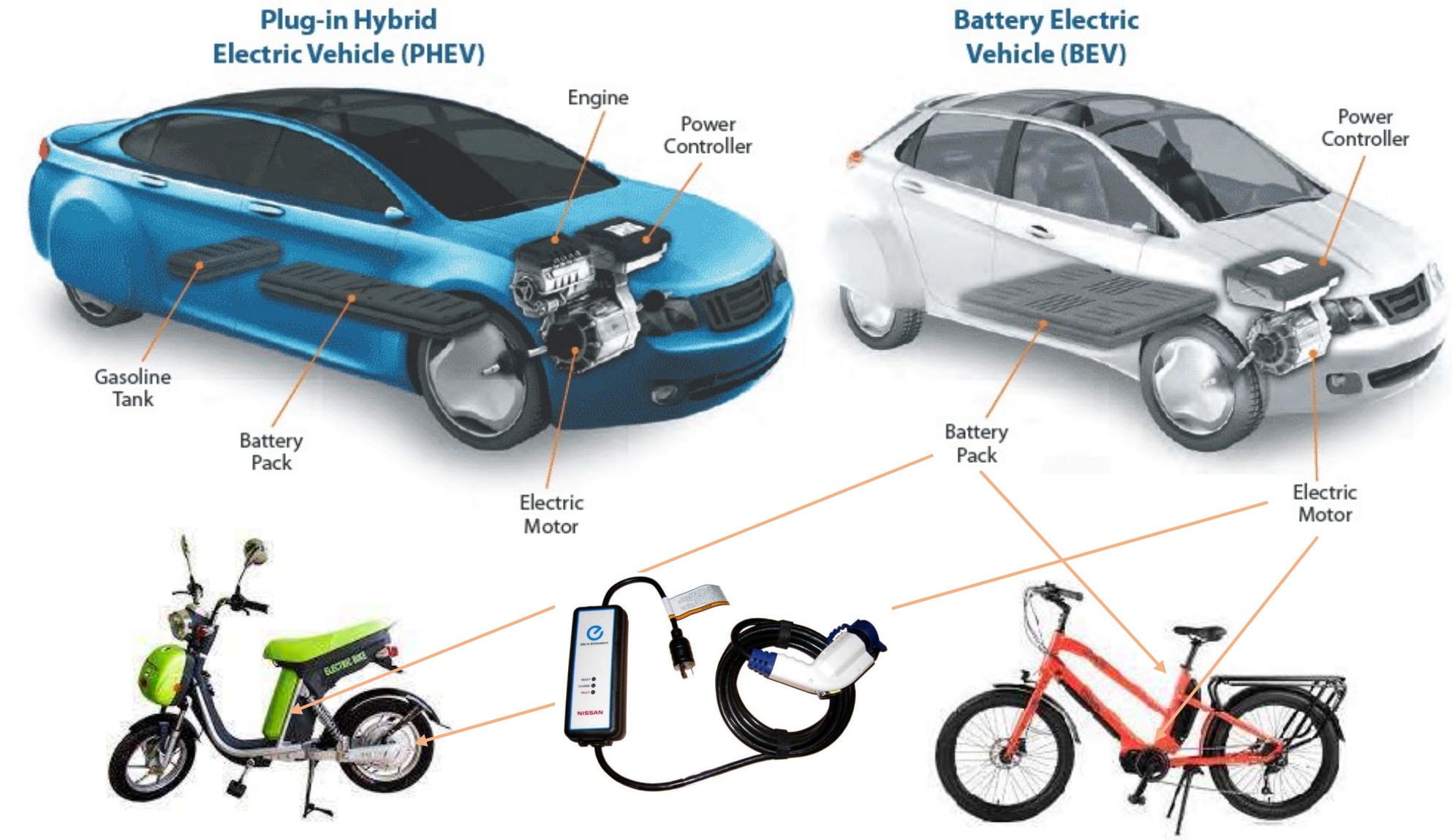
Result → variety of e-mobility solutions expanding

