ELECTRIC VEHICLES by REA
RENEWABLE ENERGY ASSOCIATION

REA POSITION PAPER

The feasibility, costs and benefits of three phase power supplies in new homes

An REA publication sponsored by WPD
August 2018

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Western Power Distribution (WPD) is the electricity distribution operator for the Midlands, South West England and Wales. Employing more than 6,000 staff, it delivers electricity to 7.9 million customers over a 55,500 square kilometre service area. Its network consists of 220,000 kilometres of overhead lines and underground cables as well as 185,000 substations.

It is the largest Distribution Network Operator (DNO) by geography in the UK and is widely acknowledged as its industry's leader. It was the only electricity or gas distribution business to be fast-tracked as part of regulator Ofgem's business planning process which sets operational, environmental and customer service challenges and price controls for DNOs for the eight years from 2015.

Traditionally, WPD's responsibilities have included maintaining the electricity network, repairing it when faults occur, reinforcing the network to cope with changes in the pattern of demand and extending the network to connect new customers.

But there are new challenges on the horizon. The Government has set objectives for decarbonising energy which is leading to more solar panels being installed, electric vehicles replacing petrol and diesel engines, and increasing use of electricity storage.

The scale of the change is such that the traditional network design of transferring electricity from large central power stations to homes and businesses using transmission and distribution networks is evolving quickly.

Generation is becoming cleaner and more distributed. Networks are becoming smarter and more active. Customers are beginning to benefit from an increasingly efficient and flexible system.

WPD recognises that the change from a DNO to a Distribution System Operator (DSO) is essential to driving performance and efficiency from its network and to ensure it can meet the future energy demands of all customers. The enhanced capabilities it is developing also gives customers the freedom to access other opportunities within a developing energy system.

WPD regards the planning and operation of a more active regional distribution network as a natural extension of its current role and believes it is uniquely placed to lead the management of an efficient and cost effective electricity system at a local level.

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INTRODUCTION

The Department for Transport's (DfT's) Road to Zero Strategy commits the Government to consulting on compelling new homes to have charge point infrastructure installed in England. The REA strongly supports this and argues that this should include three phase connections for all of the associated benefits outlined in this report. The EV market has grown rapidly in the UK in the past few years and is now set for exponential growth. From around 140,000 EVs in the UK at present, to millions in the next few years, it is clear that how we manage this growth will be critical. We need to avoid delays to the transition and remove barriers for consumers, and maximise the environmental and economic benefits for us all.

The transition is eminently achievable and this is partly what makes it so exciting - it is a market and policy challenge as the necessary technology and certainly the engineering skills are already in place in this country. The need to ensure appropriate charging infrastructure is central to achieving our aims of mass EV roll out. UK homes were not necessarily designed for the new loads that electric vehicle charging will bring. We believe that for new homes an upgrade is required in order to future-proof our homes for the exciting new energy system we are heading towards, which goes beyond just EVs and includes more solar photovoltaics (PV) and renewable heat. Three phase connections could do just that.

This report should act as a starting gun for such discussions and we are delighted and grateful for the support and contributions from many of the REA's electric vehicle members, in addition to the particular support of Western Power Distribution (WPD). As the network operators will be critical to deploying the infrastructure required, it is heartening to see a forward-looking one supporting these discussions.

We also hope that this paper spurs discussions beyond new homes, and helps us develop our thinking about what will be needed in blocks of new flats and in new commercial premises - for example providing 'passive charging' capabilities to be built providing the physical space and capabilities for the future installation of charging infrastructure on-site at associated parking spaces.

A well-managed development of charging infrastructure and future-proofed homes is critical to achieving a more sustainable, smarter transport and energy system and the REA believes that the recommendations in this report will play a critical role in achieving this.

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SUMMARY

The REA's Three Phase Power Position

The REA propose that all new housing developments in the UK be fitted with a three phase power supply. We see this as supporting the rapid growth of electric vehicles and the deployment of heat pumps, both of which will become necessities if the UK is to meet its transport and heat emission targets. Solar PV deployment on larger roofs or east/west facing roofs will also be supported by three phase power connections as the array size will not be limited by a single phase connection as is currently the case.

Such a move would empower consumers who wish to charge their vehicles more rapidly at home using a charger with a capacity of up to 11kW (whilst acknowledging that 7kW is sufficient for the majority), and would help build the market for EVs which auto manufacturers will need if they are to significantly manufacture EVs in the UK. Additionally, homes will be future-proofed as the heating and power sectors become more renewable.

This position on three phase power for homes is part of a wider series of 'policy asks' relating to EVs and building regulations being proposed by REA members.

