

Developing a solar sensor network to improve solar power forecasting

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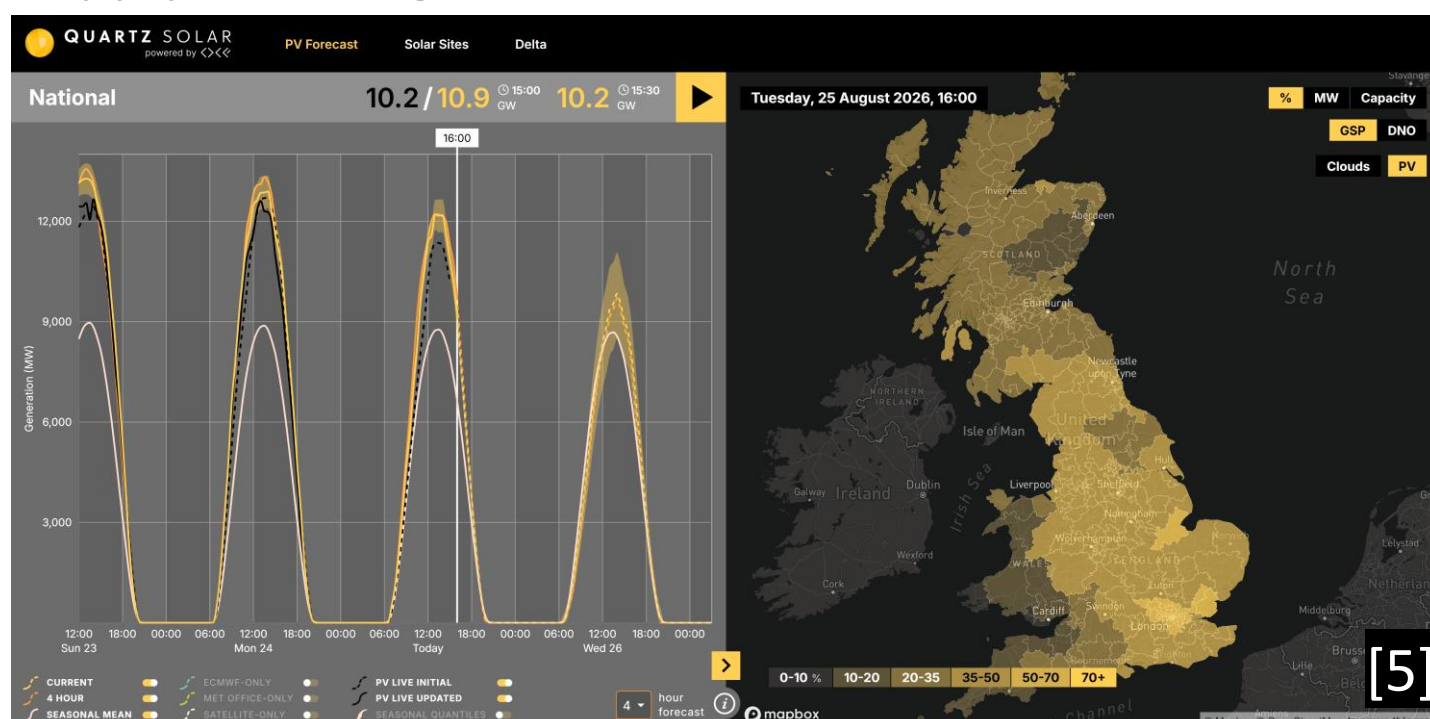
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1. Background

- **Solar photovoltaic (PV) can exceed 30%** of instantaneous generation in Great Britain on sunny days [1] but can be highly variable and difficult to forecast.
- Solar forecasting is valuable for several stakeholders, including the National Energy System Operator (NESO) who must procure reserves hours in advance [2].



