Department for Transport

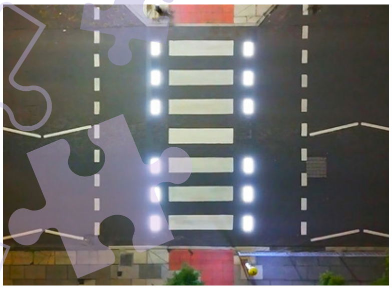
ADEPT LIVELABS2 Decarbonising Local Roads

LIVERPOOL LIVE LABS DRIVING DECARBONISATION

LIVERPOOL LIVELABS

CASE STUDIES

These case studies highlight the extensive scope of collaboration with a goal to create a framework for decarbonising local roads in the UK in order to achieve net zero by 2030.



Liverpool City Council · COLAS WE OPEN THE WAY · Pell Frischmann Excellence through innovation · Bird & Bird · Decision Equipped. proving

Liverpool John Moores University · Aberdeen City Council · GAP Group Hire Solutions · Newcastle City Council · Huyton Asphalt · Dowhigh · TARMAC A CRH COMPANY

LIVERPOOL LIVELABS CASE STUDIES

INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

This Intelligent Lighting and Smart Streets case study forms part of a wider suite of case studies capturing the findings from the Liverpool Live Labs programme and reflects the city's commitment to decarbonising highway infrastructure.

Live Labs 2 is a three-year, £30 million UK-wide programme funded by the Department for Transport, running until March 2026 and followed by a five-year extended monitoring and evaluation period.

Authored by: Krishna Priya Sivaprasad, Kira Jefferies, Pamela McGuinness, Alexis Magne

FOREWORD

The ADEPT Live Labs 2: Liverpool programme has been an enriching learning experience for Liverpool City Council, our highways teams, our communities, and the many SMEs that form the backbone of our local innovation ecosystem. Decarbonisation sits at the core of long-term resilience, and with Liverpool's ambitious goal of becoming a net zero city by 2030, this programme has played a critical role in accelerating our progress, alongside our wider evolution as a Council.

Through Live Labs 2, Liverpool is now equipped with a cohort of professionals who are familiar with a nationally accepted carbon assessment and capture methodology – giving us the tools, understanding and confidence to make informed, accountable decisions about carbon reduction across the lifecycle of our highways assets. This capability will long outlast the programme itself, embedding a legacy of informed, data-driven decarbonisation in the city's operations where these have been proved by the programme.

Within the programme ecosystem, we tested **26 innovations**, spanning far more than materials alone. These included new processes, toolkits, decision-making approaches, and practical interventions that collectively support our commitment to building a functioning highways decarbonisation ecosystem. Supported by an expert panel, each option was rigorously assessed for its innovation potential and its ability to meaningfully reduce carbon before being adopted. Our ambition from the outset was clear: embrace innovation, remain open to challenge, and work collaboratively to understand what truly moves the needle on carbon reduction.

Despite needing to align with wider changes within the Council, and the challenges faced by nearly all Authority's across the UK, the programme succeeded because of the strength, expertise, and dedication of our partners across the ecosystem. We would like to extend our sincere thanks to the core members of the innovation ecosystem developed through the programme:

- **Colas** – Programme Delivery & Innovation Management Partner, also realising new ways of including carbon impacts into road condition-based Asset Management approaches.
- **Bird & Bird** – Co-developer of a pioneering procurement toolkit.
- **Pell Frischmann** – Developers of the Options Configurator Tool.
- **Proving Services** – Independent testers of our assumptions and carbon assessment approaches.
- **Liverpool John Moores University** – Innovators in materials development.
- **Dowhigh and Huyton Asphalt Civils** – Our committed local contractors installing innovation products and embracing new ways of working.
- Newcastle City Council and Aberdeen City Council - Partner cities for demonstrators and vital knowledge sharing.

Another defining strength of the programme was its **verge-to-verge scope**. This was not limited to resurfacing or traditional asset management innovations. We trialled solutions in road marking, drainage, reuse and recycling, operational processes, and more – reflecting the full complexity and opportunity of the road environment.

From the 26 innovations we trialled, 17 innovations spanning categories such as Decision-Making & Network Management, Road Markings, Intelligent Lighting, Asset Maintenance, Drainage, and People-Focused Street Enhancements have already been adopted or are moving toward becoming business-as-usual, provided the site conditions are suitable. Others are undergoing extended monitoring and evaluation over the next five years to better understand performance, durability, and long-term carbon reduction potential. And while not every innovation delivered the outcomes we hoped for, each trial provided valuable learning - an essential part of any genuine innovation journey.

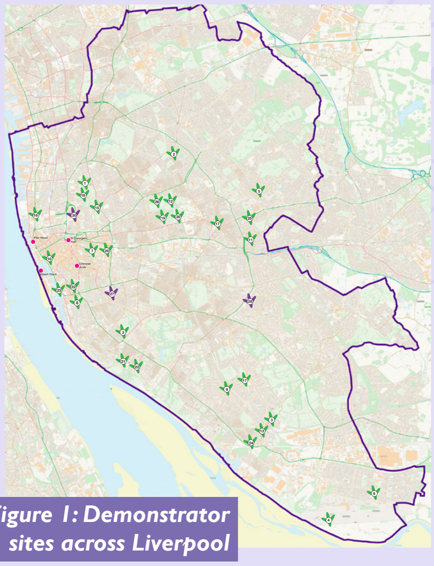


Figure 1: Demonstrator sites across Liverpool

As we present this suite of case studies, we do so with pride in what can be achieved with a laser-sharp focus, unwavering dedication and a culture of collaboration. These pages represent countless hours of collaboration, problem-solving, curiosity, and shared ambition across partners, teams, and communities.

On behalf of Liverpool City Council, I would like to extend our sincere thanks to the Department for Transport (DfT) and ADEPT as the funding and commissioning bodies, whose support and leadership have been essential in enabling this work. I would also like to thank every partner, every member of our LCC teams, every contractor, SME, academic, and every community voice – big or small – who contributed to the success of this project. Your effort and commitment have not only delivered a highly successful programme but have also helped build the foundations for a cleaner, more resilient, and more sustainable Liverpool.

Director of Sustainability Transport, Highways and Parking, Liverpool County Council

CONTENTS

INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

1. Executive Summary

The Intelligent Lighting & Smart Streets category examines how adaptive street lighting technologies, renewable energy powered assets, and dynamic road sign activations can significantly reduce carbon emissions compared with traditional lighting and traffic infrastructure. Conventional systems typically operate at a fixed output throughout the hours of darkness, driving high electricity use, while static signage and physical traffic calming features incur substantial embodied carbon through manufacture, installation, and ongoing maintenance.

Each demonstrator in this programme was selected for its potential to deliver quantifiable carbon savings against its respective Business As Usual (BAU) baseline. Rather than comparing innovations against one another, the trials were independently assessed to determine the carbon reduction benefits and overall suitability for broader deployment.

