Imperial College London

Solar Energy

Steps towards a brighter future

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energy futures lab

Introduction – Solar energy

1% of global electricity demand[1]

227 GW global installed capacity[2]

50 GW capacity installed in 2015[2]

Costs fell from €4/W_p in 2008 to €1.3/W_p in 2015[3]

A journey to tackle key hurdles for Solar

Large Scale

Decentralised systems

Technology improvement opportunities

Effective policies

Impact on the Grid

Integration in commercial buildings

Integration in isolated minigrids

Emissivity control

Solar Chimney

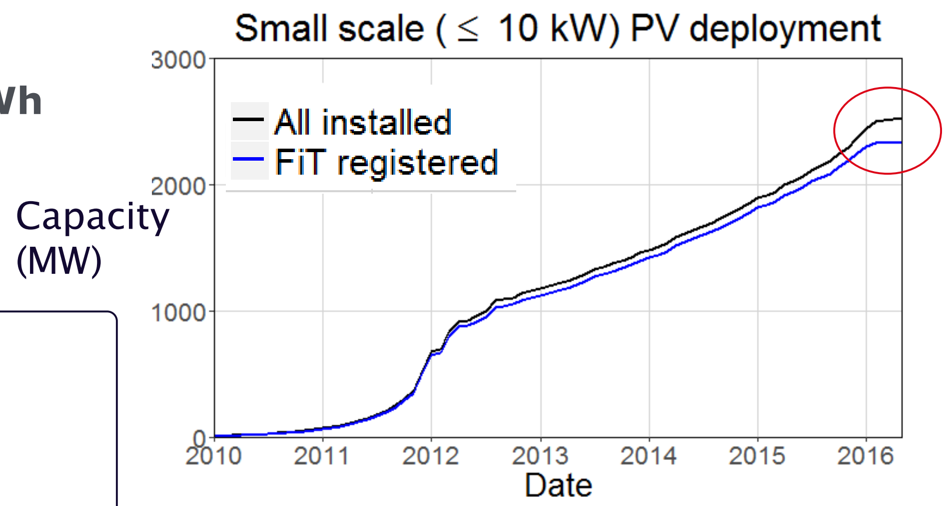
Rooftop solar panels in Great Britain

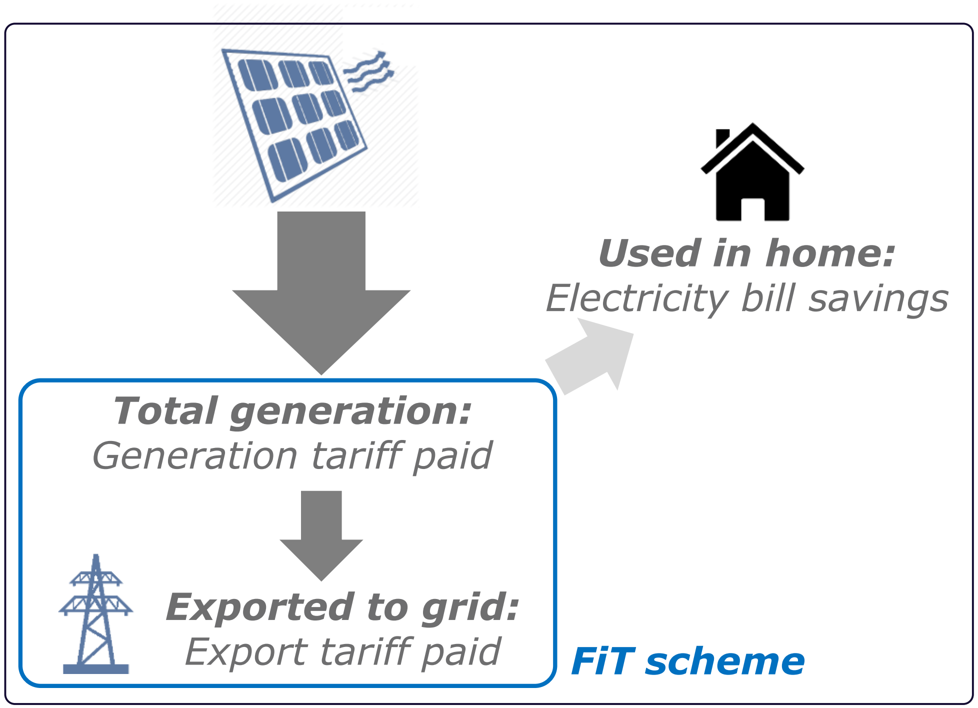
An evaluation of past and future support policy

Phoebe Pearce

Domestic solar PV in the UK: 2010-2016

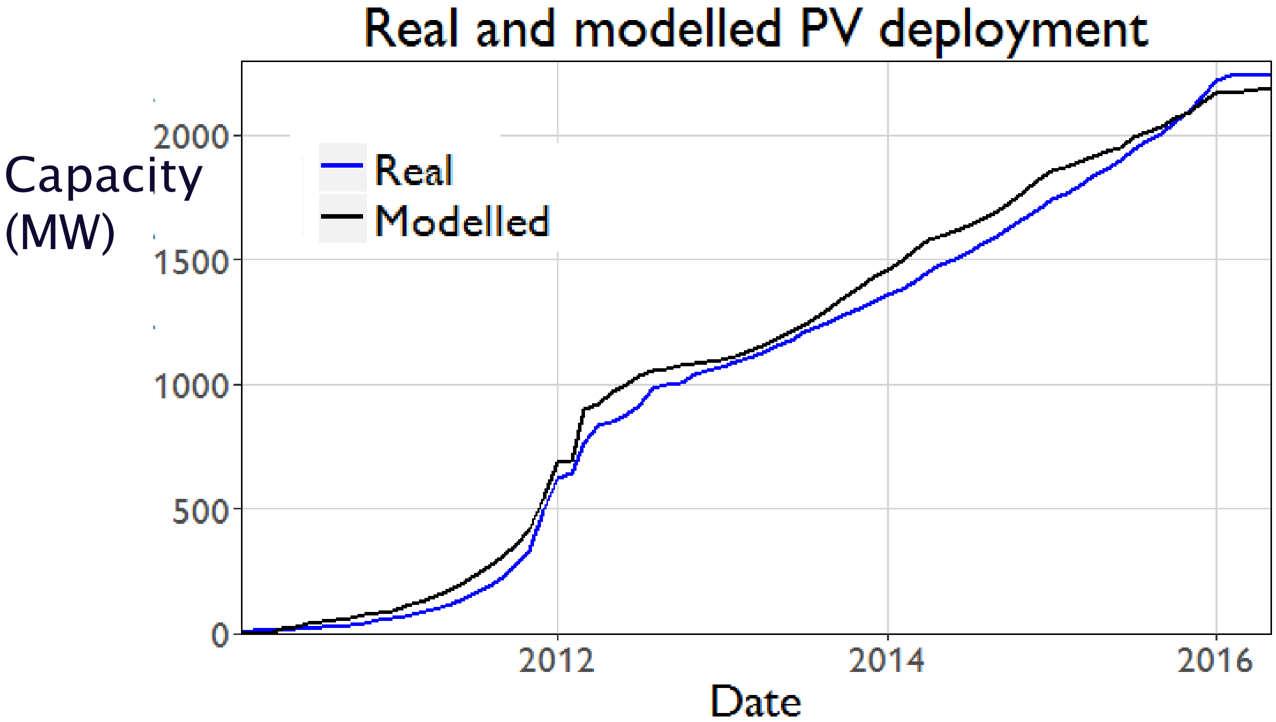
- Feed-in tariffs available since 2010
- Have decreased from **49p/kWh** to **4p/kWh**
- Currently **> 2 GW** installed
- Costing over **£500 million** a year
- Installation has stalled in 2016





Assessing policy effectiveness: Agent-based model

- Compare reality against alternative scenarios
- Make projections
- Beyond optimisation: **Agent-Based Model**
- Agents based on real UK data
- **Calibration**



