Webinar:
Development and Evolution of a Sustainable City and Community

New Paradigms in Sustainable Bus Transit

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NEW PARADIGMS IN SUSTAINABLE BUS TRANSIT

Paul Bromley

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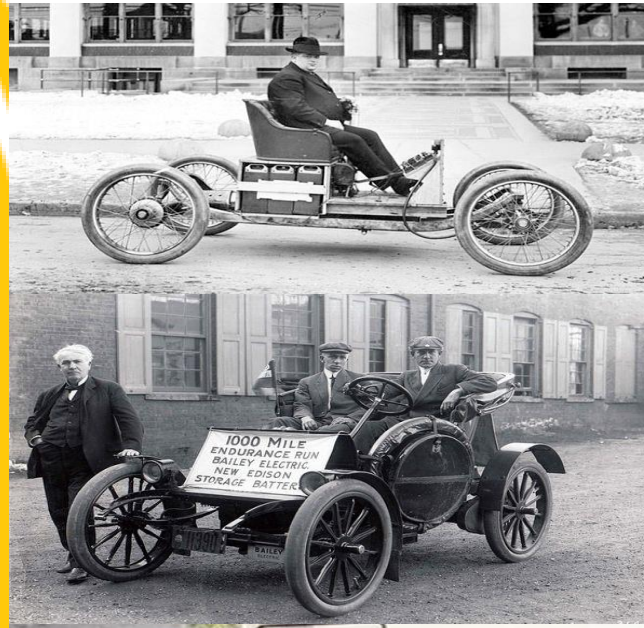
Paul Bromley B.Tech., C.Eng., M.I.Mech E.

