Decarbonisation of Small Vessels: An Overview

UNIVERSITY OF PLYMOUTH

European Union
European Regional Development Fund

MARINE

Decarbonisation

- Undergoing a climate crisis
- UK Government has goal of zero carbon by 2050 and in 9 years reduced to 78% that of 1990s levels [1]
- UK Clean Maritime Act: “the expectation that the maritime sector will transition away from fossil fuels extends to all parts of the sector” [2]
- IMO has set plans to reduce shipping emissions by 40% for 2030, and has already enacted binding regulations to improve efficiency of ships [3]

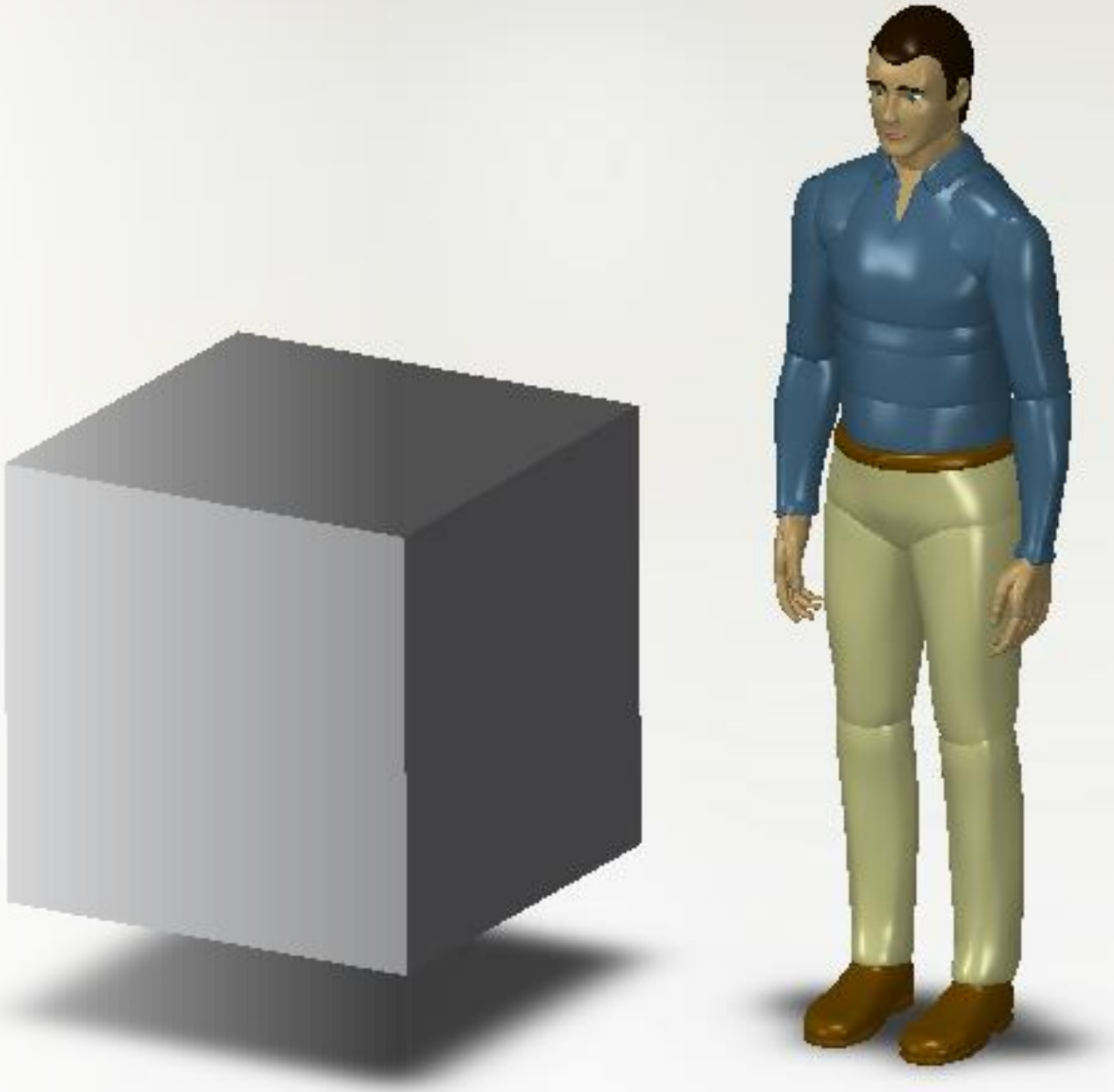
Conventional Drive: it's Solar

- Currently using internal combustion of fossil fuels
- Crude oil is prehistoric marine plant matter refined through geological pressures to form a hydrocarbon rich liquid
- Crude oil is millions of years of stored sunlight; 1 litre of fuel would require 27 tons of prehistoric plant matter
- To replace our energy use today with burning plant matter, we would have to burn 1/3rd of all above ground land-based plant matter.

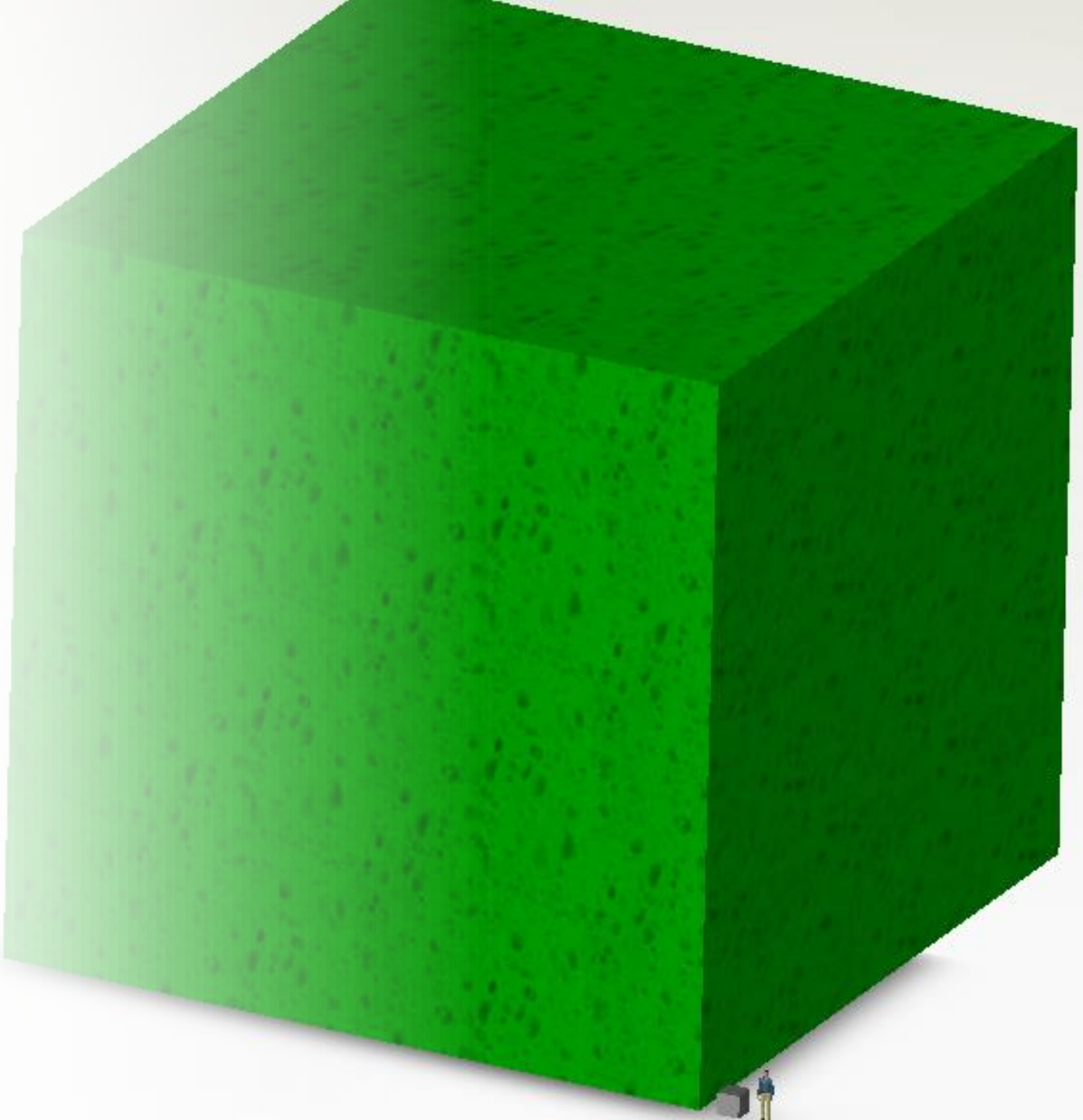
Ref: [4]