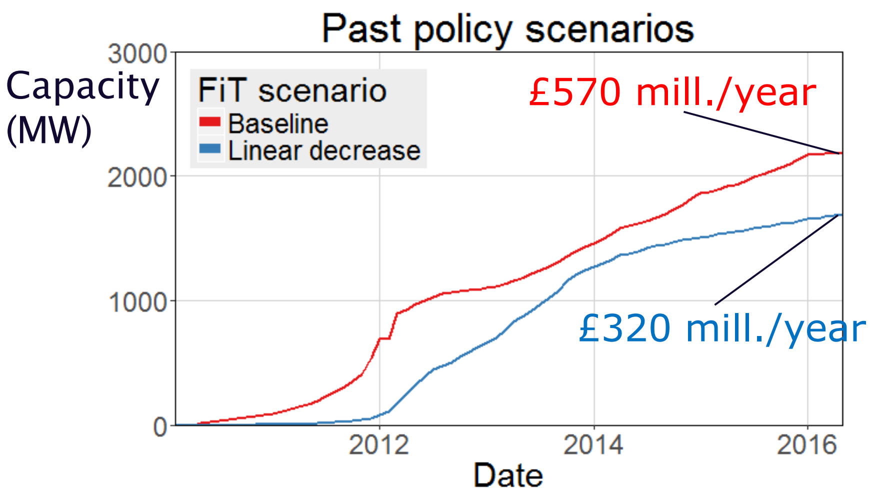
Policy scenarios

Historical policy scenarios

1. **Baseline:** real historical FiT policy
2. **Linearly decreasing FiTs**

Compared to the baseline, **scenario 2** has:

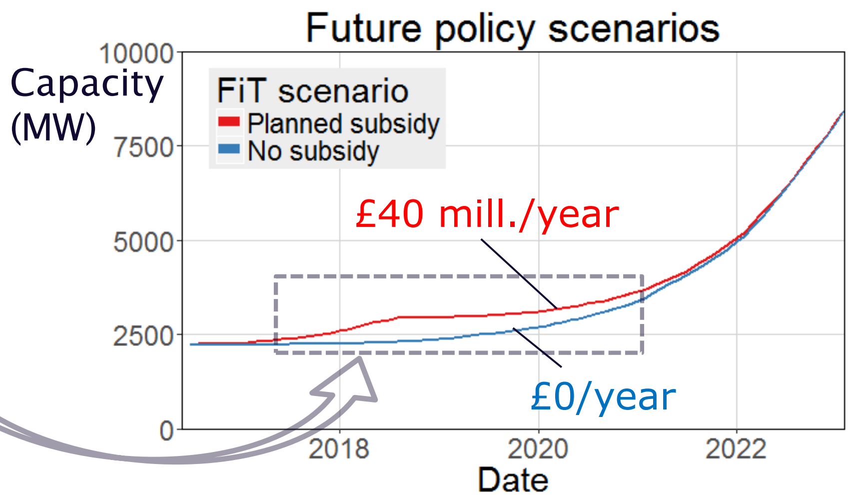
- **20% lower deployment**
- **45% lower annual cost**



Future policy scenarios

1. **Planned policy:** deployment caps up to March 2019
2. **No subsidies** from May 2016

- Low FiTs only encourage **earlier adoption**
- No difference in deployment by 2023



Conclusions & Policy recommendations

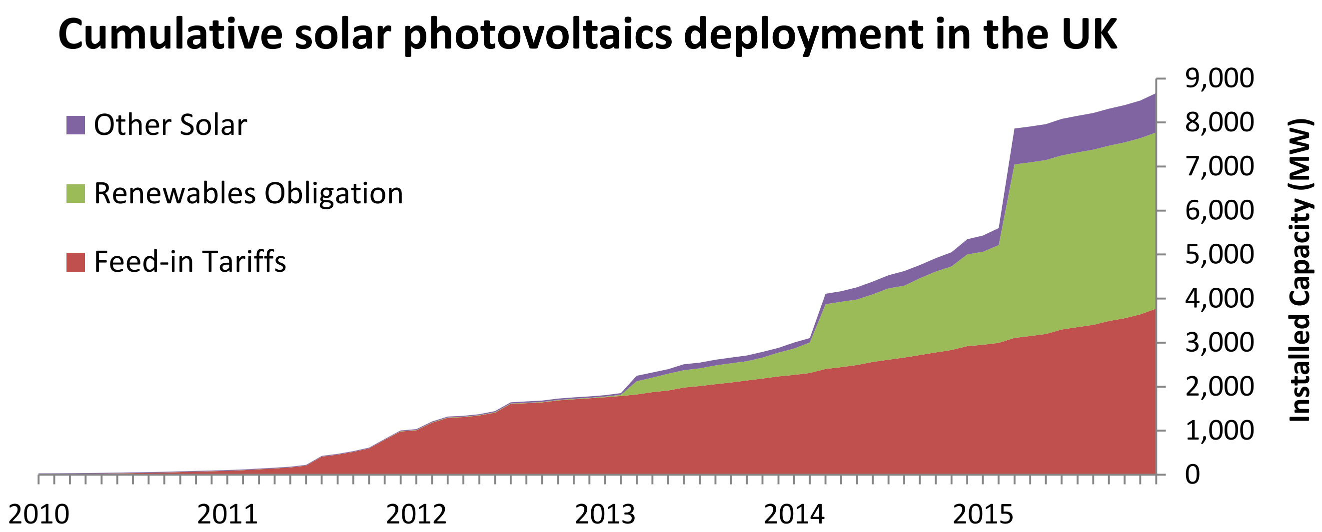
- Need a **nuanced cost control framework** to **avoid escalating costs**
- Current FiTs are **too low to encourage adoption** in the short term
- Current **policy should be reevaluated** around 2018 considering PV prices

Optimising connections of PV farms in constrained feeders

Konstantinos Kalogeropoulos

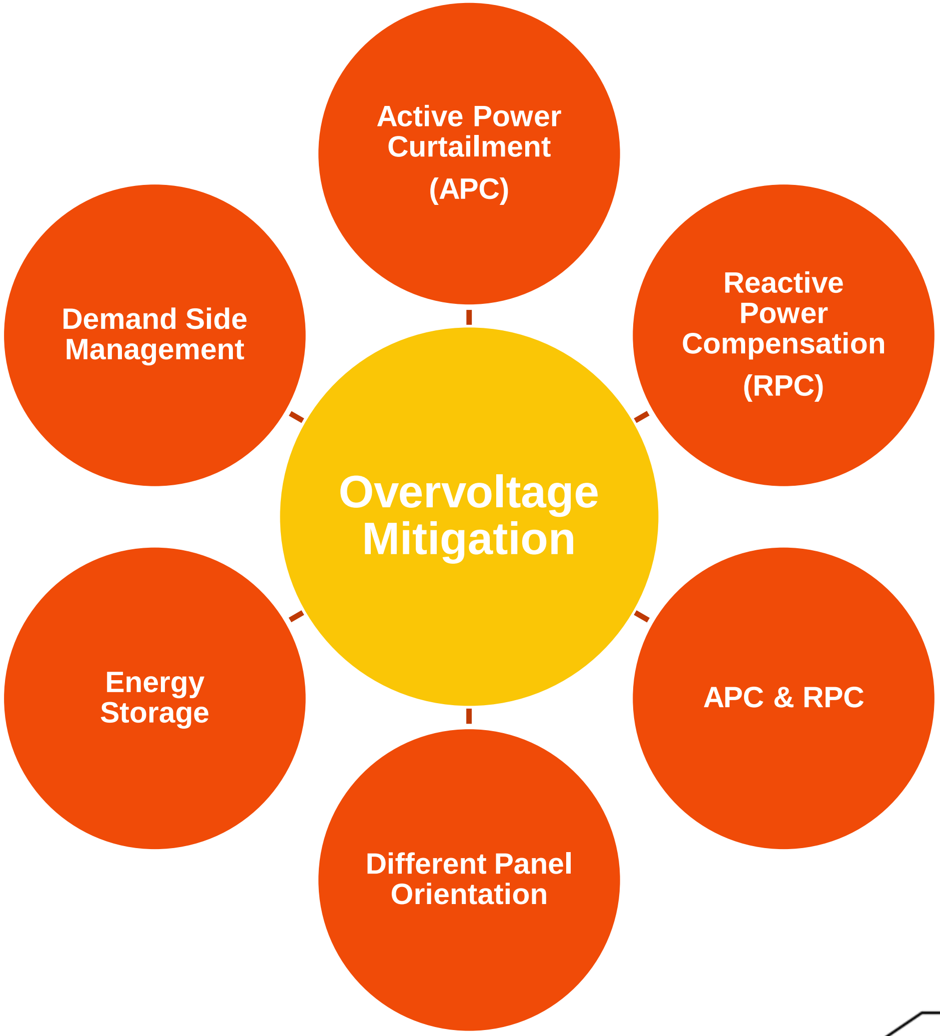
PV Growth and Impact

Immense growth of PV in the UK over the past 6 years



- This puts high stress to the Distribution Grid
- Issue of focus in this project: **Overvoltage**
- Conventionally resolved with grid reinforcement

