Zero Carbon Shropshire

Transport Working Group Reports January 2021

1. A reduction in commuting and work related travel
2. A greater proportion of local journeys made by bike or on foot
3. More journeys made by public transport and fewer journeys made by car
4. Transport integration
5. Increase in the proportion of zero emission vehicles
6. Car Clubs and Car Share
7. Reduction of carbon footprint due to transport of freight and goods
8. Aviation and Shipping
9. Case studies – Meole; rural development
10. Embodied Carbon in Transport

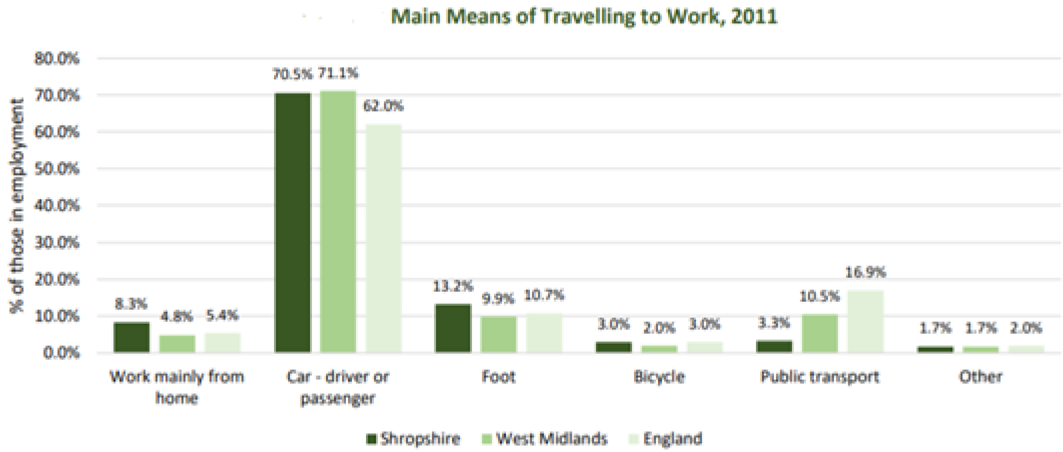
The pathways to 2030 transport calculations show that the private car use and mileages we will need to travel in 2030 will only require about 20% of the current number of cars for us to travel the miles we need to travel. This will require a major shift from private car ownership to car sharing and car club use.

1 A reduction in commuting and work related travel

Where are we now:

1.1 In 2018, commuting accounted for approximately 16% of all personal journeys, and for 20% of all personal miles travelled. As these journeys tend to be concentrated at the same time, they can put pressure on road and rail infrastructure.[1]

1.2 Shropshire's rurality also means that car dependency is high. Just 15.8% of households in Shropshire do not have a car compared with just over a quarter of households (25.8%) nationally.

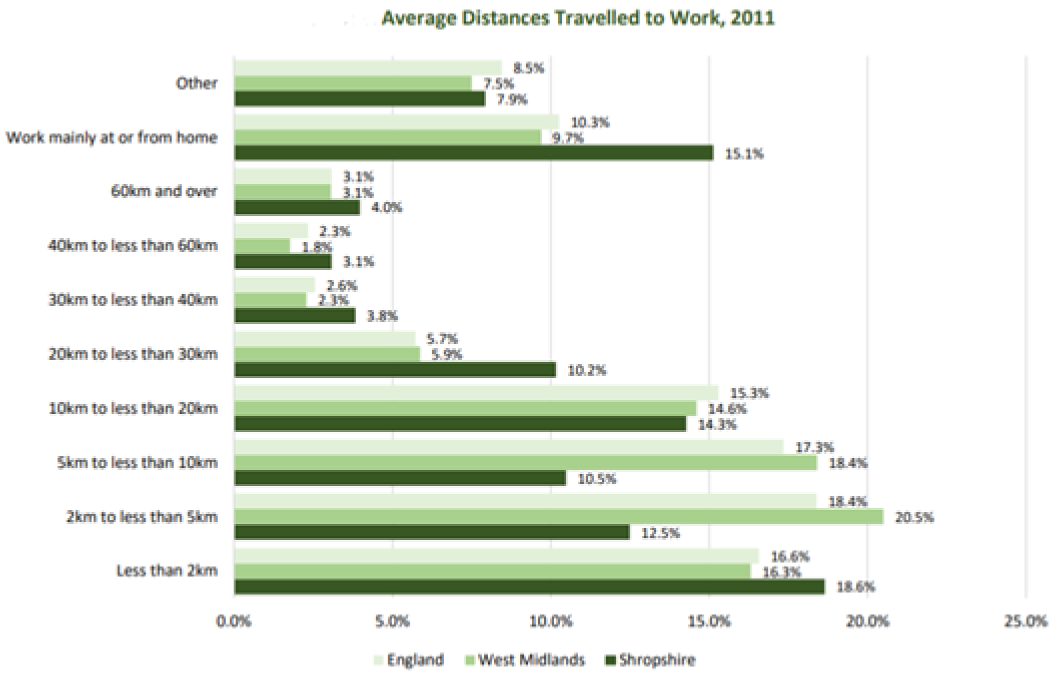


There is also a high reliance on cars as the principal means of travelling to work. In 2011, 70.5% of those working used a car (either as a driver or passenger) as their principal means of travelling to work compared with 62% nationally. Far fewer workers in Shropshire use public transport; just 3.3% in 2011 compared with 16.9% nationally[11].

1.3 Shropshire has close economic ties with neighbouring local authorities and levels of commuting have risen over the last two decades. Numbers travelling into Shropshire to work have risen by 45%. Numbers commuting out continues to surpass in-commuting, but the gap has narrowed[1]

1.4 Out-commuting plus the large and rural nature of Shropshire impacts how far residents travel to work. Higher numbers than average of Shropshire residents work mainly from

[1] https://shropshire.gov.uk/media/10209/commuting-patterns-and-travel-to-work.pdf

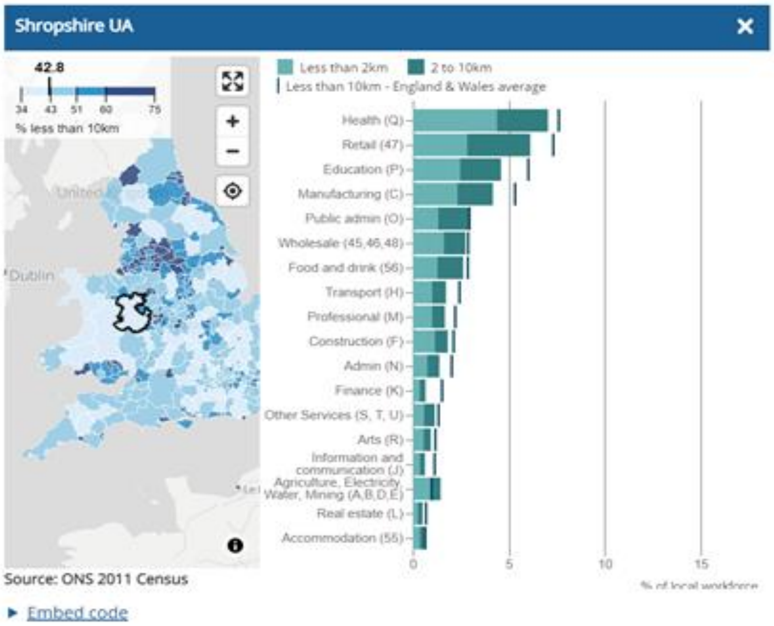


Source: ONS (2011), Census, Crown Copyright – 2018

home.
However proportionally higher numbers also travel considerable distances to get to their workplace. 21% of Shropshire workers travel 20km or more to get to work. The average commute for Shropshire residents was 18.7km in 2011.

1.5 However, Shropshire has a significant proportion of its population which both live and are employed in Shropshire (82,151 people). This means that 70.5% of Shropshire residents work within the county (origin containment). There is also a high level of job containment in Shropshire, with 73.8% of employee jobs in Shropshire filled by people who also live there (destination containment). Compared with much of England and Wales, this level of self-containment is high; Shropshire ranked 40th and 42nd out of 346 Unitary and District Authorities in terms of its level of destination and origin containment respectively in 2011[1].

1.6 Four industries are responsible for the largest amount of commuter journeys of less than 2km. These are health, retail, education, and manufacturing[2].



1.7 The coronavirus (COVID-19) pandemic has led to major changes in commuter travel patterns. Many workers stopped travelling to a workplace either because they were furloughed, began working from home or in some cases lost their jobs. The number of people travelling to a workplace therefore declined sharply[2].

<u>So, where now?</u>

1.8 Radical changes will be required to the amount and to the way we travel; changes are needed to our transport system. A network of safe cycling and walking routes must be established to encourage people to walk and cycle shorter commutes. This would have health as well as environmental benefits, and would decrease noise and air pollution in urban areas.

1.9 Better joined up public transport – bus, coach and rail – especially at peak commuting time and better serving the rural areas to enable people to move away from car use, reducing road congestion, energy use and GHG emissions.

1.10 Make better use of the remaining cars by increasing average occupancy. By arranging car sharing, either informally or via car share schemes and car club, the average occupancy of cars could improve from the current average of 1.2 people per vehicle to 2.0[3].

[2]https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/coronavirusandtraveltowork/june2020

2 A greater proportion of local journeys made by bike or on foot

2.1 In 2017 The Department for Transport published Local Cycling & Walking Infrastructure Plans[2] in which the following aims and target were set: for 2025:

a) to aim to double cycling, where cycling activity is measured as the estimated total number of cycle stages made each year, from 0.8 billion stages in 2013 to 1.6 billion stages in 2025, and to work towards developing the evidence base over the next year
b) to aim to increase walking activity, where walking activity is measured as the total number of walking stages per person per year, to 300 stages per person per year in 2025, and to work towards developing the evidence base over the next year
c) to increase the percentage of children aged 5 to 10 that usually walk to school from 49% in 2014 to 55% in 2025

2.2 To achieve these targets local authorities have been urged to draw up Local Cycling and Walking Infrastructure Plans (LCWIPs) as a new, strategic approach to identifying cycling and walking improvements required at the local level. They enable a long-term approach to developing local cycling and walking networks, ideally over a 10 year period, and form a vital part of the Government's strategy to increase the number of trips made on foot or by cycle.. Telford & Wrekin has adopted a Cycling in Walking Strategy in 2017[3]. Shropshire Council's is yet to be published but they plan to do this before finalising LTP 4.

