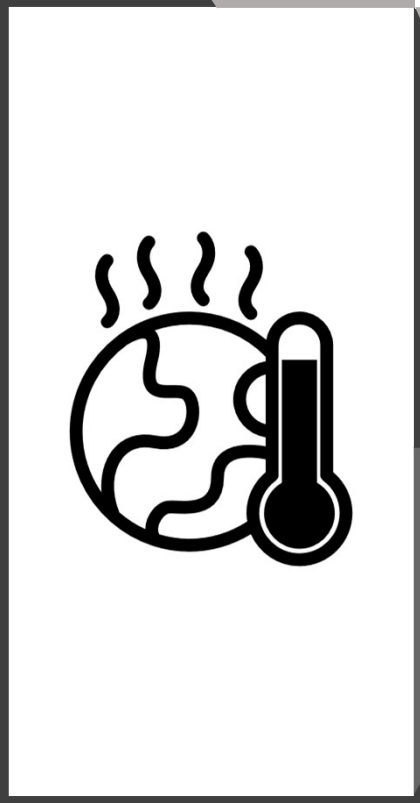
E-Mobility – Global Status

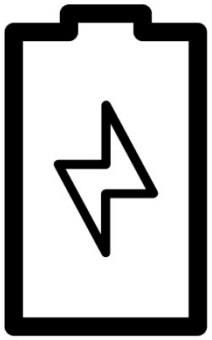
Andrew Campbell

28 November 2022

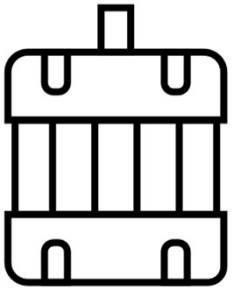


What is driving change?

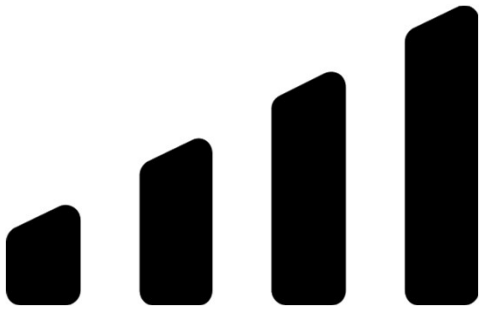
- Climate Change
- Cost of fuel imports
- Local air quality
- Resilience
- Personal safety
- Convenience
- Improve level of service
- Improve quality of life
- Congestion
- Waste minimization



Batteries



Motors



Networks/comms

Smartphones

GPS/satellite tech

Enablers of change:

Technologies are developing rapidly →

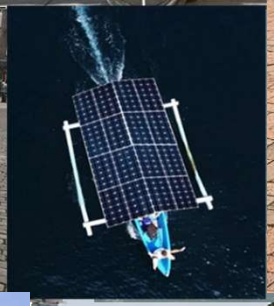
- **Falling costs**
- **Rapidly increasing capability of technology**
- **IT and IoT**
- **Clever combinations = new ways, providing more affordable and accessible transport**
  - **→ accelerated uptake of e-mobility**
  - **→ micro- and small-format mobility**
  - **→ shared vehicles**
  - **→ connected, on demand services**
  - **→ i.e., mobility as a service (MAAS).**
- **When will steering wheels become illegal???**

