The Whole Energy Systems Accelerator

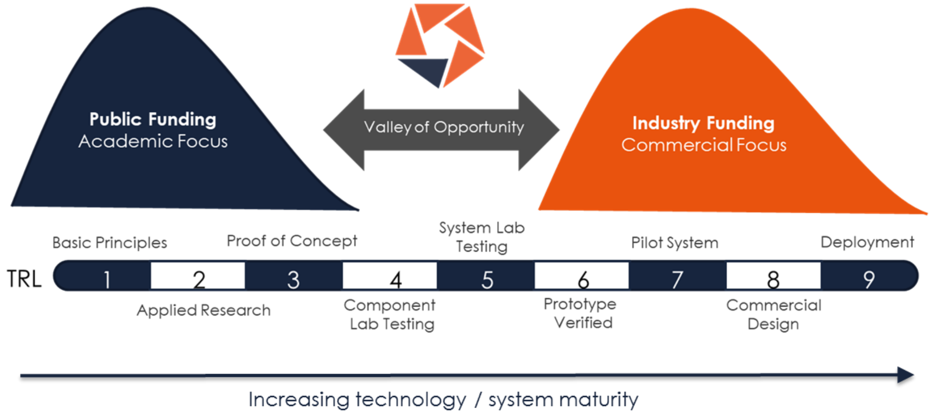
28 February 2024

Agenda

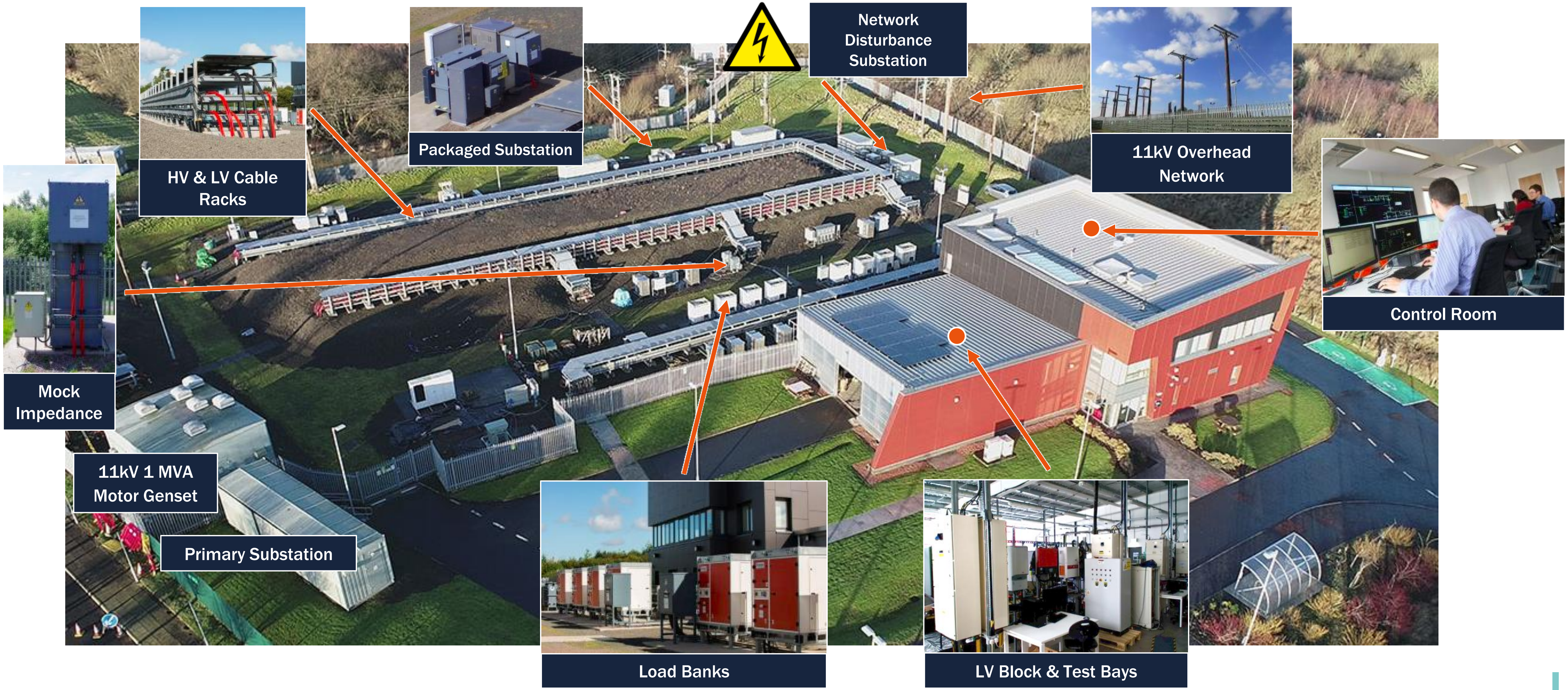
Section
Introduction
Concept of the Whole Energy System Accelerator (WESA)
Deep Dive into WESA Technical Aspects
Case Studies
Conclusion

