MORE Final Conference

Embodied Carbon in the Streetscape

17th September 2022

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769276.

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Units of Measurement

CO2 – Carbon dioxide

CO2e – Carbon dioxide equivalent is used to compare emissions from various greenhouse gases based on their global warming potential, in relation to the comparative CO2 impact

Embodied/capital carbon – the CO2 emissions related to the production/materials/manufacture of an element

Operational carbon – the CO2 output relating to the operation of an element

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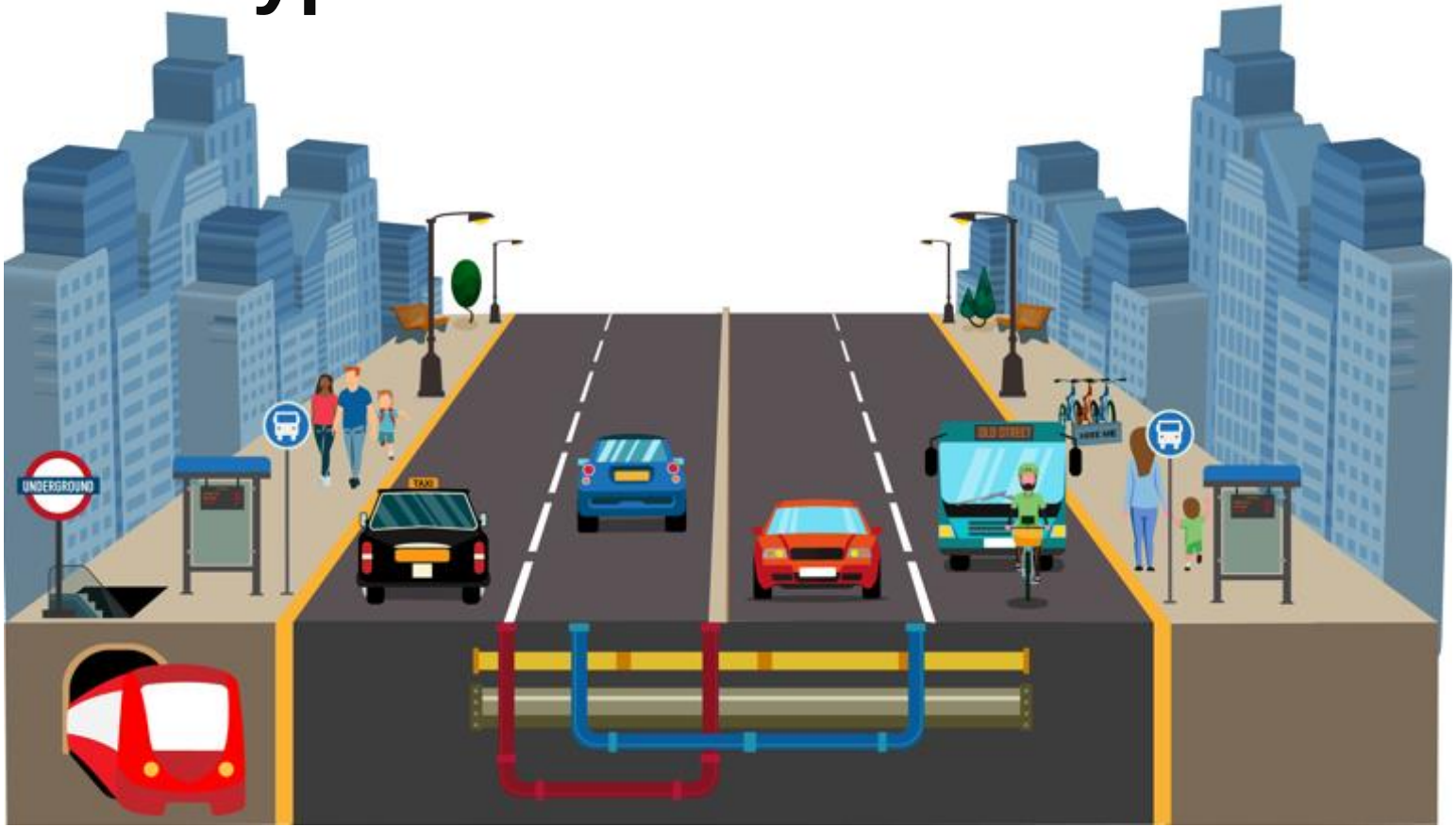
The Typical Street



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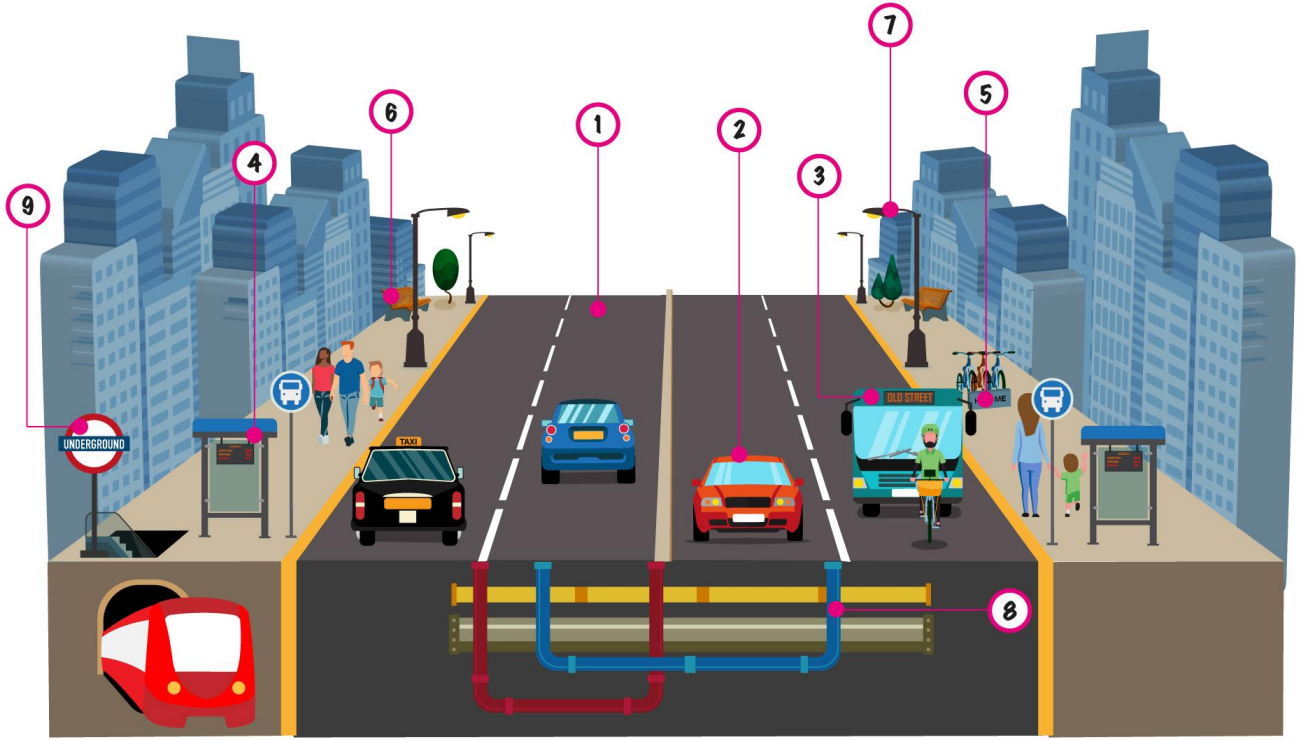

