



Electric Vehicles and Batteries Can Drive Growth of Residential Solar

EV and Battery Cost Reductions Important for Encouraging New Demand

Executive Summary

This report assesses the prospects for residential solar, batteries and electric vehicles (EVs) in Britain and Germany. These technologies are expected to be at the centre of global energy system disruption in the future, because of declining costs and their close fit with a global energy system increasingly transitioning towards decarbonisation, decentralisation, digitalisation and democratisation. Strong mutual benefits make these technologies even more disruptive together than in isolation. The potential contribution of battery storage towards the electrification of mobility and heating further increases its relevance and impact.

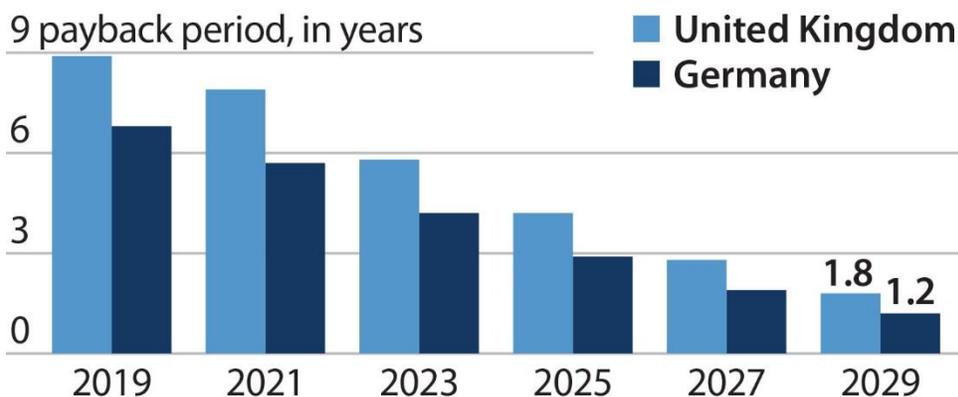
Our focus is on Britain and Germany, as two of the top four solar and EV markets in Europe. As time goes on, we expect to see even bigger opportunities in southern European and emerging economies. Like many European countries, both Britain and Germany are now reducing support for solar power, potentially slowing the transition to renewables. Britain ended all residential solar subsidies as of March 31, 2019 and support is steadily falling in Germany, and could be phased out under present guidelines, in the second half of 2020.

This report looks at opportunities for near-term growth in the residential solar, battery storage and EV markets. We show that batteries and EVs can boost the economics of rooftop solar, by enabling households to use more of the solar power they produce, thereby increasing savings on their electricity bills. These savings rise over time, as the cost of rooftop solar, batteries and EVs falls. In addition, we review how regulators can reform grid services markets, to put these technologies on a level playing field with conventional generation, which further boosts income. While not a focus of this report, we note that smarter domestic tariffs that reward consumers for using off-peak power can further drive demand, as will smarter EV chargers that contribute towards grid stability.

Our analytical approach was to estimate how many years of electricity bill, road fuel and other savings it would take for households to recoup their initial investment on various combinations of solar, batteries and EVs. Such payback periods are a useful measure familiar to households making these investment decisions. The models were developed using actual cost data as provided by a range of solar, battery and EV providers in Britain and Germany. Various cost reduction assumptions were made to calculate the payback periods for new projects through 2030.

Solar + Battery + EV Accelerates Payback Time

As costs fall, payback will be shorter in UK and Germany.



Source: IEEFA

Main Findings

We investigated four themes: the drivers behind adoption of residential solar in Britain and Germany, the extent to which batteries and EVs can add value, the potential for grid services markets to boost adoption, and the impact on adoption of continued cost reductions over the next decade. We summarise our main findings, for various combinations of market standard systems for residential solar (4kW), battery (8kWh, 5kW) and a small EV (35kWh).

- Solar feed-in tariffs and higher retail power prices in Germany result in far shorter payback periods for residential solar systems.** In Britain, the payback period for stand-alone solar is 19 years, compared with six years in Germany. Stand-alone solar in Britain currently has an annual return on investment (ROI) of minus 2.7% compared to 10.3% in Germany. Phasing out feed-in tariffs in Germany would double present payback periods to 12 years (ROI 1.5%). After removing solar feed-in tariffs and export income, Britain is now also poised to scrap reduced VAT for solar and battery installations. Such a move would increase the upfront cost of solar installations by 14%; add more than a year to payback periods (to above 20 years); and lower ROI further to minus 3%.
- Smart devices almost halve solar payback periods in Britain,** to 10 years. Such devices, produced by the likes of Smappee and Tiko, can intelligently operate large controllable loads, such as electric heat pumps (where available), to coincide with daytime solar generation. In this way, they increase energy bill savings. They also cut solar payback periods in Germany.
- Adding an EV and/or battery system reduces solar payback periods in Britain.** EVs in Britain generate net annual savings of around £700 compared with an equivalent conventional vehicle, paying off the upfront price premium in less than six years and generating a positive ROI of 4%. In Germany, EVs have a

longer payback period because of higher power prices and lower road tax savings. By providing a new outlet for residential solar generation, EVs increase self-consumption and enhance bill savings. A combined solar-battery-EV system in Britain today has a payback period of nine years and an ROI of 0.9%; in Germany it is seven years with an ROI of 6.4%.

