

Train powered by Organic Waste led by Ultra Light Rail Partners and BCU's IDEA Institute

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Above: [BioUltra](#) train illustrated on-track

In November 2020 the PM launched his 10-point plan for a Green Industrial Revolution aimed at creating and supporting 250,000 jobs, focussing on the UK's industrial heartlands including the West Midlands and crucial in the run up to the COP26 climate summit in Glasgow this November.

Previous government impact assessments had indicated our economy would shrink 8% in the event of a hard Brexit with fewer jobs and lower wages. Since then industry has breathed a sigh of relief that a trade deal has been done with the EU block, but the dual impact of Covid and the thin Brexit deal, has left many manufacturers reeling in the face of ongoing uncertainties.

Against this backdrop, as Chairman, [Ultra Light Rail Partners Ltd](#), an established spinout from the IDEA [institute at Birmingham City University](#), I was delighted to be awarded our second Innovate UK (IUK) grant in September 2020. This built on our £350k IUK grant for 'Project [STEAMUltra](#)', [culminating in our successful trials in July 2020 when we demonstrated our single carriage train powered by a biomethane \(or renewable natural gas\) engine in a bogie-frame as a 'UK first'](#).

'Project BioUltra' has required producing a feasibility study, centred around designing an affordable, clean, lightweight double-bogie train, known as the BioUltra, with two biomethane engines and battery-packs making up a hybrid carbon-neutral powertrain. Designed to carry 120-people, it incorporates Covid-resilient features and requires no overhead wires, gantries or external power.

Once awarded this second £60k IUK grant in October, our design concept and technical schematics were due to be completed by end December, providing a demanding timetable for our team which included specialist engineering designers from [Invizio](#), based on Malvern Hills Science Park.

The BioUltra train is intended for use in urban and rural locations, opening up opportunities for public transport that is clean, affordable and safe. The team aims to get it into production over the coming year and a further grant is being applied for to begin construction in the West Midlands in April 2021 with a one-year build programme. Paddy Fawcett, award-winning designer and founder director of Invizio, has brought considerable depth of experience to the team as former Head of Product Design at QinetiQ and Strategic Product Manager at General Dynamics. Christopher Maltin, Director of [Biomethane Ltd](#) and technical director for the BioUltra is a globally acknowledged expert in biomethane power. The team were pleased to produce designs and technical drawings for the BioUltra, (illustrated below), on schedule and to budget, enabling the successful conclusion of our second IUK project in December 2020.



Above: [BioUltra](#) train illustrated on-track

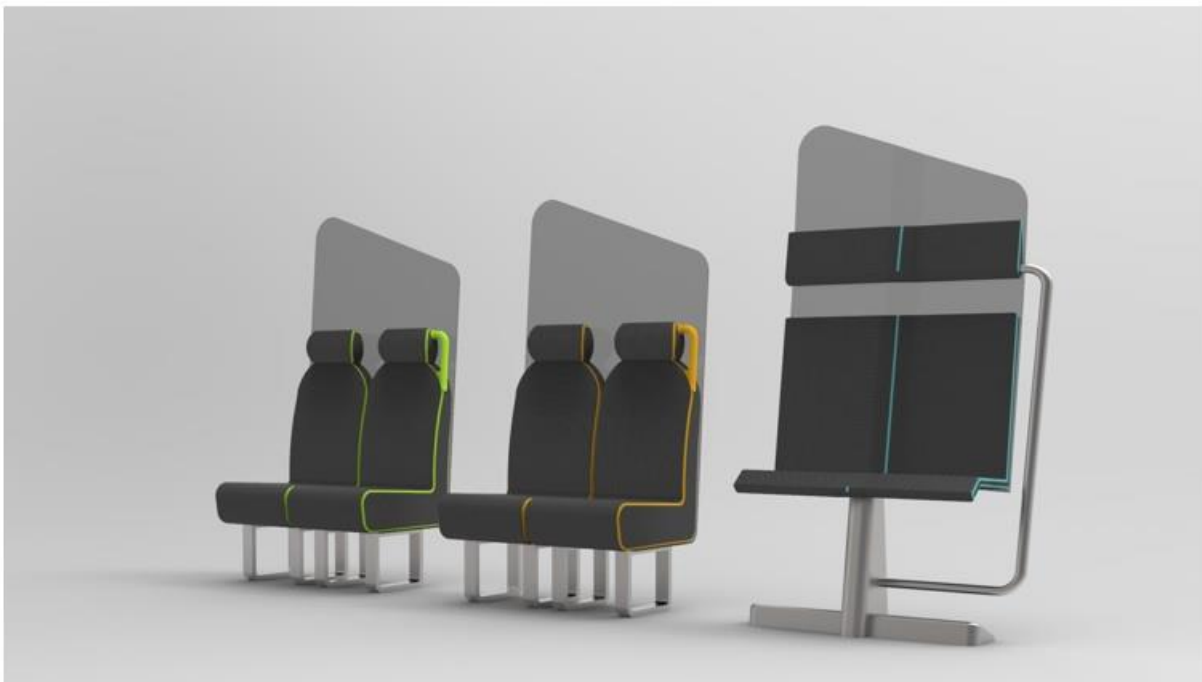
We gained wide press coverage in [The Times](#), [The Independent](#), [The Daily Mail](#) and as far afield as [UAE](#), [India](#) and [USA](#) in pieces highlighting some of the advantages of the BioUltra offering a lower-cost, safer, quieter, more comfortable, cost-effective, ultra lightweight, net negative carbon, mass-transit alternative.

