Personal Electric Transport for Visitors to Powys and the Brecon Beacons[1]

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1 Executive Summary

Visitors to the Brecon Beacons National Park (BBNP) average 50 car miles a day and produce 50,000 tonnes of carbon a year. The challenge is to entice visitors to use low energy, low carbon alternatives to explore the area during their stay.

Electric and electric assist vehicles use much less energy and Powys generates enough electricity from natural renewable resources to power all its local travel by electric. This could be a Unique Selling Proposition (USP) for the region.

There are currently only about 3000 pure electric cars in the UK and most have a range of less than 100 miles. Few will be visiting Powys in the next couple of years. Those that arrive will stay overnight and be charged from a standard 13 amp socket. This is how most electric cars are charged (at home) today.

Plug-in hybrid (or range extended) electric cars are able to reach mid-Wales using their on-board generators but would prefer to use mains electricity to power their vehicles during their stay.

Powys can welcome electric car drivers by ensuring that most accommodation providers and other long stay destinations offer re-charging. Zero Carbon World will provide free charge points to tourist businesses where visitors are happy to stay for 3 plus hours. Around 17 have been deployed in the area to date and this will grow to 100 by October. This is already more than any other rural UK region.

High speed charging for electric cars is more difficult and costly and is not yet standardised. It isn't particularly necessary for visitors *staying* in Powys, being more important for top-end electric cars travelling through the area and not willing or able to stop overnight or break their journey for several hours.

Electrically assisted pedal bikes are very low energy and encourage potentially reluctant cyclists to try cycling even in a hilly area. E-bikes take most of the effort out of climbing hills or travelling longer distances and also facilitate carrying or co-riding with children or disabled people.

Rented electric bikes don't really need re-charging en route (as they are unlikely to cover more than 30 miles) but can be made welcome by e-bike friendly

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[1] Report commissioned by Sustainable Tourism Powys and Brecon Beacons National Park as part of Visitor Transport Plan for Powys.

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destinations which provide access to a 13 amp socket if the bikes carry their own chargers. Unlike electric cars, electric bikes do not generally have on-board chargers making public charging points difficult to provide.

Powys is ideally positioned to offer visitors the chance to try travelling 'electric' during their stay as part of their holiday experience and a reason to visit the area.

To reduce car miles and carbon, electric alternatives need to be available in large numbers, diverse forms (electric bikes, cars, quadricycles and buggies), offer a different, fun experience to ride or drive (or people won't bother) and be accessible where visitors are actually staying.

If visitors have to make a separate car journey to reach a rental hub, fewer will participate, no carbon will be saved and visitors' car-centric mindset and behaviour will not have been disrupted.

There are some tourist destinations in Powys which offer 10-20 mile "scenic drives" e.g. Lake Vyrnwy. A small percentage of carbon can be saved by offering e-bikes or electric vehicles at these destinations, as an alternative to driving round by car, but it would be 1 trip per car per day.

To significantly reduce carbon from visitor car journeys, Powys and the BBNP need to find an economically viable way of flooding the area with electric vehicles and e-bikes – 1 or 2 available at as many accommodation points as possible.

The Eco Travel Network (BBNP), Electric Bicycle Network (3 National Parks) and Exmoor Unplugged are all exploring ways of offering this on a sustainable economic basis. The projects are all experimental, and are operated by not-for-profit CIC's. These do not hire vehicles and bikes directly to visitors, but effectively lease them to local tourist businesses to promote and rent out to their customers. This spreads the purchase, insurance, and running costs across many small tourist businesses who take the rental revenue themselves.

This model requires start-up subsidy by the National Park or local sustainable transport initiatives. It could be managed by the local authority or National Park itself, by a new CIC or by one or more of the existing hire businesses.

2 Introduction

Powys and the Brecon Beacons National Park (BBNP) want to encourage more sustainable visitor transport in their area. Visitors to the park currently consume 50,000 tonnes of carbon a year[3]. This report explores the potential for low-energy, low carbon *personal* transport – powered either by electricity or a mix of electricity and human power.

Earlier research[4] showed that visitors to the Brecon Beacons average around 300 miles return trip by car to travel here but drive the same number of miles during a 1 week stay. Even a walk or cycle ride involved an average of 14 miles in the car to get to the start and yet visitors who come here to walk or cycle almost never walk or cycle for their utility journeys (shopping, visiting the pub) even if these are only 1-2 mile journeys.

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[3] Calculation based on 5m visitor days and 50 car miles a day http://www.nationalparks.gov.uk/press/factsandfigures.htm

[4] http://theprospectory.files.wordpress.com/2011/08/b-bug-visitor-travel-report.pdf

Can we change this pattern – i.e. entice visitors out of their cars to travel around the area by more sustainable means *and* make this an appealing part of their holiday experience?

Technical advances in electric motor and battery technology are creating low-carbon, low-energy personal transport alternatives which could work well in our rural area and offer visitors an attractive alternative to using their cars for local journeys *once they reach the area*.

There are 3 aspects to address:-

1. **Technical** – what lower energy alternatives are there for visitor transport in the form of electric cars, bikes, boats and their required infrastructure?

2. **Behavioural** – how do we attract visitors to opt for these alternatives rather than using their cars?

3. **Economic and Organisational** – how can we make them affordable and conveniently accessible on a large enough scale to make a difference?

3 Technical

3.1 Transport Energy

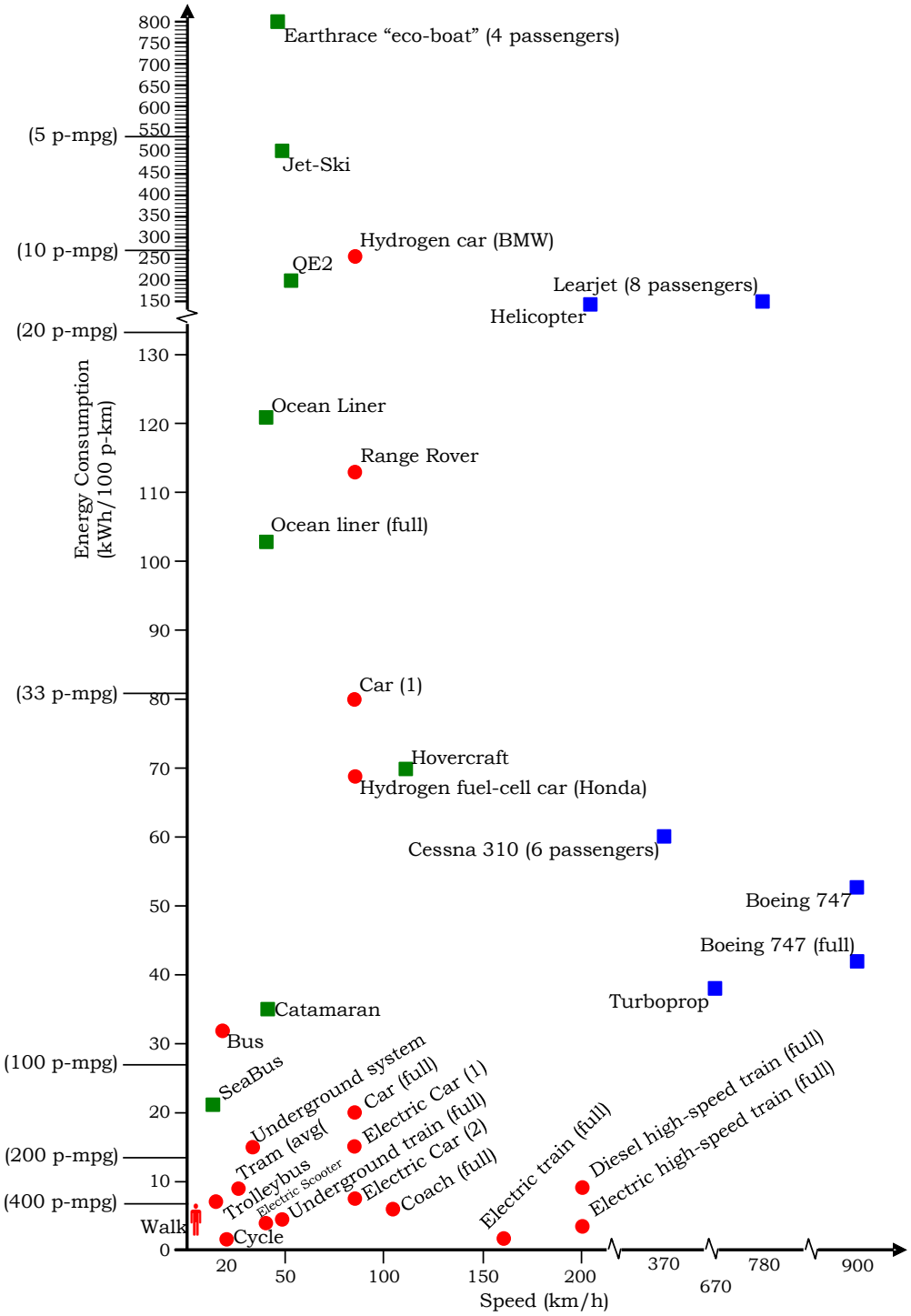
Sustainable travel means:-

1. Moving around using much less energy per person per mile (regardless of how that energy is generated). This means lighter vehicles, more efficient motors, lower wind resistance, multiple passengers and slower travel.