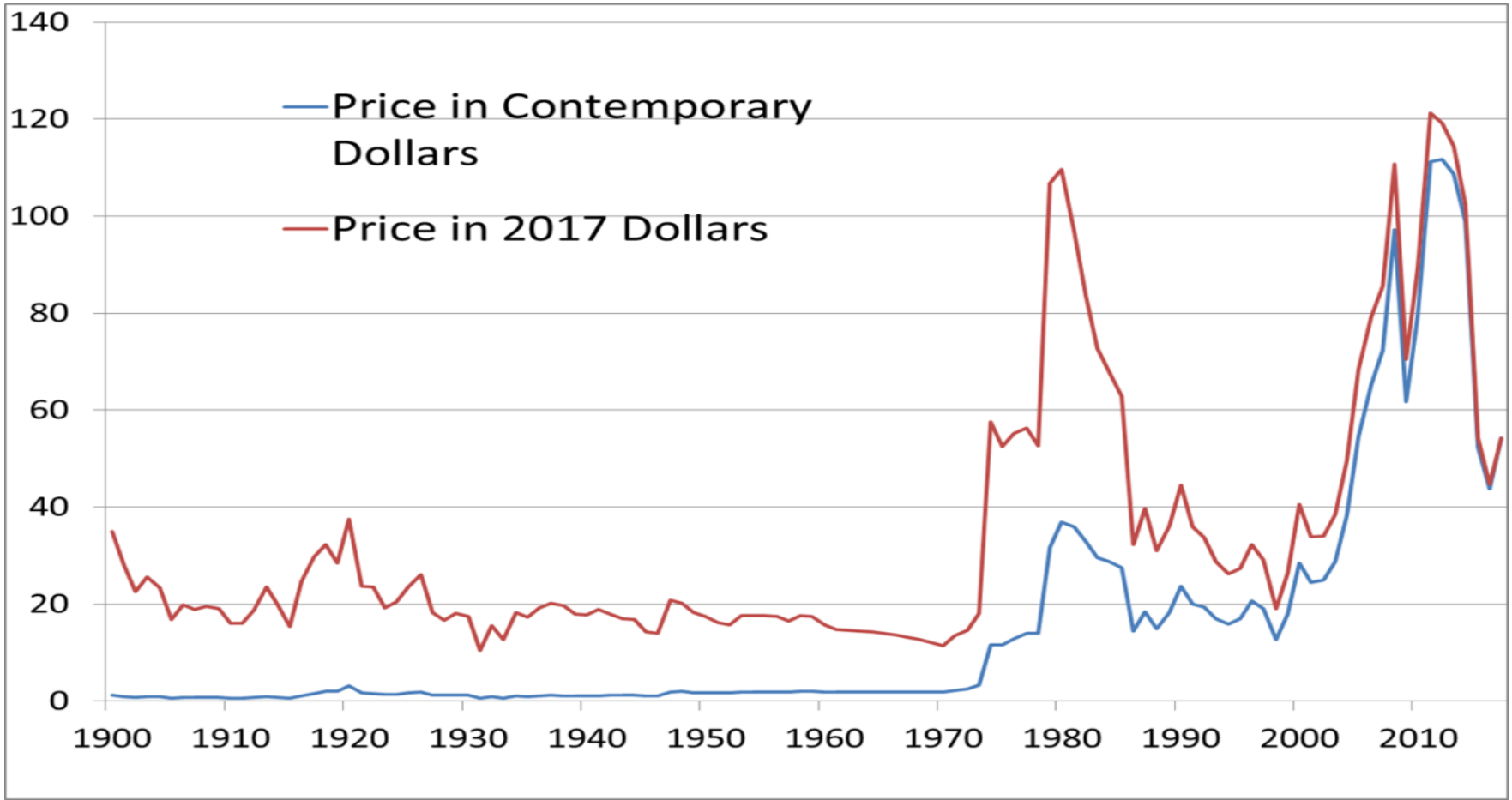
- A Hong Kong based Chartered Engineer with a degree in Automotive Engineering from Loughborough University in the UK with 34 years commercial vehicle industry experience, latterly focusing on new energy vehicle technologies.
- Currently working as an independent consultant under his own company of Phoenix Business Consulting focusing on the introduction of e-vehicles and new energy technologies within a variety of markets including Hong Kong, SE Asia, India and Europe through utilising existing networks of OEM's, operators, systems integrators, governmental and NGO bodies.
- From a deliverance perspective Paul has personally conceived, championed and overseen the successful launch of a number of ground-breaking products using new energy technologies in a number of global markets. This includes launching CNG buses in the UK, conceiving and facilitating the launch of hybrid buses in Hong Kong, developing electric buses for the China and Hong Kong markets as well as latterly advising on battery and charging infrastructure technologies for Indian, Hong Kong and European markets.
- Previously having worked for Dennis Specialist Vehicles, Leyland DAF Trucks, Plaxton Bus & Coach, Bedford Commercial Vehicles, Millbrook Proving Ground & Goodyear in a variety of senior operational roles including New Product Introduction Manager, Head of Engineering, R&D Manager, Technical & Commercial Director and Head of Operations (starting up commercial and manufacturing operations in Malaysia/SG) across Europe, North America and the APAC regions. For the past 16 years Paul has been based in the Asia Pacific region.
- In addition Paul sits on industry advisory committees and is a frequently invited speaker at seminars and professional bodies such as UITP and I.Mech.E. to talk on the latest developments in new energy vehicle technologies and strategies.

E-Vehicle History

- In 1900 38% of vehicles sold in the US were electric powered
- Road building encouraged longer distance travel and gasoline stations could charge in relatively short time
- The forced break up of Standard Oil in 1911 introduced competition to the market
- Mass production of the Model-T Ford reduced costs
- 1912 - invention of the electric starter motor
- By 1930's fossil fuelled vehicles prevailed

