Our Electric Vehicle Future Starts Today

Andrew Campbell
We need urgent and significant change

- Climate Change
- Cost of fuel imports
- Local air quality
- (Congestion)
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)
  • 1/10\textsuperscript{th} cost for same kWh
  • 1/3\textsuperscript{rd} weight for same kWh
  • 1/3\textsuperscript{rd} 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)
• Small and light-weight batteries → advances/new micro/small mobility
• Expect far greater battery performance in the future.
One of many results → expanding e-mobility solutions
Interest is in **plug-in e-mobility**

- 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'

AC to DC Converter

Battery Management System (BMS)

Battery (DC Device)
Charging basics ...

AC Mains Supply

Standardised Charging Connector

DC

AC to DC Converter

Battery Management System (BMS)

Battery (DC Device)

'AC Charging'

Charging basics ...

Battery (DC Device)

Battery Management System (BMS)

Standardised Charging Connector

AC Mains Supply

AC to DC Converter

DC

AC
Charging basics ...

'DC Charging'

- **AC Mains Supply**
- **AC to DC Converter**
- **Charging Cable (DC)**
- **CCS Standardised Charging Connector**
- **Battery Management System (BMS)**
- **Battery (DC Device)**
On the go/journey (and ‘oops’)

Types of Charging

- **AC slow charging**
- **DC fast charging**

Use proportion

Destination

At work

Normally slow to medium

At home

AC slow charging

and in neighbourhood
Global incentive schemes for EV car uptake

- 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).

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.
Global incentive schemes for EV car uptake

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

### Population

- 300 million on roads in China alone (Bloomfield)
- 34 million produced in China in 2020 (IDTechx)
- 10 million on road 2020 (<1% global cars) (IEA)
- 600,000 on road 2020, >99% in China (IEA)
- Globally, 31,000 on road 2020 (IEA)
Let's look wider across the ‘Technology Catalogue’ of transport options
### 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

### Technologies

- 37 Technologies

---

**Work**
Commissioned by NZ Ministry of Foreign Affairs and Trade (MFAT)
| Vehicle/transport option | Walking | Wheelchairs | Bicycles | E-Bikes | E-Push Scooters | Mobility Two Wheelers | Petroleum Two Wheelers | Electric Two Wheelers | E-Trikes et al. | ICE Passenger Car | BEVs | PHEVs | HEVs | EV Charging | Electric Minibuses | Electric Buses | Electric Trucks | Electric Track |
|-------------------------|--------|-------------|---------|---------|----------------|-----------------------|-----------------------|-----------------------|----------------|-----------------|------|------|------|-------------|-----------------|----------------|--------------|---------------|----------------|
| Overall suitability | H1 | 5 | 5 | 4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| H2 | 5 | 5 | 5 | 5 | 4 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| H3 | 5 | 5 | 5 | 5 | 5 | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Global technology outlook (feasibility/availability) | | | | | | | | | | | | | | | | | | | | |
| Affordability/ cost | | | | | | | | | | | | | | | | | | | | |
| Whole of Life | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 |
| Purchase | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 |
| Ongoing | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 |
| Future TCO | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 | $5 |
| Supply/ availability | | | | | | | | | | | | | | | | | | | | |
| Whole of Life | 5 | 4 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Purchase | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Ongoing | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Future TCO | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Carbon footprint | | | | | | | | | | | | | | | | | | | | |
| Whole of Life | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Purchase | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Ongoing | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Future TCO | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Energy security | | | | | | | | | | | | | | | | | | | | |
| Whole of Life | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Purchase | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Ongoing | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Future TCO | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Convenience, comfort, safety and accessibility | | | | | | | | | | | | | | | | | | | | |
| Whole of Life | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Purchase | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Ongoing | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Future TCO | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Infrastructure & refuelling requirements | 4 | 2 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Operation & maintenance requirements | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Waste/ end of life disposal | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Environmental & social impact | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Local value chain/ economic opportunity | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Required complementary measures | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Other considerations | | | | | | | | | | | | | | | | | | | | |
The current catalogue ...