Alternative Solutions

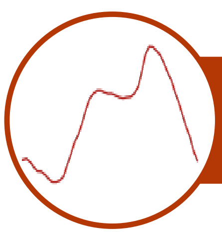


Simulation Model

Solar Irradiance Data

PV Farm Characteristics

Distribution Grid
Characteristics

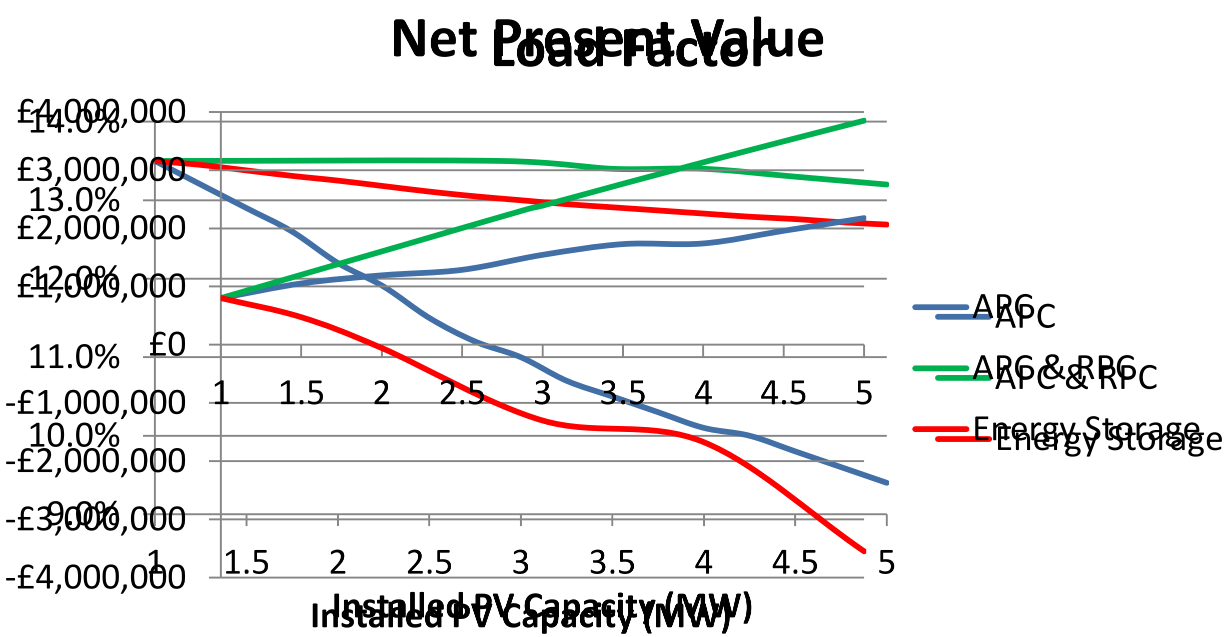


Electricity
Demand Profiles

Simulation
Model

- Hosting Capacity
- Load Factor

Techno-economic Results and Conclusions



Integrated optimisation for PV and storage systems in UK commercial buildings

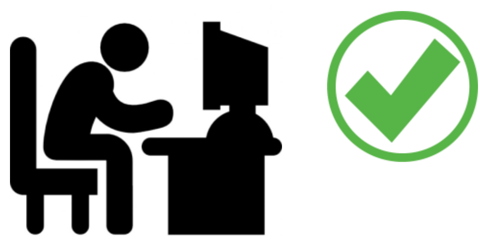
Arthur Mariaud

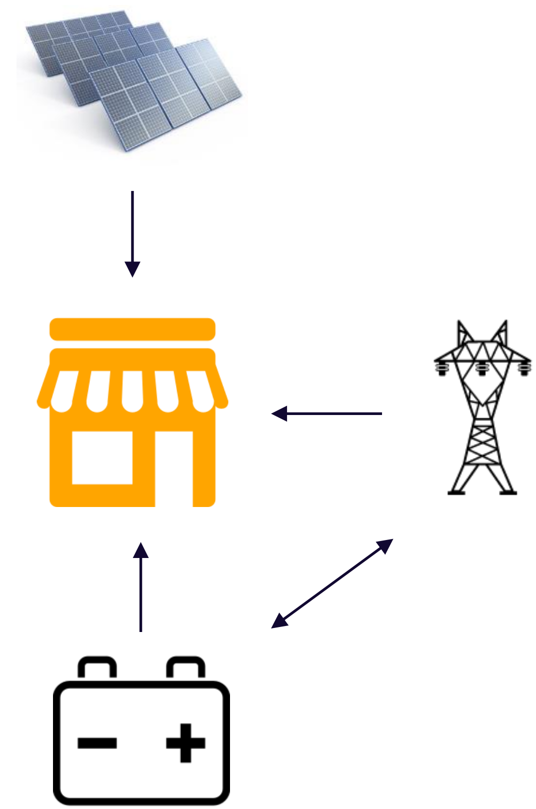
Background

- Climate Change
- Decarbonisation agenda
- Rising electricity prices
- Boost corporate green image

Necessity for a user friendly optimisation model as a guidance for decision makers

BOB





The optimisation model

Inputs:

- Irradiance Data
- Electricity Prices
- Building's Features
- PV Features
- Battery Features
- Policies

