Title : Creating demand in fleets for EVs, infrastructure and demand driven energy supply through enabling software that can significantly improve the TCO model of the complete system

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Short Abstract

Historically the EV market has focused on providing services such as charging infrastructure based on master planning in the hope that end users will want to use the provided assets. This model has been shown to fail in certain instances with stranded assets and non-viable business models. This paper demonstrates how Route Monkey is working with partners to create demand within fleets for the deployment of EV's by identifying where the vehicles work effectively in duty cycle terms and Total Cost of Ownership (TCO) Thereafter; supplying solutions in the form of products and services that de-risk the procurement and subsequent planning process and maximise the ROI of the assets.

1 Introduction

Significant research, and practical testing of that research, has been undertaken by the author over the last two years. Working with major fleets in the UK the author identified the numerous factors and market place drivers; that encourages fleet managers to deploy EVs into their fleets on a commercially viable basis. The evidence was developed through work at The Climate Group (TCG) in 2011 and then tested in the market through 2012 with partners EST, EDF Energy and Route Monkey within a DfT and TfL funded programme supporting 20 participating fleets. There is now a software 'engine' based upon intelligent algorithms that looks at the value chain for EVs in business (Specifically fleets) from infrastructure and energy provision through to the vehicles scheduled to undertake their daily work. Throughout the life cycle of this vehicle, the software is now capable of adding value to the total cost of ownership for the vehicle and assets that it uses.

1.1 The context to this paper, and relevant history of EVs in UK fleets

Pioneering work was undertaken by TCG in 2011 managed by the author who was Head of Transport during this period. At this time, CSR and climate change issues were considered the way of encouraging EV deployment in fleets, but this resulted in poor utilisation of vehicles and overall a bad impression of the technology. TCGs work showed that by focusing on TCO and the duty cycle for the vehicle, the decision needn't be one of CSR but could be proven on solid business grounds. The evidence defined a simple process by which EVs could be deployed:

- Does the duty cycle suit an available EV or PHEV?
- Does the TCO stack up?

- What are the infrastructure implications for the company?

Following the publication of TCGs report on this work [1] the UK government (DfT) and TfL provided funding to test the theory in practice (Plugged in Fleets Initiative – PiFi). Findings of the TCG report were confirmed within PiFi. A partnership developed between EST, EDF E and Route Monkey which introduces the second author into this paper. Route Monkey software became the core tool for the detail analysis work (The conclusions and key market requirements for EVs to become prevalent in fleets were identified in a report [2]). PiFi concluded in January 2013 and was recognised as a significant step forward by major players in the UK EV Market resulting in further funding from DfT being made available.

The work identified in this paper takes the evidence developed by the authors into new business models that will significantly increase EV uptake in fleets. These new business models are predicated on the statement that *'Generating demand is more important than providing products and services ahead of the demand and hoping demand will follow'*. These software driven products and services are both innovative in concept and are based on core research and practical testing with our clients.

1.2 The core engine behind the product offering

Route Monkey developed scheduling software backed by a government innovation fund to improve the efficiency of fleet vehicles compared with manual scheduling activities. The platform (Engine) focused on energy use for vehicles and this is unique in the scheduling market. The platform also focused on alternative fuelled vehicles and specifically how you would optimise a limited energy capacity EV to maximise range and load. Scheduling software overlays multiple parameters that are used within the software such as:

- Range
- Battery status
- Weight to discharge ratio
- Cost
- Topography
- Temperature
- Driver profile
- Charging points
- Maximise ROI

The software is utilised when a fleets activities are input into the programme and then the tool is asked to calculate the most efficient use of the vehicles at the programmes disposal (The existing fleet). Using the software a typical fleet would save energy or fuel at between 10 and 20 % when compared with a manually scheduled fleet using like for like vehicles (Normally gasoline and diesel). The primary reasons for this are:

- Complexity of task
- Likelihood that a planner would schedule in region
- Likelihood that a vehicle by vehicle schedule will be created rather than considering the overall system

In this scheduling tool the vehicles are planned in a flower and petal approach, each vehicle is optimised resulting potentially in vehicles that could be removed from the fleet, and the overall system is considered rather than each individual vehicle in isolation. This paper is not intending to explain the merits of scheduling in detail but it is important to understand the principle in order to see the opportunity that using scheduling can bring to introducing EV's into a fleet at an improved TCO

