



GOING BEYOND ZERO

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NOT EVERYONE IS A 'MEDIUM'

DIFFERENT NEEDS



AT DIFFERENT TIMES



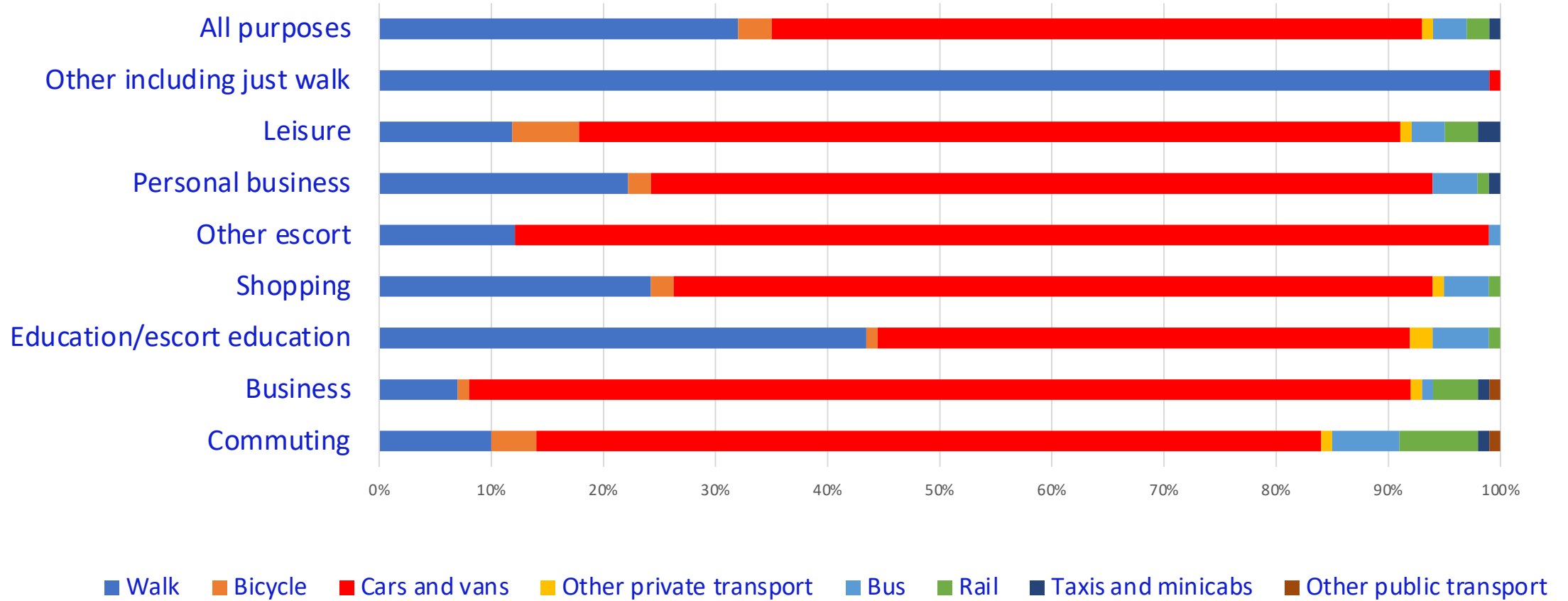
IN DIFFERENT PLACES



UNDERSTAND WHY & HOW PEOPLE TRAVEL

UK Travel by mode & purpose 2020

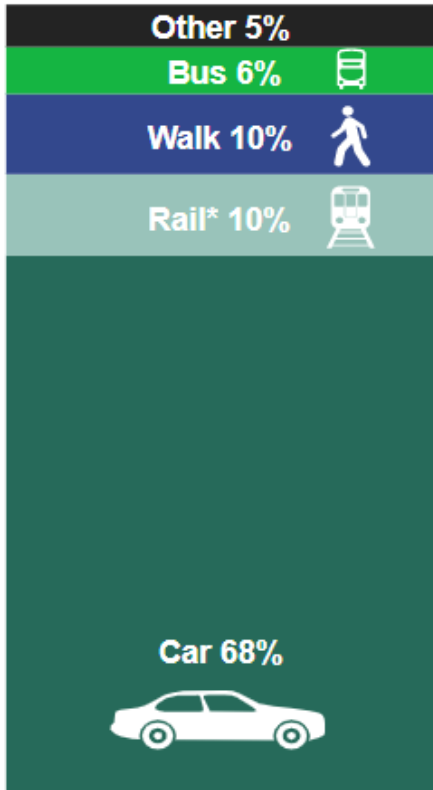
**58% of all journeys
by CAR**





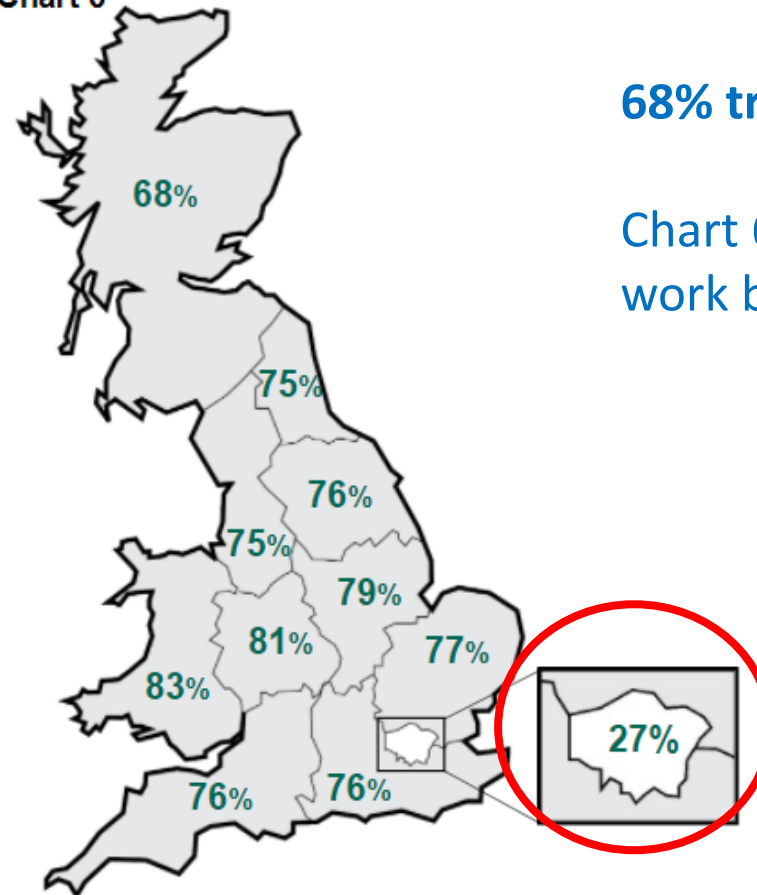
REGIONAL VARIATIONS IN VEHICLE USE

Chart 5



* Rail includes travel by National Rail, underground and light railway systems and trams.

Chart 6



