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All electric cars are not the same and why the call for 'real' electric cars should be resisted

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Abstract

Battery powered cars have many merits over traditionally powered cars: they are more energy efficient (i.e. less GHG emissions), less polluting and quiet.

However, not all electric cars are the same and there is a 'break point' at a range of around 50-75 miles. Up to this range battery packs can be made affordable, compact and manageable in size and weight. Vehicles with this range are already produced today at affordable prices and do not need dramatic technology breakthroughs. Nevertheless, in the popular media and among commentators and politicians there is a sense that such vehicles are not an adequate replacement for traditional ICE powered car's long range, fast refuelling and high performance. Such a view ignores the potential of small BEV's to deliver adequately and economically on the actual mobility requirements of the majority of the population.

In the United Kingdom the average car journey is only 8 miles long and the average speed is only 24 mph. This suggests that the capabilities of most current cars are vastly in excess of their actual requirement. This apparent paradox is easily explained by a brief look at the price list of a typical car manufacturer's range. By the nature of the global, large scale car production process the marginal costs of extra performance, space and features is relatively small. The free market and consumerism do the rest.

These economics do not apply to BEVs where the cost of the energy storage system imposes a large cost on vehicle size, performance, range and features. This paper concludes that smaller, short range BEVs are nevertheless such good match to actual consumer mobility needs and have so many societal advantages that the economics of carbon pricing and fuel price rises already make them cost competitive with traditional ICE powered cars in selected markets. As consumers re-evaluate how much they are prepared to pay for range and performance in particular, they are likely to opt for vehicles that match their actual needs at an affordable cost. Therefore small BEVs specifically should be encouraged as a means to create affordable and clean access to individual mobility in the shorted possible timescale.

ev (electric vehicle), market,mobility, range, policy

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1 Introduction

There is now a wide-spread acceptance of the need to tackle climate change and electrification of transport is accepted as the only realistic solution to meet the GHG reduction required [1].

The enthusiasm for electric cars has belatedly been adopted by the popular media and automotive commentators and led to a growing call for 'real' electric cars: all-electric cars match the range, performance and features of the current traditional car. Indeed the UK Government announcement in April 2009 indicates that future subsidies will be subject to minimum range and performance thresholds [7].

This paper raises concerns about such views. Approaching the development and popularization of the electric car as a plug-in version of current car will miss an opportunity to make fundamental improvements in congestion, transport efficiency, climate change and social access to individual mobility. An electric car that re-charges in minutes provides a range of 250 miles and has the space, speed and acceleration comparable with a typical current family car is, technically, a viable and interesting prospect. But from a societal and commercial point of view, such a vehicle should not be the priority of the industry or the politicians and risks being rejected by the market.

In-depth studies of societal and individual mobility needs and preferences suggest that the solution is more likely to be found in small, short range city BEVs alongside other solutions: plug-in hybrids, fuel cell hybrids, shared car use and integrated multi-mode public transport.

This paper will show why short range, small electric cars will make sense for individuals and for society as a whole and why the desire to replicate current car concepts and to these encourage their uptake in the mass market with false incentives is misguided.

2 Modern cars: the embarrassment of riches

In the past decades the automotive industry has been consolidating and globalizing. The results have been the establishment of a large scale industry and global 'platforms'. Today's typical family car is designed for use around the world in a wide diversity of conditions.

The production model of the modern car has lead to a situation where that it is often cheaper to fit a feature to all cars and let the volume take the marginal price down to virtually nothing. The result is that most traditional ICE cars currently on the road are equipped with capabilities that vastly exceed their real world need:

- Average journey (UK)[2]	8 miles;
- Capable range	350-500 miles
- Legal maximum speed (UK)	70 mph,
- Average UK car speed [2]	24 mph;
- Typical top speed	100-125 mph
- Average occupancy [3]	1.3
- Typical seats	5 adults
- Temperature extremes	-5 to +30°C
- Climatic capability	-40 to +50°C

Much of our current car fleet's capability is redundant and will rarely be used in the vehicle's lifetime. This may appear to be not such a big problem. This is the free market where consumers wish to choose an emotional element and are always keen on perceived value: 'why not have the extra feature or performance if it does not cost anything extra?'