2.3 Measures which can be used to promote cycling and walking fall mainly into two camps: 1) appealing to the hearts, minds and predispositions to maintain good health amongst members of the community; and 2) improving walking and cycling infrastructure. It is well recognised that one of the biggest deterrents to cycling is the road hazard, i.e. the absence of feeling safe when using routes shared with motor vehicles. Covid-19 lockdown periods showed that once motor traffic reduced, bicycle use multiplied rapidly[4]

2.4 If people can be persuaded that more active travel has personal benefits then behavioural change will follow. Research[5] shows that the complexities and contingencies that most people encounter in everyday life often make such behavioural change difficult. Perceptions of risk; constraints created by family and household responsibilities; and perceptions of normality are the main issues preventing modal shift. Unless such factors are tackled directly then policies to increase levels of walking and cycling will have limited success. There needs to be a more integrated approach to transport policy that combines interventions to make walking and (especially) cycling as risk-free as possible with restrictions on car use and attitudinal shifts in the ways in which motorists view other road users. Such policies also need to be linked to wider social and economic change which, in combination, creates an environment in which walking or cycling for short trips in urban areas is perceived as the logical and normal means of travel and

---

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/908535/cycling-walking-infrastructure-technical-guidance-document.pdf
[3] https://www.telford.gov.uk/downloads/file/7995/cycling_and_walking_strategy
[4] https://www.bbc.co.uk/reel/video/p090h6zl/why-2020-was-the-bicycle-s-best-year-in-decades
[5] https://www.researchgate.net/publication/257427290_Policies_for_promoting_walking_and_cycling_in_England_A_view_from_the_street/link/56f131cf08aec63f4c9b4c6c/download

using the car is viewed as exceptional.

2.5 Local authority planning should promote a combination of the following infrastructure options:

a) Redistribution of street space in built up area: pedestrianised streets and widened pavements. To make walking an attractive option, footpaths need to be in good condition and well lit, and traffic speeds and car parking kept low. [6]Advice on strategies to promote walking and cycling can be found in The Conversation[7]
b) Segregated and wider cycle lanes. These are proven to be far more effective at encouraging cycling and improving safety (and perceived safety) than cycle lanes painted on the street. . The latest infrastructure design standard, LTN1/20[8], sets out a clear requirement for segregated cycle lanes. This has been adopted by SC for all new highways schemes.[9]
c) Bike hire infrastructure. This includes bikes, docking stations and vehicles to transport them.
d) Secure bike parking.
e) Traffic lights that prioritise pedestrians and cyclists. This allows pedestrians shorter waiting time to cross the road
f) Junctions redesigned to maximise safety for pedestrians rather than traffic speed.
g) Employers can play a part by providing showering and changing facilities, offering occasional cyclist breakfasts and promoting the employee benefit Cyclescheme [10]

[6] https://www.c40knowledgehub.org/s/article/Pedestrians-First-Tools-for-a-walkable-city?language=en_US
[7] https://theconversation.com/encouraging-walking-and-cycling-isnt-hard-here-are-three-tried-and-tested-methods-147490
[8] https://www.gov.uk/government/publications/cycle-infrastructure-design-ltn-120
[9] https://www.gov.uk/government/publications/cycle-infrastructure-design-ltn-120
[10] https://www.cyclescheme.co.uk/

3 More journeys made by public transport – in towns, between towns, and in rural Shropshire – and fewer journeys made by car

Current situation

3.1. Bus services in Shropshire are provided by one national and several local operators. Though many routes require public subsidy and have their timetable and fare structure determined by Shropshire Council (or neighbouring authority) there is no Shropshire network of integrated or connecting services with common ticketing within the bus mode, or between bus/rail.

3.2. The level of public subsidy has reduced over the past decade and some bus routes have ceased completely, or have had their early and late departures, and Sunday departures, terminated. In Shropshire trips by bus reduced by 30.6% in the ten years to 2019/20 from 6.2m to 4.3m journeys1.

3.3. Train schedules are currently designated under public franchise subsidy though the Welsh Government has announced its intention of taking the Wales and Borders franchise into public ownership2. Services have seen considerable growth in usage over the past twenty years; both the Wales and Borders and West Midlands franchises are in the process of increasing service frequency with the Wales and Borders franchise expected to add some additional destinations beyond Shropshire.

3.4. The Local Transport Plan has presented a limited vision for public transport and many of the ideas presented in that document have not been implemented.

Shared Vision for 2030

3.5. A Shropshire integrated transport system that is

a. Comprehensive (the best possible service for all areas)
b. Affordable (low-cost, and free for some additional groups such as young adults)
c. Attractive (high quality door to door experience)
d. Green (consistent with our obligation to cut carbon emissions to zero in line with the Paris Agreement and to minimise other environmental impacts) [3]
e. Connecting every settlement of more than 500 population to an hourly frequency of service, 15 hours a day, seven days a week; densely populated towns to have a service 18 hours a day at a half hourly frequency. A single timetable is issued by Shropshire Council in partnership with bus operators and rail authorities, with joint ticketing.
f. Ensuring planning approval for new housing and industrial developments only where they meet minimum criteria for housing density, for ease of access by buses, and for shortness of walking distances to bus stops.

g. Avoids additional interchanges such as from a rural bus to a shuttle bus at the outskirts of a sizeable town

The outcomes for such a scheme implementation should be:

Number of journeys undertaken by bus to triple the 2010 figure (18.6m trips)
Journey trips by car diminish by 20% (this will depend also on increases in cycling and walking, car sharing, and fewer journeys being undertaken)

Conclusions Reached So Far

.

3.6. Transport emissions can reduce through improved technology (for example electric propulsion); and/or if people change from low occupancy private cars to well loaded public transport A diesel powered bus with twice as many passengers as heretofore will halve its per person emissions; if the additional passengers previously used cars there is a real reduction in carbon emissions for each trip undertaken.

3.7. A diesel powered bus with twice as many passengers as heretofore will half its per person emissions; if the additional passengers previously used cars there is a real reduction in carbon emissions for each trip undertaken.

3.8. There are examples where investment in public transport has brought about increased usage (such as Cornwall, Devon and Nottinghamshire). To bring about a modal shift from car to bus and rail there needs to be continued appeal to the current user base, alongside strategies to attract new users particularly car drivers. 43% of drivers say they would drive less if there was better public transport4.

3.9. The key variables which will define that choice are (compared to driving):

a. journey time and reliability,
b. relative cost,
c. quality of the door to door experience[5].
d. Frequency
e. Availability throughout the day

Helpful Strategies So Far Identified Towards Achieving ZCS Vision [with action agencies]

1. Bus priority corridors in towns with measures to eliminate delay [Shropshire Council, town councils, bus operators]
2. Integrated timetabling to ensure speedy and easy connections between bus services and between bus/rail [Shropshire Council, bus partnership schemes, Transport for Wales and West Midlands franchise, bus operators]
3. Integrated ticketing within the bus network and between bus/rail [Shropshire Council, bus operators, Transport for Wales and West Midlands franchise]
4. Express bus routes on services which can attract large numbers of passengers [Shropshire Council, town councils, bus operators]

5. Service timetables to cover 0700 to 2200, seven days a week, for every settlement of 500 or more inhabitants [Shropshire Council, town and parish councils, bus operators]
6. Service timetables to cover 0600 to midnight, seven days a week, for densely populated towns [Shropshire Council, town councils, bus operators]
7. Carbon and pollution levy to be raised on car use in Shropshire to subsidise public transport, with the aim of extending free travel beyond the current age and ability limits [Shropshire Council]
8. Car parking charges to be increased as part of the carbon and pollution levy [Shropshire Council, town councils]
9. Easy access to bus stops which have clean illuminated shelters and live bus information; bicycle undercover parking adjacent [Shropshire Council, town and parish councils]
10. Introduction of bus services to new developments to be in operation before developments are first occupied [Shropshire Council, developers]
11. Modern equipment with increasing use of electric powered vehicles [Shropshire Council, Marches LEP, bus operators]

Recommendations for Action

1) Formation of a bus partnership with stipulated levels of service [Shropshire Council].

2)A new Local Transport Plan that focuses on actions to reduce carbon emissions by measurable amounts.

References

[1] Passenger journeys on local bus services by local authority: England (DfT statistics)

[2] https://gov.wales/welsh-government-take-rail-franchise-under-public-control

[3] ttps://www.transportforqualityoflife.com/u/files/200619_A%20Wales%20Transport%20Policy%20fit%20for%20the%20Climate%20Emergency_v5_FINAL-FINAL-FINAL.pdf A Wales Transport Policy fit for the Climate Emergency (Transport For Quality of Life)

[4] https://www.theguardian.com/uk-news/2020/nov/09/covid-set-back-attitudes-to-public-transport-by-two-decades-says-rac

[5] Decarbonising transport: the role of buses (Local Government Association)

4. **Transport integration: Easier connection between different modes of sustainable travel – walk and ride, cycle and ride, park and ride, bus and train**

4.1. Appropriate on-line information such as traveline (https://www.traveline.info/) upgraded to provide real time information can boost the use of public transport, but interchanges must be convenient especially for passengers with luggage. [This is a matter of concern in Shrewsbury where the Big Town Plan is considering pedestrianising the station approaches and abolishing the Bus Station].