1.3 The basic proposition of increasing asset utilisation through scheduling

The key reference project currently in the public domain that we can refer to is the Plugged in Fleets initiative. This has significant background to how Route Monkey was able to support the decision making of fleet managers engaging with the project in transitioning to EV's. The basic process that was undertaken with a fleet was:

- Gather a fleets workload, operating rules, vehicle data and input into RM scheduler

- Understand what is driving the decision for the fleet – operational costs, no of vehicles, carbon, delivery times, increasing turnover and CSR, etc…
- Undertake a like for like benchmark exercise with the fleet so they are happy with the scheduling outcomes
- Substitute existing and available EV and range extended EV's from cars through to vans into the scheduler and see where EV's can be deployed on a like for like basis and total cost of ownership modelling.
- Allow the scheduler to optimise for EV usage (Rather than gasoline or diesel operation) and open the scheduler to reschedule according to the rules of the fleet as defined in the first stage

The reference PiFi report shows many places where EVs can be deployed but in principle a like for like comparison on TCO is limited in most cases to between 5 and 10% of fleet vehicles (Although we did see cases where 100% conversion would be feasible). When we were allowed to flex the complete system and reschedule the fleet vehicles substituting EVs where they worked best and modifying schedules to ensure (Within operational rules) that we hit sweet spots, we were able to develop plans where typically 30% or 40% of vehicles would work on EV and be cost effective.

Through this analysis we developed an understanding of what are the key parameters that need to occur in order for EVs to become effective and some of these are also included in the report. The key findings are that the sweet spot of EV deployment is around urban deliveries in small vans where the mileage per day is between 50 and 70 miles. Incentives also play a significant part in tipping the balance and congestion charge in London made the EV story compelling.

The conclusions to this work essentially show that EV deployment is limited, the market for pure TCO focused around the vehicle only is limited and fragile – dependant on incentives. Many variables can and potentially will change in the next 2 years (Not least fuel which we sensitivity tested with and is a major influencer). We completed the work and remain optimistic that EV deployment sweet spots will grow and the paper here highlights just a couple of the public visible projects we are working on built on the engine we have as an EV focused scheduler.

The key to increasing the sweet spot of EVs in fleets is to widen the TCO model. Ultimately this will include finding value in the energy sector in matching grid performance and damping a smart grid system, but this paper focuses on the shorter term opportunity of developing the engine to support the optimisation of the charging infrastructure asset and further developing the TCO for the vehicle.

1.4 The algorithms that overlay onto the engine

In this paper we will concentrate on work that has been funded by TfL (Small mapping project) and a collaboration project funded by UK government Dept BIS known as regional growth funds. The first of the programmes (Which has now gone to a major mapping programme due to its success) looks at how the engine can be used to increase mileage of fleet vehicles through planning and scheduling charge stops into the day's work for the vehicles. The second project works with Alphabet GB Limited (Lease Company) to understand residual values and how they may be affected by battery degradation based on monitored vehicle usage linked through telematics data into the scheduling engine. These two project in a portfolio of work underway, highlight that a focused approach to algorithm deployment overlaid onto the core scheduling engine will increase sweet spots for EVs in fleets and ultimately move the system towards a robust TCO model not dependant on incentives.

1.5 The projects that create the algorithms

1.5.1 Infrastructure mapping project

Transport for London (TfL) have been supportive of our work since the pioneering Climate Group work of 2011. The positive results shown within PiFi resulted in TfL funding a further PiFi 100 programme which is a light version of the findings of the PiFi project supporting up to 100 fleets. Route Monkey remains a partner on this project but PiFi 100 is not furthering the science and focuses on increasing awareness and uptake of existing sweet spots. In the course of our PiFi work we realised the opportunity provided by 'optimising assets' within the EV value chain rather than just vehicles. This is simple to consider and a

complex problem to realise in practice. If a vehicle has to make a scheduled and planned stop of more than 15 mins there is an 'opportunity' charging option that will extend the range of the vehicle allowing it to do more miles or displace other vehicles. In this paper we do not consider this as 'opportunity' charging. The real terminology should be 'scheduled charging' where benefit is achieved through scheduling the stop so it is part of the vehicles duty cycle. In this way the vehicles range is significantly enhanced as well as the business model for the charging post (Where value can now be attributed to the energy transfer to the vehicle). Under this same analogy all charging becomes scheduled and planned with vehicle 'overnight' charging also becoming scheduled charging. By thinking in this way, you are able to question the whole 24hour (And indeed the whole life) of the assets in a different way.

