Enabling Smart Home Energy Responses

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11:00 – 12:30

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Project Overview

- Smart Energy Services for Homes (Residential Buildings)
- Leverage Smart Meters for Data Collection in Homes
- Use of Digital Twin Technologies for Forecasting & Optimisation of Energy
- Provide Online Dashboards to Guide Users in their Energy Consumption
- Development of Peer to Peer trading Platform
- Investigation of Dynamic Time of Use Tariffs
- Test 2-Way Dynamic Energy Market Virtually

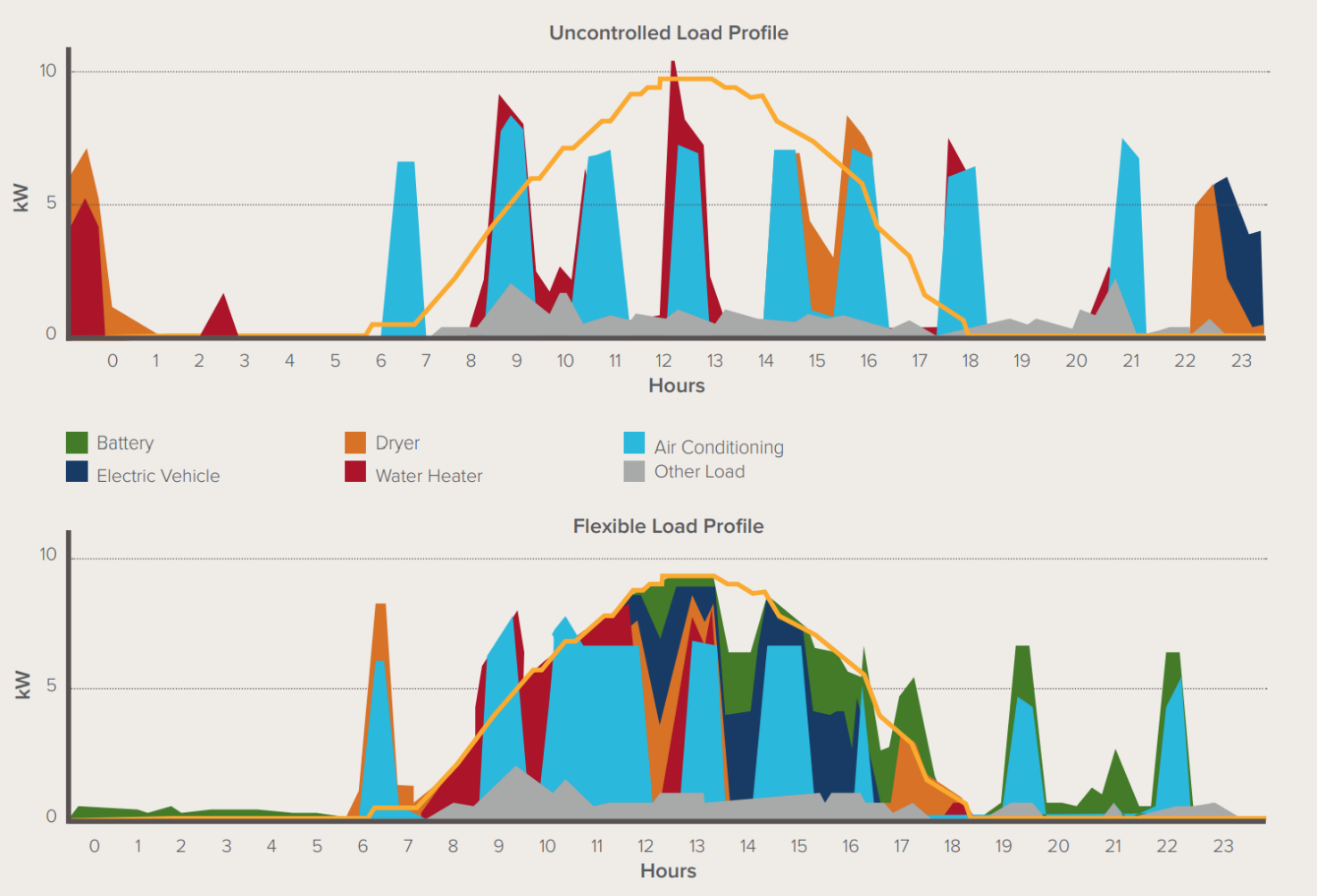
Project Overview – Partner Introductions

