

Australia's Transport Dilemmas



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This presentation will:

- Provide an overview of problems facing Australia in the provision of energy for transport
- Examine policies / plans to address these problems
- Examine solutions
- Conclusions

- The smell of cars' smoke as I wade through traffic overshadows the fresh fragrance of Mother Earth drenched in rain. There can be no greater testimony to man's progress!

Vijaya Gowrisankar

Transport Drivers

- Growing Aust. Population 1.6%pa
- Econ. Growth in SE Asia – goods and services (Source: World Bank)

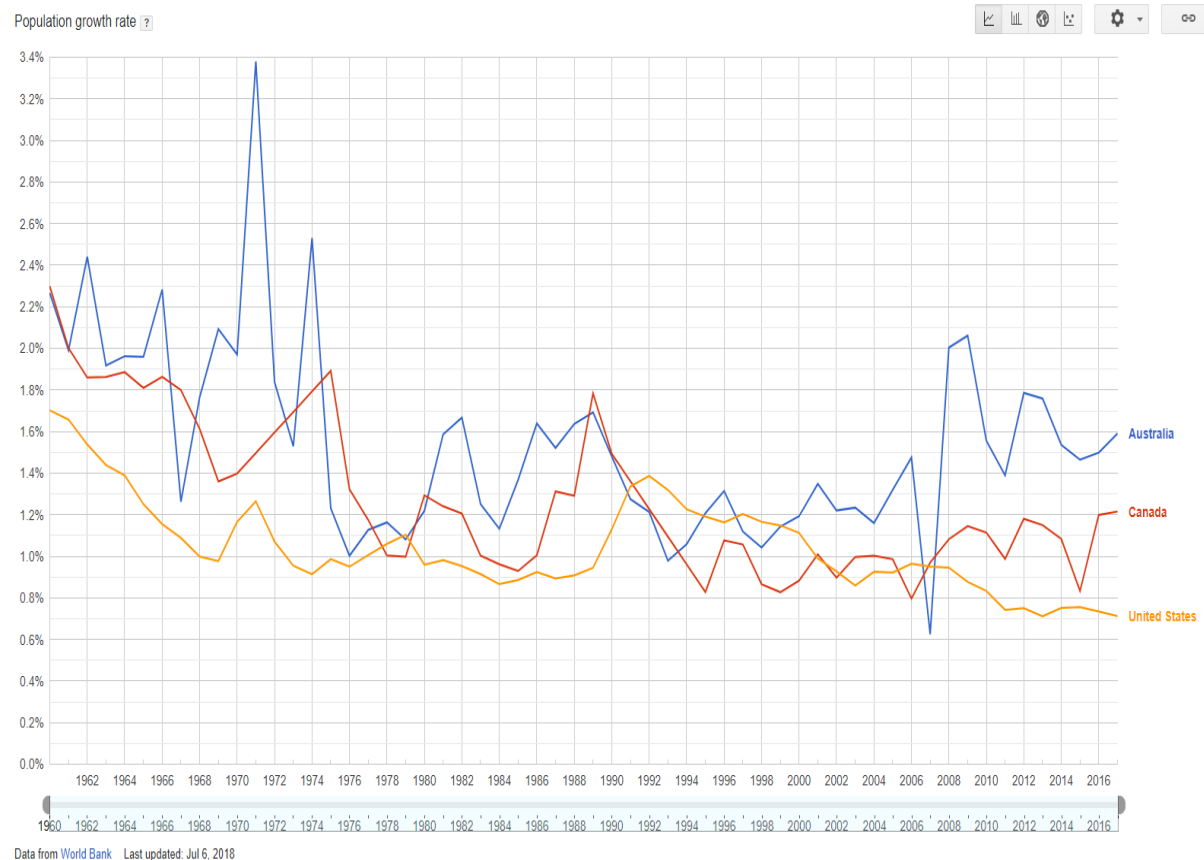
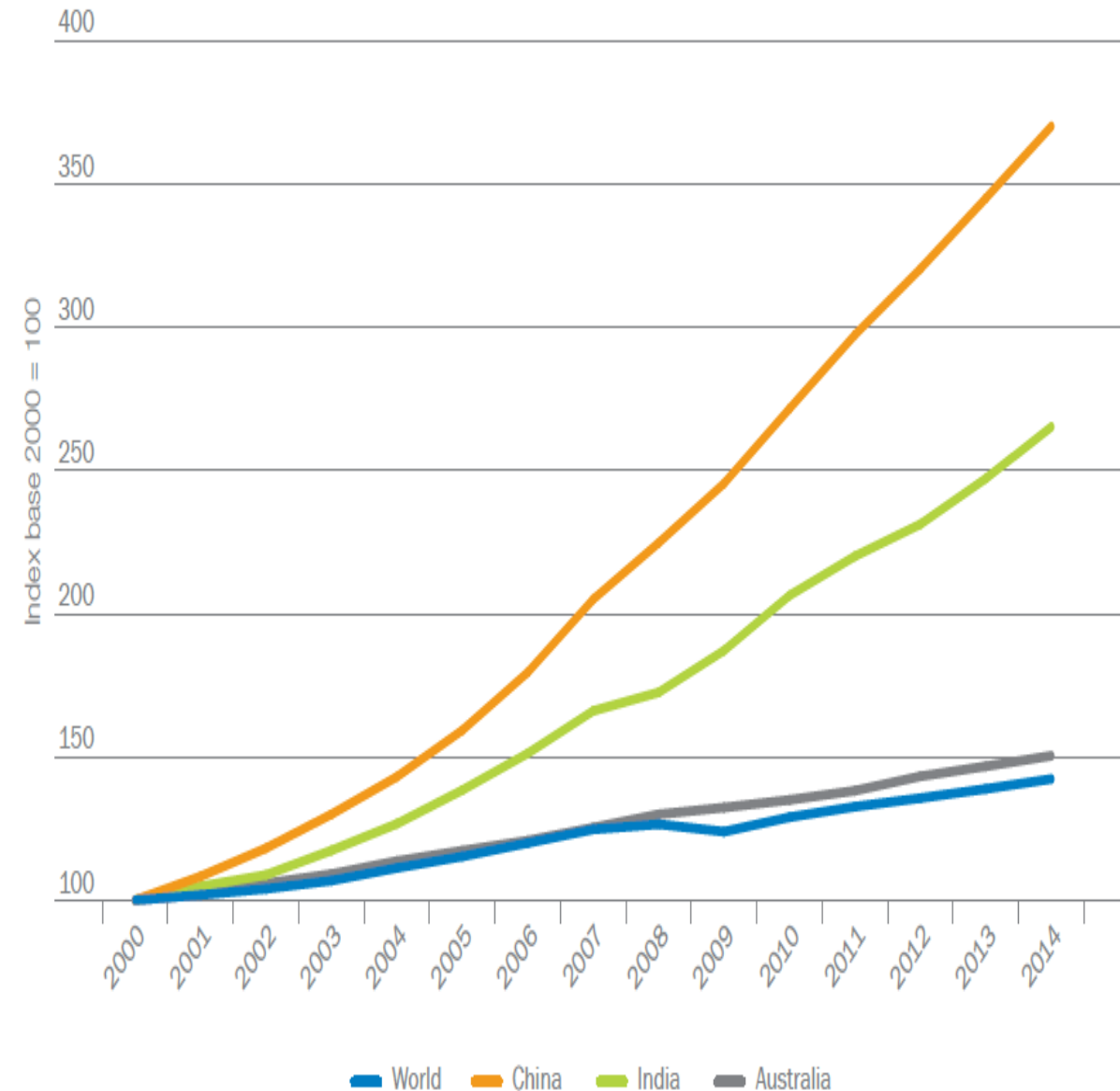


Figure 1.1: Annual GDP Index, selected countries



Source: World Bank 2015, World Development Indicators.

Mobility — the ability to move or be moved *freely and easily* (my emphasis) Dictionary Definition

We need it:

- To move ourselves or goods and services to work or where they are needed, & access services or play
- How much is enough?



What we need is Sustainable Transport?

- Sustainable mobility –
 - closer connection between transport planning and land-use
- The main objective -
 - to reduce the need for mobility by
 - reducing the number of trips and
 - length of distance travelled.

Source: <https://unhabitat.org/wp-content/uploads/2013/06/pr1.pdf>

Drivers of Innovation and Disruptors?

Reducing need to move as far/as often

- Big Data - Internet of Things
- New business models - shared economies (Uber/Amazon?)
- Automation / Robotics / GPS – improving control / safety / efficiency
- Autonomous Vehicles – free up space – parking / roads / reduce costs

- Climate Crisis
 - > Weather Extremes > resulting \$\$
 - Disaster relief
 - Recovery assistance
 - Infrastructure repair
- Increasing Population
- Increasing Inequality

Basics of Motion & Energy Use

More Energy use if:

- Heavier
- Faster
- Blunter shape
- Larger rolling resistance
- Poor Driver behaviour

- Energy Efficiency (EE)
= Distance Travelled/Energy
= km/MJ
- Energy Consumption = Inverse EE
= Litres/100km
Petrol 32 - 34 MJ/L
Diesel 38MJ/L

Factors affecting Energy Consumption

Weight - Heavier vehicles have:

- Greater inertia
- Greater rolling resistance

Both increase fuel consumption

A recent study found that for every 100 kg reduction, the combined city/highway fuel consumption could decrease by about 0.4 L/100 km for cars and about 0.5 L/100 km for light trucks (MIT 2008)

Source: MIT 2008. On the Road in 2035: Reducing Transportation's Petroleum Consumption and GHG Emissions. Massachusetts Institute of Technology

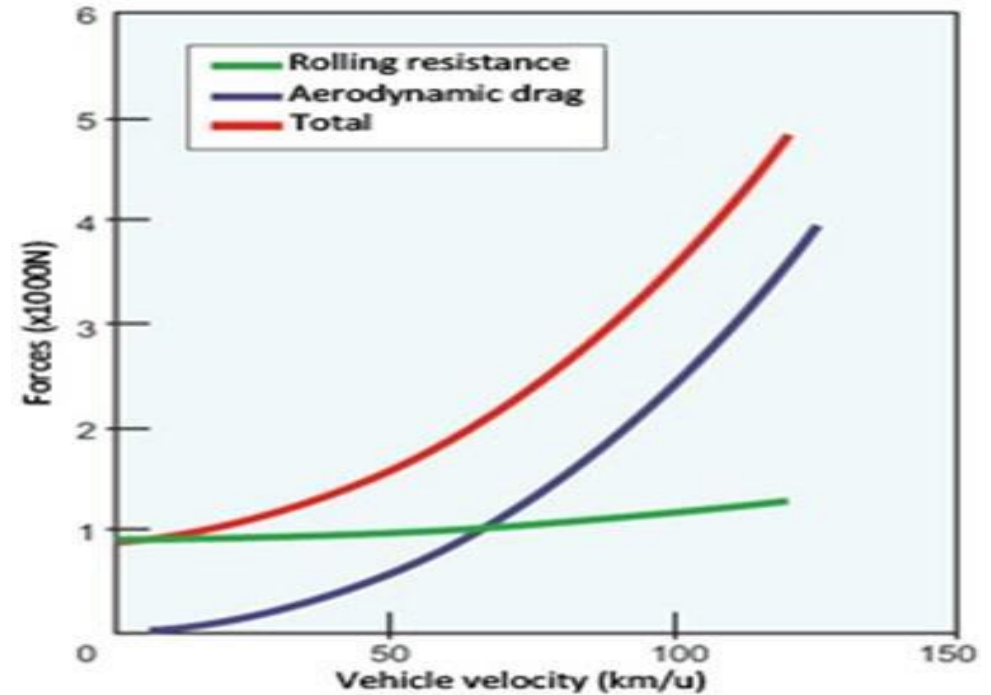


Factors affecting Energy Consumption

Air Flow Resistance

- Drag Coefficient x Frontal Area
- Increases with Vel. X Vel. ($2 \times 2 = 4$)

Rolling Resistance – increases with Vel.



