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Bridge Owners Forum

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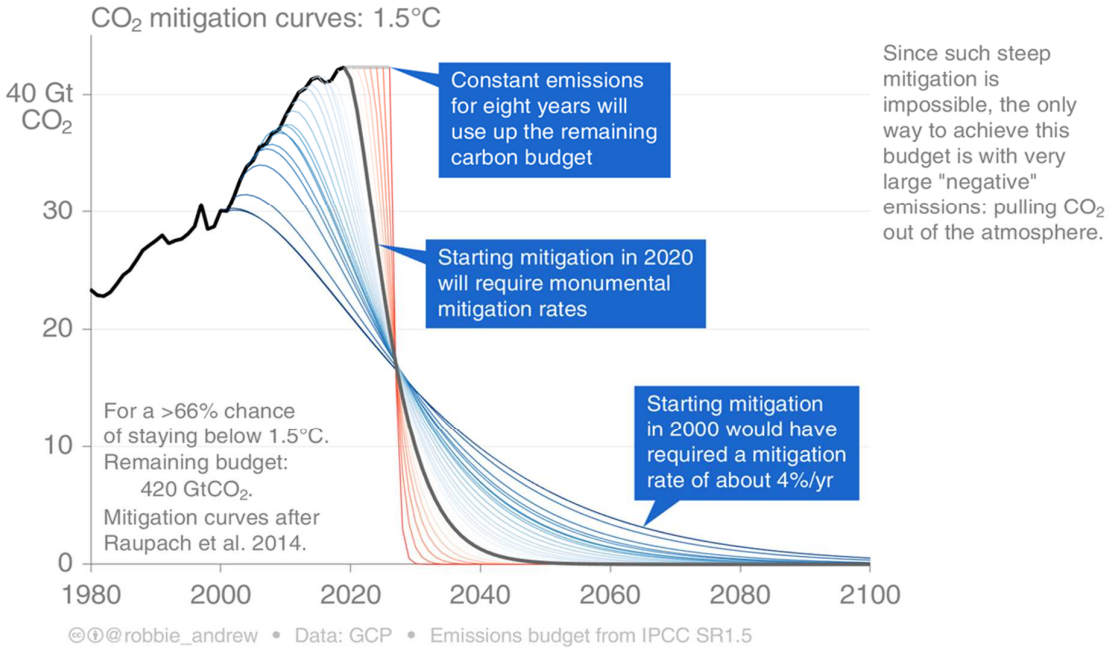
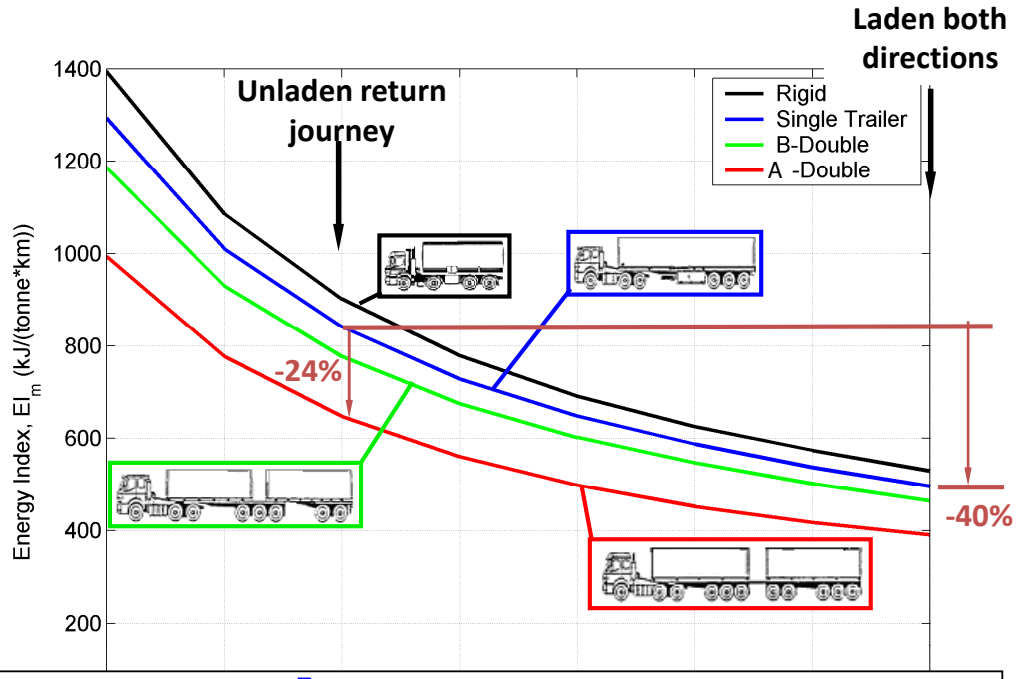
Background - Urgency