1. Road surface
2. Cars (Internal combustion engine)
3. Buses (Internal combustion engine)
4. Bus stops
5. Cycle hire stand
6. Street furniture
7. Street lighting
8. Utilities
9. Underground/Metro

Typical Street - Road Surface

- In the UK asphalt is used to construct over 95% of roads
- 44% of capital CO2e derives from the aggregate and binder
- 42% of capital CO2e is emitted through heating and drying
- 14% of capital CO2 comes from mixing and delivery
- **Capital Carbon – approx. 50 kg CO2e per tonne of asphalt**

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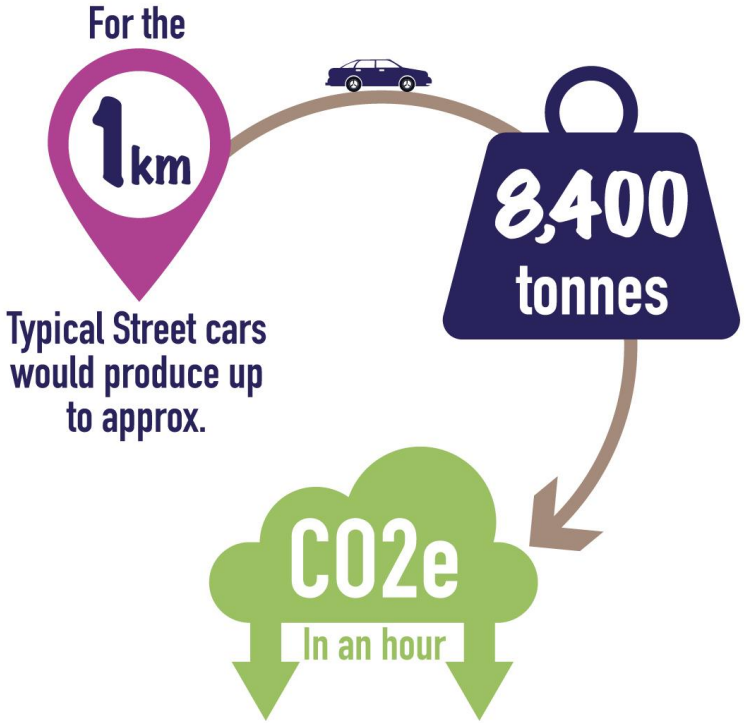
Typical Street – Cars (ICE)

- ICE refers to Internal Combustion Engine
- Embodied carbon values vary widely
- Some sources state that in the production stage an average ICE car generates 720kg of carbon per £1,000 spent
- A medium car worth £24,000 is therefore estimated to generate 17 tonnes of CO2e before driving its first mile
- Other sources state that a mid-size ICE is calculated to generate around 5.6 tonnes of CO2e in its production phase. This figure has been used to estimate the impact on the Typical Street
- **Capital Carbon – approx. 5.6 tonnes CO2e per medium sized car**
- Over the lifetime of a car (average 13.9 years) this medium sized car is a further 27 tonnes of CO2e



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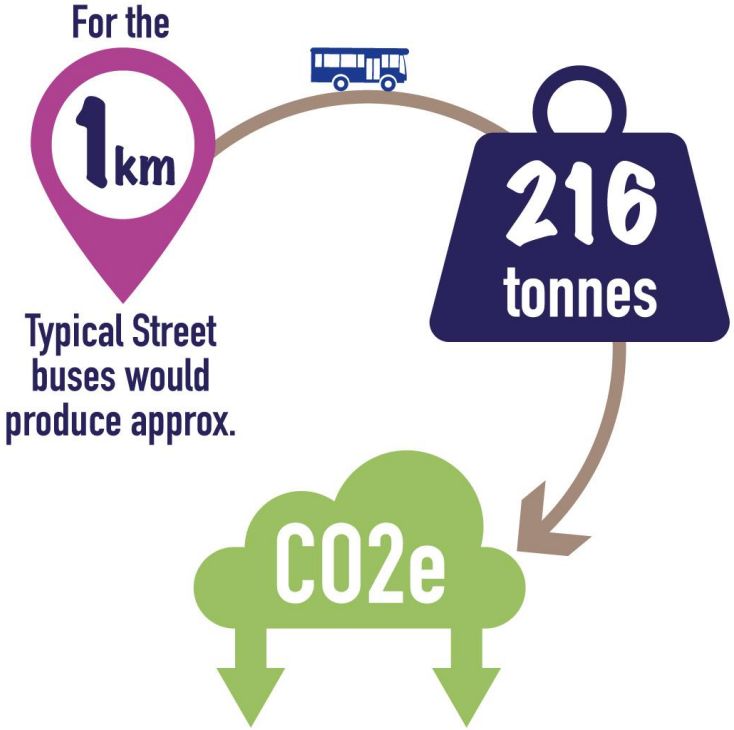
Typical Street - Buses

- A standard diesel bus at 12m produces between approx. 45.5 to 54 tonnes of CO2e in materials
- Metals make up around 1/3rd of the capital CO2e followed by electrical components and double glass
- The materials form approx. 1/3rd of the capital emissions from manufacture (excluding the process and transport emissions)
- **Capital Carbon – approx. 54 tonnes CO2e per bus**
- Over its operational lifetime is when the majority of CO2e is emitted, this being an average of 822g of CO2e per km driven (approx. 3,431 tonnes of CO2e per bus)