Overview of paper

The key points are:

- As industry adapts to meet the Government's Road to Zero Strategy and 2040 ban on the sale of new conventional petrol and diesel cars and vans, and the sale of electric vehicles grows, increasing demands will be put on the UK's electricity distribution networks. Three phase in new homes will better enable these to be managed.

- Recent data shows that around 80% of consumer interaction with charge points takes place at home. While 'smart charging' will reduce local network demands, the additional power supply into homes that three phase would bring could improve the speed, flexibility and consistency of home charging.

- Upgrading from single phase to three phase power in new homes would allow for greater draw when required most. It would also enable greater time-shifting of home charging.

- A three phase power supply would also allow for larger domestic solar PV systems to be installed than the current circa 4kW restriction imposed by a single phase supply, as well as enabling the easier integration of heat pumps into homes as the UK's Carbon Budgets require significant emissions reductions from the building sector in the coming decades.

Background and electric vehicle market growth

Tackling climate change

The Climate Change Act of 2008, hailed earlier this year by energy and climate minister Claire Perry as the "gold standard" in emissions reduction legislation, committed the UK to reducing its greenhouse gas (GHG) emissions by 80% by 2050[1]. Of the subsequent proposals emanating from Government, the 2017 Clean Growth Plan is a crucial strategy which lays out how the UK aims to achieve its legally-binding decarbonisation targets to 2032[2]. The DfT's Road to Zero Strategy outlines 46 measures to decarbonise road transport, including support for EV charging.

Global industrial change

As a pillar of its climate actions, the Government announced that it intends to ban the sale of new conventional petrol and diesel cars and vans by 2040. £246m in 'Faraday Challenge' funding, released as part of the Industrial Strategy, is designed to complement the 2040 ban and stimulate innovation and investment in the UK's electric vehicle supply chain. Similar bans and funding strategies have emerged globally; France has also confirmed a 2040 ban and is working with the European Commission to develop an "airbus-style" Battery Alliance to support battery manufacturing in the EU. China is incentivising new battery and electric vehicle manufacturing and has compelled auto manufacturers to adhere to a "Zero Emissions Vehicle" mandate, which forces them to sell a certain number of electric vehicles onto the market. California has taken up a similar strategy.

EV sales growth

In the UK significant cost reductions are anticipated for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). The Committee on Climate Change's (CCC) 'Central scenario' outlines that in order to meet the UK's Carbon Budgets, 60% of new car and van sales will be electric by 2030, making up approximately 30% of the total population of vehicles on the roads of the UK. The REA anticipates potentially rapid technological development, their EV Forward View forecasts that 50% of new car and van sales could be electric by 2025. CCC analysis estimates that nearly 29,000 public charging points, such as alongside motorways and at 'destinations,' are needed by 2030 to support the predicted increase in quantities of EVs[3].

Encouraging manufacturing

One of the Government's major priorities at present, as evidenced by the Industrial Strategy white paper and numerous sector deals that have been confirmed to date, is to increase domestic manufacturing of high-value goods post-Brexit. In the automotive space, the REA and its members are keen to emphasise that to manufacture electric vehicles, and batteries for power storage domestically, companies need stable domestic markets to sell into. Domestic success will also provide a launchpad for exports.

Encouraging home charging (as part of the wider ecosystem of charging forms) will be crucial in creating the consumer confidence that will result in the establishment of a domestic market.

Heat decarbonisation

The decarbonisation of heat is an additional looming issue. The Committee on Climate Change has identified the need for a 36% reduction in the UK's CO_2 emissions between 2016 and 2030, 20% of which is anticipated to come from the building sector. To decarbonise this, a variety of strategies may be implemented, one of which being the installation of heat pumps[4].

