THE HIDDEN COST OF NET ZERO

REWIRING THE UK

Mike Travers

The Global Warming Policy Foundation
Briefing 48

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Contents

Summary

Plans to decarbonise the economy will probably require homeowners to install:

- heat pumps
- electric vehicle charging points
- electric showers
- other electric devices.

The extra demand for electricity will overwhelm most domestic fuses, thus requiring homeowners to install new ones, as well as circuit-breakers and new distribution boards. Most will also have to rewire between their main fuse and the distribution network. In urban areas, where most electrical cabling is underground, this will involve paying for a trench to be dug between the home and the feeder circuits in the street.

In addition, increased demand along a street will mean that the distribution network will need to be upgraded too. This will involve installing larger cables and replacing distribution transformers with larger ones. Most urban streets will need to be dug up. In rural areas, where electricity is normally carried on overhead cables, it may be possible to just replace the wires, but it is more likely that cabling will have to be buried instead.

The cost to the country of rewiring alone will probably exceed £200 billion, or over £7,000 per household. This figure excludes the cost of new equipment, such as EV chargers, heat pumps and electric showers.

About the author

Mike Travers CEng, MIMechE, FIET spent twenty years in the Royal Engineers and in the 1960s ran a Geodetic Satellite Tracking Station. In the 1970s he worked in the hydroelectric sector on the Columbia and Snake River systems in the USA. He was also a member of the IET Wiring Regulations Committee. In the 1980s he was in the design, construction and then operations teams of a large hydrocarbon cracker. He was the industry representative on the committee that rewrote the Grid Codes for Scotland. He finished his career as the engineering director of a fine chemicals company.

1. Introduction

I am sure every one of us in the UK supports cutting waste, not polluting the oceans with plastic, collecting our rubbish (though people are still throwing tons of waste out of car windows), reducing discharges of all types into our fragile atmosphere and still maintaining a reasonable lifestyle. To do this we need to plan, engineer and build in a sensible way. What we cannot afford to do is inflate electricity prices and other costs: this will simply result in manufacturing industry leaving the country and the export of our carbon dioxide emissions.

Nevertheless, businesses and consumers have been facing steadily increasing electricity bills for the last 12 years. The price I pay for electricity has risen from 6p to 16p per unit.[1] That is more than 150% in 12 years, faster than any other commodity. This is partly the result of poor planning of the system. Engineers have long since lost control of the electrical supply, and the regulators, accountants, and lawyers who now hold sway have conspired to prevent sensible improvements to the system. As my father used to say, 'An engineer can do for sixpence what any damn fool could do for half-a-crown'.

But a great deal of the extra cost can be put down to efforts to decarbonise the electricity system. Gas turbines can generate electricity at a quarter of the cost of wind turbines, so the focus on renewables means it is inevitable that prices will go up. Add in the cost of dealing with the intermittency, and the bill to be paid becomes very high indeed. As we head towards a fully decarbonised grid, the expense will become truly astronomical.[2] We even have to pay windfarms to switch off. These so-called 'constraint payments' reached £140 million in 2019.[3]

And the hit to consumers' pockets is going to become worse still as the scope of government plans moves beyond the electricity system and into people's daily lives. They have been encouraging homeowners to install more insulation, or even forcing electricity companies to do so, for 20 years now (although even the most economical measures, like loft insulation, will be hard to justify if the house is not made airtight at the same time; retrofitting more extensive measures is prohibitively expensive[4]). But as electric cars and heat pumps are made compulsory, considerable upheaval and, of course, much more cost is coming the way of the British householder. Some of these impacts have already been the subject of considerable public discussion. This paper considers some other important costs and public inconveniences that have not received so much attention.

2. The coming changes

Electric car charging

At present battery electric vehicles (EVs) represent a niche market. If and when they become mass market, there will be considerable problems for householders.

The take-up of electric cars so far has mostly been among the wealthy; typically people with two cars and with offstreet parking and a garage. However, only around 60% of cars are parked on the homeowner's land; the rest are parked on the street. If plans to force fossil-fuelled cars off the road come to fruition, these vehicles will be hard to keep charged. Their owners will have to use fast chargers, either on the street or perhaps at their place of work, although of course the latter option is not available to many.

Charging also tends to be quite slow. Filling up with diesel and petrol at the pumps takes only 3–5 minutes. However, even so-called rapid chargers (120 kW) can take 30–40 minutes. Because of this, EV owners may well disappear to do something else while their car is charging, and inevitably they may not return promptly after the charging process is complete. Street chargers will therefore inevitably involve lots of conflict, and examples of charge-point rage have already been documented.[5]

It is possible that dedicated charging points could be set up in the streets for individual households, with cabling owned and paid for by the householder. However, it is likely that councils would charge for these, perhaps the £500 per year that is the present rate for parking at work. It is also possible that councils will own the cabling, contracting out the operating of the charging pillar to a private company operator. In such cases, the cost to recharge could be very high.