EVs are one part of the ‘transport solution’

H1: 0-5 Years
H2: 5-10 years
H3: +15 years
Countries now take a wide look at meeting GHG obligations

Example from New Zealand

**Transport Sector Priorities**

- reduce reliance on cars and support people to walk, cycle and use public transport
- rapidly adopt low-emissions vehicles
- begin work to decarbonise heavy transport and freight
- Stay informed about decarbonization of marine and aviation sectors.

EVs are one part of the ‘transport solution’ ... an important one ... incl. micro/small vehicles
Why multiple GHG reduction pathways are required ...

GHG Emissions

- Heavy vehicle ICE
- Medium vehicle ICE
- Light vehicle petrol
- Light vehicle diesel
- Two wheeler ICE
Why multiple GHG reduction pathways are required ...

- Heavy vehicle: ICE → EV (... later)
- Medium vehicle ICE → EV (today ... or later)
- Light vehicle:
  - ICE → EV (start today)
  - Diesel
  - Petrol

Shift to walking & e-micro/small mobility (start today)
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’.
• Target: to become ‘EV-ready’:
  • Manage barriers.
  • Support capacity building.
  • Familiarisation and 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).
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:

- **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.

- **Energy Efficiency and Conservation Authority**
  - 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.

Together, responsible for developing and maintaining the EV Roadmap.
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.
  - 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.

• It is expensive for a supplier of new EVs agent 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 availability of ‘Technician YouTube’)

• Expensive for a charging provider to set up.

• It is important for government to support these early movers, especially in ‘PIC-sized’ markets.

• Important role of government/policy to manage/remove barriers (and assist appropriate, early movers).

• Government-lead information/awareness campaign and marketing critical (as task too big for early mover individuals).
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.
<table>
<thead>
<tr>
<th>Time in Life Cycle</th>
<th>Electric Vehicles</th>
<th>Charging Infrastructure</th>
<th>Electricity to the Plug/Charger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Development, tech development, market</td>
<td>Standards, related hardware and IT, overall plan, compatibility.</td>
<td>Electricity supply system, planning</td>
</tr>
<tr>
<td>Build</td>
<td>Market demand by vehicle class</td>
<td>Capacity, demand by different type</td>
<td>Gen Co.s/Line Co.s</td>
</tr>
<tr>
<td>Support</td>
<td>Meeting demand, shipping, import, certification.</td>
<td>Availability, meeting demand, shipping, import, certification.</td>
<td>Gen Co.s/Lines Co.s, general information on</td>
</tr>
<tr>
<td>Purchase</td>
<td>Information, overcome barriers, fit for purpose, available models.</td>
<td>Fit-for-purpose purchase decisions, future-proofing, grid-aligned, compatibility, available models</td>
<td>Gen/network upgrade, generation type switching ... company and country plans</td>
</tr>
<tr>
<td>Install</td>
<td></td>
<td>Approval, site works, certification, industry training.</td>
<td>Gen Co.s/Lines Co.s</td>
</tr>
<tr>
<td>In-service</td>
<td>Understanding of, best driving practices</td>
<td>Awareness, controls (pricing and other).</td>
<td></td>
</tr>
<tr>
<td>Charging</td>
<td>Understanding of, options, costs, best practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Servicing/maintenance</td>
<td>Understanding of, industry capability and capacity, industry training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breakdown</td>
<td>Guidelines/best practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident</td>
<td>1st response, repair, fleet re-entry</td>
<td>Decision to, re-use/upgrade through scrap</td>
<td></td>
</tr>
<tr>
<td>Retirement</td>
<td>Decision to, reuse of battery/electrics through scrap/recycle.</td>
<td>Decision to, re-use/upgrade through scrap</td>
<td></td>
</tr>
</tbody>
</table>

**Early focus areas for EV roadmap:**
- **Standards:** EVs and charging.
- **Fitting EVs into vehicle reg. systems.**
- **Awareness/information**
- **Building industry capacity**
- ➔ becoming EV Ready
• 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.
Questions?