NICRE
National Innovation Centre
Rural Enterprise

# Innovation Concept Review

## E-cargo bikes and rural green logistics

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## Non-technical abstract

Achieving net zero ambitions in the UK requires action to reduce emissions from road transport. From a business perspective, innovative opportunities for reducing emissions lie in 'green logistics': more sustainable ways to transport and handle products from source to sale. Growing demand for online shopping and home delivery has made the 'last mile' to the customer's door increasingly important for logistics innovation.

This NICRE Innovation Concept Review (ICR) examines the potential for using electric cargo (e-cargo) bikes for last mile delivery in rural areas. The review draws from research evidence to consider how e-cargo bike logistics can help to reduce carbon emissions from the last mile, and whether e-cargo delivery services can bring benefits to rural businesses. The opportunities and challenges involved are outlined through four potential use cases:

1. Replacing existing local fuel delivery vehicles with e-cargo bikes.
2. Shifting parcels to e-cargo bikes for last mile delivery.
3. Using delivery to reduce individual shopping journeys in private vehicles.
4. Using delivery to support purchasing from local businesses.

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# Summary


Transport is currently the largest emitting sector for greenhouse gases in the UK (DfT 2021). 91% of these emissions come from road transport (DfT 2021). Achieving net zero ambitions requires action and innovation to reduce emissions from road transport. This will involve improving transport **efficiency**, **altering** journeys and transport modes, and **reducing** the need to travel or distance covered.

From a business perspective, innovative opportunities for reducing emissions lie in '**green logistics**': more sustainable ways to transport and handle products from source to sale. Growing demand for online shopping and home delivery has made the '**last mile**' to the customer's door particularly important for logistics innovation.

**Electric cargo bikes** (e-cargo bikes) offer one potential solution for reducing last mile emissions. To date, e-cargo bikes have largely been used in urban centres. However, e-cargo bikes' comparatively long range, small load sizing and ability to traverse difficult terrain are also suitable for rural conditions.

This NICRE ICR outlines the background to green logistics, considers the rural context, and introduces e-cargo bikes as an opportunity for rural enterprise. Four **potential use cases** are explored:

1. Replacing existing local fuel delivery vehicles with e-cargo bikes.
2. Shifting parcels to e-cargo bikes for last mile delivery.
3. Using e-cargo bike delivery to support local shopping.
4. Sharing an e-cargo bike in a village or market town.

There is empirical evidence that e-cargo bikes can reduce **direct (Scope 1) emissions** in one-to-one replacement for existing delivery vehicles (use cases 1 and 2) or substituting for individual journeys (use case 3). However, **indirect (Scope 2) emissions** are highly dependent on the electricity source for battery charging. E-cargo bikes cannot be truly claimed as a contribution towards net zero without accounting for indirect emissions.

There is currently insufficient evidence on the **business case** for e-cargo bikes in rural areas. Bike purchase remains a significant investment for a small business (use case 1), and third-party operators (use case 2) need a viable volume and business model. Although there are high hopes for supporting local shopping (use case 3), consumer behaviour is difficult to influence, and specific market research insights are still needed.

In sum, this review shows the potential for e-cargo bike logistics in rural areas but cautions against treating bikes as a simple solution for improved sustainability performance. Rather, using e-cargo bikes for green logistics requires **responding practically and pragmatically to local needs, challenges, and levels of demand**.

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# Background

### Transport and net zero

Transport is currently the largest emitting sector for greenhouse gases in the UK (DfT 2021). While emissions from energy, waste, and business have declined in recent decades, transport emissions have remained relatively static. 91% of emissions from transport come from road transport, including cars, taxis, heavy goods vehicles (HGVs), and vans (DfT 2021). Achieving net zero ambitions demands action and innovation to reduce emissions from road transport.

Transport is complex, and there is little agreement on exactly what a more sustainable transport system should look like (Berger et al. 2014). In general, transport researchers (e.g., Banister 2011, Berger et al. 2014, Creutzig et al. 2015) consider that improving sustainability performance involves three key changes:

- **Efficiency:** technologies to improve efficiency and reduce emissions.
- **Alteration:** shifting to more sustainable journey patterns and modes of transport.
- **Reduction:** reducing the need to travel, or the distance travelled.