4. **Solar-battery-EV systems presently compete on an unlevel playing field in grid services markets.** These markets offer incentives for electricity generation and storage that can help balance network demand and supply in real time. At present, they unfairly benefit large, conventional power plants, for example through codes which make it costly to certify small energy assets. In Britain, some battery providers, such as Moixa and Powervault, give households a small income annually in return for permission to access their batteries for the sale of aggregated grid management services. We assume this income is presently £25/kW battery power/year. Doubling it reduces the solar plus battery payback period to 12 years, from 14 years. In this report, we assume zero grid-services income for management of EV batteries. In reality, EVs are likely to become an important or even critical source of grid stability over the next decade, as a massive, and largely idle, grid-connected energy source.
5. **Combined solar-battery-EV systems could quickly become an obvious choice for households with available roof-space and EV home-charging if our cost reduction assumptions bear out.** By 2025, in Britain, a solar-battery-EV system will have a four-year payback period, falling to one year in 2030. Similarly, in Germany, the same combined system has a three-year payback in 2025, falling to below one year in 2030. In Britain, we conservatively assume no policy change to the export tariff, keeping residential solar power unrewarded through 2030. Systems would become even more attractive under seemingly no-brainer regulatory reform that allows households to sell their solar power at wholesale power market prices, and by doubling today's grid services income.

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Introduction

This report investigates how small-scale solar PV, batteries and EVs in combination can add value and drive mutual growth. We see these technologies as having strong complementarity, given expected cost reductions; a close fit with energy sector trends of decarbonisation, decentralisation, digitalisation and democratisation; and with energy and climate policy prioritising electrification of transport and heating.¹ Integration of the electricity, transport and heating sectors is expected to help achieve energy system decarbonisation affordably, while preserving reliability and adequacy.

We also seek to understand how regulatory changes can boost growth in solar, batteries and EVs by increasing access to grid services markets. These markets help network operators balance electricity demand and supply and maintain grid stability, and today are typically restricted to conventional power plants.

We assess the potential for solar, batteries and EVs, focusing on Britain and Germany.

However, we expect the trends discussed here to apply equally or more in sunnier countries in southern Europe and beyond. Historically, solar power has proved popular in both Britain and Germany, as a result of feed-in tariffs that provided a guaranteed price premium over a certain contract length, typically 10 to 20 years. These subsidies were intended to foster a low-carbon transition, and to provide a return on investment for households. Solar feed-in tariffs are now being withdrawn, however, threatening such growth. In Britain, all support for solar power ended as of end-March 2019. That support has not been replaced, which means that, at present, new projects will earn zero income from electricity generation and grid exports.

**In Britain and Germany,
solar feed-in tariffs are
now being withdrawn,
threatening growth
in the sector.**

In Germany, the feed-in of electricity from solar power into the public grid is still subsidised. However, this tariff is falling over time, linked with rising installed capacity. Present legislation requires grid operators to end feed-in tariffs for new rooftop installations, once total installed capacity reaches 52 gigawatts (GW).² At present installation rates, that point might be reached in the second half of 2020.³

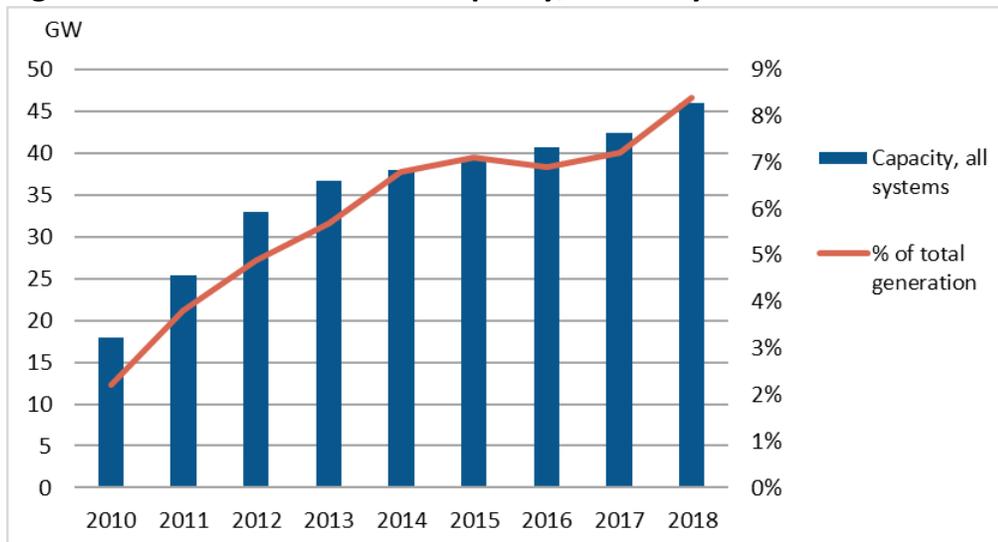
¹ European Parliament, 2018. [Sector Coupling: How can it be enhanced in the EU to foster grid stability and decarbonise?](#)

² Buzer.de. [Gesetz für den Ausbau erneuerbarer Energien](#) (Erneuerbare-Energien-Gesetz - EEG 2017).

³ PV Magazine, 2019. [Verbände-Allianz fordert Abschaffung des Photovoltaik-Förderdeckels](#). February 27, 2019

Regarding solar PV growth to date, Germany and Britain rank in the top four by cumulative capacity in Europe. As of end-2018, Germany had 45.4GW cumulative installed solar PV capacity, and 1.7 million PV systems.⁴ Small-scale rooftop installations, below 10kW capacity, accounted for 59% of solar installations by number in 2017.⁵ Solar PV in total accounted for 8.4% of all electricity generation in Germany last year.⁶ As of end-2018, Britain had 13GW cumulative installed solar PV capacity, across 976,000 systems, according to the Department for Business, Energy and Industrial Strategy (BEIS).⁷ Small-scale installations, below 10kW capacity, accounted for 97% of these installations by number. Solar PV accounted for 4% of total electricity generation in Britain last year.⁸

Figure 1: Cumulative Solar PV Capacity, Germany



Source: Energy Charts, based on data from AGEE, BMWi, Bundesnetzagentur, German TSOs, Destatis and EEX.