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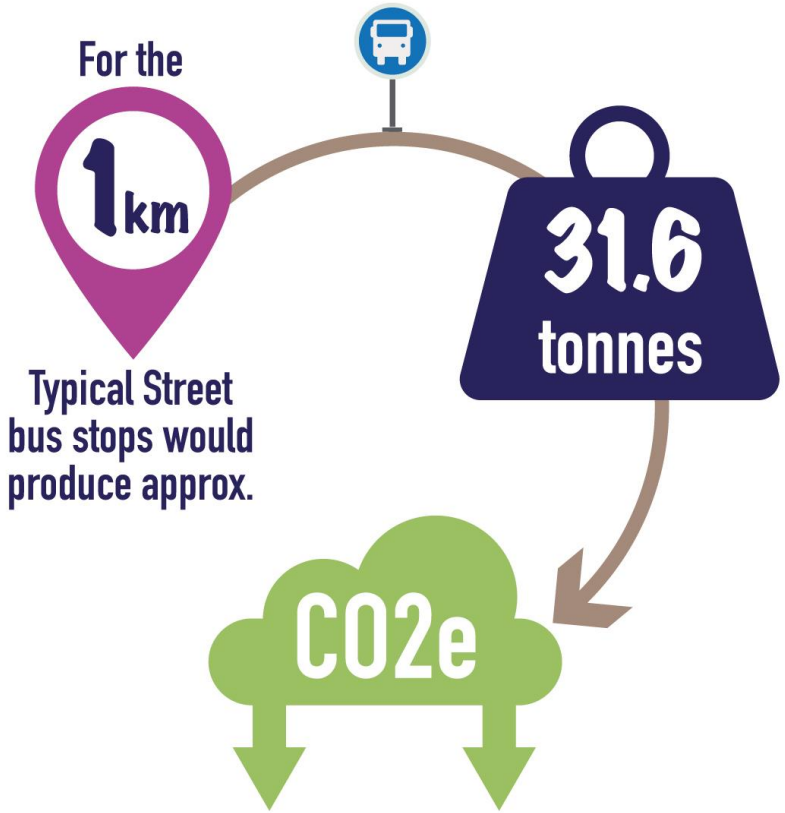
Typical Street – Bus Stops

- **Capital Carbon – approx. 7.9 tonnes CO2 per bus stop**



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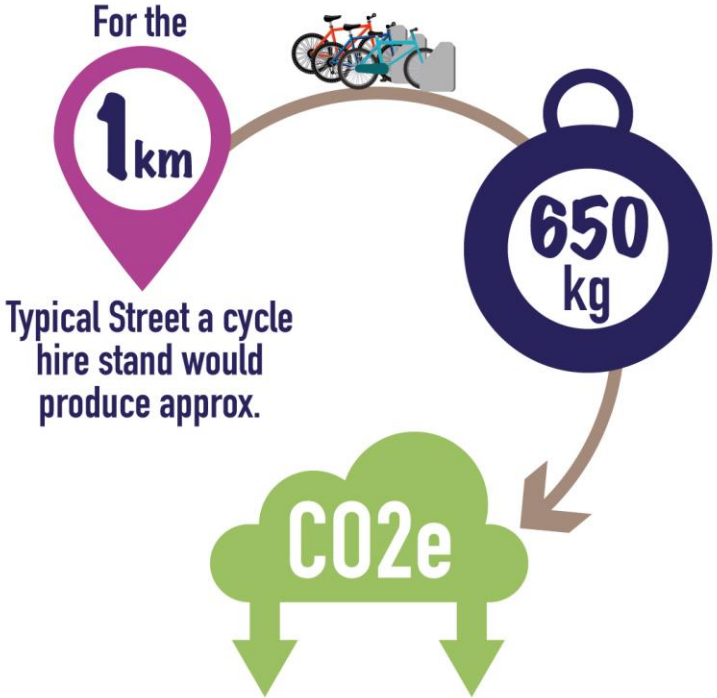
Typical Street – Cycle Hire Stand

- The carbon footprint relates to the materials, production, and maintenance (rebalancing of bikes)
- **Capital Carbon – approx. 65 kg CO2e per bike**
- The operational carbon footprint is almost neutral but will include fuel for the rider (food) and heat produced. The total carbon footprint is estimated to be approx. 2 tonnes of CO2e in 5 years



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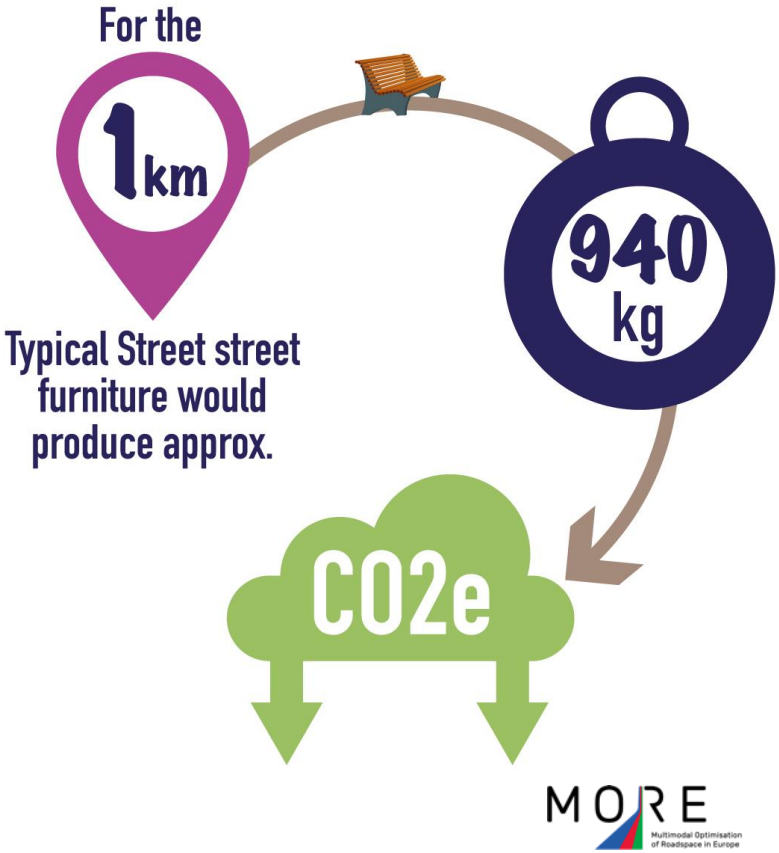
Typical Street – Street Furniture

- Street furniture varies enormously from artwork to benches
- **Capital Carbon – approx. 47 kg CO2e per average piece of furniture**



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Typical Street – Street Lighting

- LED bulbs are already replacing traditional incandescent bulbs in street lighting
- **Capital Carbon – approx. 5.3 kg CO2e per LED bulb**
- An LED bulb emits between 167 and 264 kg of CO2e over a 20-year lifespan (98% of this is the operational emissions)