IES R&D IRELAND

OLLSCOIL TEICNEOLAÍOCHTA BHAILE ÁTHA CLIATH
TU DUBLIN
TECHNOLOGICAL UNIVERSITY DUBLIN

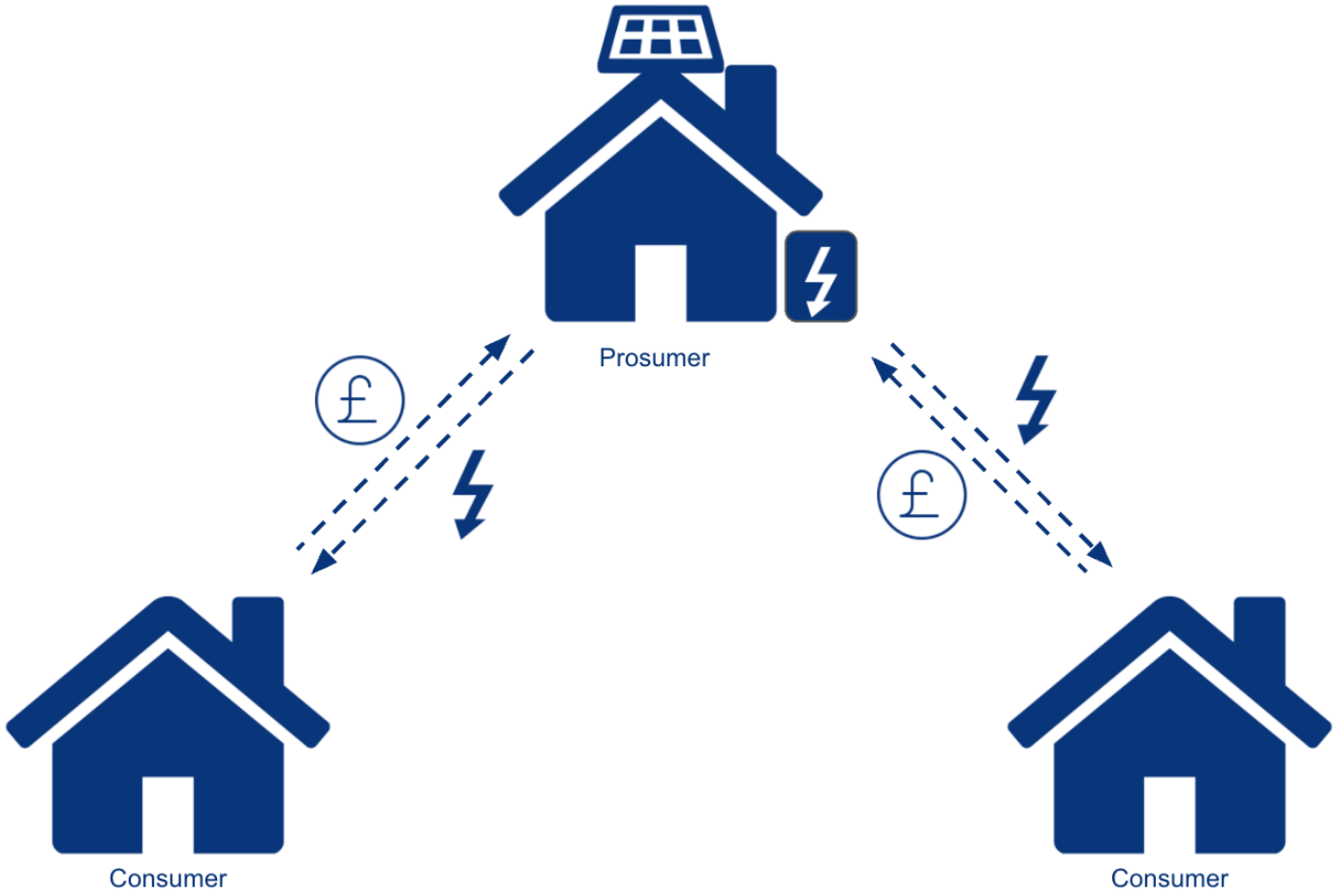
Ó CUALANN
COHOUSING ALLIANCE

Project Overview - Energy Services



https://rmi.org/wp-content/uploads/2018/02/Insight_Brief_Demand_Flexibility_2018.pdf

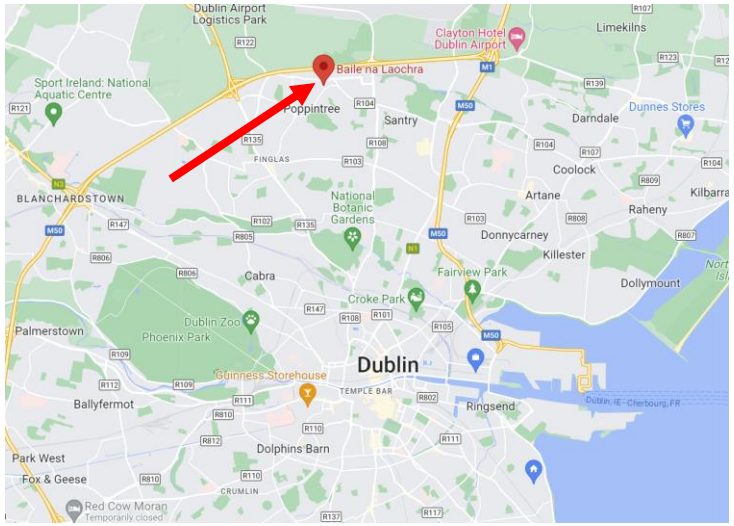
Project Overview - Energy Services



https://www.edfenergy.com/energywise/research-development-peer-to-peer-trading

Pilot Site Engagement

- Baile na Laochra
- Fully Cooperative Low-Cost Housing located in North Dublin
- 20 A-Rated Homes
- Constructed in 2017
- Contain PV and GFCH with Smart Controls



Hardware Specification

Original Hardware approach included:

- Smart Meter
- Communication Hub
- Smart Plugs / Switches

This was subsequently limited to the smart meter and communication hub following feedback from the residents owing to the following requirements:

- Disruption to occupants must be kept to an absolute minimum
- Any disruption must be accompanied by a clear added value for the occupant themselves
- Equipment placed in the home must be inconspicuous
- Follow-up visits to the homes to troubleshoot equipment failure should be avoided at all costs

Smart Meters

Smart Meter

- **Qubino:**
  - DIN-Rail Mounted
  - Some disruption during installation
  - Inconspicuous when installed
  - Minimal installation/operational issues
  - Affordable & Available
- **Aeotec One Clamp**
  - Clamp on to incomer
  - Similar disruption during installation
  - More conspicuous when installed
  - Less available at time due to semi-conductor shortage