The innovations evaluated were:

- Flowell Zebra Crossing
- Flowell 20mph Signs
- Traffic Adaptive Lighting
- Omniflow Smart Column

2. Business-As-Usual (BAU) Baseline

The typical BAU solutions used as baseline scenarios include:

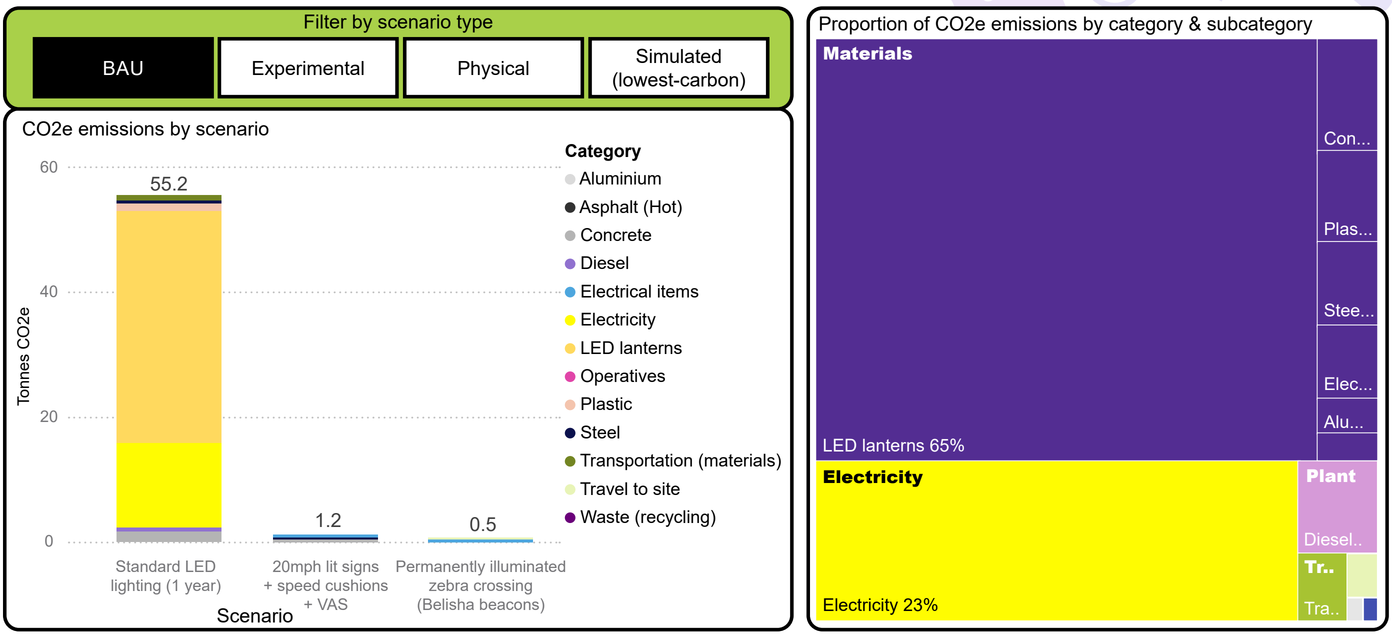
- Permanently illuminated street lighting column at zebra crossing (Belvidere Road)
- Asphalt speed cushions (Booker Avenue)
- Fixed-output LED street lighting operating at 100% intensity (Bramley Moore)
- Grid-powered LED street lighting installations (Campbell Square & Otterspool Promenade)

The most significant carbon impacts are attributable to:

- LED lanterns
- Long-term operational carbon from electricity consumption
- Plant usage for street lighting installation

The purpose of this category was to test whether intelligent systems could reduce these impacts while maintaining or improving safety outcomes.

Figure 1: Breakdown of carbon impacts for the BAU baselines for Belvidere Road (zebra crossing), Booker Avenue (20mph measures), and Bramley Moore, Campbell Square, & Otterspool Promenade (standard LED lighting)



Department for Transport | ADEPT LIVE LABS 2 Decarbonising Local Roads

LIVERPOOL LIVE LABS
DRIVING DECARBONISATION

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

3. Innovation Funnel and Advisory Panel

To support consistent, transparent and evidence-based decision-making across the programme, an Expert Advisory Panel was established to guide the evaluation and selection of all innovations considered for Live Labs trials. The panel brings together specialists from local authorities, academia, engineering, behavioural insights, lighting, and innovation management, providing a balanced and multidisciplinary review of each proposed solution. Working alongside the scoring workshop, the panel independently assesses technical feasibility, safety benefits, carbon impact, operational risks, installation constraints and long-term sustainability. Through structured scoring, expert discussion and refinement, the panel ensures that only the most suitable, high-value technologies progress to the planning and implementation stages. This process has been instrumental in ensuring that all chosen innovations are robust, appropriate for local conditions, and aligned with the overarching objectives of safety, decarbonisation and improved user outcomes.