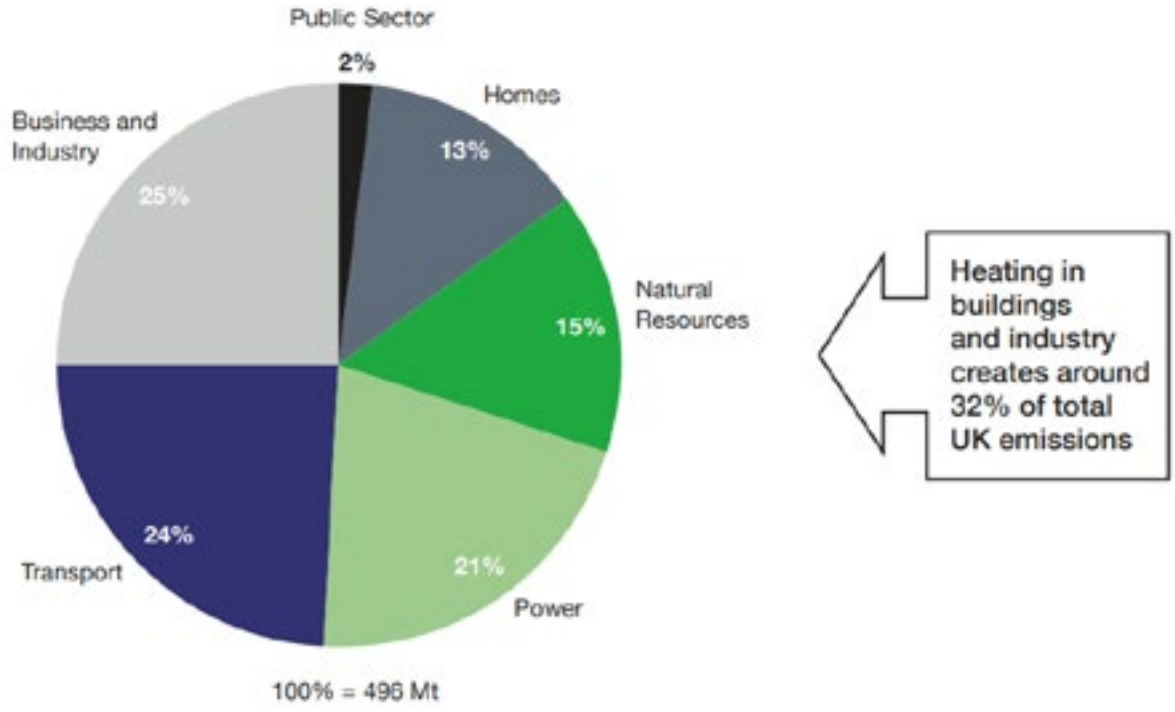


Figure 1 - Graph : UK emissions by sector : Clean Growth Strategy 2017[2]

The interaction between EVs and the electricity network

Managing electrical network demands

Increasing electric vehicle deployment is anticipated to require different thinking about the management of the UK's electricity networks. National Grid, who serves as System Operator (SO) and manages the UK's power transmission system, is pursuing plans to enable the development of around 50 ultra-rapid (up to 350kW) EV charging hubs along major motorways. Such hubs will be crucial in reducing 'range anxiety' for motorists that make longer journeys. Their analysis indicates that the changes to the transmission system necessary to cope with a rapid rise in the number of EV's on our roads are deliverable and would cost in the range of £500m - £1bn, as reported by the Financial Times.

While National Grid may be at the fore of developing rapid charging hubs, in some ways they are a step away from the rigours of home, workplace, on-street and destination charging. It is the local Distribution Network Operators (DNOs), who manage the low-voltage network that connects consumers and many businesses to their power supplies that will be on the front lines of this transition. While DNOs such as Western Power Distribution expect customers to use fast charging when on long journeys (such as the transmission-connected ultra-rapid hubs as proposed by National Grid), overnight home charging is expected by them to be the source of the majority of overall charging whilst vehicles are idle overnight.

Preliminary results from the Electric Nation project, presented by Western Power Distribution to the All-Party Parliamentary Group on Electric and Automated Vehicles in March 2018, show that the day-to-day reality for many commuters will be that the majority of charging will take place at home. The project, which involves monitoring the charging patterns of around 700 EV drivers (who come from a range of backgrounds and use a variety of vehicle models) indicates that currently around 87% of charging connection events take place at home, with 8% at work, 4% at service stations, and 1% at 'destinations' such as shopping centres (see Graph 2 overleaf).