Factors affecting Energy Consumption

Accessories

- Air conditioning
- Roof racks
- Wider tyres

Poor Driver Behaviour

- Frequent hard acceleration
- Engine idling unnecessarily
- Windows down with air con ON
- Carrying unnecessary stuff!
- Lack of trip planning

Solutions

- Increase public transport
 - Electrification of transport
 - All scales – Large (rail) to very small (skate boards)
 - Renewable Energy (RE) Electricity – can link Transport storage – EV discharges to grid peak periods
 - RE Hydrogen? – Limited – direct heating – yes, Transport – EROI too low
 - Source: Renew, Issue 148:14-18 www.renew.org.au
 - Biofuels? – Sugar to Ethanol
 - EROI too low – need land for food.
- Address excessive mobility – frees up time for other activities
 - Live closer to work - incentives
 - Work from home – incentives
 - Cycle / walk friendly urban design
 - Plant Trees – one trillion (absorb 2/3 of all emissions)

Electrification –Buses / Rail / Trucks Cars / Bikes / Boats

Today, about 17 percent of the world's buses are electric—425,000 in total. But 99 percent of them are in China, where a national mandate promotes all sorts of electric vehicles.

Source: <https://www.wired.com/story/electric-buses-havent-taken-over-world/>



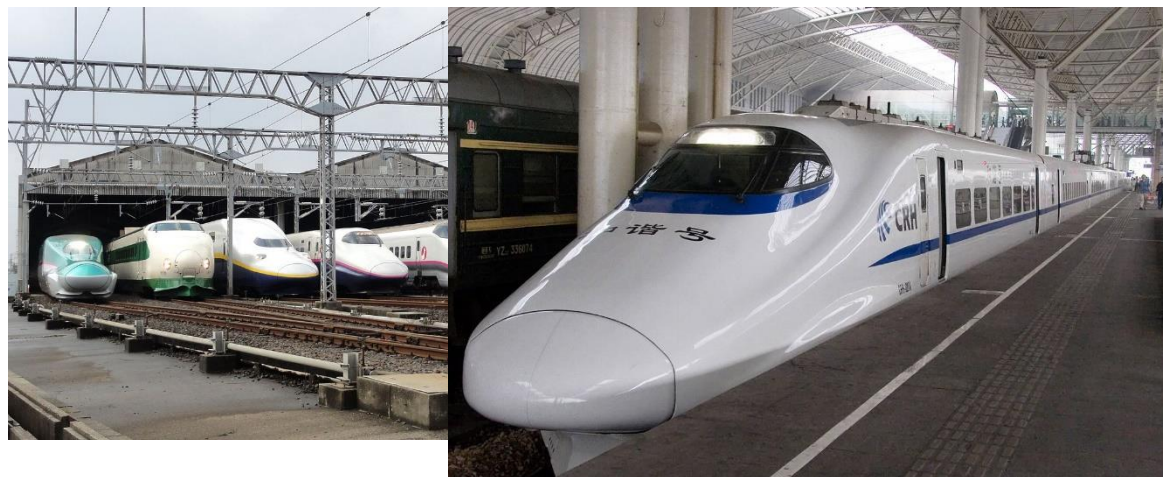
Requires:

- Charging Infrastructure
- Upgrades to Electricity System
- Renewable Energy Generation
- Capital and Policy to support implementation

Benefits:

- Quieter
- No exhaust emissions < health & building decay costs
- Lower maintenance

Japan - High Speed Rail – 300 to 500 km/yr



Beyond Zero Emissions 2014 Report

- Quieter
- Lower maintenance
- Energy efficient
- Time and cost efficient
- Runs on Renewable Energy

www.bze.org.au



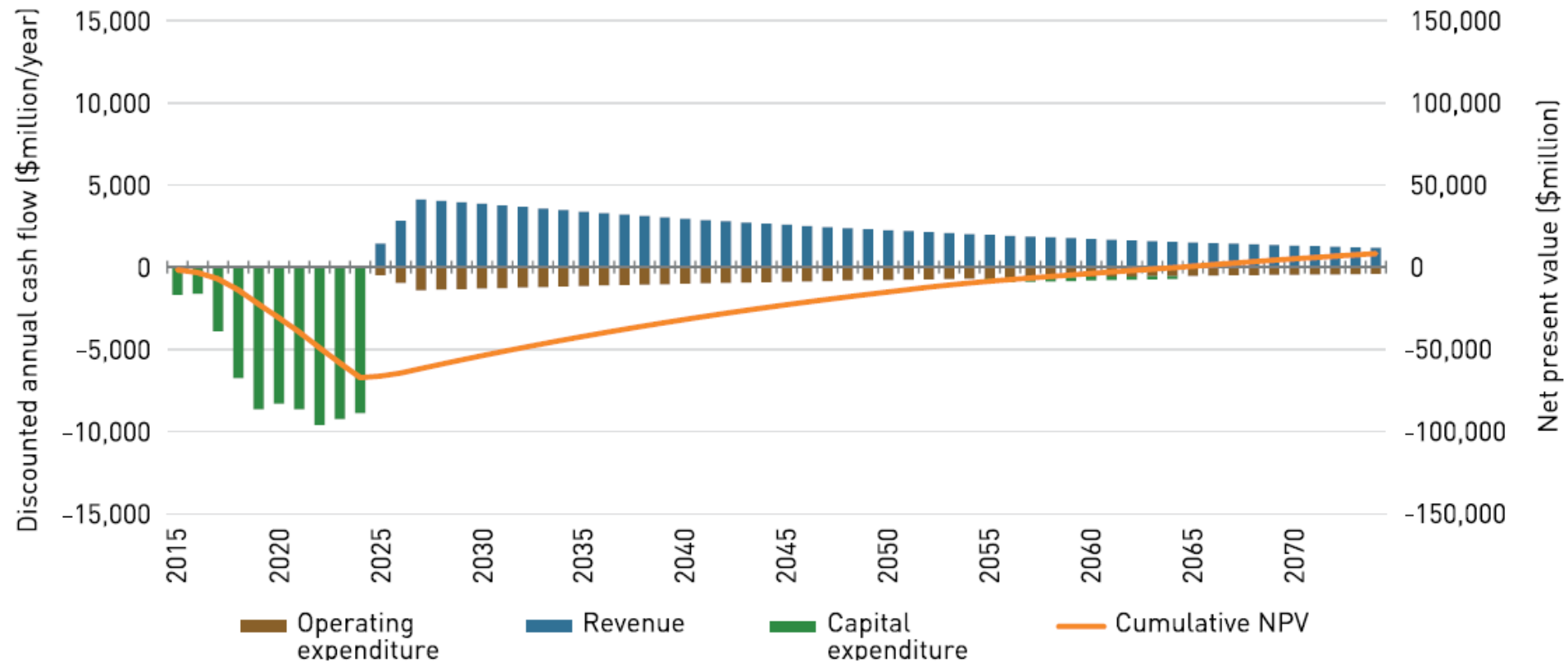
MELBOURNE
ENERGY INSTITUTE



Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center

BZE Costing of HSR

FIGURE 85 Annual costs, revenue and net present value for HSR network
(real 4% discounted 2012 dollars)



Australia's Inland Freight Project Brisbane to Melbourne <24hrs



INLAND RAIL - KEY TECHNICAL CHARACTERISTICS THAT UNDERPIN THE SERVICE OFFERING

Train Length	1,800 m with future proofing for ultimate 3,600 m train length
Axle Load / Max Speed	21 tonnes @ 115 km/h, 25 tonnes @ 80 km/h, with future proofing for 30 tonnes @ 80 km/h
Double Stacking	7.1 m clearances for double stack operation



Electric Trucks



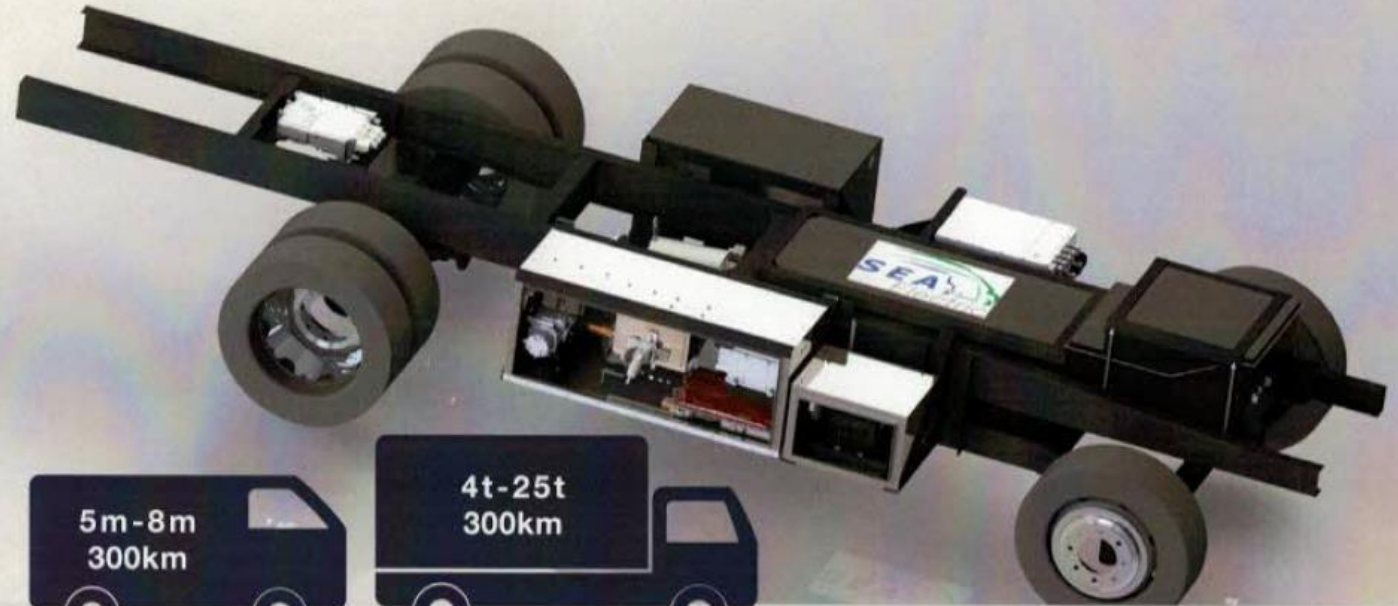
SEA Conversion



SEA-DRIVE™ Technology

OEM EV DRIVE SOLUTIONS

- Electrify existing commercial vehicle platforms.
- Low cost, short lead-time implementation.
- Most cost effective path to high efficiency EV Drive.
- Fully engineered, licenced production solution.



