2050 CliMobCity
Interreg Europe

2050 Climate-friendly mobility in cities

Appendix-Plymouth-Report

- Editor: Daniel Forster (Plymouth City council)

- With contributions from:
  - John Green (Plymouth City Council)
  - Ekki Kreutzberger (Delft University of Technology)
  - Arjan van Binsbergen (Delft University of Technology)

Version 29 7 2023

This report is an appendix to the Project Summary Report

European Union
European Regional Development Fund

Attachment-PIK-Report

This report, the Attachment-Plymouth-Report is a background report to the Project Summary.

The Project Summary gives an overview of the work process and results of the project's so-called Demonstration, the centre of the project's interregional learning. In the demonstration each partner city explored the impacts of long term mobility and land use measure packages and of powertrain and energy scenarios for mobility and CO_2e emissions in the city.

This report for the description of the city structure, transport network and mobility partly is the basis for and partly supplements the Project Summary.

Contact

For all:

- Daniel Forster MTPS
  Transport Strategy Co-ordinator
  Strategic Planning and Infrastructure
  Plymouth City Council
  Ballard House
  West Hoe Road
  Plymouth
  PL1 3BJ
  T +441752307721
  F +441752304922
  E daniel.forster@plymouth.gov.uk
  www.plymouth.gov.uk

For relation to the Project Summary

- Ekki Kreutzberger
  Project coordinator 2050 CliMobCity
  TU Delft/Faculty of Civil Engineering and GeoSciences
  Department Transport and Planning
  Stevinweg 1, 2628 CN Delft
  PO-box 5048, 2600 GA Delft
  Netherlands
  T +31 6 39112501
  E e.d.kreutzberger@tudelft.nl

- Arjan van Binsbergen
  Project and communication manager 2050 CliMobCity
  TU Delft/Faculty of Civil Engineering and GeoSciences
  Department Transport and Planning
  Stevinweg 1, 2628 CN Delft
  PO-box 5048, 2600 GA Delft
  Netherlands
  T +31 6 140 151 10
  E a.j.vanbinsbergen@tudelft.nl

City Chapter: Plymouth City Council

Plymouth is a port city situated between the River Tamar and the River Plym and at the border of the counties of Cornwall and Devon in the far south west of England (Fig.1). A predecessor settlement is known to have existed there since the Bronze Age and to have subsequently served as a trading post for the Roman Empire. A nearby settlement of Sutton was founded in the 9th century and was recorded in the Domesday Book in 1086. Its name was officially changed to Plymouth by Royal Charter in 1440.

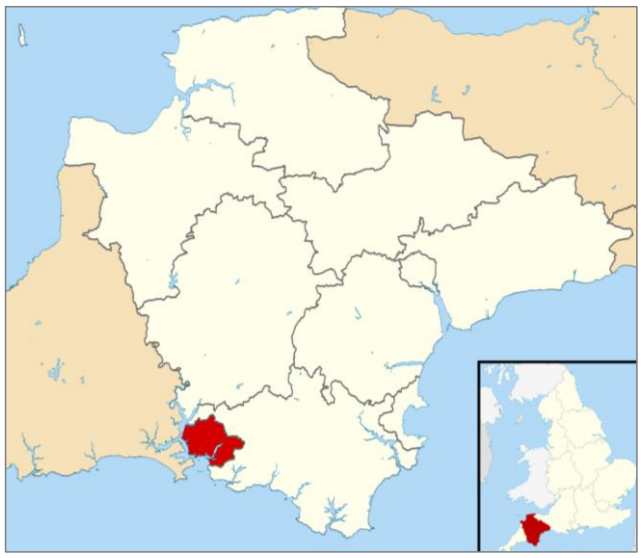


Fig. 1: Location of Plymouth within the county of Devon (inset showing Devon within UK)

Fig. 2: Charter Map of Plymouth in 1540 (Tamar estuary on the left, Plym estuary on the right)

Plymouth's rich history as a royal naval dockyard began when the English naval fleet was based in there in the 15th century. In the late 16th century, Plymouth became home to wealthy maritime traders in wool and the early slave trade, and was the departure point for early attempts to settle in North America and later (1620) the journey of the Pilgrim Fathers. In the 17th century Plymouth declined as a commercial port. However, in the 18th century its importance as a royal naval dockyard grew once again. Several new docks were built and the dockyard became the region's major employer with thousands of workers, bringing some prosperity to the city and supporting the development of other industries in the city during the 19th century. The arrival of the railways to Plymouth in the late 19th century boosted the city region's economy by enabling early season soft fruit and locally caught fish to be transported quickly to markets in London.

During World War Two the city was heavily bombed due to its importance as a naval port. The city centre was devastated, 3754 homes were destroyed and another 8,000 badly damaged. 1174 civilians and an undisclosed number of military personnel were killed.

Fig. 3: Bedford Street, Plymouth, April 30th 1941.

After World War Two a Beaux-Arts-inspired 'Plan for Plymouth' guided the redevelopment of the devastated city centre. Between the late 1940s and early 1960s remaining pre-war buildings and slum housing in the city centre were demolished and replaced with wide, modern, east-west boulevards and a grand north-south avenue that linked the railway station to the waterfront. Fig. 4 illustrates the extent to which the Plan for Plymouth was successfully implemented.

The city's urban area expanded northwards and eastwards throughout the post-war era with the building of mostly low-density housing estates (Fig.6). The city now has around 122,000 dwellings and the population has grown to around 262,000 (Table 1). In recent decades Plymouth City Council (PCC) sought to increase urban density and avoid urban expansion by successfully focussing new development on brownfield sites within the city boundary. However, as opportunities for such development depleted some urban extension developments have been planned to the east (e.g. Sherford) and north (e.g. Woolwell) of the city.

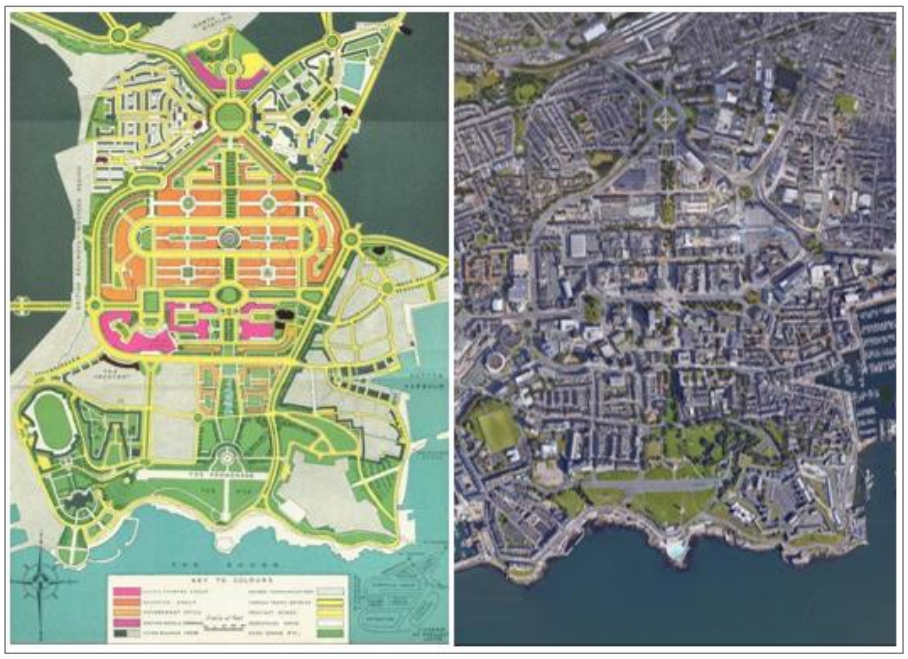


Fig. 4: 1943 Plan for Plymouth city centre plan (left) and Plymouth city centre today (right).

Fig. 5: Royal Parade, rebuilt Plymouth city centre, 1958.

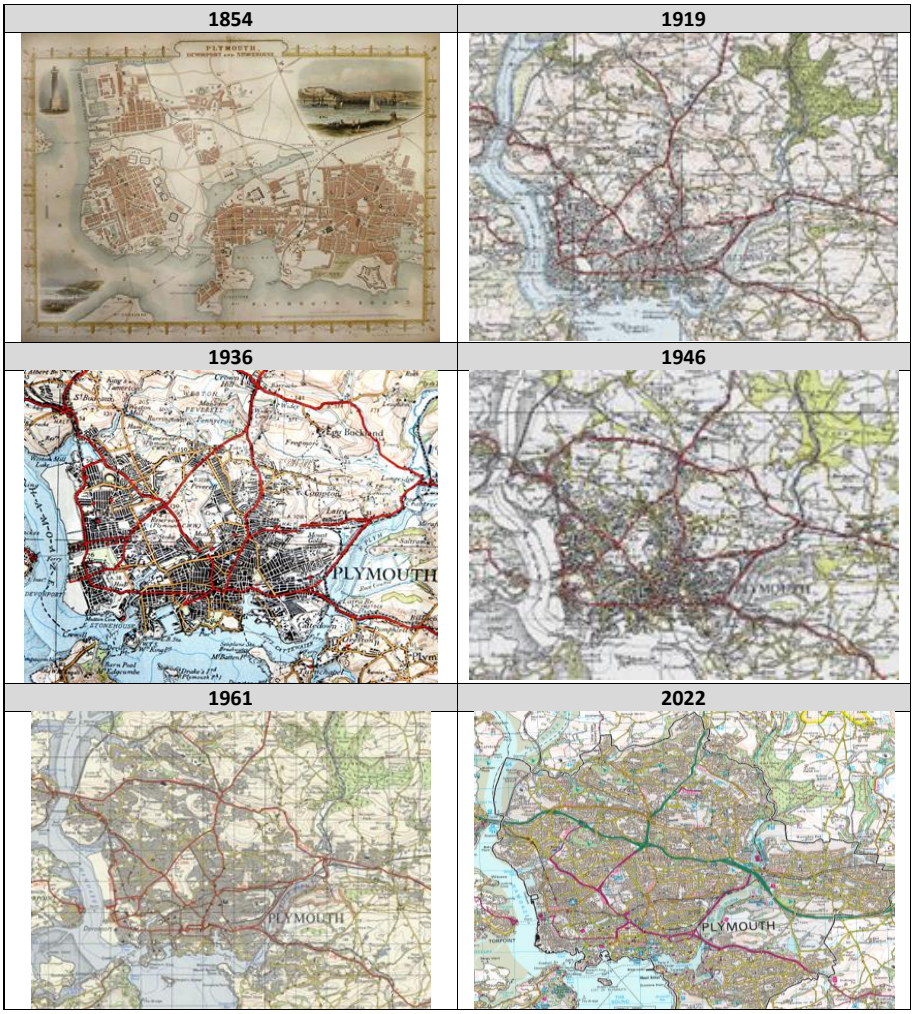


Fig. 6: Expansion of Plymouth's urban area (1854 – 2022)

Year	Population	Data source
Late 16th century	5000	Historical estimate
1801	43,000	Census
1851	103,000	Census
1901	186,000	Census
1951	208,000	Census
2001	221,000	Census

2011	256,000	Census
2022	262,000	ONS mid-year estimate

Table 1: Plymouth's population growth (Late 16th century to 2022)

The post-war era was a period of great economic change for Plymouth. Whilst Her Majesty's Naval Base Devonport (HMNB) remains the largest naval base in Western Europe and is of vital importance to the UK's defence capability, it has gradually transitioned from mass employment ship-building to a much smaller, high skill employer focussed on ship and nuclear submarine refitting. Similarly, whilst Plymouth's fishing industry still lands 13.2% of England's total fish catch each year putting it in the top 3 fishing ports in England, technological changes have resulted in it employing less than 500 people in 2020.

Responding to these trends PCC sought to diversify the city's economy. By the mid-1970s many new industries had come to Plymouth, and a government-subsidised Ro-Ro ferry route had opened up to connect the city to France and later Spain. More recently the city's university has grown substantially in both size and international stature and there is an emerging cluster of high tech marine industries based in the city. Despite this, however, Plymouth is within the 20% most deprived local authority districts in England, with unemployment higher and wages and economic output lower than the national average.

Plymouth's distribution of employment sites is distinctive: in addition to being concentrated in the city centre and Devonport (the location of the Naval Base), there are also employment clusters in the north of the city at and around Derriford Hospital and in the east of the city at Langage Business Park.

Plymouth was one of the last cities in the UK to build a covered shopping centre: the 40,000sq.m. Drake Circus opened in the city centre in 2006. Since then, the trend towards online purchasing has presented a growing viability challenge to the city's retailers, and is reshaping the role of the city centre, which now has too much retail capacity and too many large retail units that retailers do not need. PCC is working with stakeholders to repurpose many city centre buildings into accommodation (apartments) and to develop a diverse, attractive leisure offer and night time economy. Plymouth has relatively few car-dependent 'big shed' retails parks, which are perceived as a threat to the viability of the city centre retail economy.