Qubino ZMNHTD1

Aeotec One Clamp

Smart Meters

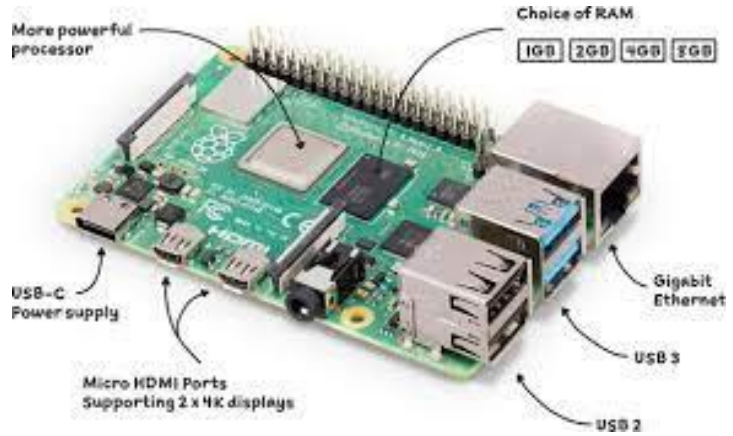
2 Qubino meters installed in the distribution panel of each property to monitor energy consumption and PV generation

Communications Devices

Communication Hub

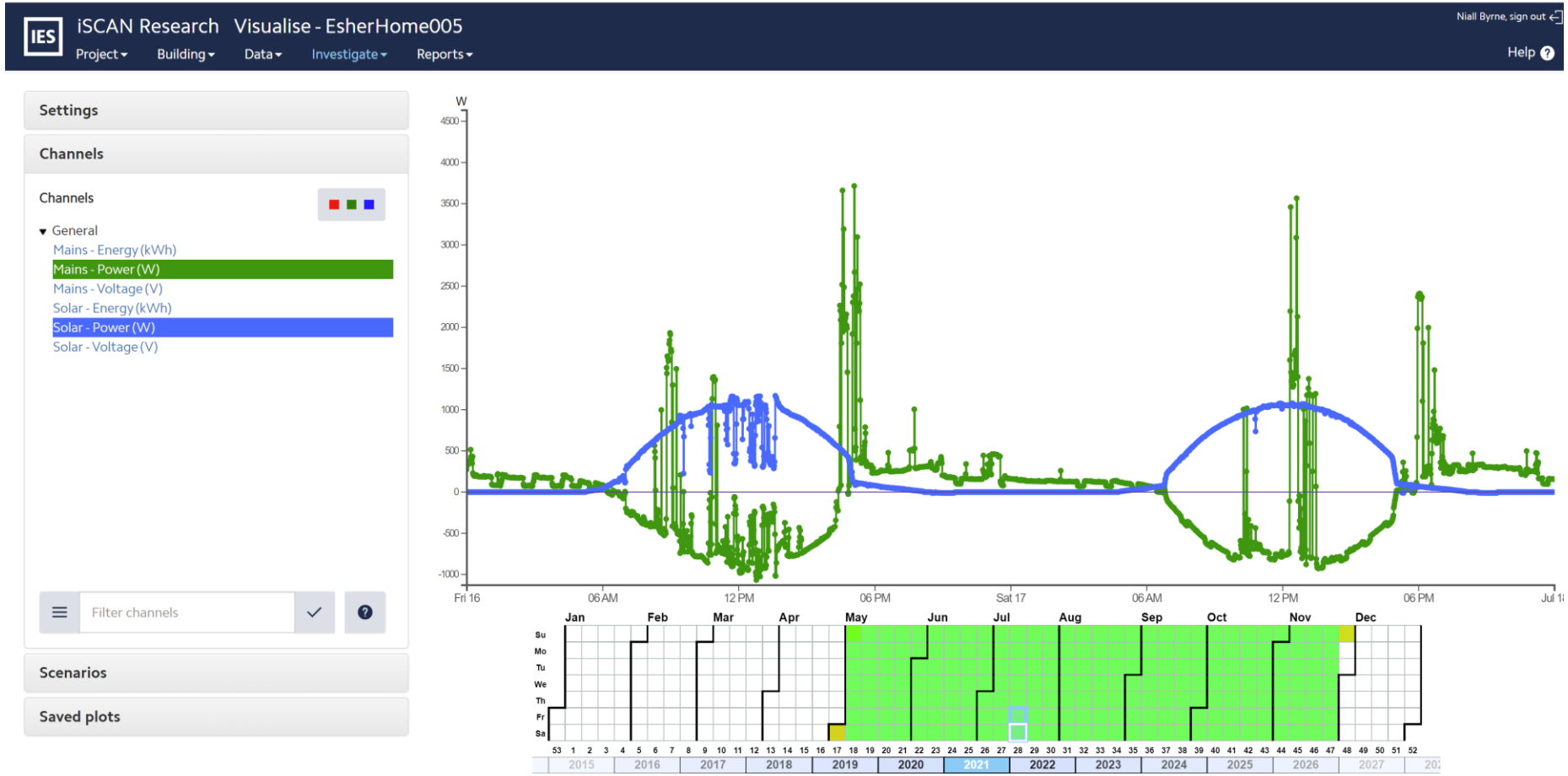
- **Samsung SmartThings Smart Home:**
  - Commercially Available & Proven Product
  - Supports numerous communication protocols
  - Easily hidden within the home
  - Minimal installation/operational issues
  - Affordable & Available
- **Raspberry Pi**
  - Experimental Device
  - Extensive Programming & Set Up Required
  - Not suitable for ordinary domestic property
  - Potential Reliability Concerns
  - Major Global Shortage of Device