PNDC Overview

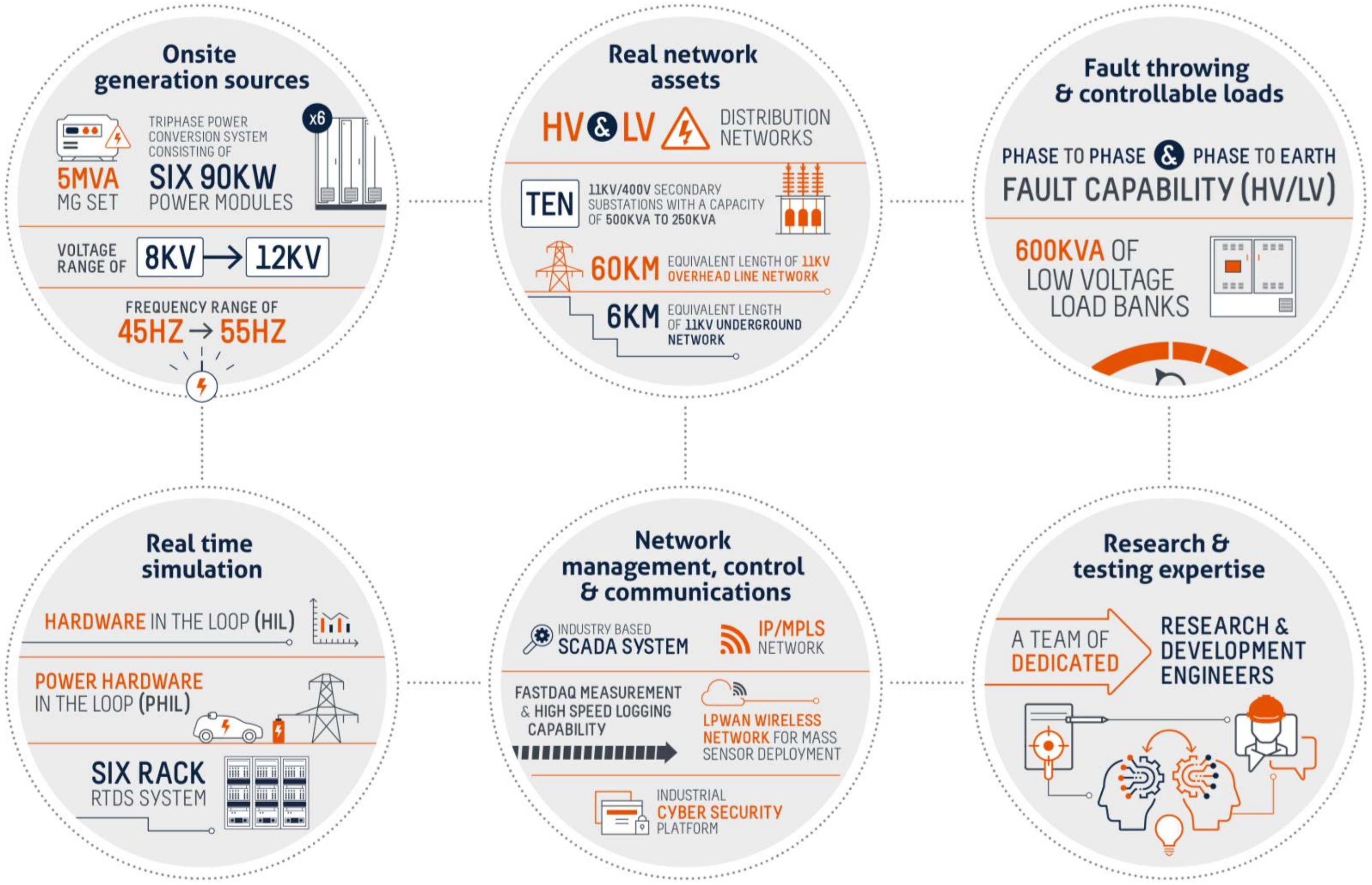
- Dedicated innovation facility, opened in 2013
- Part of the University of Strathclyde
- Focus on accelerating the development and deployment of novel energy, marine and aerospace technologies
- Dedicated expert team (~ 40 staff)
- Operated in partnership with members
- Multiple collaboration models
- Open access for engagement with Industry for projects



PNDC testing & demonstration capability

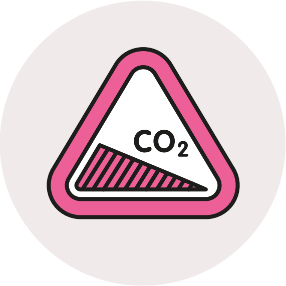


PNDC testing & demonstration capability



About Energy Systems Catapult

Mission: Unleashing innovation and opening new markets to capture the clean growth opportunity



Why do we exist?

To accelerate Net Zero innovation and deliver the future energy system

How do we work?

We do the hard stuff by taking a whole systems approach to Net Zero

What do we do?

Turboboost innovation across homes, sites, places, whole systems & networks.
Design a future energy system to drive clean growth and benefit people.

We work with
Innovate UK

Power Hardware in Loop ✓

Power Hardware in Loop ✓

+

Pesky Humans in Loop

Why do we need pesky* humans?

Humans – AKA consumers – are an essential part of the energy system.

But they have complicated needs. They live in different homes. They have different lifestyles. And they have many demands on their time and attention.

They often don't understand energy, or energy tech, very well.

They do things that seem irrational to engineers (but may seem *totally* rational to them).

And they can be quite difficult to predict.

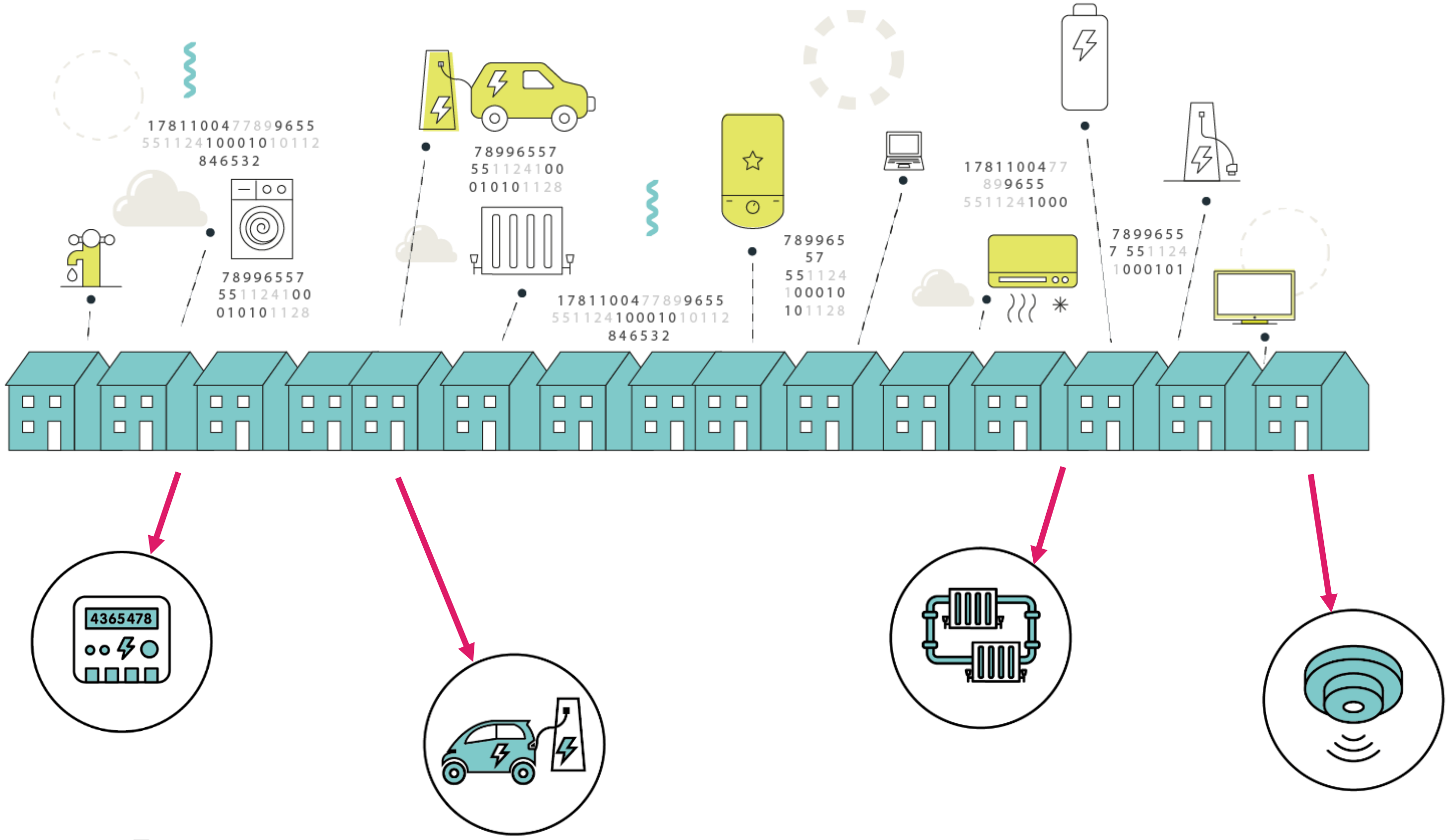
*We love them really

Energy Systems Catapult's Living Lab

UNIVERSITY of STRATHCLYDE PNDC

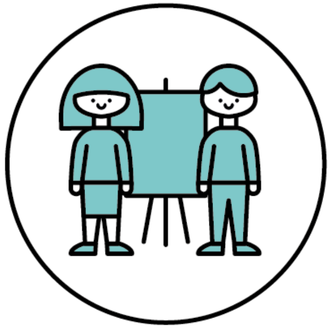
CATAPULT Energy Systems

A community of **2,400 diverse real households** who want to help the UK get to Net Zero