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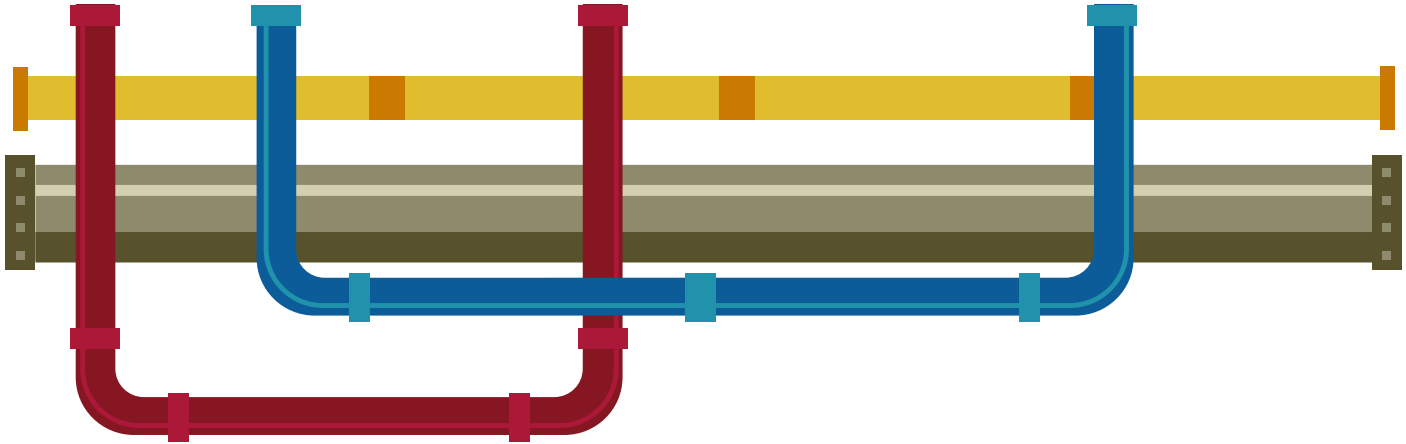
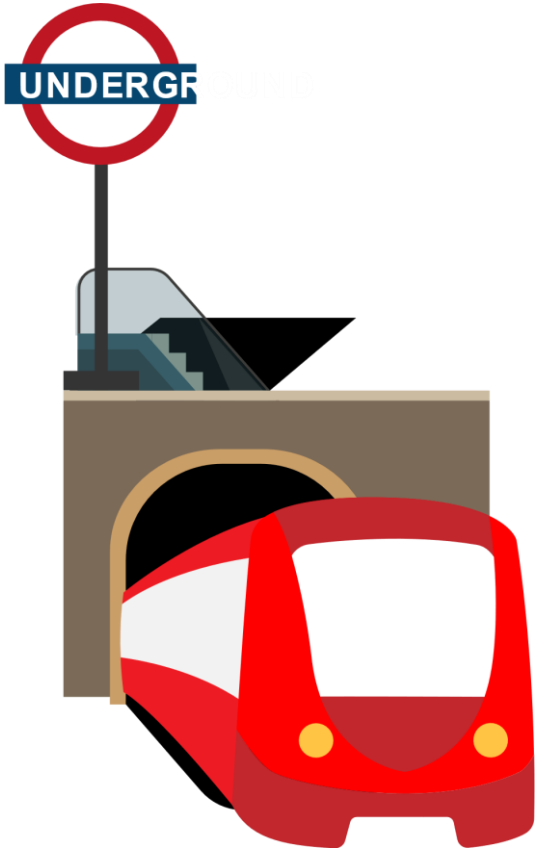
Typical Street - Utilities

- Gas lines, electricity supply, broadband cables and housing, drainage, water supply etc
- An HDPE (High Density Polyethylene) pipe has a smaller carbon impact than a streel pipe. Concrete, PVC, clay and iron lay in between.



Typical Street – Underground/Metro

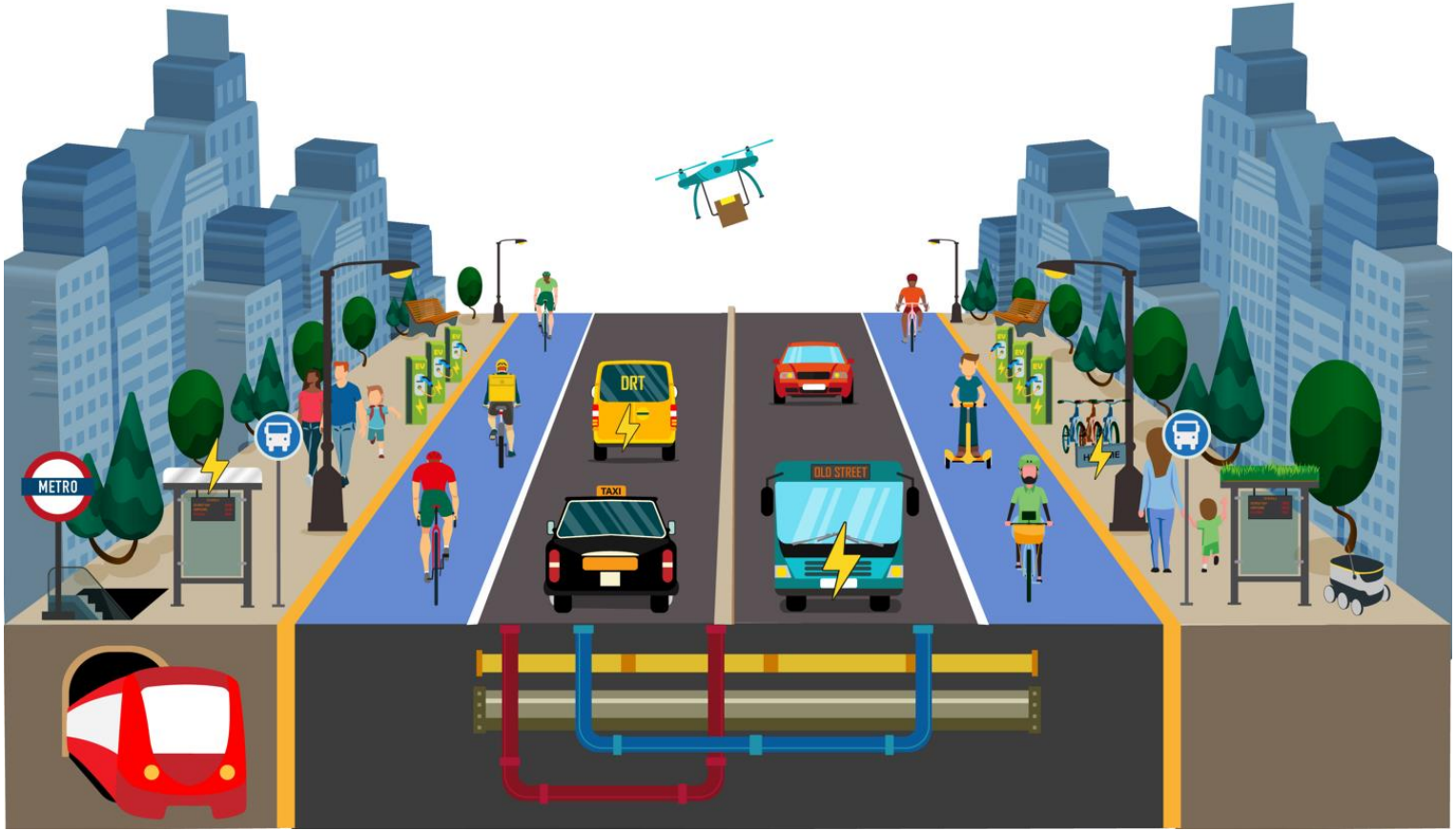
- Total carbon footprint of the London underground is approx. 754,000 tonnes of CO2e (2007/8)
- This is approx. 94 tonnes of CO2e per km in a year in operational impact