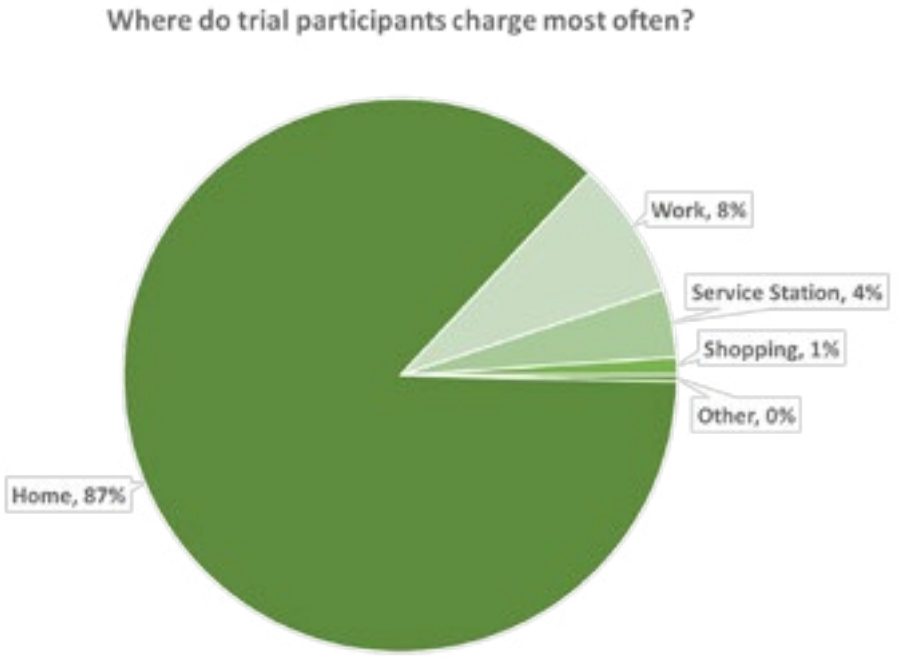


Figure 2 - Graph : Taken from WPD presentation on the Electric Nation project, 1st March 2018

Depending on the neighbourhood-by-neighbourhood level take-up of electric vehicles, local hotspots for increased electrical demand may start to emerge. The same may be said for certain shopping areas, whereas a chain or series of individual businesses or Local Authorities may incentivise customers to shop at their location by installing numerous charge points. On-site energy storage and renewable power generation can alleviate certain issues but network upgrades may also be needed. The Electric Nation project also modelled the impacts of "smart charging," which manages the demand that EVs can make on the grid at periods of high demand such as the early evening when much of the UK's working population returns home and other loads such as ovens and hobs are in widespread use, especially in winter.

Analysts modelling local grid strain also need to consider the impact of on-street charging. There is funding available from the Office of Low Emission Vehicles in the On-Street Residential Chargepoint Scheme for the approximately 40% of the UK population without access to a driveway or off-street parking.

Why three phase?

Government acknowledges the need for home charging and three phase is the best way to deliver this. In new homes, and in certain areas of particularly high local demand, three phase power supplies may ease local grid pressures as well. For the majority of customers single phase charging will be adequate, but some customers in the future may wish to home charge at a higher rate, particularly as battery ranges are extended. Additionally, under Engineering Recommendation G83 (see page 10), single phase connections currently restricts domestic export to 3.68kW AC of solar PV per phase on their rooftops, without seeking DNO permission, so three phase would allow up to three times this amount and allow for easier connections to heat pumps as the Government increasingly prioritises the decarbonisation of heat.

UK home electrical connections - the current model

The UK's distribution network is generally designed as a three phase system from the transmission grid through the local transformer with a three phase 230/400V supply running typically under the street, but homes are typically only connected to a single phase. (Figure 3 ranging in capacity from 60 Amps to 80 Amps.

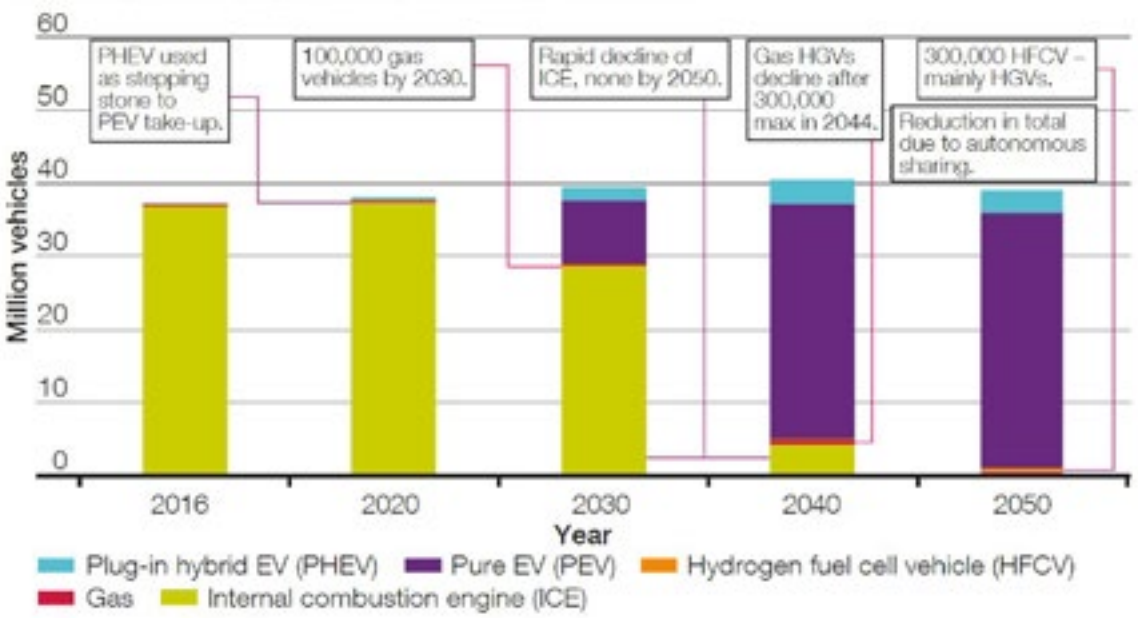
Figure 3 - Illustration of structure of single phase power in the UK

This is in contrast with the rest of Europe which is operated on a three phase system all the way into the home. In a single phase home, one of the three phases and the neutral connection are run into each house and all appliances are run on this phase, constraining the load that can be put on the house supply. The norm for new builds in the UK is generally single phase with 60A or 80A fuses.