Samsung SmartThings Smart Home Platform



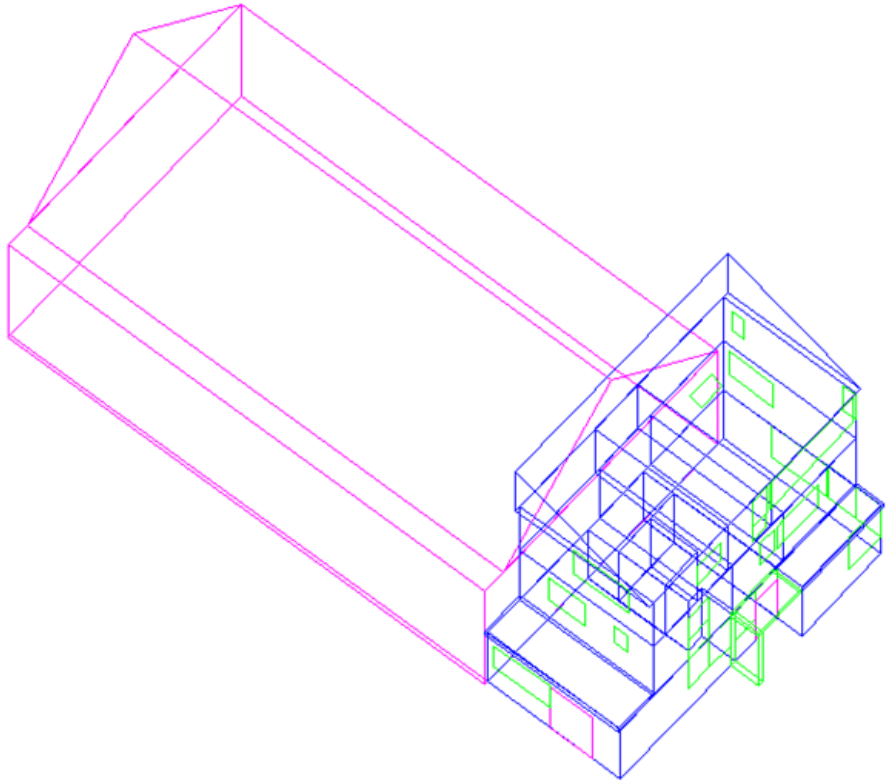
Raspberry Pi

Data Collection



Digital Twin Development

Baseline Model Development



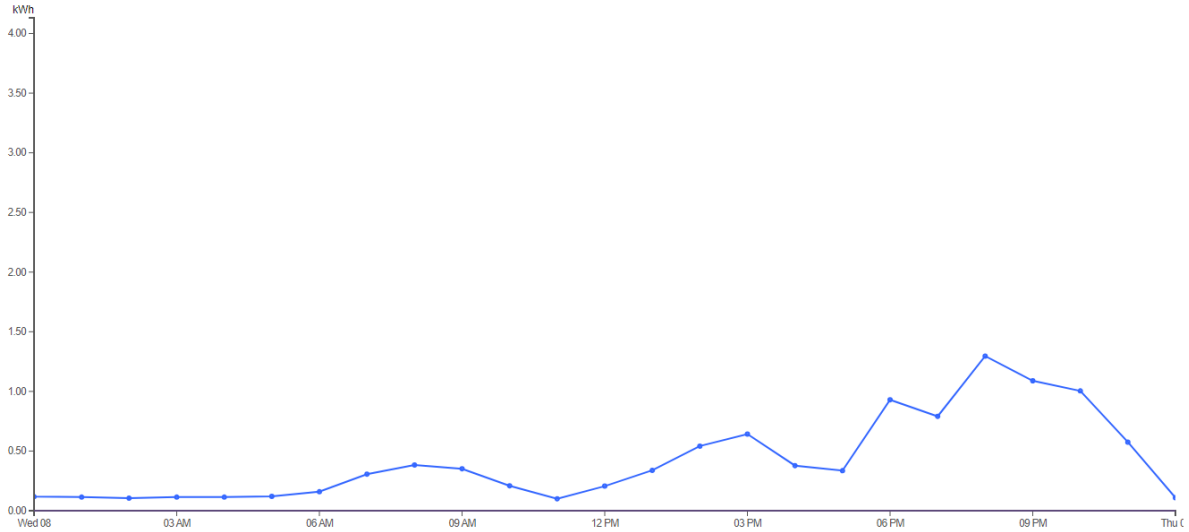
Model Calibration

Calibration Process

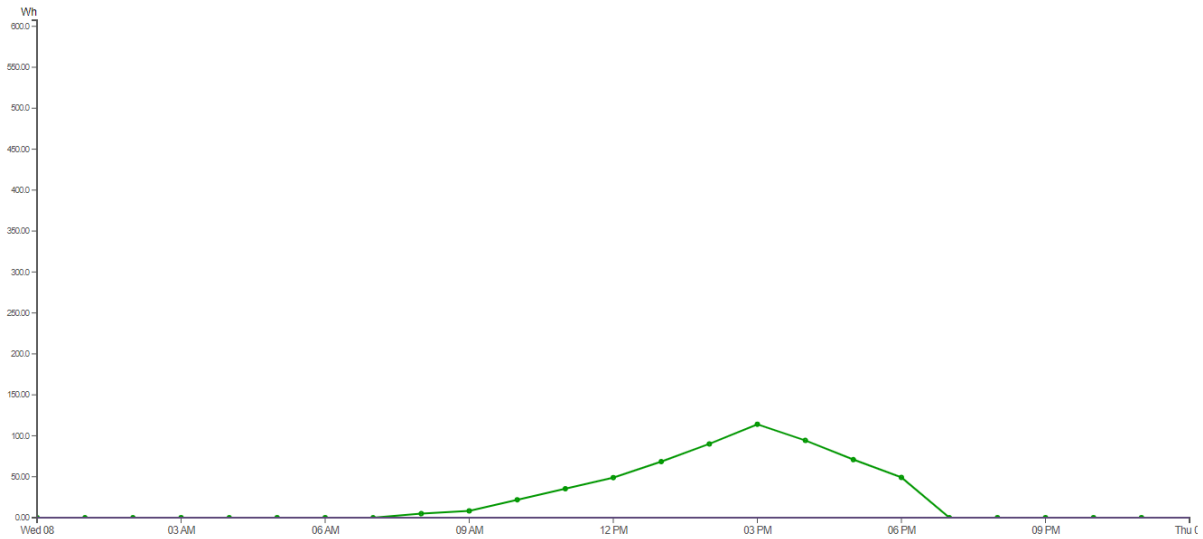
- Baseline models are then calibrated using the real data as recorded from the buildings
- Primarily calibrated according to electricity consumption and appliance usage
- Once calibrated, models will then be used to predict energy consumption for the following day using real weather forecasting from iSCAN