Examples of new mobility options enabled by the development of modern batteries

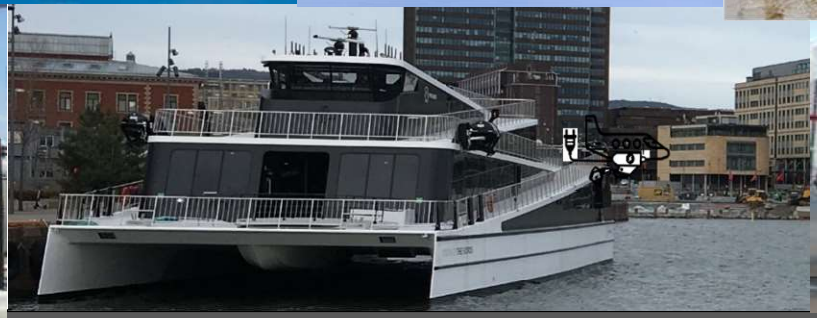






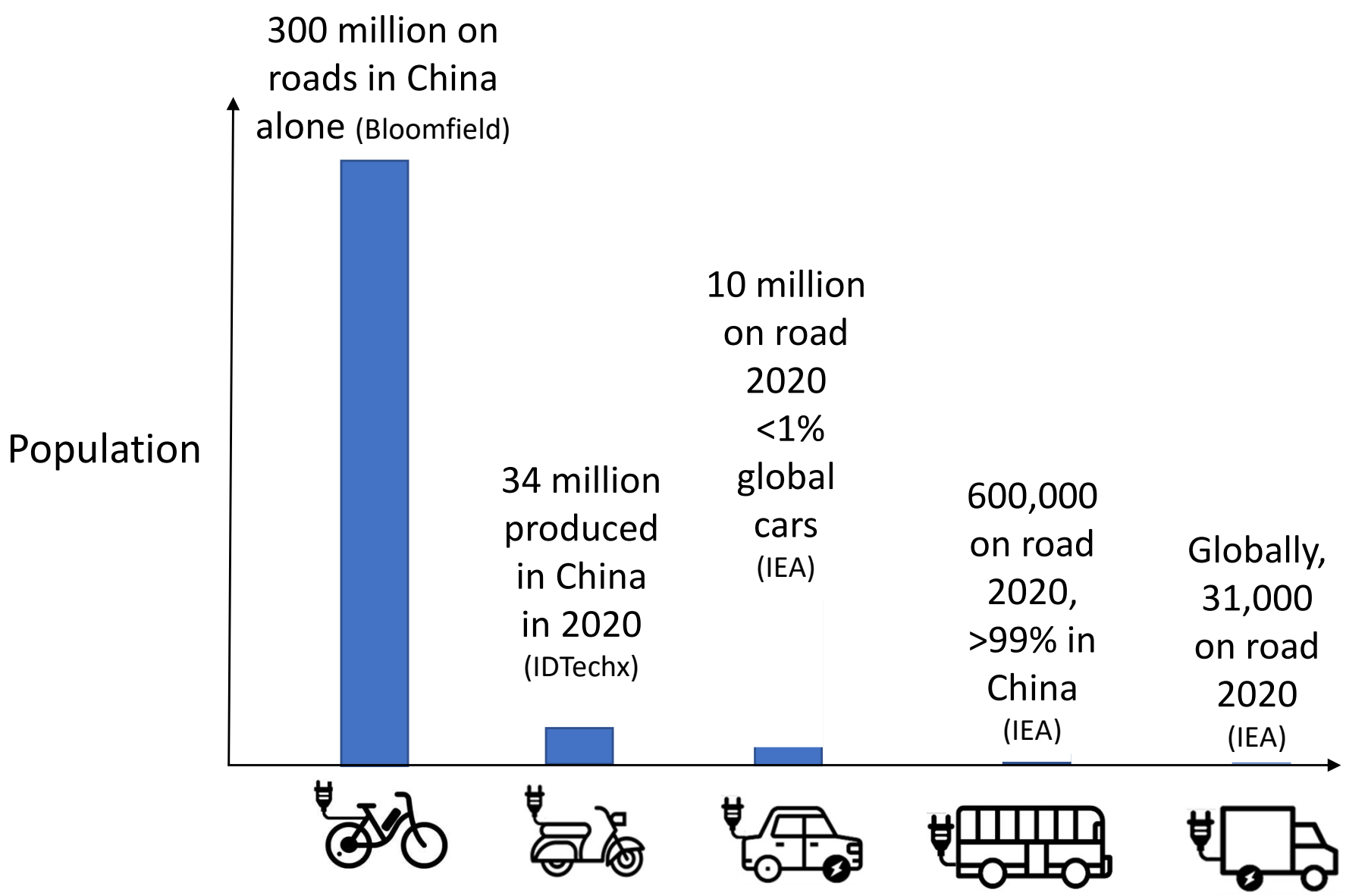



Global trends in transportation sector:

- Priority on **reducing reliance on cars** → support people to walk "**pedestrians first**", cycle, use small-format vehicles and **public transport**.
- Adoption of **low-emission vehicles** (including EVs).
- Decarbonization of heavy transport has begun in many countries.
- Use of **Shared vehicles**
- New business models developing:
  - Access to mobility via accessing **services** (UBER, Grab, other MAAS).
  - New B2B models: e.g., Gojek (not wanting to invest in assets) and Gogoro (providing e2W transaction and battery as a service platform) … with potential for Gensit to manufacture and lease.
  - **Integration of multiple mobility platforms** (through data/IoT/clever algorithms … e.g., balancing demand on local/grid electricity supply).

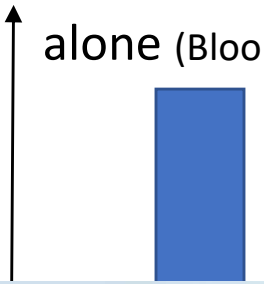
EV Global status



- 50x LEV regos compared with 2012
- China still the global EV powerhouse – IEA'22 data

EV Global status

300 million on roads in China alone (Bloomfield)



- Many countries have focused on EV cars
- But micro/small EVs have important role:
  - large GHG/travel changes with mode shift
  - affordable e-mobility option now
  - … requires suitable infrastructure (beyond roads).

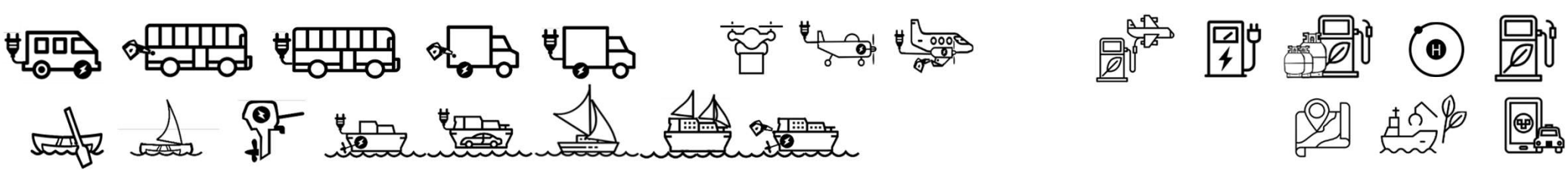
Popula

- 50x LEV regos compared with 2012
- China still the global EV powerhouse – IEA'23 data

Lets look wider across the

‘Technology Catalogue’

of transport options

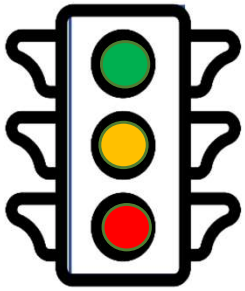


37 Technologies

Vehicle/transport option		Walking	Wheelchairs	Bicycles	E-Bikes	E-Push Scooters	Mobility Scooters	Petroleum Two Wheeler	Two	E-Trikes et al	ICE				Charging of EVs	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,	Short- and medium-distance, 1-	Short- and medium-distance, 1-	Short medi distance, multi-	several	several	several	several		distance, multi-	distance, multi-	distance, multi-	long-distance	to m-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.	Mat deve													
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		4																		
Operation & maintenance requirements		5																		
Waste/ end of life disposal		5																		
Environmental & social impact		5																		
Local value chain/ economic opportunity		4			5															
Required complementary measures		3		3	3															
Other considerations					3															

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

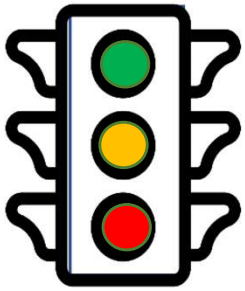


Work Commissioned by NZ Ministry of Foreign Affairs and Trade (MFAT)

Vehicle/transport option		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)		Demonstrati on.
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				