Reference Scenario

- A passenger ferry using 440 litres of diesel per day



Relative volume of organic matter required to create volume of fuel at same scale – see bottom corner…!



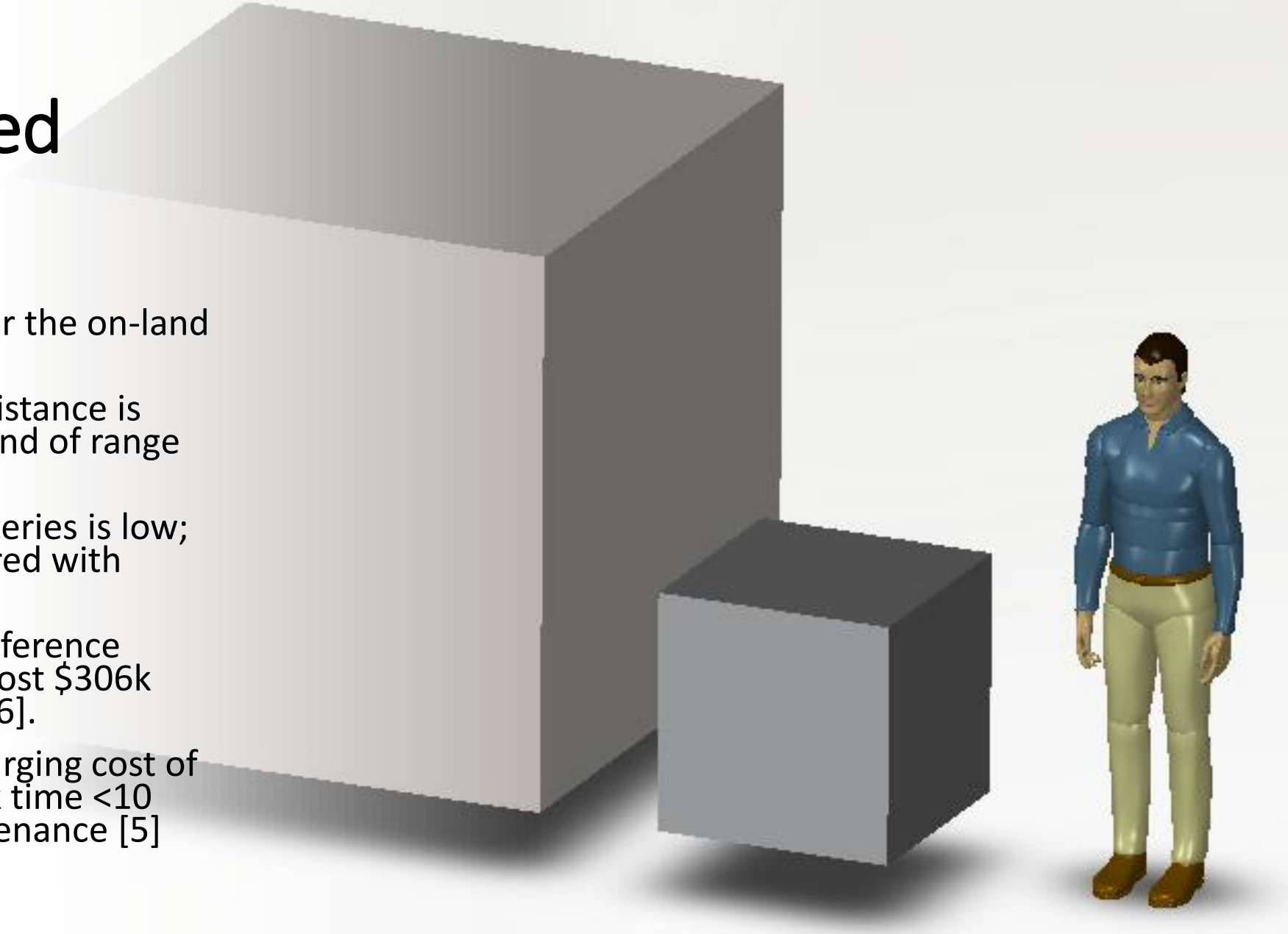
Alternative Propulsion

Several alternative propulsion options:

- Battery
- Solar Panels
- Fuel Cells
- Hybrid (Integrated electric propulsion)
- Alternative IC Fuels
- Wind

Battery Powered

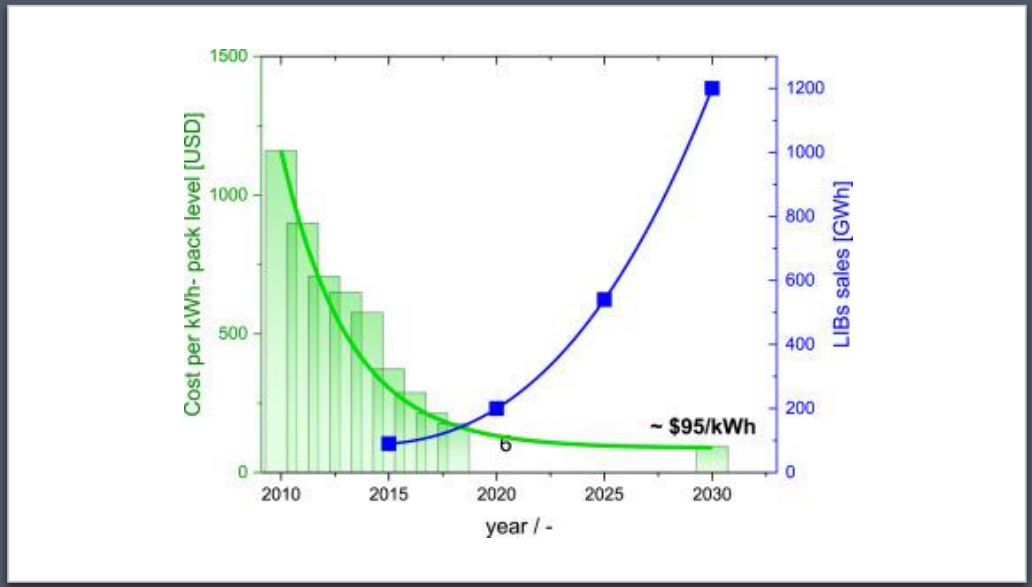
- Lower emissions, whatever the on-land energy source
- A big factor for uptake resistance is perception of initial cost and of range [5].
- The energy density of batteries is low; about 265 Wh/kg, compared with 12500 Wh/kg for diesel
- 8.7 tons needed for our reference scenario, and this would cost $306k with current li-ion prices [6].
- Fuel saving due to low charging cost of £40k per year, so pay back time <10 years, and 50% less maintenance [5]