Energy Demand / Consumption Forecasting

Predicted Consumption & PV Production

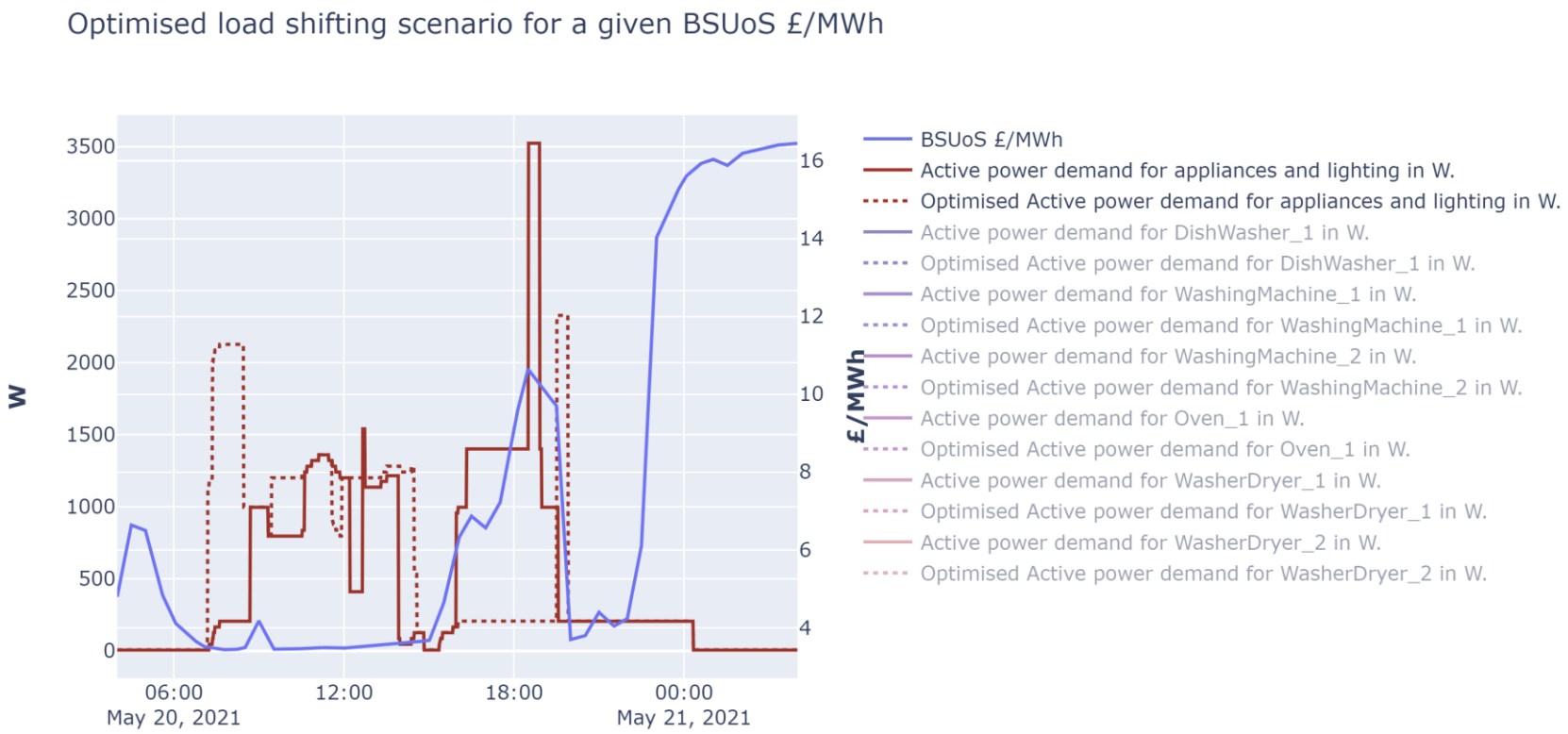


Predicted Electricity Consumption for ESHER Home 3 on March 8th, 2023



Predicted PV Generation for ESHER Home 3 on March 8th, 2023

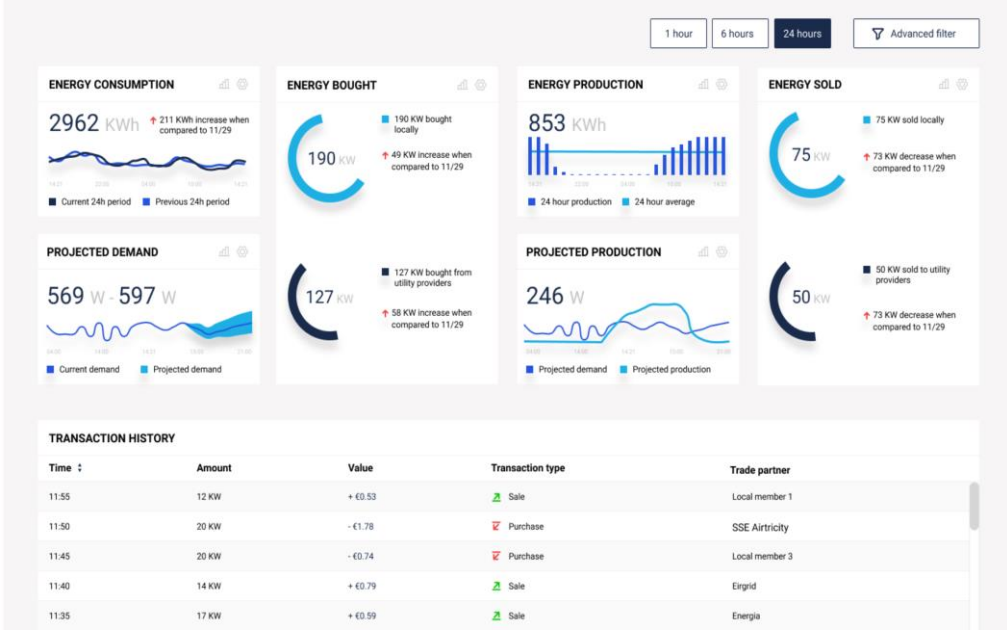
Energy Demand / Consumption Forecasting



Driving User Behaviour

User Experience Led Engagement Research

- Initial Efforts were Project Partner led Design Workshops
- Workshops were led by the IESRD UX Team
  - Initially focused on problem definition (what are we trying to solve?)
  - Identified the specific end-user (initially community-grid operator)
  - Defined the main “Pain-points” that they were experiencing
  - Attempted to define initial dashboard design to define this
- Upon reflection we realised that the main end-user for our tool should instead be the Home-Occupant
- Consequently a more involved desk-based approach was adopted



Driving User Behaviour