2. Acquiring more of our transport energy from renewable resources. In the case of Powys, which generates much of its energy from wind, water and sun, all our transport could now be powered by locally produced energy.

So, how much energy do different types of travel use? The following diagram, adapted with permission from a comprehensive study by Professor David McKay[5] gives us a feel for this.

[5] Sustainable Energy – without the hot air', David McKay, UIT (2008)



Some explanation is required here. The vertical (Y) axis is energy consumption in kilowatt hours per 100 person-kilometres, and the horizontal (X) axis the average speed. It shows, for example, that an average UK car carrying one person uses about 80kWh of energy to travel 100 kilometres at about 100 km/h. This is also expressed in “p-mpg” or person-miles-per-gallon – a measure of how many miles per gallon of fossil fuel energy (or equivalent) per person each mode of transport uses. Our average car does 33mpg, or 33 p-mpg with just one person in it. When carrying 4 people, it would still do about 33 mpg so the energy used drops to 132 p-mpg.

The diagram shows that the most sustainable forms of transport are cycling, walking, electric cars, buses and (perhaps best of all) cross-country electric trains

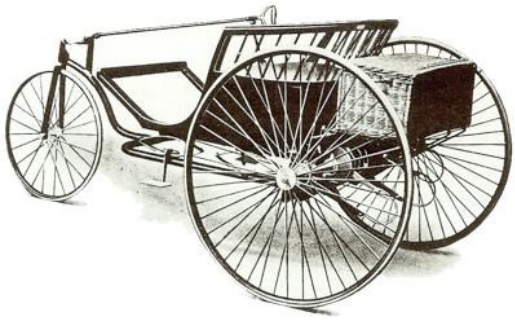
when they are full. The energy efficiency of buses and trains stems from the fact that they can carry a large number of people in long thin tubes. Travelling at any speed means overcoming wind resistance which rises with the square of the speed and is the main energy drain for anything travelling faster than about 15mph[6]. Arguably, a 30mph speed limit on all roads other than A roads in Powys would make a greater contribution to sustainable travel than almost anything else we could do.

4 Electric cars

Electric cars are a more sustainable form of transport mainly because of their far better fuel efficiency. In Powys and the Brecon Beacons they also exploit our abundant renewable electricity generation – a truly virtuous circle!

4.1 History

Electric cars have a long history.



J.K. Starley's electrically propelled tri-car in 1888 built by Henry Hollick (Alison's Great Grandfather!) – reputedly the first motor vehicle to be made in the UK.

The first automobiles made in the UK were electric. Around the turn of the last century, however, the internal combustion engine (ICE) displaced the electric motor for road transport.

Electric motors are more efficient but batteries are heavier than petrol.

Electric motors are lighter, more efficient and cheaper to make, and are the dominant source of mechanical power everywhere except road travel. Petrol and diesel hold far more power for a given weight than batteries do and liquid fuel's "power-to-weight" ratio means that ICE's dominate road transport even though they are far less efficient in energy terms.

Efficiency has started to matter.

Until recently, that inefficiency didn't matter because petrol and diesel were very cheap. This is changing as the world depletes its known reserves of fossil fuel, and starts to worry about whether releasing in a few centuries carbon sequestered over hundreds of million of years might not change the composition of the Earth's atmosphere too quickly for comfort.

[6] High speed inter-city trains are less efficient than cross-country ones because of their faster speed, so the government's plan to increase the speed limit to 80mph is a triumph of individual liberty over sustainability because a 14% increase in speed means 30% more energy to overcome wind resistance.

4.2 Types of electric transport

Electric motors dominate where the electricity can be delivered directly to the point of use.

Railways and trams use electricity from overhead catenaries, rather than on-board batteries. Cars may one day enjoy direct power delivery but only if we are willing to turn our cities into giant Scalextric sets. This isn't a near term future for the back roads of Powys.

Hybrid cars using electric motors – for example, the Toyota Prius – with a small petrol or diesel generator have been around for over a decade

Electric motors are so efficient that it takes less energy to power a car with an electric motor even when the electricity comes from an on-board petrol generator. Diesel-electric trains and ships have long done this, but it has also been used for over 10 years in what are called **hybrid** cars like the Toyota Prius to deliver better fuel economy than using an ICE to drive the wheels directly.

Plug-in hybrids (or range extended electric cars) rely on their batteries for short journeys but have a petrol or diesel generator to recharge the battery on journeys longer than the battery capacity.

The original Prius had a small battery (enough for a couple of miles) and simply used petrol more efficiently by running the generator more or less constantly but at optimum speed. Because the battery was small, it made little difference to the weight of the car. As battery technology improved, it became possible to increase battery capacity to, say, 30 miles without making the car too heavy. This meant that the car's petrol generator did not need to run as often, or in many cases at all, if the car could also be connected to mains electricity charger to recharge the battery "offline" overnight or while parked.

This kind of car is called a **plug-in hybrid**, and when batteries of sufficient capacity to meet in full the daily commuting needs of the average motorist became available and affordable, the ICE generator was only needed on journeys longer than commute distance. This kind of hybrid is called a **range-extended** electric car, to emphasise that it is *primarily* a battery electric car, mainly recharged offline from the mains, with a small on-board petrol or diesel generator to cover the relatively few car trips that exceed the range of the main battery. In the first widely available car of this type, the Vauxhall Ampera (Chevrolet Volt in the U.S.) this distance is about 60 miles.

Pure electric cars rely entirely on mains-charged batteries which can store enough electricity for between 80 and 200 miles.

The latest battery technology, now largely Lithium based, can store enough energy to power a very light car for over 200 miles. The Tesla Roadster was the first of this kind of car to reach the market. It combines sports car acceleration (0-60 in less than 4 seconds) and top speed (limited to 125mph) with long range (200 miles, though not when driven at 125mph!).

Long range/high performance pure electric cars are very expensive.

The Tesla needs 450kg of Lithium battery - nearly 40% of the car's weight - storing over 50kWh of electricity. This makes the car extremely expensive

compared with a comparable ICE sports car - £87,000 compared with the £30,000 to £40,000 for the petrol powered sports car (the Lotus Elise) on which the Tesla is based.

The Tesla Roadster is still a very lightweight two-seater sports car. To make a four-seat family car with that range and performance would be more difficult – the car itself would be heavier and the battery required to power it for 200 miles would be very expensive and add a huge amount of weight. At the moment, the industry cannot deliver a pure electric family car - i.e. one driven entirely by mains-charged batteries – with comparable range to a normal family car. Even though it could be built, it would be much too expensive for ordinary people to buy, and wouldn't make economic sense until fossil fuel prices rose dramatically.

But 88% of car journeys can be done in a car with a 100 mile range

The government's annual National Travel Survey shows that 88% of our car journeys can be done in a car with only a 100 mile range. Households who can afford more than one car may therefore buy an electric car of this range for shorter trips and commutes.

The industry can now deliver family electric cars with 80-100 mile range

The first manufacturers to sell commuter range battery cars in U.K. are Mitsubishi/Peugeot/Citroen with the I-Miev/Ion/CZero and Nissan, with the Nissan Leaf. These do between 80 and 110 miles at normal road speeds on a full charge. Renault is launching in 2012 a full range of battery powered family cars with similar specification. BMW has been extensively testing an electric version of the Mini; Smart has a version of the SmartCar ready to launch; and Ford plans to introduce a pure electric version of its Focus model to compete with the Nissan Leaf. Vauxhall has chosen to enter the market with a range extended battery car called the Ampera this year (2012).

Lightweight quadricycles are cheaper, use much less energy and will cover local journeys. They can be driven by 16 year olds.

The G-Wizz, introduced in 2005 for the London market, is a low speed (40mph), short range (< 40 miles) electric car that is classified by the government and the EU as a quadricycle due to its low weight and speed. Quadricycles can be driven in some EU countries by 14 year olds, and without a full driving licence. In the UK, they can be driven on a provisional licence by 16 year olds.

Renault is launching a modern quadricycle called the Twizy as part of its 2012 range of "Z.E" (zero emission) battery electric vehicles. It differs from the G-Wizz by not pretending to be a car at all, although it drives just like one. Its small frontal area and high-tech lithium batteries give it sprightly performance - up to 50 mph - and better range - perhaps 50 miles. It can do this with less than a third of the battery capacity of a Nissan Leaf, and can be re-charged in less than half the time.

The Twizy is a specialist vehicle designed to fulfil a common transport need as efficiently as possible. It is a car for someone who either has other vehicles for other purposes, or access to public transport or a shared vehicle for needs it does not meet. It could become a popular transport mode for urban and rural drivers if fossil fuel prices ever put today's cars out of our reach.

4.2.1 Purchase and Running Costs

Electric cars are cheap to run in terms of electricity consumed

The best electric cars do over 3 miles per kWh, so can claim lower running costs - about third of the running cost of a diesel or petrol car.

The Nissan Leaf, for example, claims over 100 miles in flat terrain on a single charge with batteries of about 24kWh capacity. In mixed driving conditions the U.S. environmental protection agency (EPA) certifies the Leaf as having a range of 73 miles on a full charge. This works out at about 350Wh per mile from the battery, and with a 75% efficient charger would mean taking 32 kWh of mains electricity to fully recharge. At the current UK average price of electricity (a little over 14p per kWh) this works out at over 6p a mile on the Leaf's certified range, though by using "Economy 7" electricity at say 8p a kWh, a Nissan Leaf owner could get about 3½p a mile.