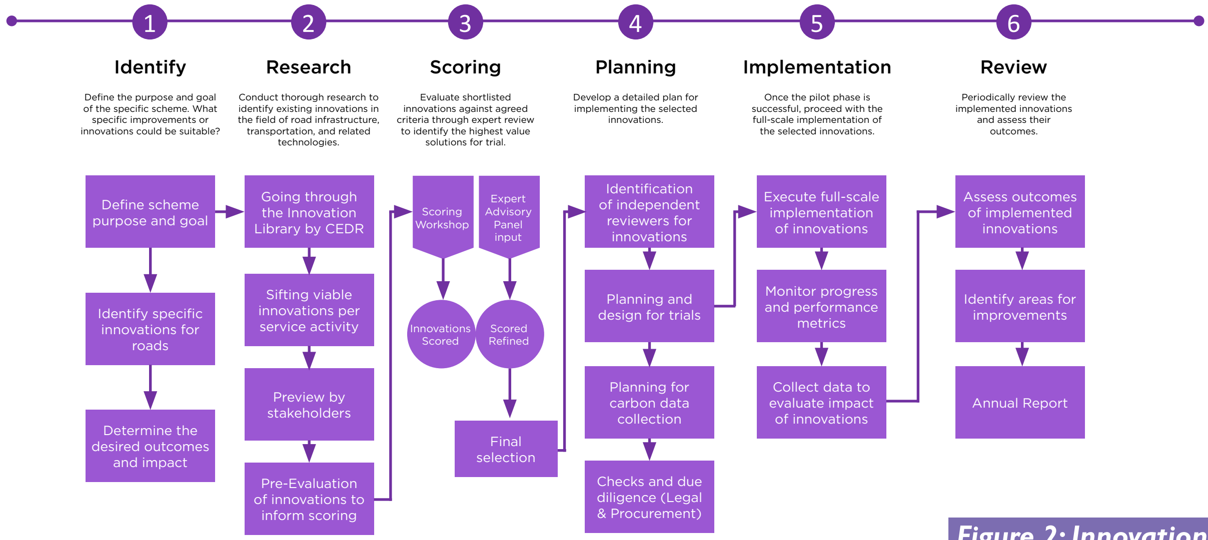


Figure 2: Innovation Funnel

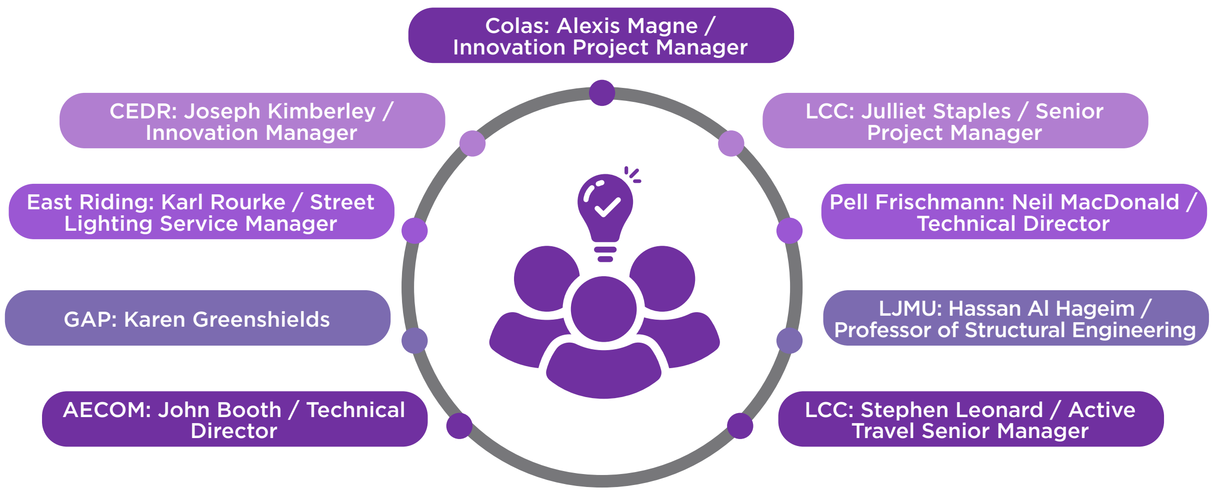


Figure 3: Expert Panel

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

4. Carbon Assessment Methodology

Each innovation was assessed against its BAU comparator using whole-life carbon principles, in accordance with the Carbon Calculation and Accounting Standard (CCAS) process (as outlined in Figure 4) and the PAS2080 carbon lifecycle stages.

Carbon calculations considered:

- The embodied carbon of the materials used
- Transportation and travel to site
- Installation processes and plant use
- Operational electricity consumption (kWh)
- The processing of waste removed from site
- Maintenance frequency
- Expected lifespan

Data collection template sent to & completed by each contractor

SCHEME DETAILS
- Location
- Asset Type
- Activity type
- Area / volume

PREMISES & SITES
- On-site fuel & electricity consumption

STAFF & CONTRACTORS
- Communting days
- Commuting mode
- Vehicle fuel & size
- Daily commuting miles

VEHICLES & PLANT
- Vehicle / plant type
- Function
- Weight / Engine size
- Fuel type
- Miles travelled OR litres of fuel consumed

PRODUCTS & SERVICES
- Materials
- Transport as a service
- Waste management
- Other purchased / subcontracted services

Carbon factors obtained from the supplier for bespoke materials, where possible

Data entered into Carbon Profiler Toolkit (CPT) to calculate CO_2e emissions for each scheme

Calculation of long-term CO_2e emissions and normalisation to scale of scheme

Options comparison and calculation of carbon savings

Figure 4: The carbon assessment process

Percentage reductions stated in the Carbon Impact section of each case study reflect the difference in carbon emissions between the innovation and its conventional equivalent.

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

5. FLOWELL (ZEBRA CROSSING)

Location: Belvidere Road

Type: Interactive illuminated road marking system

Primary Driver: Behaviour-led safety and carbon improvement

Installed on site by: McCann & Simmon Signs

5.1 Innovation Description

Flowell comprises LED-embedded road markings within the carriageway that illuminate only when triggered by pedestrians or vehicles, directing the right signal to the right user at the right time. Unlike BAU crossings, the system avoids continuous lighting and instead delivers targeted activation aligned to real-time need.

5.2 Site Selection

Belvidere Road experiences fluctuating pedestrian activity due to school peaks. A traditional solution would require constant night-time illumination, consuming significant operational energy even when pedestrian presence is low.

The site on Belvidere Road was chosen because it is an existing pedestrian crossing, nearing its end of life and due an upgrade, but with a historic record of collisions and near misses in the past, which had originally led to the installation of a traditional zebra crossing.

Figure 6: Flowell Crossing at Belvidere Road

Figure 5: Flowell Crossing Illuminated

Following installation of the original zebra crossing, collision numbers decreased; however, the location remained sensitive due to:

- Its immediate proximity to Belvedere Academy, generating heavy pedestrian activity at predictable peaks.
- The winter school timetable, where dismissal occurs close to dusk, making visibility a concern.
- Reduced driver awareness during low-light periods, despite the presence of the traditional zebra.

Flowell was therefore selected as an upgrade, providing targeted, high-visibility activation during peak hours and darker conditions to further improve driver-pedestrian awareness and improve safety performance.

5.3 BAU Comparator

The BAU comparator was:

- Permanently illuminated streetlighting infrastructure.
- Continuous energy consumption during night-time hours.

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

5.4 Impact & Carbon Performance

- 0.2 tCO_2e saving (40% compared to BAU).
- 2.4 tCO_2e saving over 40 years (62% compared to BAU).
- Estimated 42% reduction in emissions from road users due to behavioural change (not included in scope of baseline).
- 26% improvement in behavioural compliance (driver awareness and pedestrian response).
- Reduced operational energy demand due to targeted activation.
- Avoidance of continuous illumination infrastructure.
- Carbon reduction is derived primarily from the reduction in physical lighting infrastructure and the long-term reduction in electricity consumption compared to permanently lit crossings.

Figure 7: Upfront carbon profiles (top) and 40-year carbon profiles (bottom) for Flowell zebra crossing on Belvidere Road

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

5.5 Results & Interpretation

This innovation was subjected to an independent third-party evaluation by Arcadis, who analysed conditions for six months in the previous year at the same time of year as installation, and a further six months after installation, and identified significant positive changes in driver behaviour as a result of the intervention.