Historically, Plymouth has not been a major tourist destination. However, the city has been actively developing its tourism 'offer' and promoting itself nationally and internationally as 'Britain's Ocean City' during the last decade and over 5,000,000 people now visit Plymouth each year. Plymouth offers a beautiful waterfront setting, its historic Barbican area, and proximity to Dartmoor National Park, the UK's first National Marine Park, and three nearby Areas of Outstanding Natural Beauty. Since the millennium the city has built the largest aquarium in the UK, a stylish and diverse range of leisure opportunities at the redeveloped Royal William Yard, a new city centre cinema and leisure complex (Barcode) and a £50m museum, gallery, archive and exhibition space called 'The Box'. PCC has also worked with partners to increase the quantity and quality of hotel accommodation in the city and to upgrade facilities at Millbay Docks to enable more and larger cruise ships to include Plymouth on their itineraries.

Overall educational performance across Plymouth's 98 schools is below the national average. In 2019 only 57% of Plymouth's year 11 pupils achieved a grade 4 to grade 9 pass in English and maths

compared to a national average of 65%, and only 63% of Plymouth's primary school pupils are in schools judged as good or outstanding by the schools regulator, Ofsted, compared to a national average of 79%.

Plymouth University has become increasingly important in the life and economy of the city in recent years. It has over 23,000 students, employs almost 3000 people and supports a further 6000 jobs; is ranked among the top 500 universities in the world; is world-renowned for its research in marine science, medicine, engineering and robotics and is among the top 50 UK universities for research. In 2018 the university generated £897.5 million of revenue for the UK economy and £60 million worth of exports.

Transport infrastructure, services and patterns of mobility – past, present, future

Brittany Ferries run Ro-Ro passenger and road freight ferry services from Plymouth to France (Roscoff in Brittany, 6-8 hours) and Spain (Santander in Cantabria, 24 hours) (Fig.7) between Spring and Autumn. 425,000 ferry passengers and 2.43m tonnes of good travelled to or from Plymouth's ports in 2019.

Fig. 7: Brittany Ferry routes, including routes to / from Plymouth

Plymouth's nearest airports are Exeter International Airport in Devon (75km east by road) and Newquay Airport in Cornwall (71km west by road). Plymouth City Airport used to offer flights to London and a number of other UK airports, but closed in 2011 due to financial unviability. A local campaigning group lobbies actively for the airport to reopen, and PCC is currently preventing the former airport site being built on in case developments in the air travel industry render an airport in Plymouth viable once again.

Plymouth has a total road network measuring approximately 823km (Table 2). The city is also bisected, east to west, by 14km of the A38 dual carriageway (Fig. 8). Opened in 1985, this is part of the national strategic road network, which is maintained by the government owned company, National Highways.

Category of Road	Length (km)	Notes
A Class Road	29.4	Examples include the city centre ring road, A386 Tavistock Road and A374 Embankment
B Class Road	36.0	Secondary main roads including Mutley Plain, Greenbank Road, Devonport Road / Milehouse Road through Stoke Village
C Class Road	84.3	Includes key routes connecting Plymouth's neighbourhoods, such as Southway Drive and Honicknowle Lane
Unclassified Road	673.2	Includes most residential and minor roads
TOTAL	**822.9**	

Table 2: Highway assets in Plymouth (2012)

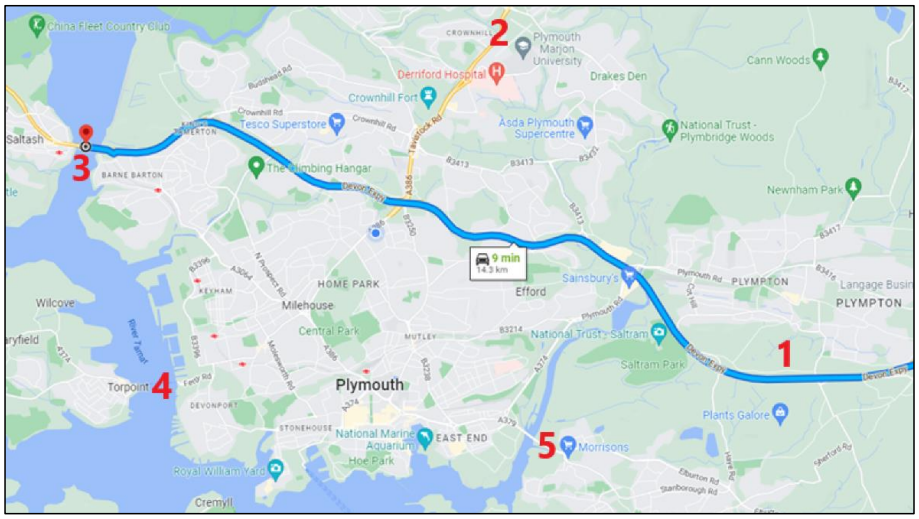


Fig. 8: Route and length of the A38 dual carriageway through Plymouth, plus the five principle road routes into Plymouth

Plymouth's road network has some distinctive characteristics. As a result of being bounded by the sea to the south and by rivers to its west and east, there are only five principle road routes into and out of the city, including the Torpoint chain ferry (see red route numbering in Fig. 8). The road network is therefore vulnerable to significant disruption if any one of these routes is blocked. Also, many steep sides valleys in the north of the city have led to the building of geographically isolated neighbourhoods poorly connected to each other by the road network (Fig. 9).

Fig.9: Steep-sided valleys (see yellow lines) that limit urban densification, separate neighbourhoods, increase travel distances and make travel on foot / by bike less attractive.

The road network is maintained to a high standard by PCC. The city has a large network of traffic cameras that are monitored at an Urban Traffic Control (UTC) centre. UTC staff use traffic management systems (SCOOT, MOVA) to keep traffic on the road network flowing freely.

Plymouth suffers from traffic congestion and traffic-related air pollution, but not as severely as many other British cities. This is due to several factors: the city is less prosperous than and has slightly lower levels of car ownership than the region and the UK; the city enjoys south-westerly winds that bring in clean air from the ocean; the destruction of the city centre during the Second World War allowed post-war planners to build wide, multi-land roads in and around the city centre; and the proportion of jobs in the city performed by people who commute into the city from outside is relatively low.

Until the mid-1980s all bus services in Plymouth were planned and operated by the PCC-owned bus company Plymouth Citybus. In 1985 the UK government deregulated the bus industry outside of London and created a free market for local bus service provision. Plymouth Citybus remained in council ownership but had to compete for passengers with new private sector bus service providers. In 2012 PCC sold Plymouth Citybus to the Go Ahead Group for £12m. Plymouth Citybus remains the largest provider of bus services in the city and operates a comprehensive route network (Fig. 10). Stagecoach Southwest is the second-largest bus service operator serving Plymouth. Most of its services connect Plymouth to towns in Devon and Cornwall.

Fig. 10: Plymouth Citybus route network

Currently, the network of bus routes is comprehensive. The City Centre and Derriford Hospital function as bus service hubs. Bus services typically run throughout the day and evening from Monday to Friday. Not all services run on Sundays and frequencies in the evenings and on weekends can be limited. PCC subsidises a small number of bus services (e.g. Sunday services that are not commercially viable and would not operate otherwise) on the basis of social need. Three park and ride services are in operation and a fourth is planned to the east of the city. Pre-Covid, bus punctuality (arriving within 5 minutes of schedule) was around 90%. Almost all buses are wheelchair accessible and accept cashless payment (card or phone). Inter-operator tickets have been available for several years. All people aged 60 or older or with a disability in the UK can travel free on all buses after 9:30 a.m.

Since 2000 bus patronage levels remained steady at around 19m bus journeys per year until 2020. Covid-19 reduced bus patronage levels outside London to around 30% of pre-pandemic levels. Whilst this has since recovered to around 80% of pre-pandemic levels, and despite significant financial support from the government bus operators are experiencing severe financial pressure and service levels have fallen.

At its height, Plymouth's rail network had 32 stations and several branch lines (Fig. 11). For various reasons, including the famous and large scale 'Beeching' cuts to the national rail network in the 1960s, the vast majority of these stations and lines no longer exist.

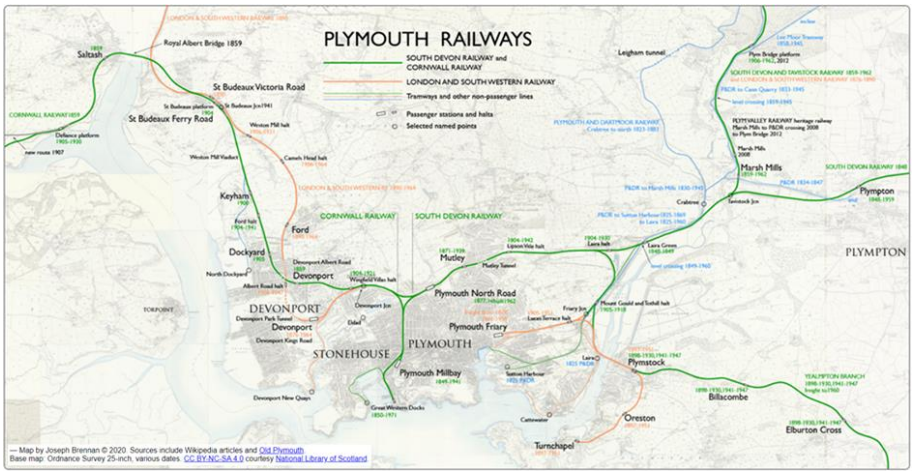


Fig.11: Plymouth's historic rail network

Plymouth's current rail network consists only of the non-electrified main rail line that connects Penzance in Cornwall to London and the rest of the UK, plus part of the Tamar Valley Branch line that connects Plymouth to the village Gunnislake, 11km to the north (Fig. 12). In addition to Plymouth's main station, there are only five suburban train stations within the city, most of which have annual footfall of less than 10,000. So, whilst annual footfall at Plymouth's main station has almost doubled in the last quarter of a century to around 2.5m (despite rail travel in the UK being among the most expensive per mile in the world) only a tiny fraction of journeys within the city are made by train.

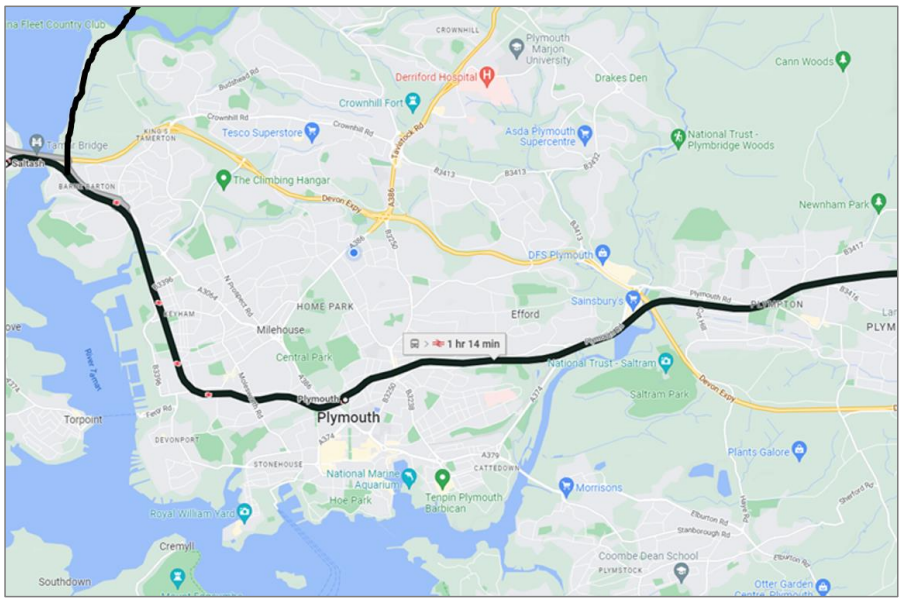


Fig. 12: Plymouth's current rail network

PCC plays no role in the operation of planning of rail services. The rail infrastructure network is run by the government-owned company Network Rail and rail services are run by private companies on a long term franchising model that was launched in the mid-1990s.

Plymouth, like most of the far south-west peninsula suffers from geographic peripherality and long road and rail distances and journey times to other regions of the county. Its road and rail links to the rest of the UK are also insufficiently resilient. The national motorway network in the south-west region does not extend beyond Exeter, and the A38 dual carriageway that connect Plymouth to the national motorway network is vulnerable to full closure in the event of traffic accidents. There is just one main rail line connecting Plymouth to the rest of the UK and this is vulnerable to closure during bad weather where the line runs along the coast at Dawlish. In 2014 a severe storm washed away the rail line at Dawlish and all rail connections to the entire south-west peninsula were cut off for six weeks (see Fig.13).