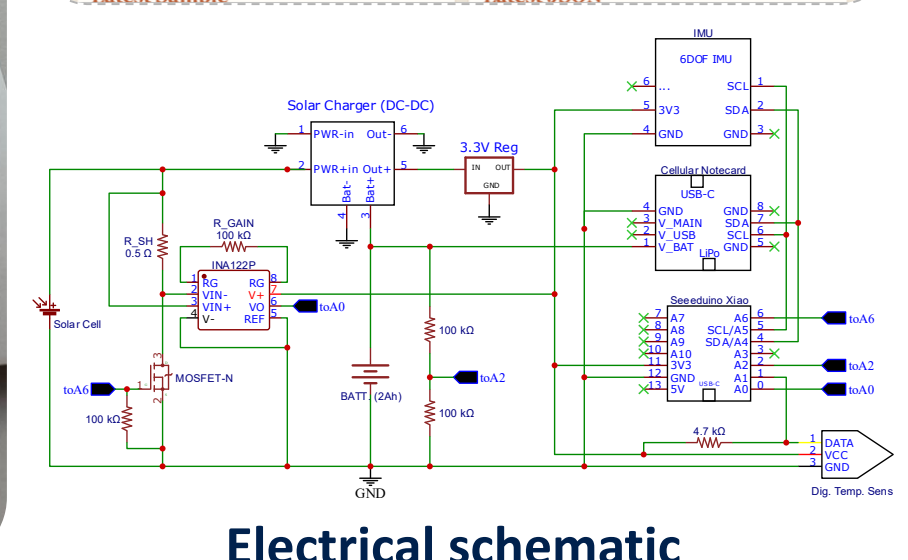
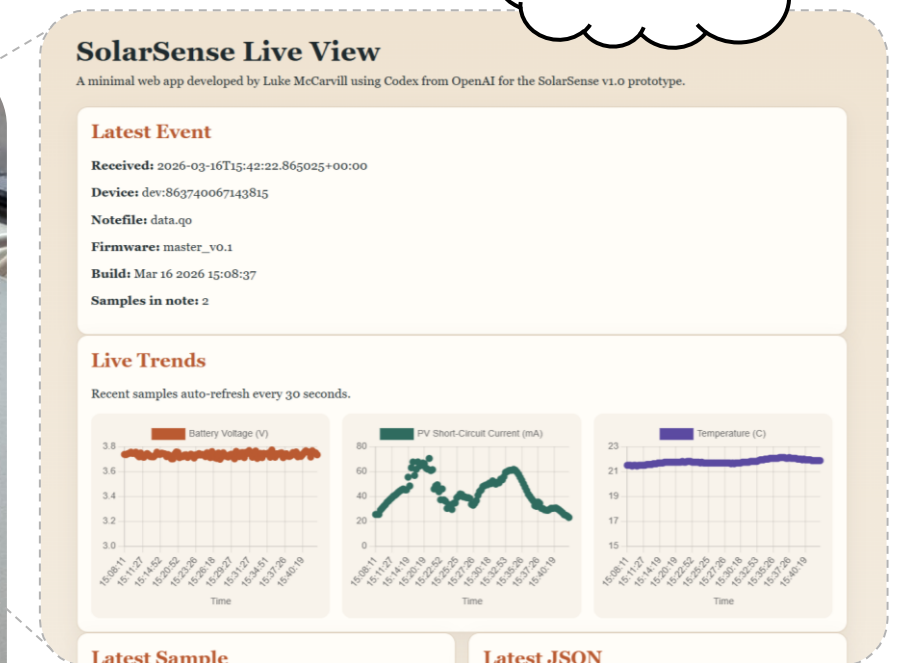
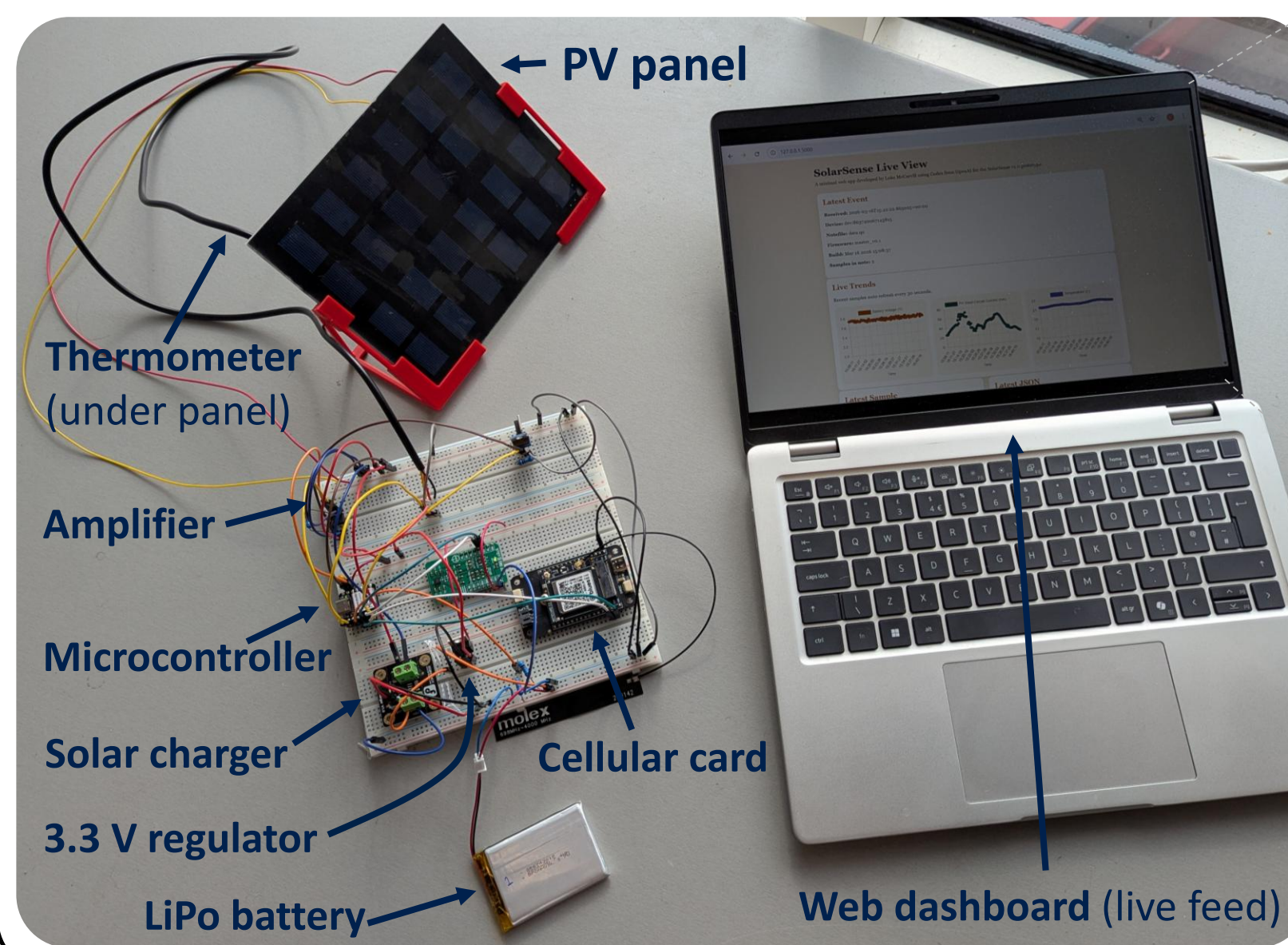
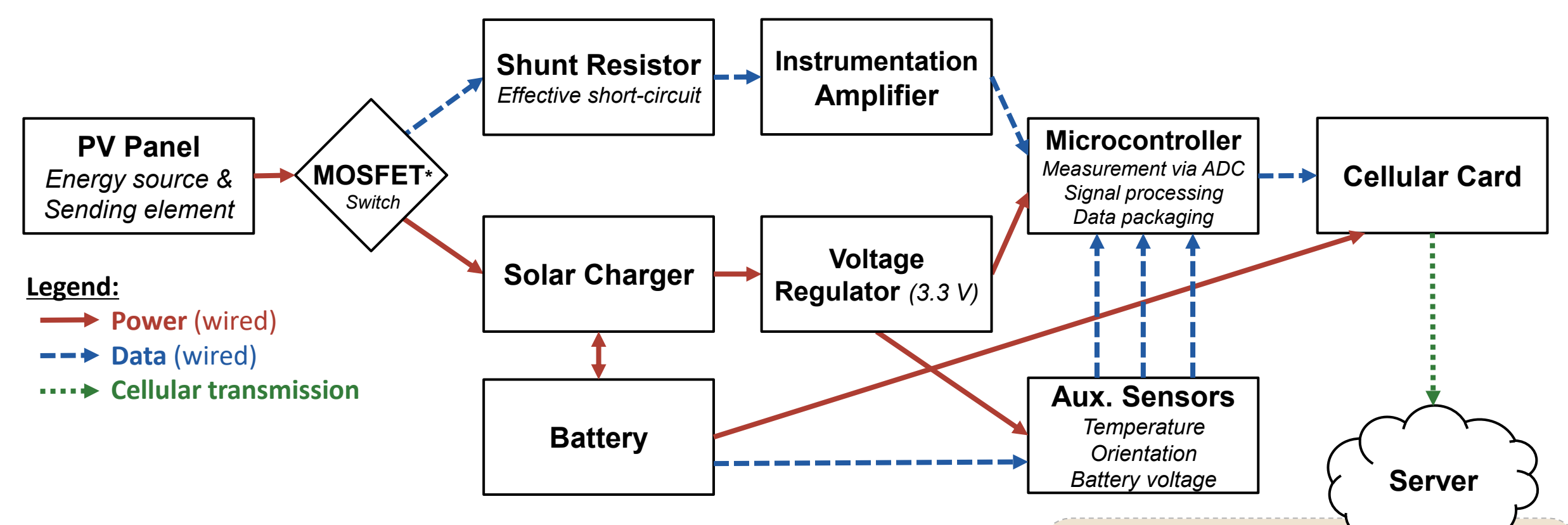
- NESO now uses solar forecasts from **Open Climate Fix** to support energy system resilience, which saves **~£30M in system costs** and **300,000 tonnes of CO₂** annually via a 2.8-fold reduction in forecast error [3].
- Open Climate Fix uses a multimodal late fusion model, combining numerical weather prediction data and satellite imagery to predict PV output in GB's 317 Grid Supply Point regions at 30-minute intervals [4].