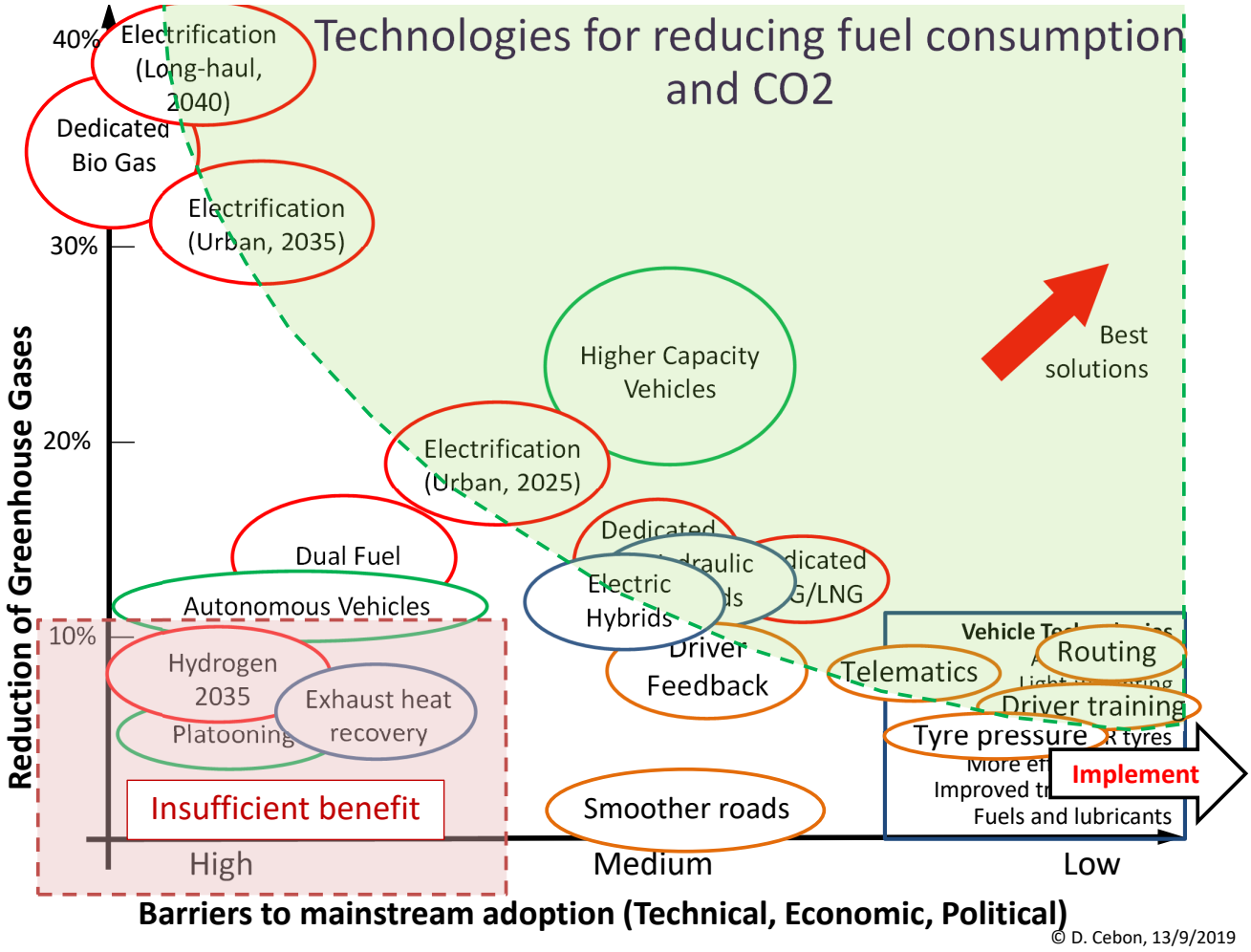


Andrew, R. Center for International Climate Research (CICERO), Norway

Technology and Logistics both matter



- **Laden return journey ➔ -40% energy for tractor-semitrailer**
- **Increase capacity of HGVs ➔ 15-25%**
- **Logistical and Engineering both matter!**



Key Issues for future energy systems

1. **Re-energising time**
2. **Vehicle Range**
3. **Costs**
   - **Infrastructure**
   - **Vehicles**
   - **Energy**
4. **CO_2 emissions**