Optimisation model applied on a building

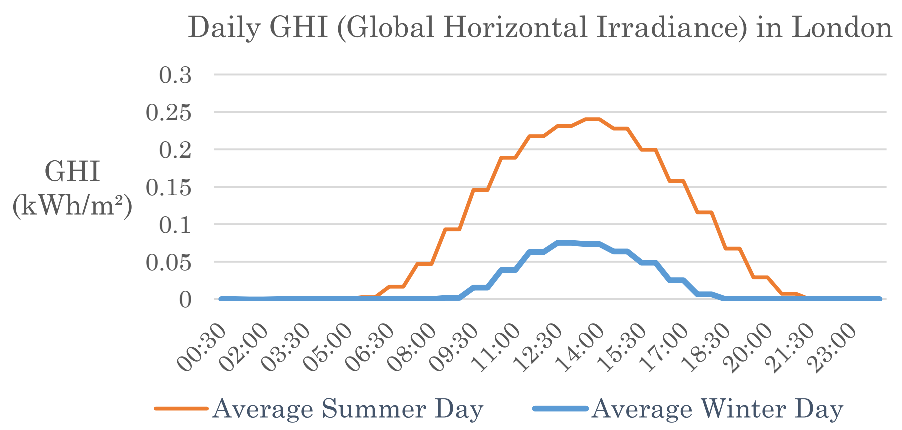
Optimised PV and Battery System

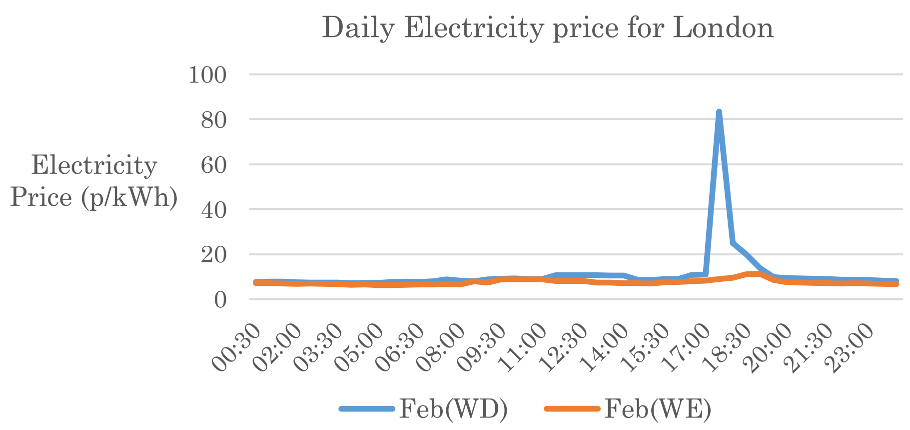
- Technologies
- Capacity
- Operation

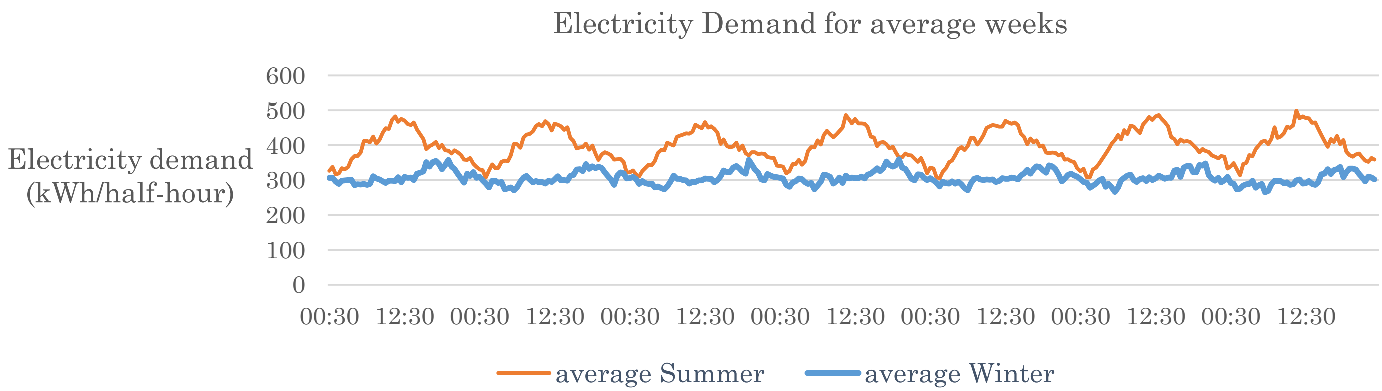
Financial Indicators

- Costs Breakdown
- Payback Period
- Internal Rate of Return
- Return On Investment
- Net Present Value