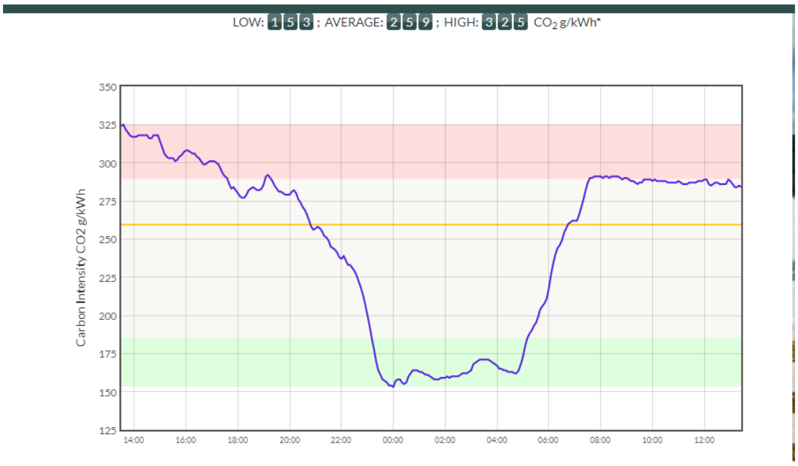
4.2. 5.6 million passengers arrived or departed from the 19 Shropshire and Telford & Wrekin railway stations in 2018/19 (most recent ORR data) up from 4.3 million 10 years ago; an increase of 30% in 10 years. Covid has been a setback but the recent increase of 3 trains/hour from Shrewsbury to Birmingham has increased passenger numbers on this route. Rapidity and quietness from electrification would increase numbers further. Currently there is no cycle hire provision at or near any Shropshire or Telford & Wrekin railway station .

5. **Increase in the proportion of zero emission vehicles including widespread adoption of electric vehicles, plug-in hybrids and green hydrogen**

5.1. At present the only zero emission vehicles with any significant market penetration are plug in electric vehicles, either of a hybrid nature, allied to an internal combustion engine in order to extend the range of a small capacity battery, or pure battery electric vehicles. The market is influenced by significant taxation advantages, which vary from time to time. In order to respond to government policies to prohibit the sale of ICE powered vehicles by 2030, the offer to the market has expanded significantly, with every major manufacturer having a portfolio of BEVs[1]. The range covers all types of motor vehicle in the passenger carrying range, with a range of vans and pick ups coming onto the market.

5.2. The plug in hybrid vehicle allows BEV use for short trips, up to 30 miles. It is therefore suited to low emission commuting, particularly when allied to workplace charging. Longer journeys may be by ICE mode. There are advantages in acceptance by sections of users concerned at limitations of full BEV use. However, Government incentives for business users are only available where the PHEV has an electric range over 130 miles[2]

5.3. The use of BEVs in the commercial and bus fleet is limited by the scaling up of battery capacity needed, but there are BEV buses entering the fleets with Government assistance[3]. Similarly, there is little market penetration by hydrogen powered vehicles, but again there are demonstration projects funded by Government.



Carbon intensity of grid electricity snapshot 10/12/20 24 hour period [6]

5.4. Vehicles of all sorts are customarily charged at home or depot. Tariffs tailored to EV charging are available[4], encouraging the use of electricity in the times of minimum demand. Continuously variable tariffs are also available which at times of power oversupply (eg at times of strong overnight wind) may turn negative, paying the user to take power.[5]

5.5. Overnight charging also coincides with the periods when the emissions from power generation are least, and the contribution from renewables greatest. It is also common for EV owners to contract for electricity with suppliers who themselves contract with renewable generators, such that their contract is for zero emission power[7] - apart from the embedded carbon in the provision of wind turbines or solar panels.

5.6. The technology, and in particular battery size and management is young, and shows rapid development. At the present time common battery sizes are of the order of 55-70kWhr capacity, giving ranges of up to 250 miles. Given that the average length of a car trip is about 8.4 miles, and that the average business driver covers 555 miles in a year; and that the average car use per person is about 5000[8]; and that the average car travels about 7000 miles per annum, it can be seen that most trips will be well within the battery range.

5.7. There have been price disadvantages for BEV compared to ICE vehicles, but as production rises these are narrowing, particularly with the continuing Government assistance to purchase (presently £3000). Further incentives are in zero vehicle excise tax. Fuel costs at the most favourable tariffs are in the order of 1-2p per mile, compared with 13-15p for an ICE vehicle. Servicing costs are very low. There are significant tax advantages to business users provided with an EV[9]. However, the widespread use of BEVs will inevitably deprive the Government of the massive income from fuel duty, presently representing £28bn pa[10]. Some means of balancing the loss will certainly be adopted, in all probability road pricing, for which the technology exists. The cost of running a vehicle will then rise to a fiscally acceptable level.

5.8. There are very significant potential benefits in adapting EV technology to public transport. Self guiding technology enables the major personnel cost to be greatly reduced. Transport units can then become smaller “pod” size, but run far more frequently, thus removing a major disadvantage of present public transport systems. This approach is ideally suited to small towns such as exist in Shropshire – Oswestry, Ludlow, Market Drayton and parts of Shrewsbury[11]. A case study from Oswestry will be found in Section 9 of this document.

5.9. Air Pollution from the use of the vehicle is virtually eliminated. There are no emissions at all from the motive power unit, whereas the emissions from ICE vehicles are responsible for between 28,000 and 36,000 death per annum in the UK – pro rata this may be between 210 and 270 in Shropshire[12]. There are much reduced particulate emissions from brake dust, because the main braking is by regenerative use of the electric motor. Tyre wear, which is a major source of micro plastic pollution from all vehicles, remains. There is no engine or transmission noise.

5.10. To cater for longer trips there is a network of public charge points, which range in power, with medium power being available at locations which might involve a long stay, allowing charging at 6-7kW. For those needing a rapid charge there is a network of “rapid” chargers giving a charge rates which are generally up to 50kW, which has matched the capability of vehicles. However, vehicles are coming onto the market which will accept charge at higher rates, and there are public charge points which match that capability, at present up to 150kW charge rate. The situation is rapidly evolving, but unlike some other countries,(including Scotland) there is little Government direction in England to ensure widespread cover. Unfamiliar journeys will require planning to ensure that adequate charge will be available, and there are on line and in vehicle tools to assist[13].There are inadequacies in the system, but these are being ironed out.

5.11. Home charging is straightforward for those with off street parking, and opens up possibilities for grid smoothing (Vehicle to Grid -V2G) described elsewhere, and V2H (Vehicle to House) giving reserve supply at home allied if appropriate to Solar PV[14]. For those without off street parking, there are now a number of projects which have provided on street charging facilities[15], or rapid charging hubs[16]. Whilst there is scepticism bred from the lack of such facilities on a widespread basis, the technology and economics are proven.

5.12. There are at present some 29 Rapid Charge points in Shropshire/T&W. 10 of these are at the M54 Telford Services; 8 of those are dedicated to Tesla users. There are 5 rapid charge points at Oswestry – a rate of 1 per 3000 population. In general the provision is not outstripped by demand, since increasing battery size has reduced levels of demand from a growing fleet[11]. Charge points are generally provided by private sector companies, occasionally in concert with Local Government. Shropshire Council's "Agile Streets "programme will demonstrate the charging possibilities for those without their own facilities.

5.13. Planning policies allow the Local Planning Authorities to require charging infrastructure to be installed in new development, both commercial and residential.[17]

5.14. As in any vehicle, manufacture involves significant carbon emissions – the embedded carbon. Manufacturers sense this, and a number of makers claim zero carbon manufacturing. However, battery production is inevitably carbon intensive, such that most BEVs start life with a carbon deficit compared to an ICE vehicle. This deficit is recouped by the greatly reduced emissions from producing energy to move the vehicle, such that early in its life a BEV will be less carbon intensive. [18] The embedded carbon is made further use of by the widespread opportunities for after use of batteries. Typically, a car battery is likely to be changed when its capacity is depleted to 75%. However the battery still has a long useful life after that, often in situations which maximise the use of renewable electricity. Battery life has proven to be unproblematic, with manufacturers giving warranties typically up to 100,000 miles and 8 years, with few replacements under warranty.

[11] https://cleantechnica.com/2021/01/23/in-uk-79-of-drivers-could-charge-just-once-every-week-or-two/

5.15. The materials used in batteries come with issues concerning extraction. Lithium, whilst a relatively common metal, is often mined with highly undesirable environmental side effects[19], although UK resources amounting to the fifth largest reserve in the world without adverse environmental impact are available [20]. 70% of the worked reserves are in Australia, where developed country environmental controls apply. Up to now, there has been a significant use of cobalt. Whilst much of the supply is as a co-product of copper production, about half the world reserve is in the DRC, where working conditions have been unacceptable, involving child labour and small scale manual labour[21]. Major users have however been subject to legal action forcing some responsibility on them.[22] The likelihood that battery requirements would outstrip the world reserves has led to investigation of alternative battery technology, replacing cobalt with nickel, sulphur and other more common materials[23].Cobalt free batteries are now marketed, and likely to be produced in a German gigafactory as well as the manufacturers' China home base.[12]

5.16. The resource needs of battery production leads to consideration of fuel cell technologies, which lags behind battery technology in its adoption, particularly in the large scale production of "green" hydrogen[24]. There are also large scale projects to develop methanol, which may be used "clean" in internal combustion engine situations[25].

5.17. Green hydrogen has great promise for fuel cell electric vehicles (FCEVs): long-range light vehicles, HGVs, buses, and trains. It should complementary, rather than competitive, to battery electric vehicles (BEVs) which are well-suited to short-range light vehicles.