⁴ Fraunhofer Institute, 2019. [Photovoltaics Report](#).

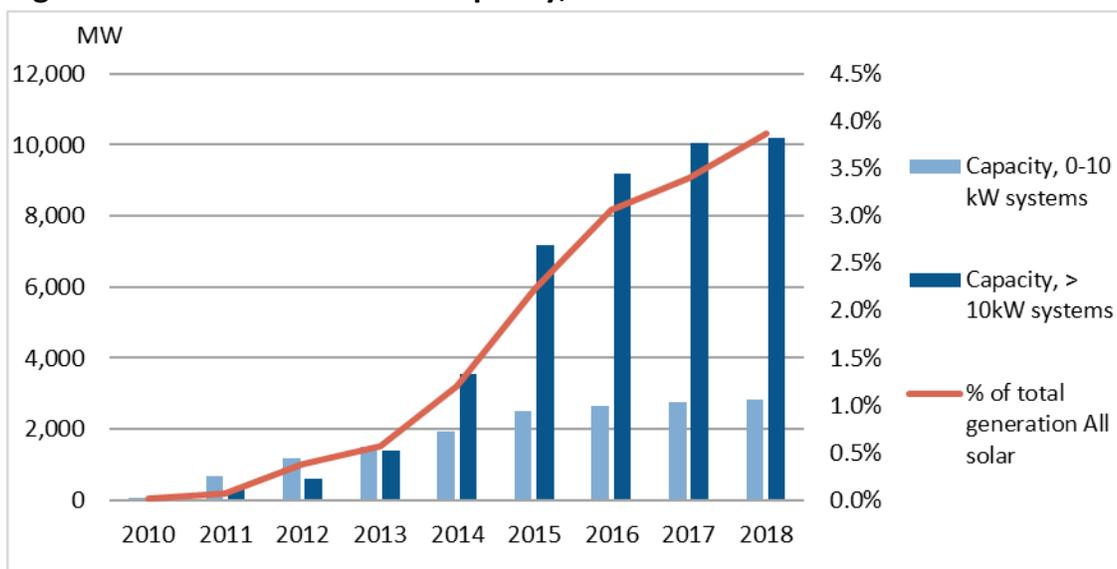
⁵ Fraunhofer, 2019. [Aktuelle Fakten zur Photovoltaik in Deutschland](#), p. 31.

⁶ Fraunhofer Institut für Solare Energiesysteme (Fraunhofer ISE), 2019. [Öffentliche Nettostromerzeugung in Deutschland im Jahr 2018](#), p. 12.

⁷ BEIS, 2019. [Solar Photovoltaics Deployment, 2019](#).

⁸ BEIS, 2019. [Energy Trends: renewables](#).

Figure 2: Cumulative Solar PV Capacity, Britain



Source: Department for Business, Energy and Industrial Strategy (BEIS).

Looking at small-scale battery storage, German consumer data company Finanztip estimates that some 120,000 households and commercial enterprises had installed batteries alongside PV systems, as of February 2019.⁹ The German government agency, Germany Trade and Invest (GTAI) sees a growing business case, and a potential annual market of 50,000 PV-battery systems by 2020.¹⁰ Britain lags in small-scale residential battery storage, with no central database recording installations to date.

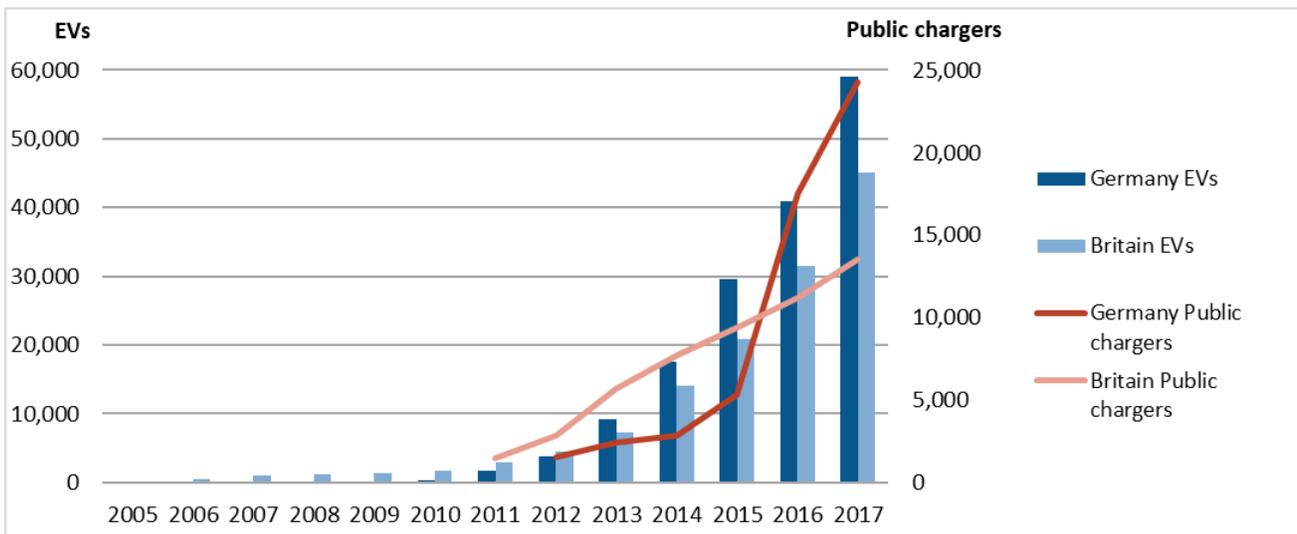
As for battery EVs, excluding plug-in hybrids, both Britain and Germany rank among the top seven markets globally, and top four in Europe, according to the latest data from the International Energy Agency.¹¹ The IEA estimates that Germany and Britain saw 25,070 and 13,550 new EV registrations in 2017, with a market share of 0.7% and 0.5% respectively. The IEA also charts growth in EV chargers, finding Germany and Britain again among the top seven countries worldwide for cumulative installed chargers, as of the end of 2017. The IEA estimated that Germany had 24,289 publicly accessible chargers, and Britain some 13,534.

