CIRCULAR
ECONOMY
IN CITIES

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DESIGNING MOBILITY ASSETS FOR COMPONENT AND MATERIAL RECIRCULATION

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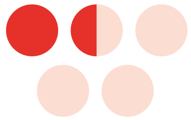
DESIGNING

The design of mobility assets – from vehicles to infrastructure – is key to reaping the benefits of a circular economy transition. Decisions made at the design stage of an asset strongly determine whether waste and pollution are designed out of the system, and whether the asset and the materials in it can be kept in use at their highest value. The design of mobility assets also has an impact on the number of vehicles on the roads, how easily vehicles can be adapted for variable use, whether mobility assets can support the urban energy system, and what type of materials they can be made of.

CASE FOR CHANGE

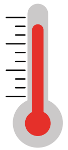


In Europe, only **1.5 out of 5 seats** are typically occupied in a car during use[1]

Only **10%** of roads are used during rush hour in Europe[2]

90%

90% of urban residents in Europe are exposed to harmful levels of air pollution[3]



50% of European inner-city land is paved for roads and parking leading to higher temperatures and higher risk of flooding[4]

One heavily loaded truck can inflict as much road damage as **10,000** passing light-duty vehicles[5]

EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITIES

Designing vehicles for adaptable and shared use

Designing vehicles of all types for maximum use potential and the ability to remanufacture is important in order to get the most out of the materials used. Modularity, in which parts can be swapped in and out, and/or space in the vehicle can be reconfigured, can enable longer use while responding to the user's needs for changes and repair.[6] Flexible interiors in freight vehicles can be designed to support the simultaneous delivery and collection of goods and recyclables. In such flexible interiors, different loads are separated in sections that can shrink or expand, which maximises the usage of vehicle capacity.[7] Vehicle automation technology can be used to support vehicle sharing and mobility-as-a-service schemes (MaaS) (see *Mobility: Accessing*).

Designing for zero-emission transport vehicles and energy grids

Designing vehicles to use renewable energy is an important measure to reduce pollution in cities and support a shift away from finite energy resources. In addition, electric vehicles and fleets in cities can support the urban energy grid via battery energy storage (see also *Mobility: Planning*), while existing conventional vehicles can switch to biofuel made from by-products with low conversion costs. Developments in zero-emission fuel-cell technology also have the potential to decrease the negative impacts of urban mass-transit vehicles.[8]

Designing transport infrastructure for adaptable use

Several permanent or flexible solutions can be applied to make better use of urban land that is used for mobility. An example includes dynamic street-use restrictions which promote specific transport modes at certain times of day (e.g., prioritising road space for bikes indicated by LED lights in the road, or freight-lane restrictions). Simple and low-cost design interventions such as moveable street furniture (e.g., moving a potted plant or a bench onto the road) can also indicate a temporary change in the use of the road.[9]

Designing regenerative, energy-positive mobility infrastructure

In cities, the design of mobility infrastructure can support the regeneration of natural systems and contribute to energy production. Permeable pavements can allow rainwater to filter through, helping cities to manage stormwater, reduce soil and water pollution, and restore groundwater stocks.[10] By adding lighter, reflective colours to pavements, cities can be naturally cooled.[11] More emerging technologies and designs are also being trialled; in Jinan in China a 1 km ring road paved with solar panels generates around 1 million kWh a year;[12] in London, a street generates electricity when people walk on it while customised paint purifies the air;[13] and London's new Crossrail is designed to capture wind energy from passing trains.[14]

RELEVANT CASE EXAMPLES

Circular vehicle design with circular business models

Open Motors provide modular, locally assembled, electric, and self-driving vehicles that are designed for MaaS systems. The service involves its customers in the designing and assembly of customised fleet vehicles. Customers are able to achieve their designs in half the time and at a sixth of the cost of a ‘regular vehicle’. The modular design allows for direct replacement of broken or outdated individual components, enabling fleets to last 10 times longer. The vehicles can be shipped in component crates and assembled locally in a simple workshop or microfactory. This process can lower environmental impact, create local jobs, and decrease import taxes and assembly costs.[15] Another innovative example of circular vehicle design is Riversimple’s Rasa. Rasa is a hydrogen fuel-cell powered car. The chassis is made of very lightweight fibre composites and weighs less than 40 kg. To fully realise the opportunities of this new design, Riversimple uses a distributed manufacturing model and maintains ownership of the vehicle by selling access to it in a circular service-based ownership package which includes use-right of the car, maintenance, insurance, and fuel.[16] See *Products: Making for more about distributed manufacturing.*

Dynamic road use in Copenhagen and Barcelona

In Denmark, Copenhagen is experimenting with intelligent LED lights in the road that divide the street into dynamic lanes that signal which form of transport has priority on the road, and when. For example, the cycling tracks can be widened during morning rush hour and then contracted when there are more pedestrians and fewer cyclists. By letting the street follow the natural rhythm of the city and not vice versa, the city expects to improve transport flows and revitalise certain areas.[17] A similar scheme has been implemented in Barcelona. Here, six boulevards alternate between restricting general traffic, freight, and residential parking while LED lights and variable road signs inform drivers of the ‘rules of the road’ in real time.[18]