5.18. To be "green", hydrogen needs to be produced by electrolysis from dedicated renewable electricity. There are two infrastructure barriers to its development in Shropshire; first, the lack of capacity in the electricity grid; second, the lack of a hydrogen network. Producing hydrogen from off-grid renewables overcomes both of these barriers, and it would allow the technology to be developed from small-scale upwards rather than being dependent on industrial-scale development. It is therefore fitting for Shropshire's entrepreneurial spirit and may present an opportunity for a home-grown business.

Case study

5.19. A concept design prepared by Lutra shows that it is possible for a mix of solar PV (500kWp) and wind turbines (500kWp), together with low-pressure hydrogen storage, high-pressure hydrogen storage and filling station, to provide sufficient hydrogen for 3million miles per year for light vehicles. This project would require a maximum land area of one hectare and would be designed to provide a regular

[12] https://insideevs.com/news/483181/svolt-cobalt-free-nmx-cell-available-order/

supply of fuel, with the variability of the electricity production being smoothed by on-site storage. Importantly, there would be no connection to the electricity grid and equipment would operate on DC electricity.

5.20. According to the Shropshire figures, in 2018 cars covered about 1500 million miles. If this range is reduced by 50% by 2030 to 750million miles per year, and if 10% of this distance (75million miles per year) are covered by FCEVs, then we would need about 25 of the one-hectare projects. With regard to timescale, it should be based it on the first such stations being ready in 2025 with linear expansion thereafter.

5.21. However, there is uncertainty about the timescale for the availability of FCEV cars, which is a bigger barrier than the production of hydrogen. Compared to some other countries, hydrogen supply points have not yet become a feature of the UK[26].

Opportunities

a. As stated above, local green hydrogen production,
b. The intervention of Local Government to ensure adequate coverage of charge points for residents without off street facilities
c. The intervention of Local Government in the filling of the Rapid Charge network, to the initial rate of 1 per 3000 population.
d. Arising from the low average use of all personal transport, the encouragement of car clubs – see section 5.
e. Taxi licenses should be restricted to low emission vehicles
f. Local authority Health services etc vehicle use should be turned to EV.
g. Business of all sorts should turn their fleets and personal use to EV. Where significant travel is undertaken, alternative means of communication should be assessed.
h. Staging of local events to bring EVs (and other carbon reduction interventions) before the public.

Conclusions

5.22. The change to low emission vehicles is well under way. Local action may smooth the way. In particular,

a. Local Planning Authorities should adopt ambitious standards for charging provision in new development.
b. Highway authorities should aim for an ambitious provision of on street residential charging.
c. Town centres should restrict central shopping streets to low emission vehicles.
d. Bus operators should change to appropriate low emission vehicles.
e. Planning and Transport Authorities should adopt autonomous public transport solutions for medium towns.

f. ZCS should stage local events to bring EVs (and other carbon reduction interventions) before the public.

---

[1] JLR, BMW Mercedes, Audi, Nisssan, Renault, Vauxhall, Peugeot, Volvo, Ford, VW, Hyundai, MG,Kia, Fiat, Mitsubishi plus new entries Tesla,
[2] https://www.edfenergy.com/electric-cars/tax-road-company
[3] https://fuelcellsworks.com/news/translink-20-hydrogen-zero-emissions-buses-for-northern-ireland-streets/
[4] Octopus;OvO;Bulb;Ecotricity etc
[5] Octopus Agile tarriff
[6] https://electricityinfo.org/fuel-mix-last-24-hours/
[7] As above 2 refs.4,5
[8] https://www.gov.uk/government/statistics/national-travel-survey-2019
[9] https://www.edfenergy.com/electric-cars/tax-road-company
[10] https://www.theguardian.com/politics/2017/jul/26/treasury-tax-electric-cars-vat-fuel-duty
[11] https://www.pocket-lint.com/cars/news/150818-driverless-autonomous-pods-are-now-being-tested-in-the-uk; https://aurrigo.com/shuttle/
[12] https://www.gov.uk/government/news/public-health-england-publishes-air-pollution-evidence-review
[13] https://www.zap-map.com/
[14] https://wallbox.com/en_uk/quasar-dc-charger
[15] https://www.gov.uk/government/news/government-doubles-funding-for-on-street-electric-car-charging
[16] https://www.gridserve.com/braintree-overview/;https://www.drivedundeeelectric.co.uk/dundee
[17] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf PARA 110e; also https://shropshire.gov.uk/media/15525/regulation-18-pre-submission-draft-of-the-shropshire-local-plan.pdf Policy SP3(f)
[18] https://www.eeca.govt.nz/our-work/research/research-papers-and-guides/lifecycle-assessment-of-electric-vehicles/; https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf;
[19] https://www.theguardian.com/news/2020/dec/08/the-curse-of-white-oil-electric-vehicles-dirty-secret-lithium
[20] https://www.cornishlithium.com/
[21] https://www.amnesty.org/en/latest/campaigns/2016/06/drc-cobalt-child-labour/#:~:text=International%20and%20Afrewatch-,Child%20miners,cobalt%20ore%20at%20the%20surface.
[22] http://www.iradvocates.org/case-update/cobalt-mining-case/child-cobalt-miners-file-amended-complaint-against-apple-alphabet
[23] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112285/jrc112285_cobalt.pdf; [23] https://uk.reuters.com/article/us-autos-tesla-batteries-exclusive/exclusive-teslas-secret-batteries-aim-to-rework-the-math-for-electric-cars-and-the-grid-idUKKBN22Q1WC

[24] https://www.rechargenews.com/transition/renewables-giant-iberdrola-to-build-europes-largest-green-hydrogen-project/2-1-847802; https://www.h2-view.com/story/plans-for-new-large-scale-green-hydrogen-hub-to-support-denmarks-green-transition-unveiled/
[25] https://www.autocar.co.uk/opinion/industry-news/opinion-synthetic-fuels-prove-electric-cars-arent-only-option
[26] https://fuelcellsworks.com/news/friday-fallback-spotlight-story-germanys-87th-hydrogen-station-opens-at-the-airport-in-hamburg/

6. A shift away from individual ownership of vehicles towards car clubs and car share schemes

6.1. Production of any vehicle requires energy and materials, which leads to embodied carbon. This varies according to the input to the car, so that a small car may have 5 tonnes embedded carbon, whereas a Land Rover Discovery or Tesla S will have about 14 tonnes. Any vehicle ie expensive to own. Whilst car ownership is high in Shropshire, there are many without the ability or wish to own a car.

6.2. Currently there are about 300,000 petrol and diesel cars in Shropshire, and on average they sit idle about 95% of the time. Replacing them all with EVs by 2030 will be completely unsustainable, but EVs have a strong role to play in decarbonisation if they can cater for more than just a single driver. The solution will be to shift rapidly from private car ownership to car clubs or peer to peer car share schemes, with a charging point on the street for every 8 homes in every neighbourhood of Shropshire.

6.3. Currently cars have an average life to scrappage of 14 years, so there is time to allow some phasing out of petrol and diesel cars by 2030 without the need to take these vehicles off the road until they reach their end of life. New petrol or diesel vehicles purchased after 2022 risk becoming a ‘stranded asset’ with a poor resale value.

6.4. There is an opportunity now to shift to car share schemes and car clubs. These give the opportunity for Shropshire residents to benefit from the latest new EV vehicles available at any time within a few yards of their front gate, whilst also saving the average car owner about £2000/year (£3000/year total cost of motoring https://www.nimblefins.co.uk/average-cost-run-car-uk minus £1000/year estimated car share cost, a huge boost for the finances of Shropshire folk of about £500Million/year). The key points are:

a. On street EV charging points on average for every 8 homes, about 15,000 cars providing enough vehicles to meet the private motoring needs for Shropshire county
b. About 20% of households with private or essential worker cars or for those who live in remote locations (about 40,000 households).
c. App based rental via a combination of car clubs such as those provided in Shrewsbury by Enterprise Car Club and Co-Wheels, and peer to peer car ownership schemes such as https://www.hiyacar.co.uk/, paying just for the actual times you need a car, with typical costs £5 per hour
d. App based car sharing and other schemes to help increase average car occupancy from 1.2 to 2.0 by the end of the decade.
e. Average car travel miles per person reducing from 6500 to 3600 by the end of the decade.

6.5. The higher utilisation of community cars (you only book them when you need them, enabling on average 8 households to share each car and utilisation reaching typical rental car values) translates into mileage averaging 40,000 miles per annum for community cars, about 4 times that of private cars, leading to a dramatic reduction in number of vehicles in the county whilst also ensuring that every resident is guaranteed a car is available 24/7 within 50 yards of their front gate. Excellent utilisation translates into excellent return on investment for each community vehicle, offering a good commercial opportunity for those who wish to invest in community enterprises or purchase an EV to share use through a peer to peer car rental scheme. One vehicle in five can be a light goods vehicle for personal use and perhaps one vehicle in ten a minibus, ideal for the school run in rural areas.

7. Reduction of carbon footprint due to transport of freight and goods

7.1. In Shropshire there are 4,800 Heavy Goods[1] Vehicles registered for use and there are 2,035 holders of a valid “Operator’s” Licences[2]. Current figures for the UK, HGV road transport accounts for 79% of all goods moved. [4] illustrate the growth.

7.2. Freight is organised into large fleet operating businesses (20 or more vehicles and trailers) supplying distribution and/or warehousing facilities usually coupled with regional, national and international haulage. Then smaller family run enterprises or SME operational HGV fleets undertake the local carriage of goods for distribution or collection or have specialised operations like road sweeping, concrete mixers, skip hire or cattle transporters, etc.

7.3. The vehicle fleet figure above does not include all HGV’s, as they belong to national operator’s licence holders based elsewhere, i.e. Builders Merchants; Jewson, Huys & Gray and Travis Perkins, to name one business sector. Equally these figures do not account for International freight HGV’s delivering in the county or onward to Eire. Local Authorities have out sourced or subcontracted their LGV fleet, e.g. Waste collection through Veolia.