For the lucky people who are able to charge their cars at home, there will be considerable upheaval. Homeowners have two main kinds of equipment to choose from:

- slow charging using a standard 13-amp supply
- fast charging using a special 7 kW (32-amp) supply.

For those with time on their hands, the 12 hours needed to fully charge a typical battery car on a 13-amp connection may be acceptable, although there is still the cost of fitting earth fault protection, which will set the homeowner back around £250.

Most people will require fast chargers, however, and indeed the government is considering making their installation mandatory in new homes.[6] It is likely that many homes will have one fast charger and one slow one.

Homeowners will therefore need to install a charging pillar. These will cost £1200 to install in new homes, or twice that to retrofit to old ones,[7] because the household distribution board is likely to require upgrading (see also Section 3). Even if only 40% of homes take a fast charging pillar, the cost to households could surpass £31 billion (Table 1).

Table 1: Cost of installing domestic EV chargers.

Assuming 60% of homes allow off-street charging, and 40% of homes have both fast and slow chargers.

	Unit cost £	% of homes	Number of homes (m)	Cost £bn
Fast	2400	40	11.2	26.9
Slow	250	60	16.8	4.2
				31.1

And even with a fast charger, there are likely to be problems. There will be a major shift in 'refueling' activity, from public places to the home. This will mean that visitors to a house will often have to impose on their hosts for a recharge. Moroever, EV charging connections are currently often different, so there is an immediate practical problem. Connections can be standardised through regulation, of course, but there is still the question of who pays. Should you charge visitors for a recharge? You might gift the cost to friends and relatives, but what about the plumber or the carer?

At present there is a false sense of how economical electric cars are. This is partly because their owners are able to charge up for free at council-run chargepoints. As the number of EVs increases, this kind of subsidy will have to be eliminated. Charging on commercial street chargers can already be very expensive, because their installation and maintenance costs are very high compared to the quantity of electricity sold. One major recharging network recently increased its prices to 79p/kWh,[8] five times typical domestic prices. At this price, it might cost £50 to charge the typical EV, and driving an electric car becomes more expensive than using petrol, if tax differences are left out of the equation.

In addition, when discussing the costs of home charging, the media likes to quote the off-peak rate of 10p/kWh, despite the fact that cars plugged in before 2300 hrs will pay much more; a typical day rate would be around 20p/kWh, so it might cost £10 to charge a car up completely at home.[9] This figure will inevitably rise considerably as wholesale electricity prices soar – potentially doubling in future.[10] Will you offer slightly irritating family relatives a free charge-up if the cost runs to £20? The spread of time-of-use billing – widely assumed to be just over the horizon – is also likely to make the question of whether to charge visitors to the house for charging their cars a fraught one.

Selling power back to the grid

There has been considerable discussion of the possibility of EV batteries supplying electricity back to the grid when the wind isn't blowing and/or demand is high. This is unlikely to happen, not because it cannot be done but because it would be ridiculous to do. Firstly, many EVs will be on charge for 12 hours per day, and thus unavailable for supplying the grid. Secondly, it is hard to imagine why anyone possessed of a fully-charged EV would allow the battery to be drained when they might need the car at any moment, and when there was a shortage of electricity. Thirdly, the battery is direct current (DC), but the grid requires alternating current (AC). It is unlikely that any homeowner would be prepared to invest £800 in a DC-to-AC inverter to allow them to sell electricity, particularly since the sales value they will derive from doing so would be small. If your EV has cost £10 to charge at 15p/kWh, would you allow the grid to take half of that charge, if it had a value of only £5? The grid would have to pay an extraordinary premium to get someone to bother to connect their car up.

Moreover, one of the likely causes of such a shortage of electricity would be a heavy load on the grid from other cars being charged in the area. It is uneconomic and wasteful to remove charge from one car to charge another. Figure 1 shows the chain of electricity supply, starting with the wind turbine, going through the transmission and distribution grids to the home and then to the car charger. At each step along the way there are power losses, so by the time you get to the car battery, 24% of the energy generated at the wind turbine has been lost.[11] If you then use the inverter to produce AC, and then charge another car battery, the overall loss has risen to 41%. Almost half of the electricity generated has been wasted (Figure 1).