Digital infrastructure to communicate with **smart meters, electric vehicles, heating systems** and **environmental sensors** (and more to come…)

Consumer insight capability to **understand the user experience** of energy innovations



The Whole Energy Systems Accelerator

Scottish Government
Riaghaltas na h-Alba

Innovate UK

UNIVERSITY of STRATHCLYDE PNDC

CATAPULT Energy Systems

Digital infrastructure linking the two facilities

- Creation of **alternative future energy system scenarios**
- Grounded in **real homes and network assets**

WESA
Whole Energy Systems Accelerator

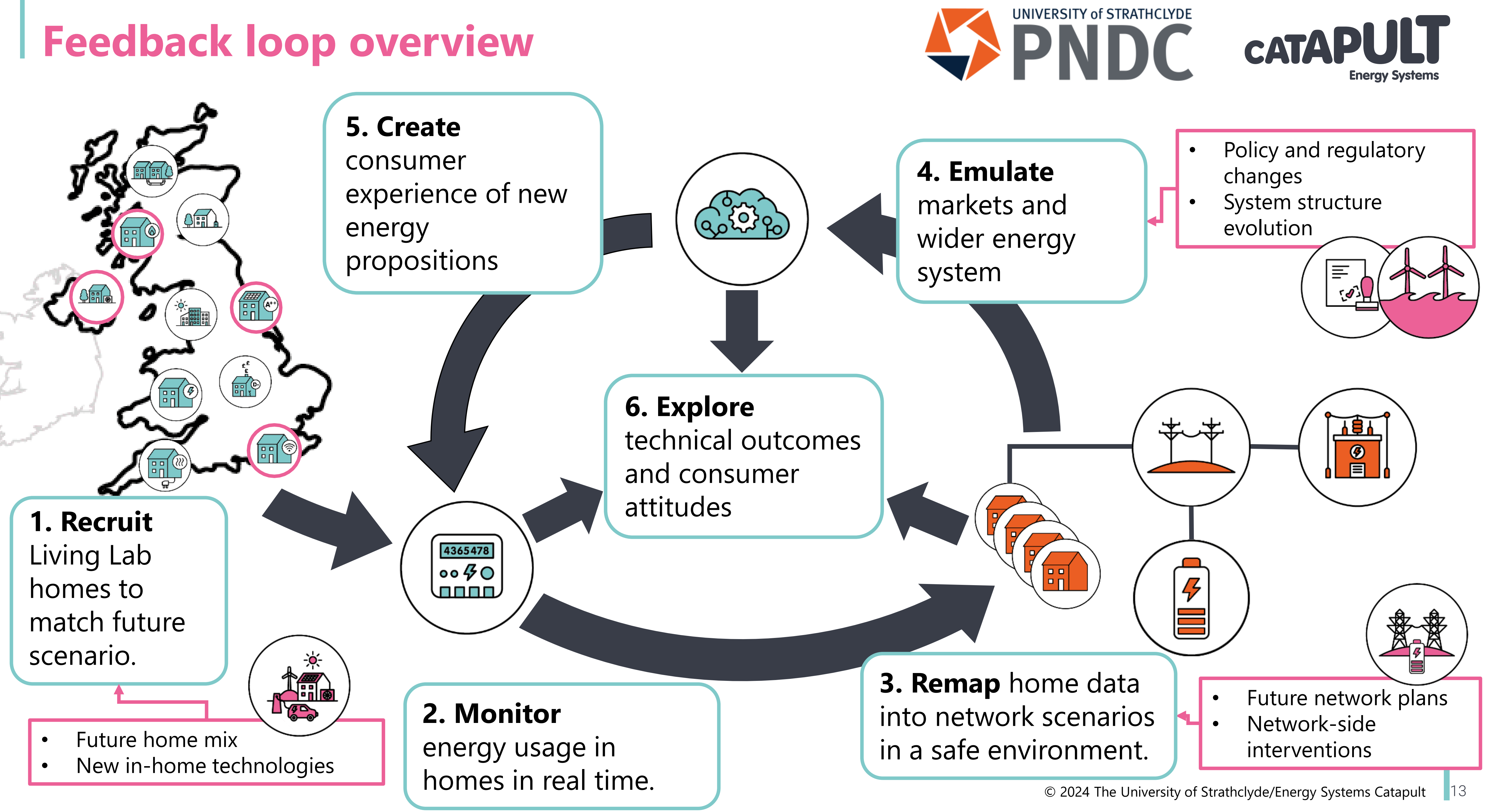
UNIVERSITY of STRATHCLYDE PNDC

LIVING LAB

- Technical, multi-vector testing capability
- High-fidelity infrastructure representation
- Safe separation from the real system

- Real consumers and homes
- Behaviour patterns and responses to interventions
- Ability to understand actual consumer experience