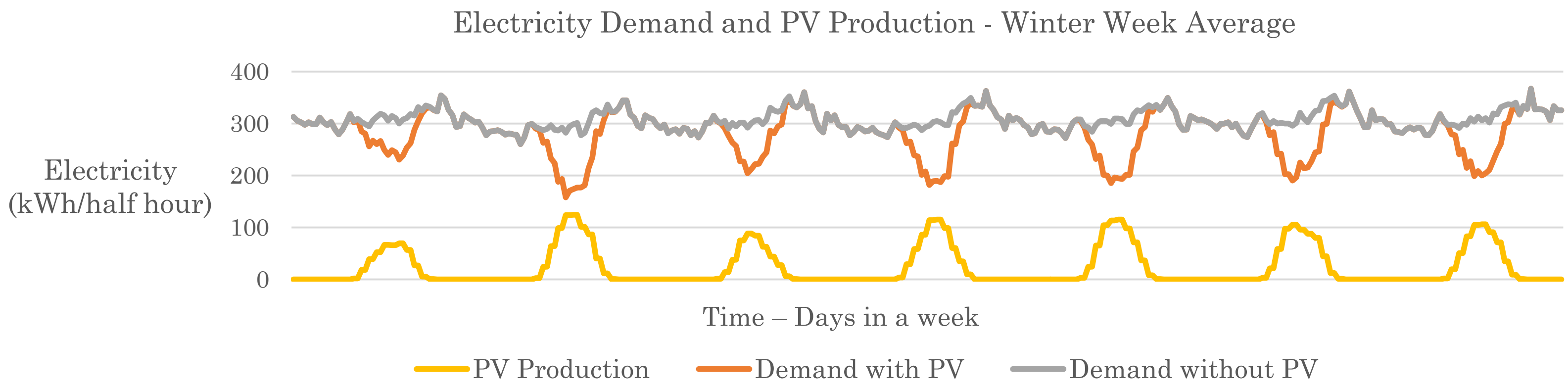
Case Study - Parameters

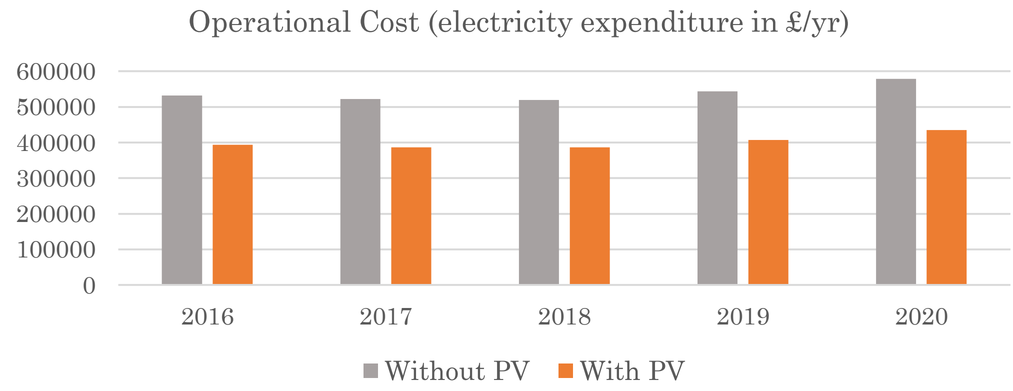




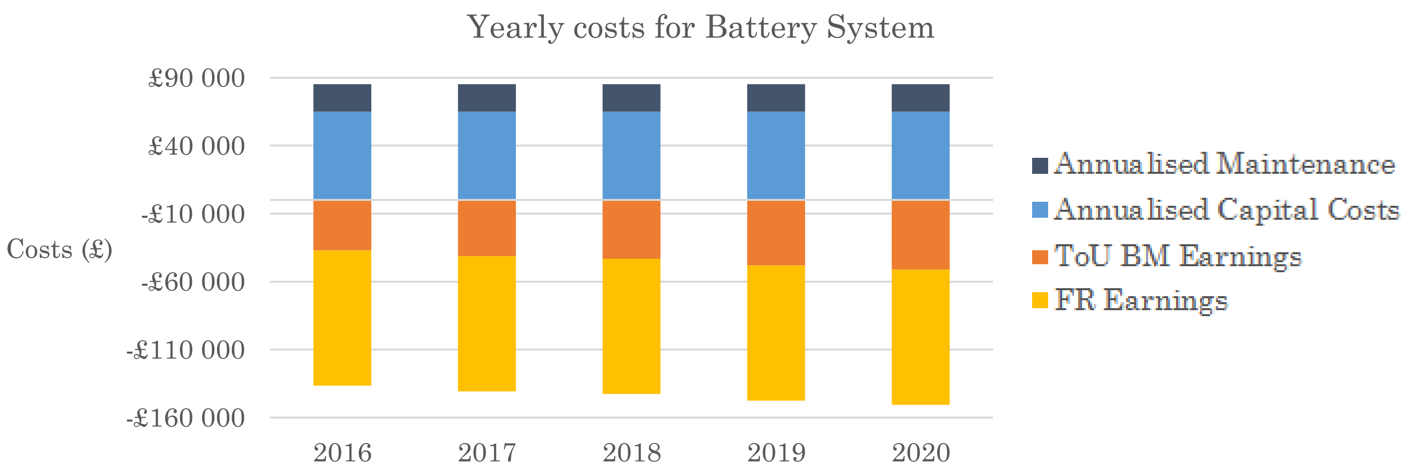


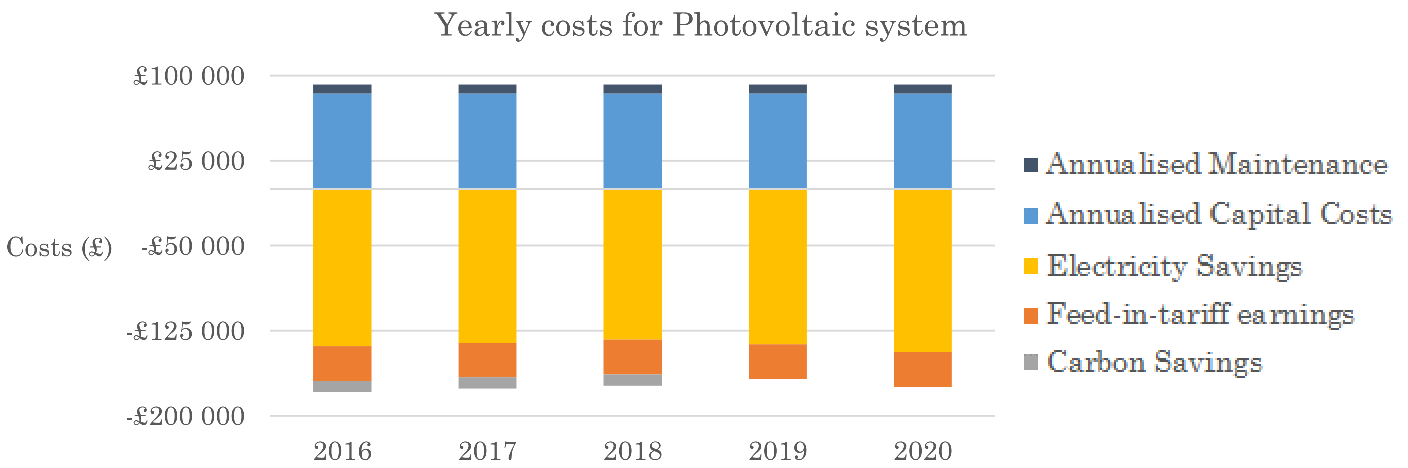
Case Study - Results



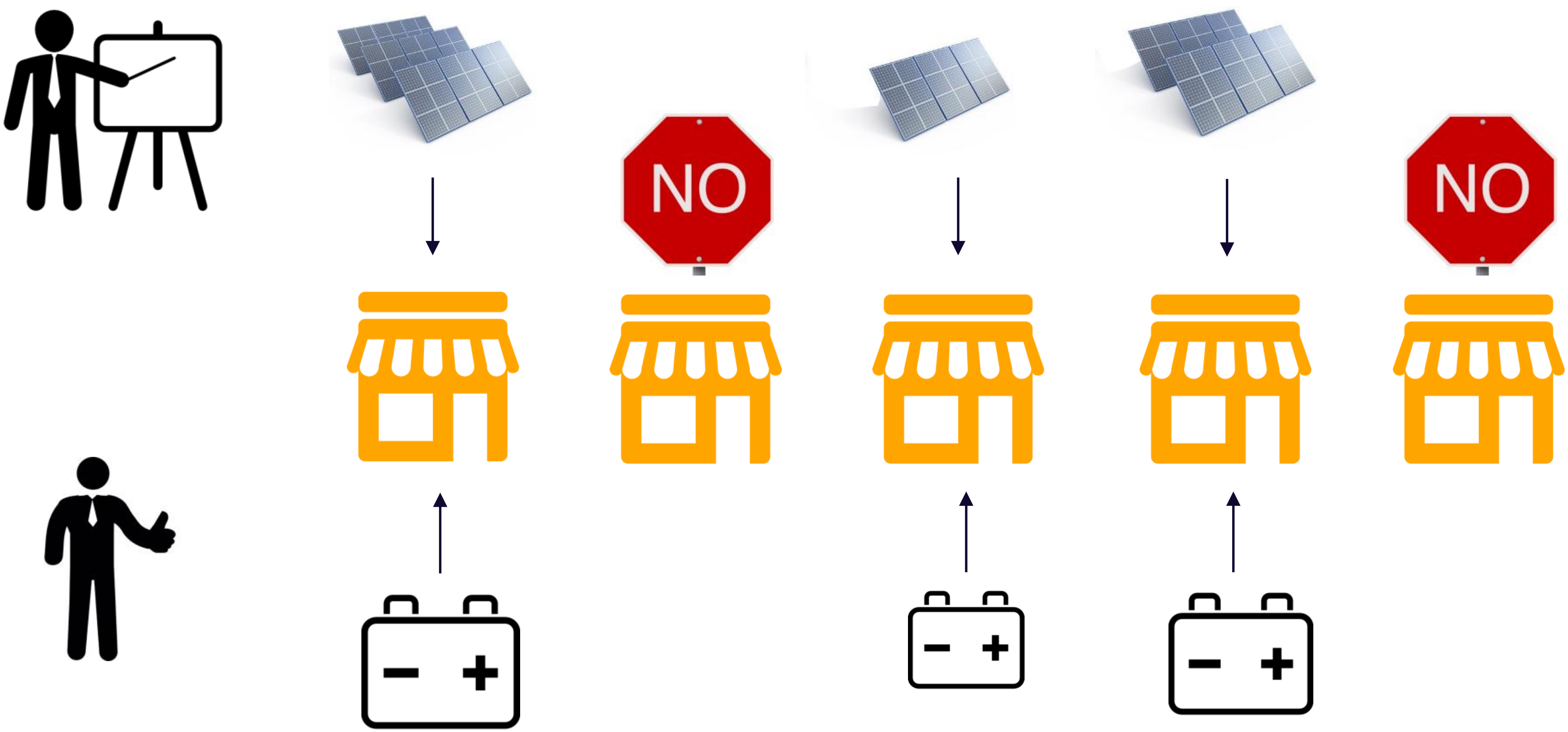


Case Study - Results





Conclusion

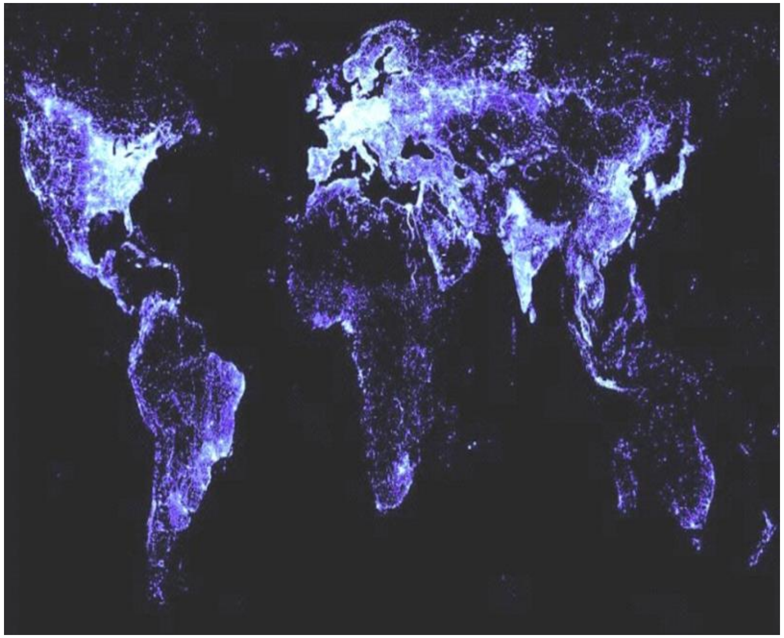


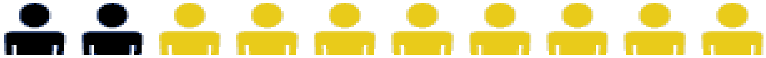
Live solar minigrids storage analysis and implementation of demand response

Andreas Livera

Background

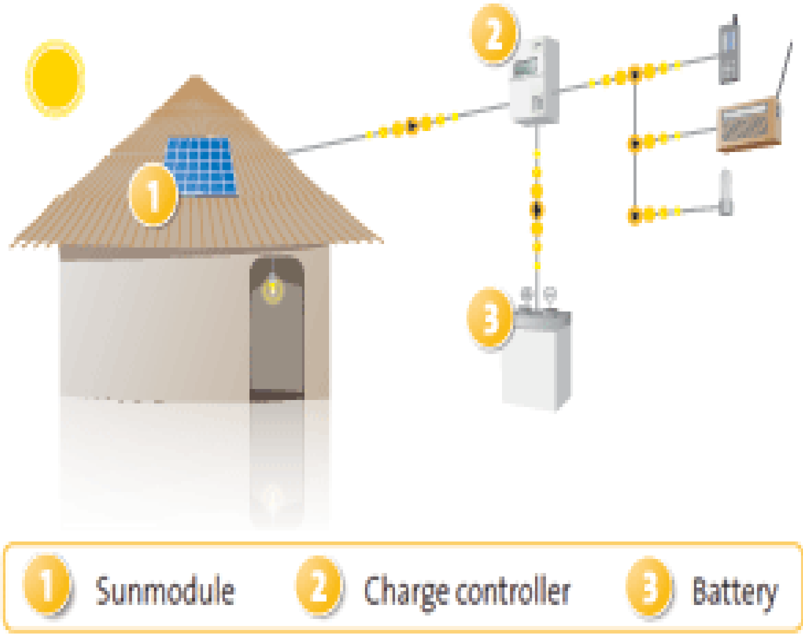
Electricity Access





Nearly 2 out of 10 people are living in the dark.