The Typical Street

Street Element	Capital Carbon	Operational Carbon (10 years)
Road Surface	16.5 tonnes	-
Cars	8,400 tonnes	3,547,800,000 tonnes
Buses	216 tonnes	686,200 tonnes
Bus Stops	31.6 tonnes	-
Cycle Hire Stand	650 kg	3.9 tonnes
Street Furniture	940 kg	-
Street Lighting	174.9 kg	-
Utilities	-	-
Underground	-	-
Estimated Total	8,666 tonnes	3.5 billion tonnes

The Future Street



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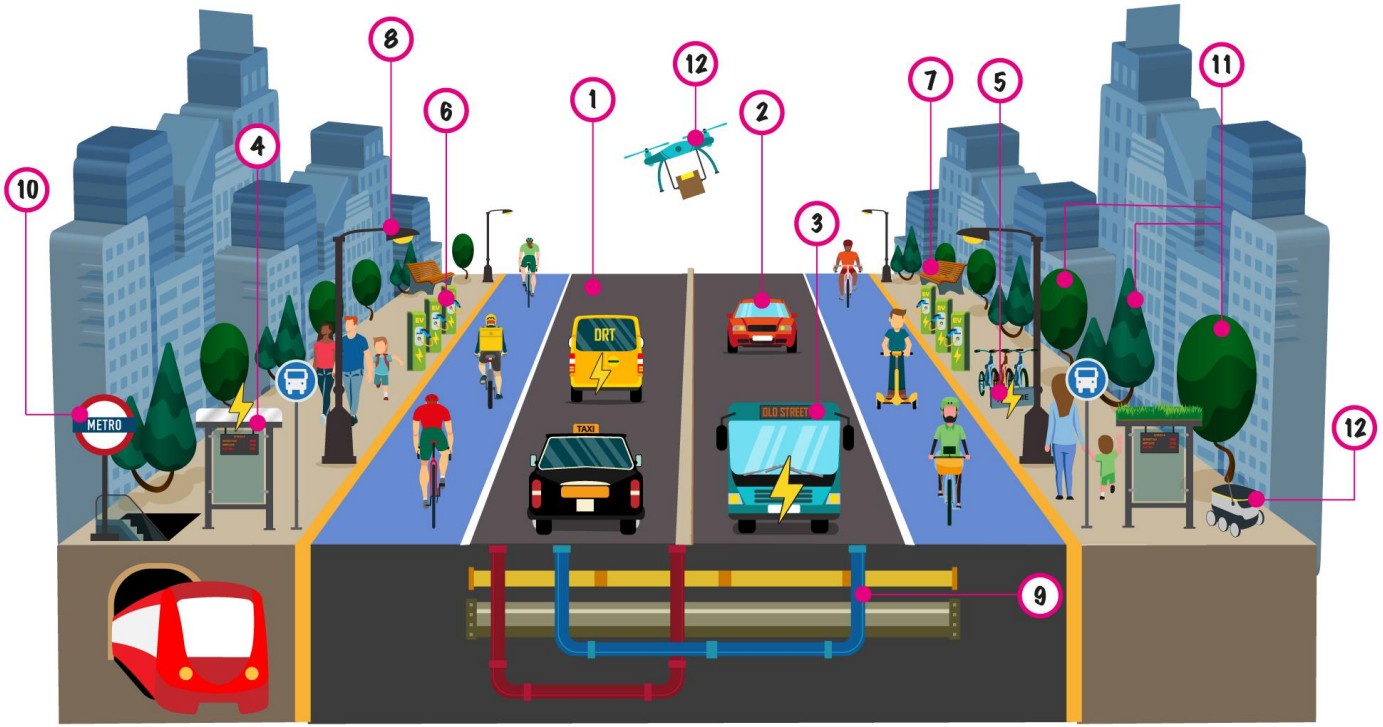

1. Road surface
2. Cars (electric)
3. Buses (electric)
4. Bus stops
5. Electric cycle hire stand
6. Electric vehicle charging point
7. Street furniture
8. Street lighting
9. Utilities
10. Underground/Metro
11. Trees & Vegetation
12. Ground & Air drones

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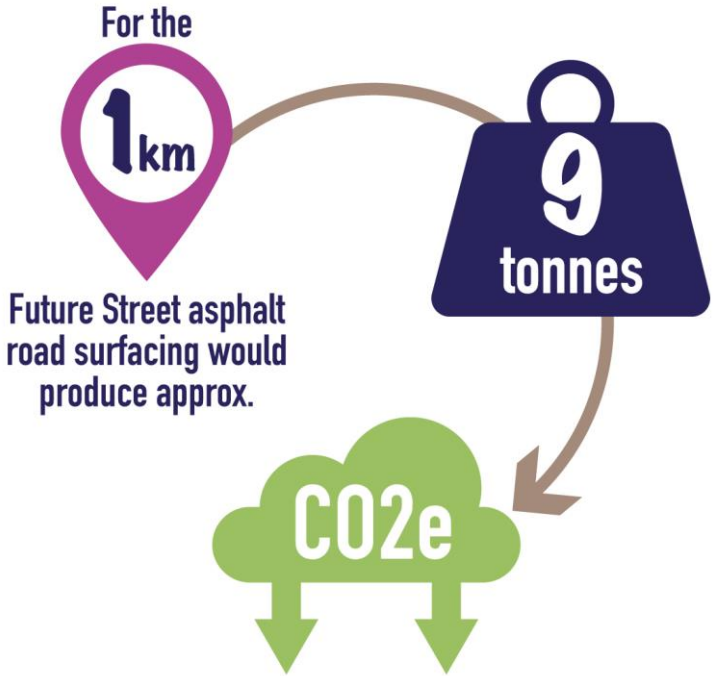
Future Street - Road Surface