5m - 8m
300km

4t - 25t
300km

Modularised & Scaleable Technology



Permanent magnet motor increase reliability & durability.
Direct drive to increase efficiency in the drive system.
Regenerative braking.



Li-NMC cells optimize energy density and specific energy.
High Voltage Interlock (HVIL) to ensure safe operation.
SEA 85/130/160/220kWh battery capacity options.



Variable speed compressor to optimize energy.
CAN based diagnostics.
Variable heating power to optimize energy.



Variable speed fans to optimize cooling.
Radiator custom design to match SEA systems demand.
Interchangeable between models.



380 VDC with Inverter and DC-DC Converter.
22kW on board charger to decrease charge time.
IEC62196 charging protocol.



Optimize driver efficiency.
Enable remote proactive and reactive diagnostic.
Central vehicle microcontroller.
SEA proprietary integration scheme and controls.

Electric Car - Beyond Zero Emissions 2014 Study – Transition Time & Costs

Source: www.bze.org.au

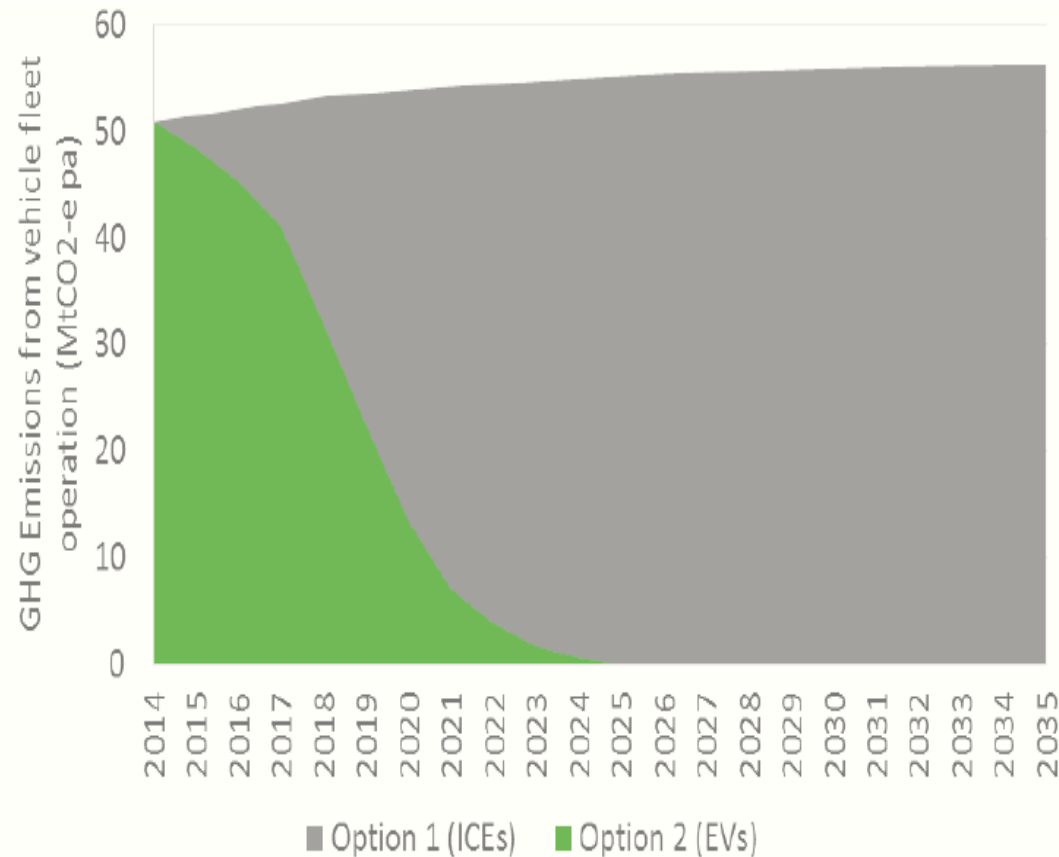


Figure 5 – Greenhouse gas (GHG) emissions related to operation of the car fleet.

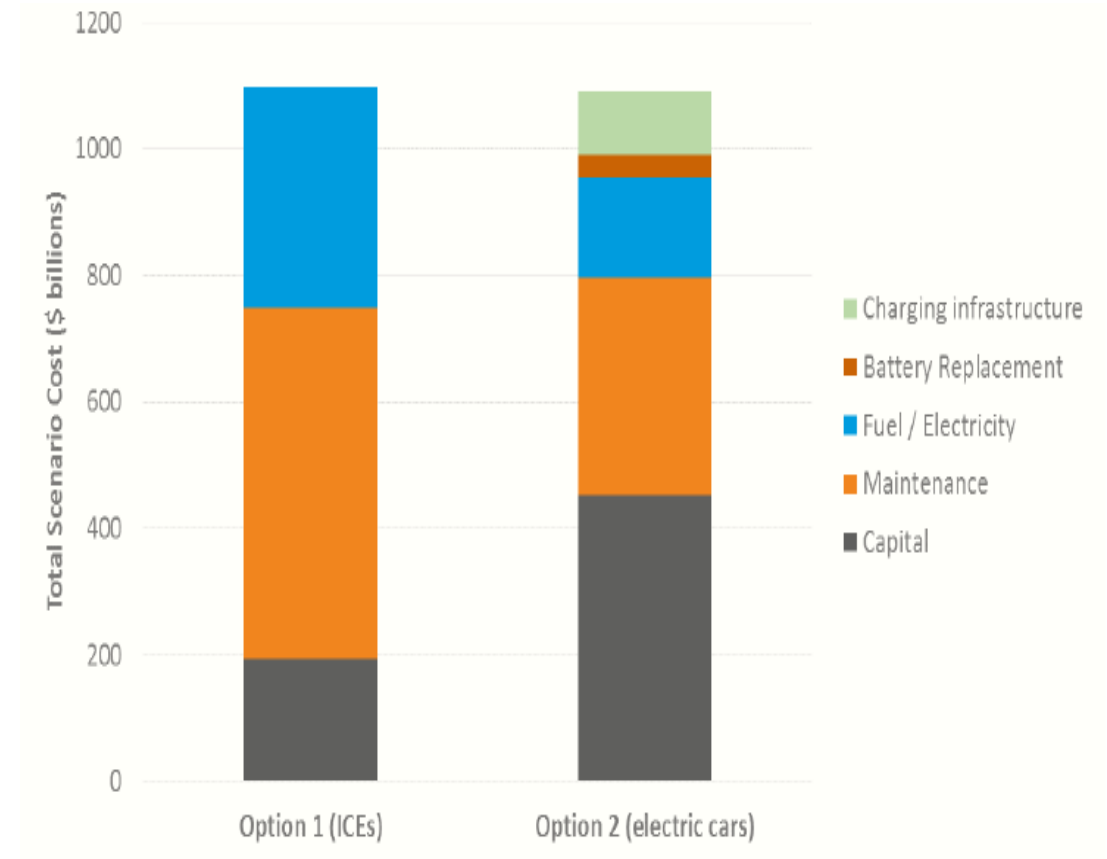


Figure 4 - Summary of Low Cost Scenario costs (Net Present Value of total cost between 2015 and 2035).

Benefits - CO2 reduction in the atmosphere

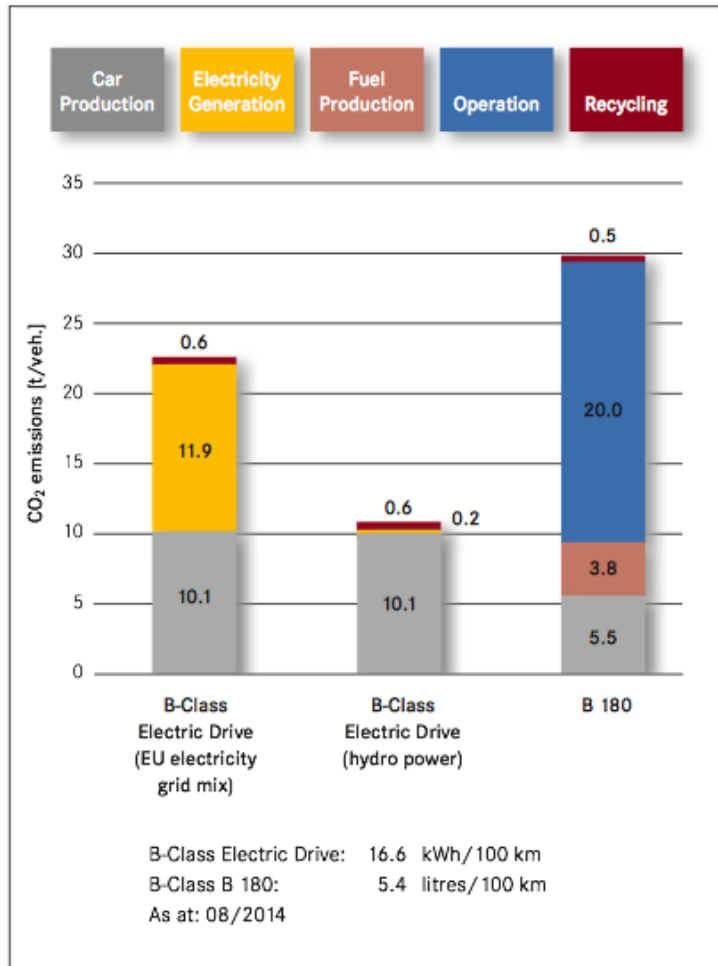


Figure 2-6: Carbon dioxide emission of the B-Class Electric Drive compared with the B 180 petrol-engine variant [t/car]

..the problem is not with the electric car...



...it's with dirty electricity production

The BMW i3 – Constructed with Renewable Energy

- 30% of Germany's Electricity is RE
- 80% RE by 2050
- Wind and Solar Power production at BMW plant



Benefits – Reduced Conflict & Costs

...global economy

...global security

... global responsibility

KEY ADF OPERATIONS 2001-2014

Operation Astute (East Timor) - \$4.3 billion

Operation Catalyst (Iraq) - \$2.3 billion

Sources: www.news.com.au 2015 Ian McPhedran National defence writer

PM Scot Morrison - Australian Fuel

Imports thru Strait of Hormuz

15% of Crude Oil

30% of Refined Oil

Source: Guardian, 21 Aug 2019 Australia to join US military to protect shipping in the Strait of Hormuz



Benefits – Electricity Network Support

...global economy

...global security

... global responsibility

EV batteries can provide
Electricity Network Support
via

- Frequency / voltage
Control
- Peak demand reduction



Electric Bikes / Trikes



Leisurely Upright

Comfortable with a commanding view, not very aerodynamic. Excellent around town.



Sporty Performance

Slightly pitched forward riding position with more pedal power transfer and less drag at speed.



Family & Cargo

Specialty eBikes for carrying kids, pets or moving lots of stuff around



Off Road Trails

Designed for climbing traction, torque & precise handling.



Folding/Compact Bikes

A folder can be taken on the metro during rush hour or stashed compactly in the office, car or apartment.



Commute Ready eBikes

Many eBikes come already outfitted with all the accessories you will need for riding in all weather, night or day, all year round.