Urban Delivery

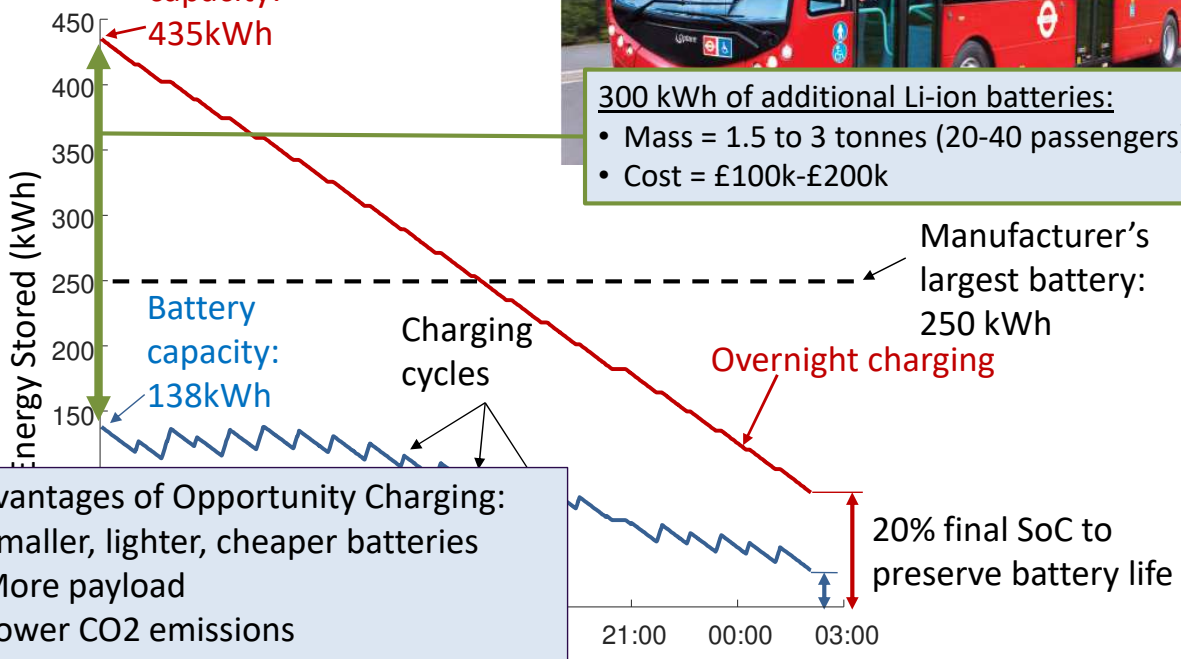
Urban Delivery

Rolling-out now!

All batteries < 85 kWh (Tesla 'S')

Bus Charging

300 kWh of additional Li-ion batteries:
- Mass = 1.5 to 3 tonnes (20-40 passengers)
- Cost = £100k-£200k



Advantages of Opportunity Charging:
- Smaller, lighter, cheaper batteries
- More payload
- Lower CO2 emissions
- Much lower overnight charging power

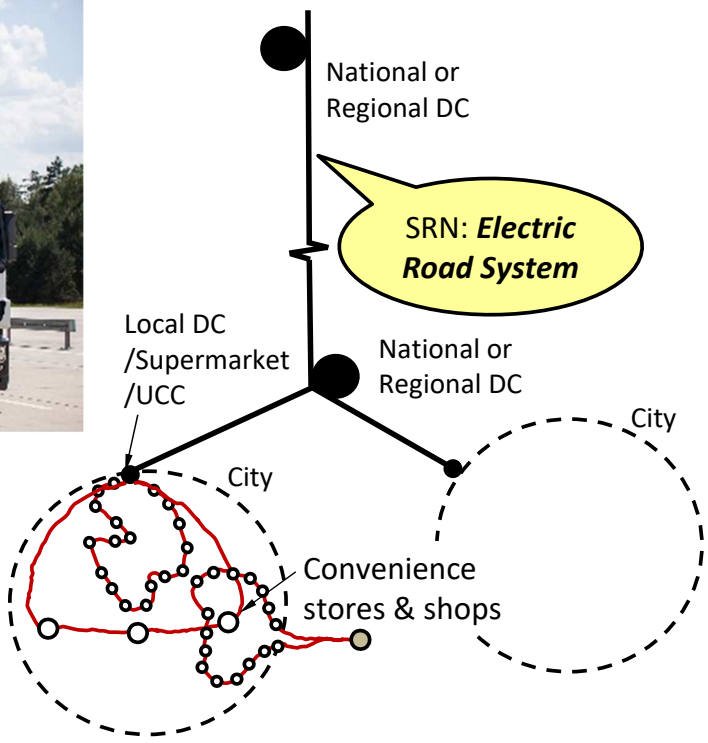
Previous Trials of Opportunity Charging

- Hamburg, Germany
- Innovation Line 109
- 4 X 300 kW conductive chargers

- Milton Keynes, UK
- Route 7
- 2 X 120 kW wireless chargers

Electrification of Long Haul

Electrification of SRN



ERS on Strategic Road Network

Key Features of SRN:

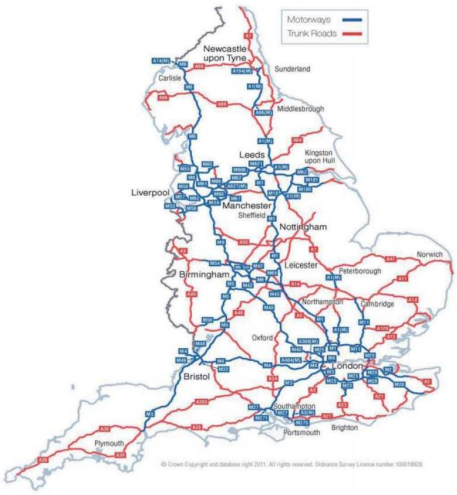
- 7000 km Motorways and key A-roads
- 2/3 Freight kms (rest mainly urban)

E-Highway Infrastructure:

- 5 separate motorway trials (Sweden, Germany, Italy)
- Cost £25b (DfT roads budget 5 yrs)
- Share substations with cars at services

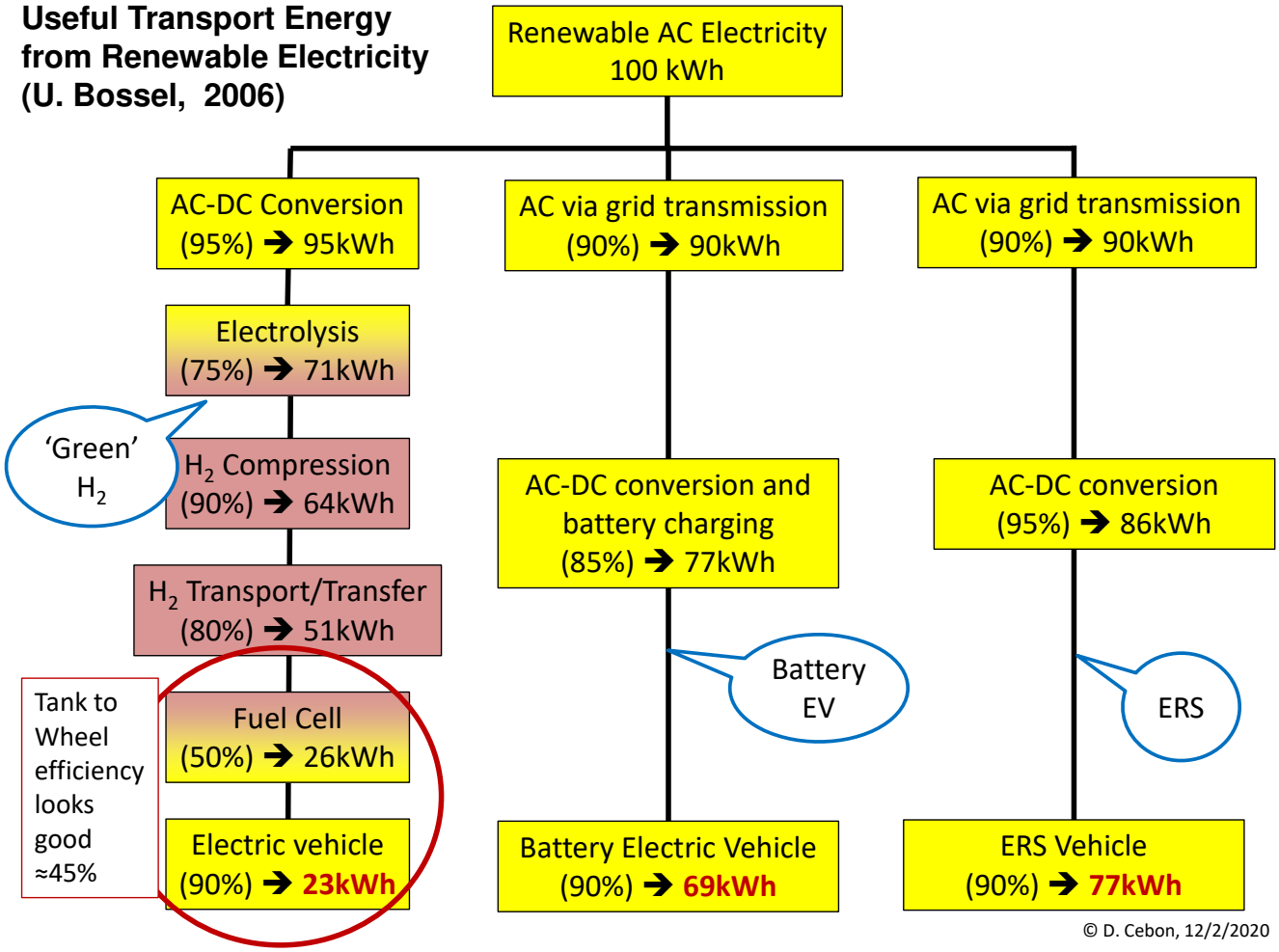
Vehicles:

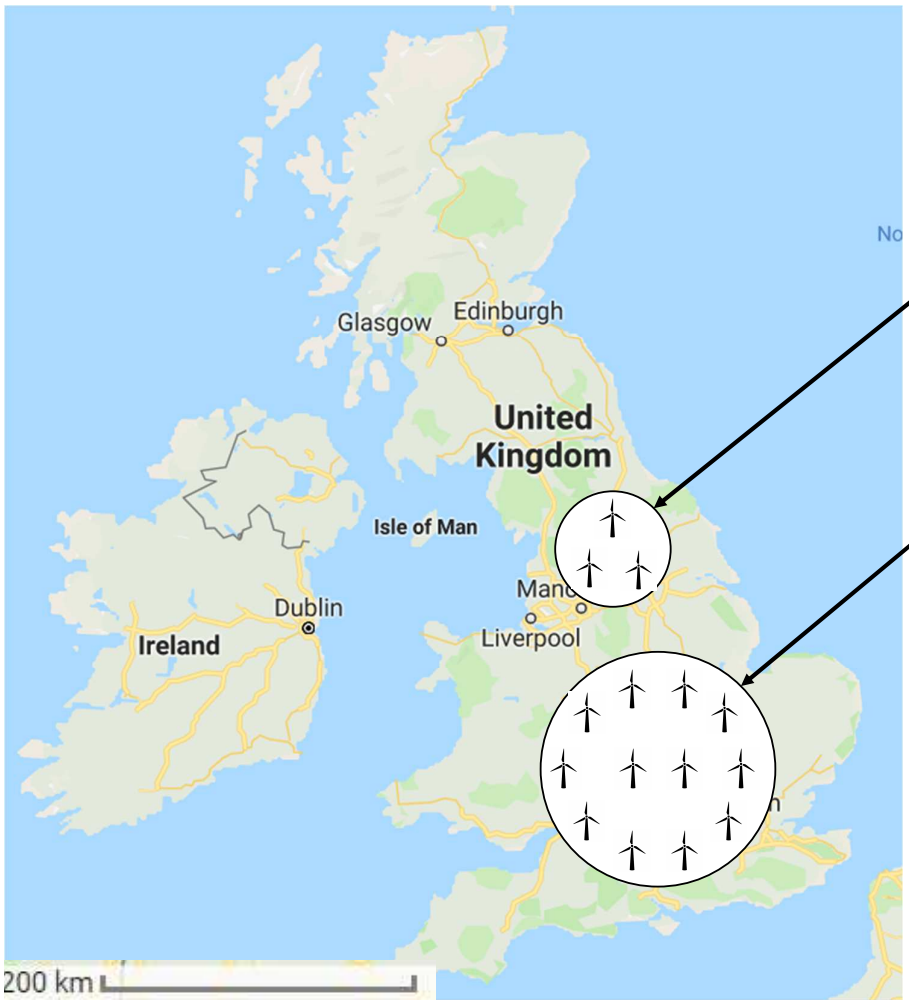
- Series hybrid (transition, resilience)
- Batteries < 85 kWh (Tesla 'S')
- Vehicle payback < 2 years



'Green' Hydrogen by Electrolysis

Useful Transport Energy from Renewable Electricity (U. Bossel, 2006)





Land areas for electrification of UK Road Freight

ERS:

- 10.6 GW
- 3,500 wind turbines
- Land Area=5,300 km^2

'Green' Hydrogen:

- 35.6 GW
  (31 GW = UK average)
- 12,000 wind turbines
- Land Area=18,000 km^2

Assumptions:

1. UK freight: 189b t.km per year
2. 0.19 kWh/t.km (44t), LF=0.75
3. Efficiencies:
   - 0.77 ERS
   - 0.23 H_2
4. Turbine power: 3MW
5. Wind power density: 2 W/m^2

Scale-up?

