HIGH EFFICIENCY HEAT PUMPS

Using system for both heating and cooling

Group 6

Varun, Somya, Xiao, Charles

Sprint 1, 2, 4

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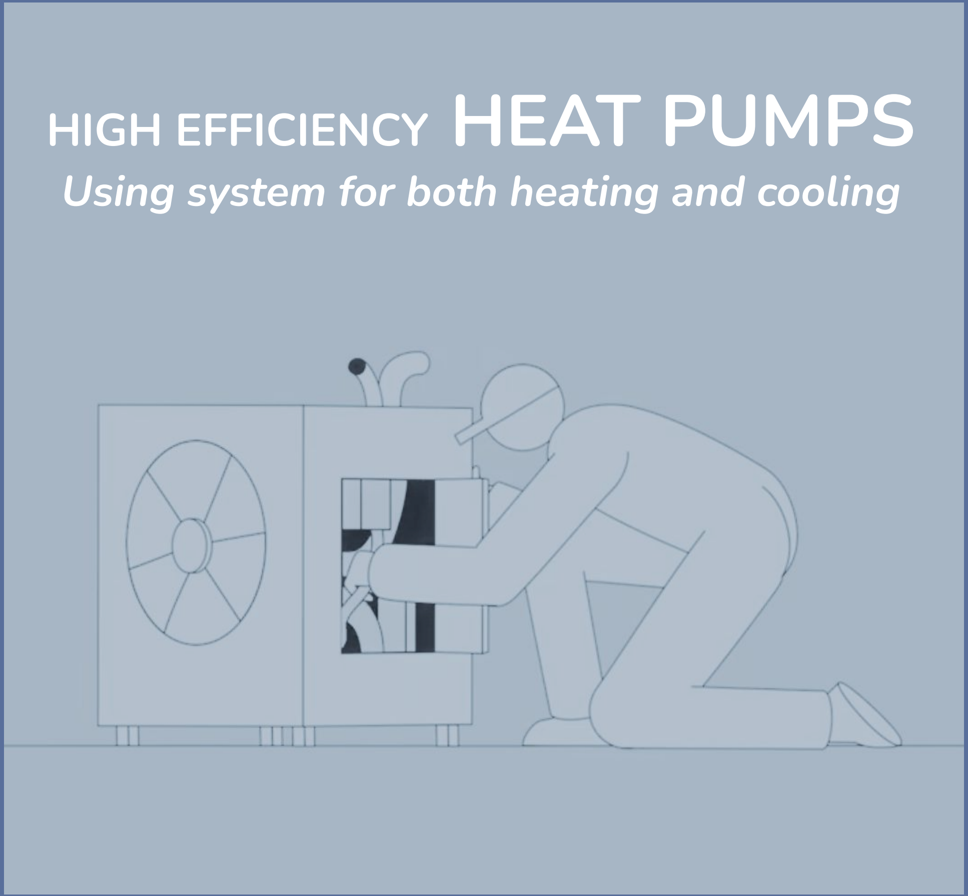

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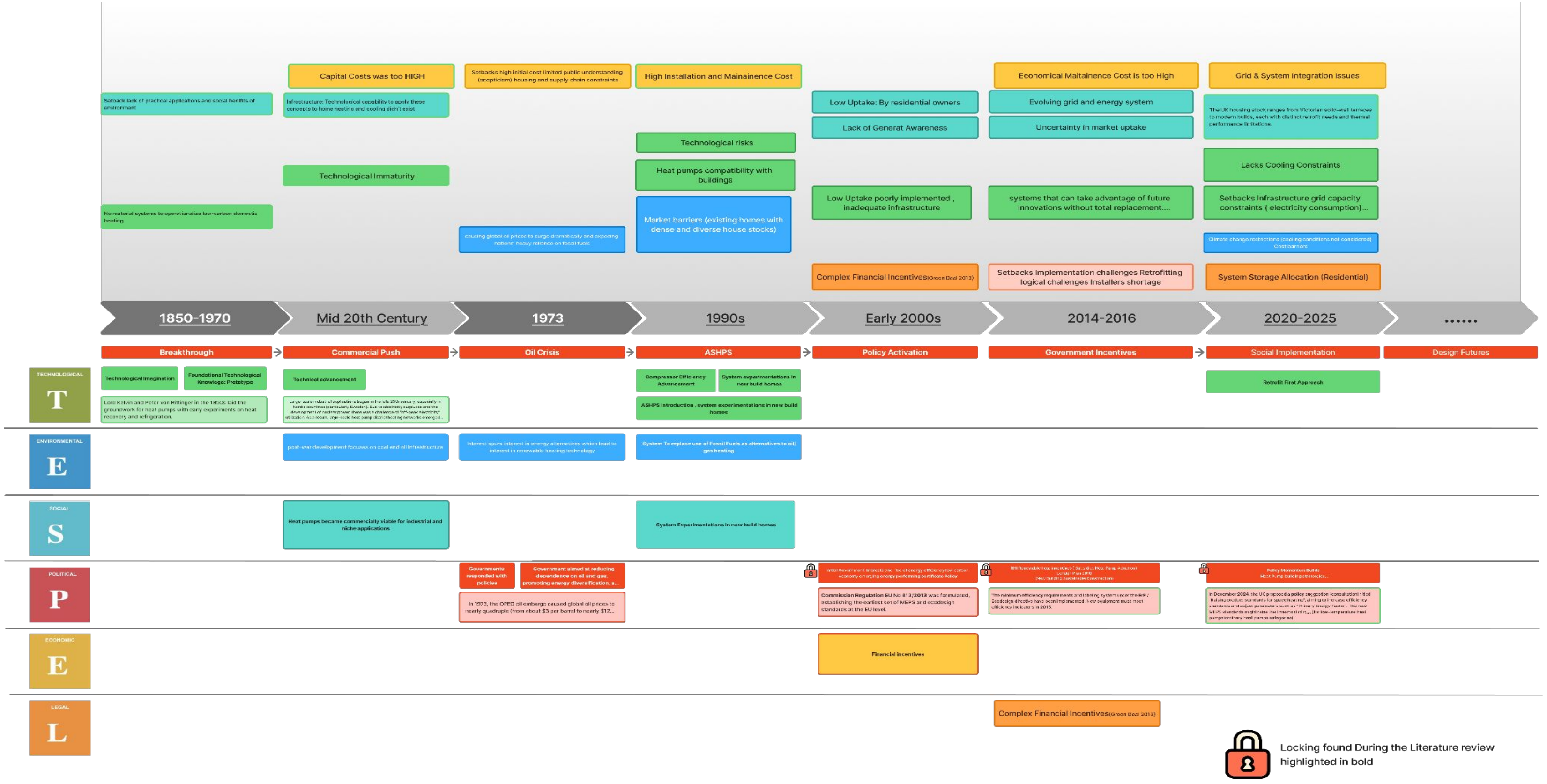
RESEARCH METHODOLOGIES UNIT