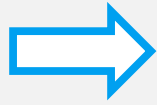
68% travel to work by car GB 2020 (chart 5)

Chart 6 : % of workers usually travelling to work by car by region of workplace GB 2020

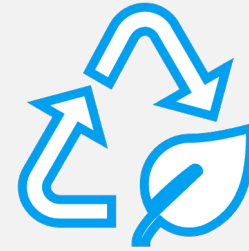
Policy must not be driven by 1 region or 1 group



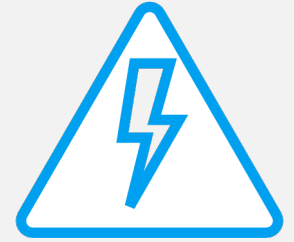
SOLUTIONS NEED TO MEET CUSTOMER & ENVIRONMENTAL REQUIREMENTS



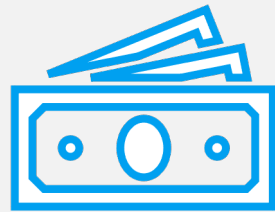
Global Applications =
mass production &
adoption



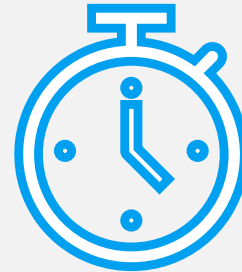
Circular Economy Sustainable
raw materials, rebuild, reuse,
recycle