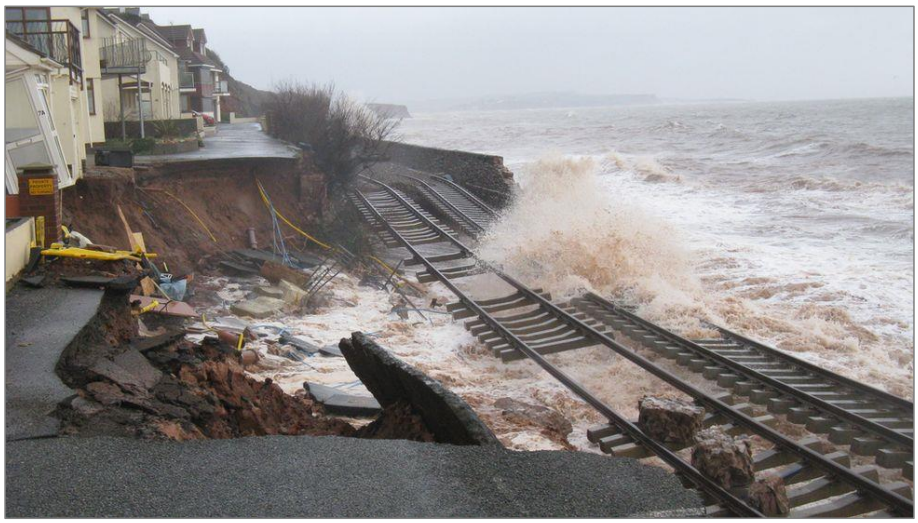


Fig. 13: Storm damage to the main railway line to the south-west peninsula in 2014.

PCC and other local authorities in the south west are active in lobbying the UK government to deliver improvements to rail infrastructure to improve rail journey times, increase rail service resilience between Plymouth and the rest of the UK, and eventually electrify the main railway line to the south west. The UK government has recently funded feasibility studies to explore the potential for some former rail lines to be reinstated, including the former rail line connecting Plymouth to the market town of Tavistock 17km to the north, which currently terminates at Gunnislake.

Levels of cycling in the UK are lower than in many European countries. In the 2011 Census only 1.2% of adults were recorded as using a bike to travel to work. In the decade since then cycling levels have roughly doubled, partly as a result of PCC's long term efforts to invest in the delivery of its aspirational Strategic Cycle Network (Fig. 14) and National Cycle Network Routes 2, 27 and 28 (Fig. 15.) and partly due to a number of British athletes achieving success in the Tour de France and Olympic cycling events and raising the profile of cycling. Despite this recent growth, cycling remains a minority activity for leisure and commuting, and developing a strong cycling culture in the city is hampered by it being among the rainiest cities in the UK and extremely hilly, and a widespread fear among potential cyclists about the danger posed to them by motor vehicles. PCC sees great potential for e-cycles to enable many people overcome the challenge of cycling up Plymouth's steep hills and have delivered a range of projects to encourage increased use of e-cycles and e-cargo cycles in recent years by both individuals and businesses. A £11m network of 50 Mobility Hubs was launched in Plymouth in March 2023 that will provide over 400 public access rental e-bikes across the city, and a national all-electric, zero emission last mile delivery operator (Zedify) has just launched its service in Plymouth.

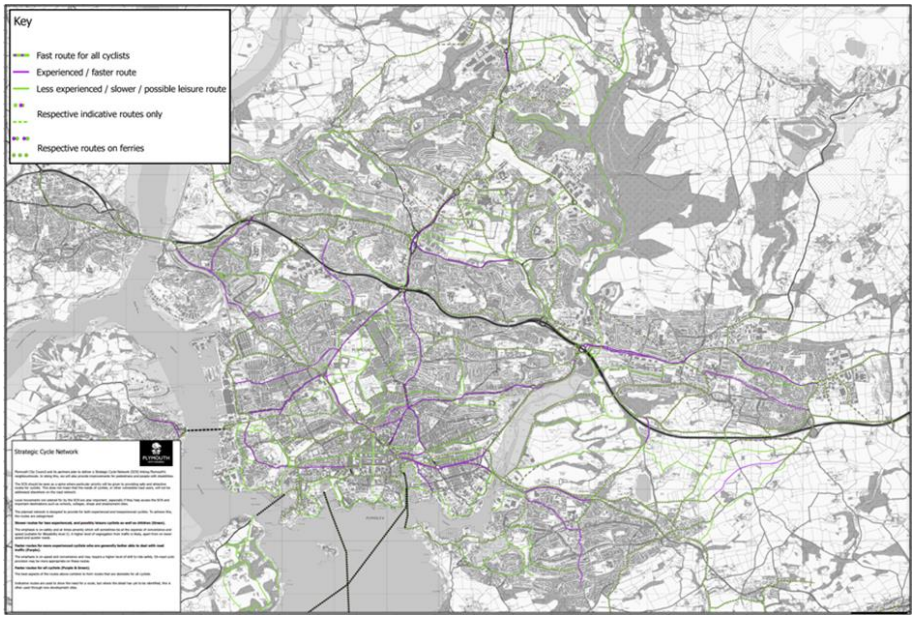


Fig. 14: Plymouth City Council's aspirational Strategic Cycle Network.

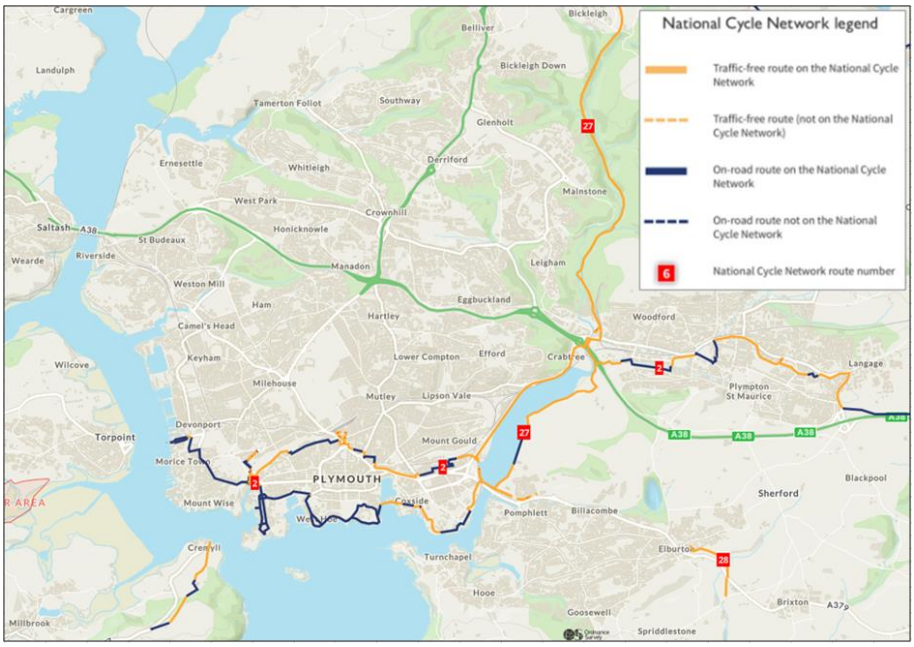


Fig. 15: National Cycle Network Routes in Plymouth.

Increases in both car ownership levels and average annual driving distances drove increases in total annual vehicle mileage in Plymouth throughout the post-war era (with the exception of the oil shock of the early 1970s and the financial crisis of 2007-2009). In the year prior to the pandemic almost 1 billion vehicle miles were driven in Plymouth. By the time of the 2011 UK Census, the percentage of Plymouth adults who travelled to work by car or van had reached 64, whilst the percentage who travelled to work by foot, bike, bus or train was just 29.

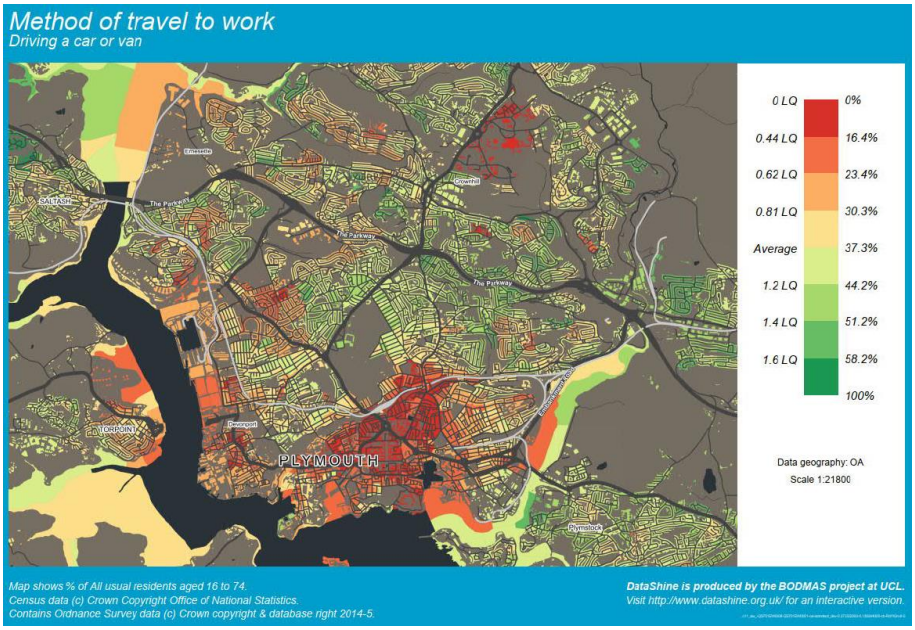


Fig. 16: Heat map illustrating spatial variation in levels of driving to work across Plymouth (2011 Census)

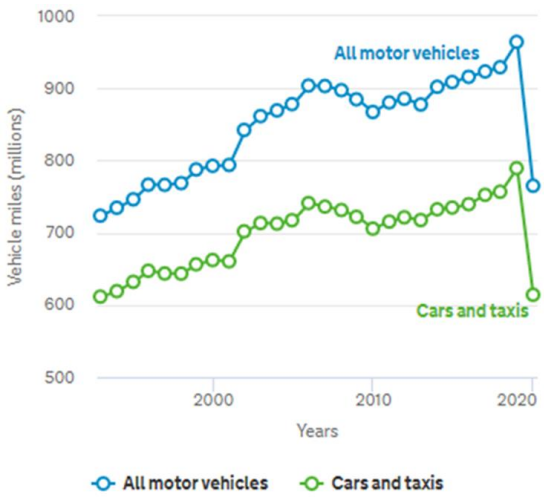


Fig. 17: Vehicle mileage driven in Plymouth, 1993-2020 (UK Department for Transport data)

The average age of privately owned cars in the city is higher than the national average, so their carbon, nitrous oxide and particulate emissions per km are slightly higher than the national average. Levels of car ownership in Plymouth are lower than the national average, however. Take up of electric vehicles (EVs) in Plymouth has lagged behind more prosperous British cities. PCC has sought to take advantage of a range of government funding sources and use the development planning process to expand the city's EV charge point network and ensure that availability of reliable, conveniently located charge points is not an impediment to the growth of EV use. Despite this, the number of charge points per 100,000 people in Plymouth is currently 34.6 (lower than the regional and national average) and they are unevenly distributed throughout the city (Fig. 18).

Sustainable energy company Gridserve has plans to build an electric forecourt in Plymouth with 32 rapid and ultra-rapid charge points. There are currently no hydrogen refuelling stations in Plymouth or in the entire south-west region, and the national network of hydrogen refuelling stations is developing very slowly.

Met opmerkingen [EK1]: Nationalle operating private company, I assume?

Met opmerkingen [DFM2R1]: Yes, that's correct. Well, it only has a small number of electric forecourts in operation at the moment but it intends to operate nationally.

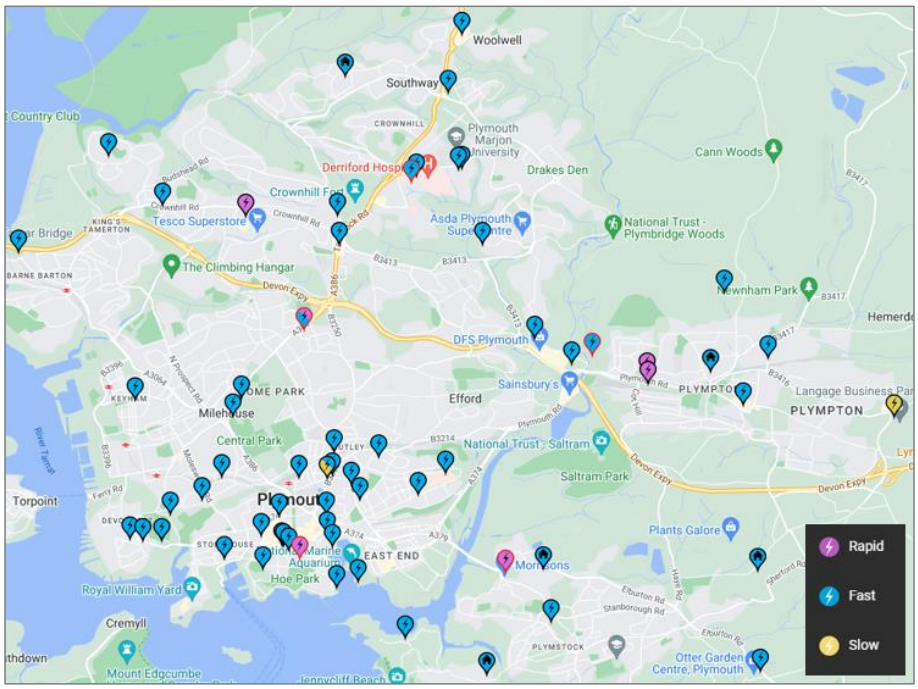


Fig. 18: Publicly accessible electric vehicle charge points in Plymouth (June 2022) (Zapmap.com)

There are over 1000 taxis in Plymouth which are licenced and regulated by PCC. Most have diesel engines, and the average age of the fleet is higher than the national average as the taxi market in the city is not very lucrative compared to many other UK cities. For the same reason, the number of EV taxis in Plymouth is low and the transition of the taxi fleet to EVs is likely to lag behind the national transition.