When the grid system was designed, UK homes were drawing relatively little power and therefore this method of balancing the phases was sufficient. This though can now lead to imbalances between the phases on the local transformer, since houses in developments are connected in rotation between the phases: the first house on phase 1, the second on phase 2, the third on phase 3 and then the fourth on phase 1 again and so on. If many houses on a local transformer are drawing high currents, this can also lead to greater losses due to heating of cables and the imbalance of load between phases supplying the houses.

More electric vehicles will require more charging points which will increase the demand for electricity at the locations that they are installed. Most cars at home will not be charged through a normal 13A plug and socket, and instead will be charged through bespoke chargers and circuits being used for charging. The common design of chargers integrated into vehicles are limited to 32A per phase, which gives an effective limit of 7.4kW on a single-phase supply. In every future National Grid scenario electric vehicle numbers are expected to increase (Figure 4[9]).

Figure 4 - Graph of expected EV uptake : National Grid, Future Energy Scenarios 2018[9]



Consequently, increased demand will be placed on the distribution network as the need and number of slower home and faster on-street or destination charging points increase.

Solar deployment

Since the introduction of the Feed-in Tariff in 2011, around a million homes and businesses across the UK have installed small-scale rooftop solar panels. This is a significant increase on the expected rate of deployment by the regulator, Ofgem (as evidenced in the Graph opposite).

In the coming decades, installing a rooftop solar system will continue to be an obvious solution to ensure that home and business owners' electricity bills are reduced, to decreasing our reliance on energy imported from overseas, and to decarbonising our power, heat, and transport sectors. Costs for solar modules have continued to fall in the past decade and analysis from Bloomberg New Energy Finance, Eaton, and the REA indicates that costs for generating energy from most solar technologies will more than halve again in the coming years.[5]

Households currently installing solar PV modules on their rooftops are often curtailed as they can only install a system with an exportable capacity of 3.68kW on a single phase system without having to seek permission for installation from their local DNO. Applying for permission can add delays and sometimes incur additional costs. Solar PV can currently generate a maximum of 17.4A output (an increase on the output limit of 16A originally stated in G83)[10]. A three phase power supply could support a higher capacity system and therefore increase effectiveness by permitting 16A per phase and trebling the capacity of the system to be installed. This would still comply with G83, meaning that homes with a three phase system can install an increased amount of solar on their rooftops without having to request permission from the DNO.

G83 and three phase

To give it its full title Engineering Recommendation G83, sometimes abbreviated to EREC G83 or simply G83, is published by the Energy Networks Association (ENA). The purpose of this Engineering Recommendation is to simplify and standardise the technical requirements for the connection of Small Scale Embedded Generators (SSEGs) for operation in parallel with a public low-voltage Distribution System, by addressing all technical aspects of the connection process from standards of functionality to site commissioning. G83 for single generating stations with G59 dealing with anything over 16A phase. See http://www.energynetworks.org/electricity/engineering/distributed-generation/dg-connection-guides.html.

Many energy companies installing EV charging infrastructure are also in the business of developing rooftop solar and battery storage. Numerous products are available to let consumers monitor their generation and usage via an app, and their self-generated power can be supplied directly into their EV. Three phase supplies, therefore, will help both the growth of the domestic solar market and the decarbonisation of the transport mix.