But batteries are actually the main running cost of an electric car.

Electric cars with substantial battery capacity use Lithium batteries, which cost about £375 per kWh. £8,000 worth of lithium battery is needed to give a car a range of 100 miles. Without a hefty government subsidy, most electric cars would cost well over £30,000 for a vehicle that would cost less than £20,000 with an internal combustion engine. And while batteries can obviously be re-charged, they can't be recharged forever.

So "fuel" costs are dwarfed in practice by the costs of replacing batteries which you may only be able to recharge 1,000 times before they lose around 20% of their capacity. It is difficult to calculate what this replacement cost is per mile, but since Renault leases the batteries in its electric cars, we can figure out what Renault thinks it is. For the Twizy quadricycle, you pay £45 a month - £540 a year - to lease the batteries for 4500 miles a year or less. Crudely speaking, that's about 12p a mile for the cheapest and most efficient car available. It will be more for the full size electric cars.

Electric cars are significantly more expensive than their ICE equivalents even with the £5k government subsidy

The UK government is keen to see the wider adoption of electric cars, and offers a £5000 subsidy on their purchase price. Despite that, full electric cars are much more expensive to buy than "equivalent" petrol or diesel powered cars. They do attract zero road tax in the UK and avoid congestion charges in London - but so, now, do the most efficient petrol and diesel models. The table below lists the cars that currently (April 2012) qualify for the UK government's £5000 subsidy. In each case the electric range, speed, battery capacity and fuel costs are listed, along with the purchase price after deduction of the subsidy:

Make and Model	Available	Max Electric Range	Top Speed	Capacity (kWh)	Full Tariff Charge	Grant Price	
Citroen CZero	Now	93	80	16	£3.09	£21,216	
Mia Electric Mia	May-12	75	62	12	£2.32	£22,000	
Mitsubishi i-MiEV	Now	93	81	16	£3.09	£24,000	
Nissan Leaf	Now	109	90	24	£4.64	£26,000	
Peugeot iOn	Now	93	81	16	£3.09	£26,216	
Renault Fluence ZE	Apr-12	99	84	22	£4.25	£17,495	+ £76pm battery
Smart forTwo electric drive	Now?	87	75	17	£3.40	£19,000	

Toyota Prius Plug-in Hybrid	2012	14	112	4.4	£0.85	£27,800
Vauxhall Ampera	2012	50	100	16	£3.09	£29,000

Table 1. Electric Cars which qualify for the UK Government £5,000 Grant[7]

Note that table 1 does not include the Tesla Roadster – which might otherwise be eligible but for some reason has not applied for grant qualification[8]. Nor does it include the G-Wizz (~£10k), or the new Renault Twizy (~£7k), both of which are quadricycles. The grant conditions specifically exclude quadricycles, and also include minimum speed and range criteria.

4.2.2 Penetration

There are only around 3,000 battery electric cars in the UK and growth is slower than predicted

The number of electric cars registered in the U.K. is difficult to establish but is well below government and industry targets. There are probably around 3000 battery electric cars in the UK, but over 80,000 hybrid vehicles (electric powered cars that cannot recharge from the mains) have been sold since they were first launched over 10 years ago. Since the UK government introduced its £5,000 subsidy, the registration figures according to the Society of Motor Manufacturer and Traders are as follows:

	2010	2011
Total Pure Electric	**138**	**1082**
….of which, plug-in Grant eligible	111	1052
Total hybrid	22127	23370

These figures do not include quadricycles, which at the moment are probably still the most common type of electric "car" available. The latest model of the G-Wizz has Lithium batteries which have extended range to 75 miles from about 50, but its price from about £10,000 to about £16,000. Since this car, as a quadricycle, does not qualify for the government grant but is now as expensive as a normal mid-range car, it could have a very limited market.

4.2.3 Charging Infrastructure

Poor take up of electric cars is sometimes blamed on absence of charging infrastructure

The poor take-up of electric cars has been attributed by some disappointed champions to the lack of a universal charging infrastructure. This was famously publicised by the BBC's Top Gear programme last year. It *looks* like a "chicken and egg" problem, but the situation is actually more complicated.

85% of electric cars are charged entirely at home and overnight[9] (because they are used for daily commuting)

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[7] see www.thechargingpoint.com for guide and reviews of electric cars as they are released.

[8] It's possible that Tesla feels some embarrassment claiming a £5,000 subsidy on an £86,000 car for its customers. At that price, they can hardly claim that it's a *necessary* incentive, and it's difficult to believe it would have much effect on take-up of Tesla cars!

[9] http://www.thechargingpoint.com/beginners-guide.html

In reality today's electric cars are designed to be charged overnight in their garages, over the course of 8 to 10 hours, from domestic power sockets. All the cars on sale can be charged at home like this using an on-board charger. Most electric cars can also be charged at a dealer using a specialist off-car charger that replaces between 80% and 100% of the battery capacity in between 30 minutes and an hour. To fully charge the car with the largest battery in Table 1, the Nissan Leaf, takes over 30kWh of electricity from the wall, no matter how long it takes. While this is a lot of electricity, but on a cheap overnight tariff it would still cost less than £3.

Quadricycles have smaller batteries and charge more quickly

The lightweight quadricycles have smaller batteries, and use much less power. They can *only* be charged from standard domestic sockets, and even a full charge would take only 2 to 3 hours and use only about 75p worth of electricity.

The only universal charging standard today is the 13 Amp plug (in UK)

For safety reasons, and to ensure they will work everywhere, on-board chargers limit themselves to 10 Amps of current when connected to a standard 240V electric socket. This is to avoid overheating domestic sockets when drawing maximum current for an extended period. UK house wiring standards allow several outlet sockets to share a single main circuit. A charger with its own dedicated domestic circuit can draw 16A or even 32A using a different plug, and this will reduce charge times accordingly.

Charge Standards are being defined but are not yet implemented

The industry defines 4 modes of electric vehicle charging, in 3 distinct configurations and is working on standardising plugs, sockets, and voltage specifications. The most controversial standard will be that covering rapid charging where an in-house charger (costing thousands of pounds today) converts an industrial (400V 3-phase) supply into a very high DC current of up to 50kW. This poses wiring and safety challenges. Since high speed charging currently offers a competitive advantage to electric cars that can use it, we can expect standardisation efforts to be slow.

4.2.4 The Future of Electric Cars

Take up is currently slow

At present, despite the best efforts of government and industry, take-up of electric cars in the U.K. has been poor. The technology is new, the products too expensive, and buying an electric car today does not make much sense for most of us. There *is* widespread anxiety about the rising price of fossil fuel, and recognition that such a rise is inevitable in the long term as demand increases and supplies run out and/or become increasingly expensive to extract.

Government targets have been unrealistic, but industry is responding.

The government originally wanted 20% of new cars to be electric or hybrid by 2020. This is very unlikely on current projections. However, all the major car manufacturers either have introduced or are planning to introduce electric models in the near future. They may only be doing this for publicity, or because of government incentive, but this will have an effect on public outlook and

eventually, perhaps, on sales[10]. Prices will come down, but the widespread belief that battery technology will improve enough to match the power to weight ratio of combustion fuel remains a dream[11].

Electric cars are the long term future

A future where pretty well all cars are electric cars is still very likely, but it is a longer term future than we may think at the moment. Car ownership in the U.K. and the U.S. is actually in slight decline[12], but this is more than compensated by the massive growth in car ownership in China, India and Brazil. Brazil is expecting to (literally!) fuel this growth on renewable combustion engine fuels. India is developing cheaper fossil fuelled cars for its home market and exporting cheap electric ones to the rest of the world.

China is the most interesting player and in our view will decide the fate of electric cars.

China's growing middle class is a huge car market, and the signs are that China realises that fossil-fuelled cars are not the answer for them, and for two reasons:

1. They would have to import most of that fuel from countries they cannot rely on, in competition with America and Western Europe and

2. Densely populated Chinese cities already suffer levels of air pollution that have economic impact and create serious popular dissatisfaction.

So whether or not Europe and the U.S. adopt electric cars in the short to medium term, China probably will, and relatively quickly because they don't have the same legacy of a fossil-fuelled automobile based economy to protect, and their political system is perhaps more effective at fulfilling governmental aspiration.

The Chinese government has a target of 500,000 electric cars by 2015 and 5M by 2020. These volumes will drive costs down and many Western European countries will want to take advantage of them.

The U.S. may take a different route in the short term

To the extent that there will be continuing political or economic interest about fossil fuel usage after the next election, the U.S. may put more effort into switching to natural gas as a truck and eventually a car fuel. The U.S. now has massive resources of shale gas, and will soon be a net exporter. Despite being a fossil fuel, natural gas offers significant emission reduction without the major disruption to transport technology and infrastructure that electrification requires.

The Electric Car Market outside China may have to evolve differently.

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[10] Public perception of the penetration of electric vehicles is probably wide of the mark. With every politician, film star and media personality claiming to own one, it's hard to understand why there are less than 3000 pure electric vehicles in the UK.