All three changes involve innovation, planning interventions, and behaviour change. After all, an efficient technology cannot create sustainable outcomes if it is not used or usable. Equally, however, some positive changes can lead to other less positive effects. For example, ride sharing can utilise vehicles more efficiently, while increasing demand and distance at the expense of public transport or active travel (Long & van Waes 2021).

These examples suggest why reducing energy use and emissions from transport remains difficult to achieve (Banister 2011). Road transport is embedded in our daily lives (Berger et al. 2014), producing self-reinforcing dynamics (Mattioli 2016) at three different levels (Mattioli et al. 2016):

- **Micro level:** individual actions and choices about transport.
- **Meso level:** journey characteristics and practices.
- **Macro level:** wider systems and structural conditions.

Considering these levels helps describe the recent interlinked changes that have led to a growing need for innovation in 'green logistics'.

### Green logistics and the 'last mile'

While car travel remains the largest single source of road transport emissions in the UK (DfT 2021), net zero ambitions cannot be achieved without innovation in freight and logistics (Smil 2022). For many businesses – especially SMEs – action to reduce transport emissions will realistically lie in 'green logistics': more sustainable ways to transport, store, and handle products from source to sale or consumption (McKinnon 2010).

Green logistics potentially concerns all three 'Scopes' in the widely recognised Greenhouse Gas Protocol[1] accounting standards:

- **Scope 1:** direct emissions from sources owned and controlled by a business, e.g. fuel combustion and delivery vehicles.
- **Scope 2:** indirect emissions from energy generation purchased by a business, e.g. electric vehicle charging via the national grid.
- **Scope 3:** indirect emissions in business value chains, e.g. distribution networks and purchased goods.

In green logistics, the 'last mile' has gained particular attention. The last mile describes the delivery leg to a customer's door (which may be more than a physical mile). In recent decades, consumer demand, competitive markets, and new business models have created considerable growth and change in delivery services over the last mile (Deloison et al. 2020). E-commerce is a key driver for these changes.

### Changes in retail

In the UK, online retail sales have consistently increased each year since 2006, with a rapid surge following Covid-19 lockdown measures in 2020 (ONS 2022). Currently, online sales of physical goods comprise around one quarter of total UK retail sales (ONS 2022). Sales are diverse. Food and the textiles, clothing and footwear sector represent the largest proportions of UK online retail sales, although account for less than half of the total (Allen et al. 2017).

The ongoing 'digital shift' (Deloison et al. 2020) in retail has multiple knock-on effects for logistics. While traditional retail typically left the last mile to the customer, online orders now need to be dispatched to diverse destinations, often over greater distances. This adds complexity, increases costs, and introduces new inefficiencies, such as missed deliveries and returns (Allen et al. 2017, Cárdenas et al. 2017, Hood et al. 2020). There are also concerns about congestion and emissions caused by delivery vehicles (Visser et al. 2014).

At the same time, declining high streets create concern too (Local Government Association 2022, Rural Services Network 2021), and many lament the loss of local shops (Carr et al 2020). But, as Mary Portas (2011: 2) observed in her independent review of the future of UK retail: "The days of a high street populated simply by independent butchers, bakers and candlestick makers are, except in the most exceptional circumstances, over." New business models are necessary.

### The innovation opportunity

Both rising demand for delivery and emerging challenges create opportunities for innovative, sustainable solutions for last mile logistics. E-cargo bikes offer one potential solution. The next section introduces e-cargo bikes.

[1] https://ghgprotocol.org/

# The innovation: e-cargo bikes

Cargo bikes are designed for carrying heavy or bulky loads. Cycle delivery services have long existed, but sustainability and congestion concerns have renewed interest in using cargo bikes for the last mile (Narayanan & Antoniou 2022, Rudolph & Gruber 2017). Electric assist cycle motors, plus logistics algorithms and digital platforms, have proven crucial innovations here.

Electric bike markets emerged around the turn of the millennium (Weinert et al. 2007). In the EU, e-bike sales increased more than tenfold in the decade from 2006 to 2016 (CONEBI 2017). Supply and demand have been facilitated by improved battery technologies and the entry of major automotive and component manufacturers (Stilo et al. 2021), like engineering conglomerate Bosch.