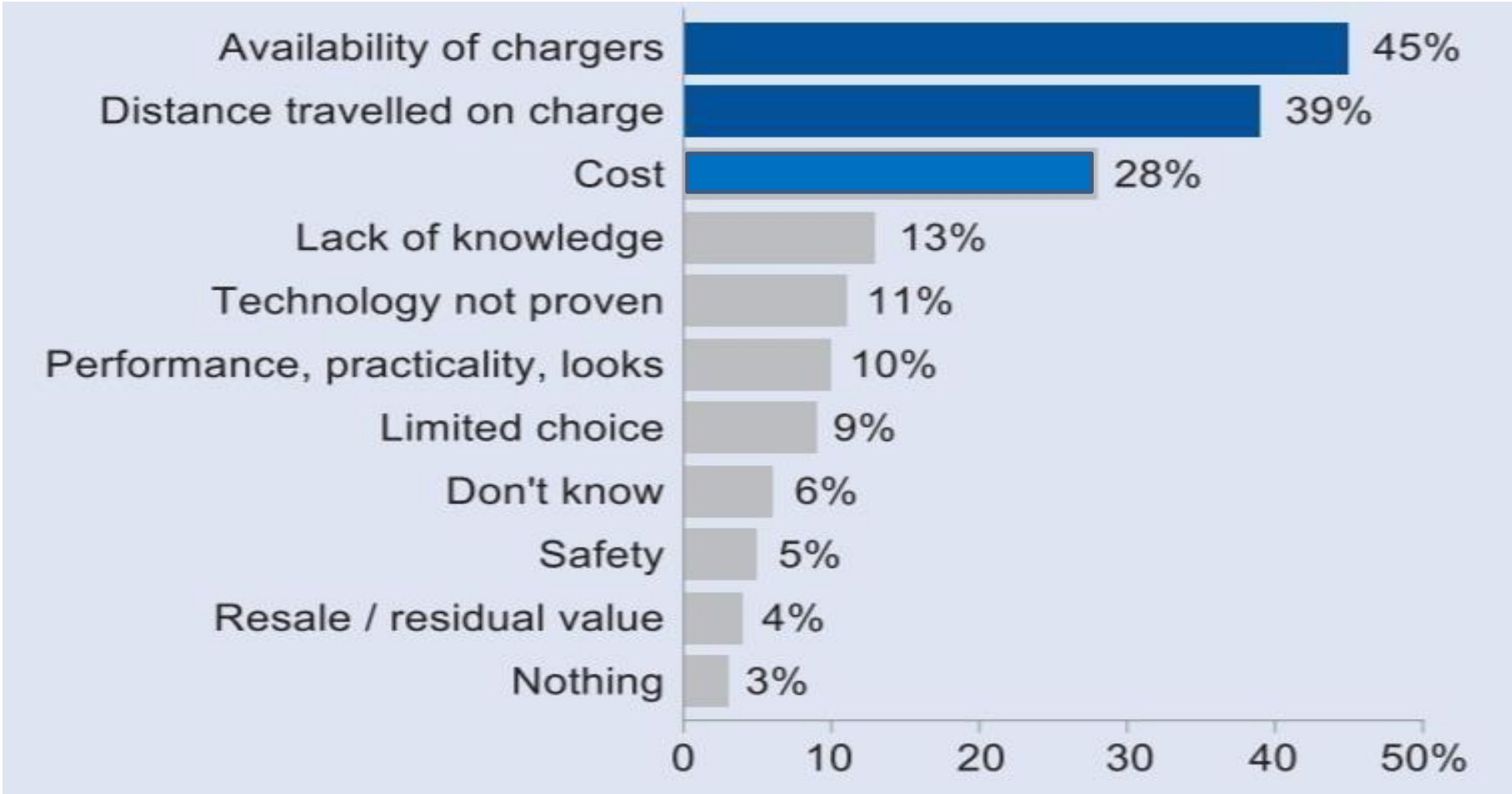


The Revival of e-vehicle Interest

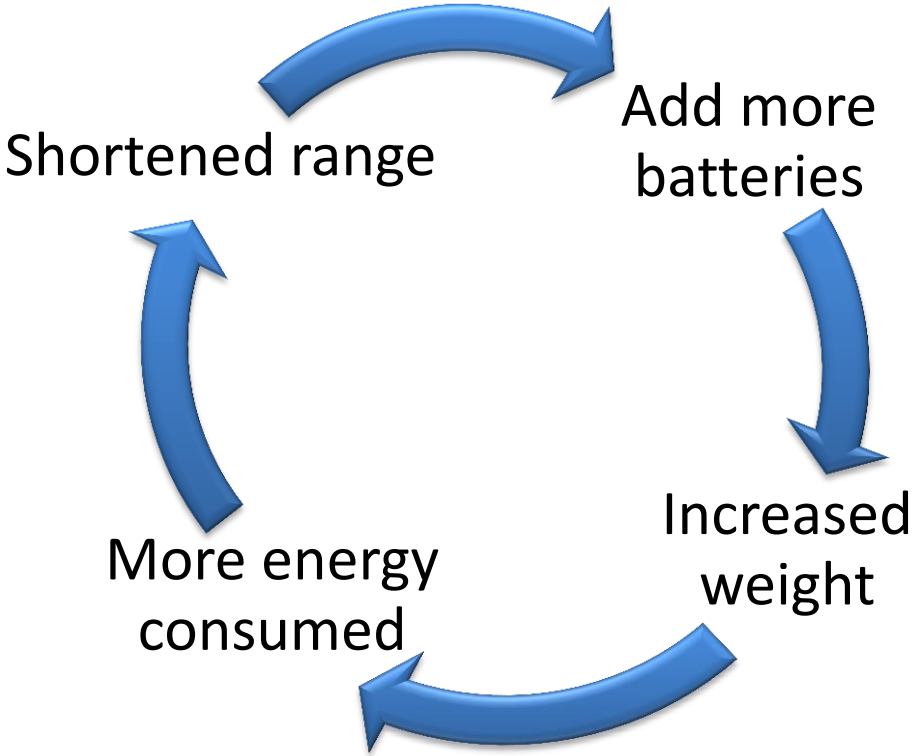


Sustainable Public Transport

Barriers to eV Adoption

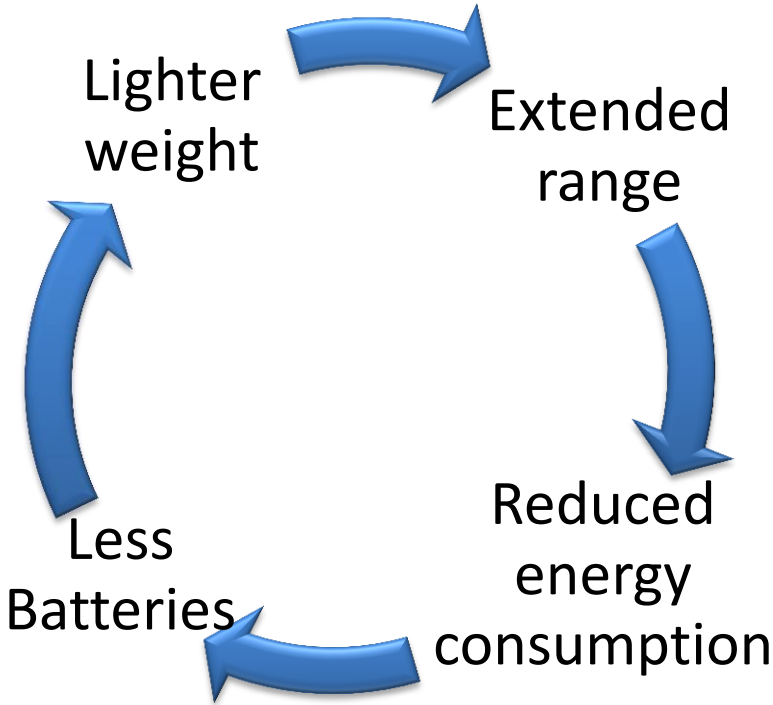


Range Anxiety - Historic e-Bus Solutions



High Capital Cost

Let’s Break That Paradigm!



Lower Capital Cost

Cost of Operation

Fossil Fuel

- Diesel @ HK$ 4 /litre
- 80,000 Km per year
- 1.5 km/litre

➢ HK$ 200,000+ p.a.

- Brake pads, oil filters, air filters, cooling systems maintenance

Electric Bus

- CLP HK$ 0.98 /kWH
- 80,000 Km per year
- 0.6 km/kWh (est.)

➢ HK$ 130,000 p.a.

- No oil changes, air filters
- Improved brake life
- Batteries??

How to Reduce Batteries?

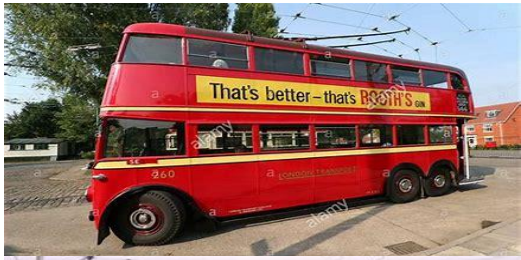
- In Motion Charging

- Hydrogen Fuel Cells

- Battery Electric Vehicle (BEV)
  - Opportunity Charge
  - Battery Swap

In Motion Charging (IMC)