PCC provides over 5000 car parking spaces in 50 off-street car parks, 19 of which are located in the city centre. Parking charges generate vital revenue for PCC but charges are lower per hour that many comparable local authorities. PCC has also designated 47 Controlled Parking Zones (CPZs – see Fig.19) where on street parking is restricted to local residents with permits in order to address the problem of non-residents parking on these streets are walking to nearby employment or retail destinations.

The number of car parking spaces provided as part of new residential and commercial development is controlled through the statutory development management process. PCC seeks to avoid either underprovision of car parking (which can lead to overspill parking on nearby streets) or overprovision of car parking (which results in inefficient use of land and the delivery of lower density development). PCC does not actively limit car parking provision in new residential developments in order to drive changes in travel behaviour as experience has shown this to be ineffective.

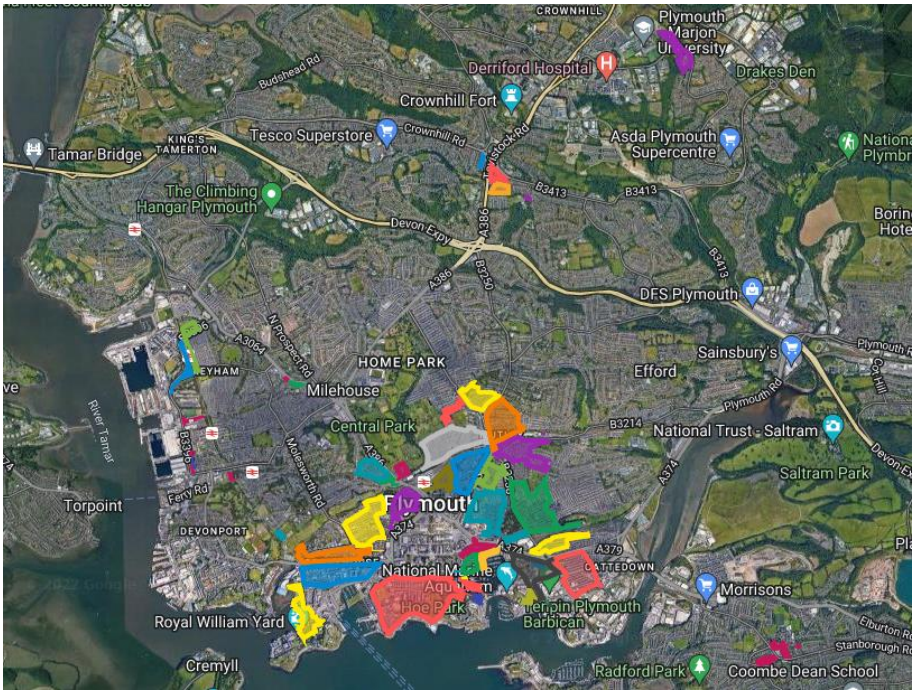


Fig. 19: Controlled Parking Zones in Plymouth (2022)

In recent decades the UK government and PCC have responded to the negative consequences of high and increasing levels of car use and low levels of public transport use, cycling and walking (increased carbon emissions and air pollution, car dominated public spaces and community severance, poor health associated with low levels of physical activity), with a range of transport and land use policies that seek to decarbonise mobility and encourage and enable a return to high levels of travel by sustainable modes.

Since 2000 all Local Transport Authorities in England have been legally required to produce and periodically refresh a Local Transport Plan (LTP) setting out their strategic transport objectives and policies and a delivery plan to achieve them. Strategic objectives and policies to support the transition to sustainable, low carbon mobility have featured in all four of PCC's Local Transport Plans and have strengthened over time.

In 2019 the most recent refresh of PCC's LTP incorporated it into the city's single, over-arching strategic plan (the Plymouth Plan) and the city's strategic land use plan (the Plymouth and South West Devon Joint Local Plan, or JLP). The transport content of these plans are set out in Table 3 and 4, below.

Plymouth Plan - Transport content of Themes, Strategic Objectives and Policies

Theme 2 - A Green City

To be one of Europe's greenest cities. Plymouth will be a place where:

5. A transport system is provided that responds to emerging technological changes for electric and low carbon forms of transport, and delivers a step-change in walking, cycling, and public transport as the travel modes of choice for those living in and visiting the city.

Strategic Objective 1 - Delivering a healthy city

To integrate health and wellbeing, promote choice and personal responsibility, formulate health-enabling local policy and develop good quality local services. This will be achieved by:

7. Providing a safe, efficient, accessible and health-enabling transport network which supports freedom of movement and active travel and promotes low carbon lifestyles that are beneficial to physical and mental health.

Strategic Objective 2 - Delivering a growing city.

To create the conditions for high quality and sustainable growth, (clean growth) which meets the present and future needs of Plymouth residents and businesses and transforms the city into a prosperous place to live, work and visit, and to empower people to equip themselves with the skills and to find the opportunities to take advantage of that prosperity. This will be achieved by:

8. Delivering a sustainable transport network that supports Plymouth's long-term growth while at the same time addressing existing carbon emissions.

Policy HEA6 - Delivering a safe, efficient, accessible, sustainable and health-enabling transport system

The City will deliver a transport system that enables and encourages sustainable and active travel choices, provides good accessibility for the city's population to jobs and services, and supports a healthy environment. This will involve:

1. Using the planning process to:
i. deliver safe and convenient facilities for walking, cycling and public transport;
ii. address air quality, carbon emissions and noise pollution;
iii. actively promote and facilitate sustainable travel choices and quiet connected communities.
2. Designing transport infrastructure projects to take full account of the needs of all users, the wider community and place shaping needs of the area, whilst also helping to minimise air quality, carbon emissions and noise pollution.
3. Facilitating and encouraging walking and cycling through protecting the amenity and safety of the public realm, avoiding street clutter and other unnecessary obstructions and structures,

making specific provision for people with all disabilities, and maintaining and improving the Public Rights of Way network.
4. Delivering the Strategic Cycle Network and facilities for cyclists which encourage both recreational cycling and the greater and inclusive use of cycling as a primary mode of transport.
5. Delivering a public transport system that everyone can use, including working with the bus companies to provide easier ticketing, clear journey planning and timetable information, and accessible boarding and alighting across the city.
6. Working with public transport providers to ensure that each neighbourhood is well-connected to the city's High Quality Public Transport Network offering good accessibility to key destinations.
7. Investing in and promoting the growth of an electric vehicle charging network encouraging electric vehicle take-up and use and continuing to work with partners to harness the benefits of alternative fuel technologies in both land and marine environments.
8. Delivering a co-ordinated approach, through new development design and retrospective modifications, to reduce road casualties and air and noise pollution, including 20mph limits and zones where appropriate.
9. Working with our partners, including the charitable sector, to provide community transport to enable people who cannot use conventional public transport to access health, leisure, shopping and social opportunities within the city and surrounding area.
10. Working with regional partners, agencies and public transport operators to deliver an integrated transport system across all modes covering key locations within and adjoining the Plymouth Travel to Work Area.

Plymouth Plan Policy GRO4 - Using transport investment to drive growth.

The City will deliver targeted integrated transport measures to help support the sustainable growth of Plymouth, in accordance with the vision, objectives and policies of the Joint Local Plan. These include:

1. Continuing to support the High Quality Public Transport Network and improve public and sustainable transport services through, where appropriate, subsidies and new infrastructure.
2. Maintaining, improving and expanding the network of Park & Ride facilities and services, addressing the needs of both Derriford and the City Centre including a new facility at Deep Lane, exploring suitable locations for new facilities and considering the reallocation of space at existing sites.
3. Continuing to support and develop new and existing local passenger ferry services, by working with stakeholders.
4. Working with partners to promote improved and more resilient local rail services, through developing and communicating the Plymouth / Devon Metro concept, reinstating the Tavistock to Plymouth branch line and investigating the need for new rail stations.
5. Improving facilities and services to encourage cycling, including continued delivery of Plymouth's Strategic Cycle Network.
6. Investing in a range of measures to enable and encourage more journeys to be made on foot, including maintaining and expanding the network of Public Rights Of Way and trails.
7. Continuing to support and where feasible expand Community Transport schemes.

8. Supporting and promoting car sharing and the establishment of coordinated car clubs in new developments. 9. Developing our Intelligent Transport Systems to increase the efficiency of the highway network to make best use of its assets. 10. Partnership working with neighbouring authorities and Highways England to ensure effective operation of the local and strategic road network and the interface between the two. 11. Development and implementation of powers to reduce the impact of works being undertaken by statutory providers. 12. Management of demand for travel through the application of accessibility based car parking standards, charging policy for car parks to discourage commuting by car, and targeted fiscal based management strategies in major employment locations. 13. Use of smarter choices and travel planning to provide and promote travel choice, through the planning process. 14. Facilitating efficient freight movements at all spatial scales, with due consideration for the most appropriate mode of travel for the freight being transported, including encouraging and enabling low emission logistics, and working with operators to identify and deliver appropriate facilities. 15. Developing and delivering targeted infrastructure interventions, consistent with the long-term vision and objectives for transport set out in the JLP. **Plymouth Plan Policy GRO7 - Reducing carbon emissions and adapting to climate change.** The City will pursue the following approaches to deliver significant reductions in carbon emissions in Plymouth, aiming to achieve net-zero by 2030 through : 6. Seeking solutions that reduce the need to travel, and encourage the move towards sustainable modes of travel. **Plymouth Plan Policy INT6 - Enhancing Plymouth's 'green city' credentials.** The City will actively pursue measures that build upon its current strengths in green technologies as well as its exceptional natural environment, to become one of the leading green cities in Europe. This will include: 3. Reducing transport related carbon emissions by offering an efficient, accessible and attractive choice of sustainable travel options for all sectors of the community, visitors, businesses and commuters within pleasant and secure environments and actively supporting the transition to low emission vehicles.

Table 3: Plymouth Plan – Transport-related Themes, Strategic Objectives and Policies

Joint Local Plan - Transport content of Strategic Objectives and Policies
Strategic Objective SO1 - Delivering the spatial strategy

To meet the needs of Plymouth and South West Devon for new homes, jobs and services through an integrated approach to the strategic planning of the Plan Area as part of the wider region which:

1. Maximises growth at Plymouth, recognising its position as the most sustainable location for major development, reinforcing its position as one the main centres of growth in the South West and acknowledging the need to prioritise the use of brownfield sites and regeneration.
2. Gives priority to delivering major growth in Plymouth's primary economic nodes of the City Centre / Waterfront and Derriford / Northern Corridor, as well as the Eastern Corridor, in order to drive a step change in the economy and housing delivery and to focus growth on accessible transport corridors where genuine sustainable transport choices can be provided to support growth.

Policy SPT9 - Strategic principles for transport planning and strategy

The LPAs and the local highway authorities of Plymouth and Devon, working with key transport stakeholders, will deliver an integrated approach to transport and planning, based upon the following key principles:

1. Sustainable growth as a key driver behind the transport strategy, whilst making sure that transport is delivered in the most health promoting and environmentally responsible manner.
2. Focussing major growth on accessible locations, where high quality sustainable travel can be more effectively promoted, with clear priorities for routes to and from the city's three Growth Areas to balance the competing demands for highway space.
3. Managing the need to travel, by having a balanced distribution of land use within the city and towns.
4. Seeking to reduce the impact of severance caused by transport networks, enabling more journeys by walking, cycling and public transport and providing genuine alternative ways to travel from home to work and other facilities.
5. Providing realistic sustainable transport choices and increasing the integration of transport modes so that people have genuine alternative ways to travel.
6. Getting the most out of existing transport networks, through measures that improve network efficiency and encourage behavioural change, with major infrastructure projects only where there are no better alternatives.
7. Supporting economic and housing growth with major transport infrastructure projects where there are proven benefits, so that transport links are not a barrier to planned development and pinch points on the network are alleviated.
8. Adopting a hierarchy of transport modes and routes based upon different spatial settings.
9. Delivering transport projects which provide a safe and effective transport system, as well as supporting place shaping and healthy community objectives, as guided by the hierarchy.
10. Taking local control of our transport future, embracing localism, generating independent resources to transform transport investment, and embracing changes in travel technology.
11. Partnership working, with local and regional partners, realising greater benefits over the life of the plan and beyond.