Electric assist motors enable cargo bikes to travel longer distances, transport heavier loads, and tackle hilly terrain with less strain on the rider (Blazejewski et al. 2020, Fishman & Cherry 2016). Multiple models are available, typically able to carry loads from 50-250kg (Narayanan & Antoniou 2022), or approximately 10-25 parcels (Llorca & Moeckel 2021). Average mileage is 50-80km per battery charge (Narayanan & Antoniou 2022, Rudolph & Gruber 2017). This makes e-cargo bikes especially suitable for last mile deliveries, where diverse destinations allow for routing smaller loads over shorter distances.

Yet, despite the relative maturity of e-bike technology and increasing e-cargo bike uptake, research on applications in last mile logistics remains limited (Blazejewski et al. 2020, Narayanan & Antoniou 2022). Most studies are small-scale, geographically specific, or speculative and based on simulation models. This makes it difficult to reach robust conclusions about e-cargo bike performance.

### Sustainability performance

Like other electric vehicles, e-cargo bikes are a low emissions alternative. An individual journey by e-cargo bike produces zero direct (Scope 1) emissions. However, e-cargo bikes *do* generate Scope 2 and 3 emissions. Manufacturing e-cargo bikes and battery components creates Scope 3 emissions (Fishman & Cherry 2016). Scope 2 emissions depend on electricity generation – as energy researcher Vaclav Smil (2021) cautions, an electric vehicle charged from coal-generated electricity is a coal-powered vehicle.

Few e-cargo bike users can control Scope 2 and 3 emissions. Without accounting for these, however, an e-cargo bike cannot be correctly described as a net zero solution. An alteration to e-cargo bikes also needs to be matched with steps towards efficiency and reduction, such as optimised loading and routing (Anderluh et al. 2019, Narayanan & Antoniou 2022, Naumov et al. 2021, Olsson et al. 2019).

These points will be revisited in the use cases further below. The next section outlines the specific challenges for last mile logistics in rural areas.

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# Rural contexts

Cities have long struggled with the negative effects of transport (Schiller & Kenworthy 2017). Volume, visibility and policy attention can make it seem as though sustainable transport is primarily an urban issue requiring urban innovation (e.g. European Commission 2011). Unfortunately, this risks widening a 'sustainability divide' between urban and rural.

### The challenge for sustainable rural transport

Rural dwellers rarely confront pollution and congestion locally (Pangbourne 2020). Common cultural images of an idyllic countryside can give the mistaken impression that rural areas are already 'green' and climate change is a problem elsewhere (Norgaard 2011, Phillips & Dickie 2019). Yet, as geographers Martin Phillips and Jennifer Dickie (2019) argue, "carbon-fuelled mobilities" underlie many rural lives, livelihoods, and lifestyles.

Rural areas in the UK are diverse, but small, dispersed populations and greater distances to services are common characteristics. Because the limited critical mass in rural areas offers few economies of scale, many areas experience 'vicious cycles' of service decline and centralisation (Bock 2016, Skerratt 2010). This includes cutbacks to public transport (CPRE 2020) and creates disincentives for rural transport innovation (Velaga et al. 2012).

Unsurprisingly, rural residents often depend on private cars (Powell et al. 2018, Smith et al. 2012, Velaga et al. 2012). This is an example of a transport 'path dependency' (Cowan & Hultén 1996) – a self-reinforcing pattern that is difficult to change. The consequence is that per capita transport emissions are likely higher in rural areas (Mattioli 2016, Phillips & Dickie 2019).

### Rural home delivery markets

Limited local shopping choices (Clarke et al. 2015, Hood et al. 2020, Kirby-Hawkins et al. 2019), long travel times and low online prices (Sousa et al. 2020) contribute to rural demand for e-commerce and home delivery. Accessibility issues (Vitale Brovarone & Cotella 2020), such as residents who find it physically difficult to get to shops, may be an additional driver for delivery uptake. However, rural consumer preferences remain a gap in knowledge (Vakulenko et al. 2022).

Interestingly, research on contemporary retail challenges the assumption that shoppers choose 'bricks *or* clicks' (Clarke et al. 2015, Harris et al. 2017). Many shoppers combine both by, for example, supplementing a planned food delivery with spontaneous in-store purchases (Kirby-Hawkins et al. 2019). These patterns raise several questions about micro level choices and meso level journey characteristics, and the consequences for sustainability. To date, however, research on logistics in general, and green logistics in particular, is underdeveloped for rural areas.