⁹ Finanztip, 2019: [Sonnenstrom im Akku speichern](#).

¹⁰ GTAI, 2018. [The Energy Storage market in Germany](#).

¹¹ IEA 2018, [Global EV Outlook 2018](#).

Figure 3: Cumulative EVs and Public Chargers, Germany and Britain



Source: IEA.

Our Approach

Our analytical approach was to estimate how many years it would take for various energy bill savings to recoup the initial investment on various combinations of solar, batteries and EVs, as well as to calculate an initial annualised return on investment (ROI). The models were developed using actual cost data as provided by a range of solar, battery and EV providers in Britain and Germany. We made various cost reduction assumptions to calculate the payback periods for new projects through 2030.

We see four key factors affecting revenues for residential solar, batteries and EVs, in combination or isolation. These are: energy bill savings, financial support, access to grid services markets, and cost reductions. The modelling assumptions for each factor are described in the section that follows.

Savings on Energy Bills

In the case of solar and batteries, energy bill savings are generated by substituting grid electricity with solar power, and in the case of EVs, by avoiding gasoline or diesel fuel purchases. Savings will increase, the higher the domestic energy prices.

- In terms of electricity bill savings, a key measure is the solar self-consumption rate. The higher the self-consumption rate, the more solar generation is being used by the household instead of being exported to the grid, and the greater the energy bill savings. Smart devices can increase the self-consumption rate by intelligently switching on controllable appliances during the daytime, when solar is available. We assume that stand-alone solar has a self-consumption rate

of 30%, and that such smart devices double this to 60% (but we note these only apply to households with large controllable loads, such as electric heat pumps). By allowing use of solar generation after sunset, batteries can increase the solar self-consumption rate up to 100%, depending on the relative size of the battery and rooftop solar system. We do not take account of seasonality in this report. Seasonality complicates the task of optimising the size of the battery and solar PV system, since the battery may be too small and solar PV system too large in winter and vice versa in summer. In general, the economics are slightly poorer if we take into account seasonality, because either self-consumption rates are lower in summer, or the battery is over-sized in winter. The latter problem can be mitigated by exploiting time-of-use tariffs to use spare battery capacity to arbitrage between winter peak and off-peak power prices.

By allowing use of solar generation after sunset, batteries can increase the solar self-consumption rate up to 100%.

- Another key metric in electricity bill savings is total consumption as the ceiling on potential savings: the higher the annual consumption, the greater the potential energy bill savings from investing in solar and batteries. EVs can help drive solar and battery adoption partly for this reason, by increasing domestic power use. We use national averages for domestic electricity use in Britain and Germany (3,100 and 3,400 kilowatt-hours [kWh] respectively). We assume annual EV travel of 15,000 kilometres, and EV efficiency of 0.15kWh per kilometre.
- We make various other assumptions relevant to energy savings, such as residential electricity tariffs and tariff inflation (German tariffs are almost double those in Britain, at 32 euro cents per kWh compared with 15 pence); and gasoline prices and fuel price inflation (see Appendix).

Government-backed Financial Support

Government support for solar, batteries and EVs includes solar feed-in tariffs, EV capital grants and reduced value added tax (VAT). Support is falling as these technologies become more competitive.

- Traditionally, rooftop solar was supported both in Britain and Germany with feed-in tariffs (FiT), which guaranteed a certain price per unit of exports to the grid (in Germany, presently around 12 euro cents per kWh), or per unit of both generation and grid exports (formerly in Britain, around 3 pence per kWh, or just 20% of the retail power price). Britain has now scrapped even this support, meaning new solar systems earn zero income from either generation or grid

exports, unless households or their aggregators can negotiate private contracts with electricity suppliers. The UK energy regulator, Ofgem, is now considering a “smart export guarantee”, where utilities would offer to buy this solar power.¹² It is unclear how much such a scheme might offer, or when it would come into force, and it is, therefore, excluded from this report. In Germany, we find solar income at present is divided equally between the FiT and electricity bill savings, underlining the impact of scrapping the FiT altogether, as in Britain. At present, in Germany, the solar rooftop FiT is due to be phased out when installed solar capacity reaches 52GW, a level expected to be reached in the second half of 2020. That may change, under pressure from various political parties. In this report, we assume that the FiT in Germany falls in a straight line from 12 euro cents per kWh in 2019 to 4 euro cents in 2030.

Britain has now scrapped rooftop solar support, meaning new systems earn zero income from either generation or grid exports.