World's largest Hydrogen Electrolysis in Shell's Rhineland Refinery

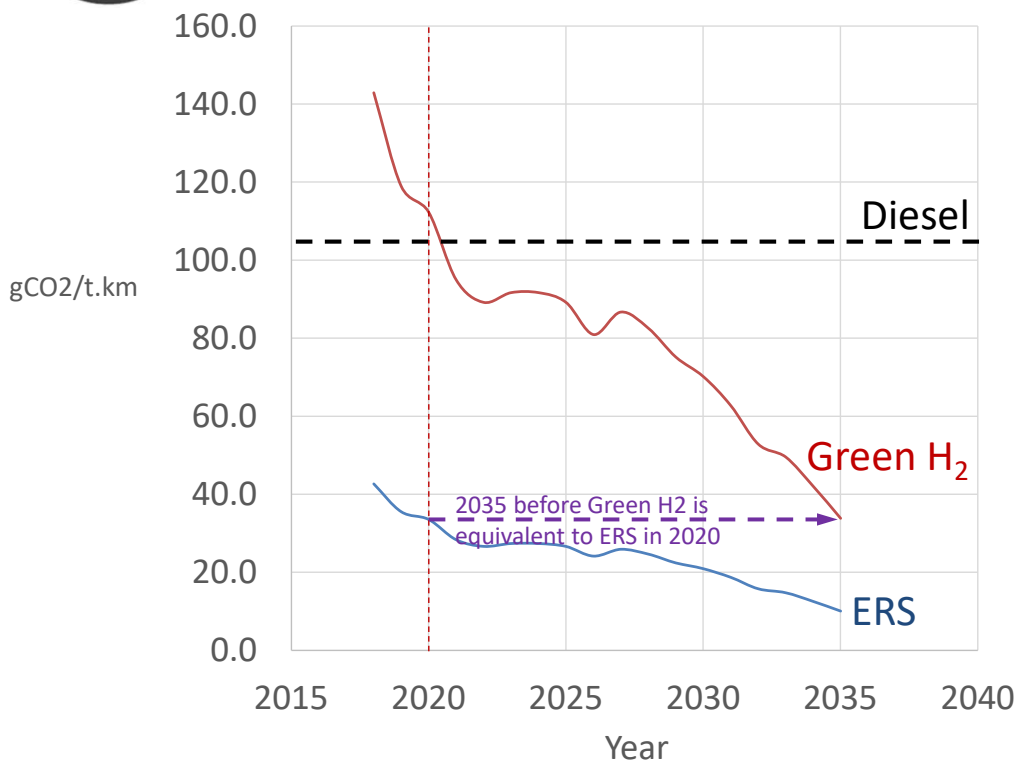
Friday, 18 January 2019 08:55

ITM Power (AIM: ITM), the energy storage and clean fuel company, is pleased to note the announcement by Shell that it is building, with ITM Power, a new hydrogen electrolysis plant, the largest of its kind in the world. The full text of Shell's announcement is set out below.

EUROPEAN CONSORTIUM WITH SHELL AND ITM POWER ANNOUNCE AGREEMENT TO BUILD ELECTROLYSIS AT RHINELAND REFINERY

Shell and ITM Power will build the world's largest hydrogen electrolysis plant at Rhineland refinery, Germany. With a peak capacity of 10 megawatts the hydrogen will be used for the processing and upgrading of products at the refinery's Wesseling site as well as testing the technology and exploring application in other sectors.

CO2 generated by 44t Lorries (BEIS data)



‘Blue’ Hydrogen by SMR+CCS

Hydrogen Economy

The Plan

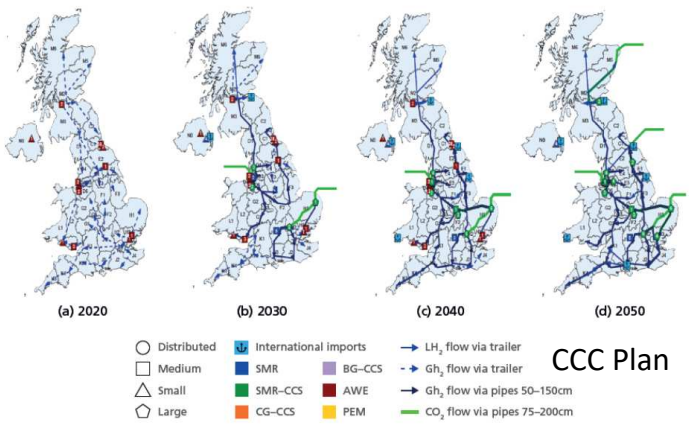
- Replace Natural Gas with Hydrogen in gas grid
- Use Hydrogen for heating and long haul freight