7.4. The provision transportation for lighter work is undertaken by Light Goods Vehicles (LGV), these vehicles weigh less than 3.5 metric tons and like HGV’s can be designed in different configurations for the work that is being undertaken. There are 37,700 Light Goods Vehicles (LGV) registered in the county.There are over 4.1m LGV’s[3] in the UK, and 96% are currently powered by petrol or diesel fuel. 17,000 of those are powered by alternative fuels.

7.5. In many cases the use and design of a goods vehicle is specialised. Technological advances toward low carbon are advancing slowly towards fleet use, principally on the light goods sector in urban areas. The following graphs show the single km / mile emissions[7] from HGV vehicles used, emphasising the need for the change to alternative fuels.

7.6. An optimised return delivery from Battlefield, Shrewsbury to Oswestry is 25 miles. If every HGV conducted that same journey, with an average load, they would have created 388,800 kg of CO2e**,** if they returned laden However as most HGV’s do not return laden, 316,800 kg of CO2e will have been generated. The heavier the load the more CO2e is emitted by the HGV.

7.7. The IEA Modern Truck scenario[6] proposes a more ambitious vision supported by three pillars:

a) Vehicle efficiency (contributes to 34% of the fuel savings).
b) Systemic improvements in logistics (contributes 42% of the fuel savings).
c) Increased uptake of alternative fuels (contributes 24% of the fuel savings).

Adoption of such measures could lead to a very different future for trucks. Oil demand would be 50% lower (13.5 mb/d) than in the reference scenario. Emissions could decrease by 75% (2.5 Gt). This IEA consider this would be sufficient to be in line with the temperature targets of the Paris Agreement.

7.8. The principle on which Zero Carbon Shropshire is based is the decarbonisation of as much activity as possible, and whilst this scenario is an advance, a 50% drop in emissions is inadequate if there are other technologies which can yield better results.

7.9. “The RHA welcomes the development of new technology such as hydrogen, battery or electric powered HGVs. However, significant practical challenges exist such as:

a. there are no clear scalable technological solutions in place that cater for the range, payload and cost-effectiveness factors demanded by haulage within the current regulatory regime;
b. the needs of haulage are diverse - for example, a possible electric or battery solution for long-distance haulage may not be appropriate for forestry or quarries;
c. the deployment of alternatively-fuelled HGVs must be supported by the required infrastructure – for example, an electricity network able to sustain rapid charging points and/or overhead gantries; strategically-located hydrogen refuelling points that ensure all parts of the United Kingdom, including remote areas, can be serviced by an HGV.

To overcome these barriers, we believe that market-driven solutions, guided by corporate social responsibility policies framed by a public awareness and demand for investment in green technology, are best placed to achieve freight decarbonisation. This will stimulate the innovation and investment needed in a sustainable way.”

Alternative Fuels in the distribution industry.

7.10. Future transportation fuels will all have an intrinsic carbon footprint from the generation of the fuel used to power them;
   a. Electric vehicles; catenary supplied or battery stored energy.
   b. Hydrogen; fuel cell electric powered vehicles; (FCEV)

7.11. Investments are required for these future power systems - either
   a. an Electric Road System (ERS) or
   b. a Hydrogen Road System (HRS) or
   c. a hybrid of hydrogen /stored battery electricity propulsion.

7.12. Each of the systems are viable to varying degrees of utility and are still being developed, concentrating on
   a. Higher battery power storage and life space,
   b. Electric motor power and efficiency rates,
   c. Fuel cell exchange efficiencies in kg of fuel to km travelled, etc,

7.13. Ultimately the vehicles designed for the future are electrically powered engines.

7.14. In 2019 the Committee on Climate Change commissioned Ricardo Energy and Environment[14] to carry out research to assess the infrastructure requirements and costs for the deployment of different zero emission heavy goods vehicle (HGV) technology options. The infrastructure considered includes hydrogen refuelling stations, ultra-rapid charge points at strategic locations, electric overhead recharging infrastructure on the roads and hybrid solutions combining these options. (Appendix 4a of the report outlines the costs.)

7.15. The research concluded:

a) It is feasible to build refuelling infrastructure to support the deployment of zero emission HGVs so that they constitute the vast majority of vehicles on the roads by 2050.
b) Looking at infrastructure alone, deploying hydrogen refuelling stations is the cheapest of the options, costing a total of £1.7bn in capital expenditure in the time period from now until 2060. The strategic deployment of ultra-rapid charge points is the most expensive, at £10.7bn. In all scenarios, a significant number of smaller electric HGVs are deployed as these options are available and operating on the streets today. The cost of installing chargers at depots for these vehicles is included.
c) When the costs of the fuel as well as the infrastructure are included, the costs of deploying electricity or hydrogen HGVs are cheaper compared to the continued use of diesel.
d) Moving to zero-carbon infrastructure for HDVs is a significant challenge and requires planning, coordination, supply chains, resource and materials and a skilled workforce as well as strong government policy to enable the market to deliver.

Overhead power systems

7.16. Overhead power catenary systems are in demonstration elsewhere.. This solution requires new infrastructure, specifically overhead cables. The cost of this infrastructure is estimated to be £1 million per km. There are approximately 7,000 miles of suitable trunk roads in the UK setting the infrastructure costs of this approach at £7 billion13 These costs appear to be optimistic compared to the cost of rail electrification. Using the costs[11] for a rail tack to be electrified. The cost is between £1 – 1.5m per single track kilometre.

7.17. Shropshire's major road network is Motorway 24.4 km and 651.5 km of A class roads. If the M54 motorway were electrified within the county with a single catenary lane, the cost would be £48.8 - £73.2million. There are known grid limitations in Shropshire.

7.18. A catenary driven HGV is 90% efficient in terms of electrical energy used, as there is little loss between the pantograph connection and the vehicle's electric motor.

7.19. Electrifying all roads is out of the question Electrifying the existing motorway system would need the vehicle to be fitted with battery storage power to enable it to join and leave the catenary system, or in the case of power outages, to go to the next live line

[13] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/780895/decarbonising_road_freight.pdf:

connection. The negotiation of complex road infrastructure, i.e. interchange, tunnel or bridge may add complexity or cost.

Green hydrogen vehicle fuel from off-grid renewable electricity

7.20. Green hydrogen has great promise for fuel cell electric vehicles (FCEVs): long-range light vehicles, HGVs, buses, and trains. It should be complementary, rather than competitive, to battery electric vehicles (BEVs) which are well-suited to short-range light vehicles.To be green, hydrogen needs to be produced by electrolysis from dedicated renewable electricity.

7.21. There are two infrastructure barriers to its development in Shropshire; first, the lack of capacity in the electricity grid; second, the lack of a hydrogen network. Producing hydrogen from off-grid renewables overcomes both these barriers, and it would allow the technology to be developed from small-scale upwards rather than being dependent on industrial-scale development, and therefore fitting for Shropshire's entrepreneurial spirit.

7.22. The last mile delivery system (LMDS) could use FCEV's or Cargo eBikes for collection or delivery to distribution hubs on the outskirts of towns and cities. Hybrid vehicles with hydrogen and battery powertrains, are now marketed. As long ago as 2017 Sheffield City Council invested in hydrogen powered vans as a pollution reduction measure[14]. DHL deliveries have fleets of around 100 vans in both San Francisco and Germany[15], and are trialling full scale truck use in Switzerland[16]

7.23. There are two main approaches for hydrogen supply. On-site production of hydrogen involves installing a hydrogen generation unit (employing either water electrolysis (WE) or steam methane reforming (SMR)) with on-site compression and storage equipment at the depot. This option is suited to customers with poor availability of local hydrogen production facilities, and can potentially allow customers to benefit from new revenue streams through providing balancing services to the electricity grid (if WE system is deployed).

7.24. Delivered hydrogen involves scheduled delivery of either compressed hydrogen via high pressure tube trailers, or liquid hydrogen via cryogenic trailers to be regasified at the depot. Advantages include reduced infrastructure footprint, fewer components (reduced on-site risk) and better flexibility to respond to increases in hydrogen demand. Hydrogen supply for road vehicles is well behind that of electricity supply. Zap-Map shows 13 stations at Jan 2021. A single company expects to expand to 12 sites during 2021[17].

7.25. However, the UK Government appears lukewarm towards hydrogen as a road fuel, presently limiting involvement to a single demonstration project in Glasgow. A similar

---

[14] https://www.sheffield.gov.uk/home/pollution-nuisance/hydrogen-vans

[15] https://www.google.com/search?sxsrf=ALeKk02SWQeAbFSRji1A3pbbquGaBko37A%3A1611054541353&ei=zb0GYIyWFYy8gQau_KSYDg&q=hydrogen+van+renault%2Fmercedes&oq=hydrogen+van+renault%2Fmercedes&gs_lcp=CgZwc3ktYWIQDDoECAAQRzoGCAAQFhAeOgUIIRCgAToHCCEQChCgAVDp5AFY6vgBYOaOAmgAcAJ4AIABxgGIAZwIkgEDNC41mAEAoAEBqgEHZ3dzLXdpesgBCMABAQ&sclient=psy-ab&ved=0ahUKEwjMsJrt7afuAhUMXsAKHS4-CeMQ4dUDCA0

[16] https://dhl-freight-connections.com/en/fuel-cell-truck/

[17] https://www.itm-power.com/h2-stations

demonstration project for conversion of diesel powered trains is also under way. Although these studies are under the heading of "UK embraces hydrogen-fuelled future as transport hub and train announced", other countries appear to be far ahead of the UK in the adoption of hydrogen fuel cell vehicles for road transport[18]. No national network of filling facilities yet exists, nor is\ there any strategy for their provision.

7.26. The development of a National Strategy for heavy vehicle carbon reduction is an urgent requirement. There is little apparent progress.