- Other financial support for solar power includes reduced VAT on capital expenditure, at 5% versus the standard 20% in Britain, and at 0% versus 19% in Germany (provided that in Germany the installer instead pays full VAT on self-consumed solar power for the first five years). In both Britain and Germany, these VAT exemptions only apply to batteries if they are installed with solar panels, rather than retrofitted at a later date.¹³ We assume 20% VAT on batteries in Britain, as batteries are often installed after the solar panels. We note that Britain plans to scrap the reduced VAT rate, but in our base case we continue to assume 5% VAT for solar, as this change is not enacted yet.
- In both Britain and Germany, EVs qualify for zero road tax, and a capital grant at purchase. In our analysis, we compare the VW e-Golf with the conventional Golf 1.5, two vehicles with similar power. In Britain, the e-Golf avoids annual road tax of £160, and in Germany a tax of €62. In Britain, the capital grant is worth £3,500; it is €4,000 in Germany. We assume the grant is phased out from 2021, as seems in line with present plans in Germany.¹⁴

Access to Grid Services Markets

Aggregators can package multiple small-scale solar and battery systems, to sell various energy services to grid operators to maintain security of supply, including to

¹² BEIS, 2019. [Consultation on Smart Export Guarantee Scheme: Impact Assessment](#).

¹³ Finanztip, 2019. [Sonnenstrom im Akku speichern](#).

¹⁴ Reuters, 2019. [German ministry wants to extend electric car subsidies: document](#).

balance demand and supply. These markets remain heavily tilted in favour of conventional power plants, with regulatory change required to give small-scale applications equal access.

- At present, grid services markets are in their infancy for small-scale generation. For example, in Britain, participation in balancing markets still requires aggregators to certify individual battery assets, even if these number in the thousands, when there are alternative options for ensuring they deliver. Other markets are still exclusively open only to large generators, such as black-start services (to cover large power outages without outside transmission network support). In Germany, primary energy markets that reward fast-response assets only recently opened to aggregators. One of the largest battery aggregators, Sonnen, passed a 1MW availability test in December 2018.¹⁵ Local energy markets that reward distributed assets including residential batteries are expected to become increasingly prevalent under new market rules introduced by the EU's recent "Clean Energy Package." One change will make local grid operators responsible for managing the low-voltage network more cost-effectively, which may motivate these firms to contract flexible generation and battery storage rather than to build out grid infrastructure. How and when network operators implement market reform is uncertain, however.
- Already, some battery operators, such as Sonnen in Germany and Moixa and Powervault in Britain, reward customers for making their batteries available for aggregated grid services, as they seek to build a customer base. Based on this income, in this report we assume household grid services income of £25/kW battery power/year in Britain. In Germany, we base grid services income on actual income in primary reserve energy markets, at €115/kW/year, and assume half this would be made available to the household, i.e. €58/kW/year.¹⁶
- In this report, we assume zero grid services income for EVs, because of the lack of clarity over how and when such services will be remunerated. In reality, EVs could become the backbone of grid balancing and stability in the 2020s, as a massive, grid-connected, distributed electrical resource which is idle most of the time. At present, extremely few EV chargers are bidirectional, where batteries can equally charge from or discharge to the grid. To optimise EV assets, governments will have to mandate bidirectional chargers in the near future. Payment for grid services by EVs could significantly boost the economics of the EVs, solar and batteries considered in this report, and accelerate wider adoption.

Cost Reductions

- We use various published market prices for solar, optimisers, batteries and EVs in 2019 (see Appendix for full details).

¹⁵ <https://sonnengroup.com/households-replacing-power-stations-germany-sonnen-putting-largest-virtual-battery-its-kind/>

¹⁶ <https://www.regelleistung.net/ext/tender/>

- a. Solar PV: we assume wholesale module prices of 30 pence per watt (25 euro cents in Germany); developer margins of 15%; balance of system (BoS) costs of 40p/W (30 cents); labour costs at 25% (Germany: 30%) of full installed cost; and annual solar operational expenditure at £50 (€50).
 - b. Solar consumption optimisers: capital cost of £300 each (€300) before VAT.
 - c. Stationary batteries, in Britain, are assumed at a cost of £355/kWh for an 8 kWh battery, based on a range of installer estimates (Germany: €428/kWh, based on published LG Chem estimates¹⁷); developer margins of 15%; fixed BoS costs of £1,000 (€1,000); and labour costs at 20% of full installed cost.
 - d. EVs: battery pack costs of £150/kWh (€150), and an e-Golf price premium of £1,500 over the conventional Golf 1.5, excluding the cost of the battery pack.
- We then apply annual reductions to these numbers, from 2020 to 2030, to take into account expected improvements in technology and manufacturing economies of scale. Our cost reduction assumptions include: solar modules @ minus 10% annually; solar BoS -5%; stationary batteries -15%; battery BoS -5%; solar and battery developer margins -5%; EV battery pack -10%; and EV price premiums -£400 (-€400).

Our Method

For calculating the payback period, we calculate the number of years it takes for total cumulative income to pay off upfront and cumulative costs, using Excel “What-if Analysis.” Costs include capital cost, debt financing and operational costs. For the financing cost, we assume the EV is 100% debt-funded and other systems (solar, battery, optimiser) are 50% debt-funded, where the cost of debt is 3.6%-4% and cost of equity is zero. Income includes government-backed financial support and energy bill savings as described in the previous sections.

For calculation of ROI, we divide initial net annual income by the upfront capex. Net income includes the variables as described above, such as financial support plus energy bill savings (year 1) minus costs including operational costs, financing costs and depreciation over seven to 20 years (see Appendix). Upfront capex includes full installed cost of the installation or EV, including VAT.