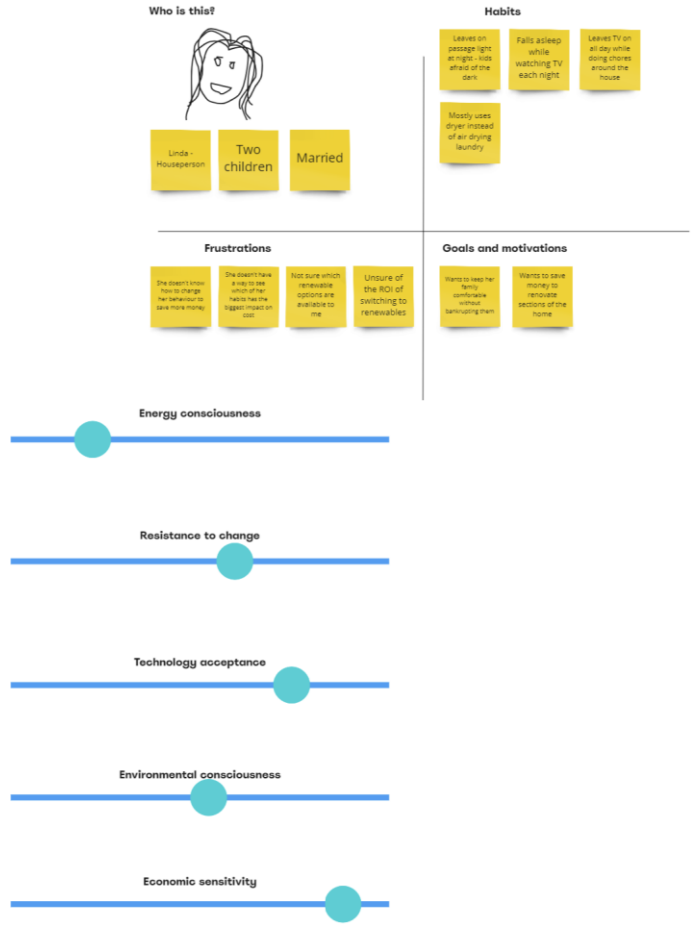
Desk Research Key Findings

- Solutions with real-time feedback and ways to conserve energy is most effective
- Appropriate messaging helps create energy-conserving habits in the long-run, particularly appealing to the users desire to appear eco-friendly
- Energy saving actions that do not jeopardise user comfort levels are crucial in improving user attitudes and acceptance of behaviour change systems
- Many energy-wasting habits need more transparency (to household consumers) about the monetary & social costs of the consumption, for example how leaving the lights on in an unoccupied space can impact the environment
- Typically, improvements in energy consumption decrease at periodic intervals after the initial improvements due to the habituation towards the prompts, cues and information. Responding to cues to conserve energy may become a long lasting habit if implemented appropriately
- Context is vital to devise successful solutions.