E-cargo bikes' comparative range, small load sizing, and ability to cover difficult terrain do seem suitable for rural delivery services. Yet e-cargo bikes have largely been implemented as a last mile logistics solution in cities. The following section explores four potential rural use cases.

# Innovation use cases

This section draws from the discussions above to identify four potential use cases for e-cargo bikes in rural areas:

1. Replacing existing local fuel delivery vehicles with e-cargo bikes.
2. Shifting freight to e-cargo bikes for last mile logistics.
3. Using e-cargo bike delivery to support local shopping.
4. Sharing an e-cargo bike in a village or market town.

Each case is outlined below and assessed against two key criteria: the likely sustainability performance, and the potential value for rural enterprise.

## 1: Replacing existing local delivery vehicles with e-cargo bikes

This use case involves the **one-to-one replacement of an existing conventional delivery vehicle with an e-cargo bike**. It is a straightforward 'alteration' innovation that can potentially be made by any individual business that provides an in-house delivery service.

### The sustainability case

Evidence offers good grounds for proposing that an e-cargo bike can reduce Scope 1 emissions in one-to-one replacement for a conventional delivery vehicle (Blazejewski et al. 2020, Fishman & Cherry 2016, Llorca & Moeckel 2021). Emissions reductions are especially likely where an existing vehicle is inefficiently utilised (Halldórsson & Wehner 2020). For example, in rural areas with lower delivery demand, an e-cargo bike may better match the size of the vehicle with the size of the load.

Performance can be further improved through optimised loading and routing (Anderluh et al. 2019, Naumov & Pawluś 2021), such as combining multiple deliveries to avoid part loads, and planning routes to reduce mileage and power. Algorithms and modelling solutions exist but tend to assume urban delivery volumes. Unfortunately, lower demand and density in rural areas offers fewer optimisation options and inefficiencies are magnified over longer distances. One solution is to manage customer expectations by limiting deliveries to specific days/times so that they can be combined (Sousa et al. 2020). Of course, e-cargo bikes still incur Scope 2 and 3 emissions, which need to be accounted for. Further, while replacing a fuel emission vehicle can reduce carbon emissions, *adding* a vehicle and/or creating new journeys may have a counterbalancing effect.

### The business case

Some studies suggest that e-cargo bikes can help reduce delivery and vehicle costs, but these costs depend on many different factors (Narayanan & Antoniou 2022). Studies tend to look at costs from the perspective of logistics providers (e.g. Llorca & Moeckel 2021), rather than retailers. Vehicle replacement can be costly for an individual business. While electric cycle technologies are increasingly affordable, purchasing an e-cargo bike is still a significant outlay (Blazejewski et al. 2020), and recouping costs depends on local demand. Financial incentives and hire schemes can support businesses here.

Know-how and staffing are further potential limitations. Know-how is necessary for optimising deliveries and may involve additional costs for training or software. Obviously, an e-cargo bike needs a rider. Although e-bikes require lower levels of fitness, staff can be understandably reluctant to swap delivery vehicles for bikes (Blazejewski et al. 2020, Rudolf & Gruber 2017). Lower overall speeds may also add to staff time and thus wage costs (Llorca & Moeckel 2021).

## 2: Shifting parcels to e-cargo bikes for last mile delivery

This use case involves **transferring parcels from longer distance delivery vehicles to e-cargo bikes for the last mile**. It is an 'alteration' and potentially 'efficiency' innovation that can be undertaken by local and/or third-party e-cargo bike operators integrating with larger logistics networks.

### The sustainability case

There are reasonable grounds for proposing that shifting parcels to e-cargo bikes for the last mile can reduce Scope 1 emissions (Büttgen et al. 2021, Llorca & Moeckel 2021). Shifting to e-cargo bikes is already used in some urban centres. In rural areas where high distance and low density pose challenges for optimisation, consolidating supply and demand may improve efficiency (Narayanan & Antoniou 2022, Sousa et al. 2020). For example, multiple freight providers could shift to the same e-cargo bike service, or customers receive multiple orders in the same delivery.

Logistics integration itself is the key barrier to improving efficiency. Large logistics providers can be reluctant to entrust delivery to third party operators (Narayanan & Antoniou 2022, Schliwa et al. 2015). Shifting freight also requires investment in local infrastructure, such as 'micro-depots' and bike parking (Llorca & Moeckel 2021), which may be best suited to market towns or larger villages (Weiss & Onnen-Weber 2019).