- Historically referred to as ‘Trolly Buses’
- Similar to trams but no rails
- Zero roadside emissions
- Full electric without carrying significant volume of batteries on board
- 1800+ fleet used in London between 1930-1960’s
- Still in current use (e.g. Vancouver, Shanghai, Wellington, Sao Paolo, San Francisco)
- Runs on catenary
- Suited for dedicated busways such as BRT



Hydrogen Fuel Cell

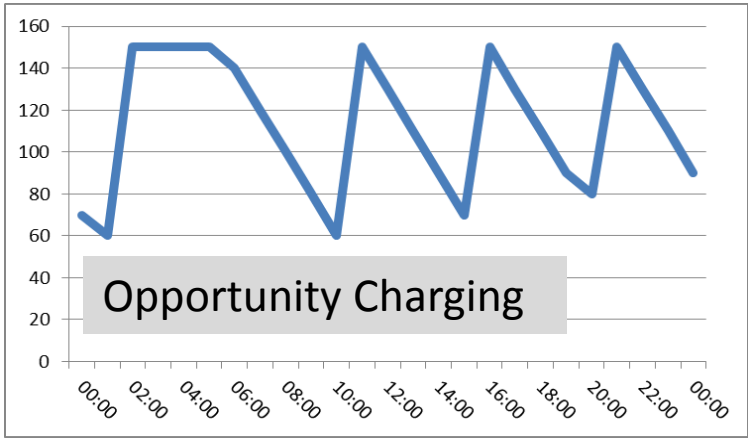
- Uses stored hydrogen and air to power a fuel cell that generates electricity used to drive an electric motor
- Zero roadside emissions (apart from H_2O)
- Hydrogen has a higher energy density ensuring range requirements (typically roof storage tanks)
- Comparable refuelling times with fossil fuels

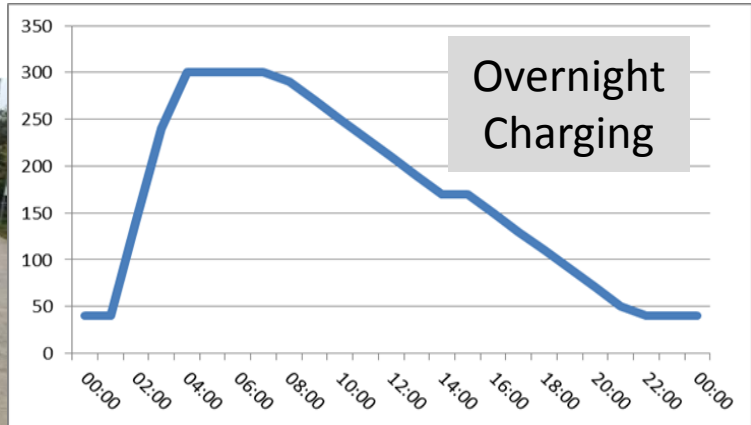
BUT

- Hydrogen needs to be produced by sustainable methods as opposed to:
  - Steam methane reformation (not e-friendly)
  - Reverse electrolysis (high energy)

BEV Opportunity (Rapid) Charging

- Overhead pantograph or underfloor inductive charging
- <10 minutes charging time
- Reduces need for battery capacity on board
- Charging at remote locations such as bus termini
- Charging points are shared infrastructure





BEV - Battery Swapping

- Less battery capacity on board means lower weight, space claim and capital cost
- Shared Infrastructure
- Automated system - no manual intervention
- Infrastructure footprint to be considered
- Batteries owned by third party supplier charging per kWh used

Hong Kong Challenges

- Hong Kong franchise bus fleet of around 6000 vehicles is 95% double deck buses
- Operators are private companies with a duty to shareholders
- One third of the energy requirements are for the air conditioning.
  - As mentioned earlier at worst case scenario of 0.6km/kWh will require 400 kWh energy per day on a typical 240km duty which if all were needed from 1 battery pack then that would determine a battery pack of 625kWh to include factors of safety
- Space and weight are critical in order to optimise passenger carrying capacity (12m x 2.5m x 4.4m box, 24 tonne maximum)
  - Consider that batteries take up around 1 cu.m per 100kWh and weighs around 1 tonne
  - The engine bay on a typical HK double deck bus is 1.5m x 1m x 2.5m = 4 cu.m

Possible Hong Kong Solutions

Full BEV

- Space and weight constraints compromise vehicle design
- Potentially high capital cost per vehicle
- Possible reduction in utility due to charging time
- Infrastructure problems for a full fleet