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						



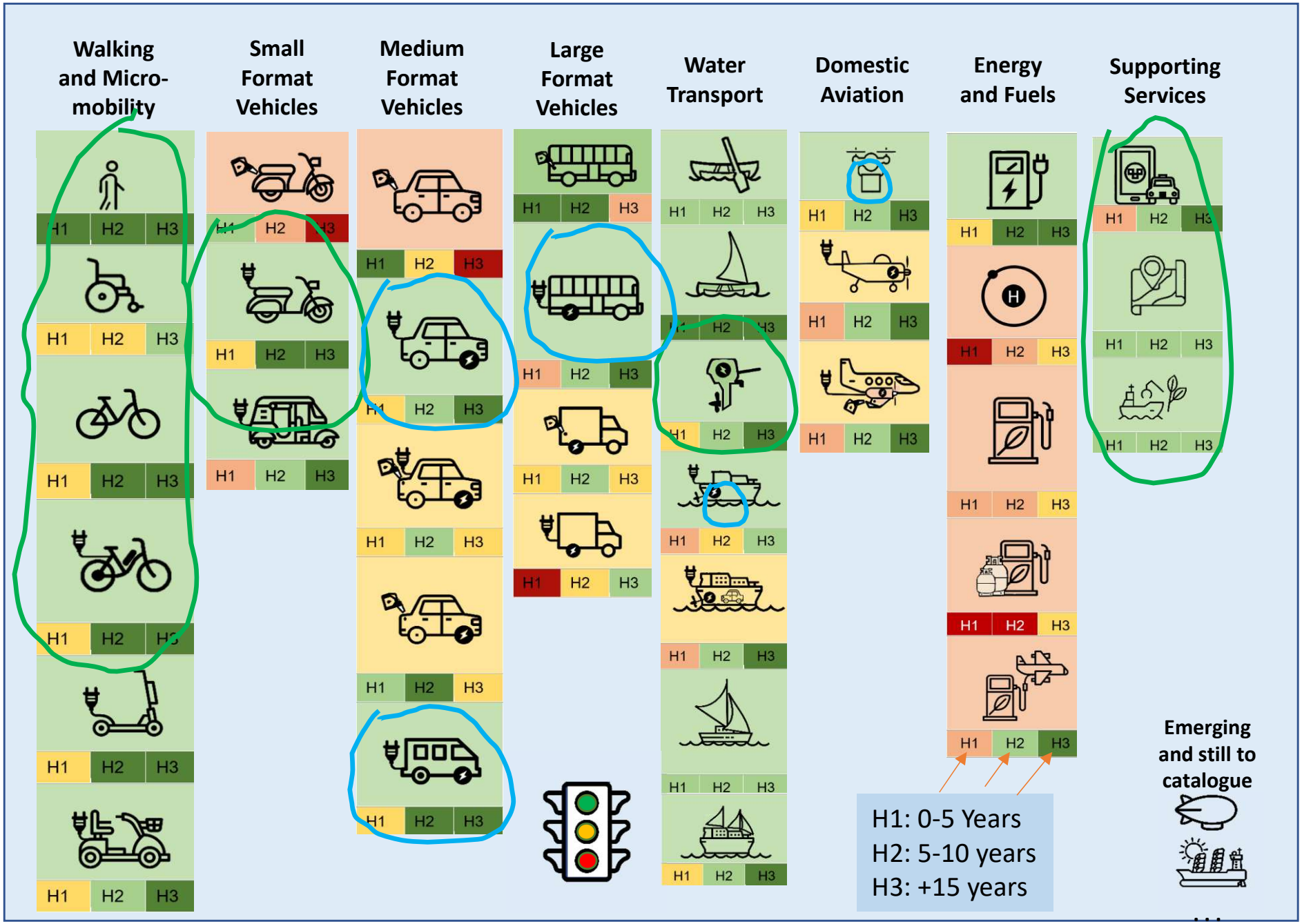
Work Commissioned by NZ Ministry of Foreign Affairs and Trade (MFAT)

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																			

The current catalogue …

PIC “deployment ready now”

PIC “pilot-ready” (noting importance to begin transition)



e-Mobility global trends - vehicles:

- Increasing models – 450 LEVs, 170 e-trucks outside of China (IEA EV Outlook 2022)
- **TCO parity:** already there for e2Ws/e3Ws and some commercial EVs applications, but light/heavy EV purchase price premium also a barrier:

  → demand-side policy to bridge price differential between EVs and ICEs, including tax reduction and budget-neutral feebate programs.