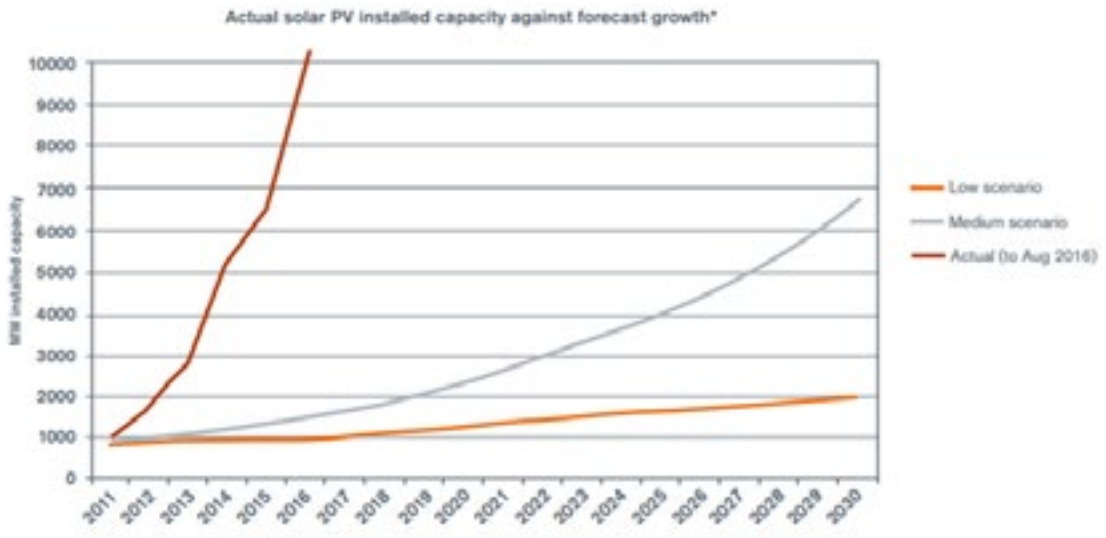


Figure 5 - Graph : Projected Solar Deployment : Ofgem's Future Insights Series Overview Paper 2016[6]

Three Phase Power - the benefits and what's involved

A three phase power system is currently used in large parts of Europe and is considered as more efficient than single phase. Appliances and circuits are assigned to different phases so that each load is balanced. Larger appliances including heat pumps and water heaters are often three phase versions using equal power from each phase. Some appliances may be equivalent to their UK equivalents but installed differently, e.g. an electric hob with each hotplate wired on a different phase. (Figure 6).

Figure 6 - Illustration of structure of three phase power as used in Europe

Consequently a charging point can either be run on one phase while the household (and potential heat pump) is run on another, or such high loads can be spread across multiple phases.

This can allow higher speed charging to take place at off-peak times, typically at 11kW (3.7kW per phase) or higher, although this may not always be required. Large battery capacities require proportionately less time to charge. It should be noted that patterns of refuelling electric cars with larger batteries are different to those of internal combustion vehicles. In internal combustion engine (ICE) cars, the mentality is more organised around refuelling only when the tank is nearing empty. Regular home 'top ups' while the battery still has significant charge is more the norm with longer range electric cars. This means that homes connected on single phase supplies will still be able to charge adequately.

Figure 7 - Table : Charging times and capacities of a large (90kWh) battery[8]

Charger Size kW	Amps	Large Battery 90kWh	
3.7	16A	24h00	
7.4	32A	12h00	
11	16A three phase	08h00	
22	32A three phase	04h00	
50 (DC)	80A three phase	01h30	to 80% State of Charge

As battery ranges extend some homes may choose to install an 11kW charging point instead of a 7.4kW charger to reduce their recharging times. The installation of a three phase system will support customers to pursue this option. We emphasise that 7.4kW chargers are adequate for much overnight charging. As car ranges and consumer uptake grows, however, it is pragmatic to begin equipping people with the ability for a higher charge rate (particularly when seen in the context of solar and electric heat deployment). Depending on how networks, regulators, and Government decide to 'manage' peak EV charging times in different regions, be it through direct intervention or market mechanisms, an 11kW charger on a three phase system would create additional consumer confidence that they would be able to take a significant overnight charge.

Following the assent of the Automated and Electric Vehicles Act (2017-19) it is likely that future home charge points will be required to have smart capabilities. This will complement a three phase supply as vehicles will be able to draw more power, at more convenient times.

It should be noted that other forms of charging, such as National Grid's proposed ultra-rapid (350kW) hubs along major motorways, are expected to be transmission-system connected (rather than to the distribution grid, which is where domestic EV charging will impact most). National Grid has proposed up to 50 such hubs are created, which, for an example of costs, could mean £500m to £1bn in transmission network upgrades.

Installing three phase in existing homes

The paragraph below is focused on how existing homes can covert to three phase power supplies. While this may be desired, or even needed in certain situations, the REA is not advocating for policy that compels existing homes to retrofit to three phase connections.

For those homes that see it as desirable to install three phase supplies into their existing structures it should be noted that this would not necessarily involve re-wiring the house. Discussions with contributors indicate that a three phase supply can be run from the street to the home and connected to the consumer unit where the electrical supply is brought into the house and then distributed to the various circuits within the house. The first phase can remain in place to power the existing household appliances, and the second and/or third phases can be connected directly to the charge point (and/or in the future, a heat pump). This would significantly reduce costs as the whole home's wiring would not need to be redone.