Renewable Energy to
fuel. On demand or from
storage



Good Total Cost of
Ownership



Non disruptive,
Convenient , Integrates



Meet Utility: range
and load capacity



TRANSITIONAL TECHNOLOGY WILL SIGNIFICANTLY REDUCE EMISSIONS



18 M

DEC 2021

Total Toyota Hybrid sales

140 MT

DEC 2021

tons of CO₂ saved vs comparable petrol engines

>625 k Toyota group hybrids sold in Europe 2021. CO₂ emission saving equivalent to taking 200k off the road = GREATER tailpipe CO₂ reduction than the best selling BEV



THE SUPPLY & DEMAND DILEMMA



MAXIMISE PRODUCTION EFFICIENCY
& LOWER COSTS



CONSUME WHAT
YOU CAN



EXCESS TO WASTE OR.....



STORE & USE ON DEMAND



THE SUPPLY & DEMAND DILEMMA



RESILIENT &
EFFICIENT





NEED A RESILIENT ENERGY SUPPLY :

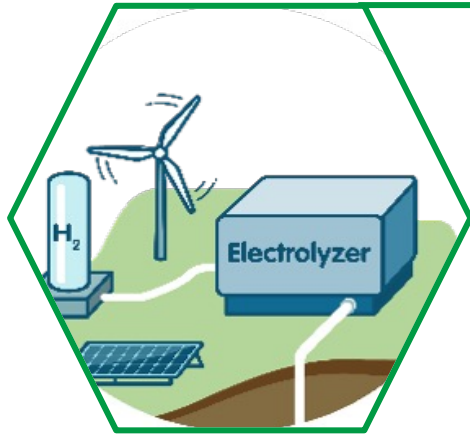
H2 : MULTI SECTOR SOLUTION

Renewable sources of energy

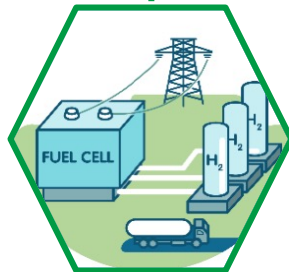
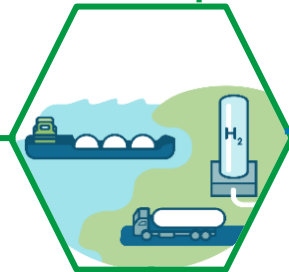
Renewable energy system

Reduce end use emissions

1. Enable large-scale, efficient local & international renewable energy integration

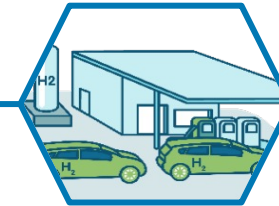


2. Global H2 production

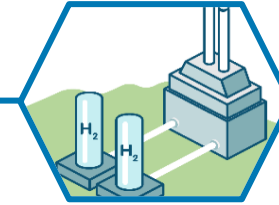


3. H2 storage & Distribution of energy across sectors and regions

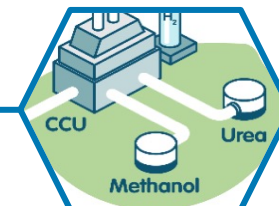
4. Decarbonise transport



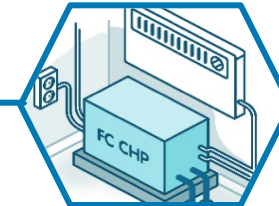
5. Decarbonise industry energy use



6. Serve as feedstock using captured carbon



7. Help decarbonise building heating & power

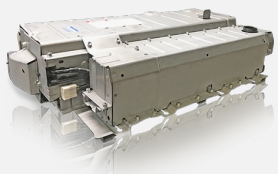




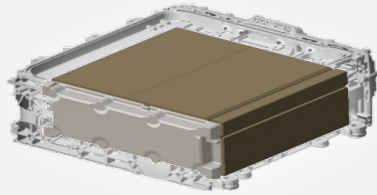
DON'T BE CONFUSED :

VEHICLE EFFICIENCY IS NOT THE SAME AS ELECTRICAL CONVERSION EFFICIENCY : **WEIGHT IS KEY**

Mirai 128Kw >400 mile range (real world)
FCV specific component weight = **~190 kg**