[15] DOI 10.1186/s12934-015-0397-z Penn University USA 2016

[16] https://eepower.com/news/first-plasma-in-worlds-most-advanced-plasma-generator/#

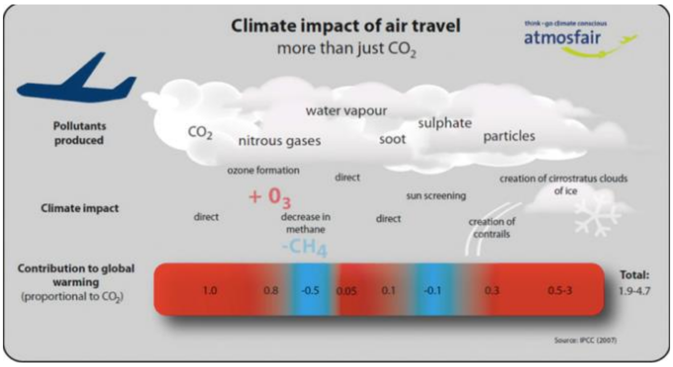
[18] https://www.cleanenergywire.org/factsheets/germanys-national-hydrogen-strategy

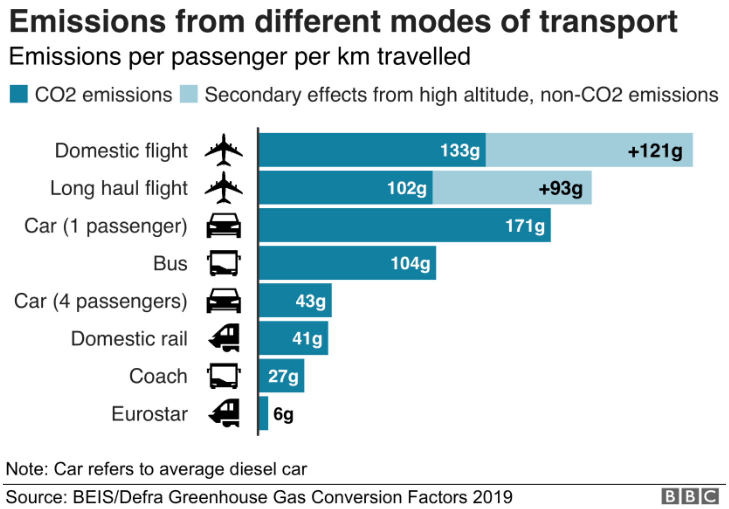
8. Aviation and Shipping

Aviation

Where are we now?

8.1. In 2018, aviation produced 2.4% of total global CO2 emissions., but because they include other pollutants, the total contribution of commercial aviation is 5% of the world's climate-warming problem. Aviation currently accounts for 7% of UK carbon emissions.





8.2. In the UK, just over 50% of people took a flight abroad in 2018. 1% of English residents are responsible for nearly a fifth of all flights abroad. A single passenger travelling on a domestic flight in Britain can lead to climate impacts equivalent to 254g of CO2 for every kilometre they travel, roughly twice that had they used an internal combustion engine car.   In any year half the population do not fly and a quarter take two or more flights, - this implies scope for rebalancing without removing the opportunity to travel19.

8.3. Passenger flights account for about 80% of all GHG emissions from aviation. Air freight constitutes only 1 percent of world trade by volume, but 35 percent by value. Worldwide daily air shipments include 80,000 flowers; 657 million packages valued at $17.8 billion; 898 million letters; vaccine quantities that save lives at a rate of approximately 7,000 daily (2.5 million lives annually); and electronics, including 1.1 million cellphones every day. Deliveries of fresh produce from Africa to the UK support the livelihood of 1.5m people.

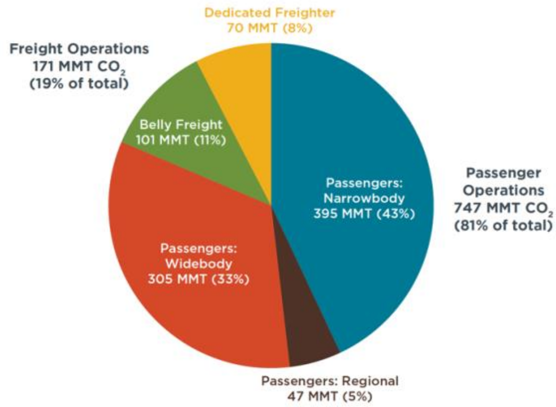


Figure 1. CO_2 emissions in 2018 by operations and aircraft class

8.4. The table below shows the carbon emissions associated with a sample of flights:20

[19] file:///C:/Users/User/Downloads/Net-Zero-Technical-report-CCC.pdf

[20] http://ecopassenger.hafas.de/bin/query.exe/en?ld=uic-eco&L=vs_uic&seqnr=1&ident=cc.058091.1606152578&OK#focus;

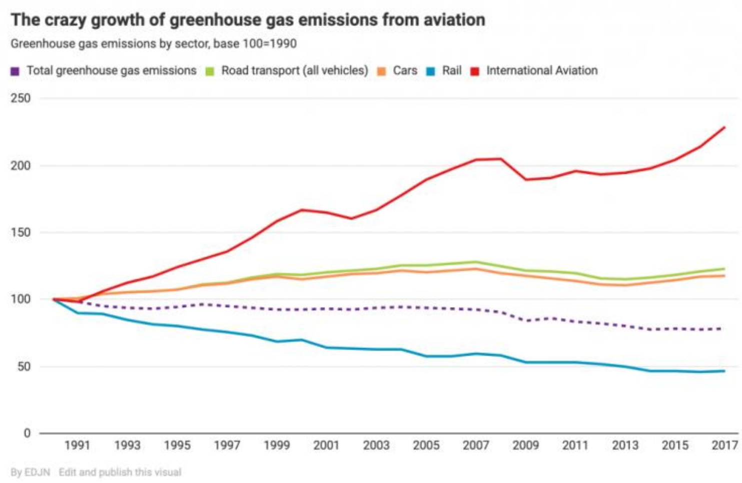
https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx

CO2 emissions*(kg) for flying and rail journeys

Journey		Economy Air one way	Premium Air return	Rail
London	New York	335	1240	-
London	Sydney	1100	4400	-
London	Vancouver	454	1780	-
London	Barcelona	116	464	48
London	Paris	55	220	16.

*these figures for pure CO2. Apply +90% for secondary effects to air travel

Zero Carbon Aviation?



8.5. International agreements exist for the improvement of fuel economy, but reductions in emissions at about 2% pa are outstripped by the pre-covid 19 growth of about 6%pa. Alternative fuels exist, but their use is so far insignificant, amounting to enough fuel to keep the world fleet flying for 10 minutes out of every year. Because we are making strides in reduction of emissions from other sources, and aviation grows so fast, it is likely to be the largest contributor to UK emissions by 2050[21]. Recent reports of Government sponsored projects for a hydrogen propulsion system for sub regional aircraft, scaleable to larger aircraft show a promising direction of travel[22],[23]

8.6. International aviation can be made more efficient, but its need for synthetic liquid fuel (which requires biomass), as well as additional climate impacts of GHGs emitted high in the atmosphere, mean we must reduce it to around a third of current levels.[24]

So, where now?

8.7. At a national and international level aviation has historically been extremely difficult to bring under any degree of control, except for safety, which has to be brought to the highest level possible due to the adverse impact of loss of aircraft, which is normally

[21] https://www.theccc.org.uk/publication/net-zero-technical-report/

[22] https://www.business-live.co.uk/technology/bristols-gkn-hydrogen-powered-plane-19713587
[23] https://www.airbus.com/newsroom/stories/hydrogen-pod-configuration.html
[24] file:///C:/Users/User/Downloads/Zero-Carbon-Britain-Rising-to-the-Climate-Emergency.pdf

spectacular, and of public concerns, even though loss of life in road travel is far greater[25].

8.8. There is no taxation of air travel beyond that required to operate the system. Since taxation is a normal lever to adjust use for other goals, the prospect of international action to limit air travel is unlikely to have significant effects.

8.9. Were the UK, or Shropshire to wish to "go it alone" they might institute a system of travel credits: People could be allocated polluting credits to cover activities such as meat eating and flying that they can sell and buy in an online marketplace. If you're short of cash, or not that bothered about eating meat or flying abroad, you can …sell your credits to someone who is, which makes this far more equitable than green taxes.26 This would no doubt be a very attractive option for the 50% who never fly – particularly those who are vegetarians!

8.10. Failing action such as this, it becomes a matter down to the residents of Shropshire. The average world citizen emitted close to 5t CO_2 per capita a year in 201427; A UK resident emitted 5.8t per head, in the US15.5t. 1% of world population emits 50% of the CO_2 from commercial aviation.28 Everyone should be encouraged to assess their own carbon budget. We should be tending towards zero.

8.11. Having assessed your carbon budget, see if you cannot offset your flying by making your house more efficient,(see under buildings) or your transport emissions less (active travel, electric vehicle, public transport use.)

8.12. If you fly, recognize that 1% of flyers contribute 50% of all aviation emissions[29]. Those 1% fly about 35,000 miles a year[30]. If you are one of them, then consider whether this amount of travel is really necessary. For long haul flights, carbon emissions per passenger are about three times higher for business class and four times higher for first class,[31]

---

[25] https://www.theguardian.com/commentisfree/2014/jul/24/avoid-air-travel-mh17-math-risk-guide#:~:text=Travelling%20in%20a%20car%20or,US%20deaths%20are%20transportation%2Drelated.