The train has an 2000-mile range and a 50mph top speed. Next best-in-class offers around 100-mile range per charge. The BioUltra is highly efficient costing 11.7p a mile to operate.

Reduced capital and maintenance costs are provided with minimal infrastructure requirements – neither catenaries nor trackside battery-pack charging is required. A lightweight spaceframe structure of rustless steel enables use of older tracks, such as those making up some of the proposed Beeching reversal lines, with a lower roofline enabling the BioUltra to fit under low bridges. Level platform boarding for passengers is included with interior fittings designed to be [DDA](#) compliant. A range of covid-resilient features includes incoming filtered air being exposed to shielded UV lighting, taken through ducting forming individual passenger shields before being passed through the biomethane engine destroying any remaining virus or bacteria. Anti-Covid copper handrails and perspex screens are also included.



Above: BoUltra train interior illustration



Above: BioUltra seating with anti-Covid shielding

With our overdependence on fossil fuels the hunt is on for practical energy alternatives that do not take too much energy to produce or cause harmful carbon dioxide emissions, ULRP has focussed on biomethane as a truly circular solution.

Renewable natural gas is produced from organic waste – animal, human, crop, and food. By using biomethane we are preventing harmful methane emissions, up to [34 times more damaging as a](#)

[greenhouse gas than carbon dioxide](#). Of the 90 million tonnes of animal manure produced each year in the UK, it is estimated that only 3% is processed.

It is not widely recognised that biomethane is interchangeable with natural gas (methane) and can be used not only for transport purposes but in every application where natural gas is used, including for electricity generation, water heating, space heating and cooking and for making other materials, such as plastics.

With estimates suggesting that present biomethane supplies could perhaps replace as much as a quarter of domestic natural gas in use, it is perhaps surprising that the UK government have stated their intention to [ban gas heating in homes by 2025](#). Firms are rushing to develop innovative new products drawing [on hydrogen](#), proposed as the main feasible alternative to natural gas, currently used in 85% of homes which, in turn, are responsible for one third of GHG emissions. As the only by-product of burning hydrogen gas is water, it is certainly carbon-free at the point of use, but not necessarily across its lifecycle.

Hydrogen does not exist naturally and, as a result, it has to be manufactured, requiring considerable amounts of energy in production. At present, 95% of hydrogen is produced from fossil fuels through an energy-intensive process known as steam reformation, emitting between 9-12 tonnes of CO₂ for every tonne of hydrogen produced. According to the IEA this leads to more carbon emissions than from the UK and Indonesia combined. Green hydrogen, made through electrolysis of water, is very expensive, priced at over £200 a barrel equivalent, although with scale production it is expected to decrease in price.

In contrast, biomethane occurs naturally – all over the planet – through abundantly available organic waste material which can be collected, cleaned and compressed as a source of energy without using any fossil fuels.