Battery 45kg



Fuel Cell module 52kg



Tanks 87kg
Hydrogen 5.6 kg

Double the range > 800 miles = x2 tanks + x2 hydrogen =
~285 kg

85 kWh 260 mile range battery pack
weight = **~ 540 kg**



Double the range ~ 520 miles = x2
battery = **~1080 kg**

Fill in minutes vs Charge in hours



COST & FUTURE PROOFING INFRASTRUCTURE

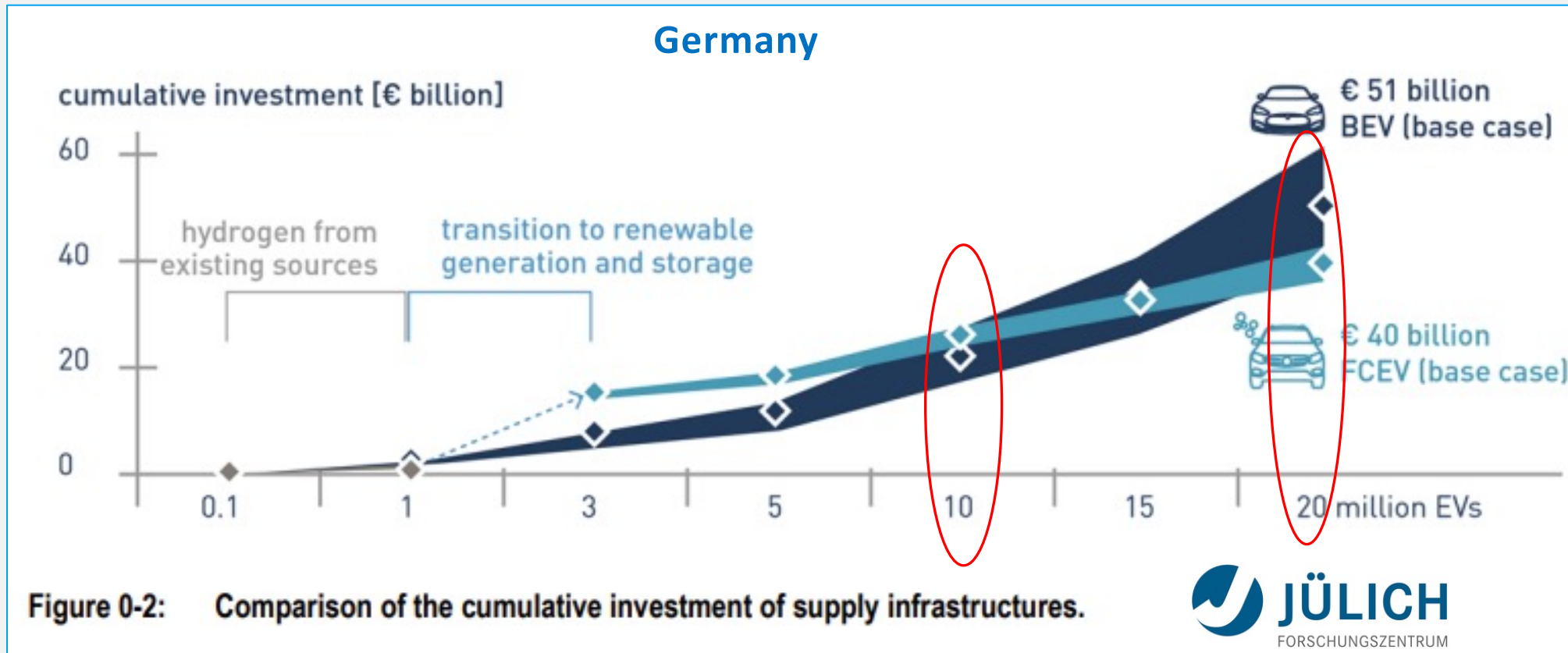


Figure 0-2: Comparison of the cumulative investment of supply infrastructures.

Electric Road Systems for freight?

Is £19.6bn for ~65% UK coverage* good value?