- Asphalt is recyclable with 100% of its materials suitable for reuse into new asphalt
- Recycling of asphalt cuts 44% of carbon emissions compared to new asphalt
- Average asphalt road lasts for 18 years
- **Capital Carbon – approx. 28 kg of CO2e per tonne of asphalt**
- Extending the life of asphalt from 20 years to 40 years, then recycling, the carbon footprint reduces from approx. 2.5 kg CO2e per tonne per year, to 0.7 kg CO2e per tonne per year



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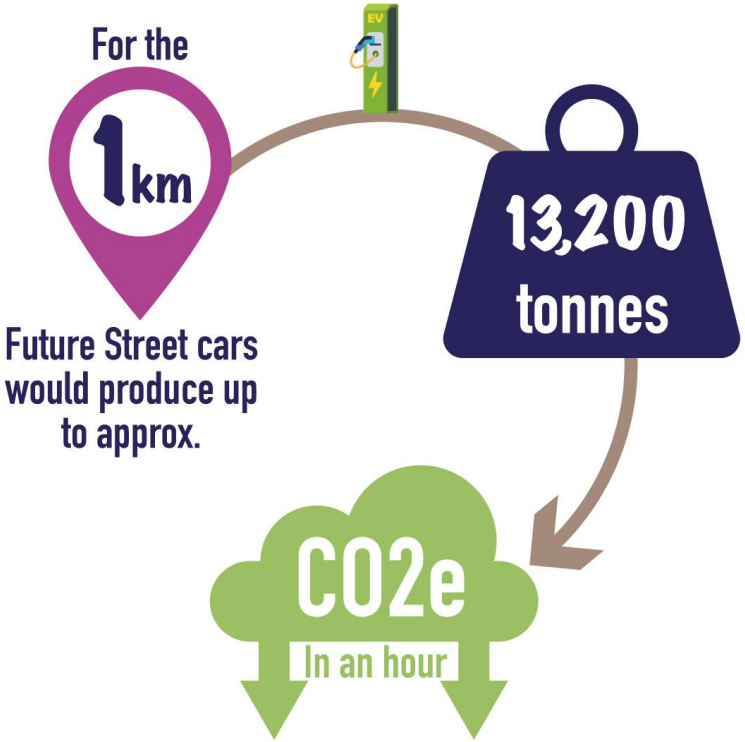
Future Street – Cars (EV)

- EV refers to electric vehicles
- Embodied carbon values vary widely based on the size/composition of the car
- Due to the high concentration of embodied carbon for the car battery, EV cars have a higher carbon impact in production than ICE cars
- **Capital Carbon – approx. 8.8 tonnes CO2e per medium sized car**
- 28,000 km driven is the 'breakeven' point where an EV has a positive carbon impact over an ICE (capital and operational carbon)
- The carbon footprint of operation relies on grid electricity production. In 95% of the world it is estimated that it is cleaner to drive an EV



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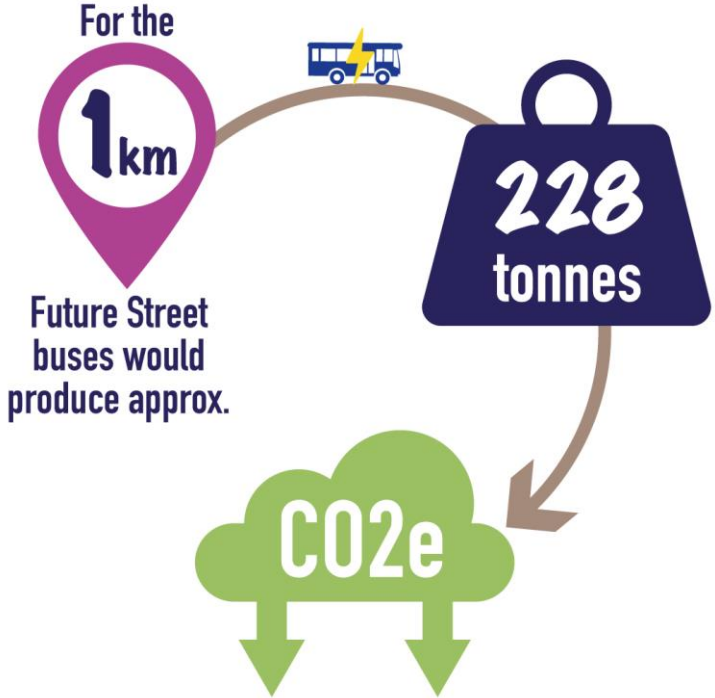
Future Street - Buses

- A hybrid bus produces approx. 49 tonnes of CO2e
- A fully converted electric bus produces 51 tonnes of CO2e
- A new electric bus produces approx. 57 tonnes of CO2e
- **Capital Carbon – approx. 57 tonnes CO2e per bus**
- Over its operational lifetime a fully electrical bus is approaching carbon neutrality dependent on electricity production powering the grid



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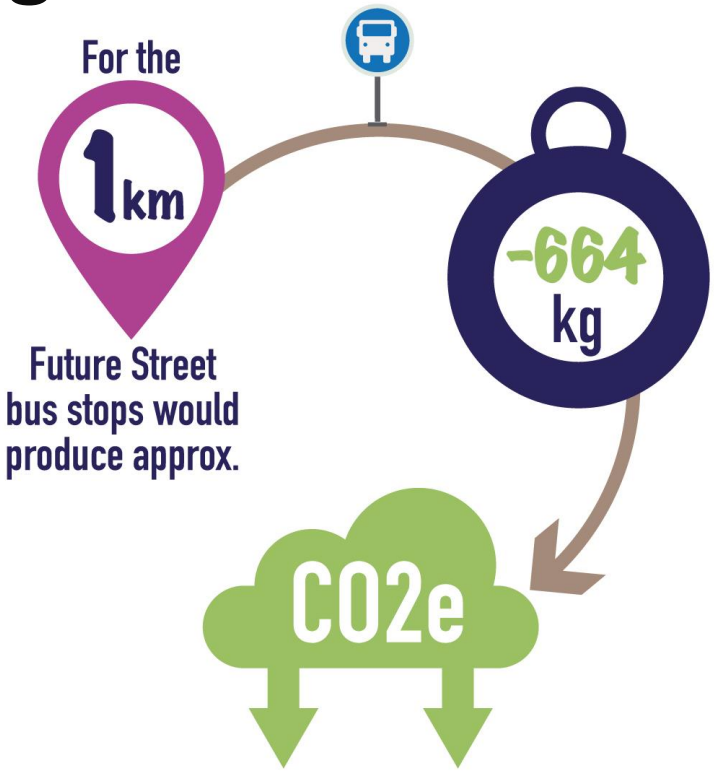
Future Street – Bus Stops

- **Capital Carbon – approx. negative 166 kg CO2 per bus stop**
- More carbon savings could be made through schemes such as ‘green roofs’