Renewable Energy based Minigrids

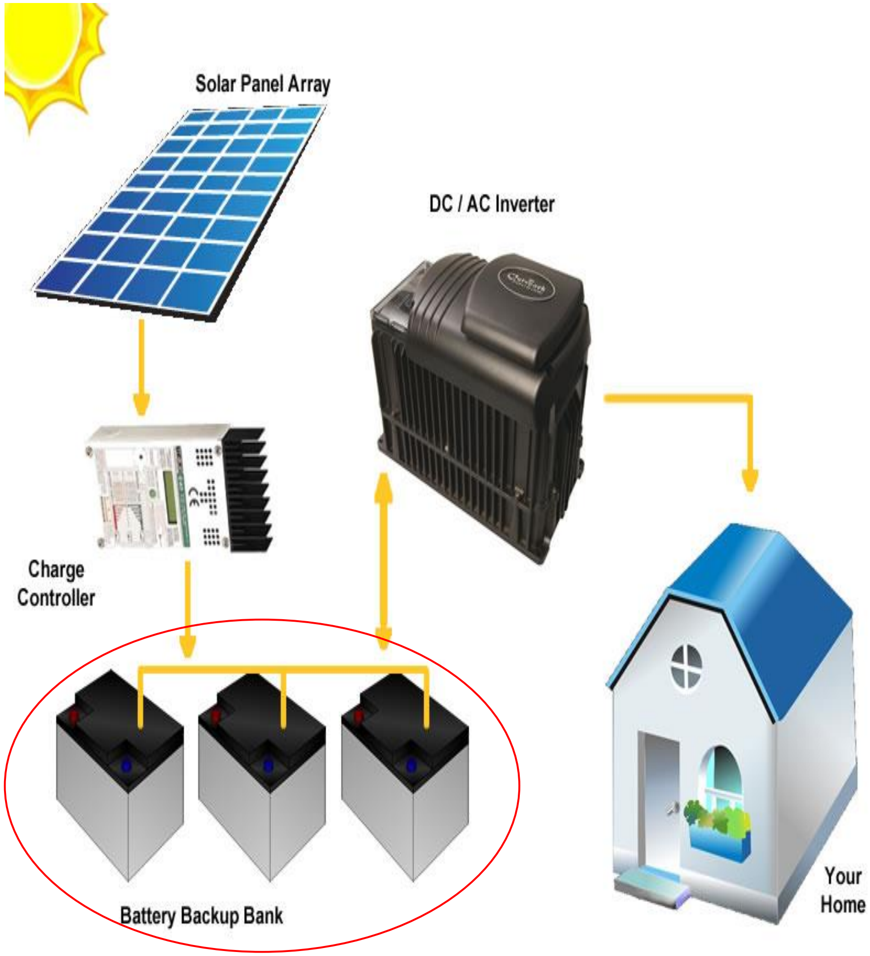


Clean, affordable and sustainable energy option.

Imperial College London

Solar mini grids

System architecture



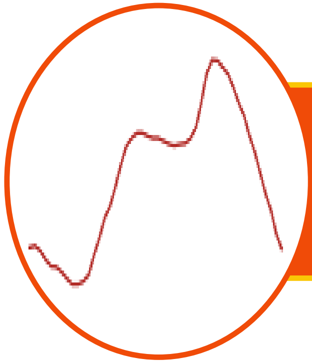
Main challenge

Solution

The computer program

Stage 1: State of Charge (SOC) estimation

Battery's Specifications



Battery current and voltage measurements over time

The computer program

Stage 2: Generation and Demand model

- This model predicts energy shortfalls within the next five days based on historic customer usage data and seasonal generation data.

Stage 3: Demand Response (DR) algorithm

- The goal of this stage is to keep supply and demand balanced and avoid the prospects of supply shortages.

- The algorithm proposes a strategy for reducing the amount of electricity consumed during peak demand periods.

Conclusions

- Battery storage analysis and implementation of DR are of extreme importance for solar powered minigrids operation.

- The computer program was successfully tested on data from MeshPower existing systems.

- The proposed program works sufficiently and it can be easily adapted and used in real time applications.

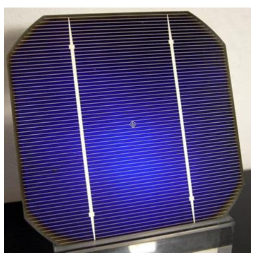
Emissivity of photovoltaic devices

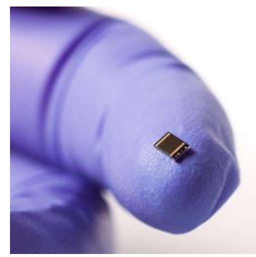
Shedding light on the behaviour of solar cells in the infrared