Hydrogen Fuel Cell

- Possible space constraints for fuel storage on board vehicle
- Hydrogen refuelling infrastructure needs to be put in place

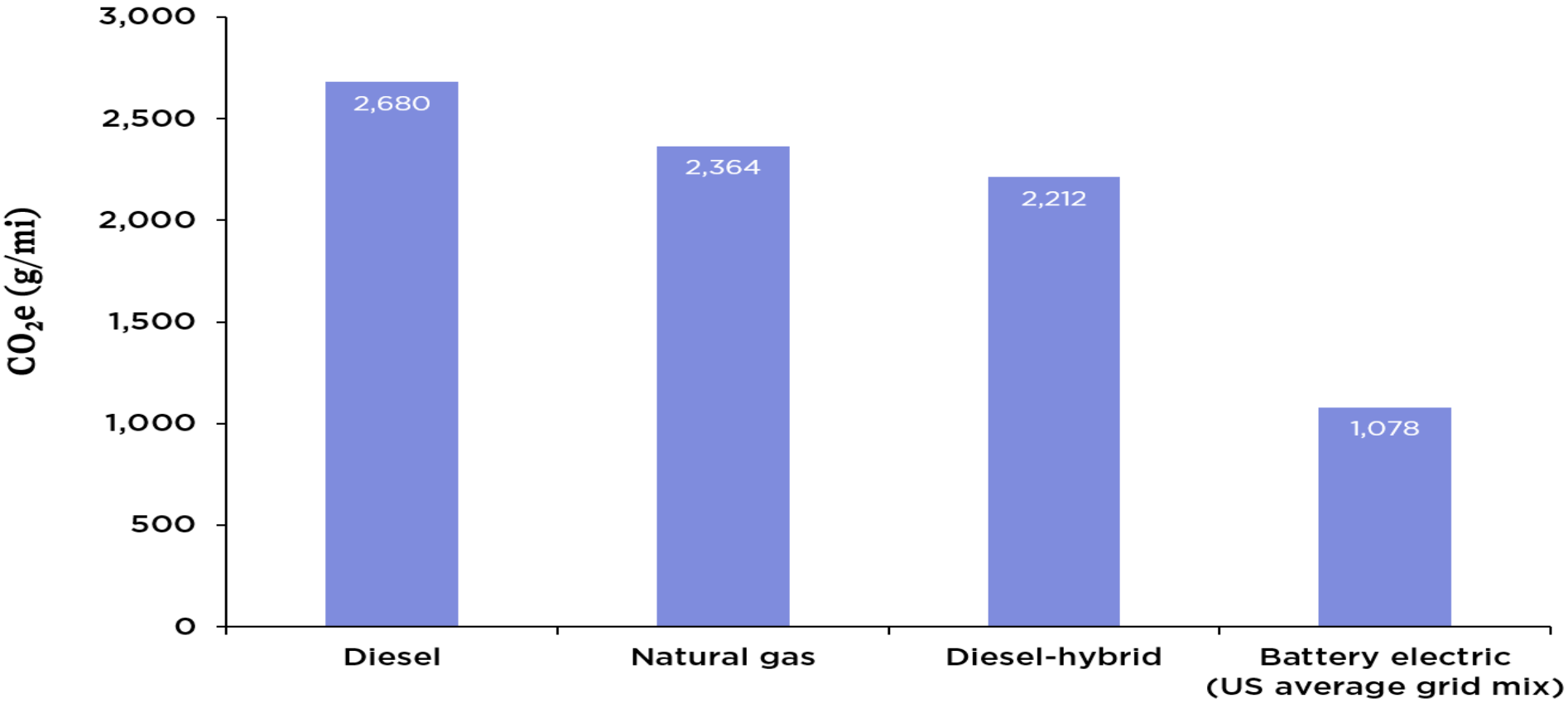
Opportunity Charge

- Lower capital cost and shared infrastructure
- Full utility for regular bus operations
- Requires recharge infrastructure at bus termini