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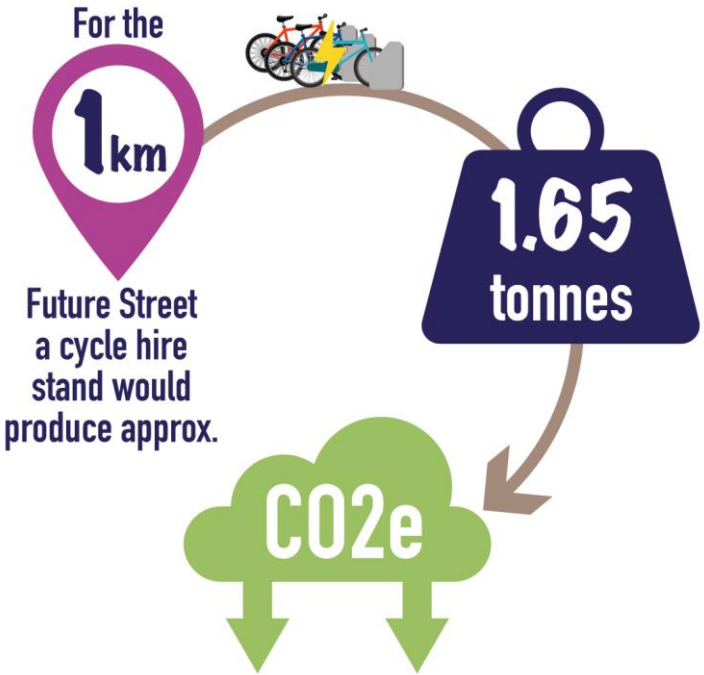
Future Street – Electric Cycle Hire Stand

- **Capital Carbon – approx. 165 kg CO2e per bike**
- The operational carbon footprint is increased from a push bike and is dependent on the electricity source. Also given the increased weight it is estimated that the impact of rebalancing the bikes is higher
- There will be wider benefits of replacing car trips with e-bikes for short to medium length journeys. The carbon impact of this has not been quantified



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Future Street – EV Charging Point

- This is a new element for the Future Street and will add to the overall capital carbon of the street. However the benefit of facilitating the use of EVs is clear
- The carbon footprint of the electricity supply determines the operational impact, this is moving towards carbon neutrality, however currently this equates to approx. 40 g of CO_2 per km driven by an EV

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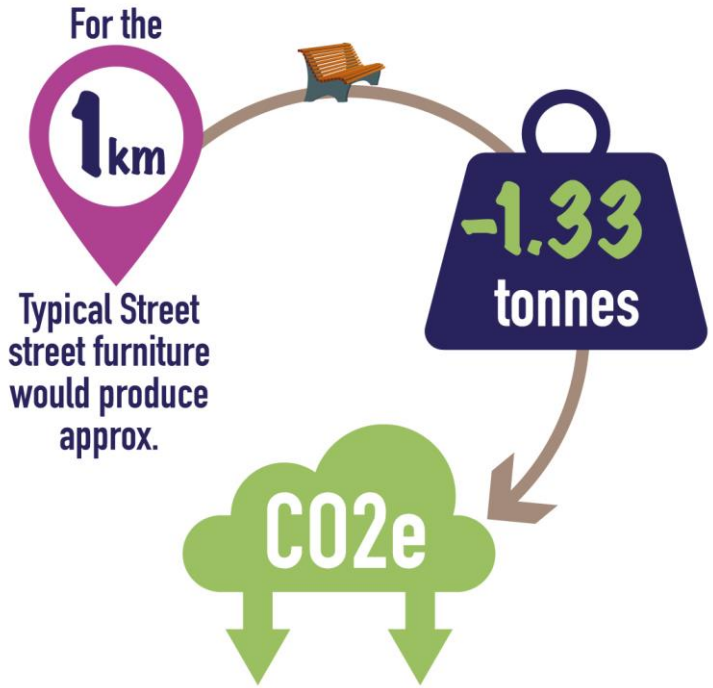
Future Street – Street Furniture

- Wooden benches have enormous benefits to carbon emissions over other materials
- **Capital Carbon – approx. negative 113.5 kg of CO2 per bench**



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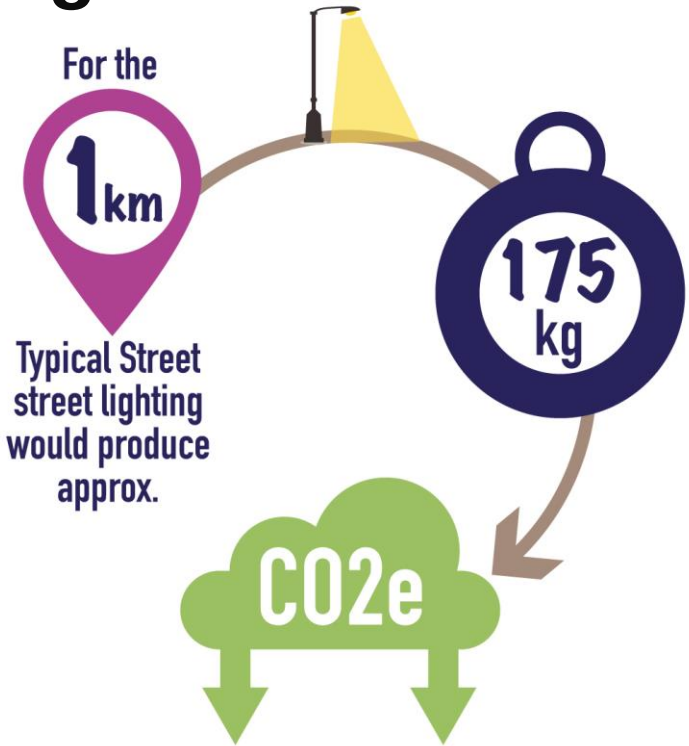
Future Street – Street Lighting

- LED bulbs are already replacing traditional bulbs
- **Capital Carbon – approx. 5.3 kg CO2e per LED bulb**
- The operational carbon depends on the energy source, which is moving towards neutrality.
- Heat will still be emitted



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Future Street - Utilities

- Material choice for utilities is restricted by the functional technical capabilities of each service
- Broadband is already moving from copper to fibre optic wiring. This results in a reduction of exchanges and less heat, meaning less cooling is needed and therefore less energy
- Extraction of 2kg of copper needed for a 200 foot length of wire produces approx. 1 tonne of CO2e
- Production of the equivalent length of fibre optic cable produces 0.06 kg of CO2e

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Future Street – Underground/Metro

- London is working towards neutralisation of carbon emissions from the Underground
- One scheme is to use the heat created by the underground to meet 38% of the city's heating needs
- It is also intended to reduce energy spent by braking less
- Solar panels are also planned to be introduced alongside railway tracks, as well as building battery storage on the network
- London is working toward a carbon neutral underground by 2050