It can also be argued that the marginal embedded CO2 is relatively low and the capability to make uniform 'world-cars' delivers more value to all customers and creates the most efficient manufacturing and design process. For example, the fact that climate control is now a standard feature on almost all cars means that the components can be manufactured at much greater volumes and therefore can be produced with less CO2 content then if they were a more exotic component. Thus the marginal CO2 balance of these added features may be quite low. Nonetheless there tends to be a ratchet effect: once used to a feature customer do not like to give up on

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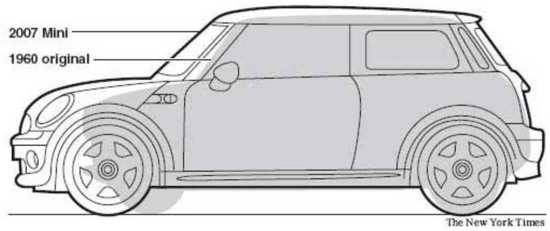
such an item. There is no conclusive evidence that the increasing amount of passive safety equipment actually reduces casualties because the balance between increased passive safety and reduced driver risk perception is unknown. But features that would be paid-for extras a few years ago (and often declined by buyers) are now claimed to be ‘must-have’ items. The result is a dramatic growth in size and weight in each car segment and a resultant growth in embedded and in-use CO2 emissions:

Figure1: the growth of our cars



	Original Mini	New Mini One
Top Speed	75 mph	115 mph
0-60 mph	29.7 s	10.6 s
Weight	1380lb	2497lb
Engine	848cc	1400cc

From a customer perspective the automotive industry delivers exciting, well-equipped vehicles where added features and capabilities seem to add little extra cost. Like computers, the price seems to remain steady but the features and capabilities continue to improve. Extra size, space, performance and equipment add very little marginal cost to the consumer in up-front costs and operating costs. Up until very recently the trend in the mature car markets has been for car and engine sizes to grow as customers chose the extras without an apparent extra cost.

This is now changing dramatically as fuel prices rise and the duty to act on climate change forces rising prices on carbon use through road tolls, taxes and parking charges and more. The extra costs of adding capabilities, features and equipment to cars will carry now a higher upfront price and higher operating costs thus forcing consumers to consider if they really need the performance and features previously enjoyed ‘for free’. Already the trends in the industry are towards smaller and lower CO2 emissions (lower taxes and lower fuel use) and the consideration of solutions that are a closer match to actual need will continue.

The switch to electric cars will put this consideration in a much starker way to consumers and is likely to have a big impact on the future direction of the electric car market. The rules of the modern automotive design and production will not apply in the same way to electric vehicles and this change will be ignored at the peril of the industry, the climate and potentially taxpayers providing misdirected subsidies!

3. The changed market economics of electric cars

It is obvious that battery powered cars do not accommodate for the same liberal use of energy to power range, performance, equipment or space. Unlike traditional ICE cars where there is plenty of ‘spare’ capacity to store energy (i.e. petrol or diesel) and power the extra features, the nature of the BEV is that energy required needs to be carried in heavy batteries and this has a disproportionate effect as weight begets weight.

This does not make electric vehicles with an extended range impossible but the commercial challenge is formidable. This particular point was already noted by Lotus when it looked at the economic cost of BEVs versus PHEVs [4] and found that above 75 miles no economic case can yet be made for BEVs.

There are also more societal challenges to the extended range BEV:

- Large batteries require a faster charge at larger currents that is less efficient for the grid and the power generation
- Large re-charge currents and voltages will require a new, capital intensive re-charge infrastructure
- Although Lithium is not a scarce material, mass demand for large batteries will add to the demand on Lithium and keep the costs of batteries high.
- A car with a large and heavy battery will need a larger frontal surface, larger footprint and a heavier structure to carry the weight of batteries The result is a less energy efficient car
- The large weight of the car is less safe for other road users with a larger stopping