Driving User Behaviour

Proto-Persona Development

- Follow-up workshop to define the characteristics of the proto-personae that ESHER wishes to appeal to, in this case a stay at home mom.
- The primary perceived behaviours, frustrations and motivations of this persona was developed through the workshop
- Follow-up interviews with suitable individuals was conducted to validate assumptions
- Learning gathered, coupled with the desk research to provide key inputs to the dashboard design



Driving User Behaviour

Proto-Persona Development

- Age 32
- Stay at home mom
- Dublin

Bio

She does not work, which enables her to tend to her two young children while her husband works full-time. Keeping her family comfortable takes preference over any cost-saving concerning energy consumption.

Frustrations

- She does not know how to change her behaviour to save more money
- She does not have a way to see which of her habits has the most significant impact on the cost
- Not sure which renewable options are available to her
- Unsure of the ROI of switching to renewables

Goals and motivations

- She wants to keep her family comfortable without bankrupting them
- She wants to save money to renovate sections of the home

Energy habits

- Leaves on passage lights at night - kids afraid of the dark
- Falls asleep while watching TV each night
- Leaves TV on all day while doing chores around the house
- Primarily uses dryer instead of air-drying laundry

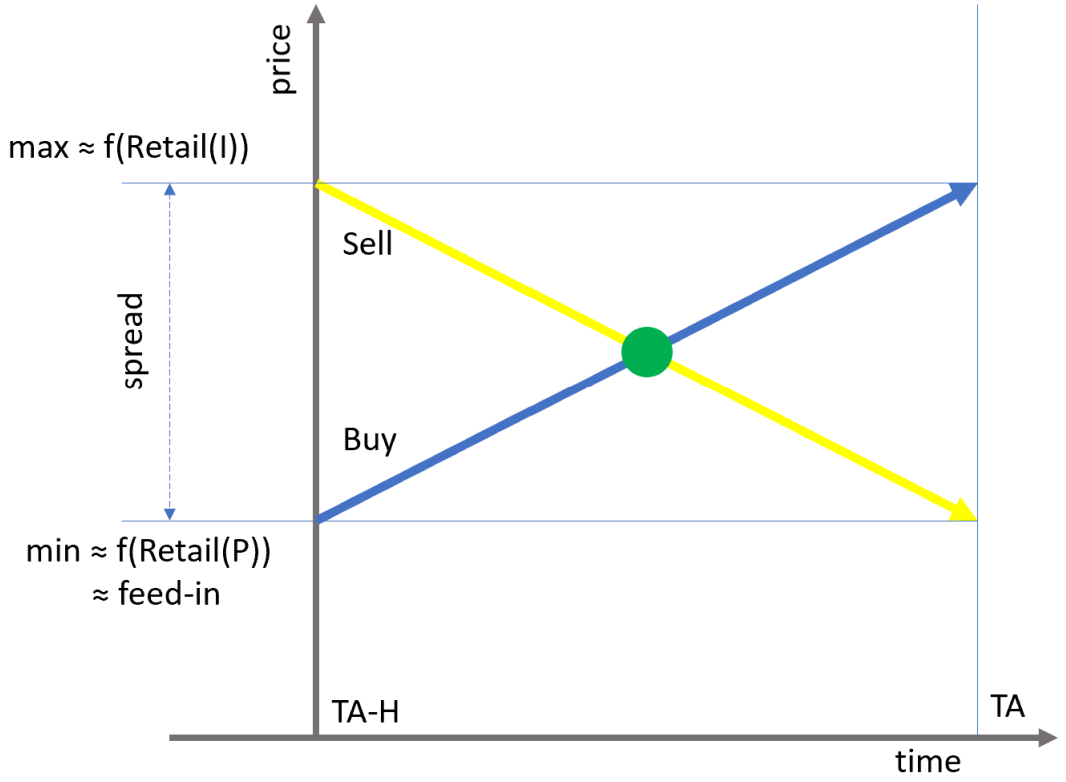
Persona attributes

- Energy consciousness: **Low**
- Environmental consciousness: **Intermediate**
- Economic sensitivity: **High**
- Technology acceptance: **Intermediate**
- Resistance to change: **Intermediate**