[11] Apart from anything else, improving the range of electric vehicles is a moving target. If they're allowed to be as slow and as light as electric cars, manufacturers can easily develop 100mpg or even 150mpg diesel and petrol cars. That means cars with a 1000 mile range or more.

[12] Particularly among the urban young.

We think that if electric cars are to make short term impact in the West, they may have to start with markets where they offer significant advantages over existing cars. A Nissan Leaf cannot fully replace a Ford Mondeo in all the latter's applications, so electric car manufacturers may do better to focus on the features of the product they can currently offer that are an improvement on conventional car transport.

An example of this approach might be to target the urban middle class second car market with something that is fashion-conscious, appealing to young drivers, safe to drive, and cheap to insure and run. It doesn't have to fit a St. Bernard in the boot, or carry large families in air-conditioned and high speed comfort to Edinburgh on a single tank. It does have to be fun and "cool", and able to take you to school or college, to the shops, and to the restaurant and you can fill it up for nothing anywhere there's a building.

If vehicles like this can establish a large enough market, the market will drive how things develop from there. Derivatives and descendants of the original concept might start to displace other types of car, or push those other types of car into concentrating on meeting needs the newcomer doesn't address. This is what is known as a "disruption" strategy, and it is how PC's came to be more important than mainframes even though they did not, and still do not, do what mainframes do. It may be what Renault is trying to do with its Twizy (and other manufacturers are starting to follow suit) and it will be interesting to see whether and how it works out.

In the interim, we predict the largest share of the electric vehicle market will be taken by the plug-in hybrid and range-extended electric vehicles. These offer a reasonable compromise between efficiency and range, but at a premium price. They also make very small demands on the existing power infrastructure, and should appeal to conservatives in the industry and the motoring public.

4.2.5 Strategic Recommendations for Powys and the BBNP

The electric car market divides into 3:

1. Conventional "hybrid" cars that use electric motors and are recharged continually and entirely by on-board generators. They use petrol or diesel as their only fuel.

2. "Plug-in hybrid" or "range extended" cars powered by on-board batteries which are re-charged mainly by mains electricity but also by on-board petrol or diesel generators run intermittently and only when necessary.

3. "Pure" electric cars powered solely by their on-board batteries and recharged solely from mains electricity.

Conventional Hybrids are simply low emission cars.

Powys and the Brecon Beacons National Park should treat a conventional hybrid car the same as any other low emission car. They need no new supporting infrastructure and have probably been driven here by visitors for many years. To the extent that they offer lower emissions through more economic use of fossil fuel they should be welcomed, but do not present any new strategic challenges or opportunities for the region.

Plug-In Hybrids and Range Extended Electric Cars need overnight charging capability at their accommodation

Since they overcome the limited range that besets pure electric vehicles, plug-in hybrids and range extended electric cars will be attractive to both residents and an increasing number of visitors. Unlike most pure electric cars, plug-in hybrids will be able to get to Powys, so we can expect visitors to arrive in them. Although they can use fossil fuel, many owners will not expect to "fill up" with petrol or diesel very often. So although visiting owners may have needed fossil fuel to get as far as Powys, but it would make a much more attractive destination for them if while they were here they could conveniently use local mains electricity.

Since we can expect their owners to be both environmentally and economically aware, provision of electric charging at destinations and accommodation providers throughout the region would mean that all travel here could be electrically powered for these visitors. Combining this with a strong message about the region's sustainable energy production (see below) would be an easily marketable strategic option.

Zero Carbon World[13] is a charity donating 1000 free charging stations (a 13/16 amp and a 32 amp unit) to businesses in the hotel and tourist industry. The businesses receive the units for free and pay their own installation costs. Zero Carbon's goal is to support the fast development of a national charging infrastructure which is public and open and thereby to facilitate the growth of electric vehicles. To date, they have donated ~90 in the UK of which 17 are in the BBNP and Powys! Welsh Road Trips[14] is helping Zero Carbon World promote 100 units throughout the region.

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The bottom line strategy for plug-in hybrids and range extended electric cars should be to ensure that as many accommodation outlets as feasible install overnight charging facilities on their premises and off the road. If we're talking about *visitor* transport there is no immediate need or advantage to providing public charge points in car parks, because these vehicles do not generally have fast charge ability, are designed to re-charge at night, and lack of charging doesn't generate any particular anxiety because of the on-board charger.

"Pure" Electric Cars aren't going to reach Powys in large numbers soon.

The reality for 2012 and the next few years is that few pure electric cars will be driving to Powys from any distance. Those that manage it in a day might have

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[13] http://www.zerocarbonworld.org/

[14] http://www.welshroadtrips.com

[15] Charge point at http://www.westviewguesthouse.com in Llowes

needed two or three rapid re-charges en route. Those that do make it here can be made more welcome by the widespread provision of overnight charging at accommodation in the region, and (to a lesser extent) at shorter stay destinations.

Powys produces a significant amount of renewable electricity from hydro, wind, and solar PV. This is enough (by our reckoning) to meet the travel demands of those visitors and residents able to take advantage of it for the foreseeable future. This gives a strong marketing message that this county and this national park offer sustainable travel for environmentally sensitive visitors, using locally generated energy, with a visitor travel strategy that includes electric cars.

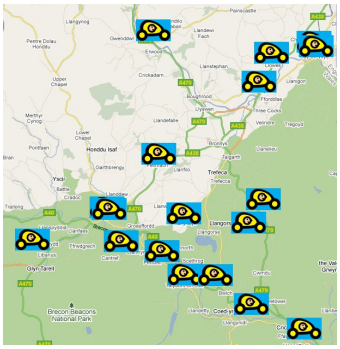
There may be a revival in the "motoring holiday" for electric car owners.

And although the challenge of reaching Powys from major population centres in the UK in a day will deter most pure electric vehicle owners for the immediate future, there may be a small group of enthusiasts who enjoy travelling 80 to 100 miles a day, stopping overnight to recharge themselves and their vehicles. This kind of pioneer might choose the region for its wide-spread charging network Powys as the ideal place for such an "electric motoring holiday".

Visitors arriving by other means may like to use electric cars while here.

Even if, for the time being, pure electric car owners won't be arriving in Powys in sufficient numbers to worry about, the region may still want to enable visitors who come here by other means to use an electric car while they are here. While this would make their travel environmentally more sustainable the challenge is to make it practical and commercially sustainable.

The b-bug trial in 2011 showed using an electric vehicle (albeit a buggy in this case) to be popular amongst visitors who enjoyed travelling differently. It turned journeys into "adventures", kept visitors more local and some didn't use their cars at all for a week. Local businesses were also very happy to act as informal top-up charge points as it brought them additional business. All they required was a parking space within reach of a 13 amp socket.



Visitors who come here by public transport or in large motor-homes occasionally rent small cars by the day, and rental companies will arrange to deliver cars to camping and caravan sites. There are, as far as we can determine, no car rental firms now at any of the train stations that serve the National Park. The local car rental firms we contacted were not planning to offer electric cars, and in the short term this is unlikely to change because of capital cost. Most national car rental companies offer electric cars, but at a significant premium and mostly restricted to London.

Aside from expense, another problem posed by electric cars is delivery. Delivering an electric car to a visitor's accommodation could deplete the battery significantly if it is any distance from the car depot. It would obviously be better if the electric car were already kept at the accommodation, but this would be a significant investment for somewhere like a camp-site or a self-catering cottage. When the costs of maintenance and self-drive rental insurance are added to that, it becomes a very marginal proposition at best for the accommodation provider.

So giving visitors ready access to more sustainable means of transport while they are here poses serious financial, administrative and insurance challenges.

5 Electric Bikes

5.1 History

Bikes are the most energy efficient form of personal transport.

In terms of energy expended per mile travelled, the bicycle is arguably the most efficient machine there is. Cycling usually expends less energy than walking and is of course much faster. To have people travel as sustainably as possible, we need to persuade them to cycle more.

But most people think cycling is hard work.

Unfortunately, while people are generally in favour of using less energy to achieve the same effect, they're even more in favour of using less of their *own* energy. Western man is not accustomed to expending his own energy except in leisure pursuits. We need gymnasiums and jogging to counter the effect of eating more than we need for the sedentary lifestyle most of us lead.

And cycling up hills is even more hard work.

Cycling up hills, like walking up hills, takes more energy to lift your weight. When cycling on the flat, the weight of the bike doesn't make a lot of difference, but when you cycle up-hill you have to lift the bike as well. In terms of Professor MacKay's diagram, flat cycling uses about ¼ of a kilowatt hour per 100 passenger kilometres, while cycling up a 10% hill would take over 3kWh. Of course, even in Powys, we don't actually have any 100 km long 10% hills, but when all that power has to come from the cyclist, some of them will feel like it.

Electric bikes use a motor to do a proportion of the cyclist's work.

Electric bikes, or to be more technically accurate, electrically assisted pedal vehicles (EAPV) have a motor which provides a variable and user-controllable proportion of the power to propel the bike whilst the cyclist is pedalling.

They are subject to stringent regulation in the EU, to avoid confusion with motor bikes. The electric motor on an EAPV will only operate when the rider is pedalling, and only up to 25kmh – about 15mph. You can pedal faster than that, but the motor will not help you above 15mph.

Subject to these regulations, EAPV's can be ridden by anyone over 14, without a helmet, motor vehicle registration or Road Traffic Act insurance.