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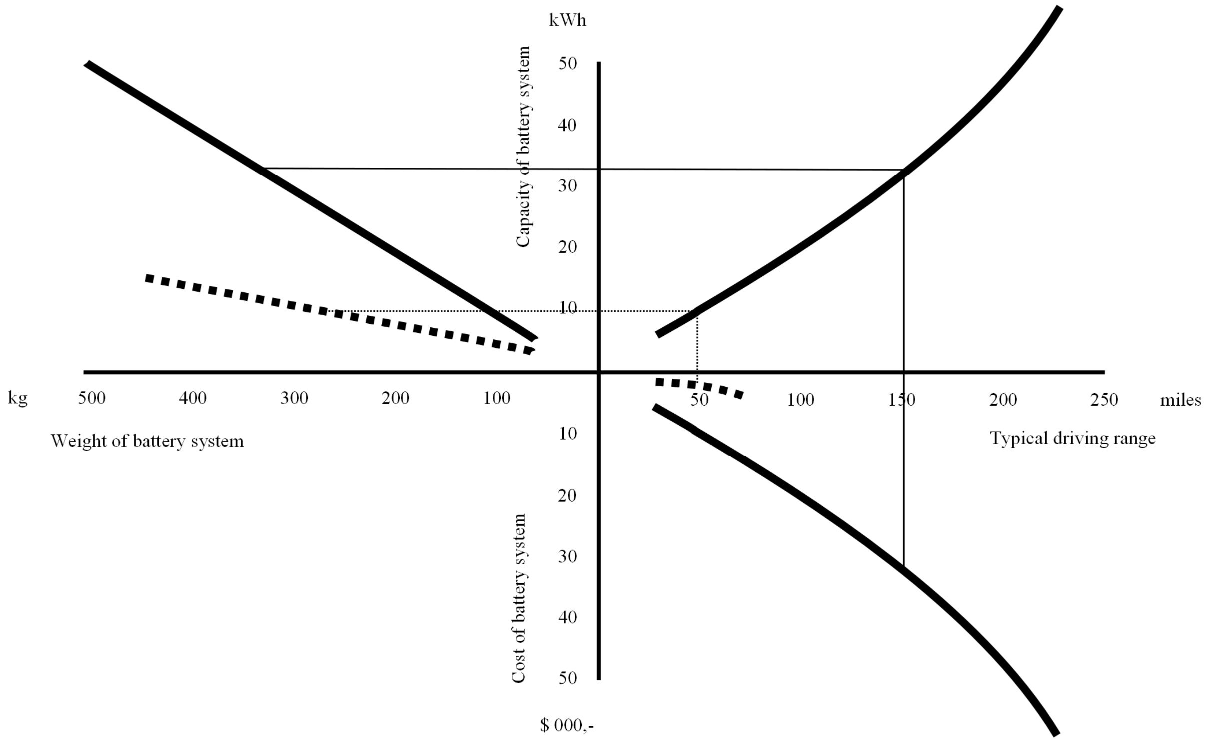
Figure2:

Impact of driving range on capacity, weight and cost of battery system

Illustrative only - Typical family car - Solid lines: li-ion - Dashed lines: lead-acid



- distance and greater damage to the other parties in an accident
- Larger and faster cars cause more congestion. Speed is a significant factor in road safety [6]

A needlessly large battery capacity that is not actually used has high costs for the customer too:

- It adds considerable cost. For the foreseeable future the price of Li-ion batteries at retail level is likely to be in the region of $1,000 per kWh. For an extended range electric vehicle, cheaper lead-acid batteries are not an option due to the weight
- Cars that need to carry such a large and heavy battery pack as required for a range greater than 150 miles need to be designed specifically. Currently only a few of such vehicles are available and traditional ICE cars do not make good platforms for an all-electric platform with an extended range
- Large batteries will require a fast charge facility instead of being able to charge from the ubiquitous domestic supply. This will be a considerable of inconvenience for drivers/owners who can no longer re-charge at home

These problems could be dismissed as typical for a pioneer industry in a changing market and that in due course the issues may be overcome. This would be complacent and ignores that the 'real-world' mobility needs of the majority of drivers cannot justify these drawbacks in any case. Whereas in a traditional ICE car the marginal purchase and refueling costs were minimal, in a BEV they are not. Whilst an extended range may offer the customer a higher degree of comfort and use-ability, it cannot yet justify it societal and consumer costs compared to the much cheaper short range BEVs or alternative solutions such as hybrids, car-clubs or public transport. Persistence of the promotion of extended range BEVs at the cost of developing smaller, short-range BEVs may seriously the market uptake of cleaner transport.

It may be also be argued that some of these downsides can be mitigated with rental or lease schemes of batteries. But although these can negate some of the upfront costs but cannot chance the total cost of ownership nor the other drawbacks.

Electric cars with an extended range are preferable over a conventional ICE car and if their availability can convince drivers to switch away from ICE cars it would be a positive development.

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But subsidies, incentives and tax manipulations required to do so should be applied equally to small BEVs which have greater societal merits and match, on the whole, mobility needs equally well.