Feedback loop overview

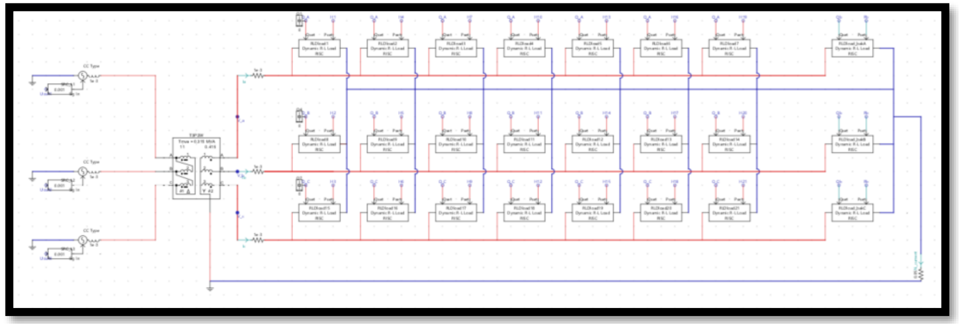


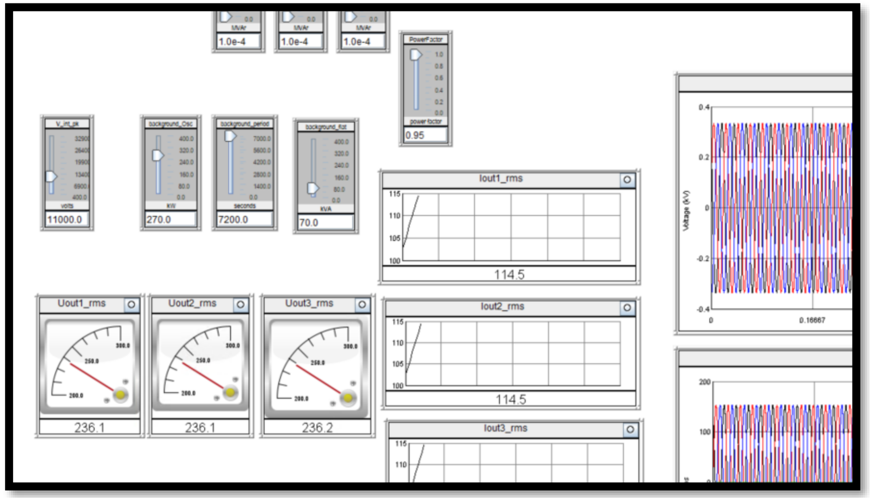
Real-Time Digital Simulator

UNIVERSITY of STRATHCLYDE PNDC

CATAPULT Energy Systems

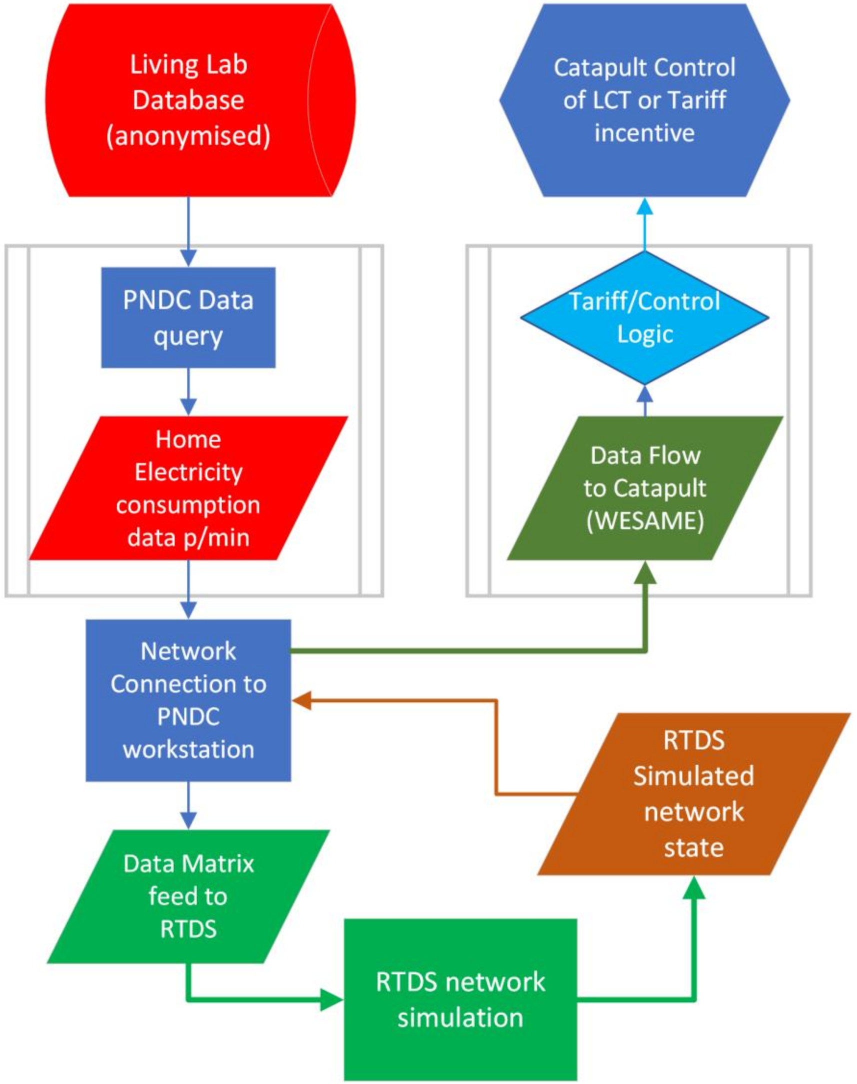
- Transient Electrical circuit simulation software running on real-time capable hardware.
- Real-time network solution for interfacing with real world,
  - Simulated network can be solved synchronously while controlling external hardware "in the real world".
- Able to represent complex electrical transmission topologies, distribution networks, generation, control, protection plus DC systems and power electronics
- Solves network model discretely at pre-defined steps,
  - Ranging from a few microseconds for power electronics components, and typically 35-50 microseconds for network models.