In figure 1 below, one of the fleets in the infrastructure mapping project was planned without scheduled stops and the distance vehicle use is shown.
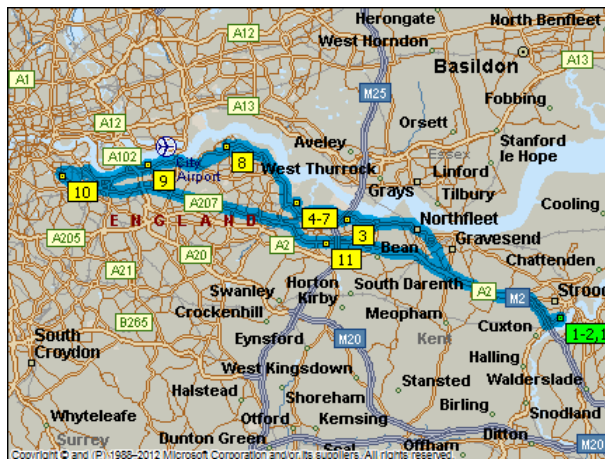
Figure 1: EV deployed without scheduled charging

In figure 2 we included scheduled stops for charging. The scheduled stop was at a forced lunch break and the vehicle was parked in a location that would allow for a charging schedule. In this case the vehicle was able to do 9 more jobs and 26 more miles.
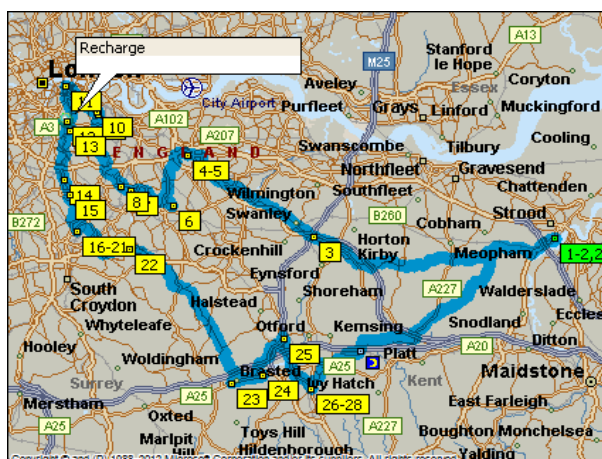

Figure 2: EV deployed with scheduled charging

The second and equally important opportunity that this project explores is 'master planning a charging infrastructure (Location, charge rate) based around a growing network of fleets that wish to use the system

to maximise vehicle TCO. Historically cities have undertaken an exercise of bulk provision of charging infrastructure with varying degrees of sophistication around where the posts should be. This approach has resulted in poor utilisation, a 'dead' system where the posts are not driven by a direct link to vehicle usage, and the resultant business models rarely work.

In the analysis Route Monkey have undertaken we have approached the provision of charging assets in a completely different direction. The key starting point is to consider the needs of the fleets operating or planning to operate EVs. Within the project we then:

- Determine how these vehicles can do the most work in a day for the minimum cost by designing an ideal charging infrastructure for each fleet combining work, home, private and public sites as well as different energy transfer rates. In most cases of analysis we worked towards a vehicle achievable range of 100 miles rather than the conservative value of 70 miles determined by risk to the fleet achieving its daily work.
- We then added in existing public infrastructure or private provision that could be accessible to the fleet.
- Through overlaying the result you could conclude the lowest cost of infrastructure for this fleet but this is not the benefit of the work and the goals for the project.
- Through considering a series of fleets in this way (All interested in deploying EVs) we then analysed what a shared network of charging infrastructure could look like to support all fleet movements and potential times when vehicles would wish to charge at.

The results of this work are remarkable in identifying a viable charging infrastructure with high utilisation of the assets (Vehicles and charging infrastructure).