Joint Local Plan Policy DEV29 - Specific provisions relating to transport

Development will be required to contribute positively to the achievement of a high quality, effective and safe transport system in the Plan Area. It will promote sustainable transport choices and facilitate sustainable growth that respects the natural and historic environment. Development proposals should therefore, where appropriate:

1. Consider the impact of development on the wider transport network.
2. Provide safe and satisfactory traffic movement and vehicular access to and within the site.
3. Ensure sufficient provision and management of car parking in order to protect the amenity of surrounding residential areas and ensure safety of the highway network.
4. Limit / control the overall level of car parking provision at employment, retail and other destination locations.
5. Provide for high quality, safe and convenient facilities for walking, cycling, public transport and zero emission vehicles.
6. Mitigate the environmental impacts of transport, including impacts on air quality, noise pollution, landscape character and the quality and distinctiveness of urban and rural environments.
7. Incorporate travel planning, including Personalised Travel Planning (PTP), which helps to maximise the use of sustainable transport in relation to the travel demands generated by the development and limit the impact of the development on the road network.
8. Ensure that access and infrastructure delivered as part of the development meets the need for walking, cycling and public transport connectivity both within the development and in the wider area alongside supporting place-shaping objectives.
9. Contribute to meeting the wider strategic transport infrastructure needs generated by the cumulative impact of development in the area.
10. Locate new homes in locations that can enable safe, secure walking, cycling and public transport access to local services and amenities.

Table 4: Joint Local Plan – Transport-related Strategic Objectives and Policies

Unfortunately, despite these very supportive local land use and transport policies, patterns of mobility have not shifted significantly towards the use of sustainable modes, and overall carbon emissions from transport in Plymouth (Table 5) have fallen only slightly and slowly (and in large part due to improved petrol and diesel engine efficiency rather than mode shift).

	Estimated emissions (Thousand tonnes CO_2)							
	2005		2008		2011		2014	
	Totals	Transport	Totals	Transport	Totals	Transport	Totals	Transport
Plymouth	1,477.0	364.7	1,421.0	359.2	1,213.8	330.6	1,055.4	321.4
South Hams	862.2	248.4	779.6	235.3	675.4	224.7	622.1	228.1
West Devon	506.1	181.9	498.0	194.6	438.4	184.0	427.0	178.2
UK	529,444.3	137,507.0	504,172.9	131,554.5	430,966.0	124,176.6	403,796.9	123,290.6

Table 5: Transport CO2 emissions (UK Department of Energy & Climate Change estimates, 2016)

PCC has begun the process of reviewing the JLP, with a view to updating it in 2024. The UK Department of Transport will shortly be issuing new guidance to local authorities on LTPs (in part to ensure that LTPs are responding adequately to the Climate Emergency) and have indicated that they want all Local Highway Authorities to update their LTPs by spring 2024. These policy review processes present an opportunity to strengthen our main policy instruments, and the outputs of the 2050 CliMobCity mobility and carbon modelling work will feed into them.

When the project 2050 CliMobCity started, Plymouth's target was to reduce carbon emissions by 50% in the period 1990-2034, as documented in the *Plymouth Plan* (*PP*, PCC, March 2019) and the *Joint Local Plan* (*JLP*, PCC, March 2019) of Plymouth and neighbouring municipalities. Both plans have the time horizon of 2034.

Since PCC's *Climate Emergency declaration* in March 2019 its target has been to achieve net zero carbon emissions by 2030 and it has subsequently produced a series of *Climate Emergency Action Plans* (*CEAPs*) (PCC, 2019, 2021, 2022) and a more recent *Net Zero Action Plan* (*NZAP*) (PCC, 2023) to drive decarbonisation efforts.

The local decarbonisation target is much more ambitious than the national one. However, national targets have also become more ambitious and in June 2019 the UK government introduced a law requiring the UK to reach net zero carbon emissions by 2050. Previously, the national target was to reduce carbon emissions between 1990 and 2050 by 80%.

Towards post-fossil fuel vehicles SS

Met opmerkingen [DFM3]: ?

Plymouth and other English cities and the national policy with regard to replacement of fossil fuel by post-fossil fuel cars and vans focus on electrification.

PCC has a number of transport and planning policies in place that are supportive of the transition to post-fossil fuel vehicles. However, the city has not, so far, published any targets or projections for this transition in any public-facing policy / strategy documents. PCC is currently commissioning consultants to produce an *Electric Vehicle Charging Infrastructure Strategy*. This work will start in August 2023 and is expected to take 3 to 4 months to complete. Its outputs will generate forecasts of future EV uptake / demand and EV charge point infrastructure requirements and delivery models / pathways in Plymouth.

At the national level, the report *Taking charge: the electric vehicle infrastructure strategy* (UK Department of transport, 2022) states: "By 2030, we estimate that up to 10 million vehicles, up to a quarter of all cars and vans, will need to be zero emission at the tailpipe. Some scenarios predict even higher levels of adoption to meet carbon targets. For example, UK's Committee on Climate Change (2020) estimates that battery electric vehicles will comprise 27-37% of the car and van fleet by 2030." These values lie between the values of the EU Reference and the Tech scenarios (see following table).

EU reference

	% BEV cars	% Hydrogen cars	% Together	% Fossil fuel remainder
Plymouth, 2015	1	0	1	99
Plymouth, 2034	13	5	18	82
Plymouth, 2050	31	13	44	56

Tech

	% BEV cars	% Hydrogen cars	% Together	% Fossil fuel remainder
Plymouth, 2015	1	0	1	99
Plymouth, 2034	39	17	56	44
Plymouth, 2050	66	28	94	6

Table 6: Share of post-fossil fuel cars (e.g. BEVs and hydrogen cars) in the base year, planning year (2034) and 2050, according to the EU reference scenario and the Tech scenario (source: base year and 2050: Taylor et al., 2019; interpolation to 2034: see Appendix-PIK-Report). Calculation example for 2034 in the EU reference scenario: 13% (BEV) + 5% (hydrogen) + 82% (fossil fuel cars) = 100%.

Met opmerkingen [FD4]: Ekki, please can you suggest a suitable title for this table?

Met opmerkingen [EK5R4]: Like this?

Met opmerkingen [DFM6R4]: Yes, but in italics ☺

On the way to such replacement levels the share of post-fossil fuel vehicles in the total of purchased road vehicles is frequently highlighted. "In November 2020, the Prime Minister put the UK on course … to decarbonise cars and vans, announcing that all **new** petrol and diesel cars and vans will be phased out by 2030" (Department of Transport, 2022; highlighting by authors). PCC monitors data on the purchase of electric vehicles. In 2019 PCC commissioned Exeter University's Centre for Energy and the Environment to produce a report called *Carbon Neutral Plymouth* (Lash et al., 2019). A recent draft update of the study observes that the development of the market share of post-fossil fuel cars is on an exponential trajectory. Assuming it is justified to extrapolate that course, a 100% post-fossil fuel car purchase will be reached in 2035, which is slightly later than the UK aim. Acceleration of the post-fossil fuel replacement is needed, as the extrapolation of the exponential trajectory might transpire to have been an optimistic assumption.

Measure package development and mobility modelling approach

Given the scale of the transport decarbonisation challenge, and the extent to which levels and patterns of sustainable transport measure implementation in the UK (outside London) in recent decades has failed to achieve significant travel behaviour change or reductions in carbon emissions, PCC opted to explore the mobility and carbon emission impacts of a single high-impact measure package.

Adapting a SATURN Highway Assignment Model (HAM) model that was updated in 2017 to enable the development and transport infrastructure proposals of the Plymouth and South West Joint Local Plan 2014-2034 (JLP) to be modelled, PCC modelled a theoretical measure package (subsequently termed 'UK Max') that sought to incorporate maximal delivery of all sustainable transport measures that have been implemented (or that it would be politically feasible to implement) within or by a local highway authority in 2021. Costs of implementation were assumed not to be an impediment.A starting assumption was that the outputs of modelling such an unprecedented and wide-ranging package of measures would be likely to show significant mobility changes and total carbon emission reductions. PCC judged that quantifying the carbon reduction impacts of a 'UK Max' measure package through a robust modelling exercise would be valuable in terms of illustrating in broad terms how ambitious the UK and government and local authorities might need to be to achieve net zero carbon emissions from mobility in the timeframe that the IPCC says is available to do so.

The 2034 Joint Local Plan SATURN HAM covers the major roads across the whole of Plymouth whilst areas outside of Plymouth are represented by a number of large zones and a less detailed road network (see Fig. 20.)

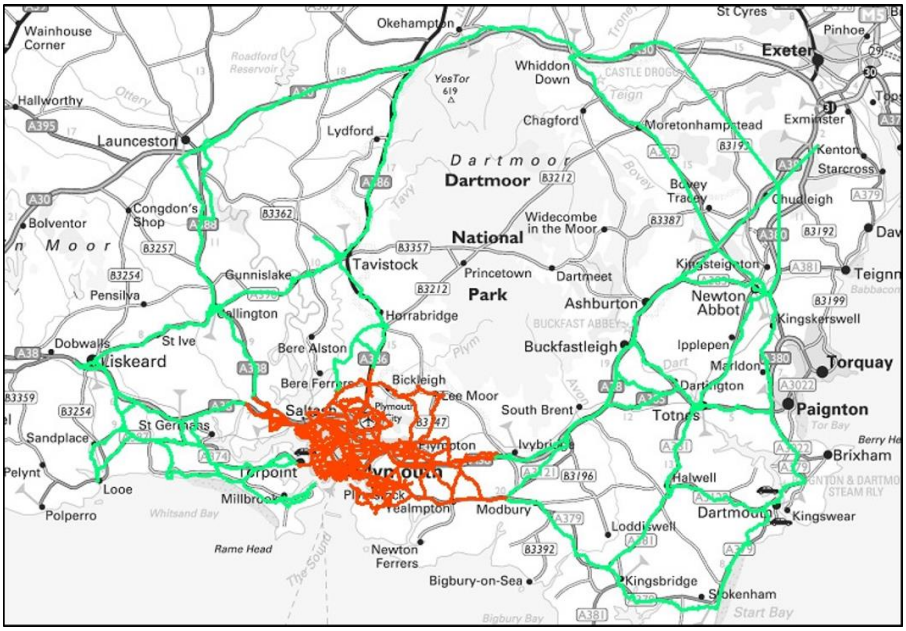


Fig. 20: Roads included in the HAM model (red within the city, green outside the city)

The model capability is limited to:

- the assignment of vehicles to routes. The preceding three steps, typical for a 4-steps transport model (modelling of the production/attraction per area, geographical distribution of trips, modal split modelling) are absent.
- road transport, distinguishing cars, busses, light duty and heavy duty vehicles.[1] It is not a multimodal demand model and provides no data about non-road mobility.

The input to the assignment model is a description of the road network and a set of trips of which the origins and destinations are known, the so-called origin destination table.[2] The model then assigns the trips specific routes. There are origin destination tables and assignments for the base year, the **BAU scenario** and the **UK Max scenario**.

The model focusses on road transport. The effects of shared cars and micro-mobility are not sufficiently known yet, and not yet well incorporated into transport modelling. The shift to post-fossil fuel vehicles is taken into account in the subsequent analysis of the reduction of CO_2e emissions.

[1] These vehicle categories are not modelled separately, but derived from splitting road volumes predicted by the model.

[2] The road origin-destination table for the base year describing the geography of the base year set of trips, is produced on the basis of local mobility surveys. The origin destination table for future years is produced by combining the base year table with nationally published growth rates and using nationally published future mobility production and attraction values for small areas in the UK.

In order to adapt the 2034 Joint Local Plan SATURN HAM for the purposes of the 2050 CliMobCity project it was first necessary for PCC and our transport consultancy partners (WSP) to re-baseline the model by:

- making amendments to the highway network coding to reflect real world network changes that had taken place in the years since the model was created (modelling phase 1), and
- making amendments to the highway network coding and the model trip matrices to take account of transport schemes that PCC had secured funding for since the model was created (e.g. the £58m Transforming Cities Fund programme of sustainable transport schemes)(modelling phase 2)

The amendments to the highway network coding to reflect real world changes that had taken place since the model was created included:

- 5 measures to support public transport (e.g. bus lane or road improvement for train station);
- Almost 30 measures referring to junctions and roundabouts: change of slip lanes, upgrade signal light system, reconstruction roundabout the signalised junction v.v., allowance or prohibition of left or right turns; other capacity increase or traffic flow improvement; 1 to prioritise active travel;
- less than 10 measures referring to links: new ones or extra lanes. 1 to support Bretonside development (in the city centre).

Having re-baselined the model, the UK Max measure package (modelling phase 3) was developed. This measures package was informed by a review of 18 months of transport media and recent significant government policy publications. Ideas were also sought from PCC officers with transport specialisms. An initial 'long list' of 50+ potential measures was assembled, including walking, cycling, bus, rail, ferry, electric vehicles, behavioural change, taxis, parking, fiscal demand management and freight measures. After careful consideration, some long list measures were excluded as it was judged that there was no acceptable means of incorporating them into the model, and a final list of measures was eventually agreed (see Table 6).

Met opmerkingen [EK7]: I recommend to put this in a footnote.

Met opmerkingen [DFM8R7]: That's fine.

In all scenarios the city's population is projected to grow from 263,000 inhabitants in 2015 to 298,000 inhabitants in 2034 which is 13% (= 0,7% per year). Although Plymouth only accounts for 4% of the JLP's land area, nearly 70% of the residents live in the city, now and in 2034.