### The business case

While Use Case 1 was limited to delivery demand for a single business, consolidating demand offers a better potential business model for a local third-party e-cargo bike service. Integration with larger logistics networks also opens the opportunity to benefit from trends to online sales, which may otherwise bypass local retail and delivery.

However, a viable third-party business model requires sufficient local throughput to (at a minimum) cover e-bike purchase and operational costs (Blazejewski et al. 2020). Obtaining accurate data about demand from logistics companies is difficult due to commercial sensitivities (Llorca & Moeckel 2021). While improving last mile efficiency can reduce delivery costs (Gevaers et al. 2014, Hood et al. 2020), smaller sub-contractors are less likely to benefit from this. Sub-contractors are also likely to lack leverage in their relationships with larger logistics firms.

Infrastructure for shifting parcels can incur additional costs, including set-up and renting space (Llorca & Moeckel 2021). While local authorities could provide support here, links to policy objectives may be less obvious in rural areas, in contrast to urban areas facing major pollution and congestion issues (Narayanan & Antoniou 2022, Schliwa et al. 2015).

## 3: Using e-cargo delivery to support local shopping

This use case involves **introducing e-cargo bike delivery services to increase demand for local businesses**. It is potentially both an 'alteration' innovation, concerning changing consumer behaviour, and a 'reduction' that replaces individual shopping trips.

### The sustainability case

Although it is often assumed that shopping locally is more sustainable, the evidence is mixed and highly contingent. 'Local' is not a reliable proxy for sustainability (Born & Purcell 2006). For example, many village shops on-sell goods produced elsewhere and emissions throughout the supply chain make comparing local 'store to door' distance with that from an online distribution centre a false equivalence.

A stronger sustainability case lies in 'journey substitution' – replacing private shopping trips with home delivery (Visser et al. 2014). When the substituted journey is by fuel emissions vehicle, there are good grounds for proposing that e-cargo bike delivery will reduce Scope 1 emissions (Blazejewski et al. 2020, Fishman & Cherry 2016, Llorca & Moeckel 2021). The effect is increased where multiple journeys can be substituted for a consolidated delivery round.

Unlike vehicle replacement (Use Case 1), journey substitution depends on consumer behaviour change (Berg & Henrikksson 2020). This is difficult to achieve in practice. Many people depend on car travel (Mattioli et al. 2016) and value the convenience (Geels 2012). Evidence suggests that local purchases are often made spontaneously (Harris et al. 2017, Kirby-Hawkins et al. 2019), increasing the likelihood of 'popping to the shops' by car. There is also a risk that home delivery could substitute for journeys that are *already* more sustainable, such as taking the bus or walking (Berger et al. 2014). In rural areas, this may further reduce demand for already limited public transport.

### The business case

The business case reverses. Technically, journey substitution does not add new sales, since only the mode of transport changes. The business opportunity for local retailers and/or delivery operators is thus using e-cargo bikes to increase demand. This might include marketing local products, new purchasing platforms, and extending delivery services to more people and/or underserved groups.

Expectations for local sales should be realistic, however. Contemporary 'omnichannel' retail (Hood et al. 2020, Verhoef et al. 2015) has changed consumer behaviour. 'Bricks vs clicks' is not an either/or choice (Harris et al. 2017), and there are inherent limits to the wants and needs that can be satisfied locally in rural areas (Kirby-Hawkins et al. 2019). Successful delivery models need to balance cost and convenience from the customer's perspective. Research shows that car owners rarely calculate the full cost of their journeys (Andor et al. 2020). This can make up-front delivery fees appear comparatively expensive, yet many retailers struggle to absorb the cost of 'free' delivery offers (Hood et al. 2020).

Growing delivery demand can lead also to trade-offs for sustainability by creating, rather than reducing, journeys (Allen et al. 2017). Negative effects can include increased Scope 2 emissions from power generation or incentivising less sustainable practices. For example, research on urban food delivery platforms shows that demand can encourage riders to switch to conventional motorcycles, increasing emissions (Lord et al. 2022).