Electric bikes effectively flatten hills and increase the distance ordinary people are prepared to cycle

Adding a motor and a battery to a bike increases its weight a bit – the battery and motor are heavy, and the bike frame needs to be on the robust side – but more than doubles the power available. That means half the effort on a flat road – bordering on "effortless" – and enough additional power to enable you to climb a 10% hill (beyond most normal cyclists) at faster than "wobble" speed. Normal hills are not much more effort than it takes to pedal a normal bike on a flat road.

Because the effort is so much less, ordinary people can now cycle as far (and in some cases as fast) as super-fit leisure and sports cyclists.

And since, as mentioned before, bikes are incredibly efficient machines, the amount of battery power needed to do this is modest, and the costs of recharging the battery negligible.

5.2 How electric bikes work.

There are two ways to motorise a bike:

1. Power the road wheels directly or
2. Power the chain

Each has advantages and disadvantages.

5.2.1 Direct Power (Hub Motors)

Hub motors are the most common type of e-bike power

A hub motor replaces the hub of either the front or the rear wheel with a unit which comprising an electric motor and (sometimes) a planetary gear box to power the wheel directly. Since e-bikes, like ordinary bikes, already have gears, e-bikes power the front wheel on bikes that use hub gears – which isn't as useful for hill climbing, but is otherwise cheaper and easier to install – while bikes with derailleur gears can house the motor in the rear wheel hub.

Although electric motors produce their maximum force (torque) at low speed, they operate more efficiently (and thus can do more work) at high speed. This means that some hub motors are not as good at climbing hills, which has to be done more slowly. One way to improve that is to put an additional planetary gear in the hub to allow the motor to run faster, but planetary gears take more energy and can reduce range on the flat.

Hub motors can be installed on existing bike frames, and when they are, the battery is usually carried in a pannier of some sort. The ability to use a conventional bike frame reduces manufacturing costs and is why the cheapest electric bikes tend to be hub-motored.

Chain drive bikes are more expensive but tend to climb hills better.

A chain drive e-bike has its motor sited on or very close to the crank – the toothed wheel the pedals drive. By driving an additional chain or a cog through which the chain passes, the motor (like the rider) powers the chain. This has the important advantage of enabling the motor to use the bike's own gear system and, for example, run more quickly when climbing hills at low speed. This type of bike tends, therefore, to offer better hill-climbing ability for the same motor power, and better range for the same battery capacity.

Central mounting means the bike frame has to be specially made for a chain drive system, and is what makes chain drive bikes more expensive. Since the frame has to be custom made, most crank drive bikes have an additional space to accommodate the battery freeing up storage space elsewhere on the bike.

Good quality electric bikes cost between £1000 and £2500.

A good quality electric bike of reputable brand now costs well over £1000. There are cheaper e-bikes, but they may have low-tech batteries which are much heavier and/or short range. Batteries account for at least ¼ of the price.

A to B cycle magazine publishes a useful 2012 review of electric bikes[16].

The battery on a good bike will power it for between 30 and 80 miles.

The (relatively) lightweight hi-tech lithium batteries used on top-end e-bikes hold between ¼ kWh and ½ kWh. Depending on the terrain, and how much assistance the cyclist needs or asks for, they will now go as far as the cyclist can. But lithium batteries are expensive – between £400 and £800 – and customers will opt (if they can) for the smallest battery that meets their needs.

Since most lithium batteries can be fully recharged 1000 times, an e-bike battery can nowadays do between 20,000 and 80,000 miles before it loses capacity. At the top end, the current generation of Lithium Ferric Phosphate (LiFePo) batteries may well last as long as the bike.

5.3 The Electric Bike Market

e-Bikes are a significant transport mode in Europe and China.

The electric bike market is more mature in mainland Europe – particularly Holland, Germany and Denmark – where many more people cycle as a mode of transport rather than as a leisure pursuit or sport. In the Dutch market, for example, e-bikes now account for about a third of all new bikes sold. China is an even bigger market – because even more Chinese people cycle as a mode of transport – and China is (as you'd expect) the dominant manufacturing nation in terms of units produced.

UK take-up has been slow and late, but is now picking up.

In the UK, cycling declined as a mode of transport as the population became more affluent, and its recent renaissance has been as a sport and leisure pursuit, particularly off-road and mountain biking. There has been a revival in cycling as commuter transport in London, because of traffic congestion.

When we ran a test of electric bikes in the Brecon Beacons National Park in 2009[17], there was only one electric bike outlet in Wales, and nearly all the bikes on sale were foreign. Now there may be as many as 100 outlets, and there are several UK brands. The most famous one is Raleigh, which now has a comprehensive high quality e-bike range, albeit manufactured in Germany.

But e-bikes still have to target "non-cyclists" in the UK.

Some big city commuters in the UK use electric bikes, but most leisure cyclists don't[18]. Some of the latter regard using electric power assist as "cheating", and from their point of view, it is. Fortunately, pretty well everyone in the UK *can* ride a bike, it's just that far fewer of them do.

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[16] http://www.atob.org.uk/electric-bikes/electric-bike-buyers-guide-uk/

[17] http://theprospectory.files.wordpress.com/2011/08/ebiketrialreport.pdf

[18] There is a clique of "spark-heads" – e-bike enthusiasts who share ways of circumventing the regulations (and risking both prosecution and the long term threat of re-regulation) by making or buying very high speed and high power machines that are not road legal.

And e-bikes can offer enjoyable transport for non-cyclists

If you cycle for the joy of cycling, you may not be particularly interested in an effortless bike, and there's no good reason why you should be[19]. e-Bikes should be seen as a mode of personal transport for people who *can* cycle but otherwise *don't* because they find it too tiring or can't travel as far as they'd like to go.

Electric assist opens up cycling as sustainable transport for carrying 'passengers' or other loads

Where cycling is well-supported as a mode of transport, there are passenger and load-carrying "rickshaw" bicycles[20] and tandem vehicles designed to carry people who cannot contribute propulsive or directive effort[21]. While a fit and healthy cyclist might be required to pedal an unpowered cargo bike, electric assist could enable anyone to do so.

There is lobbying by the e-bike industry for a change to the EAPV regulations to relax the power restriction on e-bikes and e-trikes (currently 250W) while retaining the speed restriction. This is opposed by some groups in the UK, who (rightly) fear that it will be used to sanction the production of 1kW (and beyond) bikes with potentially dangerous performance. In other respects, however, such a change would enable and usher in the development of a new generation of electrically assisted, low-speed vehicles which can be made safe and more weather-resistant while providing ultra low energy transport for most people. We hope they work out some way to make the change.

5.4 Charging Infrastructure

Electric bikes are easy and almost free to charge.

All electric bikes are charged from regular domestic sockets over the course of a few hours and to our knowledge there are no high speed chargers (or any compelling need for them at the moment). Charging draws 50 to 100 Watts of mains power – about the same as an old incandescent light-bulb – and typically uses an off-bike charger with the battery removed from the bike. However, even when an electric bike battery can be charged in situ, it is still done under cover. Unlike electric car chargers, electric bike chargers are not weatherproof. An electric bike consumes around 10 Watt-hours of mains electricity per mile of use, making 100 miles per kWh, or 0.14p a mile.

But there is no battery standard, and each type has its own charger.

Unfortunately, e-bike batteries exhibit a plethora of plugs, sockets, voltages, and capacities and battery chargers can be bulky and relatively[22] heavy, so don't tend to be carried on bikes. If e-bikes carry their chargers, then every 13A socket is a potential charge point, but unless they do we can't provide a universal charging

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[19] Actually, there is. If you are an injured or recovering leisure cyclist, or a cyclist forced to cut back on cycling because of age or infirmity, an e-bike can recover a lot of the benefits of cycling you'd otherwise be denied.

[20] http://www.pedicabshop.co.uk

[21] http://www.kidsandfamilycycles.co.uk

[22] They're less than a kilogramme so not heavy at all, except to a cyclist having to pedal them around and sacrifice pannier space

network for e-bikes because each charge point would need to invest in an improbable range of chargers for all makes of e-bike.

There is currently little incentive for battery and charger standardisation, not least because retailers are reluctant to sell a charger separately from the battery it charges. Although there are legitimate reasons for wanting to buy a charger by itself, an e-bike thief (or receiver) is an all-too-common customer. This minor detail is a real barrier to setting up an e-bike charge network.

Even if you can stop en route to re-charge your e-bike, it will only put back charge at the rate of 4 to 6 miles per hour – about the same rate as an electric car, unless it is on fast charge. Electric bikes do not offer fast charging[23].

Every e-bike battery has a unique history and lifespan.

Another approach to e-bike re-charging, and one for which e-bikes might seem ideally suited, is to swap the batteries at charge stations. This would operate like Calor Gas®, where you exchange an empty battery for full one and just pay for the gas. Unfortunately, as well as requiring a battery standard, every battery is at a different point on its decay cycle, and customers will be unwilling to swap their own battery for a different (though full) one of unknown history. Such a scheme – like Calor's – requires the charging network to own the batteries, which must all be of the same type. So while this rules out a universal e-bike battery swap (or off-bike charge) system, it is an option for a centrally owned fleet of identical e-bikes, where customers rent the bikes.