  → Local government directives: e.g., 50% delivery 2Ws to be electric by 2023, 100% PT by 2030 (Uttarakhand, India)
- **Guidance on vehicle specification required:** e-bikes lasting weeks only, use of lead-acid batteries, use of low quality lithium-ion batteries → intervention example: regen braking required to get subsidies in India.
- **e-Mobility makes financial sense today if externality costs** considered. However, difficult to introduce such due to uncertainties and little consensus on methodology and values to be used (e.g., calculated GHG reductions from e-bus charged from diesel generation ranges from 10% to 50% depending upon calculation model).

e-Mobility global trends - batteries:

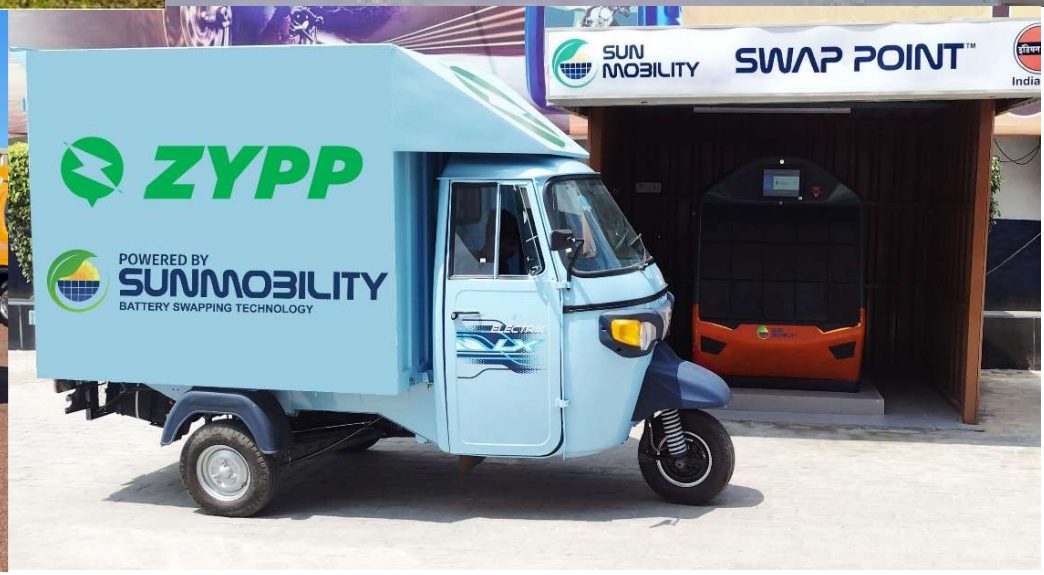
- In main EV markets, improvements in battery performance used to increase LEV range in preference to same range and decreased price.
  → design for toady's Gen 2 Nissan Leafs or tomorrow's EVs?
- 1-3 year battery warranties on e2W/e3W/marine batteries a market barrier when average ownership 5-6 years. Made worse by perception that battery at its end of life after warranty expires.
- UN GTR No.22 on In-Vehicle Battery Durability adopted March'22:
  - Batteries on LEVs to lose less than 20% original capacity over five years or 100,000 km, and
  - Less than 30% over eight years or 160 000 kms.
- India and Indonesia encouraging set up of 'gigaplants' (e.g., 50GW/y battery plant in India (IEA Outlook 2022))

e-Mobility global trends - charging:

- **Battery swapping** expanding into many countries (providing fast "recharging" of small-format e-mobility vehicles. Provided as a service, removes battery cost from vehicle purchase, specialist entity can look after 1000's batteries from introduction to end-of-life …).
- **Importance of smart charging** for grid management recognised.
- **Commercial V2G emerging** → use of EV batteries to support the grid becoming a reality:
  - UNIDO China-SAE GEF project.
  - Gogoro and grid integration of battery swap stations in Taiwan.
- Most sales in lighter vehicle categories where at home/work charging prevalent → **encourage set up of charging at home, at work**, parking spaces, government buildings …
- Electricity distribution, and oil and gas companies are entering the market (e.g., Petronas and PLN in Indonesia, both charging stations and battery swapping).