Boats

- Short distances — Ferries — Coochie Is, NSI, Brisbane River
- Solar PV powered



Voyage 480 Catamaran

35kWh Lithium Battery Pack

48V motors - 2 x 15kW

PV array 1.6kW



Silent-yachts — Luxury Cruiser

Solar Panels: 10 kWp

E-Motors: 2 x 30 kW / 2 x 250 kW

Generator: 22 kW / 100 kW

Battery Capacity: 120 kWh

Cruising Speed: 6 – 8 kt / 12 – 15 kt

Top Speed: approx. 12 kt / 20 kt

Aircraft – Solar Assisted

Aeros ML866 PV Cargo Airship

- Load capacity 60 tonnes
- maximum speed of 222 km/hr, with a cruising speed at 185 km/hr and a maximum altitude of 3.65 km.

Sources:

- <https://www.sciencealert.com/production-is-underway-on-the-world-s-largest-aircraft>
- <http://aeroscraft.com/technology-copy/4580412172>

Airlander Cargo Airship

- Load capacity 60 tonnes

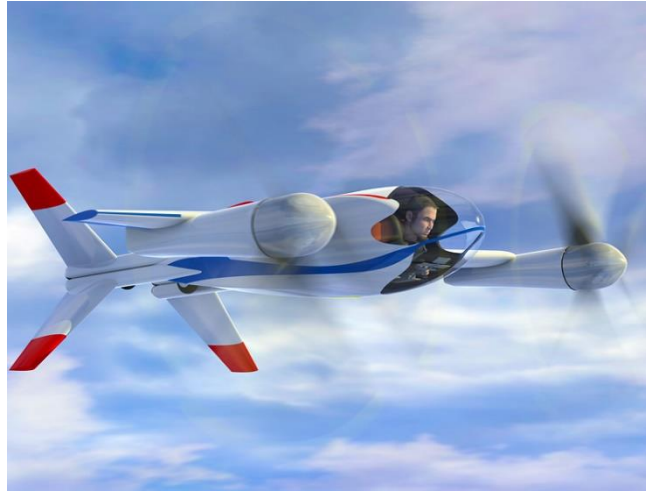
Source: <https://www.hybridairvehicles.com/our-aircraft/airlander-50>



Electric Aircraft

Short Distance – 150 to 250km

- Light aircraft - already 1hr flying time
- PAVs



Medium Distance – 500km passenger/cargo

Air transport model - hub-and-spoke or point-to-point models.

- *Smaller, more energy-efficient planes encourage point-to-point flights,*
- *Spokes form part of long-haul hub models.*
- *Higher-frequency services, > more competitive point-to-point flights, and increase the dispersion of air services to smaller airports.*

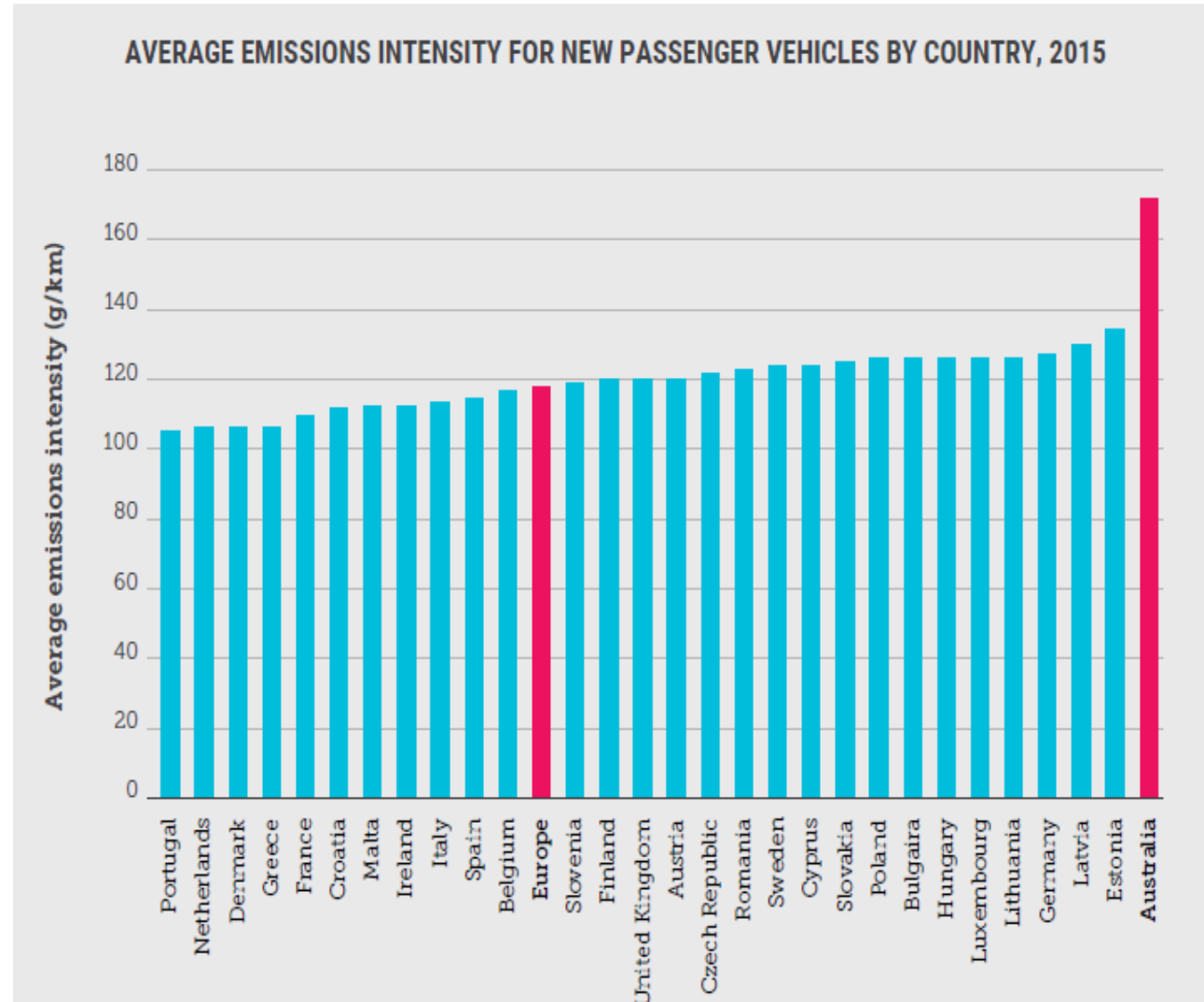
Source: <https://www.abc.net.au/news/2019-04-24/electric-aircraft-transport-disruption-coming-need-to-plan/11041940>



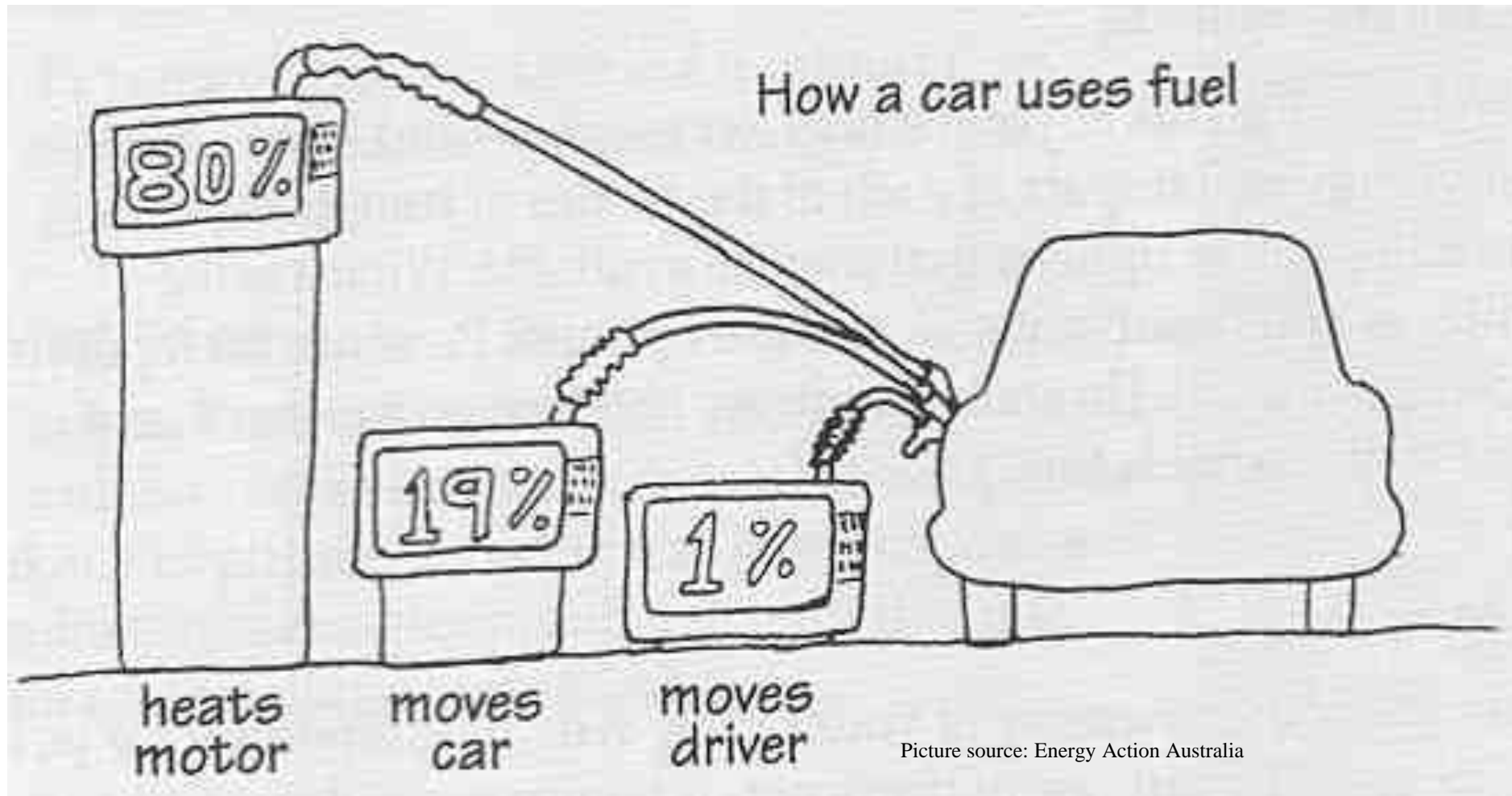
Problem 1 – A Car Culture & Efficiency

- High polluting cars
- Lack of greenhouse gas emissions standards (or fuel efficiency standards) in place ›
- High car use – almost 9 out of 10 trips
- The relatively high distances travelled per person (by car) – but mostly short trips 83% < 20km
- Car Occupancy falling 1.4 persons /trip
- Low share of trips taken by public transport - 10%
- Low ratio of capital spending on public transport compared to roads

Source: Climate Council (2018). Waiting for the Greenlight report.
www.climatecouncil.org.au



The World's Most IN-efficiency Transport Mode - Internal Combustion Engine (ICE) Car!