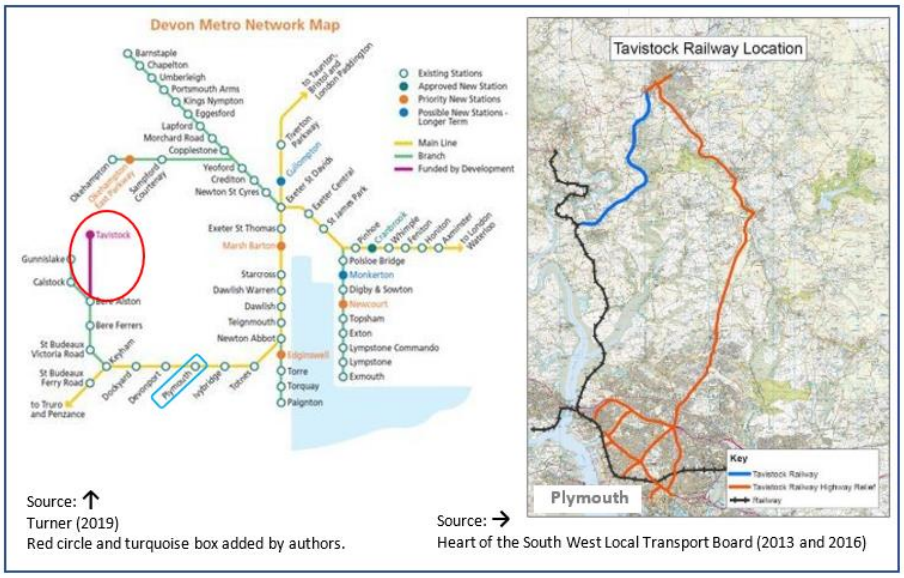
Type	**Intervention**
Bus	Bus gates at all viable locations
	Bus lanes along all viable links / lengths
	City-wide bus service improvements in line with 'Bus Back Better Guidance' following the Brighton example
	Park & Ride at Sherford
Rail	Devon Metro
	Implementation of undelivered routes on our Strategic Cycle Network

Walking & Cycling	Implementation of all routes in our Local Cycling and Walking Implementation Plan
	School Streets delivered across city
	Clean Air Zone across city centre, waterfront and key corridors?
	Bikeability in every school[3]
	Walk to School Programme
	Increased number of cars equipped with anti-collision capabilities, resulting in reduced collisions with cyclists
	Further increase in online shopping and deliveries from LGVs
	Plymouth to be one of governments 12 'Mini-Holland' funding (Gear Change report)
	Improved cycle parking at rail stations
	Low Traffic Neighbourhoods
	Buses that carry bikes (Go Ahead subsidiary East Yorkshire)
	Closing street to through traffic (Hackney Council)
Electric vehicles	New Council Staff Travel Policy to encourage sustainable business travel
	Mobility Hubs including EV charge points, e-bike charge points, and e-car club cars
	Assume as many charge points per capita as the best local authority
	Replacement of (fossil fuel) bus fleet with battery and fuel cell electric vehicles
	Introduction of public e-scooter hire facility
Behaviour change	Promote / provide free eco-driving training
	Plymotion continues at increased scale
Parking	Increase council parking charges
	Clear Air zones with charges for non-compliant vehicles (check options)
	Workplace Parking Levy based on Nottingham model
Other	e-Car club (successful)
	20 mph (ca. 30km/h) speed limits on all residential streets

Table 7. Transport measures incorporated into the UK Max scenario model (Phase 3).

[3] Bikeability is a nationally recognised programme of bicycle proficiency training for children, typically delivered in schools (though this is not delivered in every school in the country).

Regarding rail, “Devon Metro” (measure 13) in the Plymouth region involves the reinstatement of the Tavistock to Plymouth branch line (see following figure). Projected service intervals are eventually hourly, and travel times are shorter than by car, relieving traffic on the parallel highway route and reducing carbon and other emissions, assuming that rebound effects can be avoided.



Source: ↑
Turner (2019)
Red circle and turquoise box added by authors.

Source: →
Heart of the South West Local Transport Board (2013 and 2016)

Fig. 21: Devon Metro network map, illustrating the Tavistock to Plymouth branch line

The table of interventions also shows changes in the road network like introducing a maximal speed of about 30km/h on residential streets, the lowest level in the road typology.

Modelling this measure package was an unusual and technically complex exercise, requiring a lengthy dialogue between PCC officers and modelling specialists at WSP to refine the list of measures and decide how best to incorporate them into the model.

Measures were incorporated into the model through combinations of coding physical network changes, applying manual adjustments to the trip matrix, and making evidence-based assumptions re travel behaviour impacts, where possible. This process was shaped by the nature and technical limitations of SATURN, which is not a variable demand model (VDM) and is therefore unable to take account of impacts of measures on the relative attractiveness of different modes and therefore on travel choices. It was also unable to reflect the potential multiplier effects that can be generated when the implementation of multiple, complementary sustainable transport measures result in greater travel behaviour change than the combined impacts of all those measures implemented in isolation.

The specific, staged tasks undertaken to incorporate measures into the model included the following:

a) first derived modal shares for the base year from Census 2011 data about travel to work shares in Plymouth;

b) then for certain measures estimated the magnitude of modal shifts impacts. The table below shows these estimates: for instance, the share of bus trips increases 4.6 %-points because of improvements in bus services, 0.3 %-points due to Plymotion, and another 0.33 %-points due to other policies, together 5.23 %-points. The share of car trips declines by 14 %-points, with all measures contributing to this in different amounts;

c) then used the difference between old and new road shares to determine the change of the number of car trips between the base year and the **CliMobCity scenario**;

d) then changed the origin destination table in corresponding amounts, and corresponding with the types of measures involved. This lead to more modal shift for Plymouth-internal mobility than for mobility from and to Plymouth and to more modal shift for the central area of the municipality than for other parts of the city.

Before assigning the trips of the new UK Max (CliMobCity) origin destination table to routes, minor adjustments to the model road network were also made, reflecting the road measures. An example is closing a street for through traffic or the improvement of road junctions.

For a more precise follow-up analysis, all modal share results, trip volumes of non-road modes would require validation by advanced modelling. This work was beyond the scope of this project.

The described approach for the modal shift applies for the CliMobCity scenario. Although it would be reasonable to assume that part of this modal shift already emerges in the BAU scenario, no modal shift in the BAU scenario was specified. Therefore in the CO2e analysis all modal shift will be assigned only to the CliMobCity scenario.

Mode shift

Modal shift between 2015 and 2034 (UK Max) (Municipality of Plymouth, WSP, 2022)

		% Decrease	% Increase				
Initiative	Modes to benefit	Car Trips	Bus	Trains	Cycling	Walking	Other
Bus Improvements	Bus	4,60%	4,60%	0,00%	0,00%	0,00%	0,00%
Walking and Cycling Improvements	Cycling	5%	0,00%	0,00%	3,75%	1,25%	0,00%
New Council Travel Policy	Walking / Cycling	1%	0,33%	0,00%	0,33%	0,33%	0,00%
Mobility Hubs	Other	1%	0%	0%	0%	0%	1,00%
Plymotion at Your Doorstep	Walking / Cycling	1,20%	0,30%	0,30%	0,30%	0,30%	0,00%
Workplace Travel Grants	Walking / Cycling	1,20%	0,00%	0,00%	0,40%	0,40%	0,40%
Total		**14,00%**	**5,23%**	**0,30%**	**4,78%**	**2,28%**	**1,40%**

Table 8: Mode shift impacts (% change), 2015-2034 UK Max

The description of current and future mobility in the following sections focusses with regard to trips on the flows in, from and to the city, and with regard to vehicle-kms and passenger-kms on all trips (including trips through Plymouth). The consultancy firm provided model output information about (the spatial pattern of) road trips, road trip-kms, road vehicle-kms and road trip times, distinguishing types of roads and types of road vehicles. Concerning the trips from and to Plymouth the consultancy was not able to distinguish the trip part within the municipal area and outside. As a result, the vehicle-kms and travel time communicated to the project are larger than they should be according to the geographical approach the project applies for the carbon analysis (see chapter 1).

As, also, no distance information could be provided to the project, it is difficult to correct the vehicle-kms and travel time to the desired level.

Attempting to estimate the scale of difference at stake, the project consulted the origin destination matrix. It shows that the car trips from and to Plymouth represent 26% (2015) to 32% (UK Max, CliMobCity) of all car trips in, from, to and through the city. From a rough estimation of involved distances inside and outside of Plymouth, one might expect that total vehicle-kms or travel time relevant for the CO_2e analysis should be up to 15% to 20% less than what was reported, but the range is uncertain.

Without having sufficient certainty about the needed reduction, the project decided to stick to the provided data. As the changes of mobility CO_2e emissions are not presented in absolute terms, but in relative terms and as the trips to and from Plymouth are only a smaller part of all trips, the shown changes, as expected, resemble those if trip parts outside of the municipal area were excluded.

Outcomes of the mobility forecast: BAU and 2050 CliMobCity

(Trips in, from and to Plymouth)

- While the population growth in the period 2015-2034 is projected to be 13%, the total number of *car* trips in, from and to the municipal area increases by 22% (**JLP 2034, BAU**) or only by 4% (**UK Max, CliMobCity**). The number of trips of all modes together is not indicated by the model, but does increase.[4]

(Modal share expressed in trips)

- The share of car trips declines by almost 15%-points. The winners are bicycling (+5%-points), trips by bus (+4%-point), walking (+2%-point), trips by "other" modes (each about +1%-point) in the **CliMobCity scenario**.

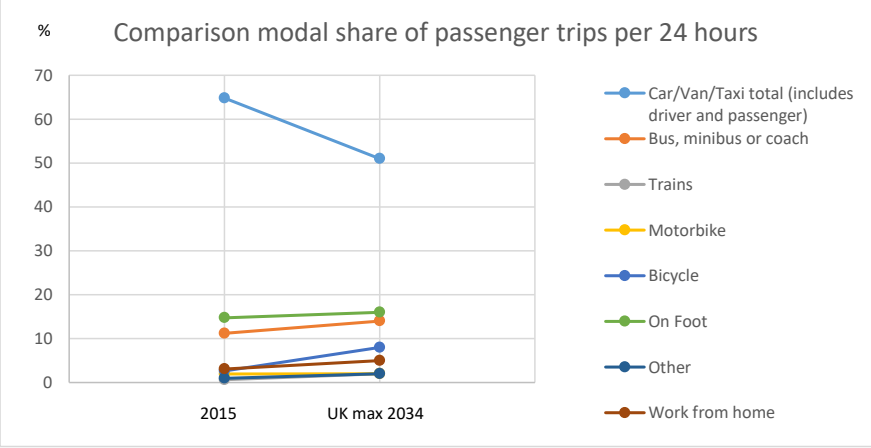
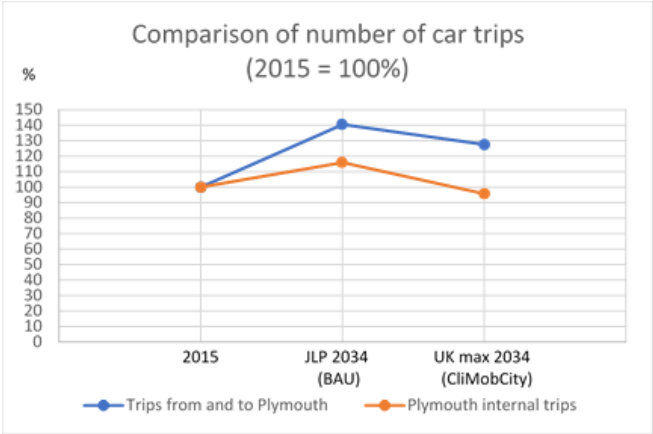


Fig. 22: Comparison of modal share of passenger trips per 24 hours

[4] This conclusion comes from calculations combining the predicted car trip development and modal shift estimates.



This type of presentation supports understanding of the relation between different results (dots).
But be aware of that:

- the line between the base year dot and BAU dots represents a developments in time;
- lines between BAU and CliMobCity dots serve the comparison, but don't represent developments in time.

Fig. 23: Comparison of number of car trips

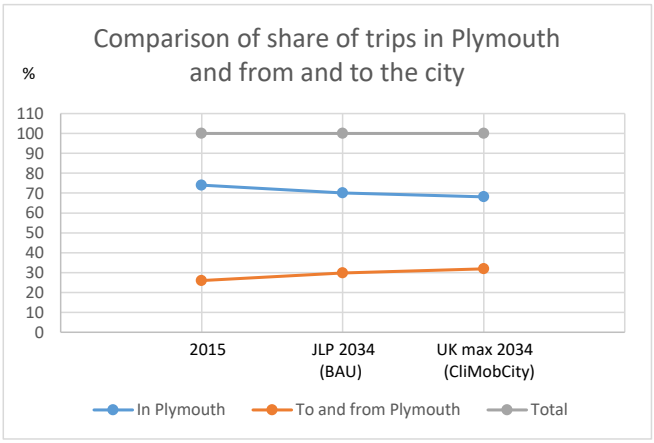


Fig. 24: Comparison of number of car trips

(**Average distance**)

- The transport model employed can't provide the average distance of passenger of vehicle trips.
- The shares of Plymouth-internal car trips (namely 74% of trips in/from/to Plymouth or 62% of all trips including throughgoing trips) and their growth rates (see following figure) indicate that average distance is increasing: the growth rates are larger for trips from/to Plymouth which are very likely to have a longer average distance than the internal trips do. The trips which may be expected to have longer average distances than the Plymouth internal ones and which have even higher growth rates than the trips from/to Plymouth, underline the trend of increasing average car distance.
  For the **CliMobCity scenario** a large part of distance increase is caused by the modal shift taking place. The shift is larger for Plymouth-internal trips than for other trips, and within that larger in the central area of the city than in other city parts. This can be concluded from comparing the car trip pattern for 2015 and the **CliMobCity scenario**.