The Flowell installation at Belvidere Road achieved measurable whole-life carbon savings and observable behavioural gains, validating the choice to upgrade a historically collision-prone location near Belvedere Academy with a target-activated crossing. Quantitatively, the scheme delivered an estimated 0.2 tCO_2e saving (-40% vs BAU) in the short term and an estimated 2.4 tCO_2e saving over 40 years (-62% vs BAU), primarily by avoiding continuous night-time illumination and associated electricity consumption.

Behavioural outcomes were positive and directionally consistent with international Flowell studies: the site recorded a 26% improvement in behavioural compliance (driver awareness and pedestrian response), aligning with external evidence that Flowell improves respect for pedestrian priority, increases safe stopping distances, and enhances legibility in low-light conditions. These effects are particularly relevant at school-adjacent sites where dusk periods coincide with pupil egress, and where visibility-led cues can deliver safety benefits without incurring permanent energy demand.

Taken together, the results indicate that "demand-on" illumination is an appropriate upgrade pathway for existing zebras in variable-risk environments. The crossing provides the right signal at the right time, sustaining safety performance while achieving operational energy reductions and avoiding further embodied carbon through heavier civil interventions.

5.6 Learning

Targeted activation is highly suited to school environments

Behavioural data from Liverpool and international studies shows that context-driven illumination improves user awareness at the moments of highest risk, especially during low-light winter periods.

Nighttime perception gains are significant

International trials consistently found far greater user comprehension and confidence at night than during daytime, reinforcing the value of illuminated surfacing where visibility is naturally compromised.

Behaviour change can replace physical calming

The improved compliance and safer driver approach behaviours reduce the need for energy-intensive or carbon-heavy infrastructure modifications.

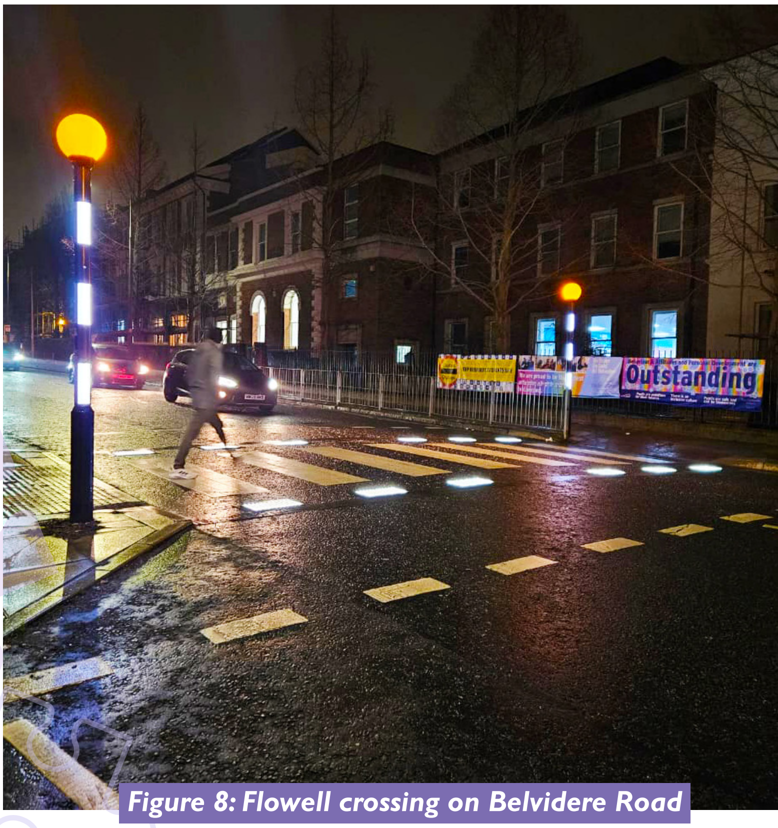


Figure 8: Flowell crossing on Belvidere Road

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

6. FLOWELL (20MPH SIGNS)

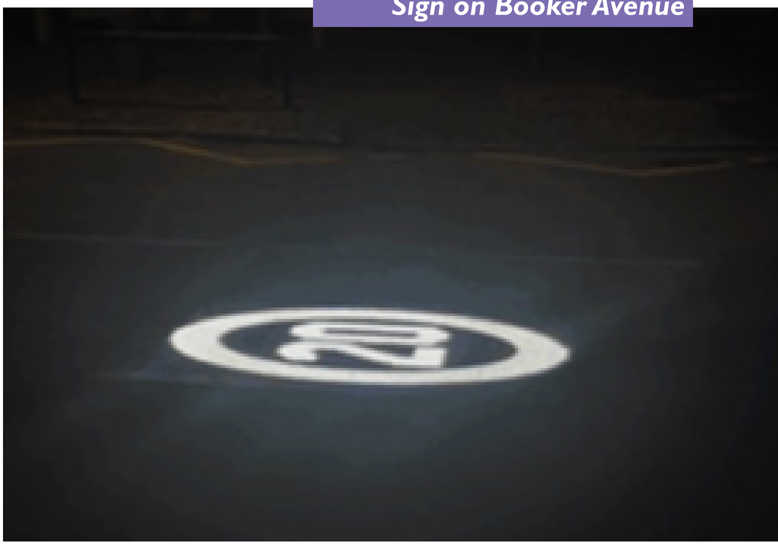
Location: Booker Avenue

Type: Dynamic illuminated speed signage

Primary Driver: Avoidance of physical traffic calming infrastructure

Installed on site by: McCann & Simmon Signs

Figure 9: Flowell Speed Limit Sign on Booker Avenue



6.1 Innovation Description

The Flowell smart speed system consists of LED illuminated 20mph signs combined with camera-based detection sensors. The signs remain unlit during normal operating conditions but automatically activate when a vehicle approaches at a speed above the designated threshold.

Key features include:

- Thermal or motion detection sensors to measure approaching vehicle speed.
- Reactive LED illumination to alert drivers exceeding the 20mph limit.
- A nonenforcement model that nudges behaviour through visibility rather than penalties.
- High impact, attention catching brightness that adapts to surrounding light levels.

In Liverpool, two Flowell 20mph speed signs were installed near the school entrance. When a driver approaches too quickly, the sign illuminates, prompting immediate deceleration. Importantly, these units do not record or fine drivers but provide a real-time warning to help protect children during drop-off and pickup periods.

6.2 Site Selection

The Booker Avenue installation was selected because the site is in the immediate vicinity of an infant school, where:

- Vehicle speeds must remain low, especially during morning drop-off and afternoon pick-up periods.
- Traditional enforcement (static signs) has historically shown variable compliance during peak congestion.
- Physical traffic-calming features would introduce significant embodied carbon and could negatively affect bus operations and emergency vehicle access.

By installing Flowell dynamic 20 mph signage, Liverpool aimed to introduce a low-carbon, behaviour-responsive method to reinforce compliance at times when children are most at risk, without resorting to carbon-intensive physical measures.

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

6.3 BAU Comparator

Traditional 20 mph compliance typically relies on static signage combined with speed cushions or humps, all carrying high embodied carbon and maintenance needs. The trial tested whether dynamic illumination could improve compliance sufficiently to avoid additional physical calming.