Bigger and Higher is Better **BUT** = Lower Efficiency

- It takes a lot of energy to move people & goods
- **+ Vehicle Wt.**
- **Average payload – 1.4 persons 120kg Approx.**
- **Average vehicle weight – 2000kg**



Sources: <https://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0>
<https://www.nrel.gov/docs/fy13osti/57187.pdf>

Aver. Car (SUV / Ute) 13500 km/yr

- 46656 Mega Joules (70% of Total LCE)
- 1485 Litres/yr of Petrol
- 3455 kg CO₂e/yr

Electric Car – Current Electricity System

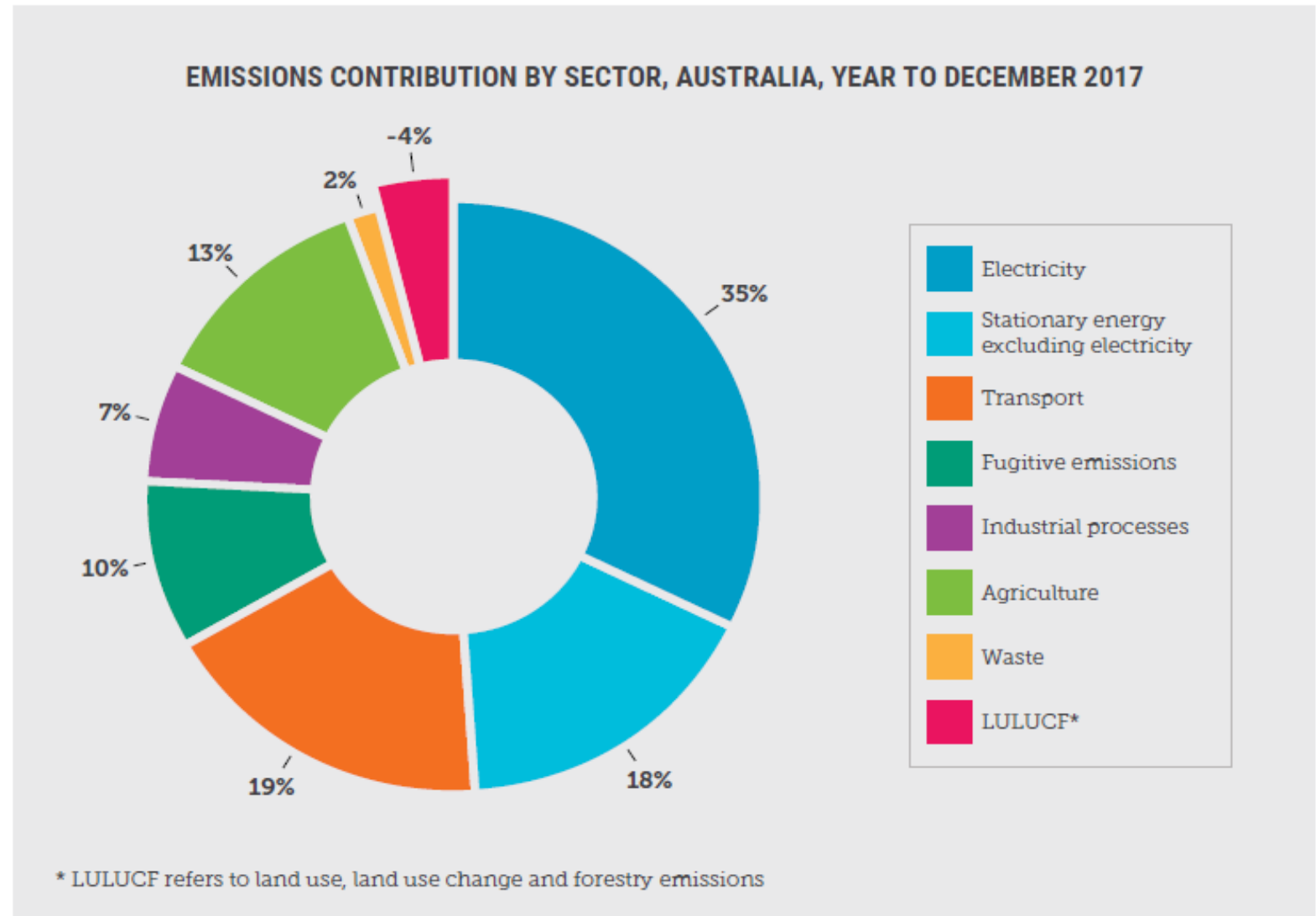
- 1060 kg /yr of Coal if all Coal Powered Elect. Generation
- 1994 kg CO₂e/yr from National Grid (80% Fossil Fuel)

Electric Car – Using Renewable Energy

- 11m² of roof area if Solar Powered Generation
- 99 kg CO₂e/yr (Source: NREL, January 2013)
- **Embodied Energy** – car / roads etc adds 30% more energy
- Sources: ABS and National Greenhouse Gas Accounts Factors 2017

Problem 2 – Australian Transport GHG Emissions Breakdown

- Transport - 19% of Total Emissions – **growing rapidly**

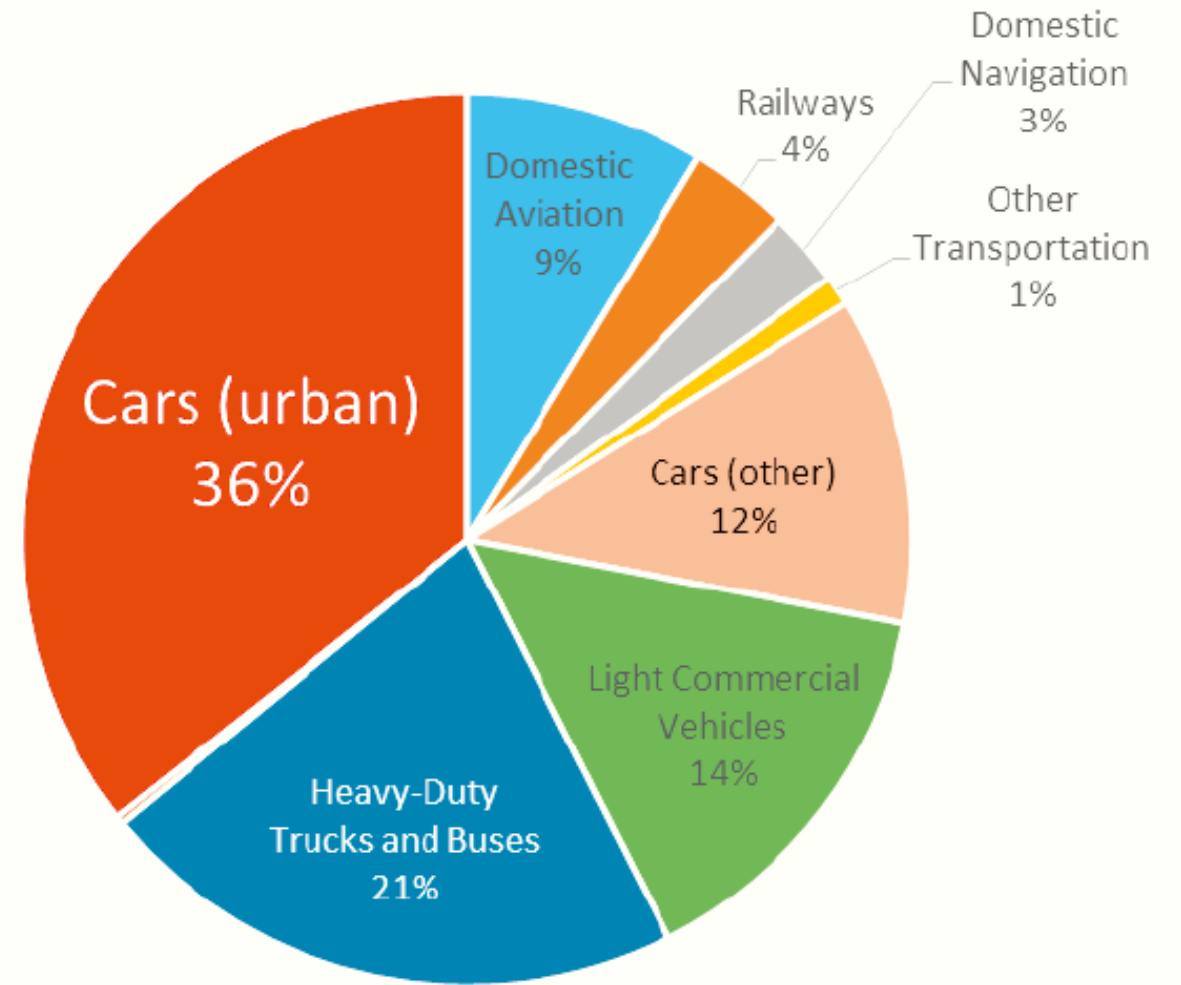


Source: Adapted from Australian Government (2018).

CO2 Emissions Australia

8% of Total Emissions from Cars

Source: BZE EV report p.13



GHG Emissions Growth Rates

- Extreme Growth Rate in Aviation 240% since 1990
- High Growth Rate Buses and Trucks
- Decrease in Domestic Marine – efficient way to transport goods
- International Shipping and Aviation not properly accounted for in National GHG Inventories