Interest is in plug-in e-mobility



- 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” …

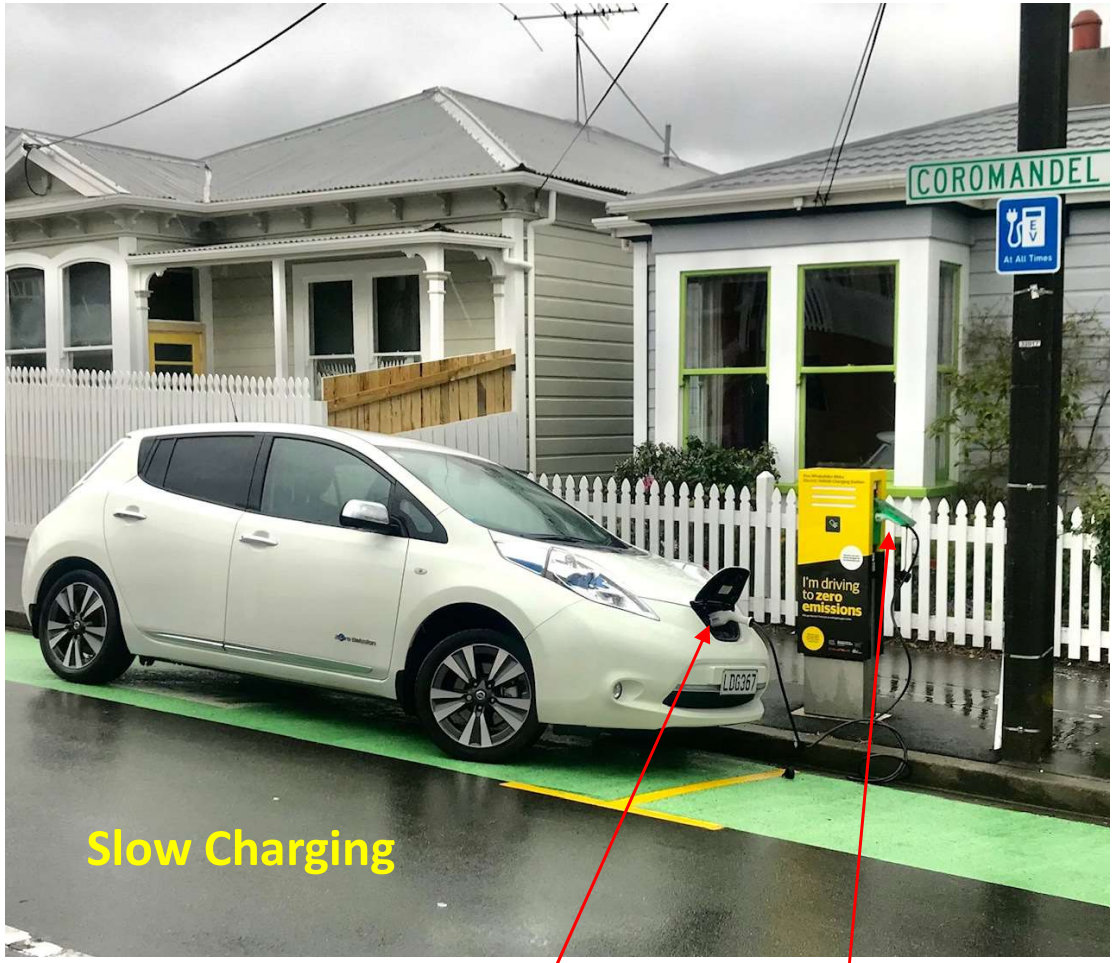
Many charging connector options. Important to guide industry to a few

	Name	AC/DC	Rate	Vehicle
	**"Type 1" (SAE J1772)**	**AC**	**1-20kW**	**Japan, US origin, Some EU**
	European Mennekes	**AC**	**3-22kW AC BYD/Tesla up**	**EU-sourced**
	**C** (ti		**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