5.5 Strategic Recommendations.

There are two main cases to consider:

1. Support for electric bike riders visiting Powys and the BBNP and ..

2. Providing electric bikes for visitors to use while they are here.

In each case, it is largely private sector initiatives that will decide the extent to which the region becomes a destination for owners or potential users of electric bikes. But widespread use of electrically assisted bikes is without doubt a more sustainable way to travel, and a credible alternative to the car for many visitors.

5.5.1 General E-Bike Support

Generally, e-bike use requires the same support as normal bike use.

Many of the needs of electric bike owners who visit the area – whether they come by bike or not – are shared by all cyclists. All need up-to-date and widely available information about cycle-friendly and cycle-only routes they can use, for example. Most electric bikes would not cope with the more severe off-road routes in Powys, but otherwise they can go anywhere a regular bike can go, just with much less effort.

e-Bikes will be used for transport, so visitors will park them more often.

e-Bikers will, we hope, be more likely than leisure cyclists to use their bikes as a means of transport rather than an end in itself. And if our goal is maximum

[23] though if they did, it could be done from regular mains sockets in about 5 minutes

sustainability, this is a use we need to encourage. e-Bikes may therefore need better "parking" support. An e-biker is more likely to use his bike for shopping, or to visit an attraction, and an e-bike is a more fragile and expensive machine than a regular bike. Secure bike parking will be doubly attractive to an e-biker especially if he is going to leave his machine for some time for example at a bus or train station.

...and when they are parked, e-bikes may benefit from top-up charging.

Wherever secure public and unmanned parking can be arranged, we might consider offering free charging for e-bikers who do carry their charger on their bikes. Unfortunately, because the battery needs to be removed from the bike to charge it, this kind of charge point will be relatively expensive to equip[24]. On balance, in rural Powys, it makes more sense to develop an informal network of tourist businesses willing to charge an electric bike battery for visitors. This would be the same as the network for lightweight electric vehicles which is happening already.

5.5.2 Making e-bikes available to visitors.

e-bike rental is already available and could be more widely publicised

Visitors who come to the area by other means can travel more sustainably while they are here on an e-bike. Many visitors already rent a regular bike while they are here and some rental outlets now offer e-bikes as an option. However, relatively few visitors rent bikes today as a mode of transport for their visit. They are more likely to make a special trip to the rental outlet to rent a bike for a day's leisure cycling. This is good news, and as activities go a day on a bike has to be one of the more sustainable ones. A day out on an e-bike will be a new experience for many visitors, and one that needs to be promoted to visitors who might otherwise never have considered cycling as at all attractive.

e-biking as a mode of transport is a harder challenge but a bigger win

But if we want people to significantly reduce their car usage by using an e-bike for all or most of their transport while they are here, we may have to go further. And starting a trend towards this kind of visitor behaviour may need some pump-priming from the local authority and from the tourist business organisations.

If you aren't (or weren't) contemplating cycling as an activity while you were here, you're unlikely to consider renting a bike *or* an e-bike. For you to opt for a low-effort fun way of getting around it may have to be placed "under your nose". This may be relatively straightforward if the visitor is staying in a town or large settlement that has an e-bike rental outlet. If not, driving to a rental outlet to pick up an e-bike – even if you were persuaded to do it – leaves you with a logistic problem of having your car parked somewhere else.

This leads us to the conclusion that **e-biking as a mode of transport will really only be taken up if the e-bike becomes a feature of the accommodation in more remote locations[25]**. That encourages as many people as possible to simply try an electric bike (and a "free trial" may be an

[24] It would require a secure and weatherproof locker with a safe 13A socket and room for a range of batteries and their chargers. We're not aware of any standard supplier of such equipment.

[25] And one would imagine that remotely located accommodation is exactly what many visitors to Powys and the BBNP will choose.

important feature to persuade visitors to experiment). Unfortunately, it also means acquiring and managing a substantial but widely distributed fleet of e-bikes that will, if only initially, have low utilisation.

Experience in other National Parks suggests that local authorities have a key role in establishing a scheme that encourages accommodation businesses to adopt (and pay for) an e-bike for use as a significant mode of transport by their guests. Such a scheme would need to be a partnership between the existing rental businesses, pioneer accommodation businesses and the authorities.

One challenge posed by distributed rental of e-bikes, as distinct from electric cars and quadricycles, is routine maintenance. A bike rental business will routinely clean, check and if necessary adjust or even repair a bike at the end of every rental. Some of these activities require skills that ordinary tourist businesses do not have. And while the equivalent electric vehicle distributed rental scheme will incorporate a standard maintenance contract, modern cars and electric vehicles do not require routine maintenance after every trip. This suggests that any distributed e-bike rental scheme would need to:

1. confine itself to relatively maintenance-free and "one-size-fits-all" bike designs.

2. ensure that such trip-level routine maintenance was easy to do.

3. incorporate a backup mobile maintenance and repair service.

This is how the Electric Bicycle Network operates in the Lake District, and since electric bikes do not need Road Traffic Act insurance, many of the tourist businesses there actually own the bikes they hire out, but pay an annual fee for routine maintenance and repair beyond the simple "check-list" tasks their own staff have been trained to carry out. This looks like a viable model for us in Powys and the BBNP as well, with the maintenance and repair functions contracted out to local bike and bike hire businesses.

6 Water Travel

Powys and the Brecon Beacons National Park are blessed with 2 canals and 3 major rivers. These offer slow speed sustainable travel with the chance to enjoy our spectacular scenery from what must be the ideal standpoint.

6.1 Sustainable Travel by Water

Inland water transport is low energy and sustainable.

Most water travel in Powys is unpowered. None of our rivers is suitable for powered boats and canoeing and kayaking are popular even on the canals. Water travel on canals and navigable rivers has always been energy efficient, and for a long time was the only way to move large numbers of people and goods. In terms of Professor MacKay's diagram, the outright winner in the kWh/100 p-km measure would be this public transport system from Llangollen.

A single horse is said to be able to pull about a ton on a dirt road, 10 tons on a (flat) railway, but up to 30 tons on a canal. This gives some idea of the energy required, and the boat above carries 60 people. It only moves at around 2mph, so they aren't going to get where they're going very quickly, but they will all get there at the same time, whereas moving that many people in, say, a single car would take 15 separate trips. What we have here is a 30 people-miles-per-hour sustainable transport system.

Navigable water is flat.

The water you can use a boat on tends to be flat, but even smooth rivers can have currents, where your speed and the amount of energy you need depends entirely on which way you are going. Canals and rivers with weirs are designed for minimal flow.

Rivers in Powys are fairly fast-flowing.

Because the stretches of the Usk, Wye and Severn that run through Powys are the more upland, youthful parts of those rivers, they aren't long, deep and slow-moving enough to support normal powered boating. Our rivers are the preserve of canoeists, who are mostly moving downstream. River canoeing is thus a great leisure activity, and eminently sustainable, but it isn't a transport system for visitors staying at a fixed location. It could, however, support a "touring" downstream holiday with overnight stops along the way.

Canals were designed for transport, but are now used for leisure.

The Mon & Brec canal is navigable for about 35 miles from Brecon to Pontypool and may eventually be restored all the way to Newport. The Montgomery canal, which originally ran from Newtown to Llangollen, has only about 11 navigable miles today, but will one day be restored to the full 33 miles. As well as providing navigation for pleasure boats and trip boats, canals also provide walking and cycle paths for visitors which are relatively low energy because there are no hills to speak of.

The Mon & Brec supports a large fleet of day-boats and narrow-boats

You can hire day-boats (curiously enough, by the day) and residential narrow-boats by the week on the Mon & Brec. The narrow-boats are nearly all diesel-powered, and on a 1 week cruise will use about 25 litres of diesel for propulsion - the equivalent of over 200 miles driven in a diesel car. With another 25L used for heating (on average), narrow-boat hire isn't a particularly low-carbon holiday!

There are 2 electric narrow boats[26] for hire and these are about 20 years old. They have an 18 mile range and electric charge points were installed by the hire company along the length of the canal many years ago to service them. Visitors find the silent propulsion of these boats attractive. Beacons Park Boats at Llanfoist are researching the possibility of designing and producing an electric narrow boat to add to their fleet. It is possible to convert an existing narrow-boat to electric propulsion, but fuel saving alone would not justify the investment particularly since the boats still need heating for large parts of the year.

There are now also 2 points (Brecon[27] and Gilwern[28]) where visitors can hire electric day boats. The 6 Brecon based ones can travel for 8 hours (Talybont and and back) on a single charge.

Canoes are popular on both canals.

Canoeists who are members of the British Canoe Federation can launch on British Waterways canals without the need for a further licence, and many visitors bring their own canoes and kayaks. British Waterways has provided canoe and kayak launch spots at frequent intervals along the Mon & Brec.

Canoe hire outlets on the canal are more difficult to find. There are a couple in Brecon canal basin and some in Abergavenny and Goytre Wharf. The Brecon Beacons National Park Splash project provides an excellent information site for those wishing to take to the water and a special 'Water trail' from Brecon.

Visitors who wish to bring their own day or trail-able narrow boats and launch them on the canal, will find access difficult. There are private slipways at Goytre and Govilon but only 2 public ones at Pontymoile Basin and Pencelli. On the Montgomery canal, there is one at Welshpool.