Domestic non-electric transport emissions growth since 1990

Source: Department of Environment and Energy

chartingtransport.com

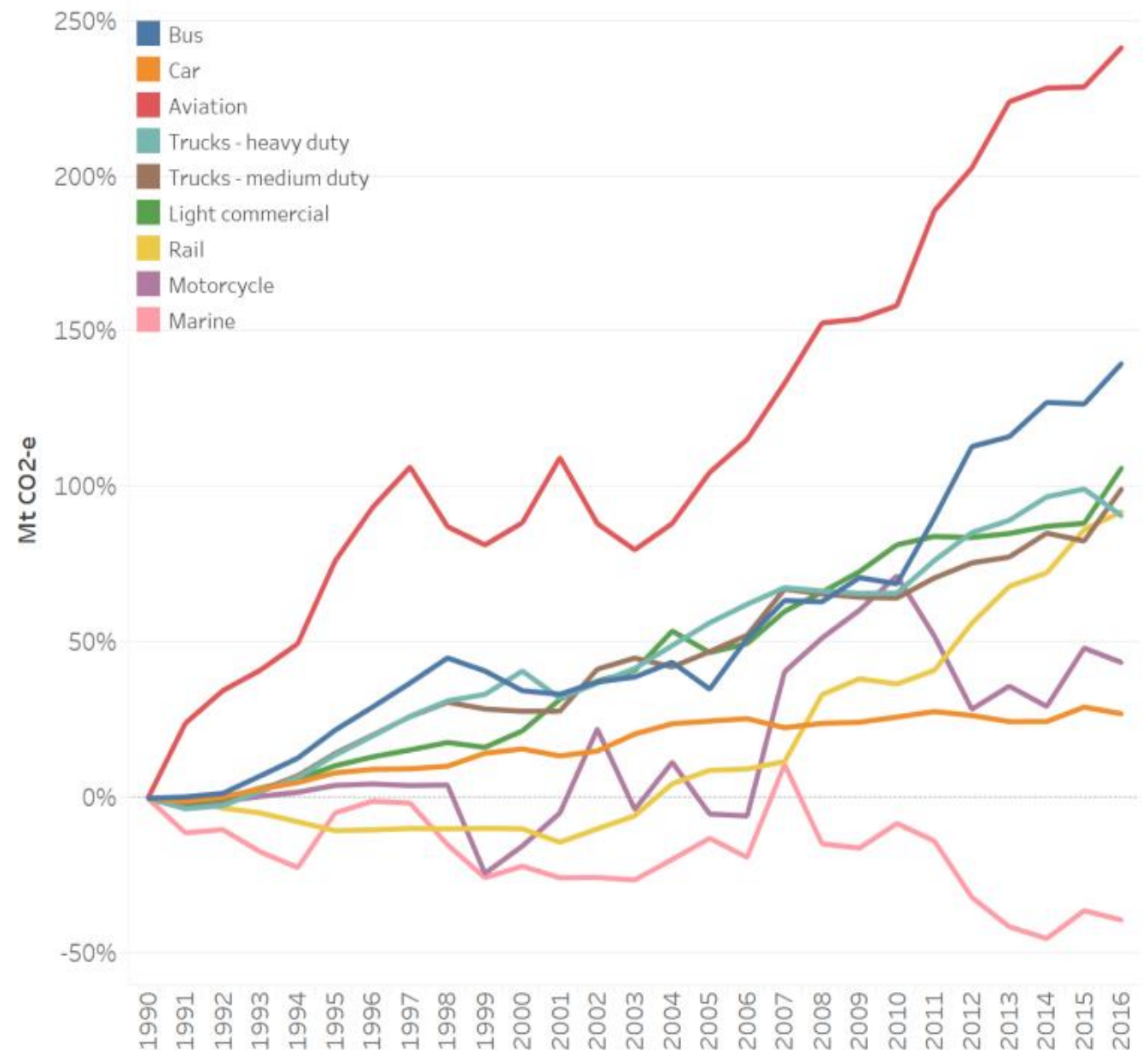
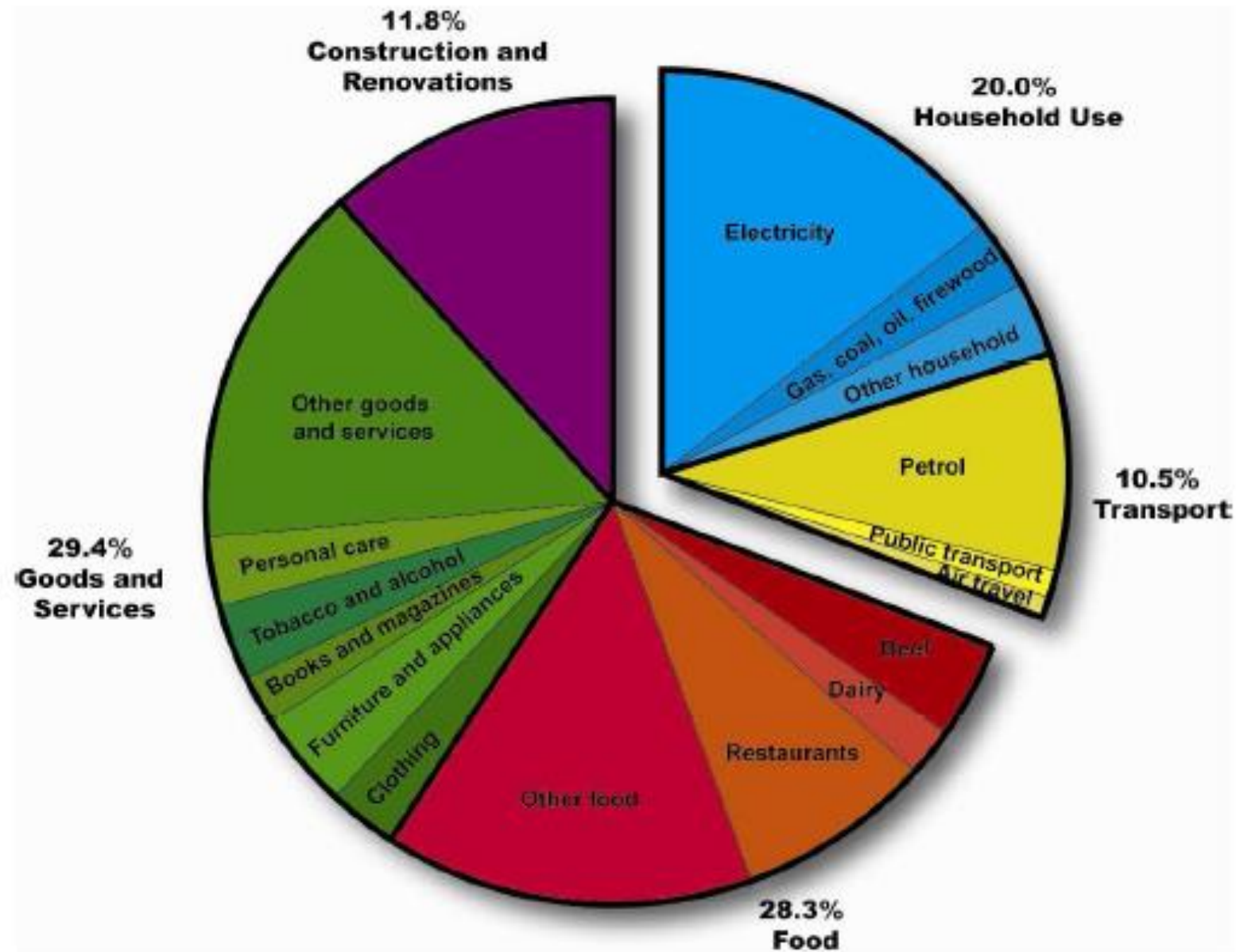


Fig 1. Average household profile: greenhouse gas pollution



Problem 3 – Lack of Good Urban Design

- Increasing Urbanisation – 66% live in cities (2012) > 74% by 2061

Source: Dean et al, 2017:21

- Still relatively low density, car oriented suburban design
- Urban consolidation areas near transport nodes – Limited benefit
- Mostly Radial Public Transport to CBD – 10 to 15% of workers

Urban Consolidation – not working

- Poor building design
- EE compromised
- No green space
- More hard surfaces > Heat island increased
- Noise increased
- Still 2 cars per home/unit
- Small increase in train use to commute



Problem 4 – Security of Fuel Supply

- Reserves Mar 2018 – 22 days of automotive gasoline, 23 days of aviation turbine fuel and 21 days of diesel (90 days UN standard) plus
- 25 days of crude oil and refinery feedstocks
- Some issues with accuracy of the data
- Off-shore stock enroute, all stock in pipelines, in transit by tanker (road and rail) and held at retail fuel sites and military stocks excluded.
- Reasonable to exclude off-shore en route stock due to diversions – if available add 20 days
- Consumer reaction to price hikes > Panic buying

Source: <https://www.abc.net.au/news/2018-05-23/fact-check-jim-molan-fuel-security/9687606>

- Middle East Conflict – currently only a small number of tankers under attack
- Asia Pacific Conflict – > Chinese bases / American bases - The Last Scramble to control OIL

Responses - Australian Institute of Petroleum (AIP)

- Market is already efficient
- Diversified supply sources
- Avoid more Govt. regulation
- Let the market decide!!
- But - AIP accepts some lack of preparation for supply interruptions!

Problems

- Major Conflict in Middle East or Asia Pacific region
- Low Energy Return on Investment (EROI) ratio of Fossil Fuels – average 6:1, 3:1 for Electricity Generation (Source: Science Daily 11 July, 2019)
- War uses lots of energy to fight and wastes a lot

Govt. Response – supports AIP views

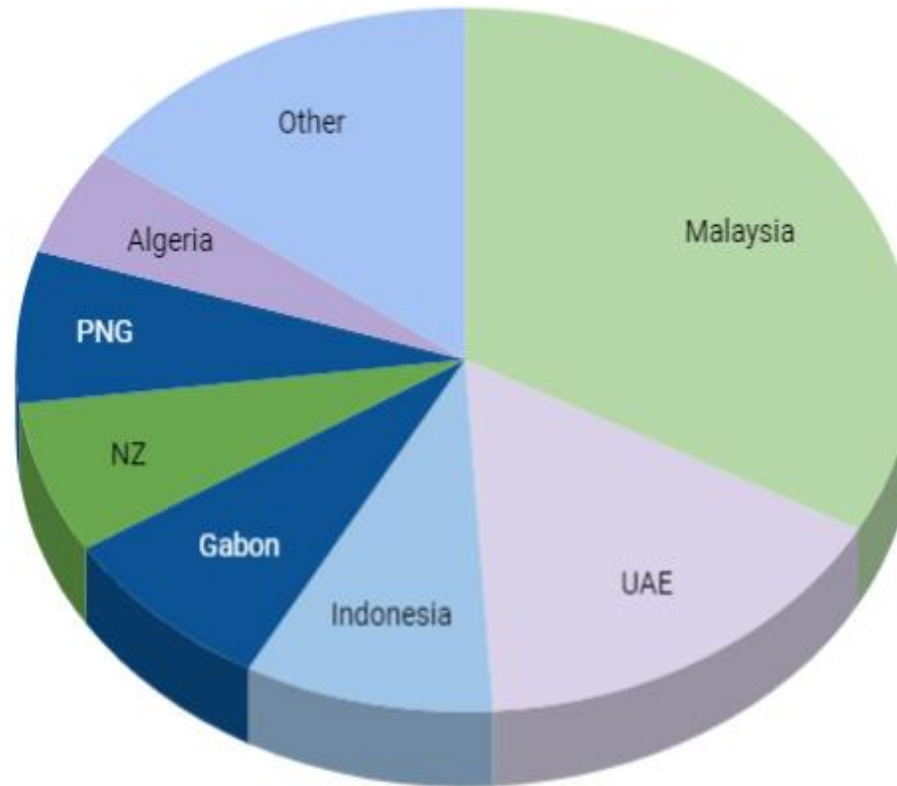
- 2011 National Energy Security Assessment said Australia had "access to well-functioning markets for liquid fuels which have helped create robust and flexible supply chains with a significant degree of resilience"