4. Short range BEVs: less is more

In April 2009 the RAC Foundation published ‘The Car in British Society’, a reference work of car use patterns and driver attitudes towards car usage in a large, developed society [2]. The report highlights the essential economic and social role cars play and shows that even non-car owners typically use cars several times each week! The objective data on car journeys suggest that the majority of mobility needs would more than adequately met by short range electric vehicles with a typical range of circa 40-50 miles. Although these are generally referred to as city cars, in fact their greatest use in the future may well be in rural and small urban areas where there is limited cover of public transport.

Small electric cars are not only appropriate but also available and affordable. They do not need technology breakthroughs and there is a range of small electric cars now that demonstrate commercial viability with only a modest amount of encouragement. Examples include the G-Wiz from REVA, the Mega e-City from Aixam-Mega and the MyCar from EuAuto Technologies. These vehicles have a range in a small car can even be catered for with lead-acid batteries thus negating much of the upfront costs.

Small electric cars can be developed faster and produced using niche scale tooling and production processes. This accelerates the introduction of electric cars and has a major effect on their ecological impact: fighting climate change is in many ways analogous to saving for a pension: the sooner you start the more effect it has.

As well as immediate availability and affordable upfront price, small, short range BEVs also offer other advantages to society and individual drivers/owners:

- They are chargeable from any regular domestic supply thus requiring no dedicated infrastructure and providing the maximum convenience for owners and/or drivers
- Slow charging, often during the night, offers opportunities for smart charging, load-leveling with the grid and utilization optimization of the power generation system
- Their low weight and modest size carries less embedded CO2
- A smaller footprint and modest speeds reduce congestion [6]
- Although this paper does not advocate quadracycles specifically, nonetheless detailed data from their use suggest that increased risk perception and lower speeds of smaller and lighter cars greatly improve safety [5]

Small and affordable electric cars will create low CO2 mobility that is socially accessible in emerging world and also the developed world where the price of fuel might otherwise excludeparts of the population from car ownership.

In summary small, short range BEVs offer immediate benefits for the owner/driver as well as significant societal benefits in a way that cannot be achieved by either extended range EVs or traditional ICE cars.

The short range will limit their application in certain segments and for some drivers/owners but in reality such a problem is easily overcome by a variety of parallel solutions:

- Ownership of a traditional ICE car alongside the short range BEV. There are many millions of such cars in use today and they a very unlikely to replaced immediately.
- PHEVs will begin to enter the market soon. Although more expensive than short range BEVs they are economically more attractive that extended range electric cars and offer a realistic migration towards a full ‘zero-emission’ car fleet
- Shared car use. Car clubs or ‘self-service’ car hire is gaining great popularity and in many European cities and such car clubs are a smart compliment to a short range car, especially if they can share facilities and offer charge points for the BEV that is providing the ‘bridge’ transport to the door of the user.
- Public transport (integrated with short range vehicle) cannot offer solutions for

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all mobility needs [2] but can compliment a short range vehicle for longer journeys or into heavily congested city centres. Modern communication systems offer ample scope for smart communications between modes of transport.

5. Conclusion

Patterns of use suggest that short range battery electric vehicles make sense for society and for individual drivers/owners if the free market choice and rising CO2 pricing prevail. Average journey of 8 miles suggest that for the majority of car users a short range is required and no premium would be paid for the extended range capability that would remain idle for the majority of a vehicle's life. Unlike traditional cars, redundant capability will carry a high cost for society and drivers/owners and will be foregone by consumers in favour of less eco-friendly alternatives.

This does not rule out a market for extended range electric vehicles. Especially in the high value performance segment or commercial and business applications electric vehicles with longer ranges already find considerable interest. The natural evolution of product and process optimization will then see the growth of electric vehicle capabilities: the price of batteries will reduce, new technology breakthroughs and evolutionary improvements are certain. At the same time the costs of traditional cars will rise and the new generation of BEVs will 'price itself into the market'

Nonetheless at this time, all-electric full size cars with a range that is too ambitious cannot yet be made commercially attractive and also do not yet make sense from societal point. If policy makers and industry leaders insist to promote vehicles that are too ambitious and do not match actual mobility needs they could damage the prospects of a change towards cleaner transport. Decision makers should not be allowed to 'define' future individual mobility to the exclusion of small electric cars that offer a better societal solution.

A distortion of the market of the kind suggested by UK government in April 2009 may damage and delay the introduction of cleaner transport.

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