6.2 Strategic Recommendations on Water Travel

If we separate the notion of travel – movement of people for some purpose other than the movement itself – the strategic opportunities for encouraging an expansion of water-borne travel are limited. The canals do link visitor destinations, and can provide a sustainable alternative to car travel between them, and the canals provide excellent starting and stopping off points for walkers. They are also excellent cycle ways and paths which attract and sustain visitor traffic.

Public "travel" on the canals is currently limited to trip boats.

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[26] http://www.castlenarrowboats.co.uk

[27] http://www.beaconparkdayboats.co.uk/

[28] http://www.castlenarrowboats.co.uk

There is a scheduled boat trip of about 2 hours from the Brecon basin of the Mon & Brec. Similar, but unscheduled boat trip are operated by charitable trusts on the Montgomery Canal at Welshpool and Llanymynech.

A few years ago, we explored the viability of an electric water bus or taxi running during summer months between Talybont and Brecon. Discussions with other UK operators (in larger centres of population) suggested that these are difficult to operate commercially. The user model doesn't quite work, either. Travelling by canal is slow and leisurely (3 hours Talybont to Brecon) and better suited to "trips" – i.e. more like a cruise than a ferry.

If there were enough "bootfall", however, it might be possible to fund a regular "shuttle" boat, with on-board refreshments, along the length of the Mon & Brec. This would at best be a marginal business, serving visitors who want to walk in the hills, say, but travel back to accommodation points on the canal. A visitor travel pass that enabled visitors to board and disembark freely anywhere where that can be safely done along the canal would help to make this popular. It is hard to see this making commercial sense by itself, but if operated by volunteers and sponsored by canal-side businesses and the local authority, it would certainly be an attraction.

Private day-boat rental would be popular if there were more outlets.

If canoe or electric day boat hire were available at more points along the canal, it might encourage more visitors to take to the water to travel somewhere else as distinct from simply enjoying boating for its own sake. This would be financially risky for a single business to operate without significant grant aid and/or other revenue streams from a supporting business.

But as with electric bikes and low energy electric vehicles, it *might* be feasible for a central organisation to own and insure a fleet of canoes but let them out to tourist businesses along the canal to hire out to visitors. Electric boats would present more of a problem than canoes as they have to live on the canal which might be physically difficult or expensive (because of mooring fees).

The Brecon Trip boat could be converted to a green flagship.

The trip boat 'Dragonfly[29]' carries 50 passengers and operates from Brecon canal basin. Boats are so efficient and low energy that this could be converted to 100% electric and back-of-the-envelope calculations suggest that its flat cabin roof can house a large enough solar PV array to provide all the necessary electricity to charge the boat for its relatively short trips during the summer months. It is also moored adjacent to Theatr Brycheiniog which certainly generates enough PV solar electricity to charge 'Dragonfly' (perhaps renamed 'Greenfly' ☺). Not many UK locations can offer a 100% green trip boat.

[29] http://www.dragonfly-cruises.co.uk/index.asp

7 Behavioural

Even when sustainable travel alternatives (electric cars, e-bikes, buggies) are available, we still have to motivate visitors to leave their cars behind and try them instead. There are more and less promising ways of going about this.

People are creatures of habit

Using the car to travel even 1 mile down the road is an unconscious habit for most people despite the fact that most of the energy (and therefore fuel cost involved in this) is to propel the weight of the vehicle rather than the people in it! Even people who are walkers and cyclists use their cars for utility journeys.

So, how do we break this cycle?

Behaviour changes attitude rather than the reverse

Environmentalists sometimes try to change people's behaviour by informing their attitudes (*"this is a cheaper or healthier or greener way to travel – try it"*). It seems obvious that our beliefs ought to determine our behaviour. But a growing body of neuropsychological research suggests that it is often the other way round – how we behave determines our attitudes. So, if you can find a way to trigger a change in behaviour (even on a one-off basis), people's attitudes (and subsequent behaviour) will follow. Cognitive dissonance[30] certainly works in your favour (rather than against you) if you take this approach.

Research has shown that simply getting people to do something trivially different (which breaks their normal routine behaviour)[31] can have a significant impact on disrupting and changing long-held habits.

People on holiday are out of their normal routines and open to new experiences

Fortunately for us, holidays provide an ideal situation for people to break a habit and try something different. They are not up against the usual stresses of time and economics and are looking for memorable experiences.

There needs to be a trigger for a new behaviour – novelty and fun are the most effective ones

To have people try doing something different (in our case travel), there needs to be some powerful trigger – something immediate and emotive which doesn't require a thought process – "*I want to try THAT*".

For most people (even environmentally conscious ones), acting "greenly" is a conscious thought process rather than an emotive one.

Fortunately, novel and fun looking electric vehicles, pedal-powered vehicles or electric bikes can have that emotional impact without the need for rational explanation – as long as visitors see them! This will only happen if they are around, eye-catching, and obviously different.

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[30] The drive to reduce conflict between what we do and what we believe.

[31] 'Flex: Do Something Different', B. Fletcher and K. Pine, University of Hertfordshire Press (2012).

People are lazy

If a new behaviour (e.g. trying a new eco-vehicle or e-bike) isn't feasible here and now – maybe requiring further research or a car journey to find it – that reduces the number of people who will bother to do it. What might have been an emotionally driven impulse will have become a rational action. And, anything that involves an extra car journey doesn't obviously reduce car usage, and won't save carbon. It might count as a visitor attraction but wouldn't constitute a change of transport behaviour to something more sustainable.

That's not to say that low carbon transport attractions (e.g. an electric trip boat or somewhere you can hire emission-free buggies for an hour) aren't good things to have, but if they require a car ride to reach them, then they don't necessarily save carbon and (perhaps more importantly), they don't change people's unconscious reliance on the car as the default vehicle to get them from a to b.

People are different[32]

Different eco-transport options will appeal to different people – some will appeal to the active or thrill-seeking, others to the people seeking relaxation or sociability.

Also, we need options that work for different groupings (couples versus families), different physical abilities (young children, disabled, unfit) and different terrains.

8 Economics and organisation for personal eco transport

Given the state of the technology, and the nature of human behaviour, we think it is feasible to set ourselves the following goals:

To make Powys and the Brecon Beacons National Park an area where low energy, eco-travel options abound and are routinely used by residents and visitors alike because:

- They are sufficiently *appealing and accessible* that people are keen to use them to travel within the region and visitors increasingly choose to come here in order to experience such alternatives as part of their holiday.

- They are sufficiently *lightweight and low energy* that they can be powered by electricity generated within Powys from natural resources – rain, sun and wind – making this a Unique Selling Point (USP) for the area.

8.1 What do we need to realise this?

1. **Numbers: a huge increase in the number of rental vehicles and outlets**

Eco-vehicles (electric cars, buggies, e-bikes) for hire from a few locations in the region may count as an attraction, but not as a sustainable mode of transport.

[32] And it takes a qualified behavioural scientist to tell you that!

We need to plan for hundreds of different eco-vehicles available for use right across the area wherever visitors stay.

2. **Diversity: 'eco-vehicles' to suit different interests, ages, abilities, terrain, weather and journeys.**

This would include: electric, pedal-powered and hybrid cars, quadricycles, buggies and bicycles for couples and families as well as canoes and electric boats for rivers and canals.

The characteristics they should have in common are: (i) zero or low carbon operation, (ii) environmentally friendly (e.g. quiet) and (iii) enabling enjoyment of and engagement with local scenery and attractions.

3. **Availability: the vehicles need to be readily available at as many accommodation 'hubs' as possible**

Many visitors come here to stay 'off the beaten track' – that is part of our appeal. To save carbon and encourage the use of these vehicles instead of the car, we need them to be available as close to where people are staying as possible, ideally no further than where their car is parked! This means:-

- **Visitors encounter them incidentally** (even when they didn't know about or weren't seeking car alternatives),
- **The eco-vehicles are as 'ready-to-go' as their car is** (i.e. they are right there ready to ride or drive away even if people are just nipping down the lane to the shops or reaching a walk 2 miles away.
- **Visitors don't have to drive their car to reach an eco-vehicle hire point** as that no longer replaces a car journey and fails to disrupt the habit of using the car as the default transport mode.

4. **An open charging Network based on local businesses**

Travellers still need somewhere they want to go, but the electric traveller also needs ready access to charge points to relieve anxiety and maximise the distance travelled in a day. We prefer the approach taken by the Eco Travel Network[33] and Zero Carbon World[34] of encouraging local pubs, cafes, accommodation providers and attractions to offer parking space and top-up charging. With lightweight vehicles and e-bikes, the minimum requirement is a regular 13 amp socket, which is also essential for overnight charging by visiting electric and plug-in hybrid vehicles.

5. **A sustainable business model to support this level of vehicle variety, distribution and accessibility**

One way to proceed is through dedicated hire businesses for the different vehicles in each of the main tourist hubs, some of which already exist. But providing sustainable transport throughout their stay for every visitor who wants it is a major undertaking. And setting up new hire businesses, particularly in smaller tourist locations, when the vehicles concerned are high value items (e.g. electric cars) will be difficult to do profitably at the outset. Most importantly, requiring

[33] www.ecotravelnetwork.co.uk

[34] http://www.zerocarbonworld.org/

visitors to travel to a rental hub, by car, to pick up alternative transport may defeat the object.