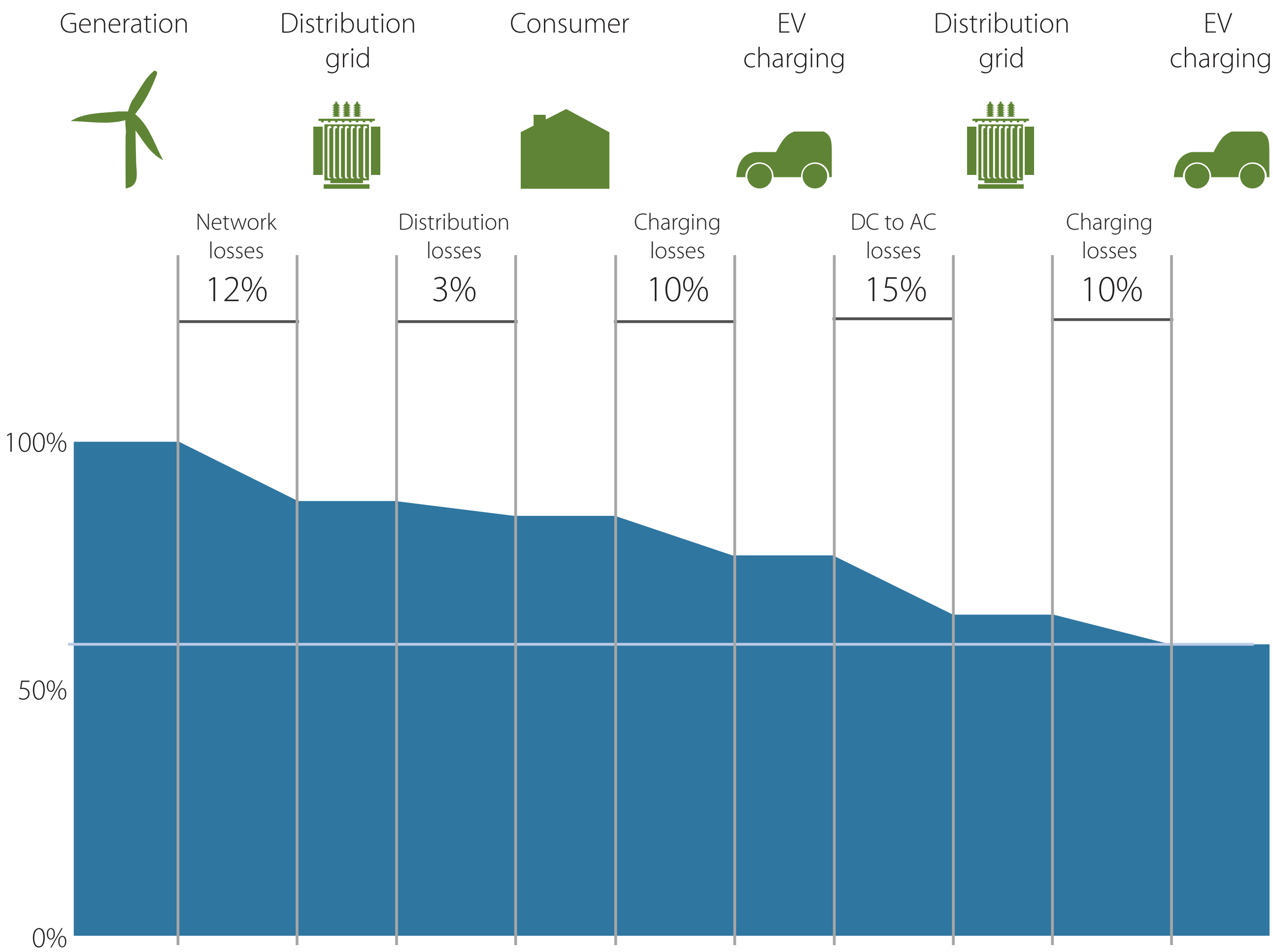

Figure 1: Energy losses from generation to charging.

Heating

Domestic heating is a major emitting sector of the UK economy, and one of the hardest to deal with. The cost of reducing emissions by retrofitting insulation is prohibitive above a rather low level,[12] so the intention is to use electrification (with the assumption that the electrical supply will in future be zero carbon). While in theory this could mean storage heaters, in reality the rising cost of electricity is likely to mean that heat pumps will be the preferred option because they use so much less electricity. A heat pump is essentially a fridge working in reverse, and there is a substantial energy gain in the process – for each unit of electrical energy expended in pumping the refrigerant around the system, several units of heat energy are extracted. On the face of it, it's an attractive technology, although there are serious issues. Most of these are not within the scope of this paper, but they are worth covering briefly.

The best alternative is a ground-source heat pump (GSHP), which extracts heat from the earth, using a network of buried pipes. However, that requires a lot of space, so they are really only an option for people who own significant plots of land or can afford the alternative of drilling a borehole. The total cost in a new house for installing a GSHP is likely to be £18,000,[13] or four times the present cost of an oil or gas heating system. The alternative is an air-source heat pump (ASHP), which might cost £10,000, gives energy gains rather less than GSHPs, and suffers from major reductions in efficiency in cold weather.