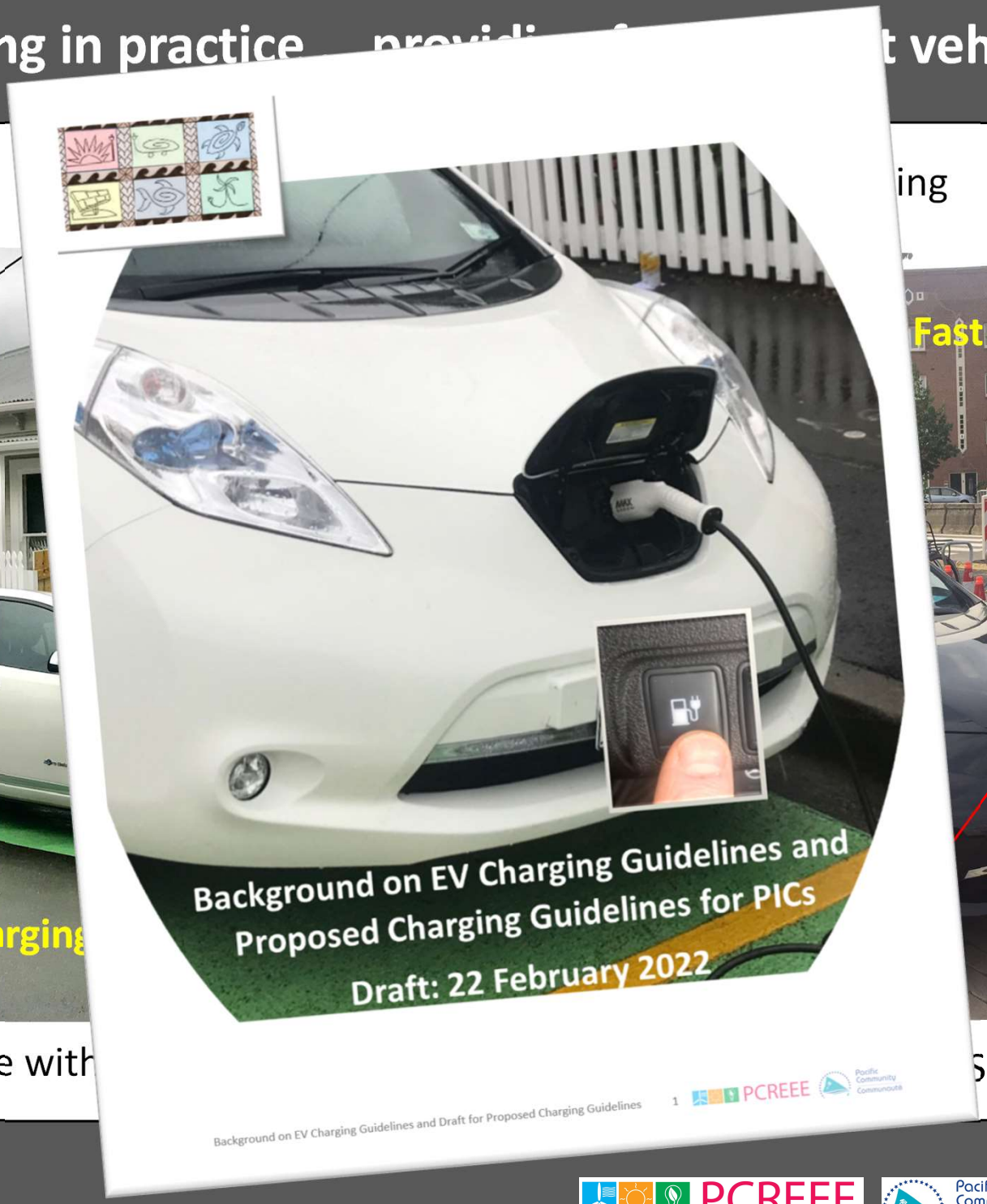


Portable cable with: Type 1 at EV and Type 2 charger

CHAdeMO CCS Type 2 Type 2

Charging in practice ... providi... ...t vehicle connectors

Portable cable with



...ing

...S Type 2 Type 2

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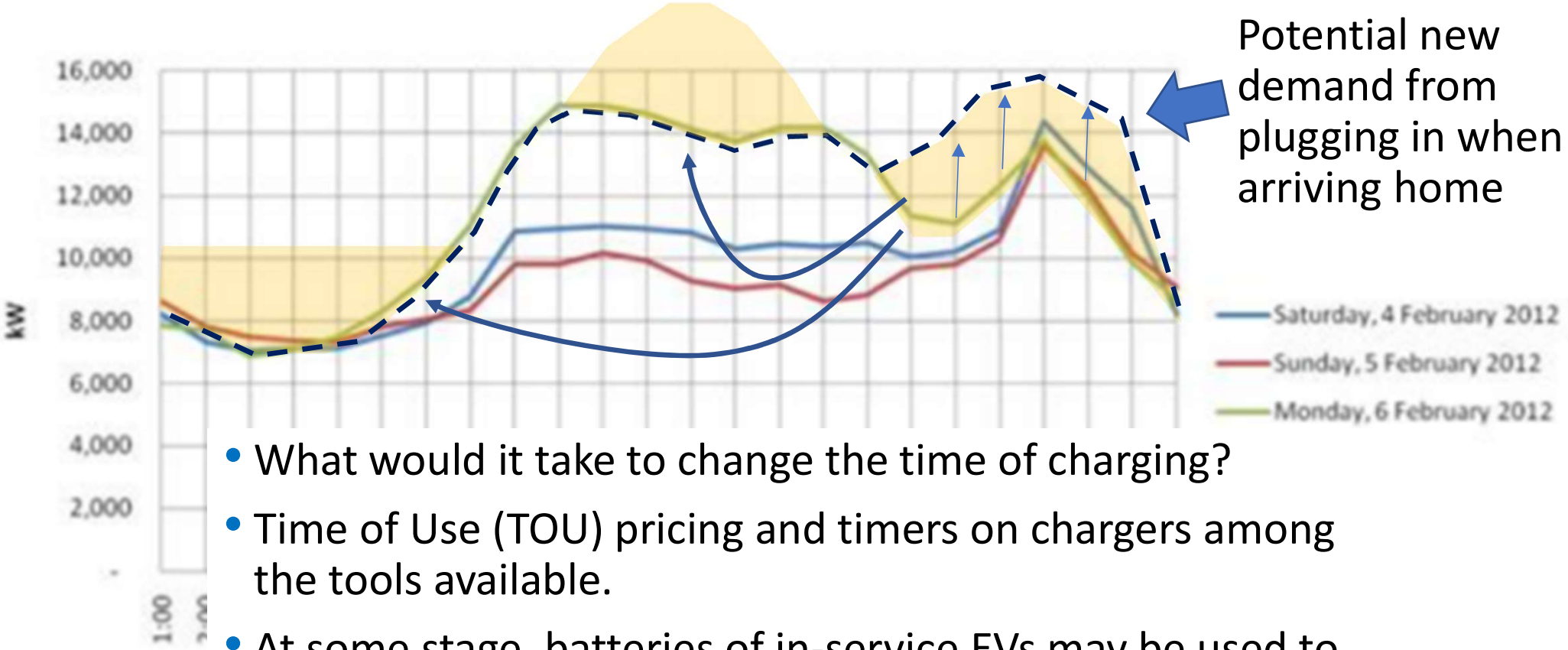
Effect charging may have on electricity demand:

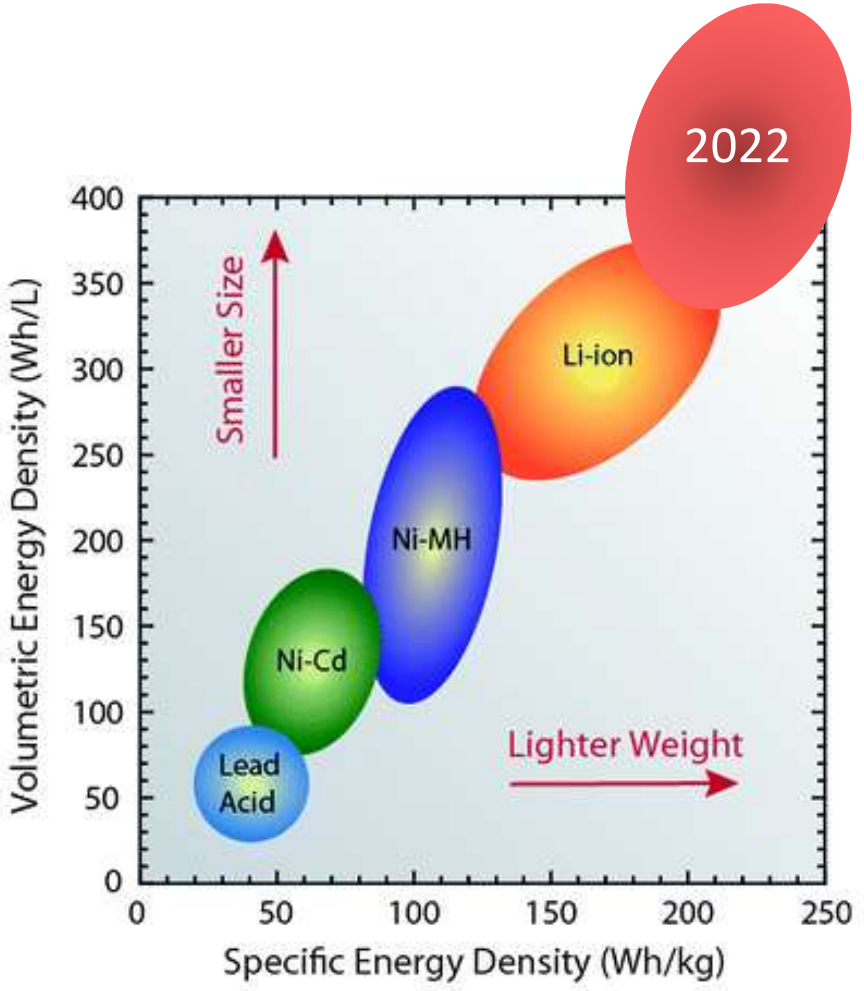


- What would it take to change the time of charging?
- Time of Use (TOU) pricing and timers on chargers among the tools available.
- At some stage, batteries of in-service EVs may be used to support electricity supply (e.g., capture solar and deliver energy when required … V2G … but some time off).

(from IRENA 2013).

Why the change? … improvements in 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

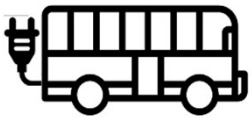


History of EV Development

The real ‘no-brainer’ but still in early phase

‘No-brainer’ development in Asia (cheaper versions)

The initial “EV” focus



Required in China to combat local air quality

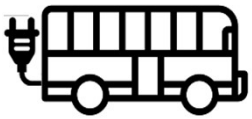
Following trend (in part driven by corporate responsibility)

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)



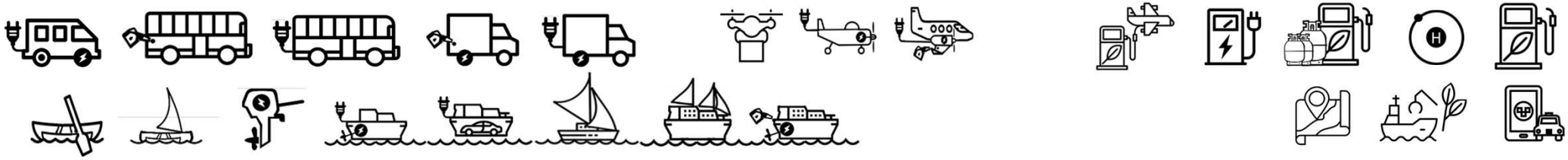
600,000 on road 2020, >99% in China (IEA)

Globally, 31,000 on road 2020 (IEA)

Looking at the wider options …

‘Technology Catalogue’

of transport options



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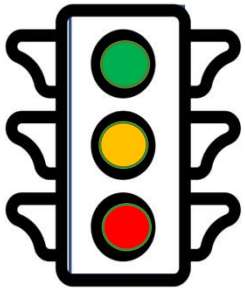
37 Technologies