- Illuminated aluminium 20MPH signs
- Speed cushions
- Vehicle activated speed (VAS) signs

6.4 Carbon Impact

- 0.7 tCO_2e saving (54%) compared to BAU
- 2.9 tCO_2e saving (52%) over 40 years compared to BAU

Savings were primarily achieved through:

- Avoidance of embodied carbon in aluminium signs and/or asphalt speed cushions.
- Reduced operational energy demand due to targeted activation.

Figure 10: Upfront carbon profiles (top) and 40-year carbon profiles (bottom) for Flowell 20mph signs on Booker Avenue

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

6.5 Results & Interpretation

This innovation was subjected to an independent third-party evaluation by Arcadis, who analysed conditions for six months in the previous year at the same time of year as installation, and a further six months after installation, and identified significant positive changes in driver behaviour as a result of the intervention.

At Booker Avenue, the dynamic 20 mph installation delivered a substantial whole-life carbon reduction by avoiding the manufacture, transport, installation and future replacement of physical traffic-calming features (e.g., cushions/humps). The assessment indicates ~2.4 tCO_2e avoided, representing an ~83% reduction vs BAU, with savings driven by infrastructure avoidance and a lower maintenance burden relative to traditional calming.

From a behavioural standpoint, the results support the principle that contextual, behaviour-triggered reinforcement improves compliance at the moments when risk is highest - specifically school peak periods. This mirrors findings from wider Flowell evaluations where dynamic visual cues increased motorists' attention to priority rules, improved anticipation, and reduced unsafe approach behaviours without resorting to carbon-intensive physical interventions. In the school context, that translates to better speed discipline when children are present, with fewer negative impacts on bus services and emergency response compared with vertical deflections.

Overall, the results demonstrate that behaviour-led digital calming can meet compliance objectives around infant schools while significantly lowering lifecycle carbon. For corridors with sensitivity to ride quality, noise, and maintenance, the evidence supports scaling dynamic 20 mph reinforcement ahead of traditional cushions/humps, provided monitoring confirms sustained compliance through the academic year.

6.6 Learning

Behaviour-led digital calming works in school zones

Behavioural studies show that Flowell improves attention to speed and priority cues, making it a viable alternative to physical calming where carbon reduction is a priority.

Infrastructure avoidance is a major carbon lever

The largest saving in this trial came from not installing cushions/humps - highlighting that smart technology can meet compliance aims with dramatically lower embodied carbon.

Dynamic messaging improves responsiveness

Drivers react more reliably to illuminated cues triggered by their own behaviour, creating better compliance without increasing street clutter or energy use.

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

7. TRAFFIC ADAPTIVE LIGHTING

Location: Great Howard Street & Derby Road, Bramley Moore

Type: Real-time adaptive lighting system

Primary Driver: Operational energy reduction over asset lifespan

Installed on site by: McCann

7.1 Innovation Description

Traffic Adaptive Lighting (TAL) is an intelligent street lighting solution designed to reduce energy consumption and carbon emissions by dynamically adjusting lighting levels in response to real time traffic conditions. Unlike traditional fixed-output street lighting, TAL uses live vehicle count data and environmental inputs to tailor illumination to actual road usage throughout the night.

Traffic Adaptive Lighting (TAL) adjusts illumination levels in real time based on:

- Traffic flow
- Pedestrian movement
- Weather conditions
- Ambient light levels

Lighting output is reduced when full illumination is unnecessary. The solution was developed to not only reduce the carbon associated with streetlighting, providing predictable energy budgeting for the Council, but to also provide better visibility for road users, lighting which can be adapted on event days (near football stadium), and the waterfront area, while also providing a more resilient infrastructure with quicker repair cycles.

Figure 11: Installing TAL at Bramley Moore

7.2 Site Selection

Great Howard Street, Derby Road, and the wider Bramley-Moore area were selected for the traffic adaptive Lighting trial due to their high traffic volumes, variable peak-time flows, and the influence of major event-related surges linked to the waterfront and stadium zone. These corridors serve as key strategic routes for freight, commuter traffic, and match-day movements, often experiencing inconsistent congestion patterns that traditional fixed-time signals cannot manage efficiently. The locations therefore provided an ideal environment to test dynamic signal-control technology capable of responding to real-time conditions, improving traffic flow, reducing delays, and cutting emissions at busy junctions. Their mix of heavy-vehicle flows, pedestrian activity, and event-driven variability enabled the team to assess system responsiveness and scalability across complex urban traffic environments.

7.3 BAU Comparator

Fixed-output lighting operating at consistent intensity throughout darkness.

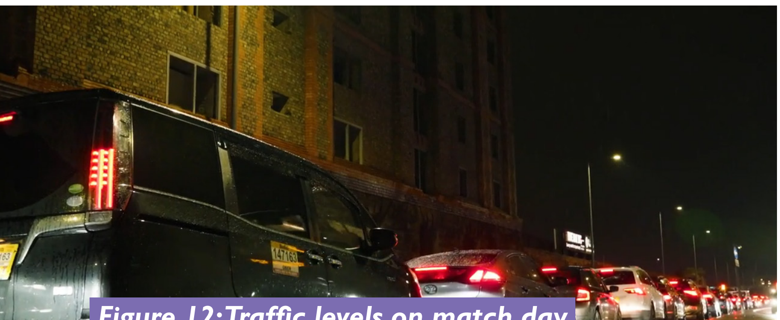


Figure 12: Traffic levels on match day

Department for Transport

LIVELABS2 Decarbonising Local Roads

LIVERPOOL LIVE LABS DRIVING DECARBONISATION

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

7.4 Carbon Impact

- 11.1 tCO_2e (22%) upfront saving
- 446 tCO_2e (75%) saving over 40 years

The most significant savings are realised through long-term operational energy reduction.