Because heat pumps run almost continuously in winter, their lifespans are relatively short. A GSHP tends to be installed in a garage (they are the size of a large fridge), protected from the elements. Many may need to be replaced every 10–15 years, similar to a gas-fired boiler. ASHPs are installed outside and can be expected to have shorter lives. In other words, the extra capital cost of a heat pump is a substantial and recurring financial burden on the homeowner. Moreover, although the energy gains noted above are real, they are only big enough to compensate for a switch from oil-fired central heating. Those who benefit from cheap, gas-fired heating would see their bills rise if they installed a heat pump.

In terms of the subject of this report, a typical domestic heat pump delivers 9 kW of heat into a house from 3 kW of electricity. The instantaneous starting current can be as high as 58 amps, but quickly dropping to the operating level of 12 amps. Because of the very short duration of the startup surges, a 60-amp fuse will not blow immediately, but repeated surges will cause it to do so eventually.

Hot water and showers

Both kinds of heat pump struggle to produce water hot enough for use in taps around the house. Typically, they can warm water to 55°C, rather than the 65°C that is normal from a gas-fired boiler. It is possible to buy a heat pump with a second circuit that steps up the temperature just to the hot water tank, but this reduces efficiency and increases running costs by 10%. The alternative is an immersion heater, but that may well become prohibitively expensive as electricity prices rise.

Additionally, heat pumps warm water up slowly. This is not a problem if the house has a hot water tank, but many no longer do – it has proven cheaper to install combi-boilers, which do not require one. Many of those who live in smaller houses may need to give up valuable cupboard space to accommodate a new hot water tank.[14]

Another problem with the water heating up only slowly is that even if a water tank is available, some larger families may need to have an electric shower as backup. The amount of power these draw from the grid is considerable; they are typically rated at 9.5 kW (40 amps). If a house has two electric showers on at the same time, the 80-amp draw may blow the main fuse, which is rated at only 60 amps in many houses. The rating of the fuse is a function of the cable delivering electricity from the street, and so if a 100-amp fuse is to be installed, the cable from the street may have to be dug up and replaced (see Section 4).[15] It is notable that the private monopolies that run the distribution networks are not regulated, and thus there may well be a tendency to overcharge.

Ventilation and heat exchangers

The trend now in new houses is to make them as airtight as possible, and if plans to move towards a net-zero economy come to fruition, this will be true of almost all homes. However, test results show that in some of these houses, because of the chemicals used such as air freshener and cleaning fluids, the quality of the air inside is worse than even the air alongside a busy road. To avoid this problem, many new houses are fitted with ducts to provide ventilation, and houses that are sealed up on a retrofit basis will need the same technologies. Air is drawn from the WCs, bathrooms, kitchen, and utility rooms and is pumped to the attic, where a heat exchanger extracts heat and passes it to a stream of fresh air drawn in from outside. These exchangers can run for as much as 18 hours per day.

However, because the heat exchanger is not 100% efficient, it is usually necessary to provide a measure of extra heating, to get the incoming air stream up to room temperature. To do this an electric heater is installed in the duct too.

This means that there are two extra draws on the supply, which together could amount to over 15 kWh per day. This is full-rate electricity and could therefore cost £2.40 per day at current prices, and potentially as much as £4 per day if electricity prices increase at the rates predicted. This therefore amounts to nearly £1500 per year. Many householders who already have these systems installed turn them off to save money, only running them for 30 minutes, twice a day; they prefer to risk contaminated air rather than to spend the money.

3. Dealing with overloads in the home

At present, the major sources of electrical load in homes are as shown in Table 2.

Table 2: Major domestic electricity loads.

	Amps
Electric shower	40
Cooker (on start up)	27*
Kettle	8
Total	75

*Falling to 12 amps once the temperature has stabilised, but this is not relevant here.

These high draws are all of relatively short duration, so the load within a house is likely to be spread over time, making overloads unlikely. However, with the 60-amp fuses that are common in UK households, there is not a great deal of headroom and in newer houses, 100-amp fuses are now frequently installed.

The elimination of fossil fuels from the home will change this equation in a fundamental way. As homeowners have to take on all the new electrical devices outlined in the previous section, they will create new loads on the fuse. Were they to do this without considering the implications, they would quickly find that their fuses become overloaded. As noted above, this is particularly an issue when the heat pump kicks in, when current consumed can rise to 38 amps. Consider the hypothetical household in Table 3, where a slow EV charger is running, and the heat pump kicks in.

Table 3: Major domestic electricity loads in a lower-demand decarbonised house.

Including slow EV charging and a heat pump.

	Amps
Existing potential peak load (from Table 2)	75
Air source heat pump (starting current)	38
Slow EV charge	12
Ventilation fan	1
Total	126

This would appear to suggest that even a 100-amp fuse would be blown regularly. It might be possible for householders to prevent this happening by controlling when they used the shower and cooker, but the difficulties would become insurmountable if fast chargers become common in homes. Consider the household in Table 4, which has two chargers – a fast one and a slow one – and a second electric shower. The extra load would blow even a 100-amp fuse.

