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Transport decarbonisation in the UK: an agent-based modelling study

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Introduction

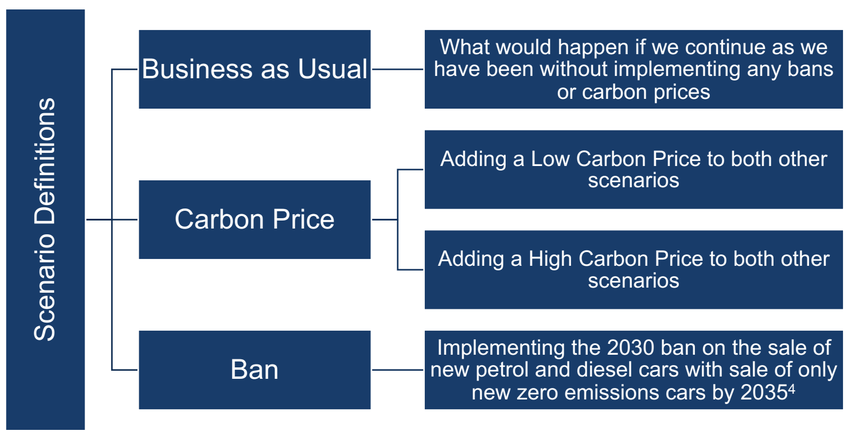
- Climate change is an important phenomena of which effects include rising sea levels and extreme weather[1]
- Global warming crisis is caused by unprecented levels of CO_2 emitted into the atmosphere[1]
- Transport is the largest emitting sector in the UK of which cars is the main contributor[2]
- Net Zero Carbon Emissions by 2050 in the UK[3]

Research Purpose

- Inform policy makers, research companies and consumers on possible future projections
- Use an agent based model to fill in a gap in literature investigating future projections of decarbonisation for car transport in the UK

Car Technology	Commodity
Battery	Electricity
CNG	Gas
Diesel	
Ethanol 85% blend	Ethanol and Petrol
Hybrid diesel	Electricity and Diesel
Hybrid hydrogen fuel cell	Hydrogen
Hybrid liquid hydrogen	Hydrogen
Hydrogen fuel cell	Hydrogen
Plug-in hybrid hydrogen fuel cell	Electricity and Hydrogen
Hybrid petrol	Electricity and Petrol
LPG	
Petrol	
Plug-in hybrid diesel	Electricity and Diesel
Plug-in hybrid petrol	Electricity and Petrol
Ethanol	

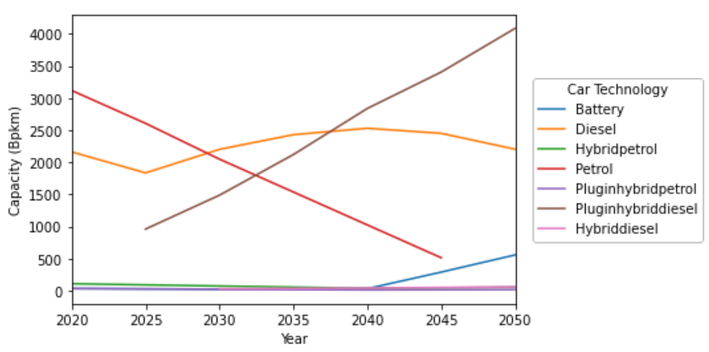
Methodology



Modular energy system simulation environment (MUSE):

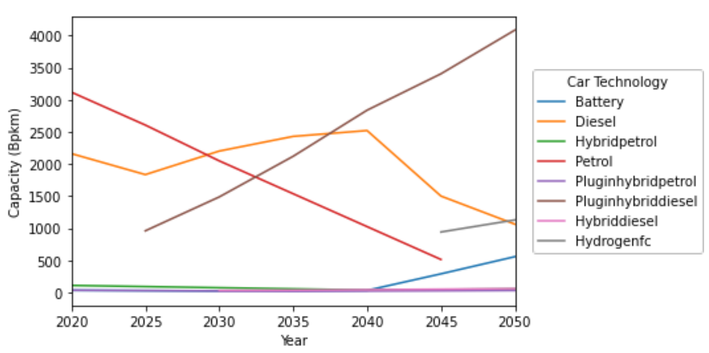
- Agent-based model allows for representation for consumer and investor behaviours and opinions[5]
- Differs from other models through the use of limited foresight leading to a more realistic representation. This is because decision makers do not have all information[6]
- Open source model and simulation environment for assessing energy systems changes over time[7]
- Run from 2010 to 2050 with results produced for each 5-year period between this range
- Model is based on data from the International European Agency (IEA) and Department for Business, Energy and Industrial Strategy (BEIS)
- Input of trajectories for existing capacity, demand and technodata including capital and fixed costs for each year and car technology
- One agent is specified with an objective of minimising cost which takes into account capital costs, fixed costs, commodity costs and if applicable carbon price.