Battery-swap stations and vehicles …

Battery-swap stations and vehicles …



Global trends – electricity supply:

- Ability to supply to e-mobility market often thought a concern:
  - Added demand only 5% in large economies (EV Outlook 2022).
  - However, added stress on local network → need for upgrades such as transformers (eg 1st CSs and Bhutan project)
  - PICs also starting from a base of small electricity demand:

    → e-mobility demand likely to be a more significant proportion of total demand,

    → high levels of decarbonization to consider,

    → high levels of variable renewable energy to consider,

    → plus electrification of heat (cooking) and new cooling demand (AC)

    → but will also take time for EV sector to develop.

Global trends marine and air:

- Electrification of marine industry rapidly evolving …
  - 2019: there were two suppliers of >40hp$_{equiv}$ outboards on plugboats.com portal. Yesterday there was 10.
- Many short-voyage large-vessels in commercial operation.
- Commercial (and military) drone use has been normalised.
- Electrification of aviation industries at an emerging level …
  - 2022 has seen many maiden flights of final-design electric commercial passenger aircraft.

All very well … but how do these fit in the PIC environment? … and where is the plan for PICs?

- What are the **transport needs** for each PIC?
- What is **each country's vision** for what this looks like at 2040?
  - What is the desired vehicle fleet … and how is it accessed?
  - What do land-based "roads" look like?
  - And at 2030?
  - **How best to prepare for this** → what does 2025 look like?
- Noting:
  - e-Mobility expected to be **part of the solution** (reason for the UNIDO/PCREEE project that developed a Regional EV Program).
  - What has not worked in the past unlikely to work going forward.
  - Expect increasing urbanization.
  - Change (and even thinking about it) will be uncomfortable to some

… how to make it happen?

Delivering … an e-mobility project example from Bhutan …

UNIDO project "Promoting Green Electric Mobility (E-Mobility) Solutions for Urban Transport in Bhutan and the Wider Hindukush-Himalaya Region"

- **Grid** electricity virtually **100%** renewable.
- A vision of **all-electric bus fleets** serving it cities.
- e-Mobility **unknown → risks** perceived high by the decision makers …
  - Do e-buses work in the cold of winter and on long, steep inclines in the heat of summer?
  - Can't consider e-bus adoption, let alone plans, unless first-hand Bhutan-real-world experience and in-service data available.
  - → e-bus pilot, specified to best provide this experience and data.
- Bus project **not considered in isolation**:
  - Fits with Bhutan's UN-backed GEF 300 e-taxi project.
  - Fits with other transport needs.
  - UNIDO supported study tour of RGoB officers to Vienna to look at e-mobility and broader transport-scape.
  - → with UNIDO support, redeveloping **EV roadmap** with considers micro- to heavy e-vehicles, and pedestrianization.