Table 4: Major domestic electricity loads in a higher-demand decarbonised house.

Including fast and slow EV chargers and a heat pump.

	Amps
Current typical peak load (from Table 2)	75
Air source heat pump (starting)	58
Second electric shower	40
Fast EV charger	33
Slow EV charger	12
Ventilation fan	1
Total	219

The upshot is that the electrics are going to need to be upgraded. Installing a bigger incoming fuse is relatively straightforward, although it comes at a cost of £600. But further works will also be required. Cables become loose in terminals over time and, as the heating effect of a loose connection is the square of the current passing through it, the increased loads as we move to a net-zero world mean there is a greater risk of distribution box terminals overheating and catching fire. As a result, all new domestic distribution boxes now have to be metal, rather than the plastic that has been used in recent decades. So when the main fuse is upgraded, it will also be necessary to replace the whole distribution board, at a cost of £2500.

Moreover, the size of fuse that is installed is a function both of the loads coming from the house and the wires delivering electricity from the grid. In other words, homeowners will probably need to pay to upgrade wires between their meter and the cables under the street, or above it. The upgrades to the wiring that will be necessitated are considered in the next section.

4. Net zero and the distribution grid

Figure 2 is a schematic of the electricity grid. Electricity from the network is delivered to distribution transformers, which lower the voltage from 11,000 volts to the 240 volts we have in the home. From there, circuits known as feeders deliver it to the end of driveways, and service cables deliver it to the home.[16] In villages and in the countryside, where housing is spread out, the feeder circuits and service cables tend to be carried overhead on telegraph poles, because this is much cheaper. For more densely packed houses in towns, the cables – up to 1 km in length – are buried in the street. This section examines whether all this hardware is up to the job of supporting net zero communities.

There are two possible approaches to dealing with all the extra need for electricity in homes: manage the demand from homes or upgrade the wiring between homes and the distribution transformer. These two alternatives are examined next.

Managing demand

Infrastructure for managing demand in homes is already being installed. We are spending a total of £15 billion on domestic smart meters,[17] but it is fair to say that their design has not been well