Trading Strategies

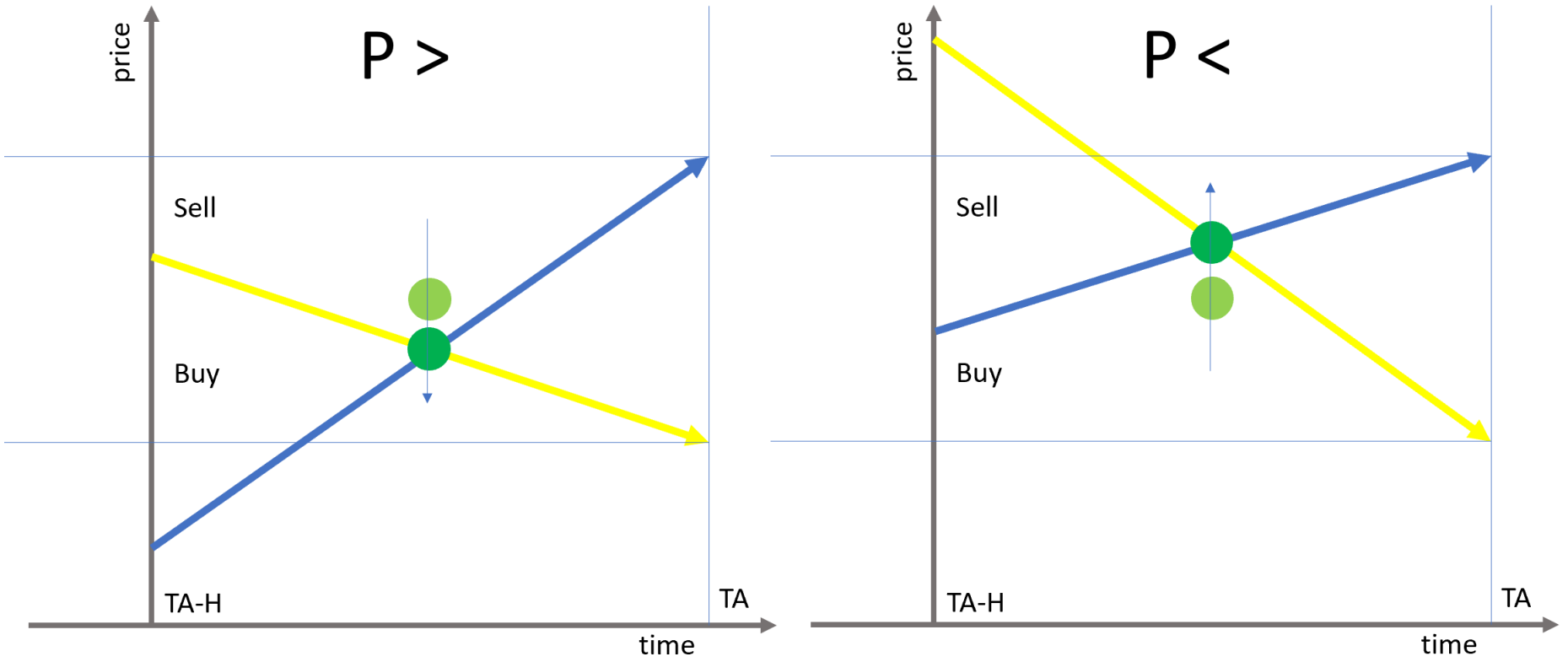
Dynamic Pricing in Hi-SEM:

Trading Strategy following Supply Demand Curve



Trading Strategies

Trading Strategy, starting bid/offer spread



Trading Strategies

Price at t, set by Trading Strategy (IP?)

$$price(TA-H) = \left(1 + ln\left(\frac{1 + c + \sum c}{1 + p + \sum p}\right)\right)(sell = max, buy = min) + \frac{(sell = min, buy = max)}{H-1}t$$

c = consumption forecast, user
$\sum c$ = consumption forecast, community
p = production forecast, user
$\sum p$ = production forecast, community

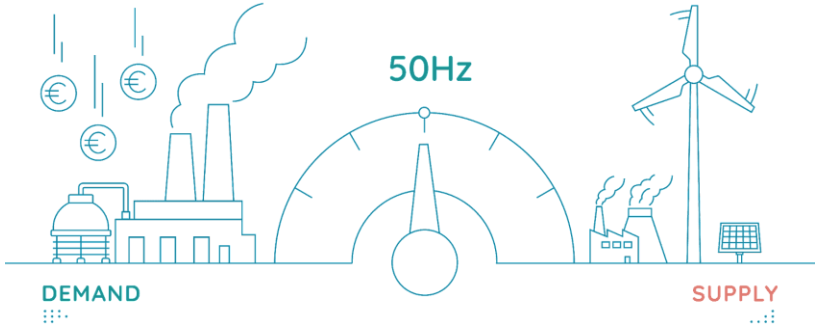
t = time [0,H-1]

Trading Strategies can be highly personalised, but can probably be described as variations of the formula:

- Not using ln function for bid/offer
- Weight of *c*, *p*.
- Non-linear pricing for t > TA-H e.g. to get earlier contracts
- …

Challenges

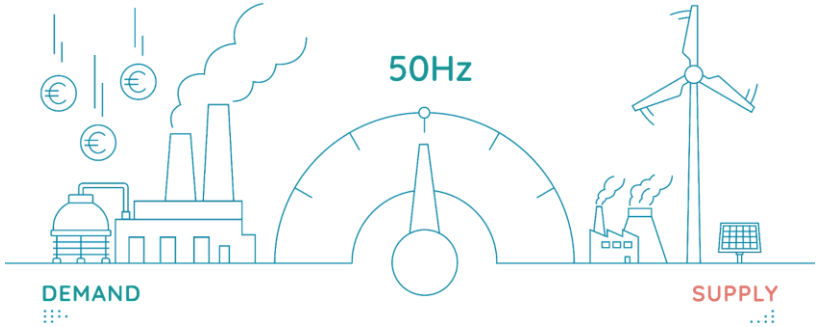
- Engagement of users was hampered by the Covid-19 restrictions
- Project delays made retaining stakeholder enthusiasm difficult
- Selection & installation of hardware solutions within Homes has a higher level of complexity owing to the low tolerance for disruption & aesthetic requirements of homeowners
- Software tools required to be used for DR & Energy Trading can be a limitation to (near) real-time energy services due to latency delays
- Engaging occupants to alter their behaviour is a complex and challenging process and generally needs to be delivered by highlighting the monetary and social costs of not changing



https://sympower.net/what-is-demand-response/

Next Steps

- Testing & Validation of User Dashboards and their ability to drive behavioural change amongst occupants
- Training of occupants in the use of the ESHER platform
- Some outstanding software integration
- Development of Time of Use Tariffs and their impact within a Trading Platform



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Questions