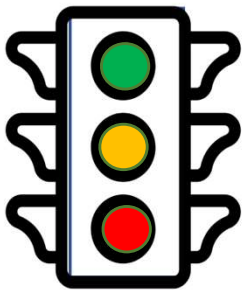
15 Assessment Dimensions

- 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



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

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	5	4	5	5	3	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						

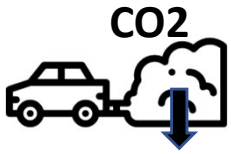


Work Commissioned by NZ Ministry of Foreign Affairs and Trade (MFAT)

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 fast 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	5	4	4	4	4	5	4	4	4	4
Energy security		3	4	4	5	5	5	4	3	5	4	3	4	4	5	3	4	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	5	4	4	4	4	5	4	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	3	5	3	2	2	3	3	2	2	4	4	2	4	4	2
Other considerations																			

Global incentive schemes

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



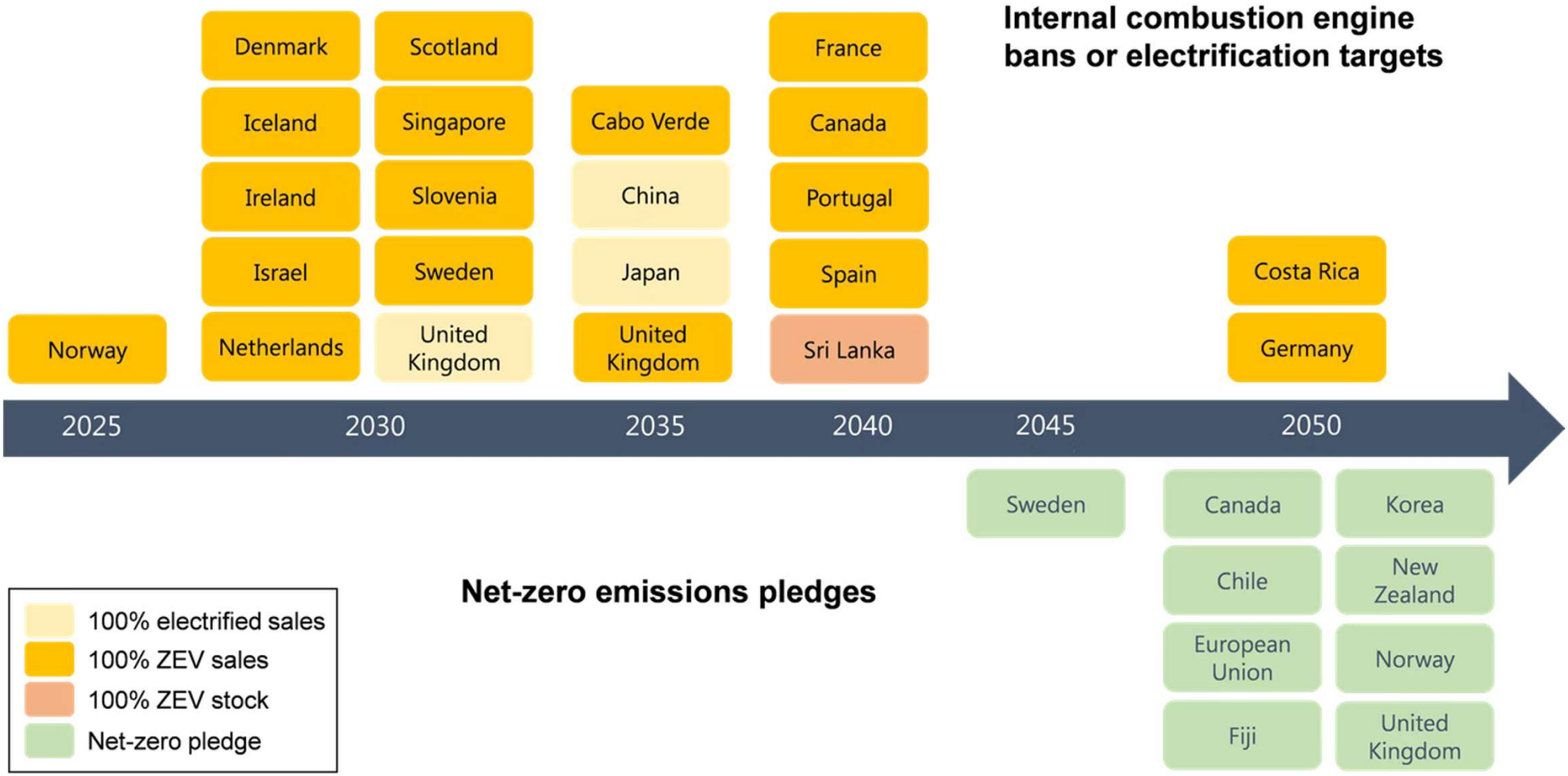
- **Tailpipe CO_2 mandates** → EVs cheaper option for EU manufacturers to meet them.