[26] https://www.airportwatch.org.uk/2019/06/might-rationing-the-amount-people-fly-be-the-only-fair-way-to-restrict-use-of-air-travel/

[27] https://www.sciencedirect.com/science/article/pii/S0959378020307779#b0480

[28] ibid

[29] https://www.theguardian.com/environment/2019/sep/25/1-of-english-residents-take-one-fifth-of-overseas-flights-survey-shows

[30] https://www.sciencedirect.com/science/article/pii/S0959378020307779; https://www.theguardian.com/business/2020/nov/17/people-cause-global-aviation-emissions-study-covid-19

[31] https://www.bbc.co.uk/news/science-environment-49349566

8.13. Keep it as short as possible – can just as much pleasure or business be obtained nearer than farther? Then ensure that the aircraft is the most economical – choose an aircraft which maximises economy rather than business class, and choose one which has the best fuel economy. And if your flight is simply for pleasure, be sure you're not killing what you are going to see - drowning Venice, melting the snows of Kilimanjaro, killing off whales by acidification of the oceans……..There is probably no such thing as an Eco Friendly holiday if you have to make a long haul flight for it.

Shipping

8.14. The global shipping industry accounts for over 80% of world trade and more than one billion tons of greenhouse-gas emissions per year – more than any but the top-five emitting countries. Shipping's share of global emissions was 2.89% in 2018. increasing by nearly 10 percent between 2012 and 2018. It is forecasted that shipping emissions will increase by up to 50 percent until 2050 relative to 2018 despite further efficiency gains, as transport demand is expected to continue to grow.[32]

8.15. The IMO33 has agreed on an ambition to reduce GHG emissions from shipping by at least 50 percent by 2050[34]. If governments can get their act together and adopt tough CO2 regulations, shipowners will have no shortage of options for meeting the new targets. For example, Flettner rotor sails can cut fuel consumption by more than 8%, and air-lubrication systems can reduce it by another 12%. merely reducing their vessels' speed by 20% would cut emissions and fuel costs by 24-34%. More than 120 major companies are already working to commercialize zero-emission vessels within the next ten years[35].

8.16. There were about 25.8 million cruise ship passengers in 2017, the average cruise ship passenger emits 0.82 tonnes of carbon dioxide-equivalent for their cruise. This is equivalent to a return air trip from London to Tokyo in economy class[36]. There are separate issues concerning the emissions of SOx and NOx from cruise ships, which are truly horrendous[37].

And in Shropshire?

8.17. Few residents of Shropshire can live divorced from these two international sources of emission. The far east is the manufacturing powerhouse of the 21st century, and it is impossible to equip oneself with the trappings of modern life without marine and air

[32] https://www.maritime-executive.com/article/emissions-projected-to-rise-50-percent-by-2050-in-imo-fourth-ghg-study

[33] International Maritime Organisation – A UN body

[34] Ibid 12

[35] https://www.weforum.org/agenda/2020/10/shipping-industry-carbon-emissions-climate-change-environment-ocean/

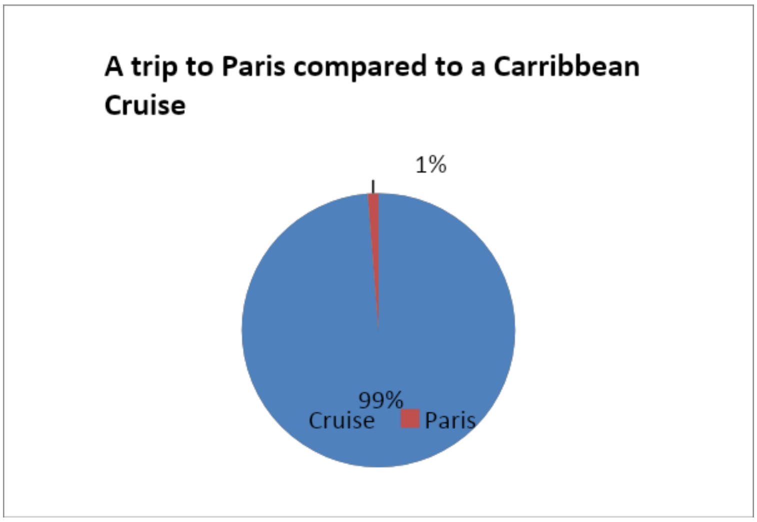
[36] https://www.tourismdashboard.org/explore-the-data/cruise-ship/

[37] https://www.transportenvironment.org/press/luxury-cruise-giant-emits-10-times-more-air-pollution-sox-all-europe%E2%80%99s-cars-%E2%80%93 - study?gclid=CjwKCAiA2O39BRBjEiwApB2IkpXybBL98bdhLh3x0YO4EJZ9uiWK1r4EkqK7gMWtOvqmSKpNYChiWhoC3fwQAvD_BwE

freight. There are significant benefits in the transfer of wealth from local UK consumers to workers in developing countries.

8.18. The immense capital embedded in these means of transport means that change takes time. It seems that shipping may eventually significantly reduce its emissions, and for freight there is little action the Shropshire resident can take. There are unlikely to be significant reductions in emission from aircraft themselves, but since many flights are for leisure purposes, many Shropshire residents can take effective action. Similarly, business should carefully examine any use of air travel.

8.19. You may be thinking of Paris in the springtime – so go Eurostar – that will be 32kg of CO2. You may be thinking of a Carribbean Cruise. Push the boat out. Do the math, as the Americans would say. Your flights, if you go premium class will emit 1687kg of CO2.



Your cruise – say it's an average sort of length – that's another 820kg. So that adds up to about 2.5 tonnes of carbon emitted. Compared to the figures above, that is half the total carbon emitted by a UK resident in a year. But we have a crisis, and our emissions should be going down, to protect the life on our planet. Your cruise will have used up between a half and all of your share of UK emissions for that year.

Conclusions

- Establish your own carbon budget at present: https://zerocarbonshropshire.org/calculate-your-carbon-footprint/
- If it's greater than the UK average – 5.8tonnes - take measures to reduce it
- Take further measures to reduce that by 50%
- Then add in your flight, or your holiday.
- Take action to reduce your footprint to 2.9tonnes.

9. Case studies

9.1. Case Study Low Traffic Neighbourhoods. This study is a demonstration of the work carried on by local people to define problems arising in their locality arising from competing demands for road space and environmental attributes. references: https://zerocarbonshropshire.slack.com/files/U01B4LK9YSE/F01GNUNUYM7/meole_traffic_case_study_for_scap_transport_working_group_bernie_bentick_and_meole_traffic_group.pdf ; https://zerocarbonshropshire.slack.com/files/U01B4LK9YSE/F01H05HSSU8/meole_traffic_case_study_maps_for_scap_transport_working_group_bernie_bentick_and_meole_traffic_group.pdf describe the study; whilst reference https://zerocarbonshropshire.slack.com/files/U01B4LK9YSE/F01FVHU6ADV/template_for_identifying_local_traffic_issues_scap_transport_working_group.pdf sets out a check list template to assist others.

9.2. Case study on amount of travel - rural housing compared to urban extension housing. The results are that a dwelling constructed in a village will lead to 6x more travel than one at an urban area, every year of its life. Here's the calculation https://drive.google.com/file/d/1XU6Kqcza0QtNX-Gngj4niFFAEuoQ1Hq2/view?usp=sharing

9.3. Case study on emissions – rural housing compared to urban housing. This showed that emissions would increase by about 1/11th of an average household's emissions defined by the CCC. https://drive.google.com/file/d/1TvDzEoeFzcg4bLwXK5rDxFW18NlWMN8l/view?usp=sharing

9.4. Case study on reorienting a locality's planned development from an urban/rural mix to an urban concentration based upon sustainable travel. The summary is below. The link gives access to a detailed presentation of the proposal. Similar approaches could be adopted for most towns. https://drive.google.com/file/d/1zDRxDJ-Hs-SJbwR585-K4ec5HbvKAQ6x/view?usp=sharing

10. Embodied Carbon in Transport

10.1. Embodied carbon is the carbon footprint of a material. It considers how many greenhouse gases (GHGs) are released throughout the supply chain and is often measured from cradle to (factory) gate, or cradle to site (of use).

10.2. In the case of transport, two sources need to be considered:

- The embodied carbon in infrastructure – roads, railways, service stations
- The embodied carbon in equipment – rolling stock, vehicles.

Embodied Carbon in Infrastructure

10.3. Work carried out for the CCC by Leeds University[38] developed a ratio of cost to embodied carbon for infrastructure works.- " Carbon Intensity kgCO_2e/£"

Table 1: Carbon intensity, spend and embodied emissions of the UK's infrastructure plans

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Carbon intensity (kgCO_2e/ £)	1.11	1.09	1.08	1.06	1.04	1.03	1.02	1.01	0.99	0.98
Total NIP expenditure minus wages at 2010 prices (£M)			27,184	28,314	24,386	24,074	25,194	19,512	19,045	71,451
NIP expenditure minus wages at 2010 prices (£M) for projects under construction			23,963	20,779	15,134	13,135	11,133	4,945	4,755	6,856
Embodied emissions for desired expenditure (Kt CO_2e)			29,334	30,120	25,580	24,906	25,194	19,670	18,929	70,098
Embodied emissions for projects under construction (Kt CO_2e)			25,857	22,104	15,875	13,589	11,363	4,980	4,726	5,726

10.4. Other estimates of embodied carbon from road works vary wildly - recent studies[39] concluded construction carbon ranged from 60-730tCO2e per £1 million expenditure with an average of 456 tCO2e per £1 million.

10.5. From this it is possible to make a broad estimate of the total embodied carbon in an infrastructure project. This must be in round terms since, for instance, a length of railway on a steel viaduct may have different characteristics to a road laid at ground level with little earthworks.

10.6. Taking a local example, the Shrewsbury North West Relief Road would have an estimated construction cost of £95.7m (reported 2020). From the first row of the Table the 2020 rate of

[38] Bridging the Climate Mitigation Gap with Economy-Wide Material Productivity. **Journal of Industrial Ecology, Vol. 23, Issue 4, pp. 918-931, 2019 Scott, Giesekam, Owen and Barrett** **https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3608273**

[39] https://www.transportforqualityoflife.com/u/files/The%20carbon%20impact%20of%20the%20national%20roads%20programme%20FINAL.pdf

carbon intensity is 0.98 kg CO_2e/£ of construction cost. Multiply this by the cost of the bypass £95.7m = 93,786,000kg = 93,786 tonnes. Since the carbon intensity/£ has been worked out at 2010 prices we need to adjust for inflation, which is a factor of 1.29/0.77. 93.786x0.77=72,215 tonnes. Alternatively, taking the average figure quoted above the embodied carbon would be about 43,600 tonnes.

