Decarbonising Residential Homes in the UK: Synergy Benefits of PV, EVs and Work-From-Home

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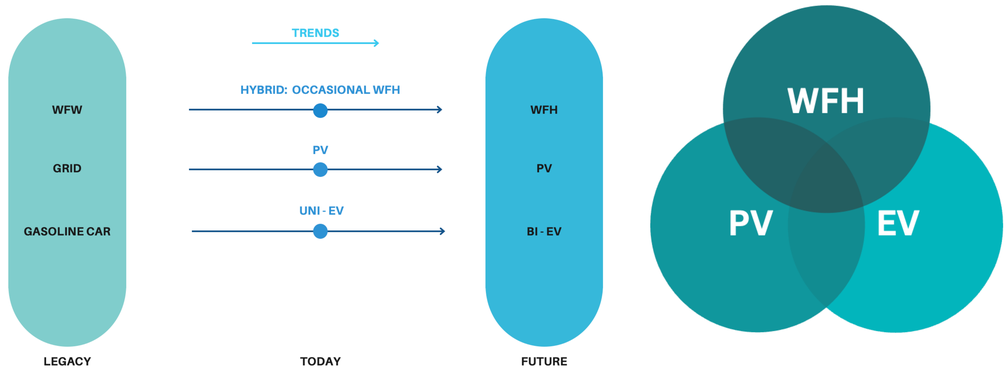
Motivation

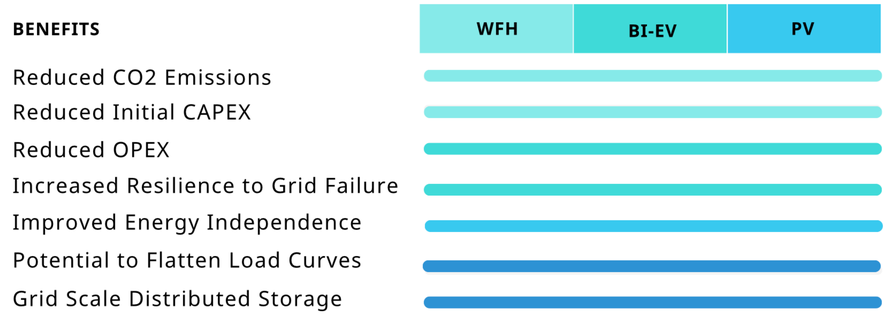
- Hypothesis: synergy benefits between PV, EV, WFH. If all three are present, home energy systems become cheaper and more efficient.
- Synergies between WFH, PV and EVs should be encouraged by policy makers.

Background

- **Solar PV:** UK solar capacity reached 15.6 GW in 2023, with ~ **5GW of rooftop solar**, government target: 70 GW solar capacity by 2035.
- **EVs**: **17.7%** of all new car registrations were **electric cars** in February 2024. Bidirectional charging is in its early development stages. UK government: address barriers to V2X by 2025 through the Vehicle-to-X Innovation Programme.
- **WFH**: In 2023, average British worker worked from home for **1.5 days** and wanted **to increase WFH ratio to 2.5** days.

Synergies: PV + EV + WFH





Method & Experiments

We have built two tools to simulate the optimal sizing and operation of residential grid-connected microgrids.
We consider single-family homes with solar PV, stationary storage, EVs offering bidirectional charging and homeowners who would consider working from home.

- **SOPEVS**: Sizing and Operation of PV-EV-Integrated Modern Homes (Berkes et. al, 2024, ACM e-Energy).
- **SPAGHETTI**: a synthetic data generator for post-Covid electric vehicle usage (Berkes et. al, 2024, Energy Informatics).
- Three major UK single-family house archetypes: 27% of the buildings are **Terraced** houses, 25% are **Semi-Detached** houses and 18% are **Detached** Houses.
- 100 load profiles for each archetype are generated with the **Faraday** foundation model from the Centre for Net Zero. The worst case and best case solar profiles correspond to Lerwick and Weymouth respectively.
- Fixed PV capacity of 4 kW and EV battery capacity of 60 kWh.

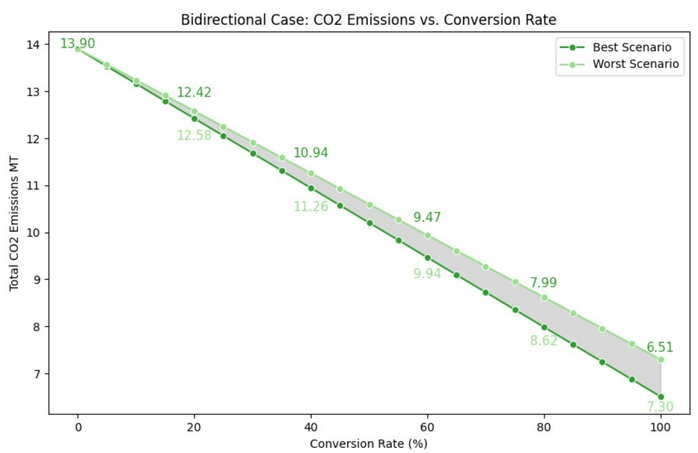
Results

Aggregated UK level:

- **Unidirectional** EVs + PV + WFH : if **60%** conversion, **- 1.25 Mega Tonnes CO_2** yearly.
- **Bidirectional** EVs + PV + WFH : if **60%** conversion, **- 4.5 Mega Tonnes CO_2** yearly.

Individual houses:

- **OPEX**: can be reduced by more than - **60%** if all PV + bi-EV + WFH are implemented.
- **CO2 emissions**: can be reduced by more than - **60%** if all PV + bi-EV + WFH.
  - 23% emissions if **only bi-EV + PV** and **- 16 %** emissions if only **WFH + PV**.
- **Grid independence**: **11 % – 15 %** across WFH frequencies and archetypes for homes with **unidirectional** EVs. Increased to **51 % – 69 %** if EV is **bidirectional**. **Increasing WFH** freq. for homes with bi-EV can increase grid independence by up to + **16**%.



Conclusion & Future Work

- We demonstrate and quantify the benefits of combining PV + EV + WFH in residential homes in the UK to achieve faster carbon emission reductions.
- There is a lack of policies that encourage all three trends together. We encourage policy makers to develop integrated incentives that encourage the combined adoption of solar PV, bidirectional EVs and some WFH.
- Future work could extend to more countries, as well as incorporate the electrification of heating into the analysis, to see if there also exist synergy benefits for PV + EV + WFH + Heat Pump.

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