The chemical formula for biomethane is CH₄. The carbon dioxide released into the air is exactly the same quantity of carbon dioxide which the organic materials took out of the air when they were growing. It is a short-cycle process where carbon dioxide is taken

from the air and returned so there is no increase in carbon dioxide. When using fossil fuels, the carbon dioxide emitted is an increase in the atmosphere after millennia trapped underground, sometimes referred to as a long-cycle.

In spite of these circular credentials, biomethane carries a Road Fuel Duty charge at 24.7p per kg, with VAT added at 20%. It is nonetheless competitively priced at costs £54 a barrel equivalent , with duty added on top. In contrast, 'green' hydrogen is zero-rated for duty and VAT. Diesel costs £73 a barrel equivalent with 57.95p per kg paid in Road Fuel Duties and a 20% VAT charge. However, biomethane produced from animal manure leads to a 174% greenhouse gas emissions saving compared to diesel according to the Gallagher Review of the Indirect Effects of Biofuels Production for the Renewable Fuels Agency, Department for Transport, 2008.

With much focus on electric vehicles (EVs) there are still more biomethane-powered vehicles worldwide, despite its far lower profile by a ratio of 3:1, with 24 million biomethane-gas vehicles compared to 8 million EVs in operation.

The UK grid is increasingly strained as more transport moves to electric propulsion. The [#WM2041 Discussion Document](#) states, (p40): "The Regional Energy Strategy (states): the 42,547 GWh of energy currently delivered to vehicles in the region as petrol and diesel is nearly equal to... the entire gas network in the region and almost twice ...the electricity system. The implications for local energy infrastructure of shifting transport fuel use from petrol to electricity or gas are significant. As such, a lot of that demand will need to be met or otherwise eliminated by mass transit or active travel."

Daily traffic congestion has a negative impact on the health of our population. Poor air quality, caused by noxious gases such as carbon monoxide, nitrous oxides, ammonia and sulphur dioxide, causes over 14,000 premature deaths annually, while airborne particulates are responsible for 37,800 premature deaths across the UK. More worrying are the presently unproven effects on young children, the development of whose lung capacity is being stunted from exposure to these pollutants, causing irreversible damage permanently affecting long term health.

Whilst vehicle exhaust emissions have attracted a lot of attention, the smallest (under PM 2.5) particulates cause the most injury to human respiratory systems. During any journey by road over 1,000 times more of these health-damaging particulates are emitted from rubber tyres wearing down whilst interacting with road surfaces, than from vehicle exhausts. Trams have no tyres and rolling their steel wheels along steel rails requires 85% less energy than for vehicles driven with inflated rubber tyres with the lightweight BioUltra train using significantly less energy and no airborne particulates.

Biomethane, when used in an internal combustion engine operating an urban area with poor air quality, takes in air which travels through the engine at around 2000 centigrade, emerging cleaner than the air which went in as any particulates present are incinerated. No fuel cell or electric motor performs this 'cleaning' function.

During 2017, over 5% of deaths in the West Midlands were as a result of exposure to particulate [air pollution](#), the second highest out of all Combined Authority areas. Recent monitoring and review work by Sustainability West Midlands (SWM) for the WMCA has identified that reducing the levels of just one pollutant (PM2.5) by 50%, would prevent 952 deaths and save £1.4m of NHS costs in the WMCA area per year.

In developing the BioUltra train, the team at Ultra Light Rail Partners have seen the project as a catalyst to providing a whole new breed of environmentally-friendly ultra-lightweight vehicles opening up opportunities for smaller cities and towns which may have previously seen light rail solutions as well beyond their budgets and capacity.

Associate Professor Beverley Nielsen is Executive Director of the Institute for Design & Economic Acceleration, IDEA, at Birmingham City University and Chairman of Ultra Light Rail Partners Ltd. She is also Fellow at the Centre for Brexit Studies. She is an Expert Commissioner on [All Party Parliamentary Green Manufacturing Commission](#), co-edited [English Regions After Brexit](#); [Brexit Negotiations After Article 50](#) and co-wrote [Redesigning Manufacturing](#).