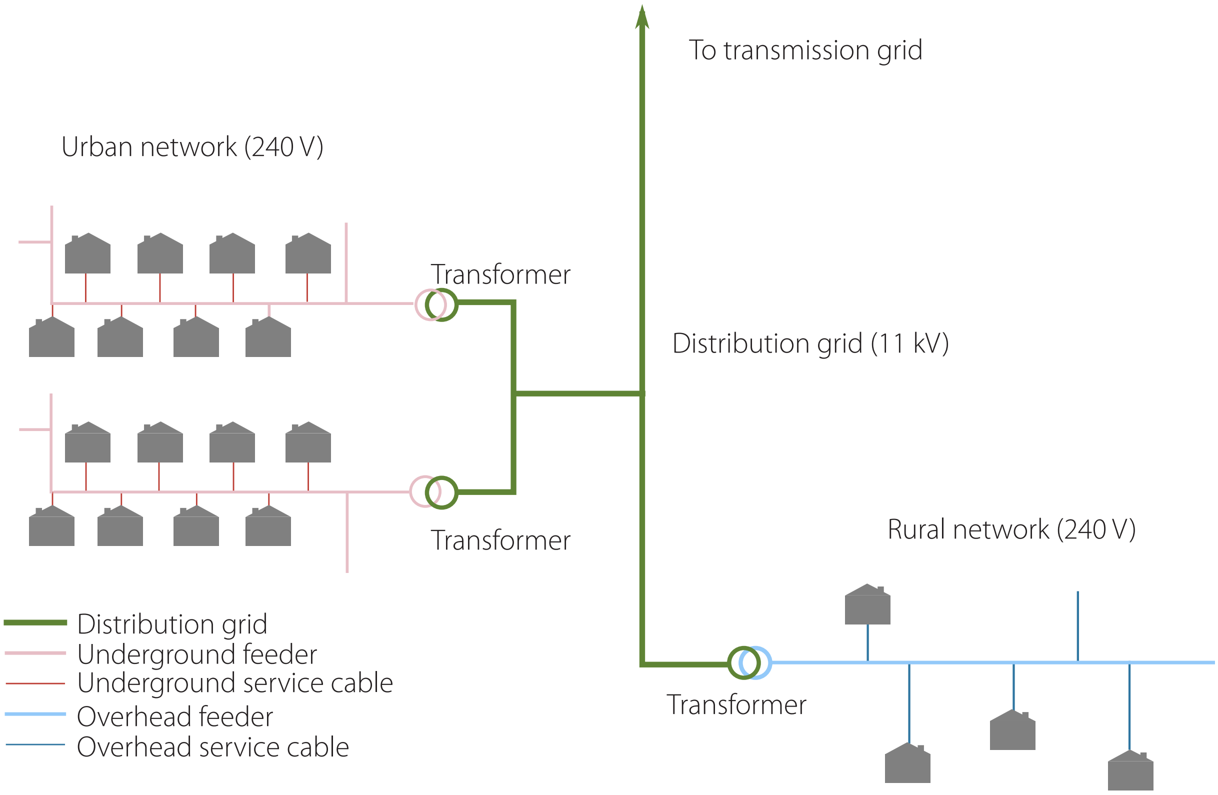

Figure 2: Getting electricity to homes

thought through. The meters that are currently being installed have a single contactor, which switches the supply to the house on and off. They are primarily aimed at allowing suppliers to remotely record consumption and switch off customers who do not pay their bills.

When the smart meter hype began, it was insinuated that these remote readings would enable the local power company to 'manage' the load in a 'smart' way; in other words that they could also be able to switch off households should the distribution transformer be in danger of overload. However, the implications of doing so would be disturbing. It would be quite unacceptable and unsafe to switch off entire households, say at 5 pm when the family are cooking over a hot stove, and particularly to do so on a regular basis. While other loads – washing machines, tumble dryers, car chargers and heat pumps – might be less critical, to enable them to be switched off while leaving critical systems like lighting with a supply, the smart meter would need at least two contactors. So the options for homeowners are:

- upgrade the smart meter to a two-contactor model
- fit a separate circuit for non-critical equipment, with its own smart meter.

The first option may well be cheaper, since the second would also require installation of a new distribution box. In essence though, there will need to be a repeat spend on 28 million replacement smart meters, so another £15 billion – perhaps £500 per household – will need to be found.

This is not the end of the story though. At present there is no equipment installed between the distribution transformer and the home that could control the process of switching off a home or homes. It would therefore be necessary to install control systems on each feeder circuit. These would need to connect with the smart meters in all the houses, to read how much current each was drawing and, equally importantly, on which phase of the three-phase supply. It would then be able to reduce demand as required, keeping the phases balanced and preventing overload of the transformer. The formulation of the algorithm to determine which householder will be cut off will be a knotty problem though. Who will decide which householder deserves priority?

In summary, the costs and inconveniences – and therefore the political ramifications – of utilising a demand-management approach appear to be significant. It seems more likely, therefore, that the distribution system will be upgraded.

Upgrading the wiring

Both the service cables and the feeder circuits themselves would need to be upgraded. There are a number of factors that make this process far from straightforward. Not least of these is the fact that many cables are very old. In Leeds, cables installed in the late 1890s – paper-insulated and bitumen-coated – are still in use.

Service cables

When a service cable is installed on new-build housing, the joint to the feeder circuit is relatively straightforward and therefore cheap (around £250). However, a joint to an old cable is not so simple, and the cost is likely to be double.

In rural areas, the cost of the heavier cabling and the installation are the main expense. These might amount to another £250, so the total cost might be £600 per home.[18] But in urban areas, the homeowner will have to pay to dig a trench and maybe install a duct for the new cable. Even a short run is likely to cost £2,500 per house, and if the work involves digging up an expensive front drive it could be considerably more.

It is important to realise that when the first household installs a heat pump or fast EV charger, the upgrade of the service cable is the only external work that will need to be performed. The extra load from this one house will be within the limits of feeder circuits, which have headroom to allow them to handle load that fluctuate - the peaks tend to be staggered, just as loads within the house are. However, as more households fall into line with demands for electrification, the load on the feeder circuits will become too great, and the component cables will need to be upgraded too.

Feeder circuits

The problem with higher-capacity cables is that they are bigger and therefore heavier. So when the time comes to upgrade the feeder circuit in rural areas, it may mean that all the poles down a street will have to be replaced with bigger ones. There are typically 20 homes on a feeder circuit. New cables and joints to the service cables are likely to cost £2,000 per pole, so that is a total of £40,000.

But it is also possible that the heavier cables will be too heavy to be carried overhead. In this case, the new cables may have to be trenched. Obviously, in towns and cities, the new cables will need to be trenched too. With 100 metres of trenching on top of the cabling and joints, the cost for a 20-home feeder circuit might come to £60,000 or so.

The cost of all this work might be around £28 billion, or £1250 per household. There will inevitably be problems in persuading householders to part with this money, so it is likely that government would impose a surcharge on bills to cover the cost. Adding to the complexity, and therefore to the cost, is the fact that all the works will need to be done while the existing cabling is in place and in use; people can hardly be expected to live without electricity while the work is completed. This will take weeks in a single road.