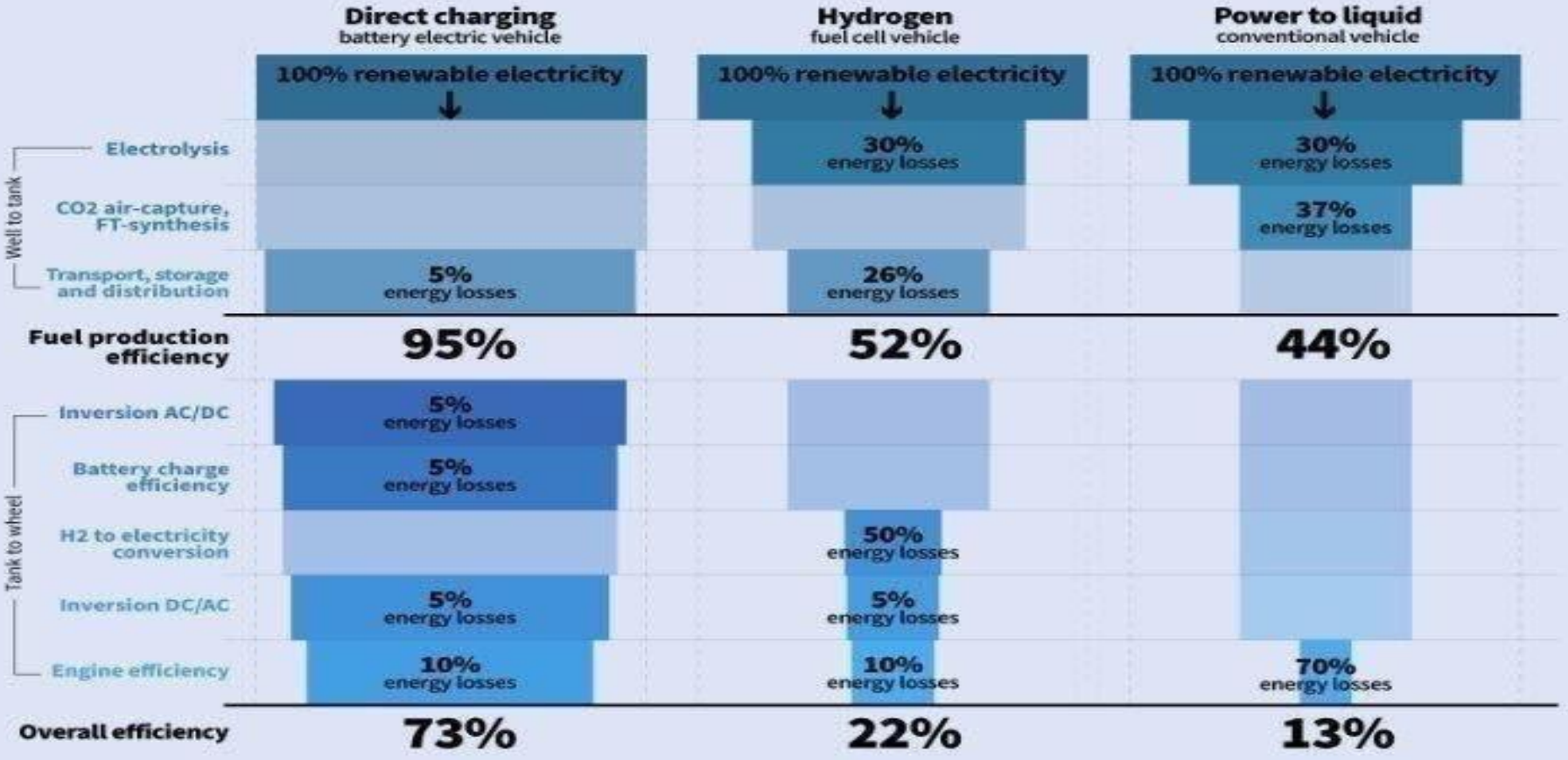
Paradigm Shifts

- There is no single universal solution to meet all requirements, different solutions meet different needs
- Consider battery, charging or refuelling infrastructure owned by third party
- Question how the fuel station model has developed and look at how this can be adapted to support new energy solutions
- Sustainable and cost-effective bus transit is already within reach but requires collective will from operators and government policy makers to implement the supporting infrastructure
- **Subsidy is the enemy of innovation – FACILITATION**

Life cycle global warming emissions from different types of transit buses



Cars: Battery electric most efficient by far



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Source: WTT (LBST, IEA, World bank), TTW, T&E calculations

Thank You

for your kind attention

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