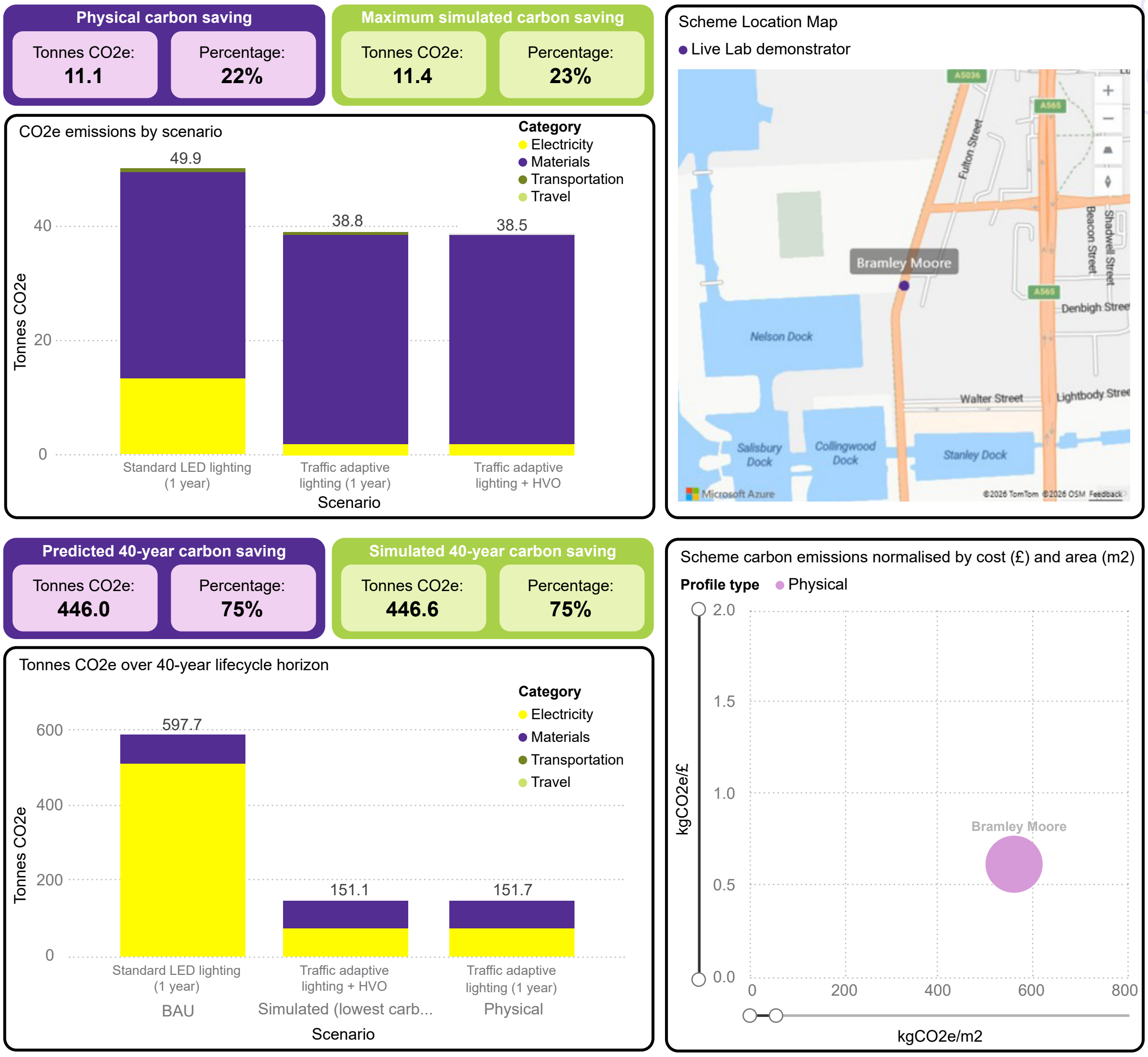


Figure 13: Upfront carbon profiles (top) and 40-year carbon profiles (bottom) for traffic adaptive lighting scheme on Bramley Moore

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

7.5 Learnings

1. **Operational optimisation delivers the largest carbon savings**

   The trial confirmed that the greatest long-term carbon and energy reductions are achieved not through replacement of physical assets, but through smarter operation of existing infrastructure. TAL's dynamic dimming, informed by real-time traffic and environmental data, produced the highest proportion of carbon savings over the system's 40-year lifecycle.

2. **Whole-life carbon modelling is essential for robust assessment**

   Upfront embodied carbon was significantly lower than the Business-As-Usual comparator, but the most substantial benefits - over 446 tCO_2e (75%) avoided across 40 years - were unlocked through operational efficiencies. This demonstrates the importance of modelling embodied and operational impacts together, ensuring that upgrade decisions are evaluated on whole-life performance rather than initial installation emissions alone.

3. **TAL is a strong candidate for BAU integration**

   The scale of carbon savings, alongside improved lighting performance and responsiveness to varying traffic and environmental conditions, positions TAL as a feasible Business-As-Usual approach for future lighting projects. Its ability to flex lighting for event surges, waterfront conditions, or fluctuating traffic patterns aligns well with the operational needs of busy, mixed-use corridors.

Figure 14: Installation of TAL

4. **Installation is minimally invasive and scalable**

   The practical deployment of sensors was straightforward, with units mounted on existing lighting columns at heights of 6–10 metres. The simplicity of this process demonstrated that TAL can be rolled out with minimal disruption to the network and without extensive civil works.

5. **Data-driven insights enhance resilience and maintenance efficiency**

   By continuously monitoring traffic patterns and lighting performance, TAL strengthens the overall resilience of the lighting network. The system supports quicker issue identification, more targeted maintenance, and adaptable lighting strategies based on real-time conditions. This creates opportunities for improved public-realm safety, energy planning, and operational predictability for the Council.

6. **The technology performs well in complex, variable environments**

   The chosen trial area - characterised by freight activity, commuter flows, match-day movements, and event-driven peaks - validated TAL's capability to manage highly dynamic conditions. The system responded effectively to fluctuations, demonstrating that adaptive lighting is suitable for diverse and complex corridors.

Figure 15: Sensors on the column

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

8. OMNIFLOW SMART COLUMN

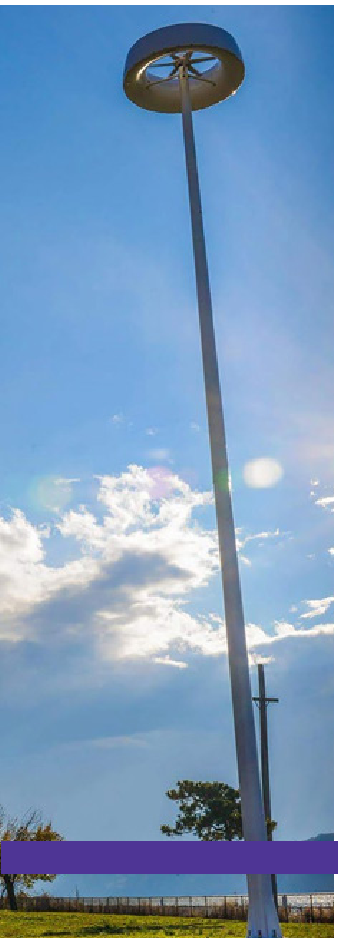
Location: Campbell Square and Otterspool Promenade

Type: Renewable-powered smart lamppost

Primary Driver: Renewable integration and grid reliance reduction

8.1 Innovation Description

Omniflow renewable posts are next-generation smart lampposts powered by hybrid renewable energy (solar + wind), designed to transform a standard streetlight into a self-powered, intelligent, multi-service urban infrastructure. They combine renewable energy generation, energy storage, and integrated IoT capabilities in a single compact unit, enabling cities to reduce emissions while improving connectivity, safety, and digital services.