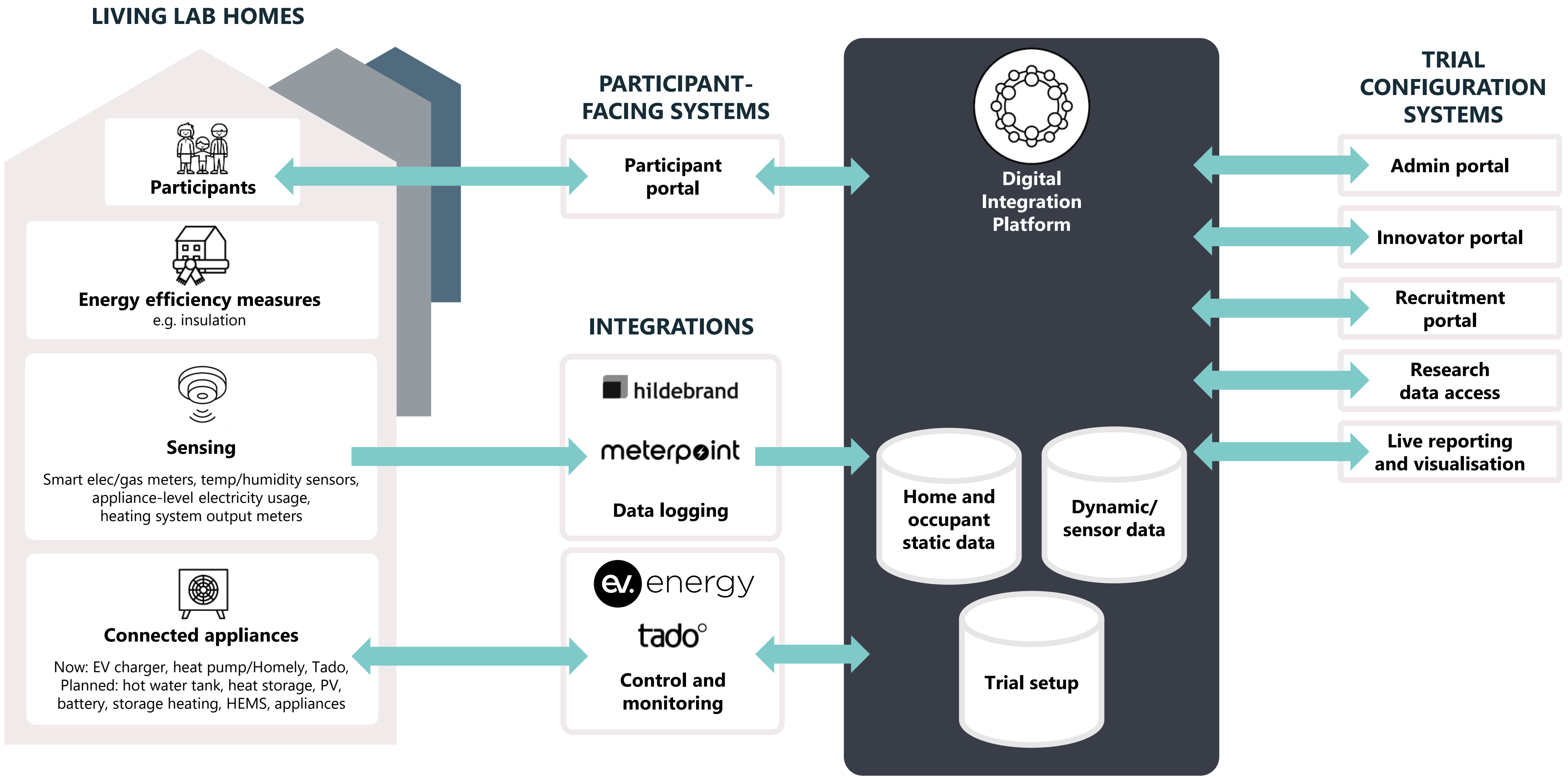


PNDC Data Flow

- Python-based network connection software tool
- Collects Living Lab data from cloud-hosted database – anonymised energy consumption
- Data securely copied and fed to RTDS via network TCP/IP socket
- RTDS simulated Network measurements are returned to the cloud-hosted database, and Energy Systems Catapult use WESAME market emulator to make control decisions based on the network state and consumer tariff