Distribution transformer

Finally, it is possible that the distribution transformer will need to be upgraded too. I have not attempted to put a cost on this exercise because transformers have long lifetimes and it is therefore likely that the upgrades would involve a large proportion of repurposing existing transformers.

5. Cost summary

If the take-up of electric cars meets predictions, there could be ten million homes requiring changes to their electrical supply in the next ten years. But in order to achieve full electrification of personal transport and domestic heat, that figure will need to increase, covering all housing apart from flats (which are beyond the scope of this report). As the rise in demand for electricity exceeds the capacity of the cables that supply these homes, the costs of upgrading will also fall to householders, either directly or through surcharges on their bills.

Table 5 summarises the direct costs to householders considered in this paper. The total bill is £410 billion, an average of £15,000 per household.[19] To this must be added the £56 billion cost of upgrading the distribution system (£2000 per household).

Other expenditure will also be necessary. Heat pumps only work in well insulated and draught-proofed spaces, but the cost of retrofitting insulation measures is not considered here. Nor are the expected increases in the cost of electricity, or the cost of replacing thousands of distribution transformers, but these figures will certainly be significant.

Table 5: Summary of costs

	Unit cost (£)	Units (m)	Cost to economy (£bn)
Household wiring upgrades			
Upgrade the smart meter for load control	450	28.0	13
Update switchboards in house for load shedding	2,500	28.0	70
Upgrade incoming fuse to circuit breaker	600	22.4	13
Service cable upgrade – urban	2,500	19.0	48
Service cable upgrade – rural	600	9.0	5
Subtotal			149
External wiring upgrades			
Feeder circuit upgrades	50,000	1.1	56
New equipment			
13A EV charging socket/ earth leakage protection	250	16.8	4
8kW fast charger for electric cars	1,200	11.2	13
Convert from gas boiler to heat pump	10,000	22.4	224
Convert to electric cooker	600	15.7	9
Install electric shower	900	11.2	10
Subtotal			261
Total			466

6. Some practical difficulties

Upgrading the nation's electrics is, to put it bluntly, a can of worms. This section outlines just a few of the practical issues that are going to be encountered.

Where are the cables?

Up to 1990 the distribution supplies were run by engineers from regional offices of the nationalised electricity company. After privatisation, geographical responsibilities ceased – for example, the HydroElectric company, which ran the North of Scotland, took over the company responsible for the Isle of Wight. With the drive to eliminate the 'fat' of the hitherto state-owned companies, area offices were pruned and the staff were made to take retirement or laid off. Record-keeping was not a priority, and so a great deal of information was simply disposed of, including details of the locations of most of the country's buried cables. After all, these had been in place for 90 years and few had given any trouble. It was not obvious why it was worth the expense of keeping information about them: their exact locations, the size and type of cable, the load capability, details of the joints and the service cables supplying each property. A private company exists to make money for its shareholders and survive in a competitive market; it is not there to provide a service to the public (which is what electricity supply should be).

Whose smart meter is it that needs upgrading?

Worse has happened. Ofgem and the Department of Energy, desperate to make the electricity market competitive, licensed 170 new companies to supply and bill customers. Most of these companies had no staff on the ground and so subcontracted important parts of their work, including the installation of smart meters. It is not clear who now owns these meters, and therefore who is responsible for their replacement should we require smart demand management.

Who is on what phase?

The electrical supply in most countries is three-phase AC. This simply means that the cables in the streets have three separate 'live' wires.[20] Before 1990, when new streets and houses were built, a three-phase cable was buried down the street. The wires had different colour insulation on them, – red, yellow or blue – so it was easy to identify the phase of the supply for any given house. Next-door houses would be connected to different phases – in other words to a different one of the three wires. So No 2 would be connected to red, No 4 to yellow, No 6 to blue, and No 8 to red again. This meant that the load on the three phases should be roughly the same. Later EU 'harmonisation' meant that this simple and effective system was thrown away. In more recent cabling, the three live phases are all insulated in brown (with neutral in black and the earth green and yellow). So now it is nearly impossible to identify which phase goes into which house. This will become important as houses install heat pumps (or EV charging points). If No 2 upgrades first there will be no problem. But when it comes to the second house – No 24 say – there is potentially a problem. If EU-compliant cabling is in place, the electricity contractor doing the work will have no idea which phase No 24 is on unless they do some testing. If they do the upgrade without testing and it turns out to be on the same phase as No 2, there will be a serious imbalance across the phases, which could lead to voltage drops in houses further from the transformer. Unfortunately, the only way to do this testing is when there is current in the wires, which is high-risk and will involve the use of staff who have been specially trained to work on live systems.

And another thing...