Omniflow combines:

- Wind turbine
- Solar panel
- Integrated battery storage
- IoT smart city capability

The system generates its own power and reduces reliance on grid electricity.

Figure 16: OmniFlow

8.2 Site Selection

To evaluate the performance, versatility, and real-world applicability of Omniflow's hybrid wind-and-solar smart-infrastructure technology, two contrasting pilot sites were selected: Campbell Square in Liverpool's city centre and Otterspool Promenade on the waterfront.

Campbell Square, located in Liverpool's busy city centre, was chosen for its high pedestrian footfall, mixed use surroundings, and suitability for testing smart city functions such as lighting, air quality monitoring, and IoT connectivity. Its enclosed, urban setting allowed assessment of how the system operates where wind and sunlight may be more limited, while offering strong public visibility for demonstrating low carbon technology.

Otterspool Promenade, in contrast, offered an open, waterfront environment with strong wind exposure and sunlight. This made it ideal for evaluating renewable energy generation, battery performance, and durability under coastal conditions. It also allowed testing of the system's potential in a spacious site.

8.3 BAU Comparator

Standard grid-powered lamppost installation.

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

8.4 Carbon Impact

- No upfront difference on Campbell Square
- 0.1 tCO_2e (8%) upfront saving on Otterspool Promenade
- 2.7 tCO_2e (25%) saving over 40 years on Campbell Square
- 5.7 tCO_2e (71%) saving over 40 years on Otterspool Promenade
- 8.4 tCO_2e overall saving (78%) over 40 years

Carbon reduction is achieved through:

- Renewable generation
- Reduced operational emissions
- Multi-functionality reducing need for additional infrastructure

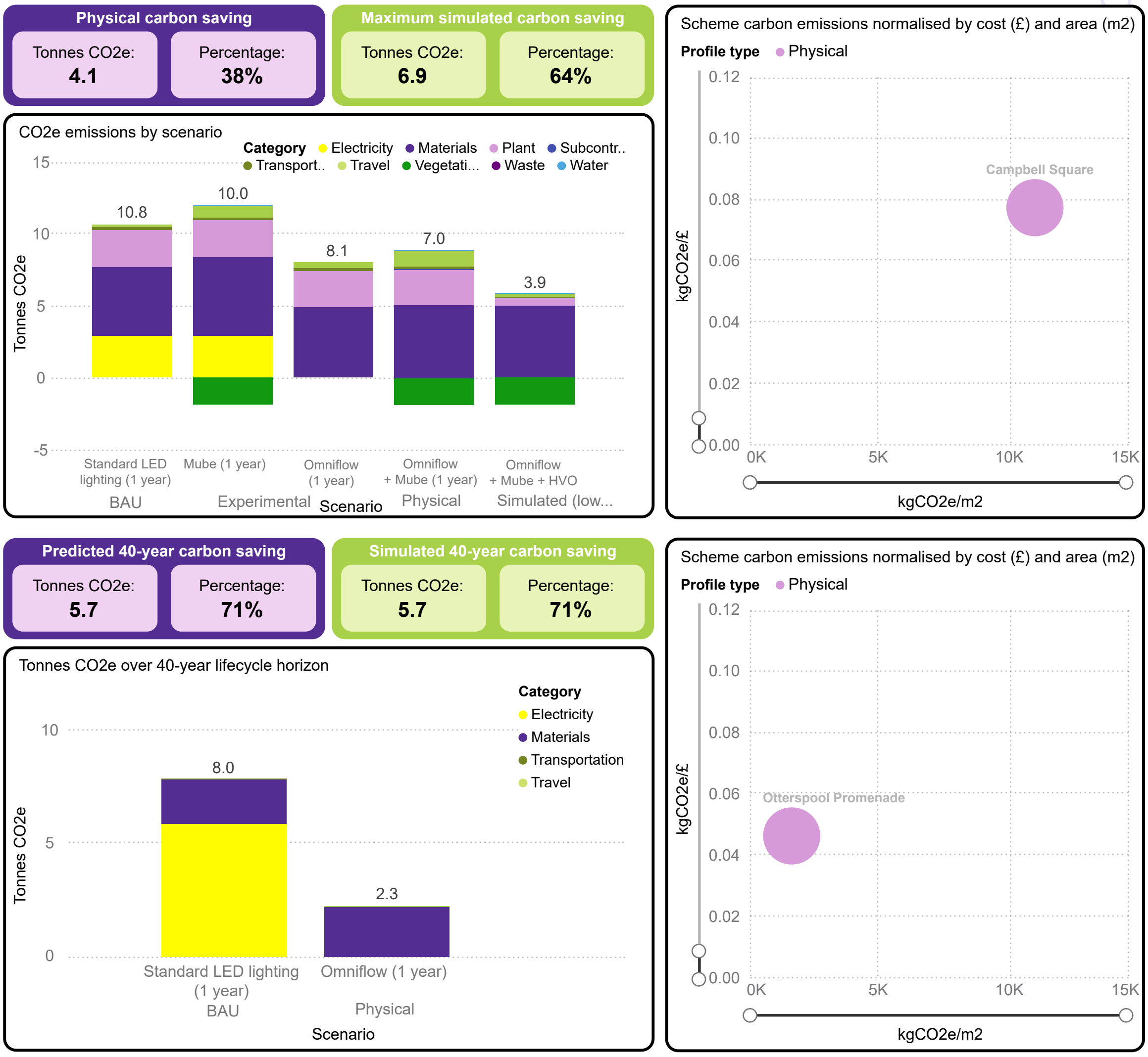


Figure 17: 40-year carbon profiles for Omniflow on Campbell Square (top) and Otterspool Promenade (bottom)