Results and Discussion



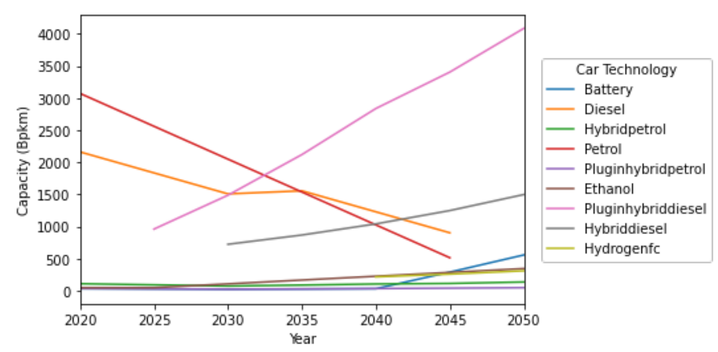
Business As Usual

- Capacity is allocated to a technology based on the agents objective of reducing costs to meet the service demand for that year. What drives this trend is that the capital cost of diesel cars is lower than petrol for all years and battery costs decrease over time with plug-in diesel cars also reducing in capital cost.



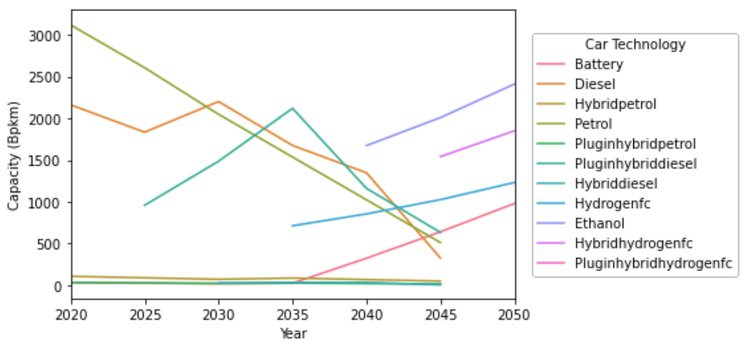
Low Carbon Price

- Using low carbon prices means a greater reduction of diesel cars and the introduction of hydrogen based cars. The carbon price will increase costs for a technology that releases emissions such as diesel cars and will mean they are less favoured.



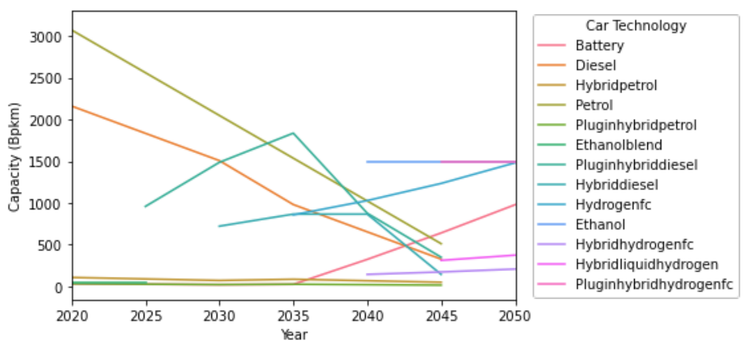
High Carbon Price

- Using high carbon prices means an even greater reduction of diesel to 0 in 2050 and hybrid diesel increasing in 2030 meaning carbon emissions are still present. Ethanol cars are also present by 2050. This carbon price trajectory allows zero emission cars to be used but is not enough to replace all cars using diesel as the costs for diesel are still low.



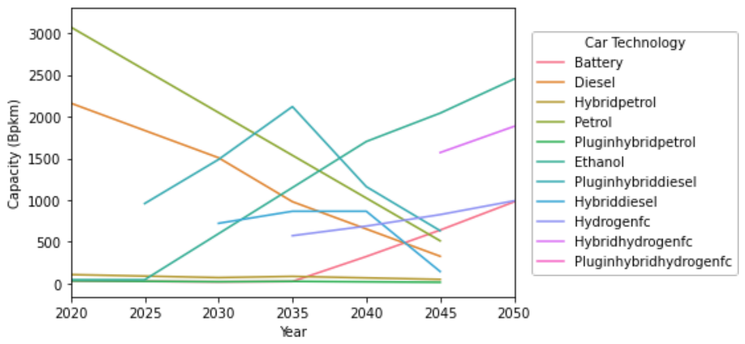
Ban

- Reducing the growth of petrol and diesel cars in 2030 and then reducing growth of non-zero emission cars in 2035 simulates the ban in the UK. Presence of zero emission cars increases after the ban is in place meaning that the use of fossil fuels is reduced drastically by 2050 and carbon emissions reach zero.



Ban with Low Carbon Price

- Low carbon price addition drives the results to a steeper decline in diesel cars. The share of technologies in 2050 change with all zero emission technologies being present in that year.



Ban with High Carbon Price

- The carbon price drives the results to use ethanol even earlier with this combination overcoming the relatively higher capital cost of ethanol cars in the earlier years.

Conclusion

- Carbon pricing allows for a greater zero emission car technology share in 2050 but using that without the ban will not achieve zero carbon emissions from the tail-pipe although it will reduce emissions.
- Applying a real world ban shows a greater uptake of alternative technologies to fossil fuel based cars leading to zero tail pipe emissions by 2050 under all scenarios with carbon pricing. Carbon pricing can effect the share of zero emission technologies, how many types of technologies are present and can allow them to be used earlier on.
- Using an agent based model allows for a consumer driven approach for future research especially if more agents are simulated to reflect different consumer mind sets such as, early adopters.

References

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