Placing hire points at the main railway and bus stations might work for visitors who arrive here by public transport – something we would surely like to encourage – but we assume (by their absence) that this has not proved a profitable business in the past, even though targeted at visitors who do not have cars. In any case, it is likely for the foreseeable future that the majority of visitors will continue to arrive by car and thus will have a familiar and accessible mode of transport available to them at all times while they are here. It is the local travel these visitors would otherwise do by car that we want to replace.

There is an alternative model which the Eco Travel Network in the BBNP and electric bike rental projects in other National Parks are exploring.

There are Community Interest Companies (CIC's) using a different business model based on the visitor accommodation network, as distinct from dedicated rental locations. A central organisation continues to own, insure and maintain the vehicle fleet *but does not operate a visitor hire business itself.* Instead it rents out the vehicles (e-bikes, e-cars, e-buggies) in ones and twos, on an annual basis, to tourist business partners – mainly but not exclusively accommodation providers – throughout the region.

The rental contract between the CIC and the tourist business includes self-drive hire insurance and vehicle maintenance. The individual businesses (campsites, hotels, pubs, B&B's) host, promote and rent the vehicles out to their customers or other co-located visitors thus generating an additional revenue stream for their business which (hopefully) covers their own annual rental costs from the central organisation. The annual rental cost to the business covers insurance, maintenance and financing the vehicles. As we understand it, it can be reduced significantly by up-front payment of a greater proportion of the vehicle cost.

This model has several advantages:-

1. It makes it feasible and lowers the risk for any interested accommodation business (or pub or café) to rent a few bikes or an electric car or buggy or even a boat (if they are canal side) for a season to see if their customers like it and use it enough for the hire charges to cover its costs.

2. It spreads the operating and promotional costs across multiple small businesses. It would even be possible for a couple of co-located businesses (or even a community tourist group) to collaborate and share the annual rental costs of a vehicle or vehicles between them.

3. It overcomes the significant problem of self-drive hire insurance which is extremely hard to arrange for a small number of vehicles. It would be both difficult and expensive today for an individual hotel or campsite to purchase and insure bikes or cars or buggies for self-drive hire.

4. It allows different rental options for different kinds of eco vehicles to evolve and flourish naturally where they work best without big business risks or failures.

5. Most businesses have the premises and staff to cater for vehicles, and can handle booking and payment from visitors. This reduces the CIC's running costs.

6. The businesses and their staff can use the vehicles themselves for their own purposes instead their cars. They can also rent them to or share them with other local residents.

7. Once an initial set of hire and/or charge points is established then clusters of tourist businesses can work together to offer interesting 'tours' between their businesses. This model is being pioneered by 3 Powys Guesthouses under the banner 'Welsh Road Trips'[35] and they plan to expand to other like-minded businesses over time to provide entire tourist routes manageable by electric bikes, cars or buggies alone.

Most critically, if the distributed model works, it spreads the access points for the eco-vehicles all across Powys – visitors will encounter them wherever they are staying and will not need to use their cars to reach them.

The Electric Bicycle Network (based in Cambridge) uses this model for electric bikes and has so far set up 'franchise' CIC's in 3 National Parks (Lake District, Peak District and South Downs)[36]. It would like to set one up in the Brecon Beacons with some capital input from the National Park and a maintenance contract with a local business to care for the bikes[37]. Exmoor Unplugged is operating a similar scheme in Exmoor[38].

With a substantial grant from the Brecon Beacons National Park Sustainable Development Fund, the b-bug project team has set up a similar style experimental scheme (a not-for-profit 'Eco Travel Network'[39]) to enable lightweight electric vehicle rental in the BBNP on a similar distributed basis. It is launching this summer with 6 Renault Twizys. If the scheme is popular with both visitors and participating tourist businesses and can prove its economic and administrative sustainability, then the Eco Travel Network could expand to include electric buggies and/or electric bikes. One challenge is finding local businesses able to offer maintenance contracts for such vehicles.

In an ideal world the tourist businesses themselves would own the vehicles.

The creation of a separate CIC to own the eco-vehicle fleet introduces an unfortunate level of bureaucracy and inflexibility into the scheme. The only problem that we have to create a CIC to address is the need for the organisation that insures the vehicles to be the same as the one that owns them. If it were possible for the vehicles to be owned by the businesses renting them out to visitors, we would have a more organic and sustainable business model, and it would be easier for the scheme to grow rapidly.

The Whipcar[40] rental organisation appears to offer just such a distributed car rental scheme for conventional cars today. With Whipcar, car owners can recover

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[35] http://www.welshroadtrips.com/

[36] They currently charge participating hotels and campsites £120/month/per bike with the businesses keeping all the customer rental http://www.electricbicyclenetwork.com/about-us/

[37] This includes a weekly check by a roving maintenance engineer of all distributed bikes.

[38] http://www.exmoorunplugged.co.uk/

[39] www.ecotravelnetwork.co.uk

[40] www.whipcar.com

some of the costs of their cars by renting them out to members of Whipcar. The basis for this is a special insurance policy negotiated by Whipcar. While there are aspects of Whipcar that don't readily translate to the kind of distributed rental model we're proposing, it does establish a precedent for a set of individually owned vehicles to be collectively insured for rental.

Perhaps a large public organisation like Powys County Council, or The Brecon Beacons National Park authority could negotiate a similar blanket policy for eco-vehicle rental by tourist businesses within their area. This could be cost-neutral to the authority, since the businesses would actually pay for their share of the insurance premium. It would give the authority oversight into how and where new visitor transport option were being made available, and would give the scheme added credibility and assurance for the visitors.

A lightweight ubiquitous charging network for Powys

A public charging network is not essential for visitors staying in the area, because most electric vehicles are fully charged overnight, and visitors will tend to stay within vehicle range of where they are staying. However, a charging network of local cafes, pubs, tourist attractions, activity centres etc does play a useful role in creating and promoting interesting routes and destinations for eco-travellers – encouraging them to use scenic back routes and visit locations that they might not otherwise discover or bother to drive to. It also relieves them of range anxiety (real or imagined) and (most importantly) the social awkwardness of asking someone if you can plug in during a stopover.

The b-bug trial also showed that charge point destinations keep visitors spending their time and money locally rather than driving further afield in their cars. The presence of a visible sticker (and an advertised location on the map) is more important than having a "proper" outside charge point for a lightweight eco-vehicle like a quadricycle or an e-bike. Somewhere to park and a willingness to run a cable through a window to the nearest 13 amp socket are sufficient. However, proper 16/32 amp charge points are available for free from Zero Carbon World and will also cater much better for the needs of pure or plug-in hybrid electric cars stopping overnight or passing through.

In our experience, it is relatively easy to create an informal charging network, and businesses have been only too willing to welcome visitors who may be staying for a couple of hours. It's important that eco-travellers know where the charge points are, and a simple printed guide and a web-site page – particularly one optimised for mobile phone access, would help enormously.

Since lightweight electric cars are low energy vehicles, journeys close to their maximum range need careful planning. A set of "eco-tour" maps of the county, which tell you not only the distances and places of interest but also the energy (for cyclists, read "effort") required for different routes, would be helpful. There is scope here for local business and tourist groups to put together route planners for their own areas featuring, for example, "20 places within 2kWh of Talybont on Usk"!

Where there is mobile 'phone reception – not currently a strong feature of Powys – there is also scope for GPS-enabled mobile phone applications which offer both a visual and an audio guide to a route pointing out interesting features visible at any point along the way.

8.2 The need to subsidise start up

Electric cars, quadricycles, bikes and buggies are expensive and have to be financed. Initially, small tourist businesses will not know what customer revenue they can expect from renting a vehicle, so the investment to take part in a central scheme will be difficult for many of them to justify. Once a vehicle starts earning revenue, the situation should become easier to calculate (and to fund!) but from a strategic perspective, we need as many businesses as possible (large and small) volunteering to take part.

It is perhaps no surprise that the Eco Travel Network, the Electric Bicycle Network and Exmoor Unplugged and have all needed public and outside private investment to help with start up costs, subsidising the purchase of the first fleet of bikes or vehicles in order to reduce the high risk cost for the pioneer tourist businesses. The recently announced 'Go Lakes Travel' programme[41] is a £6.9 million initiative being delivered in partnership between The Lake District National Park, Cumbria County Council and Cumbria Tourism in order (in part) to help small businesses take part in a distributed car and bike rental schemes. The programme offers grants of between £500 and £5000 which can be used to buy membership to a scheme. In the Lake District bike rental scheme membership fees vary from a few hundred pounds to cover just insurance and maintenance to several thousand to cover (some of) the finance costs as well. Annual rental is reduced if the business can contribute more to vehicle finance.

Once a scheme is established and receiving enough visitor rental then it should be (and will need to be) self-funding. And as the numbers of vehicles involved increases, then cheaper and more flexible insurance policies can be negotiated.

We recognise that it is generally more difficult to obtain public grant funding for capital items and that this may limit the extent to which Powys and the BBNP are able to pump-prime an area-wide scheme of this type. The strategy set out here requires capital (and a lot of it, in total) so it may be easier, as is being proposed in the Lake District, to offer small subsidies to the tourist businesses to help finance, say, a couple of e-bikes or an electric car or buggy. This would enable a cross country rental network to evolve.

[41] http://www.lakedistrict.gov.uk/caringfor/projects/smallgrant