Findings

While our modelling, in theory, allows us to analyse any combination of any size of solar system, battery and EV, for the sake of brevity, we selected what we consider

¹⁷ <https://www.dp-solar-shop.de/Speichersysteme/batteriesysteme/lg-pv-speicher/lg-resu-10-48v-lithium-ionen-speicher.html?refID=04>

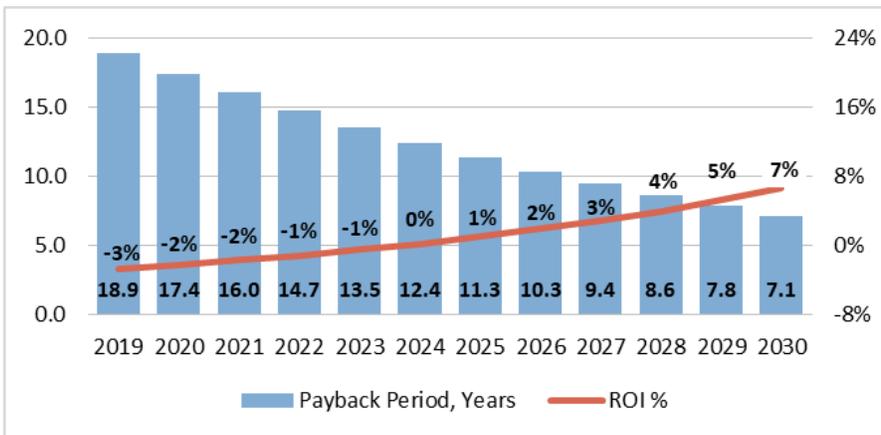
to be “typical” installations. These typical systems were 4kW rooftop solar, 8kWh (5kW) battery, and a small 35kWh EV. We calculated the payback period and ROI for these systems in isolation and in various combinations. We also considered a smart solar optimiser that doubles the solar self-consumption rate by allocating solar generation to controllable daytime loads.

Stand-alone Solar

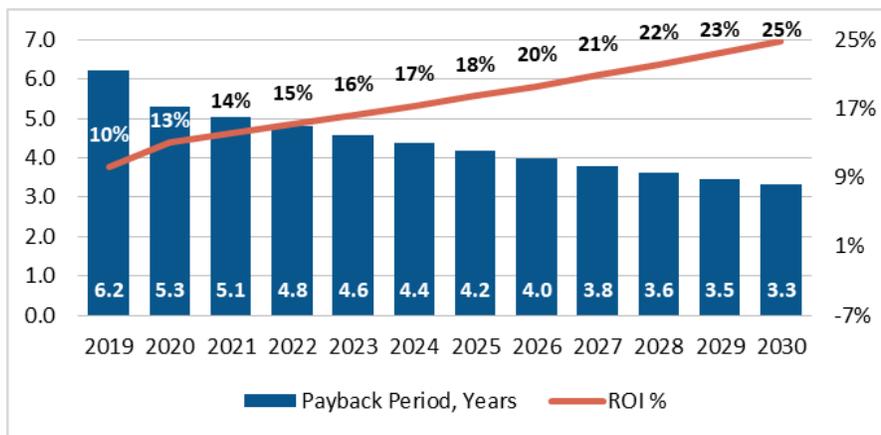
We find stand-alone solar presently has a payback period of 19 years in Britain, and an ROI of -2.7%. Because of solar export tariffs and higher domestic energy bills, stand-alone solar is far more attractive in Germany, with a six-year payback and an ROI of 10%. Assuming no policy change through 2030, stand-alone solar will remain less attractive in Britain than it is in Germany, today.