- Real-time PV generation would be a valuable additional input, but reliable behind-the-meter data are sparse and difficult to access operationally.
- **Motivation: create a scalable, standardised, low-cost source of ground-truth solar data.**

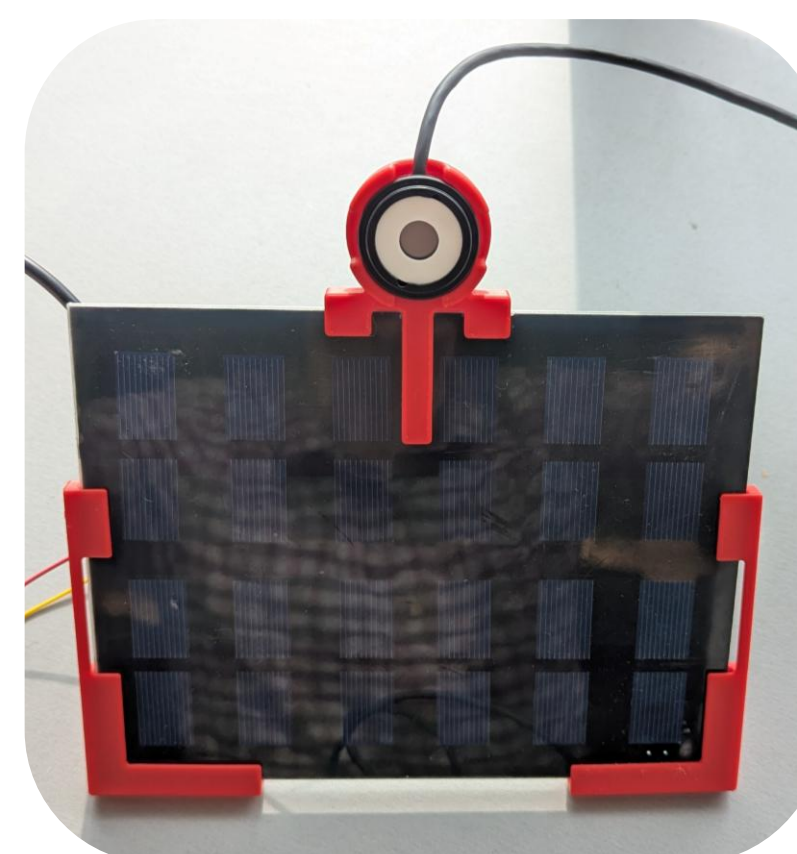
2. Method: embedded systems design

- A low-cost embedded system prototype was designed that uses a PV panel as both its sensing element (as a proxy for irradiance) and as its power source.
- The firmware (C++) alternates between sensing and charging modes, processes electrical measurements, and transmits small text payloads through a cloud-connected pipeline at 30-minute intervals. Temperature, battery voltage, and tilt & azimuth angles also collected.