## 4: Sharing an e-cargo bike in a village or market town

This use case concerns providing **an e-cargo bike as a shared asset in a village or market town**, for multiple businesses to use or hire. It is potentially an 'alteration' or 'efficiency' innovation, that can be implemented through local government funding or through community-led development initiatives.

### The sustainability case

Bike-sharing schemes have been regularly advocated for sustainable transport (Berger et al. 2014). Yet, research points to mixed results and unintended consequences, such as under-utilised and discarded bikes, and replacing journeys that are already sustainable, (de Chardon 2019, Long & van Waes 2021, Nikolaeva & Nello-Deakin 2020).

The sustainability case for shared e-cargo bikes is likely to be locally contingent. A locally shared e-cargo bike could provide both vehicle replacement (Use Case 1) and journey substitution (Use Case 3) benefits, depending on how and why it is used. The sustainability performance will vary accordingly, as will the challenges.

Sharing an asset may offer added efficiency gains, like maximising bike use over 'idle' individual vehicles (Long & van Waes 2021). There may also be potential to reduce Scope 2 emissions through charging infrastructure since shared assets are more likely to attract funding for docking stations or connect with community-owned power generation. However, platforms that share bike *time* rather than load *space* will limit opportunities to optimise loading and routing (Anderluh et al. 2019, Naumov & Pawluś 2021).

### The business case

A shared asset can mitigate the costs of purchasing an e-cargo bike (Blazejewski et al. 2020) and will likely reduce the costs of operating an individual delivery vehicle (Andor et al. 2020). Similarly, sharing schemes can offer businesses the opportunity to trial an e-cargo bike (Narayanan & Antoniou 2022), reducing the risk of up-front investment.

More than a financial case is needed, however. Research indicates that transport innovations are usually only adopted when they meet users' needs, habits, and routines (Berger et al. 2014). A shared bike must 'fit' multiple business routines. Moreover, businesses will need to provide or access a suitable rider, which implies staff time and labour costs (Blazejewski et al. 2020, Rudolf & Gruber 2017).

Bike-sharing schemes have been criticised for reinforcing existing inequalities, because they primarily cater to those who are already willing and physically able to use them (de Chardon 2019). This suggests the possibility that a shared asset may benefit those businesses and communities that are *least* in need of support. As ever, case-by-case planning and local market research is needed.

# Conclusions

E-cargo bikes are a **low emissions alternative to conventional vehicles for logistics over the 'last mile'**. There is empirical evidence that e-cargo bikes can reduce Scope 1 emissions in one-to-one replacement for existing delivery vehicles, or where one bike substitutes for multiple individual journeys.

While rural trials have been limited to date, there are reasonable grounds for proposing that e-cargo bikes offer **opportunities for innovation in rural areas**. Potential opportunities include new delivery-based business models and local bike sharing schemes. In practice, how e-cargo bikes are used will depend on local needs and challenges and respond to rural business requirements and customer demand.

While there is certainly potential, e-cargo bikes **should not be over-hyped as a simple solution for green logistics in rural areas**. This is for four main reasons.

First, e-cargo bikes still **accrue Scope 2 and 3 emissions**. Bike and battery manufacturing is not carbon neutral, and actual emissions depend on the source of electricity used for charging. Without accounting for these factors, an e-cargo bike may contribute to 'net zero' in a rural business or community but displace emissions elsewhere.

Second, like any asset, **an e-cargo bike needs to be used wisely**. Whether or not loading and routing are optimised affects the sustainability performance. Recouping purchase and operating costs also requires a viable business model and sufficient delivery volume. This can pose challenges in rural areas where the 'last mile' is characterised by long distances and low density.

Third, the local economic potential of e-cargo bikes directly depends on consumer (and for bike-sharing, business) demand. Consumer behaviour is complex and difficult to influence. **Local market research remains essential**, and expectations must be realistic.

Fourth, any innovation introduces trade-offs. Transport and logistics are complex systems, and it is very difficult for any single intervention to achieve efficiency, alteration, and/or reduction effects. E-cargo bikes may be part of bigger solutions, but they do not exist in isolation and involve **new challenges, choices, and (potentially) unintended effects**.

Despite these challenges, there are important opportunities for **future innovation in green logistics in, with and for rural areas**. These range from platforms to bundle delivery supply and demand, to shared asset models, and from micro-generation infrastructures to connections to community-owned energy. Future research is needed to validate these opportunities and compare results across different regions and contexts.

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