Figure 4: Stand-alone Solar Payback Period and ROI

Britain



Germany

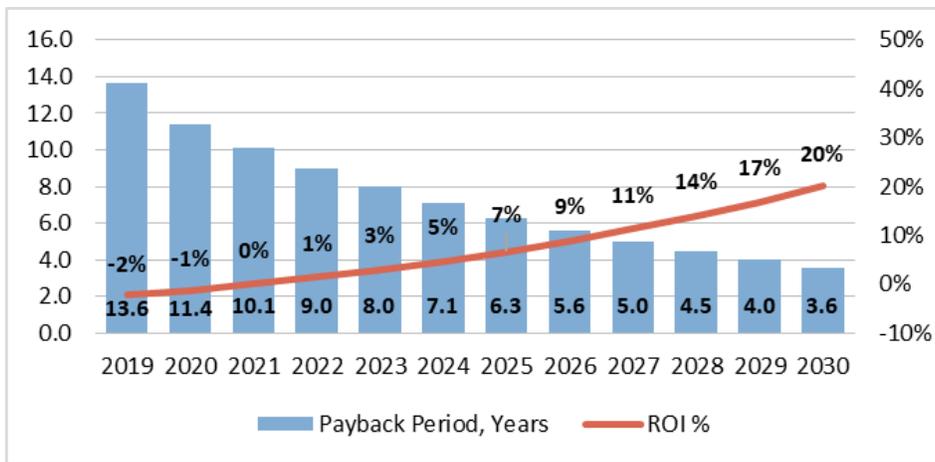


Solar Plus Battery

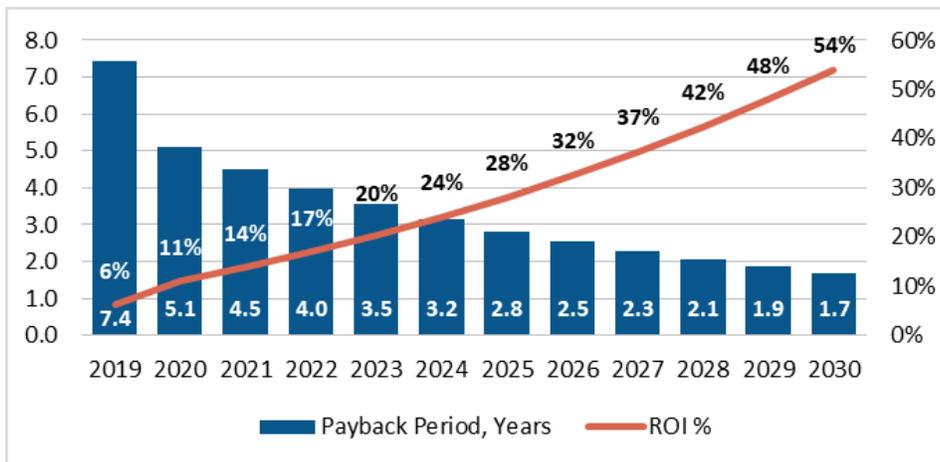
Because of the disadvantages for solar in Britain (zero grid export revenues, lower residential power prices), solar plus battery systems only become attractive around 2025 (six-year payback, 7% ROI), and increasingly thereafter with further solar module cost deflation. In Germany, solar plus batteries become increasingly attractive from the early 2020s, when payback periods fall below five years, and ROI reaches double digits.

Figure 5: Solar Plus Battery Payback Period and ROI

Britain



Germany



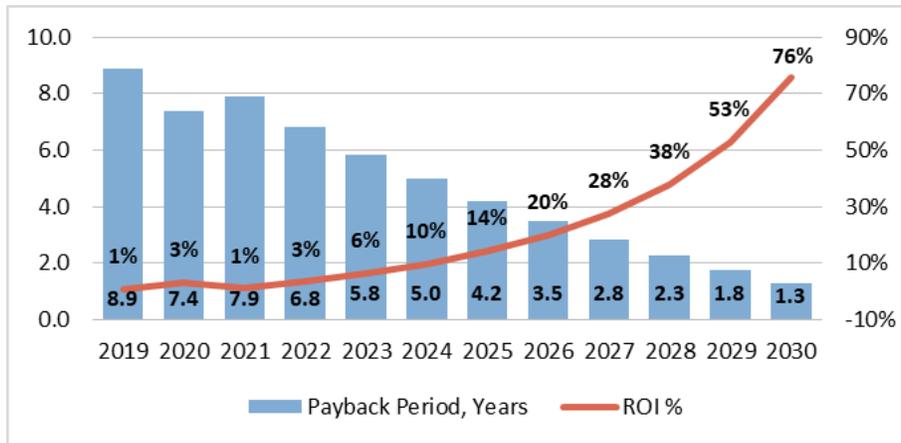
Solar Plus Battery Plus EV

In Britain, EVs already boost the economics of solar and batteries, because they deliver cost savings compared with conventional vehicles, and so have a low payback period compared with solar on its own. By 2025, we find a combined solar-battery-EV system in Britain has a payback period of four years, falling further to

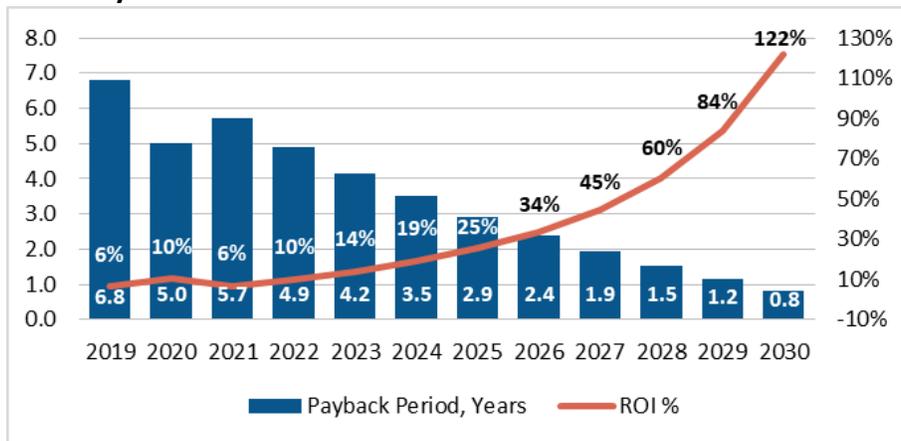
one year in 2030. Similarly, in Germany, by 2025 a combined solar-battery-EV system appears a no-brainer, with payback periods falling below three years, and below one year by 2030.

Figure 6: Solar-Battery-EV Payback Period and ROI

Britain



Germany



Conclusions

We conclude that EVs will be an increasingly potent driver of change in home energy systems and wider electric grids over the next five to 10 years, supporting the societal shift from electricity consumption to more active “prosumption.” EVs, solar and batteries fit well together, because home-charging of EVs provides a new source of domestic demand for rooftop solar and batteries, to self-generate and store electricity, and thereby reduce energy bills. While our focus was on Britain and Germany, as two forward-looking countries that have advanced growth in these fields, we expect the benefits of integrating residential solar, battery storage and EVs to follow in sunnier countries, including in southern Europe and beyond.

EVs are already relatively low-cost, with a payback period of six years in Britain (Germany: 9 years, because of higher power prices, and lower road tax savings), and a positive ROI of 4% annually (Germany: 0%). The annual cost of driving an EV in Britain is barely one-third of the cost of a conventional internal combustion engine (Germany: two-thirds), which means that as the EV price premium disappears altogether through the 2020s, they are likely to become the investment of choice for transportation. For households with off-street parking and south-facing roof space, EVs could provide an important new source of demand for rooftop solar and battery storage. Cost reductions from each technology can drive bigger cost reductions in combination. Already in Britain, adding an EV reduces the payback period for solar or solar-plus-battery. By 2025, payback periods for combined solar-battery-EV systems may fall to levels low enough to accelerate more rapid adoption of all three technologies.