Delivering … an e-mobility project example from Bhutan …

oting Green Electric Mobility (E-Mobility) Solutions
Bhutan and the Wider Hindukush-Himalaya Region”
ually **100%** renewable.
.
the decision makers …
on long, steep inclines in
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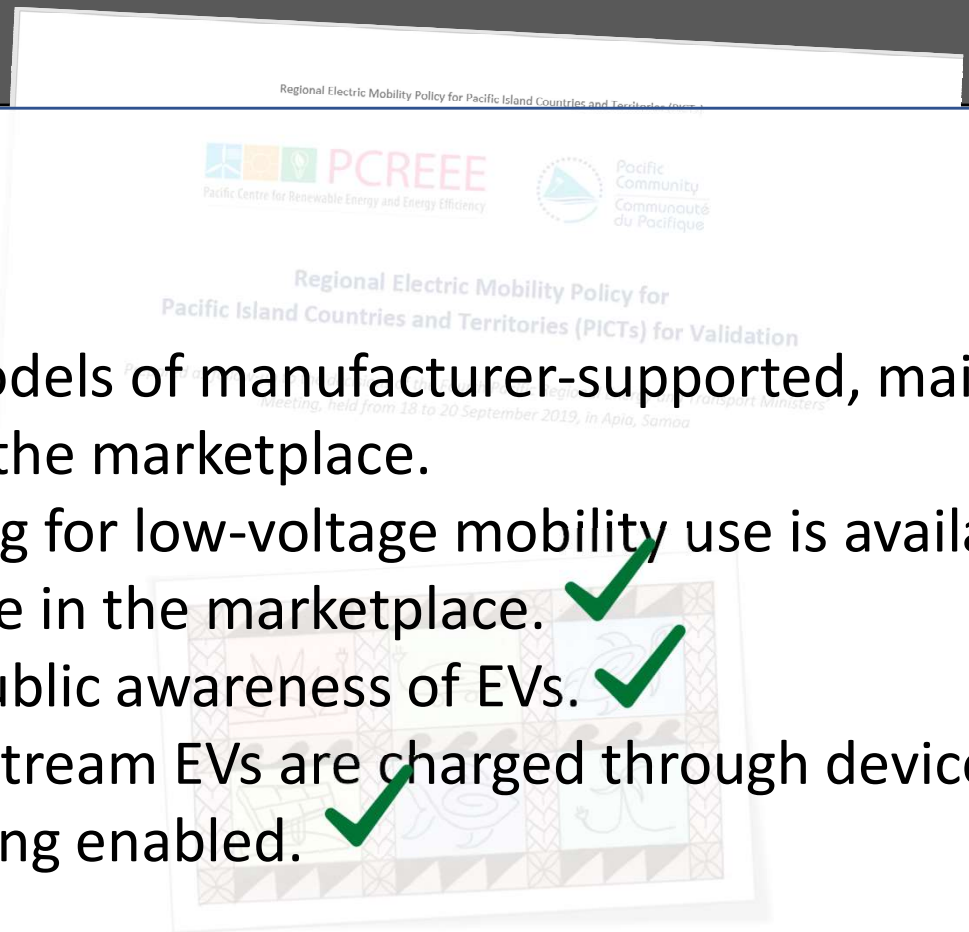
- → e-bus pilo
- Bus project **not**
  - Fits with Bhutan’s UN backed GEF 5
  - Fits with other transport needs.
  - UNIDO supported study tour of RG
    e-mobility and broader transport-sc
  - → with UNIDO support, redevelop
    micro- to heavy e-vehicles, and ped

Current status:

- Procurement by the “City Bus Service” using a National Competitive Bidding process → ensuring a there is a national entity to hold responsible.
- Supplier to supply both bus and chargers … largely avoiding purchaser involvement should any incompatibility between them be found.
- Specifications based on a 9m modern city bus (although proposed routes did not allow the use of a low-floor model) with reasonably fast charging (120kW).
- Procurement exercise won by local entity already involved in supplying EVs and chargers to Bhutan, supplying:
  - Skywell buses (build 1,000s of e-buses each year)
  - BlueSky chargers (build 1,000s of chargers each year)
- Manufacturer training of City Bus Service and local supplier, plus use of remote monitoring and diagnostic tools → the latter vital to provide expert support in deployments of new technology in new regions.

To conclude, let's revisit the PIC Regional e-Mobility Targets for ~~2030~~ 2025 (released in 2020)



~~Ten~~ fifty different models of manufacturer-supported, mainstream EVs are available in the marketplace.

2. Battery swapping for low-voltage mobility use is available on a commercial scale in the marketplace. ✓
3. There is good public awareness of EVs. ✓
4. 50% of all mainstream EVs are charged through devices that are managed-charging enabled. ✓


TESLA
Questions?