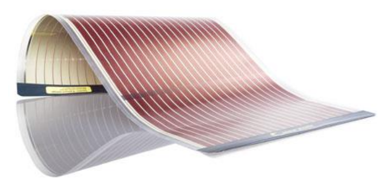
Liav Harel

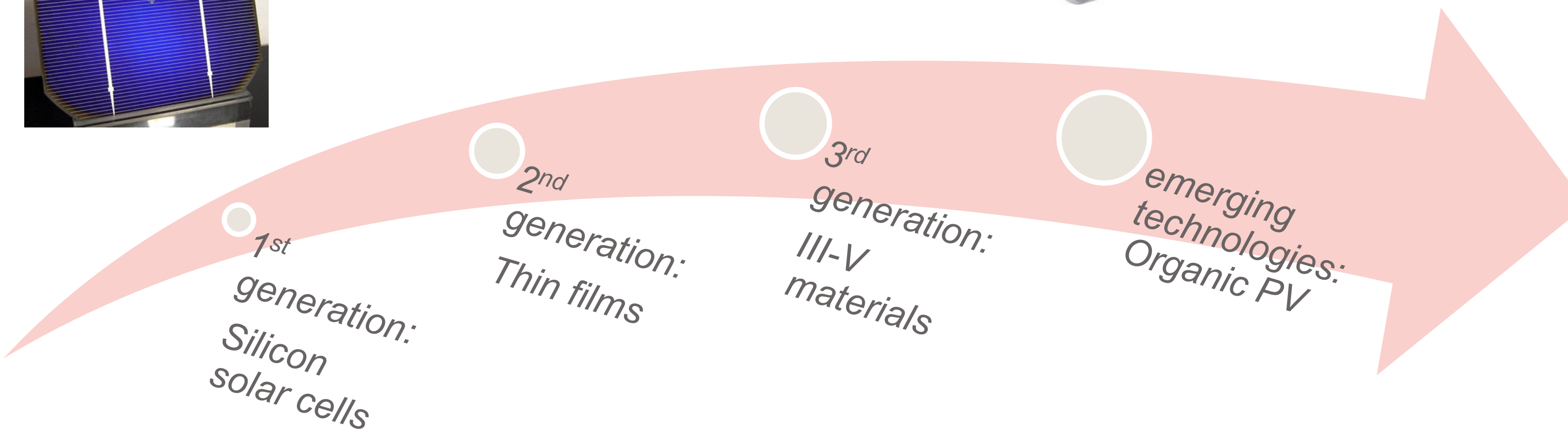
Background

Photovoltaic technologies



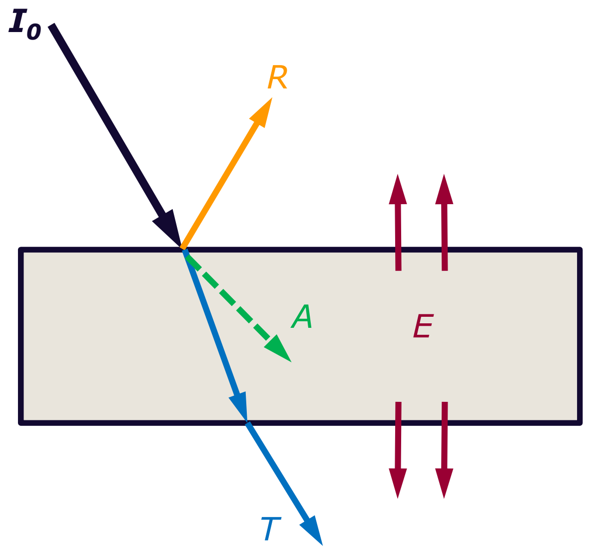




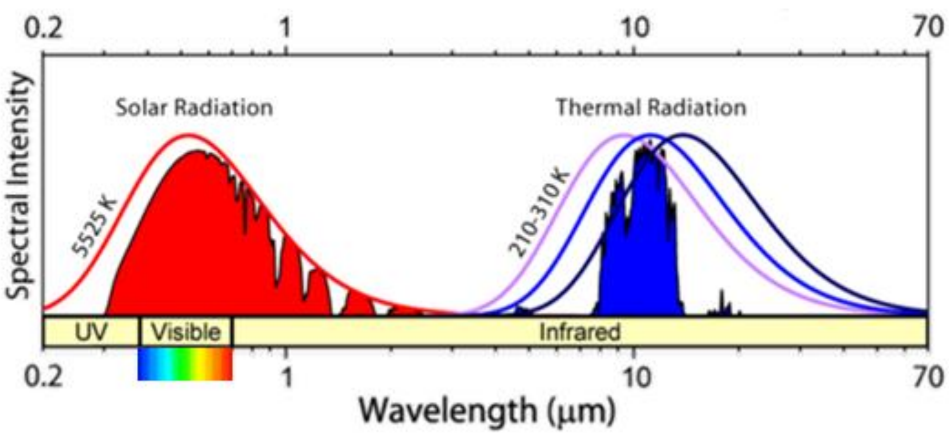


Background

Optical properties of substrates



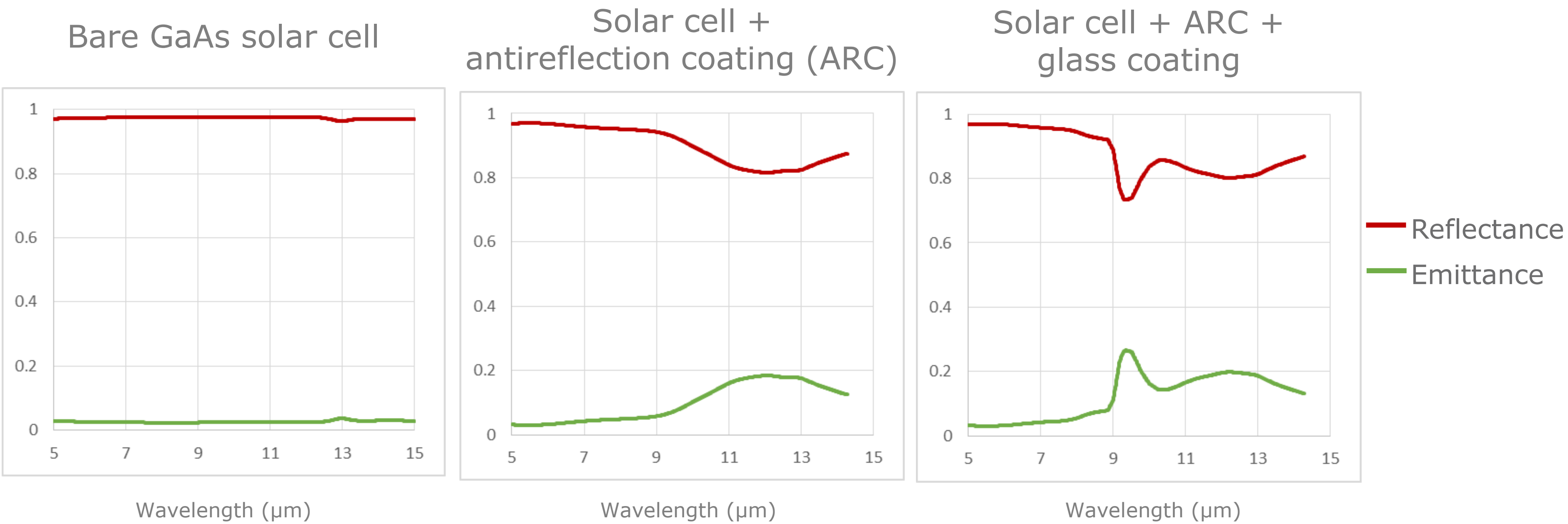
Spectral emissivity



Results

3rd generation solar cell

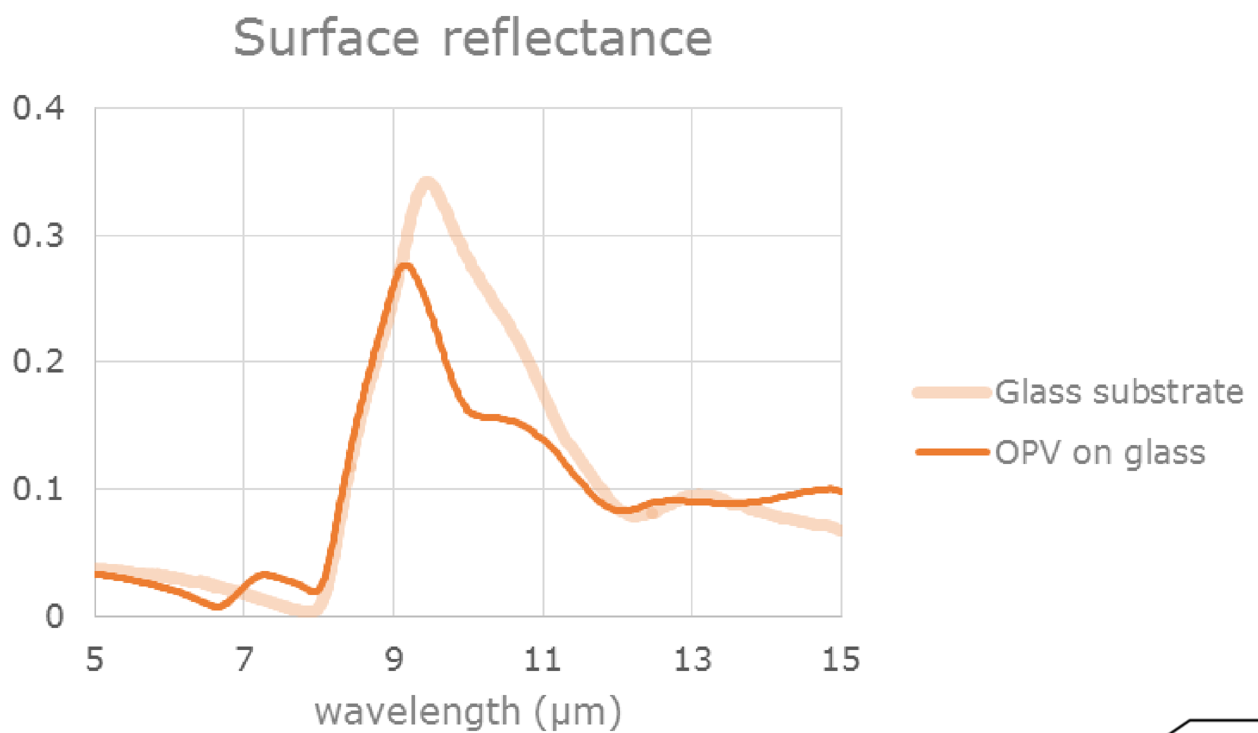
- Antireflection coating (ARC) dominates thermal emissivity
- Additional cover glass further increases emittance



Results

Organic PV solar cell

- Substrate dominates the emissivity



Potential applications

Space[1]

Hybrid PV-thermal[2]

Wearables & appliances[4]

Buildings & agriculture[3]