Both countries should continue to support the further rollout of EV chargers, which are vital to encourage adoption.

Such an energy transition will benefit not only private households with capital, power supplies and off-street parking, but also society at large. The wider public benefits of private investment in solar-battery-EV systems include the decarbonisation of road transport, reduced fossil fuel imports, cleaner air, and reduced grid upgrades by utilities and network operators whose costs are typically passed on to all energy consumers.

It makes sense for regulators to accelerate adoption of small-scale solar generation and battery storage by allowing these resources to compete on a level playing field with conventional technologies. In Britain, that includes introducing new market rules that pay households for exporting solar power to the grid, at least at wholesale power market rates. In both Britain and Germany, it will also entail improving access for residential energy systems to grid services markets, for example via virtual aggregation of batteries. Both countries should continue to support the further rollout of EV chargers, which are vital to encourage adoption. That will include bidirectional chargers, which at present are almost non-existent, and are vital to help EVs contribute to grid stability, by both charging from and discharging to the grid, as required by electricity network operators.

Appendix

Our basic input assumptions, for modelling of ROI and payback periods in Britain and Germany follow.

INPUT VARIABLES (2019)		Britain		Germany	
HOUSEHOLD		Units	Value	Units	Value
	Annual power consumption excl EV	kWh	3,100	kWh	3,400
	Domestic tariff inflation	%	6.92%	%	4.50%
	Domestic tariff	£/kWh	0.156	€/kWh	0.320
	RPI inflation	%	2.97%	%	2.00%
SOLAR PV					
	Capacity	kWp	4	kWp	4
	Average load factor	%	10.8%	%	10.8%
	Self-consumption rate	%	30%	%	30%
	PV Module cost, annual change	%	-10%	%	-10%
	PV Module cost	£/watt	0.30	€/watt	0.25
	BoS materials cost, annual change	%	-5.0%	%	-5.0%
	BoS materials cost	£/watt	0.40	€/watt	0.30
	Labour cost (% of total materials cost)	%	25%	%	30%
	Opex (incl. any insurance & contingency)	£/ year	-50.00	€/ year	-50.00
	VAT	%	5%	%	0%
	Solar degradation rate	%	-0.40%	%	-0.40%
	Solar generation FiT	£/kWh	0.00	€/kWh	0.00
	Solar export FiT	£/kWh	0.00	€/kWh	0.12
	Solar export FiT annual change	£/kWh	0.00	€/kWh	-0.01
	Depreciation period	# years	20.00	# years	20.00
SMART OPTIMISER					
	Price, excl VAT	£	300.00	€	300.00
	VAT	%	5.00%	%	0%
	Depreciation period	# years	15.00	# years	15.00
BATTERY					
	Battery system, rated capacity	kWh	8	kWh	8
	Battery system, rated discharge power	kW	5	kW	5
	Battery system efficiency rate	%	98%	%	98%
	Battery system inverter loss impact	%	96%	%	96%
	Battery depth of discharge	%	90%	%	90%
	Battery cost, annual change	%	-15%	%	-15%
	Battery cost	£/kWh	355.00	€/kWh	427.50
	BoS materials cost, annual change	%	-5%	%	-5%
	BoS materials cost	£	1000	€	1000
	Labour, year 1 cost (% of battery system cost)	%	20%	%	20%
	VAT	%	20%	%	0%
	Grid share income	£/kW battery	25.00	€/kWh battery capacity	58.00
	Depreciation period	# years	10.00	# years	10.00
SOLAR + BATTERY					
	Developer margin, annual change	%	-5%	%	-5%
	Developer margin	%	15%	%	15%
	% debt funded	%	50%	%	50%
	Cost of debt	%	4%	%	2.75%
	Cost of equity	%	0%	%	0%
	WACC	%	2.00%	%	1.38%
	Borrowing term	# years	3.00	# years	3.00
	VAT charged on self-consumption	%	0%	%	19%

INPUT VARIABLES (2019)		Britain		Germany	
EV		Units	Value	Units	Value
	Battery system, rated capacity	kWh	35.8	kWh	35.8
	Battery cost, annual change	%	-10%	%	-10%
	Battery cost	£/kWh	150	€/kWh	150
	VW e-Golf price premium, annual reduction	£	400	€	400
	VW e-Golf price premium excl battery pack	£	£1,500	€	1,500 €
	EV subsidy, annual change	%	-10%	%	-10%
	EV subsidy	£	-£3,500	€	-4,000 €
	Annual mileage	km/ year	15,000	km/ year	15,000
	Conventional veh efficiency, annual change		-2%		-2%
	Conventional vehicle efficiency	litres/km	0.048	litres/km	0.048
	Conventional fuel price	£/litre	£1.20	€/litre	1.36 €
	Annual conventional fuel savings	£/ year	£864.00	€/ year	979.20 €
	Annual road tax, annual change	%	2.97%	%	4.81%
	Annual road tax, Golf 1.5	£/ year	£160.00	€/ year	62.00 €
	EV efficiency, annual change	%	-5%	%	-5%
	EV efficiency	kWh/km	0.15	kWh/km	0.15
	WACC - EV	%	3.60%	%	3.60%
	Borrowing term - EV	# years	3.00	# years	1.99
	Depreciation period	# years	7.00	# years	7.00

About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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