(Vehicle-kms and passenger-kms)

- The kilometrage per 24 hours of road vehicles increases from 2015 to 2034: for cars +19% (**BAU**) or +5% (**CliMobcity**), for HGVs a (staggering) +59% (**BAU**) or 35% (**CliMobCity**) and for LGVs +18% (**BAU**) or +17% (**CliMobCity**). Bus-kilometrage remains unchanged in both scenarios.

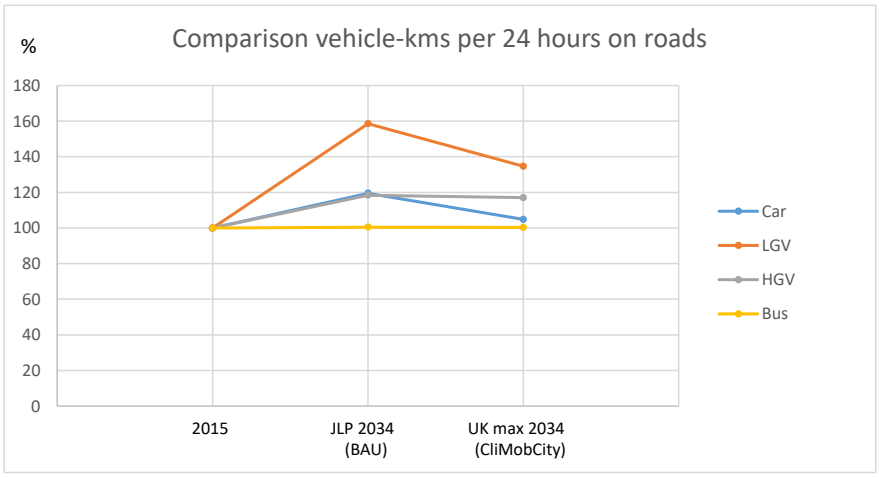


Fig. 25: Comparison of vehicle-kms per 24 hours on roads

(Traffic impacts)

- There is a large growth of vehicle-kms between the base year and 2034, given BAU policies, for all road types, national highways showing the largest growth (+35% in JLP 2034 [BAU] and +25% in **UK Max 2034 [CliMobCity]**), residential roads the smallest (see following figure). The modal shift from road to other modes in the **CliMobCity scenario**, mainly expected to take place within Plymouth and in particular in the more centrally located areas, implies a (near to) zero change of car-kms between 2015 and 2034 on collection and residential roads. On main roads and highways the vehicle-kms increase, although less in the **UK Max 2034** than in the **JLP 2034 scenario**.

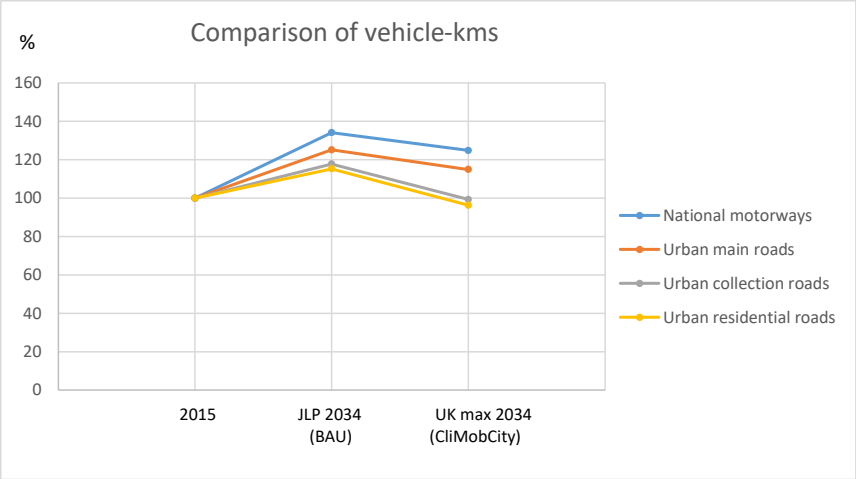


Fig. 26: Comparison of vehicle-kms

- Traffic speed slightly changes. On highways a modest decline of average vehicle speed is expected between the base year and 2034. The decline is larger in the **BAU scenario** (5%) than in the **CliMobCity scenario** (3%). On urban roads, junctions are crucial for traffic flow, the average junction V/C (V = volume[5]; C = capacity = maximal volume) and queue lengths are key indicators. From the base year to 2034 the junction V/C increases by 15% (BAU) or stays the same (**CliMobCity**). A similar picture applies for each specific road types except for collection roads in where the average junction V/C declines towards 2034, less in the **BAU** than in the **CliMobCity scenario**. Queues are significantly longer in the BAU scenario, and slightly longer in the **CliMobCity scenario** than in 2015.

A rough interpretation of the results

- The number of car trips increases substantially (22%) between 2015 and **JLP 2034 (BAU)**, but the increase can be limited to 4% in **UK Max (CliMobCity)** despite a 13% population increase.
- The shift of passenger trips from car to other modes in the UK max scenario mainly takes place in Plymouth's central area and for trips with shorter distances.
- Deviating from the preceding bullet, the Tavistock to Plymouth rail line project impacts longer local trips. The shift from car to train trips correspondingly reduces car-kms considerably, some of which occur in the Plymouth area. However, the trains are not expected to become electric. The reduction of CO_2e emissions will therefore be less than would be the case for (battery) electric trains.
- The **UK Max 2034 (CliMobCity) scenario** leads to less growth of road vehicle-kms than **the JLP 2034 (BAU) scenario** does: still car-kms increase by 5%. For freight vehicles the growth is even higher, for LGVs (vans etc.): 35%. The induced reduction of car-kms is less than would be the case if the shift occurred more along longer car trips.
- This all gives reason for reflection, knowing that the reduction of fossil fuel road vehicle-kms is the central metric relevant for energy consumption and CO_2e emissions, and knowing that fossil fuel *vans* compared to other fossil fuel *trucks* emit the most CO_2e per ton-km of freight. To achieve the climate aim there must either be more behavioural measures for personal mobility

[5] Actually: intensity = number of vehicles passing per hour or other unit of time.

and logistic innovation to reduce carbon from road vehicle kms or CO_2e reduction will largely depend on the electrification of road (and train) vehicles or switching to other post-fossil fuel vehicles.

- Regarding electrification etc., the PCC currently has no formal targets regarding future shares of post-fossil fuel cars in the city's car fleet. Based on external scenarios (EU Reference, Tech) the share of fossil fuel cars may still lie between 82% and 44% in 2034, meaning a decrease in the proportion of fossil fuel car of 17 to 55 %-points. The associated CO_2e reduction will be less given the energy mix of electricity production in 2034.
- The growth of vehicle-kms on national highways and urban main roads tends to increase problems at notorious congestion points. Nevertheless, the general picture is that traffic flow remains relatively stable on all road types.
- The prediction of future mobility in Plymouth is characterised by the absence of a multimodal transport model. The result is that – despite of the well-argued shift – there is little certainty about the extent the assumed modal shift would be backed by mode choices on the basis of comparative mode performances. Validation by improved approaches would be likely to add knowledge relevant for future decision-making.
- As already indicated, the transport modelling does not show the effects of measures entailing shared cars and corresponding mobility hub nodes on future mobility.

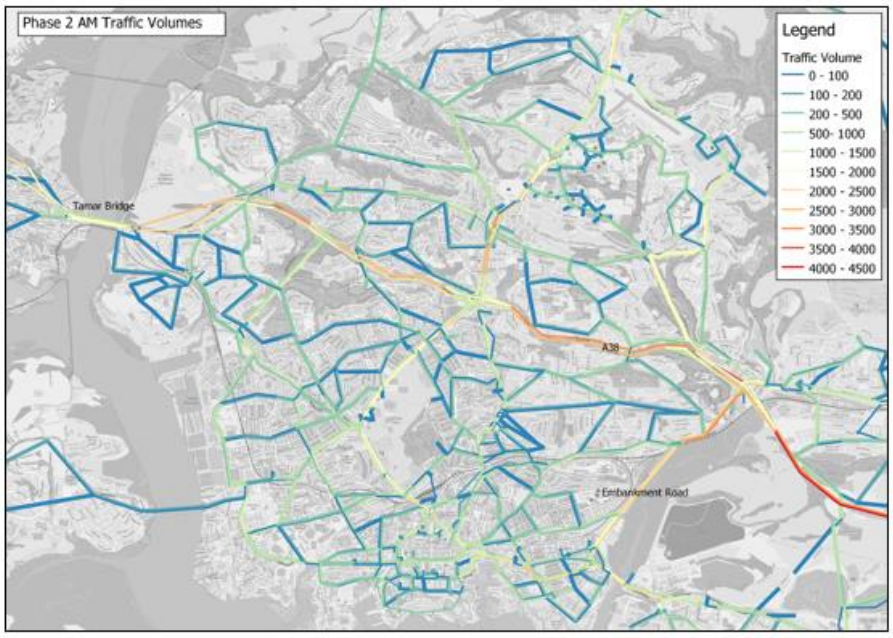


Fig. 27: Traffic flow volumes on model links (Phase 2 AM peak period)

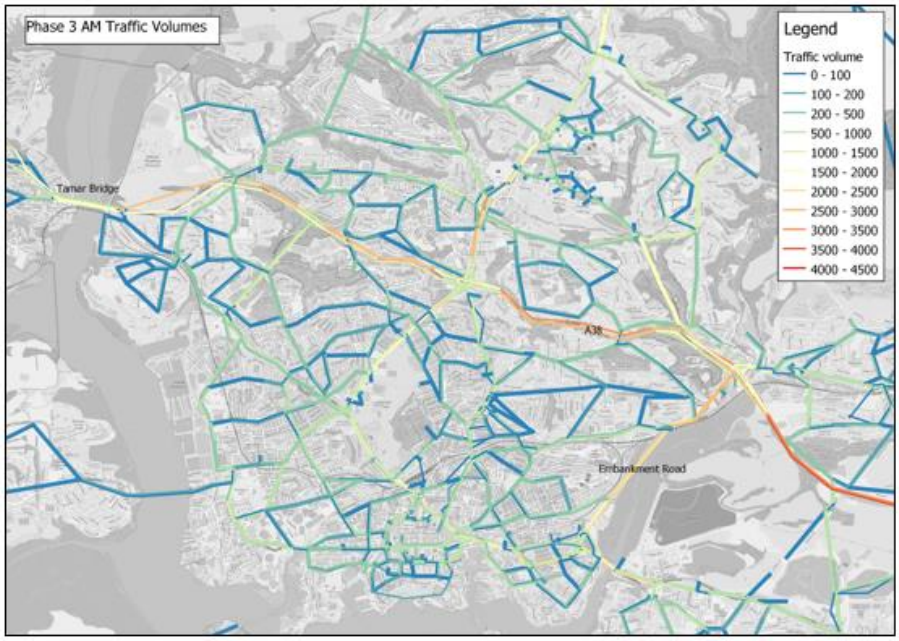


Fig. 28: Traffic flow volumes on model links (Phase 3, UK Max scenario, AM peak period)

Analysed reduction of CO_2e emissions From 2015 to **JLP 2034 (BAU)** car-kms and other LGV-kms increase by almost 20%, HGV-kms by much more. Without shift to post-fossil vehicles this would mean an increase in CO_2e emissions as well. However, there is some shift to post-fossil vehicles: in the EU reference scenario the share shifts from 1% in 2015 to 18% in 2034. This provides a decline of CO_2e emissions of 5% (see blue line in the following figure).

In the **UK Max (CliMobCity)** scenario the volume of car and HGV-kms declines compared to 2015, so do the CO_2e emissions. Still along the blue line (EU reference scenario), between 2015 and the 2034 **UK Max** scenario CO_2e emission declines by 9%.