Vehicle

- Fast refuelling
- Good range
- Logistics models as now

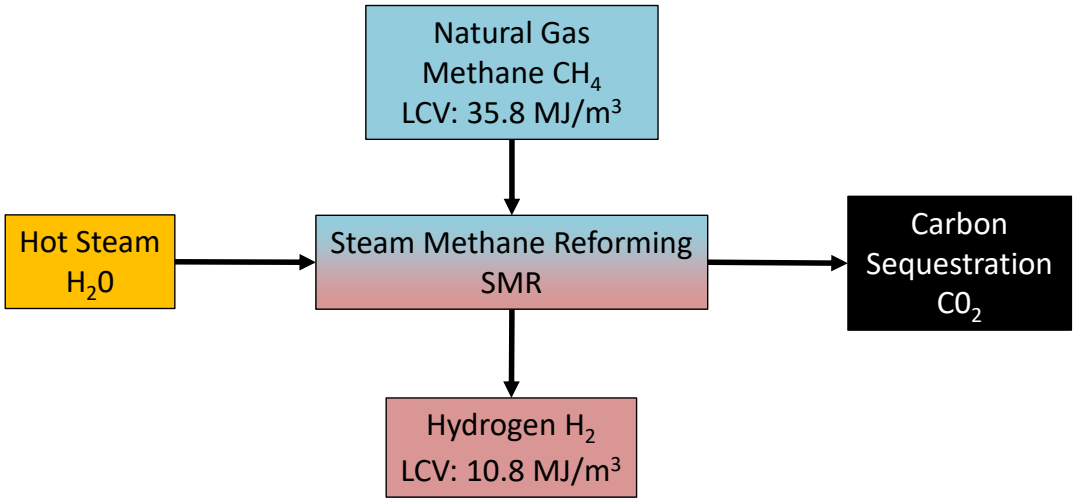
Fuel

- SMR and CCS at scale



CCC Plan

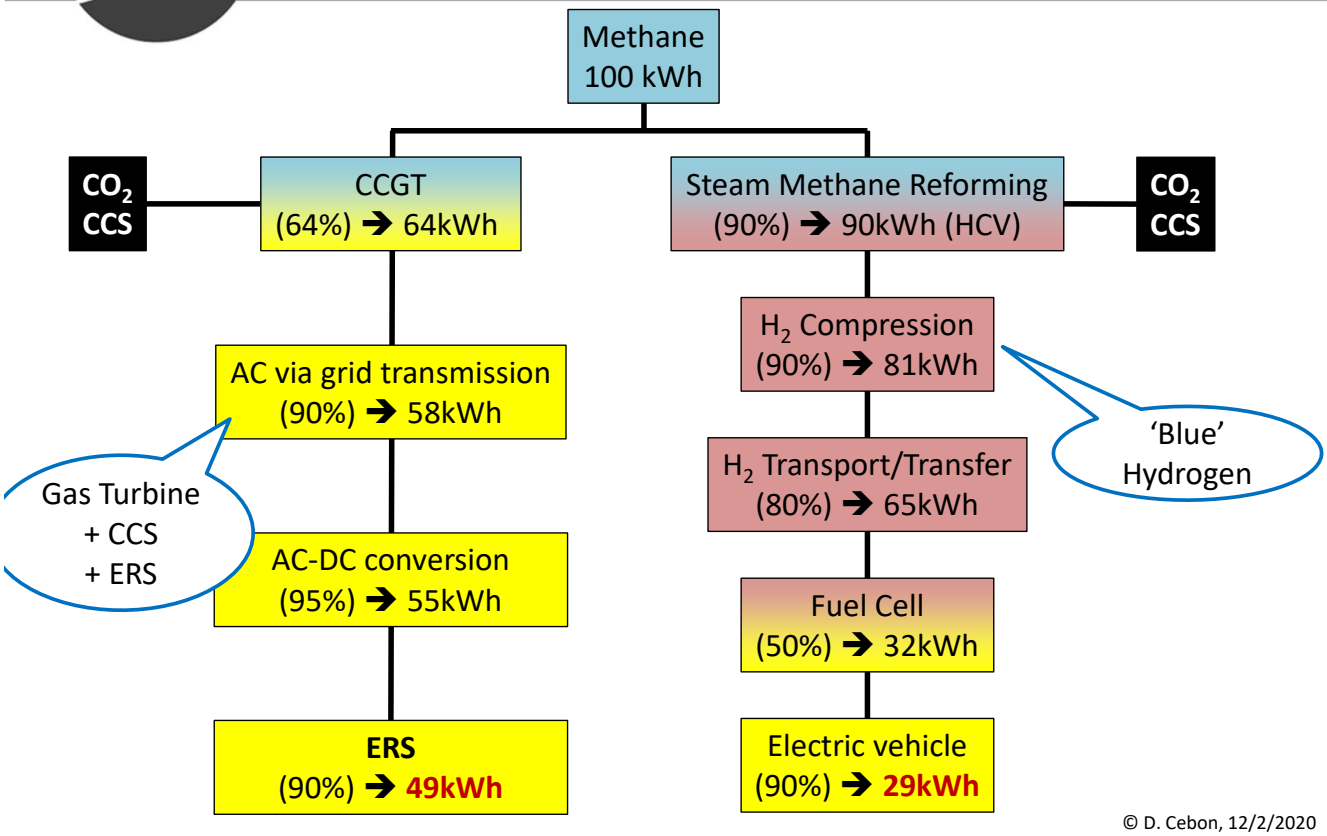
Steam Methane Reforming (SMR)