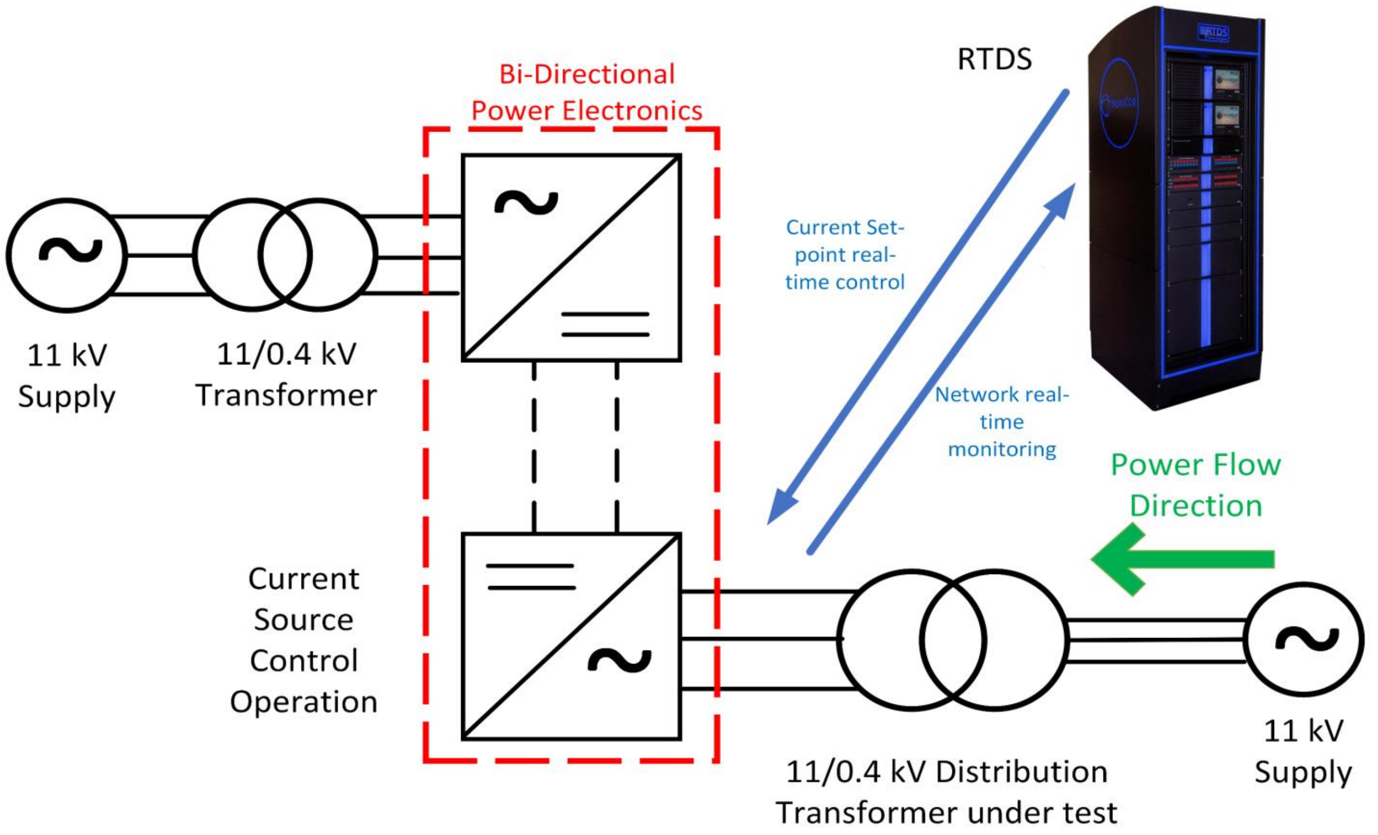


Living Lab architecture

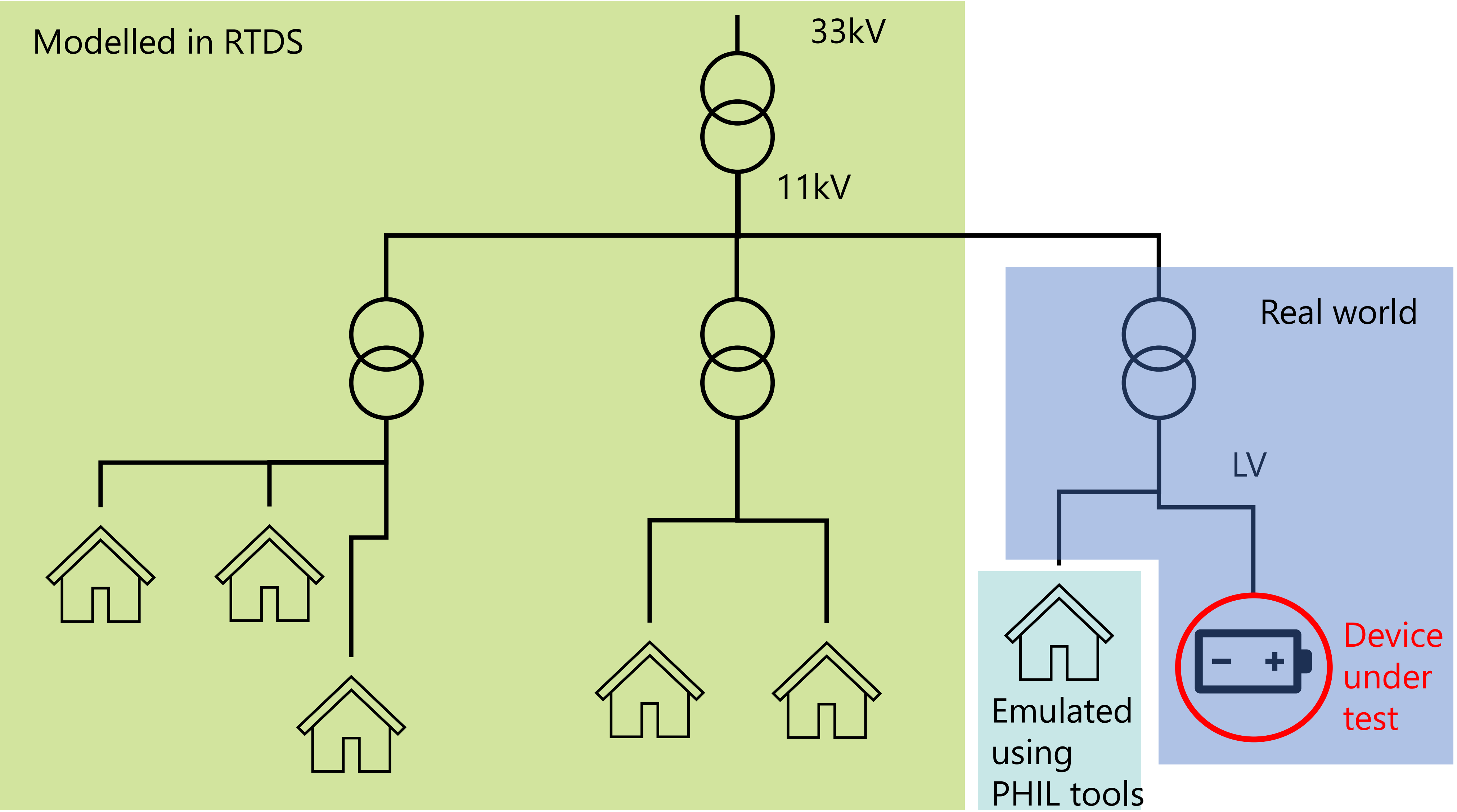


Power-Hardware-in-the-Loop

- Example PHiL configuration for WESA
- Studying network impact by loading real distribution transformer with modelled scenario data.
- Other options
  - Energy storage connected at substation
  - Protection systems
  - Other power electronics
  - e.g: Soft Open Point hardware



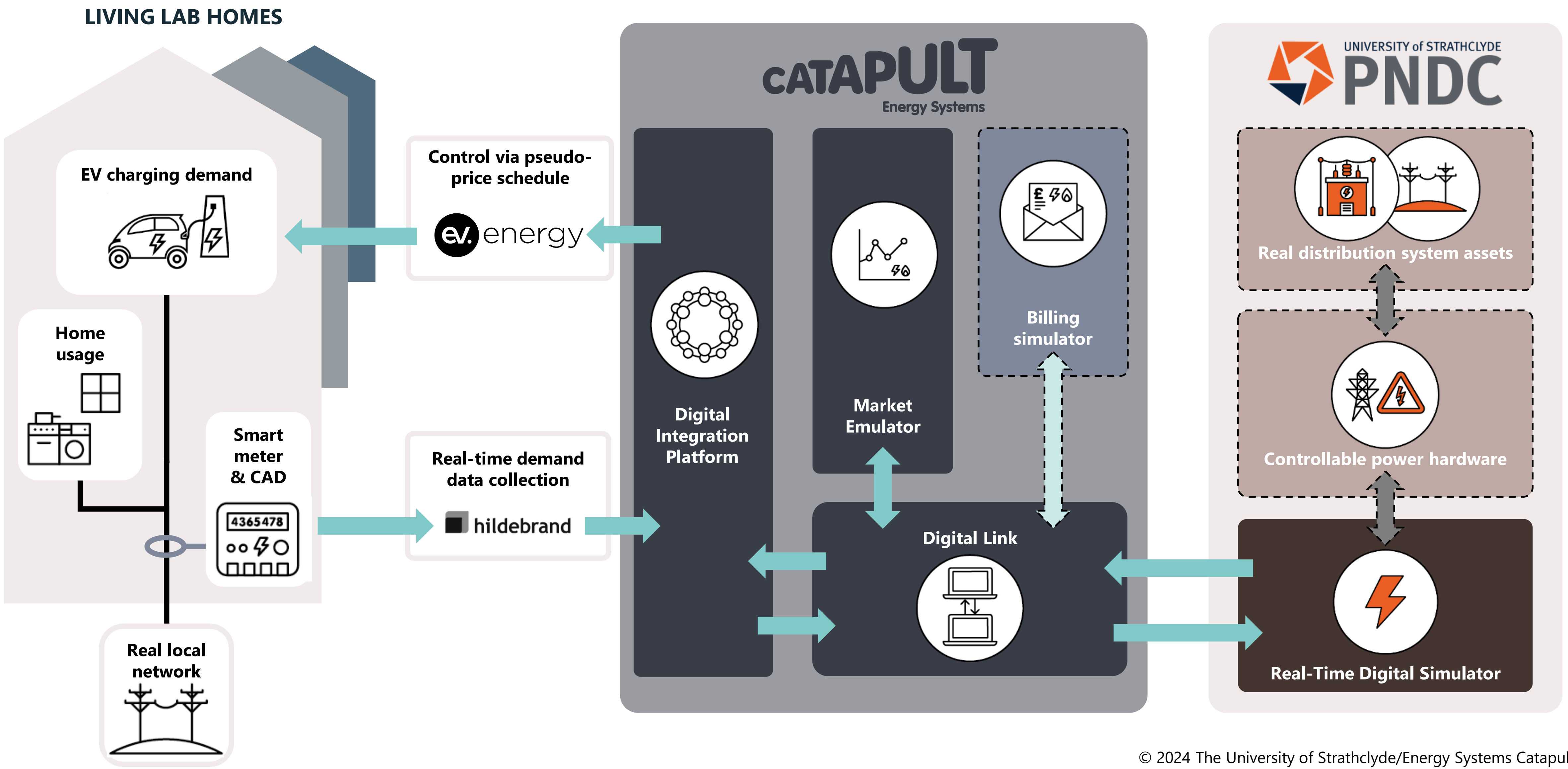
Example structured network configuration with PHIL