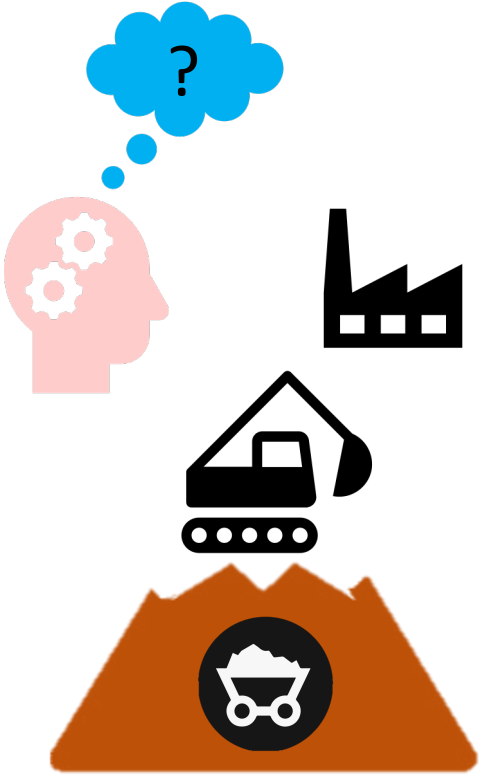
~£12bn for H2 infrastructure = 15k T a day = 100% coverage

* Source : The Centre for Sustainable Road Freight



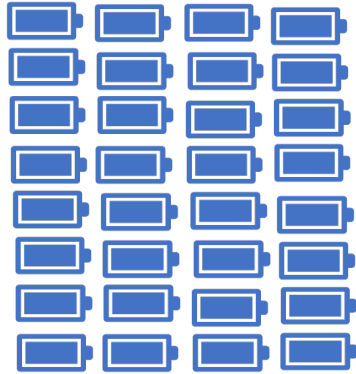
THE RESOURCE, BATTERY & ENERGY DILEMMA

What should we do?

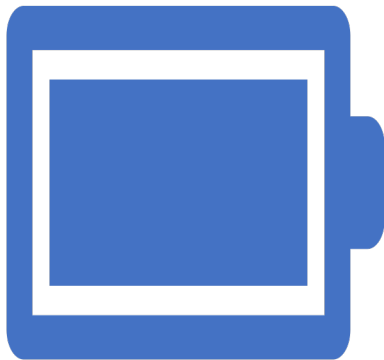


How do we:
1.Reduce environmental damage from exploitation? 2. Use finite raw materials efficiently?
3. Make production sustainable?