The steps involved with installing three phase supply to an existing house include:

- Checking with your DNO and arranging for works
- For retrofits, seeing if others in the area also need upgrades
- DNO investigates to see if local transformer needs upgrades

- Cables need to be run from the DNO cut-out (main fuse) to the cable feeding homes in the street via new or existing ducting, or connected to overhead lines
- An appropriate consumer unit needs to be in place, with potential upgrade costs for retrofit
- Wiring in the house needs to be installed - for new builds the circuits within the home could utilise different phases with large appliances balanced across phases. For retrofits, the extra phases can be directed to the garage or parking space

What about apartment blocks?

The REA is advocating that new commercial properties with car parks, including blocks of flats, should be built with passive EV charging, meaning that minimum power supplies should be required which will allow for charging to be installed more cheaply and quickly as the EV market grows.

Consideration should be given to stipulating that Local Authorities follow the draft London Plan, which outlines that 20% of car parking bays in a new car park need to have a charge point, and that the enabling cabling and ducting is laid to ensure that more charging points can be quickly rolled out once the market matures.

Evidence from REA members indicates that pre-equipping such premises with power supplies and ducting can be about 70% cheaper than retrofitting.

Industry perspectives on three phase in homes

Interviews with a DNO, an installer and a land developer

As part of this report the REA conducted a series of interviews to obtain industry perspectives and data. Companies consulted included; isoenergy, Western Power Distribution and Savills.

The REA asked numerous questions throughout these interviews relating to the costs and feasibility of installing a three phase supply in new, and existing, homes. Questions also related to the technical process of doing so and the benefits as the UK's energy system moves towards a more decentralised, decarbonised, and electrified model. The following is a summary of the discussions:

The costs in comparison

Committing new build homes to a three phase power system provides the appropriate infrastructure requirements needed for increasing numbers of solar panels, electric vehicles and heat pumps. The current low voltage grid arrangement may not be sufficient to support these developments and could lead to over-loading if it is not upgraded.

When planning a new housing development the DNO will provide a price for installing a supply and connection to each house. By law they have to give the lowest cost (detailed in Ofgem guidance as the "lowest cost, efficient, coordinated and economic solution") which is currently a single phase connection.

As the UK currently installs a single phase supply as default, without government intervention it is likely that this practice will continue as this is the cheaper option, albeit not by much. If regulation was introduced to compel the installation of three phase systems in new homes and in renovations, cost would be likely to fall.

Costs when fitting new developments with a three phase system mainly arise from:

- Installation of three phase cabling,
- Installation of distribution boards and a termination box.

Three phase in new buildings

Following discussion with a wide range of companies the REA estimates:

- The price of three phase cable would only be a couple £/m more and would fall to near parity with the right volumes.
- Trenching and ducting costs would be small and equivalent to those currently in-place for single phase.
- Mains joints could be more expensive but this cost will reduce as they become more commonly used.
- Plans need to be drawn up on how to build houses like this and what the best way to subdivide the house would be.

WPD are planning a three phase trial in a 'green' low carbon housing development in South Wales. If this is successful and effective they may consider changing their company design policy to make all housing estates three phase.

An issue may be with Independent Distribution Network Operators (IDNOs) as they can build and operate to independent design standards which may undermine efforts.

Three phase in retrofit homes

WPD are currently undertaking another project with refurbishment to see how much it would cost to change a series of developments to a three phase system. WPD are aiming to conduct this with as little impact to the buildings as possible. They predict that homes built in 1970's onwards would be fairly simple to change as they have plastic connection ducts. However, systems in homes built before this are more complicated and holes would have to be drilled at either end of the cables to remove and replace these.

WPD has made clear that their test retrofit programme is designed to better understand costs for those homeowners who elect to have their power supplies upgraded.

The distance between the network and the settlement plays a big factor in overall costs as it affects the quantities of trenching needed to be dug and cabling that needs to be laid. The distance also influences where the transformer can be mounted. It could be expensive to re-wire mains cables in the street compared to laying initial cables (as stated above). Cable cost is relatively low (£10/m) however excavation and relaying costs could be as much as £100/m.

isoenergy provided several case studies into past projects they have completed. The cost of retrofit seems to be considerably higher than the potential costs for new developments and increase with distance from the substation. Laying a new cable to an existing house 10m from the substation was found to cost £6K whereas a house 100m away costs £22K and one 1,000m away costs £45K. The standing charge for a new connection will also rise as capacity does, subsequently there will be an ongoing cost to keep that connection.

Conclusions

Three phase connections should be introduced as standard as this can be done for only a slightly higher cost to at present and will become even more pressing given Government commitments in The Road to Zero Strategy. The main struggle with developing new builds on a three phase system is finding an initial developer who is willing to participate. Developers want buildings to be built at as low a cost as possible as a way of maintaining margins. First movers and regulation is needed too as many are unwilling to make the first move and someone is needed who will take the initial steps. IDNOs could present a distinct problem as the Merton ruling does not extend to them and they would not be obliged to construct developments on a three phase arrangement.