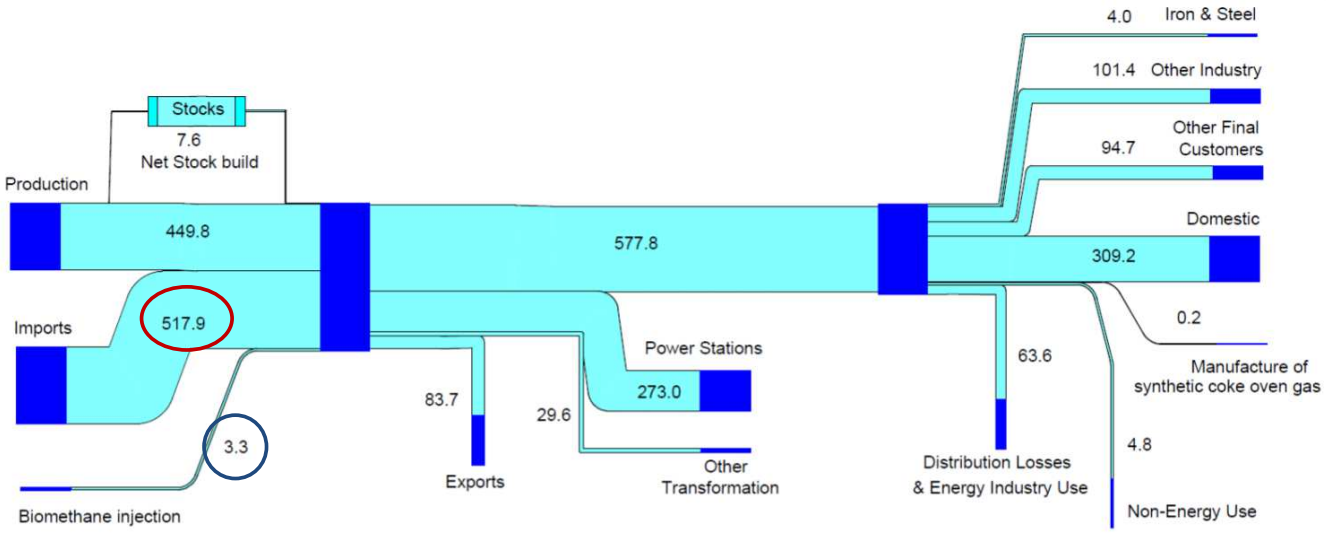
Implications lower volumetric energy:

1. 3.3 x larger volume of H_2 needs to flow than CH_4 for same energy
2. 3.3 x pipe area (at same pressure) = 1.8 x pipe dia ➔ replace gas grid

Useful Transport Energy from Methane

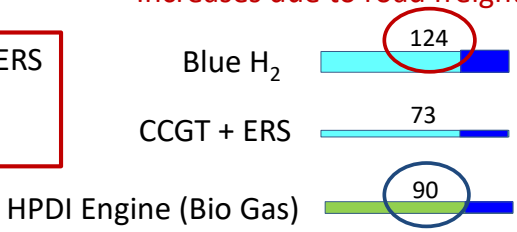


UK Natural Gas, 2018 (TWh)



- 70% more CH_4 needed for Blue H_2 than for CCGT+ERS
- Increase CH_4 imports by 24% (Blue H_2)
- x27 increase in Biomethane to fuel truck fleet

Increases due to road freight



Conclusions

1. Best of the low-hanging fruit is High Capacity Vehicles ➔ 20%
2. Electric urban delivery is coming ➔ Supply chains for EVs
3. Green Hydrogen (electrolysis):
   - Inefficient ➔ excessive renewable electricity
   - High economic costs
   - Alternative electricity storage systems are more efficient
   - Questionable timescale
4. Blue Hydrogen (SMR + CCS)
   - 3.3 times higher volume flow needed ➔Replace gas grid
   - 70% more gas than [Power station + ERS] ➔Energy security + Trade deficit
5. ERS (eHighway)
   - Lowest energy and CO2 emissions
   - £ less than DfT 2020-2025 budget for roads
   - Well tested, Implement immediately
6. National ERS + battery electric urban delivery:
   ➔Decarbonise most UK road freight operations by 2035-2040