30 + hybrid or FCEV batteries



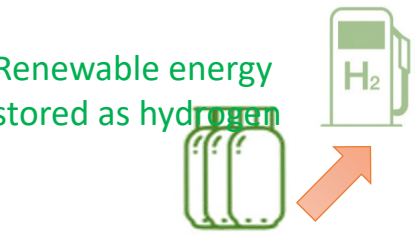
Or



1 large BEV battery

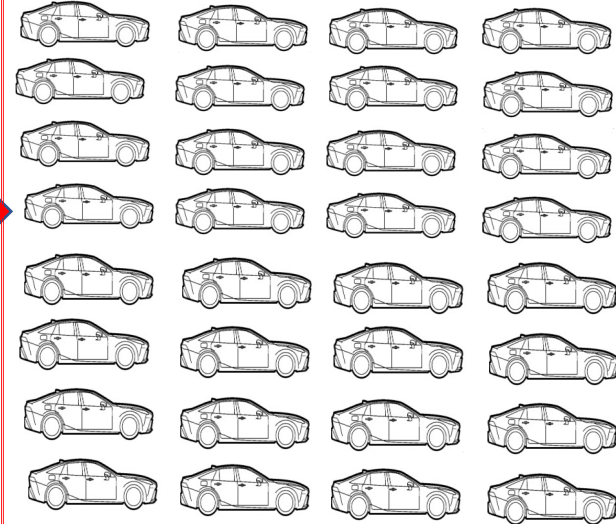
All need on demand refuel

Renewable energy stored as hydrogen



Renewable energy cannot always be available on demand for BEV charging

30 + Fuel Cell
Zero tailpipe emission cars



1 BEV
Zero tailpipe emission car

Fuel Cell can reuse or ~100% recoverable & recyclable



Li difficult & costly to reuse or recycle safely



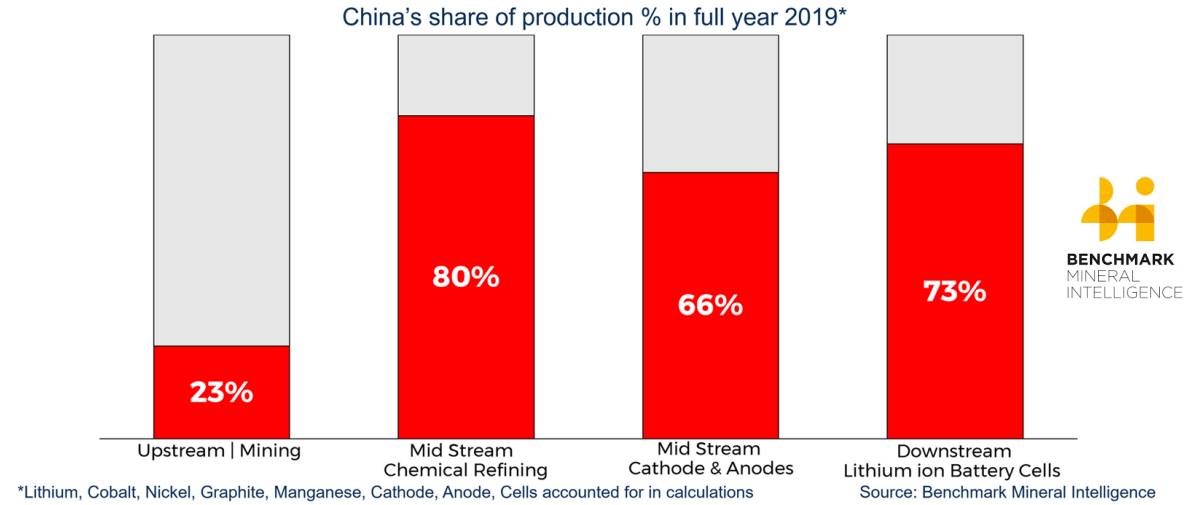
RAW MATERIAL CHALLENGE – COST +400%

Year on Year change in costs of a typical battery core materials (60kWh)
From \$1395 to \$7,400

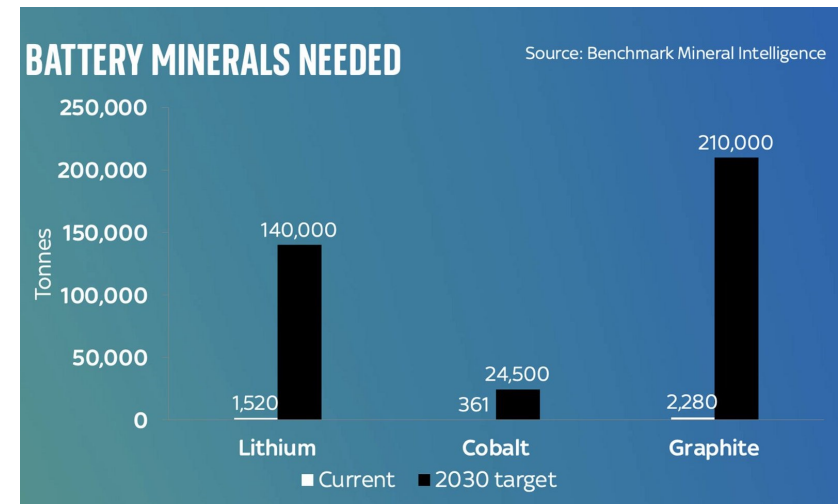
| | Amount | Cost March 2021 | Cost 8 th March 2022 |
|--|------------------------------|--------------------------------|------------------------------------|
|  | 38.8 kg Lithium Hydroxide | 465 USD 12 USD/kg | 2440 USD 63 USD/kg |
|  | 47.5 kg Nickel | 785 USD 16.5 USD/kg | 4750 USD 100 USD/kg |
|  | 2.7 kg of Cobalt | 145 USD 55 USD/kg | 210 USD 80 USD/kg |
| Total: | | 1395 USD per Vehicle | 7400 USD per Vehicle |

Source: Roland Zenn, Farasis 03/22

China's Dominance



UK Battery Raw Materials required by 2030





DIVERSITY



INNOVATION+ UTILITY + RESILIENCE



THANK YOU

We need people who are
**BRAVE ENOUGH
TO CHALLENGE
THE STATUS QUO**

Dr. Katsuhiko Hirose

Product General Manager Toyota Fuel Cell Development Group



Jon Hunt

Manager Alternative Fuels Toyota GB

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