Example scenario

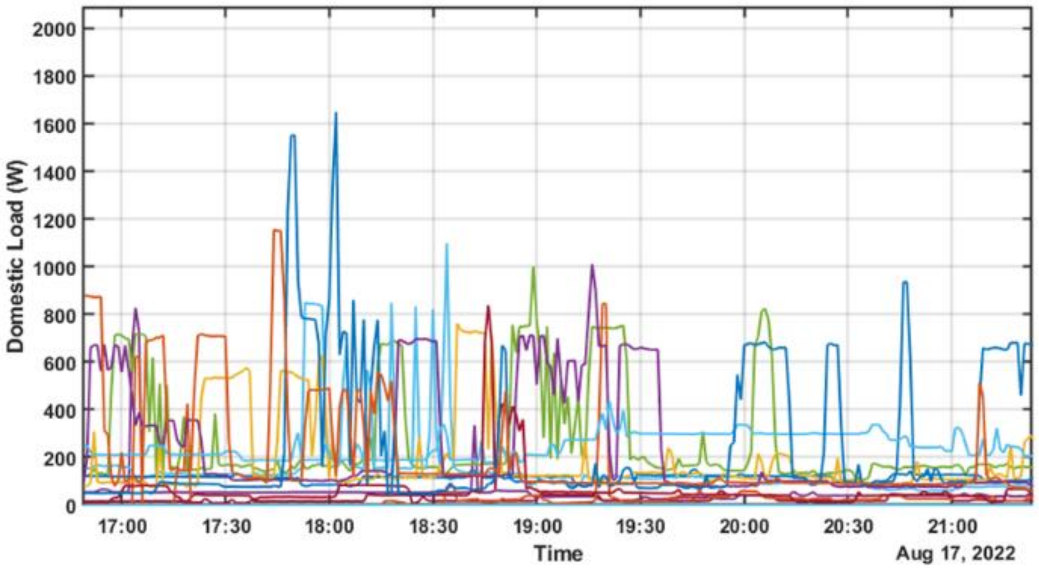
- Management of thermal constraints at Low Voltage
- Real-time Distribution System Operator decision-making
- DSO direct dispatch of domestic assets
  - Analogous to “Secure” service in Great Britain

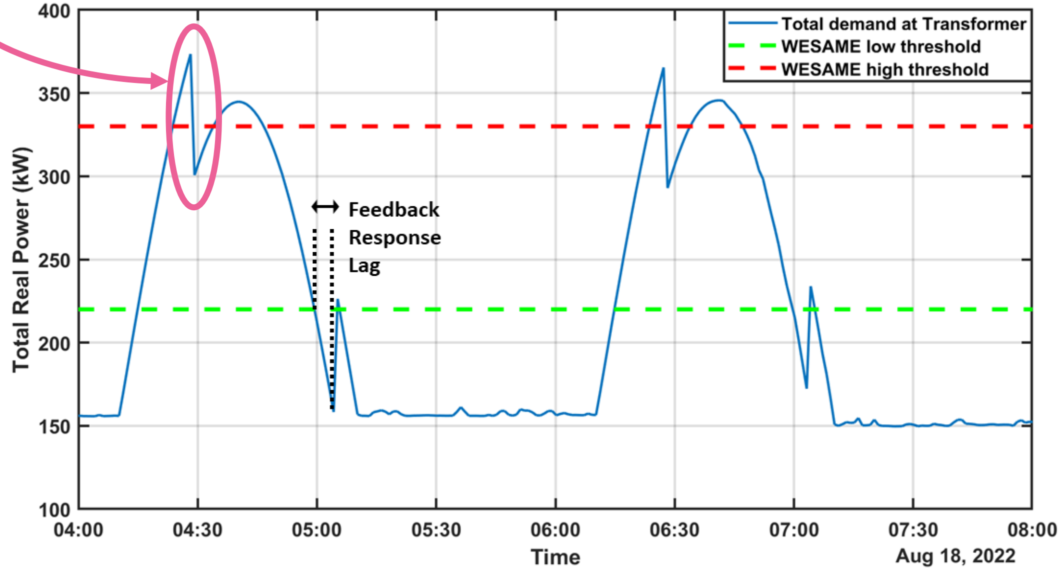
WESA configuration



Results

- 10 Living Lab homes + sinusoidal base load
- 2 domestic 7kW EV chargers
- Threshold-based control
- Demand scaled to match network definition
- Demonstrates management of real-world demand
- …but also limitations of real-time control





Neighbourhood Green

UNIVERSITY of STRATHCLYDE PNDC

CATAPULT Energy Systems

Aim: Assess future normal domestic loads and After Diversity Maximum Demand (ADMD) and its impact on the grid

Approach:

- Gather historic data/insight from Living lab homes and other trials
- Real world trial at 60 homes with at least one form of LCT to monitor energy usage over time
- Virtual clustering of living lab homes and assessing the impacts in different weather conditions including extreme scenarios at PNDC

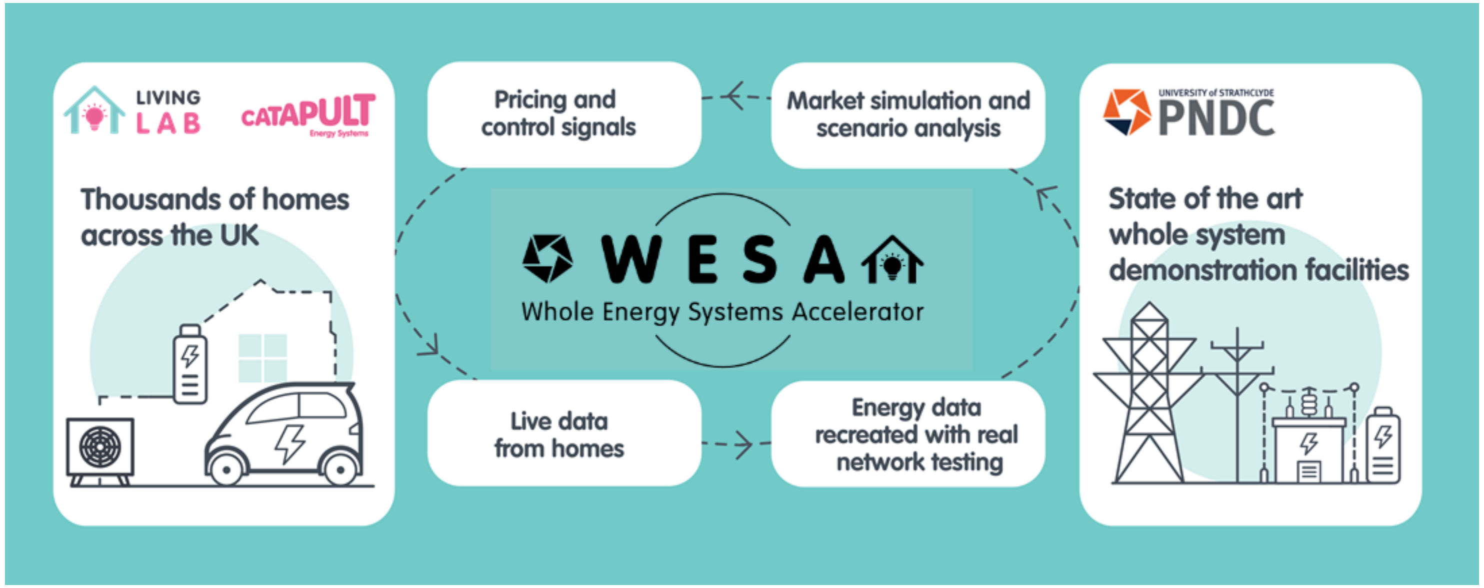
Learnings:

- Under severe weather
- HPs run at full capacity --> no ADMD
- ~20% HPs on UK GDN --> 20% transformer overloading
- 50% HP --> transformer overload by 60% --> hotspot temperature of around 150°C --> significant reduction of transformer life

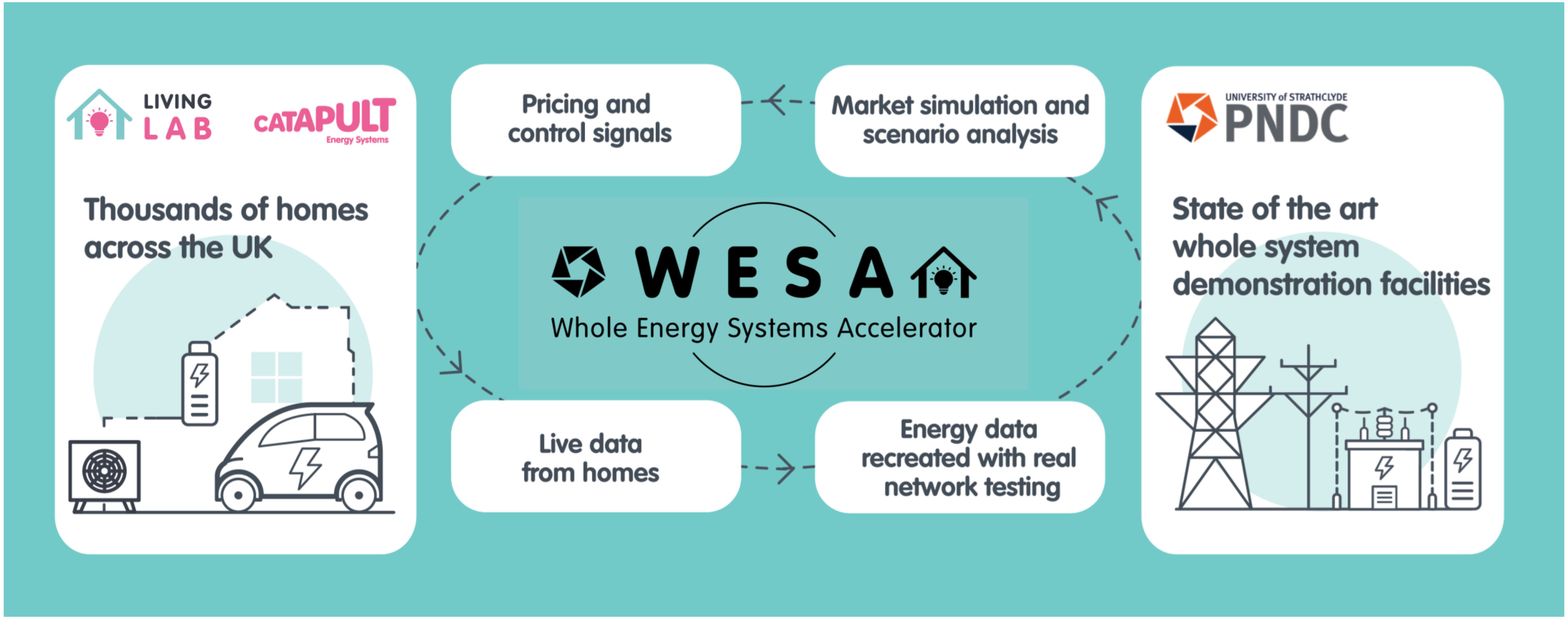
EXTEND

Aim: Develop, test and demonstrate a new generation of thermal storage optimised for space heating that allow homeowners to decarbonise their homes, and understand the network impact and flexibility benefits of an aggregated fleet of Sunamp thermal storage devices.

Approach:



WESA combines the Living Lab with PNDC's capabilities



- **Real-time monitoring and historical data** for homes at device and whole-home level
- **Network impact studies** – *in silico* and real-world via Power-Hardware-in-Loop (PHiL)
- **Future LCT uptake scenarios** by tailoring consumer population
- **Future electricity market** emulation
- **Feedback for pricing/control signals** to participating homes to influence demand
- **Consumer insight** into experiences of new technologies and propositions

Considerations and constraints

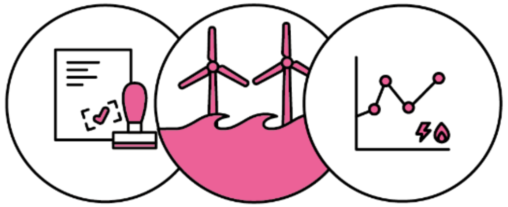
- Forms of flexibility
- Geographically distributed households
- Distribution network levels
- Real-world scaling
- Technology automation roadmap

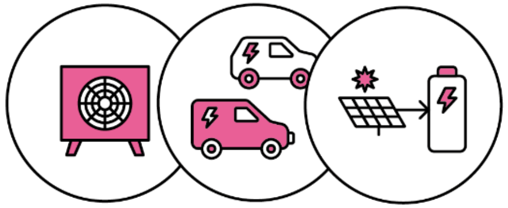
What can WESA do?

UNIVERSITY of STRATHCLYDE PNDC

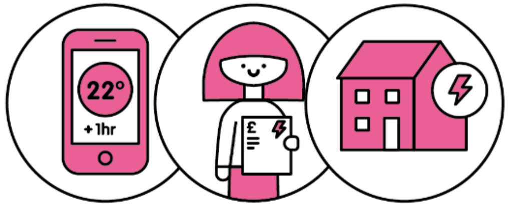
CATAPULT Energy Systems

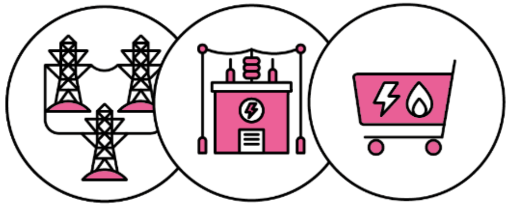
We ...





So we can...





Simulate future market conditions in a safe sandbox

- New policies and regulatory changes
- New consumer propositions, such as retail tariffs
- Changes to system structure, such as changes in generation mix, level of network reinforcement, uptake of consumer LCTs
- New consumer-facing entities, e.g. V2G/H providers

Control low carbon technologies in homes

- Send pricing and control signals to EV chargers, heating systems, (more to come).
- Capture consumption data and usage of LCTs

Understand the consumers' experience of living 'in the future'

- Testing new technologies
- Trialling new retail propositions
- In-home monitoring of energy usage and outcomes
- LCTs in homes responding to pricing and control signals
- Realistic simulated bills and incentives
- Insights research to understand their behaviours, experiences and opinions

Observe real effects on networks and other market players

- Would a new product, service, network technology, or policy/regulation deliver the intended benefits to the system?
- Are there unintended consequences?

Thank you

pndc.co.uk
pndc@strath.ac.uk
@PNDC_UK

es.catapult.org.uk
wesa@es.catapult.org.uk
@energysyscat