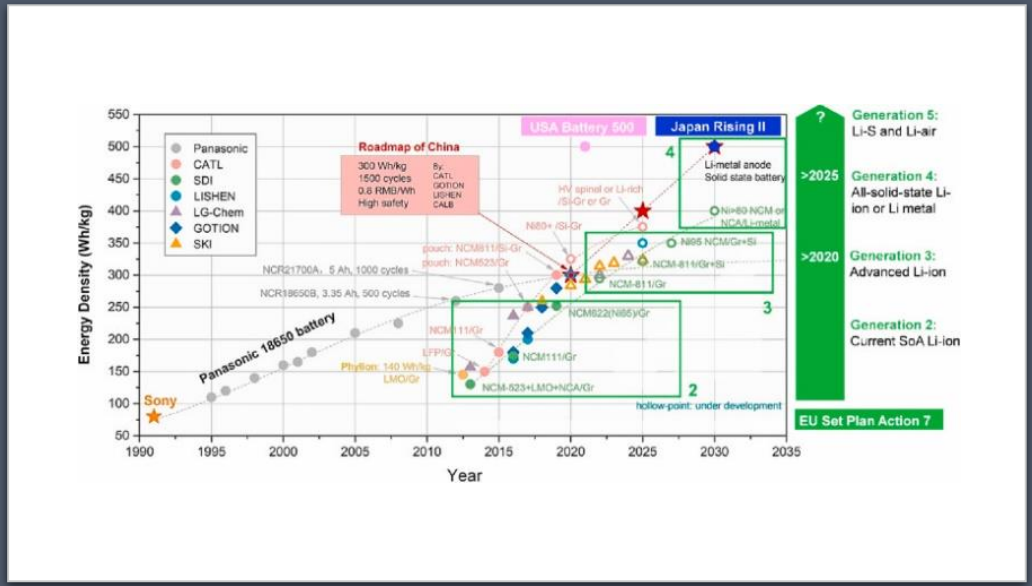


Battery Powered

- Changes in operation
- Batteries are improving, and costs are going down
- Predictions by 3035 show density might increase to 500
- By 2035 our reference battery requirement of 8.7 tons should be 4.7 tons.

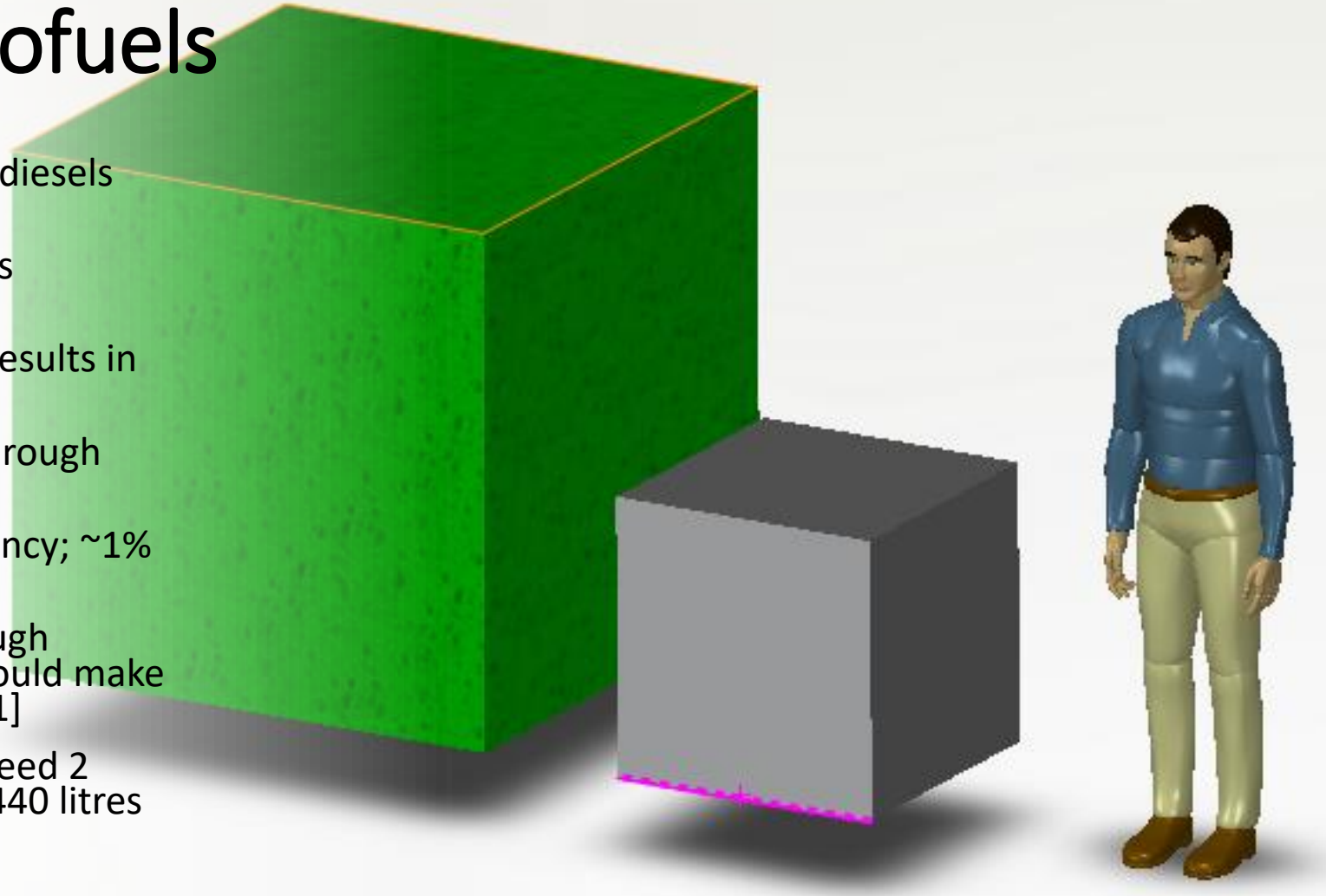
Ref: [7,8]