Solar Chimneys

Energy without the smoke

Pedro Augusto de Araujo Falcao Pessoa

Main Components

Collector

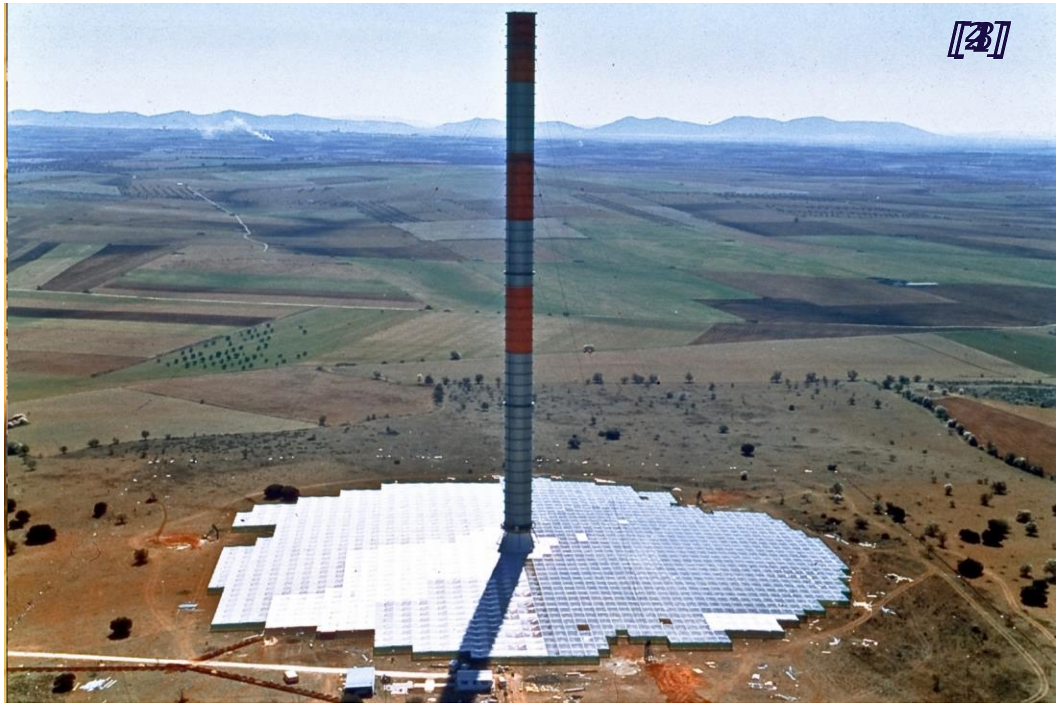
- Transparent roof

Chimney

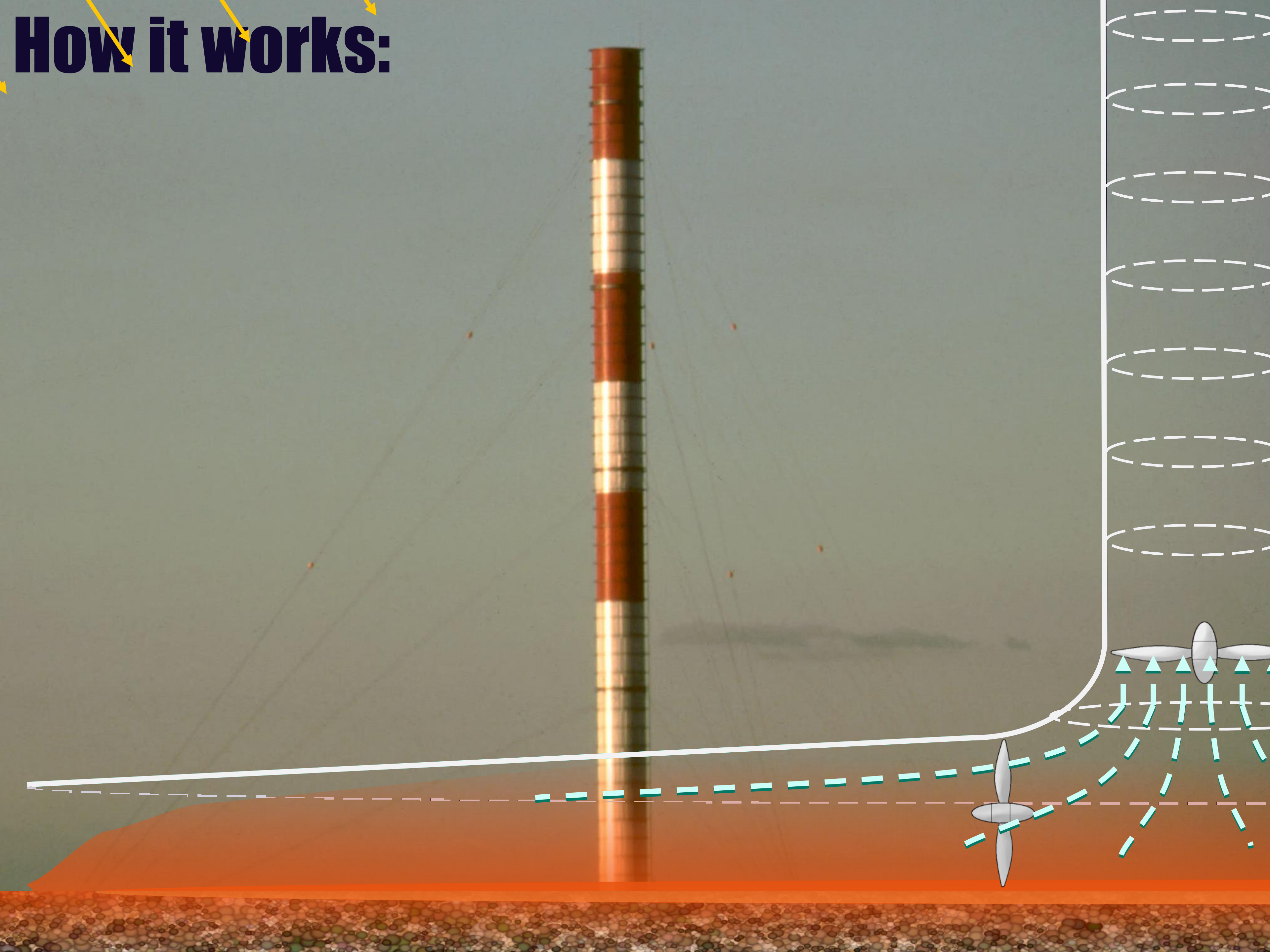
- Connects warm air at ground level to the cold air at the top of the chimney

Turbines

- Convert kinetic energy from airflow into electricity



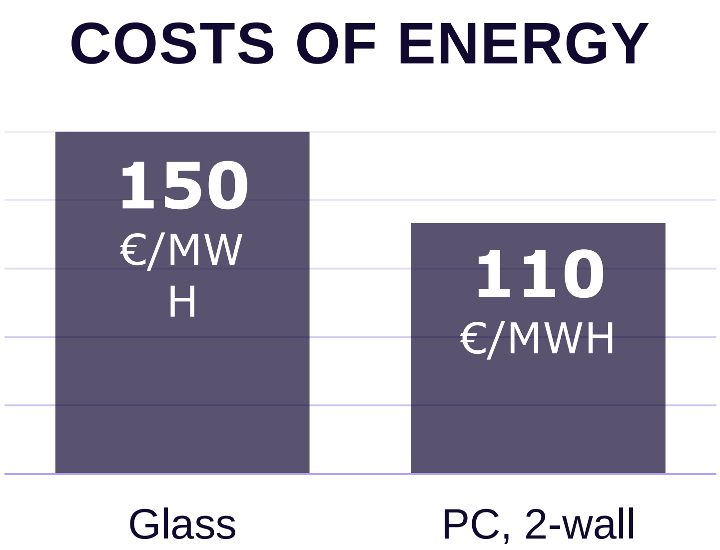
How it works:



Findings and Conclusions

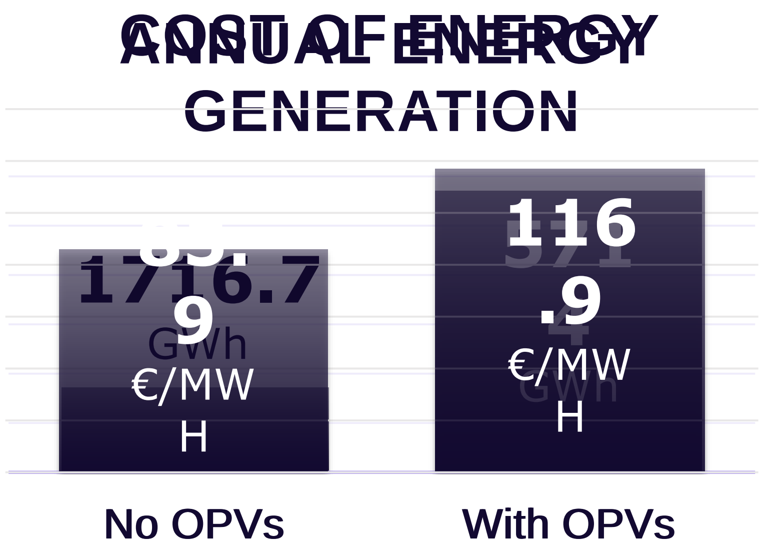
Collector Roof Materials

- *Roof material selection can greatly impact the thermal and economic performance of the plant*



Semi-Transparent Organic Photovoltaics

- *Inclusion of OPVs can increase energy output but decreases profitability*



If you want to discuss further...

Phoebe Pearce – Poster 51

Konstantinos Kalogeropoulos – Poster 48

Arthur Mariaud – Poster 50

Andreas Livera – Poster 49

Liav Harel – Poster 47

Pedro Augusto de Araujo Falcao Pessoa – Poster 46

Thanks for your attention

Special thanks to our supervisors
Dr Salvador Acha
Dr N. J. Ekins-Daukes
Prof Timothy Green
Dr Alexander Mellor
Prof Jenny Nelson
Dr Raphael Slade

Questions?

References

Slide 2
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