Flood proofing and smog-eating streets in Chicago

In the City of Chicago, 65% of open space is paved and heavy rainfall in the area exacerbates the issues of flooding and water pollution. Through a range of new pavement projects, the city is addressing these issues and, at the same time reducing air pollution, the heat-island effect, and waste production, and improving walking and biking facilities. For example, alleys and sidewalks are paved with a permeable surface, which includes 30% recycled content. Some streets also use photocatalytic cement which ‘eats’ air pollutants through a chemical process.[19]

EXAMPLES OF WHAT URBAN POLICYMAKERS CAN DO

Infrastructure **financing** can be an important focus for city governments and improved in **partnership** with others. By implementing circular economy principles in **public procurement** specifications, city governments can incentivise better designs of roads, bridges, and publicly owned vehicle fleets. Some cities also have the authority to restrict the use of polluting vehicles through **fiscal measures** (taxes, charges) or **regulation** (bans, zoning) which also create market incentives to further vehicle design developments.[20]

To explore further see **Policy Levers**

EXAMPLES OF LINKS TO OTHER SYSTEMS AND PHASES

Building: Planning and Mobility: Planning Compact city development can be a key opportunity to free up land used for transport and increase utilisation and cost effectiveness of urban mobility infrastructure. Subsequently it can also reduce the need for additional infrastructure by countering urban sprawl.

Mobility: Making The phases of designing and making overlap and are interconnected, increasingly so when the design phase takes material sourcing, manufacturing, and construction methods into account from the outset.

Mobility: Operating and Maintaining Vehicle and infrastructure design will have a significant impact on the maintenance and repairability of mobility assets and components.

Products: All The way the products system works in cities, from planning, designing, and making to accessing, operating, and maintaining is strongly linked to how the mobility system is planned and designed.

EXAMPLES OF BENEFITS

ECONOMIC PRODUCTIVITY

Reducing remanufacturing costs

Designing vehicle parts to be remanufactured can reduce the cost of remanufactured vehicles by 30–50%.[21]

Reducing maintenance costs

Maintenance costs of electric vehicles can be 50–70% less than internal combustion engine vehicles as they do not require transmission fluid, engine tune-ups or oil changes, and experience dramatically less brake wear due to regenerative braking.[22]

Reducing public spending

The electrification of Shenzhen's 16,000 buses resulted in 70% savings in fuel costs.[23]

Increasing road-use efficiency

With sufficient take-up and integrated implementation, autonomous vehicles could close the space between cars (1.5 metres versus 3–4 car lengths today), reduce congestion, and improve road use.[24]

RESOURCE USE

Reducing urban car fleets

And OECD study estimates, that the introduction of shared autonomous vehicles integrated with mass-transit could, in theory remove 9 out of 10 cars in European cities and free up a significant amount of parking space.[25]

Substituting fossil fuels

A transition to locally produced biofuels for publicly owned heavy vehicles in the Central Denmark Region led to the substitution of 11 million litres of diesel annually.[26]

HEALTH AND ENVIRONMENT

Reducing particulate emissions

Electrification of Shenzhen's 16,000 buses was a key factor in meeting the city's air quality goals and reducing the annual number of smoggy days from 115 in 2010 to 35 in 2015.[27]

Reducing CO^2 emissions

A transition to locally produced biogas (from manure and agricultural by-products as well as industrial ones) for publicly owned heavy vehicles in the Central Denmark Region led to a reduction of 26,700 tonnes of CO^2 annually.[28]

Reducing soil and groundwater pollution

Studies have seen permeable asphalts, concretes, and pavers remove up to 99% of some pollutants (such as metal, oils, and bacteria) from infiltrated stormwater – preventing those toxins from entering the groundwater or stormwater system. Average run-off reduction from porous pavements varies between 50% and 93%.[29]

Reducing accidents

With sufficient penetration and integrated implementation with the expansion of public transport, autonomous vehicles can cut accidents by up to 90%.[30]

Countering urban heat-island effect

Reflective pavements can reduce temperatures by up to 20°C.[31]

JOBS, SKILLS, AND INNOVATION

Creating jobs

A transition to locally produced biogas (rom manure, agricultural, and industrial by-products) for publicly owned heavy vehicles in the Central Denmark Region has led to approximately 100 new jobs developing the required infrastructure.[32]

ENDNOTES

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22 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 56

23 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 66; See *City Case Study: Shenzhen*

24 Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: a circular economy vision for a competitive Europe* (2015) p. 56

25 OECD, *Urban mobility system upgrade: How shared self-driving cars could change city traffic* (2015) p. 5

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