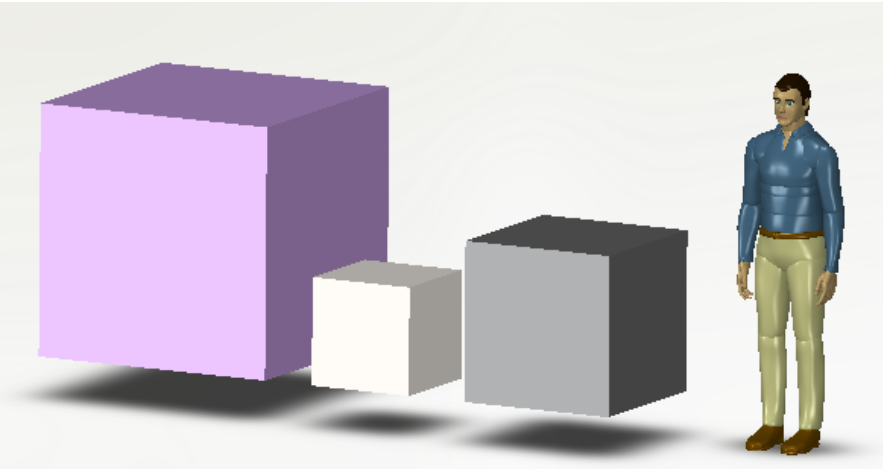
Alternative Fuels: Biofuels

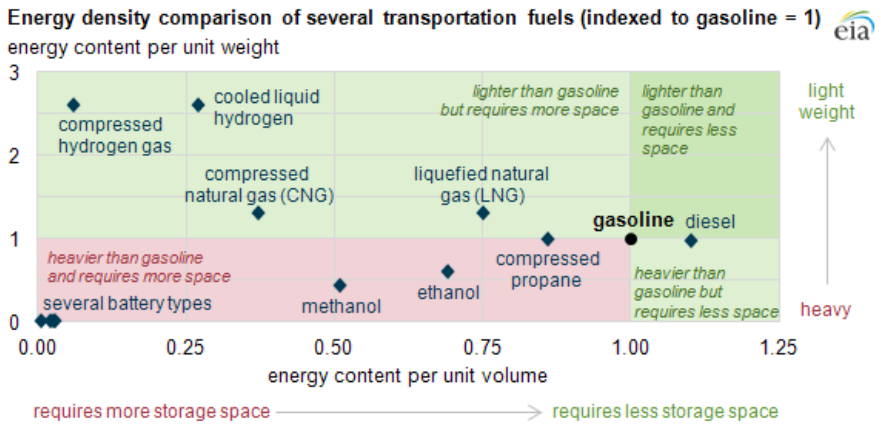
- Either ethanol from fermentation or bio diesels from plant oils
- Claim to be carbon neutral, though this is contentious
- Displaces land for farming, and directly results in an increase of food costs
- Incentivises the loss of natural habitat through expanding farmland
- Still solar energy, though with low efficiency; ~1% energy conversion [9]
- Waste cooking oil is a viable option, though current total vegetable oil production would make 1/10th current diesel consumption [10,11]
- With our reference scenario we would need 2 tons of soybean biomatter to make our 440 litres fuel [ecoinvent]