We now have the elements of a master planning tool that:

- Creates a fledgling charging infrastructure that adds value to the group of fleets who use it.
- Has the ability to add fleets into the system and there workloads at any time creating the opportunity for increasing utilisation and adding further to the shared network of infrastructure

If we extrapolate further from this work that proved the case, we now have an interesting offer to a city or region wishing to build an infrastructure that will enable the shift of transport to EVs (Or by implication and fuel system requiring a new fuel infrastructure). Through a combination of PiFi project and this mapping project you can now:

- Identify fleets operating in a city and categorise them by type
- Define typical fleet activities by category
- Identify their operating regions (Through post code and likely catchment area)
- Define 'typical' schedules for a set of fleets (PiFi 100 project)
- Create a master plan base charging infrastructure for the city and region
- Work with the fleets identified to build demand and add charging infrastructure in a planned way to minimise asset allocation ahead of demand

1.5.2   Tracked battery degradation project

Gateshead College and the Zero Carbon Futures team http://www.zerocarbonfutures.co.uk/ have funded a collaborative regional growth project.

If we stop concentrating on the asset utilisation for a moment, but still use the scheduling engine that we see as the platform that all our work adds algorithms to, then one of the projects we are exploring is how through telematics data linked to the scheduling engine, can track the life of a vehicle as a 'free' add on to our existing products that are already cost effective to the fleets that use them. The benefit of this is that we can now start to put real value on the battery within a vehicle and this in turn allows our partners (Alphabet Leasing) to make judgements on the closing payment (Effectively the residual value) that they agree with the fleet.

Consider the graph below. Currently the market for second hand EVs is not established and the result is that underwriters will not accept the perceived risk of battery degradation. The avoidance of risk in the market place results in a dramatic drop at the 3 year lease point and a significant problem for the fleet market wishing to adopt EVs due to depreciation. The PiFi programme provided insight into how increasing lease life manages this problem better, but ultimately we believe that the market will eventually

return the ideal depreciation curve shown and this work looks at how through tracking battery activity it should be possible to start reducing the risk to underwriter and hence a 'passport' for the vehicle and battery pack that allows higher closing payment values based on a fleet managing their EVs better.
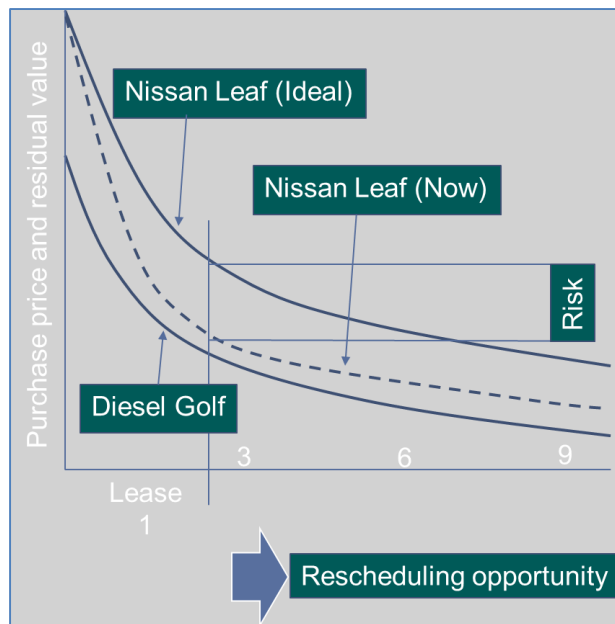

Figure 3: ideal and current depreciation graph for a typical EV

A significant and growing number of our fleet clients purchase telematics from us and use it to manage their scheduled routing in real time. This has many advantages that we do not go into in this paper, but the opportunity is to use key battery degradation parameters to follow the battery continuously throughout its life. The data will come from a combination of signals from GPS, Battery and charging infrastructure and in the case of Leased and Scheduled vehicles this is almost free as the fleet manager has purchased them to do other tasks.

The problem is by no means simple given that there will be a number of algorithms driving the calculations for battery life given the inputs and signals from the telemetry, but we believe that we have a product that will start to move the market towards a battery 'passport' and that as we build data and compare the algorithms with real degradation the algorithms will become more accurate and the risk to the lease company will reduce.