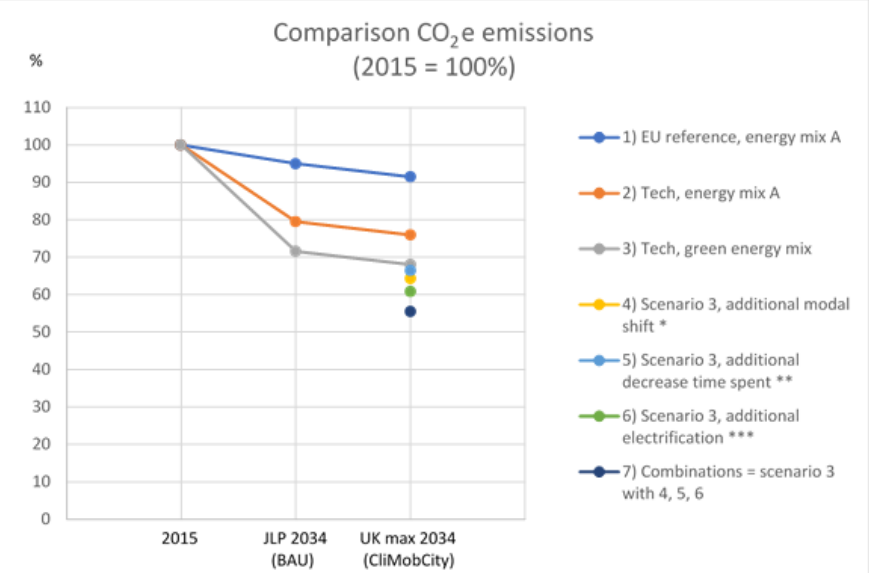


Fig. 29: Comparison CO2e emissions

If the replacement of fossil fuel by post-fossil fuel vehicles takes place more quickly, as in the Tech scenario (the share of post-fossil fuel vehicles reaching 56% in 2034), larger CO_2e reductions can be achieved. The CO_2e emission then from 2015 to **UK Max** then declines by 24% (orange line).

If also all electricity was produced renewably, the CO_2e emissions in between 2015 and **UK Max** would decline by 32% (see grey line in the following figure). Still the remaining CO_2e emission level would be 68% of the 2015 level.

Experimenting with the levers in the carbon model shows – in a what-if fashion – that:

- additional modal shift (share cars -10 %-points; bus + 5 %-points, active travel +5 %-points) provides another 4% CO_2e reduction;
- 10 % additional reduction of the "time spent" (= arising from shorter distances) provides another 2% CO_2e reduction;
- additional share of post-fossil vehicles of 10 %-points provides another 7% CO_2e reduction;
- the combination of additional measures together provides a further 13% CO_2e reduction in comparison to scenario 3.

CO_2e emission in 2034 after these lever experiments is on the level of 55% of the 2015 emissions, barely half way towards the PCC's target of climate neutrality by 2030.[6]

All of these changes take place in the context of a growing population. The percentage **reduction** of CO_2e emissions **per capita** is 7 to 11 %-points higher than the total CO_2e percentage reduction, dependent on the scenario. This development is not shown in the following figure.

The emissions **remaining** after scenario 7, the combination of additional measures, are composed as follows: car 54%, LGV (e.g. trucks) 35% and public transport busses 11%. Closing the remaining gap would/will still require the planning and implementation of a whole set of additional, powerful measures to reduce the number of fossil fuel road vehicle-kms and average travel distance. We discuss major options in the last chapter of this report.

As already indicated, the transport modelling does not show the effects of measures entailing shared cars, micro-mobility services and corresponding hub nodes on future mobility, which may have the potential to substantially reduce CO_2e emissions of mobility. But whether this is likely, it is not sufficiently validated by research yet and certainly depends on the context of implemented concepts. We briefly also discuss this in the last chapter of this report.

Action Plan

Informed by the outputs of the mobility and carbon modelling and seeking to utilise and leverage the learning from the project PCC's 2050 CliMobCity Action Plan included the following actions:

ACTION 1:	Commence construction of Plymouth's Mobility Hubs network (included as action 3.35 in Plymouth City Council's Climate Emergency Action Plan (CEAP3 (2022)).
1 Relevance to the project	Learning gained from participation in the 2050 CliMobCity project has proved valuable in informing the planning and design of Plymouth's Mobility Hub project. A presentation was given by project partners from Leipzig on their city's Mobility Hub project in (check meeting and date). Following this meeting, further information was obtained by the Plymouth City Council team on the practical implementation of the project in Leipzig. In addition, a presentation was given in Utrecht during the kick off meeting in September 2019 by Lomboxnet on the implementation of vehicle to grid vehicle charging infrastructure which helped the Plymouth City Council team to understand the issues and opportunities arising from using this technology. The design of the Mobility Hubs then started in October 2021, utilising the learning gained, in particular with respect to the location of the Hubs in relation to other public transport infrastructure, the branding of the Hubs, the size of the Hubs and the technologies used. The way in which car sharing, bike share schemes and EV charging stations are integrated in Leipzig provided useful insight that has directly shaped the Mobility Hubs in Plymouth. Detailed design of the hubs

[6] One immediately needs to emphasize that the mobility forecasts and CO_2e analysis refer to all mobility in Plymouth, but also include the distances of travellers from and to Plymouth covered outside of the municipal area, as mobility data limited to the municipal area could not be provided to the project. For the absolute results of carbon reduction this makes a difference. For the relative values presented in this chapter the difference will be rather small, as the municipal measures will to a larger extent also effect the kms driven outside of the municipality.

	will commence in September 2022 and construction of the hubs will start in March 2023.
2 Nature of the action	The Mobility Hub project is required to be delivered by March 2023, as defined by the terms of the UK Department for Transport grant funding agreement. Construction will commence in summer 2022, with operation starting at some sites by March 2023. Plymouth City Council has sole responsibility for designing and delivering the network of Hubs. The project will help the Council to deliver on its Climate Emergency objectives and also its Local Transport Plan, which forms part of the city's overarching strategic plan (the Plymouth Plan).
2b. Estimated impact	An economic impact assessment of the project generated a Benefit Cost Ratio of 5.24, representing very high value for money. The project aims to replace over 1 million car miles per year with e-bike usage and 800,000 car miles per year with electric car club vehicles.
2c. Relations	None
3 Stakeholders involved	Plymouth City Council is working in partnership with a range of delivery partners including Beryl (rental e-bikes), Bikespace CIC (e-bike servicing), Gamma Energy Limited (EV charge points) and Co Cars (car club vehicles).
3b. Responsible Actor	John Green, Low Carbon City Officer, Plymouth City Council
4 Timeframe	Since September 2019 - Content of hub planning influenced by 2050 CliMobCity Summer 2022 – Construction commences Spring 2023 – Operation commences at some Mobility Hub sites We envisage that 10 Hubs will be fully operational during Spring 2023. We will monitor the progress of the construction and the launch of each of the individual Hubs.
5 Costs	£11.6m
6 Funding sources	£9.8m – UK Department for Transport (Transforming Cities Fund) £1.8m – Private sector and other match funding
7 Priority	The Mobility Hubs project is the flagship project within the City Council's programme of Transforming Cities Fund initiatives. It is being given the highest priority by the Council's officers and also the political leadership of the Council.

ACTION 2:	Systematically assess other projects explored / showcased within the 2050 CliMobCity project for potential inclusion in Plymouth City Council's Climate Emergency Action Plan 4 (2023).
1 Relevance to the project	Seeking to maximise interregional learning experiences this action will ensure that opportunities to learn and borrow good / best practice from project partners are identified and exploited to deliver mobility-related carbon reduction outcomes in Plymouth.
2 Nature of the action	At the conclusion of Phase 1 of the project / commencement of Phase 2 of the project (August 2022) PCC officers will undertake a thorough review of all presentations and notes relating to all the projects explored / showcased during the project meetings. Any projects that are assessed as having potential for inclusion in

	CEAP 4 (2023) will be taken forward for further discussion and consideration. CEAP 4 (2023) will be published in December 2022.
2b. Estimated impact	Dependent upon whether any measures are identified as suitable for inclusion in CEA4 4 and what they are.
2c. Relations	Information regarding projects showcased / explored within the 2050 CliMobCity project that are not progressed through CEAP4 but are assessed as being potentially valuable and applicable in Plymouth in the medium / long term will be considered in the policy review and development activities within Action 3.
3 Stakeholders involved	None.
3b. Responsible Actor	Daniel Forster, Transport Planning Officer, Plymouth City Council
4 Timeframe	August 2022 – Undertake review of projects. Summer / autumn 2022 – Discuss projects identified as having potential for inclusion in CEAP4 with officers responsible for the CEAP content.
5 Costs	No costs other than staff time.
6 Funding sources	N/A.
7 Priority	Medium. Must ensure that projects identified as having potential for inclusion in CEAP4 are fed into the CEAP development process in a timely manner.

ACTION 3:	Fully leverage the findings of Plymouth City Council's 2050 CliMobCity mobility and carbon modelling work in the forthcoming formal policy review of the JLP.
1 Relevance to the project	Seeking to fully leverage the findings of Plymouth City Councils's 2050 CliMobCity mobility and carbon modelling work and maximise interregional learning opportunities in pursuit of an improved policy instrument this action will ensure that officers responsible for policy development and implementation and relevant political decision-makers are aware of the key learning outcomes of the project and take this evidence into account during the forthcoming review of the Plymouth and South West Devon JLP.
2 Nature of the action	Through direct engagement and collaboration with the JLP team as follows: - The production of JLP scoping papers on (1) Sustainable Transport and Active Travel and (2) The Climate Emergency. Aiming to improve JLP policies, the scoping papers will identify issues and challenges focusing on what has changed since the JLP was prepared, specifically considering the Climate Emergency, current / emerging policy any new evidence. Preparatory work, July to September 2022. - Specific actions needed to address these issues and challenges will be identified, new evidence to support any revised policy approach will be reported to Members (including via the 5 December 2022 JLP Partnership Board meeting to report key findings, gaps, and commissioning of any new evidence, including learning from the 2050 CliMobCity Project. October 2022 to March 2023.

	- Develop options for new or amended JLP policies, working with a wide range of stakeholders, the public and elected members to test and explore how policies could be amended. March 2023 to August 2023.
2b. Estimated impact	Low impact in terms of direct reductions to carbon emission from mobility. Direct impact on the policy difficult to estimate in advance, however, carbon impacts will be addressed in the scoping papers.
2c. Relations	Information regarding projects showcased / explored within the 2050 CliMobCity project that are not progressed through CEAP4 (Action 2) but are assessed as being potentially valuable and applicable in Plymouth in the medium / long term will be considered in the policy review and development activities within Action 3.
3 Stakeholders involved	None
3b. Responsible Actor	Daniel Forster, Transport Planning Officer, Plymouth City Council
4 Timeframe	August 2022 to August 2023
5 Costs	No costs other than staff time.
6 Funding sources	N/A.
7 Priority	High. This action is fundamental to the aims of the project. It is urgent as the review of the Plymouth and South West Devon Joint Local Plan is already underway and the window to influence the policy instrument is time limited.

Feedback from the municipal reflection on the CO_2e reduction (DF, JG)

The UK Max scenario envisages the simultaneous, rapid, planning and implementation of all local transport interventions (30 physical and local policy measures altogether) in Plymouth that have been implemented at least once in the UK and that would, by a variety of means, aid in the decarbonisation of mobility in Plymouth.

Against the backdrop of very limited success to date in decarbonising mobility (despite this being an explicit national and local policy objective for around two decades), this deliberately ambitious theoretical exercise provided an unusual and valuable opportunity to assess the potential for the wide array of local measures currently delivered and deliverable in the UK to achieve decarbonisation of mobility at the scale needed to meet the city's decarbonisation target.

Given the sheer number and range (and in some instances, scale) of measures included in the UK Max scenario, model outputs indicating significant per capita carbon reductions were anticipated. Equally, however, the preponderance within the UK Max package of measures intended to improve the attractiveness of the sustainable modes 'offer' alongside the relative scarcity of measures available to UK local authorities that would serve to deter the continued predominant use of private internal combustion engine car use (by impacting on their speed, geographical access or cost of use), informed an expectation that the results would show that the UK Max measure package, while ambitious, would nevertheless prove insufficient to enable our decarbonisation target to be met. Consequently, model outputs suggesting a per capita CO_2e reduction of up to 20% are within range of expectations and seem plausible, if mobility measures as in UK max show the expected mobility

change. If also the electrification of cars can be accelerated, a per capita reduction of perhaps 35% may belong to that range.

The CO_2e model results are also sobering: through the CliMobCity 2050 project it has been established that an extremely ambitious measure package which PCC, in common with other UK municipalities, has no immediate prospect of having the funding or organisational capacity to fully deliver in the necessary timeframe would only take the city around one third of the way towards achieving its decarbonisation target.

Consequently, responding to comparable preliminary CO_2e modelling outputs in 2022, PCC was determined to comprehensively exploit the many and diverse learning opportunities and insights that have arisen from participation in the 2050 CliMobCity project through site visits, seminar presentations, and the mobility and carbon modelling outputs to bring forward new or improved concrete measures or improvements to our policy instruments.

In addition to an Action Plan (AP) action relating to the construction of Plymouth's Mobility Hubs network (launched in March 2023), this resulted in an AP action to '*systematically assess other projects explored / showcased within the 2050 CliMobCity project*' for potential delivery in Plymouth both during and beyond the AP delivery period. It also resulted in an AP action to '*fully leverage the findings of Plymouth City Council's 2050 CliMobCity mobility and carbon modelling work in the forthcoming formal policy review of the JLP*' in pursuit of concrete improvements to our policy instrument via a formal, multi-stage policy review process that will be vital if we are to close the gap between MoP's current mobility carbon emissions trajectory and our Climate Emergency goal to achieve net zero by 2030.