Imports – Crude Oil and Refined Fuels

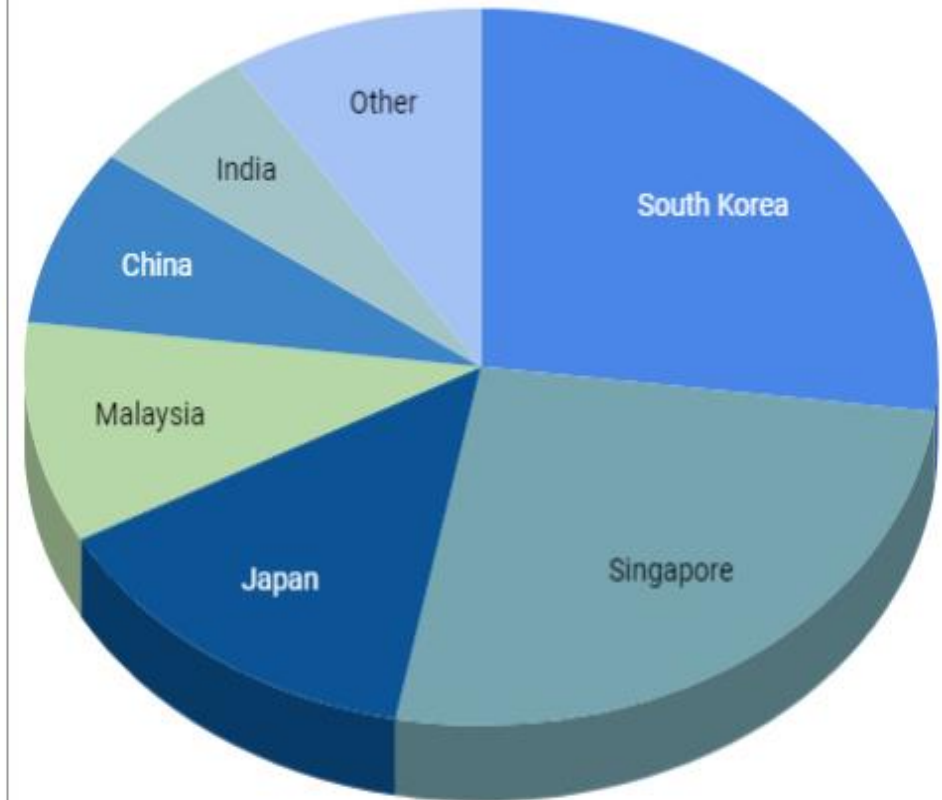
ABC Fact Check

Source:
<https://www.abc.net.au/news/2018-05-23/australian-fuel-imports/9791912>

Australian crude oil imports



Australian refined petroleum products imports



Responses – Engineers Aust. & NRMA

Engineers Australia

- Australia's energy network (electricity, liquid fuel, gas) is an ad-hoc system, organised within stovepipes of energy types, creating system and systematic vulnerability. In the short-term Australia is faced with significant risk in liquid fuel security and there are no easy solutions to addressing it.

Source: EA 2019 submission to Department of the Environment and Energy, Liquid Fuel Security Review

NRMA

- High dependence on imports 90%
- Reduction in refineries – only 4
- No ability to refine some Navy fuel
- Source: NRMA report 2014

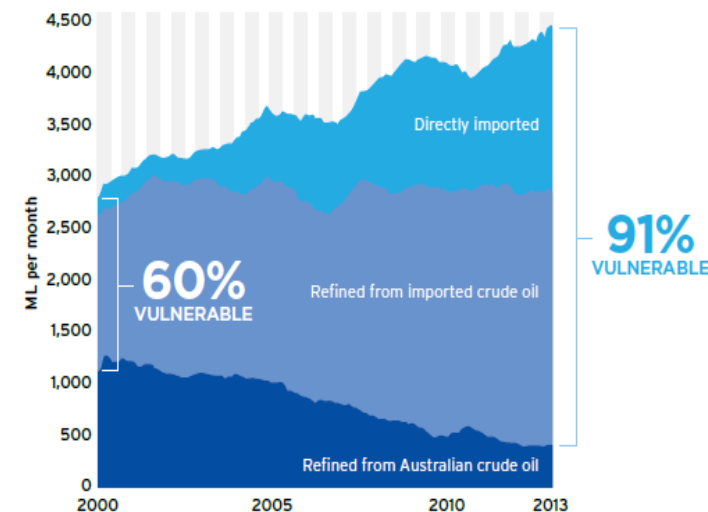


Figure 5: Declining local supplies and Increasing Imports of fuel products⁹

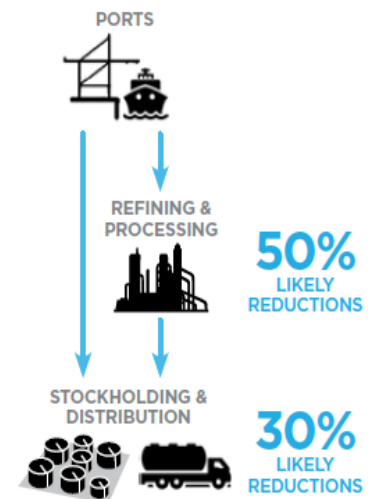


Figure 6: Fuel supply infrastructure in decline

Days of fuel stocks

- Australia at the bottom
- Source: NRMA report 2014
- Why?

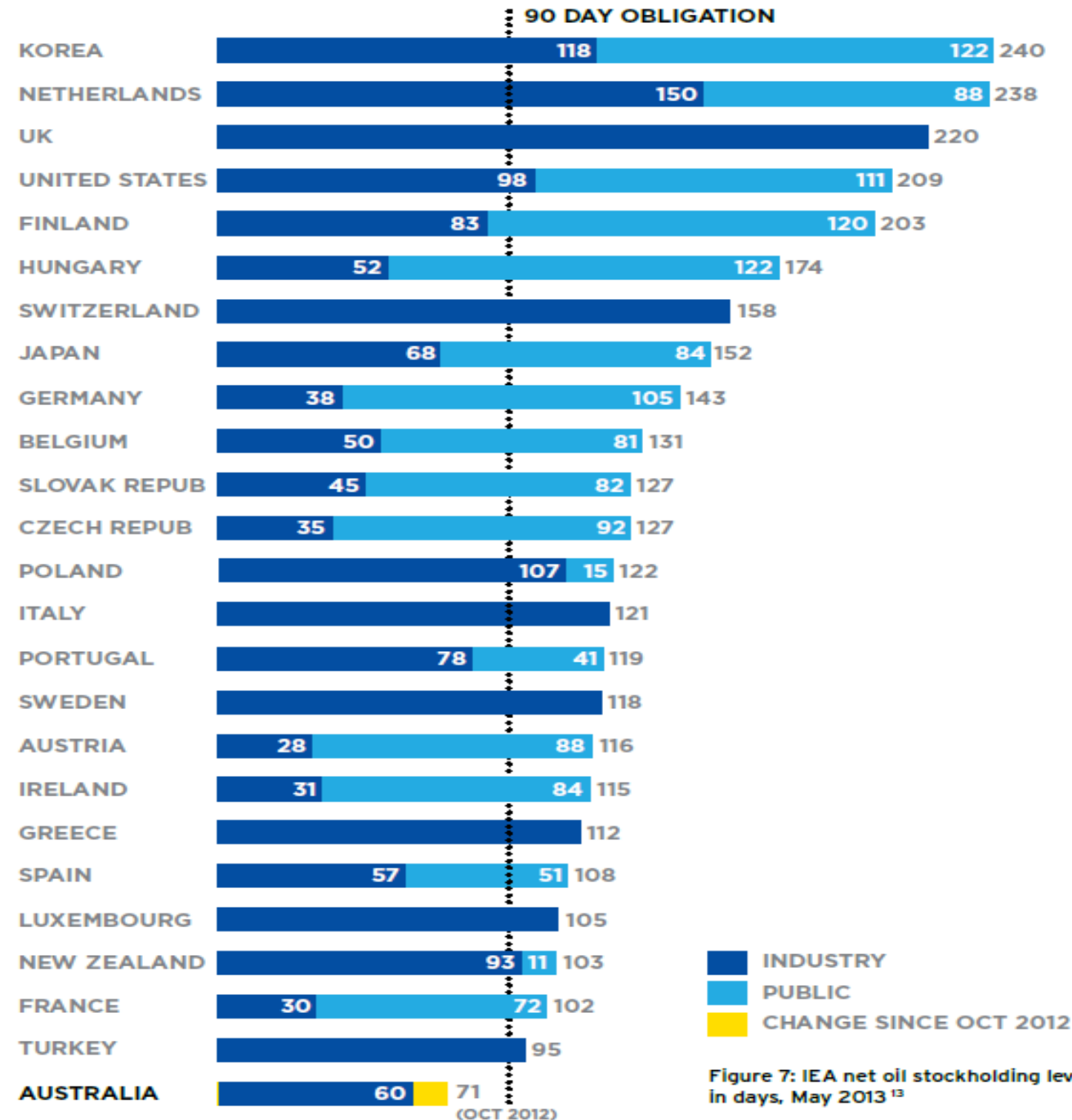


Figure 7: IEA net oil stockholding levels in days, May 2013¹³

Problem 5 - Structural Issues



- Just in Time Delivery –
 - fuel intensive,
 - high number of small shipments,
 - often cannot be loaded to their full capacity.
- Takes products off the most efficient transport eg. truck instead of rail

Source: Wehner, J. 2018:11

- Products kms (food miles) – huge in many cases

Strawberry Yoghurt Study Germany

- “ ...embarrassing, even ludicrous, transport intensity of this product”
- Ingredients/Materials – 3500km per cup
- Transport to final use – 4500km

Source: Lovins et al (1997:117) Factor Four: Doubling wealth, halving resource use, Club of Rome Report

Road Fatality Rates – 4.91 per 100,000

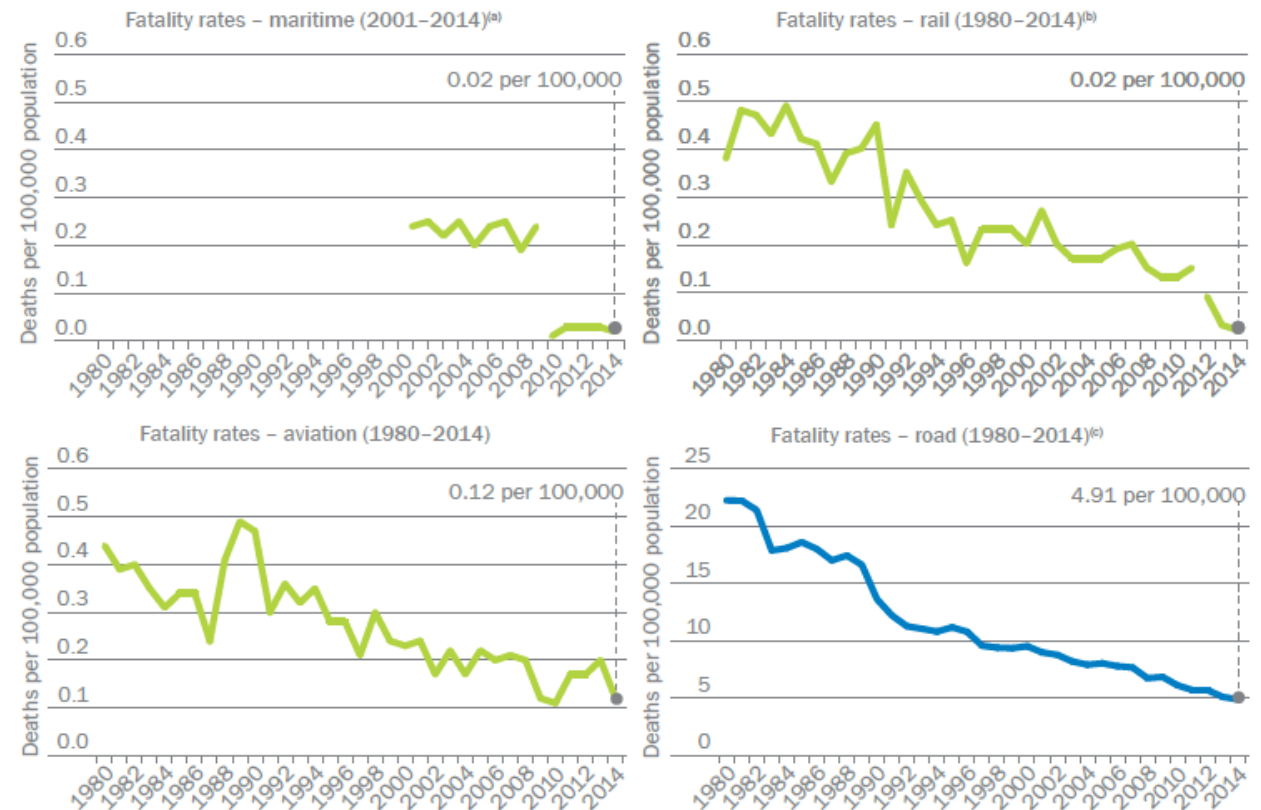
- 41 times aviation
- 245 times rail

- \$27 billion pa.