1. New developments

Building new developments with a three phase power system would not incur significant additional costs and, any that did occur, are likely to be reduced as the market becomes more competitive.

As new-build houses increase their loads through the use of electric showers and other technologies such as heat pumps, inadequate service cables supplying the buildings could overload and cause losses. Installing three phase power would reduce imbalances and help improve the efficiency of local networks.

As the Government will need to reduce our reliance on natural gas for heating and cooking, other heat-generating systems will be needed. Heat pumps have been widely suggested as a legitimate alternative and the extent of their roll-out is being presently considered by the Government's heat strategy team. However, they present a similar problem to charging points in that their load on a single phase system could cause significant issues. Running these on a different phase to charging points and household appliances would increase efficiency and prevent any short circuiting.

The Government and industry need to see the opportunity to support the introduction of three-phase supplies in new homes - as a policy it will support the decarbonisation of the UK's building stock, and will help the Government achieve its Industrial Strategy goal of building new British industry.

2. Existing homes

Retrofitting established developments will be more challenging and will incur higher costs than new-build, especially in builds pre-1970. It is likely that costs would be reduced as competition and the increased demand for materials increase. Certain up-front costs will remain regardless of volume however, such as the costs of trenching and relaying cable from substations, especially to dwellings located a significant distance from the substations.

It is unlikely a significant number of homes will elect to do this given the associated costs, the feasibility for many on charging on a single phase, and the new market-mechanisms being discussed by the sector for managing any additional peak demand from EVs.

3. Points to be addressed as highlighted during this investigation:

- Convincing developers/IDNOs to construct new buildings on a three phase power system while single phase is currently cheaper.
- Plans need to be created to aid in the development of a standard approach to three phase conections, in particular, what will be connected to each phase to balance demand.
- High additional costs of retrofitting especially in remote buildings and those dating back to pre-1970.

Case Study: Parc Eirin Energy Positive Homes

Introduction

The Parc Eirin innovative scheme is an initiative between the Pobl Group, Tirion Homes and Sero Homes. Parc Eirin has been developed through the planning process and is consented as a traditional garden village scheme consisting of 225 homes. The project will be enhanced with technologies and delivery methods which will combat fuel poverty, reduce carbon dioxide emissions, improve air quality and facilitate a transition to clean and affordable transport. The aim is to create a development that generates as much energy as possible (at least as much as it consumes), is flexible in operation and features technology that is well integrated into the existing building design. The technologies represent a switch from fossil fuels to renewable technologies that will decarbonise further as the grid becomes 'greener' over time.

This project will seek to take part in the Welsh Government Innovative Housing Programme 2018/2019, demonstrating that homes which look and feel familiar to consumers can play a better role in the future decarbonisation agenda. The three companies involved will achieve this by seeking to make the homes look, feel and operate very much like traditional homes.

Image: Parc Eirin CGI

Renewable technology

The technologies have been chosen to provide flexibility in energy consumption and to take consumers off the grid at peak times. The homes will generate heat and electricity through a building integrated photovoltaic and solar thermal roof (PVT), this provides a good contribution to the heat and electricity demands of the home. A combination of thermal and battery storage ensures that the consumer retains low cost energy for use at peak times. The homes will also feature smart heating controls, smart appliances and electric vehicle charging.

Western Power Distribution ("WPD") is actively assisting the developers of Parc Eirin because the electrification of heat and transport presents a challenge in network regulation and stability. Sero Energy (a sister company of Sero Homes) is developing a forecasting and load control system which is well aligned with WPDs transition to becoming a Distribution System Operator (DSO).

Three phase supply

A risk with the proliferation of home vehicle charging is that the traditional three phase grid becomes imbalanced because certain single phase homes will have a charger and others will not. This places an imbalance not foreseen when the grid was designed.

The Parc Eirin project will utilise a three phase supply to each home and distribute loads evenly across the phases to aid balancing. Lithium ion batteries, photovoltaics and heat pumps will be used to evenly distribute generation and demand. Three phase will also enable the project to adopt faster charging rates and maximise generation whilst future proofing for smarter grids.

The project will investigate the best configuration for wiring in the home to allow diversification of load across each phase within it and across the development. The additional cost for installation should eventually be marginal. However, it is anticipated that an additional cost will be inevitable on earlier projects due to scarcity of three phase equipment and the new electrical design.

The project will be designed so that it can participate in demand side response (DSR) activities, the three phase supply will allow greater turn up demand capacity and rapid charging of connected vehicles.

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