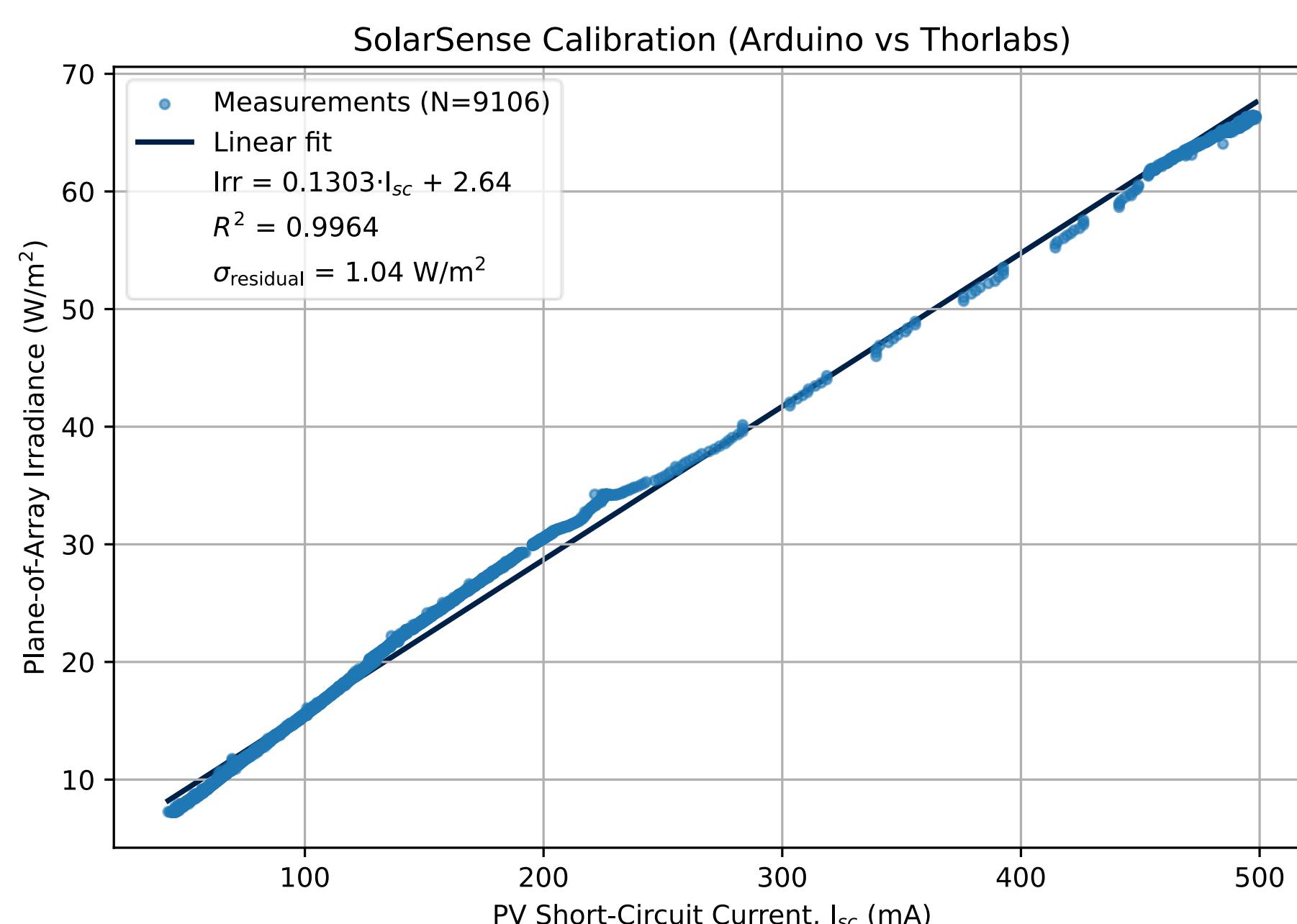


3. Results

- ✓ End-to-end functionality of the prototype successfully demonstrated.
 - Sensing → processing → cellular transmission → server ingress
- ✓ The PV panel was calibrated against a reference irradiance sensor and demonstrated a strong linear relationship in initial testing:
 - $R^2 = 99.6\%$, residual standard deviation = 1.04 W/m^2
- ✓ Total cost: £132, with plans for further cost reductions.
- **Key limitations:**
 - Calibration and testing conducted over a short period and under controlled indoor conditions.
 - Reliability in realistic field settings not tested.
 - Breadboarded power path proved fragile.
 - Effect on forecast accuracy not yet tested.



Thorlabs S120VC photodiode sensor mounted onto the panel for calibration.

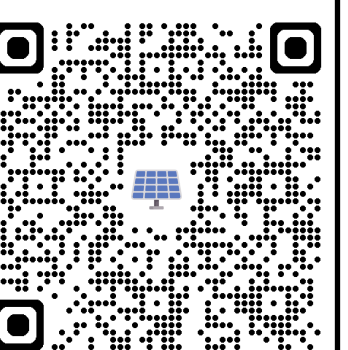


4. Future work

- **Design and build** a robust V2 on a custom PCB to survive realistic field settings.
- **Deploy** 10-100 of these devices in Southern England, piloting in Oxford.
- **Evaluate forecast performance** after modifying an open-source forecast model (e.g. PVNet from Open Climate Fix) to incorporate sensor data.
- **Evaluate the value chain** for this device/service for key stakeholders.
- Real-time data could plausibly improve forecasts by 10–20%! (OCF experiments [6])

References

- [1] 'PV_Live – Sheffield Solar'. [Online].
- [2] 'What does the Electricity National Control Centre do? | NESO'. [Online].
- [3] 'Open Climate Fix'. [Online].
- [4] D. J. Fulton, J. Bieker, P. Dudfield, S. Cotton, Z. Watts, and J. Kelly, 'Forecasting Regional PV Power In GB-', 2024.



Acknowledgements

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