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

8.5 Learnings

1. **Installation was straightforward, but import logistics caused delays**

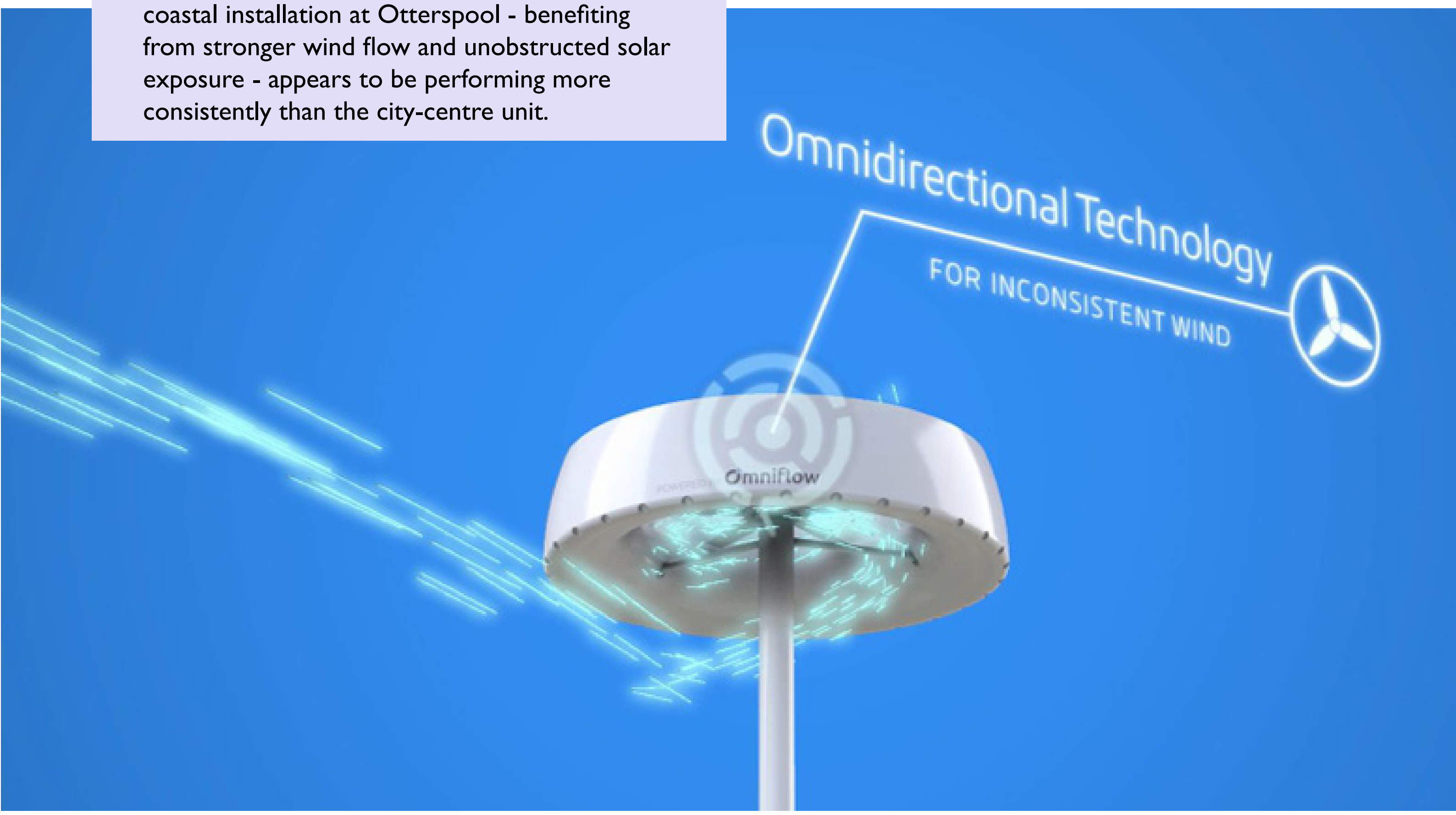
   The physical installation process itself was simple and efficient, with the units designed for quick assembly and minimal on-site disruption. However, importing the product from overseas resulted in longer lead times due to customs processing. Once the product becomes available directly within the UK market, this stage is expected to be far more streamlined, significantly reducing delivery and deployment times.

2. **Renewable performance is context dependent, with early indications favouring coastal locations**

   Although it is too early in the trial to draw definitive conclusions, initial observations suggest that the coastal installation at Otterspool - benefiting from stronger wind flow and unobstructed solar exposure - appears to be performing more consistently than the city-centre unit.

3. **Smart functionality provides added long-term value**

   Beyond renewable-energy generation, the integrated smart features - such as environmental sensing, IoT connectivity, and air condition monitoring - demonstrate strong potential for enhancing long-term operational value. These capabilities extend the usefulness of the infrastructure beyond lighting alone, contributing to wider smart-city objectives and improving return on investment over time.



Department for Transport

ADEPT LIVELABS2 Decarbonising Local Roads

LIVERPOOL LIVE LABS DRIVING DECARBONISATION

CASE STUDY INTELLIGENT LIGHTING & SMART STREETS

Reducing Operational & Embodied Carbon in Lighting Infrastructure

9. Trail Findings

Across the Intelligent Lighting & Smart Streets innovations trialled within Liverpool Live Labs, several consistent themes emerged regarding carbon reduction, operational performance, installation feasibility, and long term suitability for BAU integration.

1. Intelligent operation consistently outperforms static BAU infrastructure

All innovations demonstrated that smart, adaptive, or demand led systems can significantly reduce operational energy use compared with traditional fixed output lighting or always on road infrastructure. Targeted illumination, dynamic activation, and data driven control enabled meaningful whole life carbon savings across very different use cases.

2. Avoidance of physical infrastructure is a major carbon lever

Solutions such as Flowell 20mph signs and Flowell zebra crossings achieved substantial reductions by avoiding carbon intensive physical interventions (e.g., speed cushions, permanently illuminated columns). This reinforced that behavioural technologies can often deliver equivalent or improved safety outcomes without the embodied carbon associated with heavy civil engineering.

3. Renewable integration shows strong potential but is highly context dependent

The Omniflow trial highlighted that hybrid solar wind systems can reduce operational carbon on suitable sites. Coastal, unobstructed environments (e.g., Otterspool Promenade) demonstrated significantly stronger renewable generation than urban locations like Campbell Square. Early results suggest that renewable powered street assets perform best where consistent wind flow and solar gain are available, making careful site selection essential.

4. Smart functionality delivers long term strategic value

Beyond carbon savings, several innovations (particularly Omniflow and TAL) demonstrated strong potential to enhance safety, provide real time data insights, and support future smart city evolution. Their multifunctionality - such as data analytics add ons - creates broader operational value that extends beyond lighting alone.

10. Recommendations for Business-As-Usual Integration

- Use adaptive and demand-led systems by default where reducing operational carbon is the main driver, as they deliver strong whole-life savings compared with static lighting.
- Prioritise behaviour-led digital solutions (e.g., dynamic signs, targeted illumination) over physical calming where appropriate, as these avoid high embodied carbon and still improve compliance and safety - especially near schools.
- Deploy renewable-powered assets only at suitable sites, focusing on open or coastal locations with good solar and wind exposure, supported by pre-deployment energy assessments.
- Implement interoperable, data-driven systems, enabling integration of sensors, analytics, and remote monitoring to enhance resilience, maintenance efficiency, and long-term operational value.
- Continue long-term monitoring, particularly for renewable-powered systems, to confirm seasonal performance and verify whole-life energy and carbon outcomes.

11. Testimonials

These upgrades are a vital step in making Liverpool's waterfront safer, smarter and more sustainable. We've listed to residents and stakeholders, and we're delivering lighting that meets the needs of a growing city, enhancing visibility, reducing energy use, and supporting our commitment to achieving net zero.

Councillor Dan Barrington, Cabinet Member for Transport and Connectivity