Results for the work on a battery passport have allowed us to consider (Many) future scenarios:

- That the lease company will be able to offer a better residual value based on usage patterns
- That the lease company will provide a set of recommendations for optimising a specific vehicles life allowing the fleet manager to tailor fleet operations to improve residual as part of the planning of fleets
- That Route Monkey software is further enhanced with the full detailed algorithms and each fleet vehicle has its own passport with the fleet manager. This has multiple possibilities in its own right but a key couple will be the ability to schedule more accurately for the vehicle as its battery degrades, and the second is that the fleet manager knows where the residual value is heading in a live scenario
- Second and third life for the vehicle become a matter of scheduling based on the passport
- The fleet manager will be able to determine whether to hand the vehicle back, extend its lease, reuse the vehicle on other duties matched to the passport

1.6   Conclusions and the future

This paper and our developing set of algorithms on a scheduling engine provides a platform that can significantly increase the utilisation of assets within the value chain for EV deployment. Ultimately this will embrace the generating sector through to the fleet vehicle and each element of the system will be added to the platform.

Route Monkey have many other projects working with partners and clients that are currently in progress and confidential at the time of writing, but each one will increase the sweet spot where EVs make economic sense.

The strong advantage we see with this work is that the base scheduling software effectively provides fleets with a significant saving over manual scheduling and when this is realised the client will then have all the elements to progress to EV deployment with minimum additional costs from the platform we provide.

Route Monkey are actively working with specialist businesses to collaborate and share both our partners software, and hardware to bring down the cost and add functionality to the platform we are presenting, but the products are already available to deploy.

References

[1]   EV report on Plugged in Fleets by author http://www.theclimategroup.org/_assets/files/EV_report_final_hi-res.pdf

[2]   PiFi   report   http://www.energysavingtrust.org.uk/Publications2/Transport-fleets/Research-and-statistics/Plugged-In-Fleets-Initiative-Charging-Forward

Authors

Biography – Robin Haycock, Architect, Route Monkey Ltd

Robin Haycock is an independent consultant specialising in sustainable mobility. He is a Non-Executive Director of Route Monkey and has a strategic role in the creation of software that will enable new business opportunities for fleets, infrastructure providers and energy companies wishing to deploy EVs or supply services to this market.

Previously roles include EV advisor to Energy Saving Trust (EST) where he played a significant role in the Plugged in Fleets Initiative. He was Head of Transport for The Climate Group (TCG), worked within Government in the Office for Low Emission Vehicles (OLEV), and was seconded from industry to the Dept BIS as an auto industry specialist to advise on the development of policies to support the UK auto industry.

Robin started his career as an apprentice with AEA Harwell, he went on to graduate from Bath University and worked in the motor industry for Jaguar Cars and then at specialist consultancies including Cosworth and AVL (Austria) finishing as Design and analysis manager for AVL in the UK, whilst also completing a part time MSc at Warwick University.

Robin moved from the automotive sector into energy consulting and transport roles within Arup, and during this period he has worked with a diverse range of clients to establish economic routes for sustainable transport in both retrofit environments and new planned eco cities.

Biography – Colin Ferguson, CEO, Route Monkey Ltd

Colin Ferguson is the CEO and founder of Route Monkey Ltd. Since its formation in 2006, Route Monkey has grown to become one of the UK's leading suppliers of routing and scheduling solutions for fleet and transport managers.

As a former CPC holder and transport operator, Colin fully understands the key challenges facing fleets today - reducing fuel spend and lowering emissions from road transport. He founded Route Monkey to address those challenges, ultimately delivering a technology which also provides a return on investment. Route Monkey provides scheduling and routing software solutions that save commercial vehicle fleets up to 20% on their fuel bills. This self-funding software helps lower transport mileage, increase vehicle utilisation and streamline fleet management.

Uniquely, Route Monkey can manage mixed fleets of conventional and electric vehicles (EVs). Route Monkey's EVOS software is the first fleet optimisation tool specifically designed for EVs. Through virtual trials, the software can identify suitable routes for EVs before fleets actually invest in the vehicles. Furthermore, EVOS can optimise EV use to help fleets "sweat the asset", thereby reducing the payback period for EV investment.