Source: DIRD, 2016:15

- We might be smart but are we wise?

Figures 3.1, 3.2, 3.3 and 3.4: Fatality rates by transport mode



Source: Bureau of Infrastructure, Transport and Regional Economics Yearbook 2015: Australian Infrastructure Statistics

NB: Time-series are not consistent due to data limitations

(a) Marine fatalities data from 2010 onwards were compiled using a different methodology and should not be compared with earlier results.

(b) Rail fatality and serious injury data from 2012 onwards excludes suspected suicide and trespass occurrences. They were compiled using new methodology and should not be compared with earlier results.

(c) Y-axis range is not the same as other transport modes.

Problem 4 – Impacts & Costs of Current Energy / Climate Policy

- **Air Pollution** (including from Global Warming Impacts)
 - Annual Pre-mature Deaths - 3,056 & Health Costs - \$11.1 billion to \$24.3 billion

Source: Dean et al, 2017:5

- Reduce property values by \$571 billion by 2030
- Insurance Risk Costs – \$85 billion in 2030 to \$117 billion in 2100 – Unaffordable 1 in 19 Owners
- Coastal Inundation and Erosion - \$226 billion by 2100
- Agricultural Impacts - reduced agricultural productivity and labour productivity from climate change projected to exceed \$19 billion by 2030 & \$211 billion by 2050

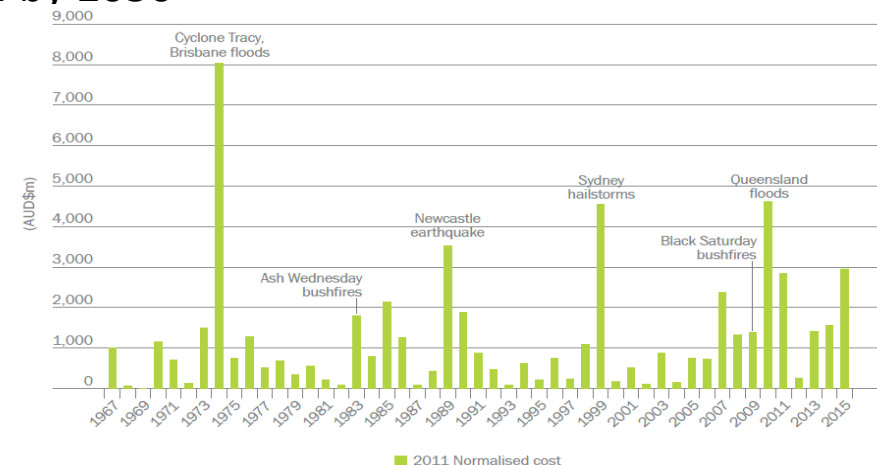
Source: Climate Council, 2019:7

- Road Congestion - \$16.5 billion pa. . \$30 bill. 2030

Source: DIRD, 2016:5

- Extreme Weather Insurance Losses -

Source: DIRD, 2016:15



Source: ICA (2014e), ICA Data Globe 2016 and Productivity Commission, 2014, Natural Disaster Funding Arrangements, Australian Government.

Policies to Promote Resilient Efficient Transport System

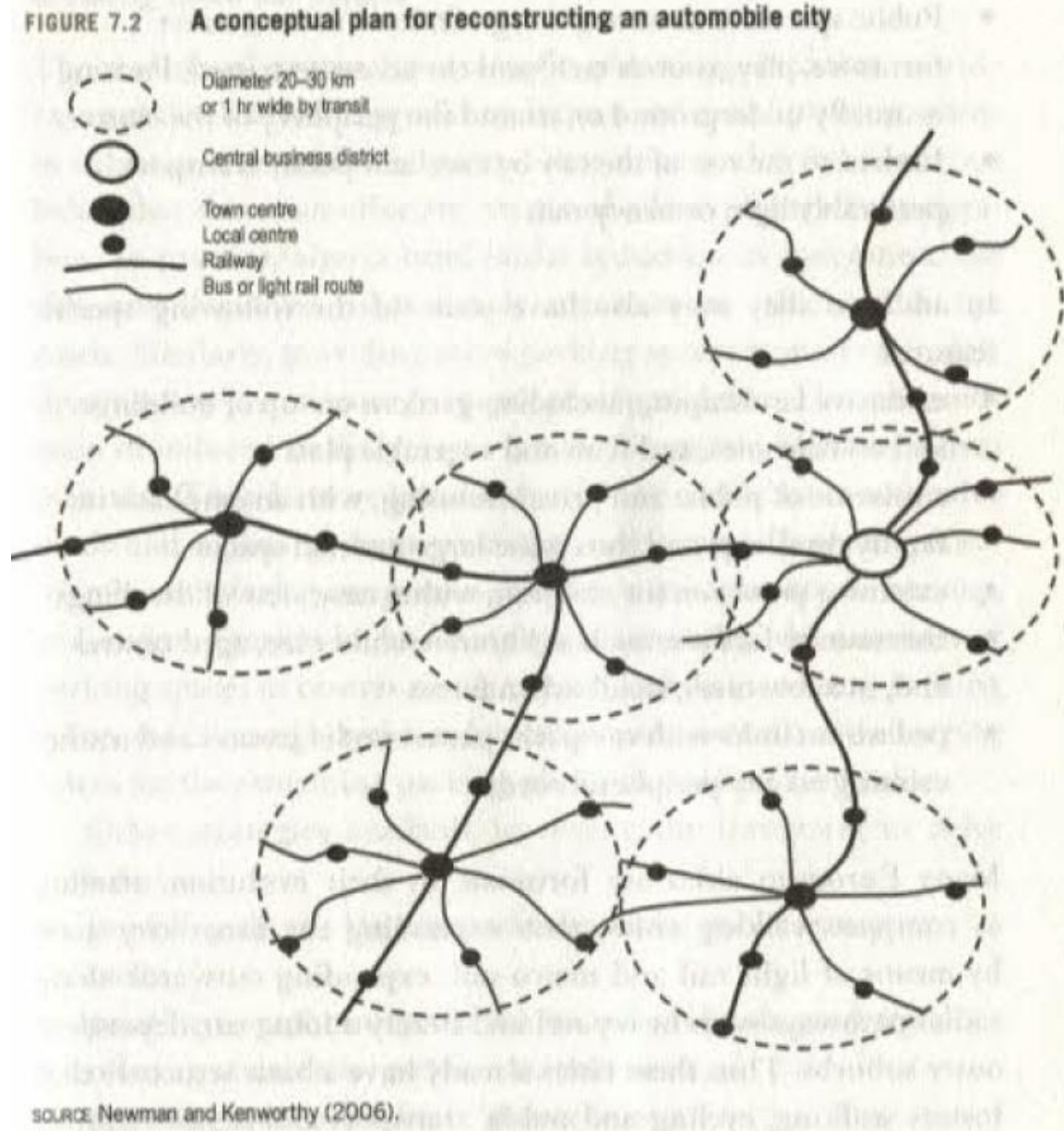
Commit to infrastructure:

Long – Medium Distance

- High speed coastal rail - passenger
- Finish inland rail – cargo
- Reduced need to travel
- Shared cars

Short Distances (most trips)

- EVs – buses / trucks / cars / bikes etc
- Shared / autonomous EVs
- Walk /cycle



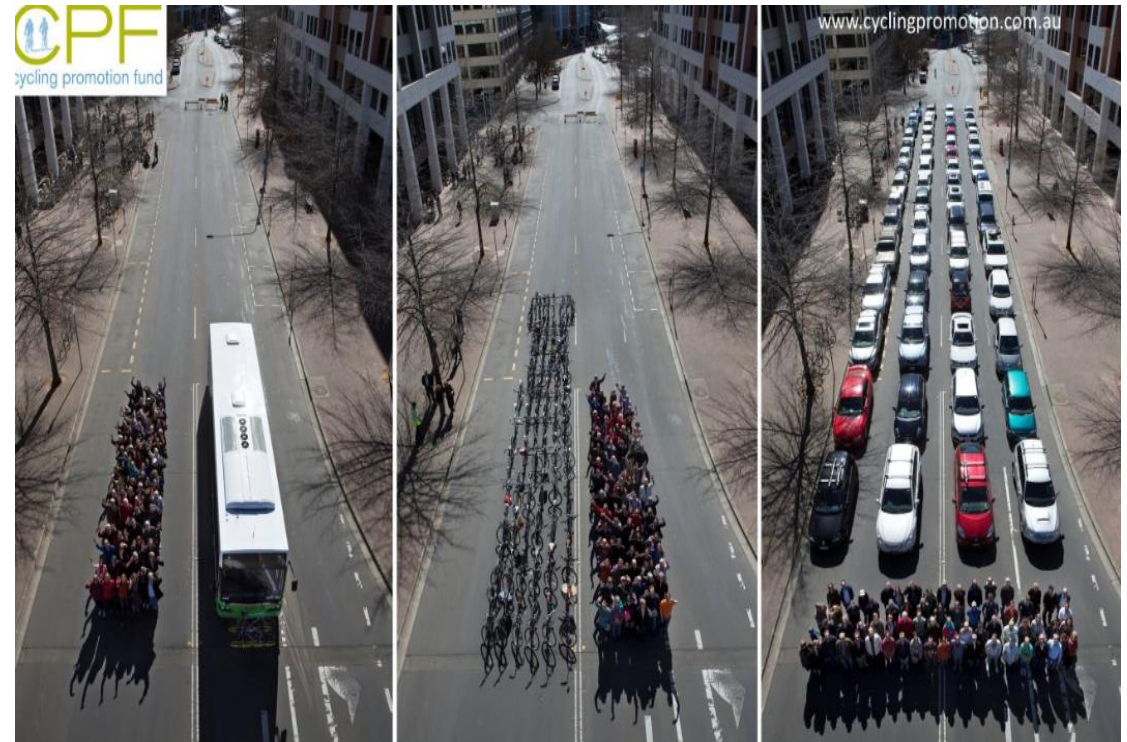
Conclusions

There are solutions:

- Most travel is local and short distance 80% < 20km
- Massive restructuring + Electrification
- Renewable Energy Powered
- Cooperation / sharing
- Re-thinking globalisation – local VS global
- Turning around the Neo-liberal experiment

World's Most Efficient Transport - Combining Space and Energy

- Bike – peak 0.025 kWh/km.
- Tram/Train - 0.05 to 0.08 kWh/km
- Car / Plane – 0.52 to 0.56 kWh/km (> 20x)



<https://www.bikecitizens.net/efficiency-master-for-modes-of-transportation/>

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