Natural Gas

- Fossil fuel comprising mostly of methane
- High energy density means reduced CO2 emissions
- Diesel and petrol engines can be retrofitted to use natural gas





Going Forward

- There is potential to make decision now that can reduce emissions
- Batteries offer the highest reduction in CO2, however, requires the most compromises
- Biofuels have issues with sustainability claims and impacts on word food security and loss of natural habitat
- Natural Gas could be a cheap way to reduce emissions whilst maintaining capability and current equipment

e-Voyager & e-Link

- The e-Voyager is the UK's first sea-going electric ferry launched Oct 2020 and is also the first e-vessel to have been recognised by both the MCA and a Classification Society as satisfying the exacting standards of both organisations
- Copper (eLink) is a 364 day water taxi also using local technology for the refit
- Both vessels developed via ground breaking partnerships with locally developed technologies
- Refits funded via an Impact Lab project grant
- Environmental sensors installed

Plymouth's
Marine e-Charging Living Lab

- **Network of e-charging installed by Aqua superPower**
- **Partnering with Plymouth City Council, Princess Yachts and Aqua superPower**
- **Strategic input from National Grid, Western Power Distribution and local industry partners**

Plymouth's
Marine e-Charging Living Lab

Outcomes:

- Working installations at multiple sites with different power requirements
- Development of Toolkit to disseminate information
- Enable model to be replicated and adapted in other locations nationally

Plymouth's
Marine e-Charging Living Lab

Impact:

- Supporting different types of vessels
- Multiple sites across Plymouth Sound
- Enabling growth across the industry by providing the infrastructure
- Links to National Marine Park / Freeport / OceansGate / Smart Sound

Plymouth's
Marine e-Charging Living Lab

University of Plymouth Research –

- **Installation of sensing equipment for environmental impact**
- **Logistics specifically linked to Freeport**
- **Data analytics on UK Fleet**

Next steps

- **Expand along the SW Coast and other interested areas**
- **Potential link with European networks**
- **Research longer term impact on our Environment and Marine Life**

References

[1] https://www.gov.uk/government/news/uk-enshrines-new-target-in-law-to-slash-emissions-by-78-by-2035

[2]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/815664/clean-maritime-plan.pdf

[3] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx

[4] Dukes, J. S. (2003). "Burning Buried Sunshine: Human Consumption of Ancient Solar Energy." Climatic Change 61(1): 31-44.

[5] Hemez, C., et al. (2020). "Environmental and health impacts of electric service vessels in the recreational boating industry." Water Practice and Technology 15(3): 781-796.

[6] https://electrek.co/2021/11/30/electric-vehicle-battery-cost-falls-132-per-kwh-might-go-up/

[7] Marinaro, M., et al. (2020). "Bringing forward the development of battery cells for automotive applications: Perspective of R&D activities in China, Japan, the EU and the USA." Journal of Power Sources 459: 228073.

[8] Varzi, A., et al. (2020). "Current status and future perspectives of lithium metal batteries." Journal of Power Sources 480: 228803.

[9] Condon, N., et al. (2015). "Impacts of ethanol policy on corn prices: A review and meta-analysis of recent evidence." Food Policy 51(C): 63-73.

[10] https://www.statista.com/statistics/282774/global-product-demand-outlook-worldwide/

[11] https://www.statista.com/statistics/263933/production-of-vegetable-oils-worldwide-since-2000/