A related problem arises from a more recent approach to wiring a new neighbourhood. House builders (or their contractors) have found that the cheapest way to wire up a new housing estate is to split the three phases, and run single core cables up a street. In other words, each street is on a single phase. Provided the new estate is divided into three equal groups of houses, that's not a problem. However, that ideal situation is rare in practice. Estates are nowadays normally built with mixed houses, and it is likely that the larger houses will be on a different street to the small ones. As noted above, it is the wealthier households that are going to switch over to heat pumps and EV fast chargers first. This means that there will be a rapid rise in demand on one phase only, unbalancing the load.

7. Who should be looking at these problems?

It is clear that the costs of supporting all the plans the government has for transport and homes is going to be very high, and it is going to be made worse by the fact that the changeover is not being thought through, let alone planned effectively. Part of the problem is that there is no institution or organisation in a suitable position to do so. The distribution companies own the transformers and cables, but may or may not be responsible for the smart meters. They therefore have little interest in some form of smart control. As profit-making companies, they also have no interest in investing for the future load increases, as they can charge for all the upgrading work as it is required and are often able to pass large bills to the consumer.

What about the Wiring Committee? This body, part of the Institute for Engineering and Technology, is responsible for setting standards, but only those that relate to today's requirements. Blue-sky thinking about future needs is beyond their mandate. In fact, they have even been ignored on many current issues, like smart meters, presumably because their advice would not appeal to politicians and others who prefer to think short-term.

Building Standards would seem an obvious way to drive the requirements for the future. But there is a problem. Driven by political priorities, there is a focus on delivering heat pumps and electric vehicles, but not on the dull practicalities of how the electricity required will be generated and delivered to homes. Until that happens, and sensible plans and policies are put in place, it will amount to mere 'greenwash'.

Notes

1. Prices vary across the country and some people, particularly the poorest, often pay more..
2. Gibson C and Aris C. *The Future of GB Electricity Supply: Security, cost and emissions in a net-zero system*. Technical paper 4, Global Warming Policy Foundation.
3. Constable J. A decade of constraint payments. REF blog, 30 December 2019. https://www.ref.org.uk/ref-blog/354-a-decade-of-constraint-payments.
4. Kelly M. *Decarbonising Housing: The Net Zero Fantasy*. Report 38, The Global Warming Policy Foundation.
5. https://www.driving.co.uk/video/charge-rage-watch-heated-row-electric-car-charging-point/
6. DoT. Electric vehicle charging in residential and non-residential buildings. Report, Department of Transport, 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/818810/electric-vehicle-charging-in-residential-and-non-residential-buildings.pdf.
7. DoT, Electric vehicle charging, op. cit.
8. Benoit C. IONITY increases electric vehicle charging prices 500% starting January 31. Electrek website, 17 January 2020.
9. Assuming a 60 kWh battery capacity and 10% charging losses.
10. Gibson C and Aris C. *The Future of GB Electricity Supply. Op. cit.*
11. Transmission 12%, distribution 3%, charging pillar 10%.
12. Kelly M. *Decarbonising Housing. Op. cit.*
13. This is the cost for a GSHP using a borehole. Since most new houses have restricted grounds, this is the only viable option, although it is an expensive one.
14. At least if they are installing ASHPs – they are not required for GSHPs which incorporate the tank as part of the main unit.
15. The main fuse is on the 'wrong' side of the meter, so fixing it involves calling out the electricity company. It is possible that in future, electricity companies will upgrade to circuit breakers, which would allow homeowners to reset the system themselves. However, once a circuit breaker has been tripped a few times, it may need to be replaced anyway. And it is still on the 'wrong' side of the meter, so this approach may prove impractical.
16. Strictly, one should refer to overhead lines and underground cables, but I use cables throughout, for the sake of simplicity.
17. NAO. *Rolling Out Smart Meters.* Report, National Audit Office 2018. https://www.nao.org.uk/wp-content/uploads/2018/11/Rolling-out-smart-meters.pdf.
18. Allow £250–500 for joint, plus £250 for cable.
19. £410 billion and 22.4 million households, the rest of the UK's 28 million homes being flats.
20. Each carries alternating current with the waveforms out of synch by 120°. Cabling for a three-phase supply is cheaper than for a single-phase one.

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The Global Warming Policy Foundation is an all-party and non-party think tank and a registered educational charity which, while openminded on the contested science of global warming, is deeply concerned about the costs and other implications of many of the policies currently being advocated.

Our main focus is to analyse global warming policies and their economic and other implications. Our aim is to provide the most robust and reliable economic analysis and advice. Above all we seek to inform the media, politicians and the public, in a newsworthy way, on the subject in general and on the misinformation to which they are all too frequently being subjected at the present time.

The key to the success of the GWPF is the trust and credibility that we have earned in the eyes of a growing number of policy makers, journalists and the interested public. The GWPF is funded overwhelmingly by voluntary donations from a number of private individuals and charitable trusts. In order to make clear its complete independence, it does not accept gifts from either energy companies or anyone with a significant interest in an energy company.

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