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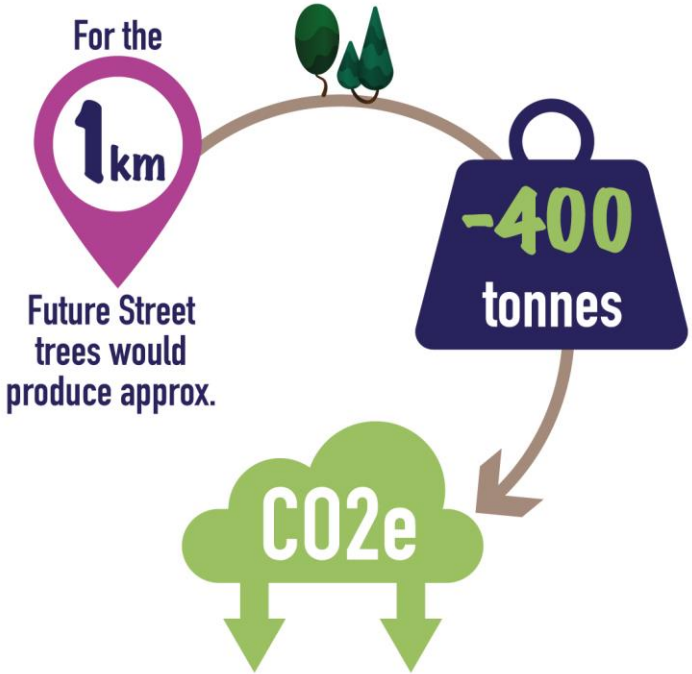
Future Street – Trees & Vegetation

- Many streets already have grass verges and trees, although it is thought that more can be done to create carbon sinks in the streetscape
- Trees sequester a meaningful amount of carbon once fully grown and over a lifetime
- **A typical tree sequesters approx. 1 tonne of CO2 over a 100 year lifetime**



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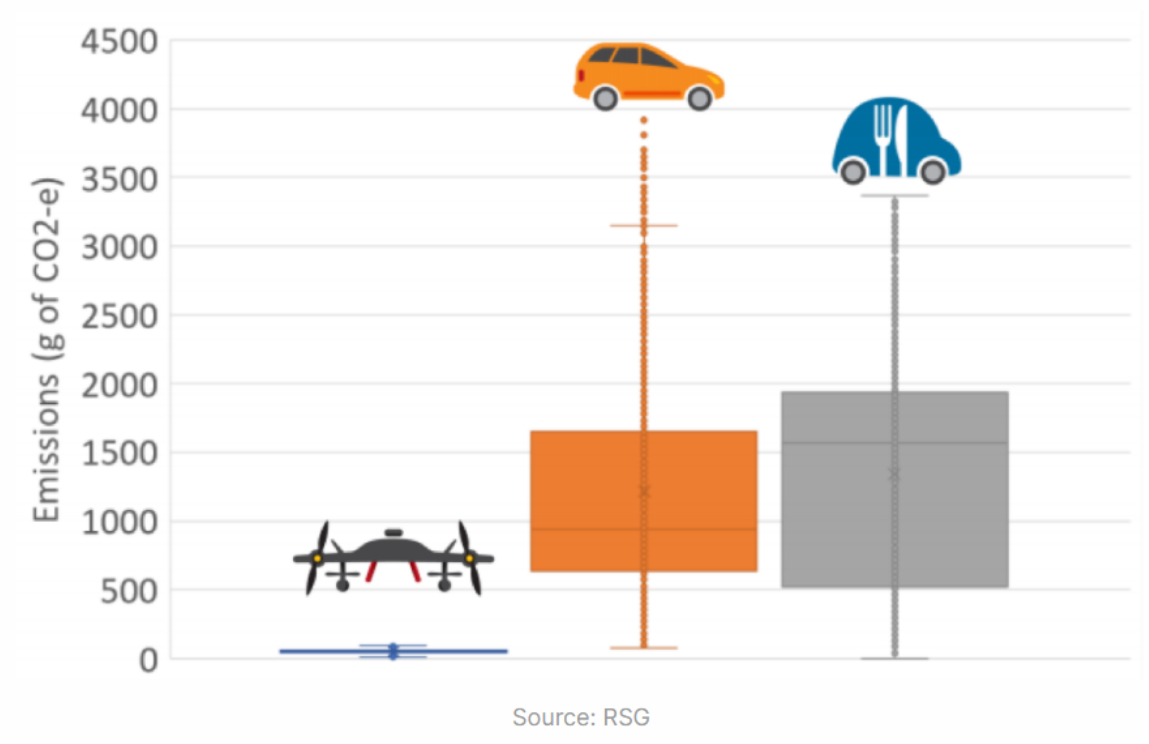
Future Street – Ground & Air Drones

- Ground and air drones are a new innovation which are rapidly gaining in popularity for deliveries, replacing car and van trips
- An air drone is at least 26 times more efficient than the alternative mode of transport



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The Future Street

Street Element	Capital Carbon	Operational Carbon (10 years)
Road Surface	9.24 tonnes	-
Cars	13,200 tonnes	Neutral
Buses	228 tonnes	Neutral
Bus Stops	negative 664 kg	-
Cycle Hire Stand	1.65 tonnes	Neutral
EV Charging Point	-	-
Street Furniture	negative 1.33 tonnes	-
Street Lighting	174 kg	Neutral
Utilities	-	-
Underground	-	Neutral
Trees & Vegetation	negative 400 tonnes	-
Ground & Air Drones	-	-
Estimated Total	13,037 tonnes	Neutral

Carbon Savings in the Streetscape

Street Element	Capital Carbon	Operational Carbon (10 years)
Road Surface	-7.26 tonnes	-
Cars	4,800 tonnes	-3.5 billion tonnes
Buses	12 tonnes	-686,200 tonnes
Bus Stops	-32.3 tonnes	-
Cycle Hire Stand	1 tonne	-3.9 tonnes
EV Charging Point	-	-
Street Furniture	-1.5 tonnes	-
Street Lighting	-900 g	-
Utilities	-	-
Underground	-	-
Trees & Vegetation	-400 tonnes	-
Ground & Air Drones	-	-
Estimated Total	**4,371 tonnes**	**-3.5 billion tonnes**

Limitations & Future Research Needs

All values reported are approximations and average values are used

Information on the capital carbon of street lighting, EV charging points, drones, and utilities

Capital carbon composition including materials and manufacture of buses

Capital carbon of an underground service

Further research on the impact of streetside buildings including materials and services

The impact of working from home/remotely on carbon in the streetscape offset against higher energy spending within the home and attributed trips (shopping etc)

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Thank you !

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