10.7. Zero Carbon Shropshire is what it says in the title. It involves all sectors of society driving carbon emissions to zero by 2030. Any carbon embodied in that time has to be compensated for. The common simple example is the planting of trees to offset the carbon embodied. Planting 1ha sequesters about 200tonnes C/700 tonnes CO_2, [40.] To offset the carbon embodied in the NWRR would require the planting of 173ha forest, which would not sequester carbon until long after it had been emitted in the construction works. ZCS is not advocating offsetting[41].

10.8. It may be that the carbon embodied in infrastructure is “refunded” by the effect of use of the construction. For instance, a wind turbine cannot be constructed and installed without embodying carbon in the metals and plastics used for the tower and blades, the concrete and steel used in foundations, and the copper used in connecting the structure to the grid. This is rapidly paid back by the renewable power produced, which would otherwise be produced from fossil fuels. Recovery is quoted as 64 days for a 3.4 MW turbine[42].

10.9. It may even be that some road and rail schemes may repay; but in general the issue boils down to minimisimg the overall carbon emissions of the transport system.

10.10. Also, it is necessary to take account of the life of the item. Thus a road or railway may provide utility for the public for decades to come. On the other hand, the embodied carbon in the construction of a petrol filling station will have a life of 20 years; and given the adequate supply of such infrastructure, the embodied carbon may only be balanced by some commercial benefit.

Embodied carbon in motor vehicles

10.11. The larger and heavier a motor vehicle, the greater the embodied carbon. There is a wealth of comparison between ICE powered cars and EVs, which demonstrate that after a period, the lower carbon of electric power offsets the larger embodied carbon in battery production. Nevertheless, every vehicle has significant levels of embodied carbon, whatever its means of propulsion, and given the widespread ownership (85% households in Shropshire), the embodied carbon is highly

Carbon footprint of cars

Emissions from cars over a 150,000 km lifetime (tonnes of CO2 equivalent)

Lifetime Emissions	Embodied Carbon		
38.7	6.9	<---	Average Eu Car
25.5	6.45	<---	Prius Eco
10.95	10.95	<---	Nissan Leaf 40kWh (Norway)
15.3	10.95	<---	Nissan Leaf 40kWh (UK)
18.75	10.95	<---	Tesla 3 UK (US batteries)
26.7	18.9	<---	Tesla 3 UK (Asian batteries)

Source: Carbon Brief Factcheck:
How electric vehicles help to tackle climate change
https://www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change

[40] https://academic.oup.com/forestry/article/72/3/237/581042
[41] https://www.unenvironment.org/news-and-stories/story/carbon-offsets-are-not-our-get-out-jail-free-card
[42] longdom.org/open-access/life-cycle-analysis-of-the-embodied-carbon-emissions-from-14-wind-turbines-with-rated-powers-between-50-kw-and-34-mw-2090-4541-1000211.pdf

significant. Typical levels are [43]:-

Citroen C1, basic spec 6 tonnes CO2e
Nissan Leaf 40kWhr 10.5 tonnes CO2e
Ford Mondeo, medium spec 17 tonnes CO2e:
Land Rover Discovery, top of the range 35 tonnes CO2e:
Typically720kg per £1000 cost (2020)

10.11. Similarly to fixed infrastructure, the extent of use of the artefact is an important consideration. Carbon embedded in commercial and public transport vehicles, including aircraft has an extremely high work rate, such that, when spread over the distances travelled, either by the vehicle or its passengers, the embodied carbon is extremely low compared to that in a private car, whose average mileage in the UK is about 8000, and which for much of the time sits idle. For instance, embodied carbon in an average diesel fuelled truck accounts for only between 1- 4% of its lifetime emissions.[44] For a diesel bus it may account for 13% of lifetime emissions, amounting to 1473 tonnes CO2e. For a BEV coach, it will account for some 35% of a much lower life cycle emissions of 455 tonnes. The lifetime is likely to cover 50-80,000km/yr over a 12-15 yr period.

[43] https://www.theguardian.com/environment/green-living-blog/2010/sep/23/carbon-footprint-new-car
[44] file:///C:/Users/User/Downloads/LowCVP-LCA_Study-Final_Report.pdf

DATA SOURCES

England walking & cycling
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/906698/walking-and-cycling-statistics-england-2019.pdf

Shropshire Rural Buses FIT report
http://integratedtransport.co.uk/wp-content/uploads/2019/03/FIT-Shropshire-Buses-Report-web.pdf

England bus passenger journeys by local authority see table BUS0109
https://www.gov.uk/government/statistical-data-sets/bus01-local-bus-passenger-journeys

ORR station footfall for Shropshire + Telford & Wrekin
https://drive.google.com/file/d/1lsVjxCd5tiZ1x73PEB4woPWpgFce7MhC/view?usp=sharing

DfT Road Traffic Statistics Shropshire
https://roadtraffic.dft.gov.uk/local-authorities/116

DfT Road Traffic Forecasts 2018
https://www.gov.uk/government/publications/road-traffic-forecasts-2018

National Travel Survey (for England)
https://www.gov.uk/government/collections/national-travel-survey-statistics

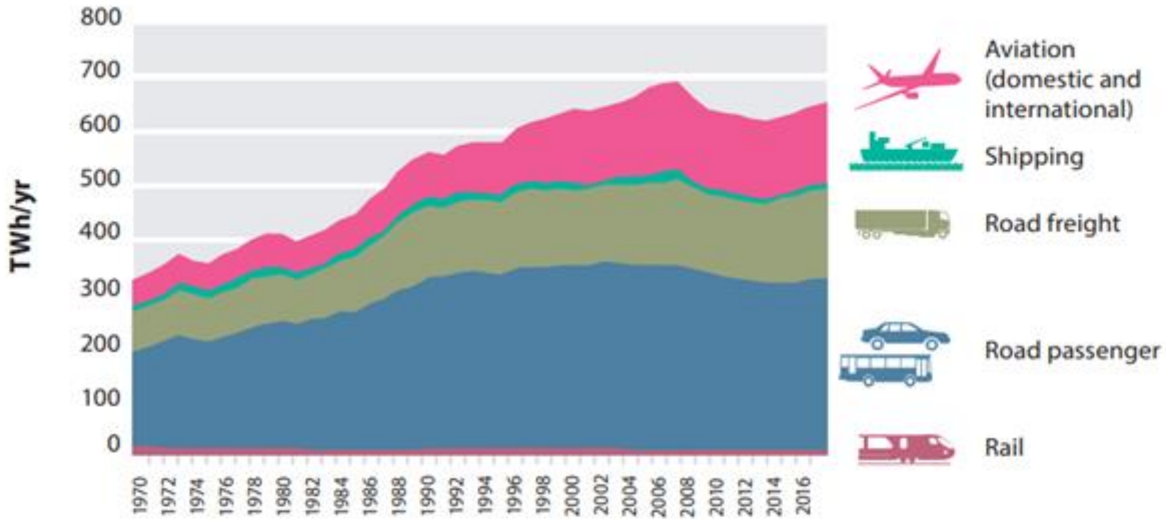
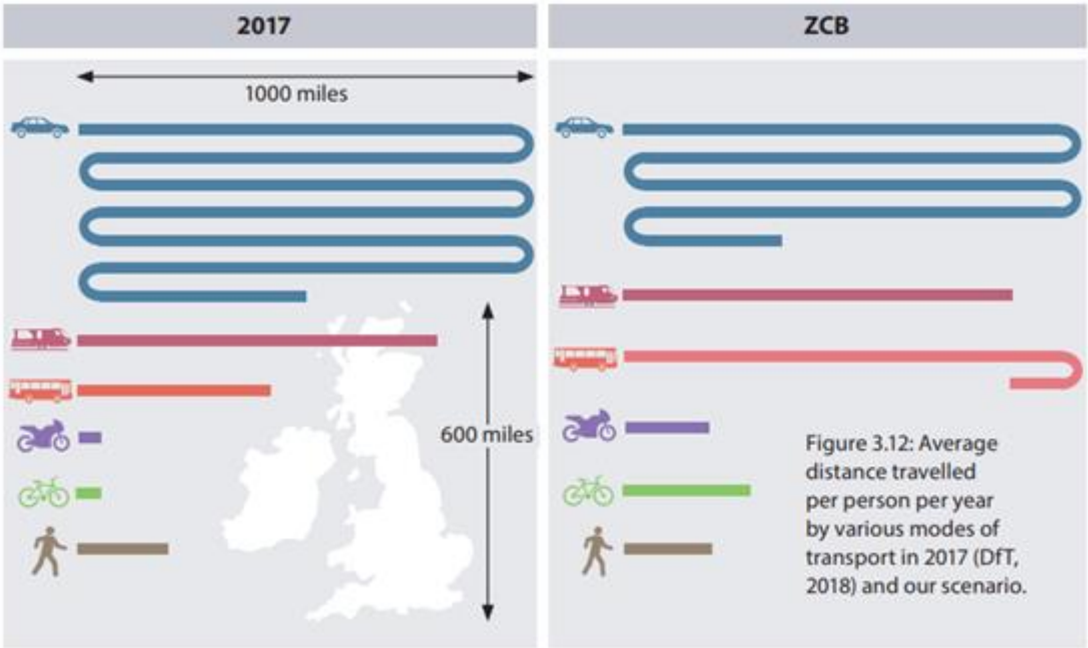


Figure 3.11: Energy demand for UK transport over recent decades (excludes international shipping (BEIS, 2018)).



Zero Carbon Shropshire has adopted the scenario put forward by CAT. For ZCB read ZCS