- **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



Common success themes in EV Roadmaps

- 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.

Developing an EV Roadmap

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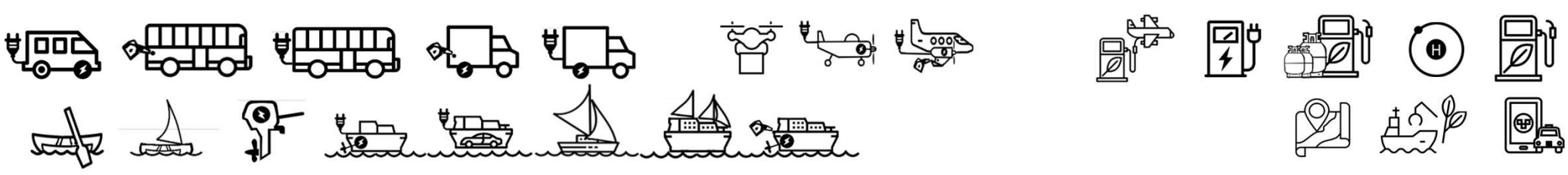
Planning: look at the ‘Technology Catalogue’ of Transport Options



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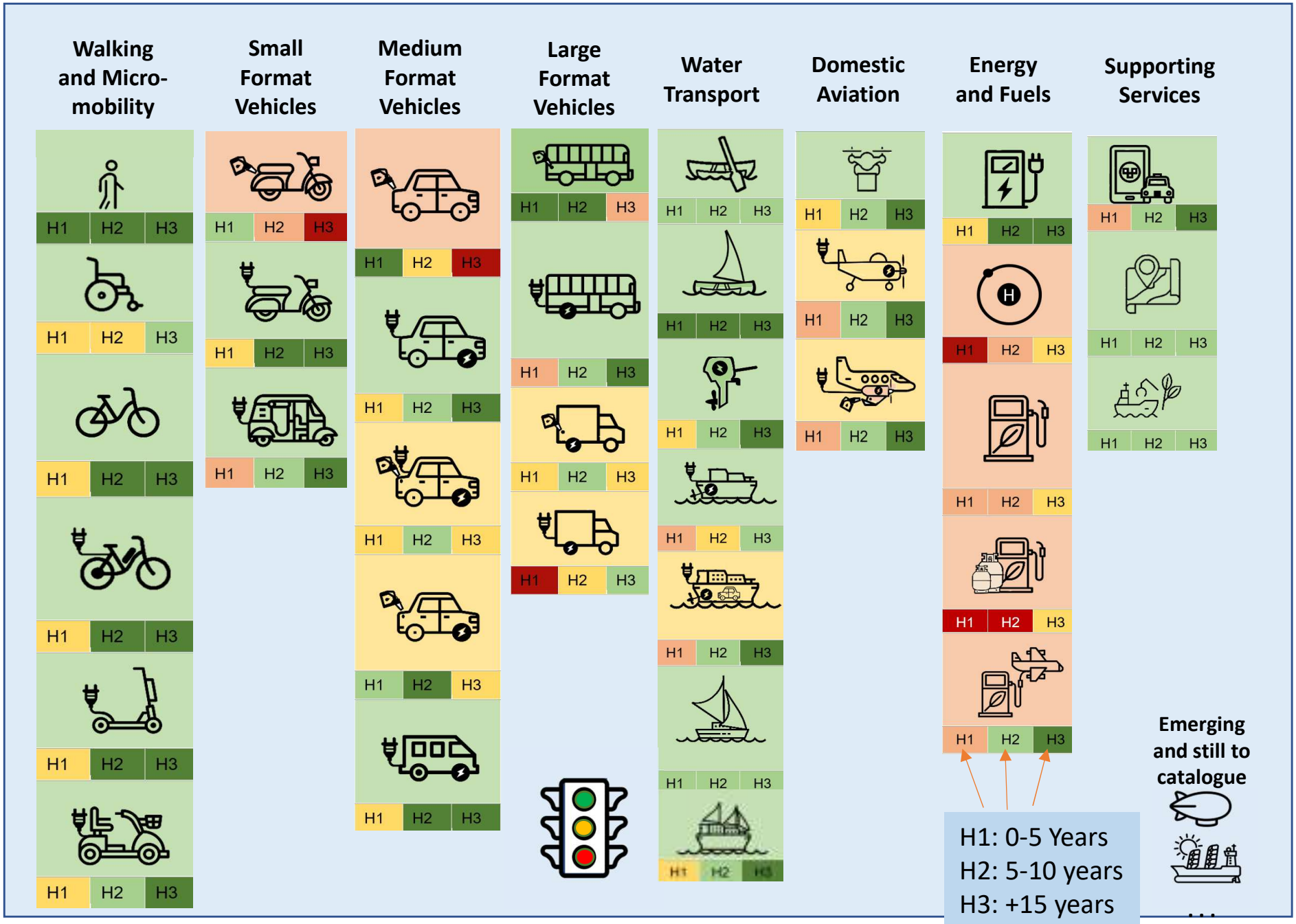
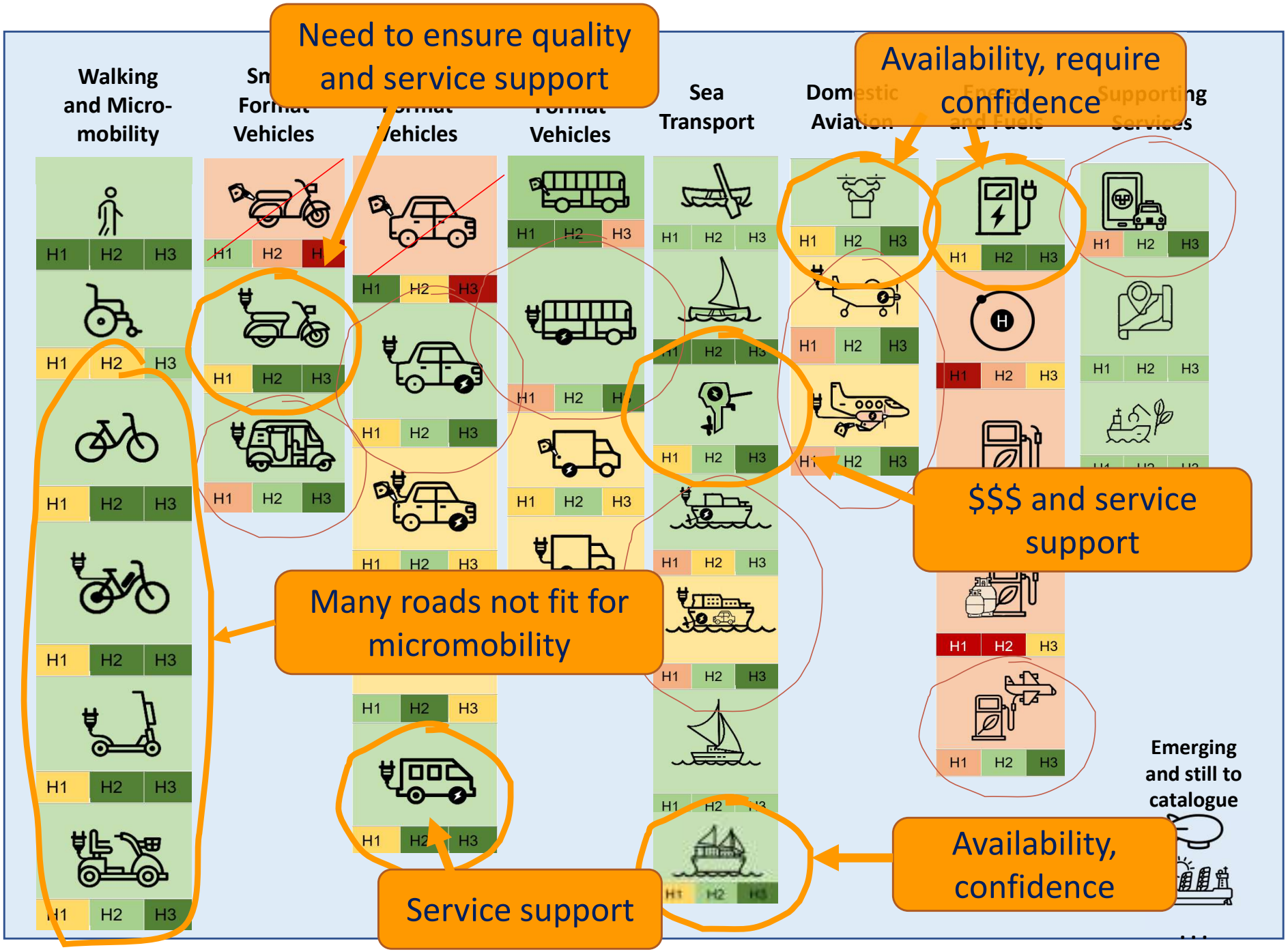
The current catalogue …

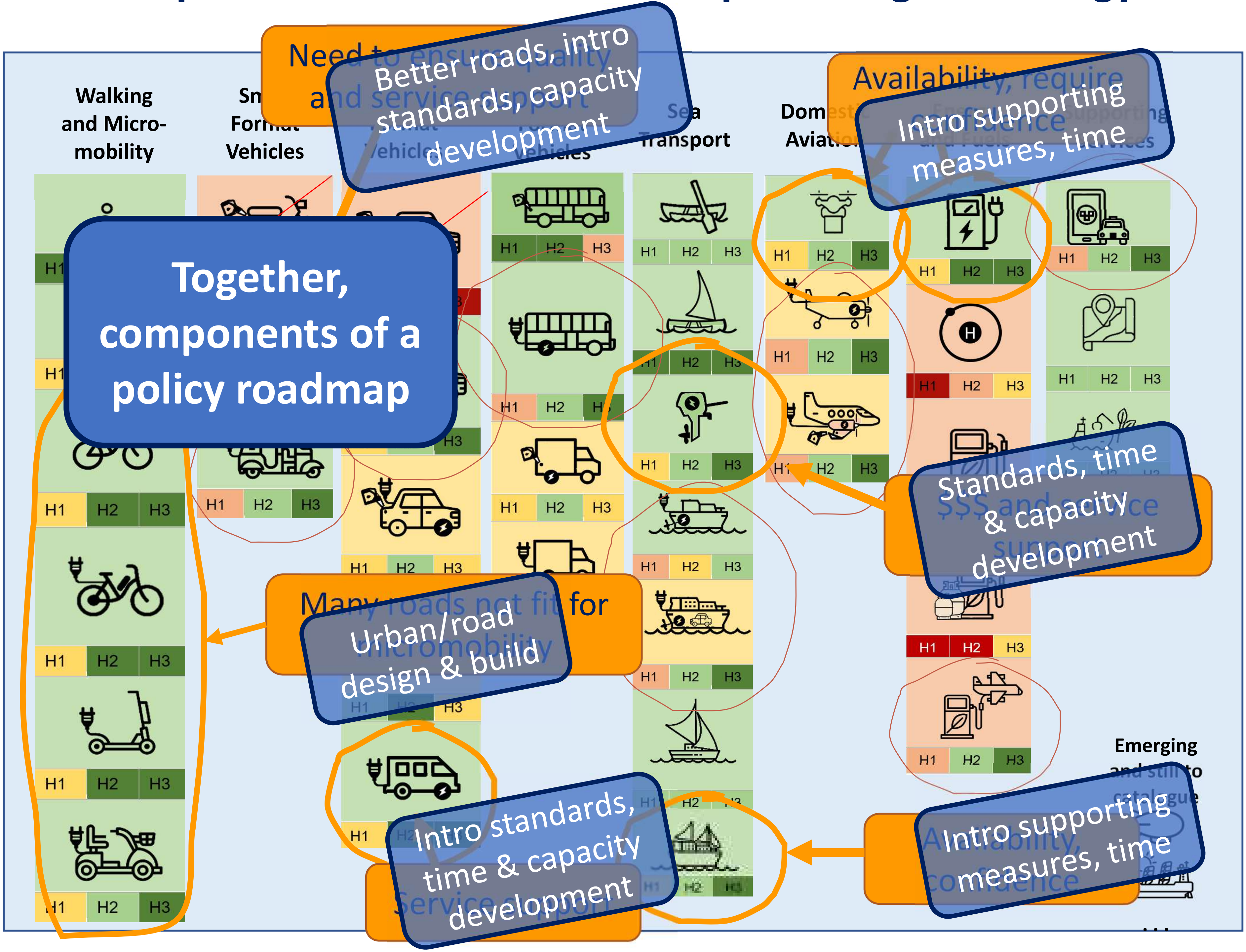


For example: consider the barriers to promising technology …



How do we best prepare for these potential futures?

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



Key points when looking across the technologies:

- 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).

What Government Structure to Manage the Change?

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Example from New Zealand:

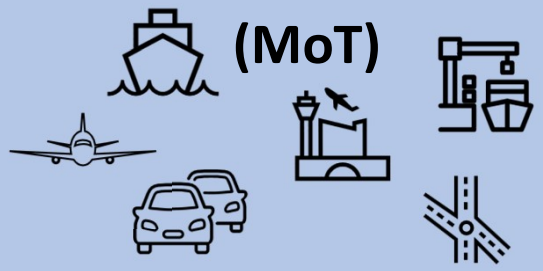
Cabinet Office

Vehicle/Roadside-Related

Execution

Electricity Supply and Charging

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.

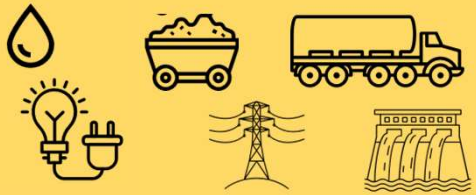
EECA

(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.

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:

- 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

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

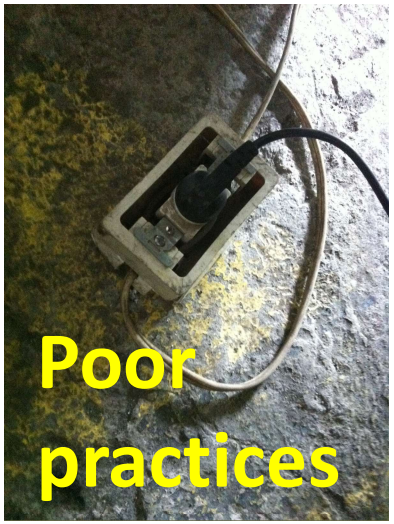
Consider the time in the life of an EV:

- **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, 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, 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	1st response, repair, fleet re-entry	1st 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

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, 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, 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 drivi practices	signage	Awareness, controls (pricing and
Charging	Understanding of, options, best practice		
Servicing/ maintenance	Understanding of, indus capability and capacity, in training		
Breakdown	Guidelines/best practi		
Accident	1st 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.

Questions?

PCREEE
Pacific Centre for Renewable Energy and Energy Efficiency

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