Sprint 1

SPRINT 1-Timeline and PETSEL



European Heat Pump Association (EHPA) (2022) *Heat Pumps in Renovation Update 2022: The Most Flexible Technology When Renovating Any Kind of Building.* Brussels: EHPA.

SPRINT 1-Timeline and PETSEL

1850-1970

Breakthrough

Scientists like Lord Kelvin did early theoretical experiments that laid the groundwork for heat recovery and thermodynamics. But expensive expenses and technology that wasn't ready for real-world use kept it from being used in the actual world.

Significance: This is where heat pump technology first came to mind in science, before it was put to use in real life.

1973

Oil Crisis

The global oil crisis showed how fragile fossil fuel dependence is, which got people and politicians interested in renewable heating options.

Importance: This is a historical turning point where outside events changed the priorities for energy innovation.

2014-2016

Government Incentives

The UK started the Renewable Heat Incentive (RHI) and MCS certification, which formed the first regulated market for renewable heating systems.

Importance: A time to bring together policies and make heat pumps a part of national plans to cut carbon emissions.

2020-2025

Social Implementation

The UK has a legally binding goal of reaching net zero by 2050, and the Boiler Upgrade Scheme (BUS) helped speed up adoption by providing money and rules.

Importance: This is the social implementation stage, when heat pumps go from being a specialty technology to a popular one in the energy transition timetable.

SPRINT 1-Timeline and PETSEL

Political

1. Early incentives for renewables favored solar PV over heat pumps, which slowed the growth of the heat pump business.
2. The Renewable Heat Incentive (2011, started in 2014 for homes) was the first big UK initiative to boost heat pumps.
3. London Climate Change Mitigation & Energy Strategy (2011): GLA sets goals for heating that doesn't use carbon.
4. The London Environment Strategy (2018) called for the end of heating using fossil fuels.
5. COVID-19 recovery plans (2020): Energy efficiency/retrofit plans included heat pumps.
6. GLA initiatives: London boroughs are trying out low-carbon heating projects and heat networks.

Economic

1. Gas grid dominance: Since the middle of the 20th century, we have relied heavily on natural gas, which makes it tougher to switch to low-carbon heating.
2. Low uptake since the application process is complicated and there are charges up front.
3. Barrier: Gas boiler installations are still subsidized and cheaper, which locks in the path.
4. Boiler Upgrade Scheme (2022): £7,500 grant led to more people using it.
5. Record installations in 2023–2024: over 250,000 certified heat pumps in the UK → market trust goes up.
6. Mechanism: Paid homes and businesses every three months for seven years to make renewable heat.

Technological

1. Building stock legacy: Old housing stock (Victorian/Edwardian terraces, mid-century flats) → bad insulation and problems with retrofitting.
2. MCS is the UK's quality mark for small-scale renewable energy systems like solar panels, heat pumps, and battery storage. are put in place by skilled workers who use high-quality materials that meet strict safety and performance criteria.
3. Dependence: BUS depends on RHI's MCS framework, while local pilots depend on national funds.

Social

1. Low uptake in London was due to bureaucracy and high upfront expenses. This also shows social acceptance obstacles and behavioral inertia.
2. Market confidence goes up (2023–2024) because more people trust and know about low-carbon heating methods.

Environmental

1. Policies like the London Environment Strategy (2018) and the Net Zero by 2050 regulation, which aim to decarbonize heating systems and make them more energy efficient, show this indirectly.

Legal

1. IRHI → established certification systems (MCS)*, which shaped later policies (BUS requires MCS-certified installs).
2. IParis Agreement (2016 UK ratification) → locked UK into net-zero planning.
3. UK Net Zero by 2050 law (2019): Long-term commitment → pushed heat pump onto central stage.
4. Dependency: Legal net-zero → shaped Boiler Upgrade Scheme design.
5. Future Homes Standard (2025) depends on legal net-zero trajectory.
6. RHI – Renewable Heat Incentive (2011–2022): Created the first certified market for heat pumps under government legislation.

UK Department for Business, Energy & Industrial Strategy (BEIS) (2021) *Heat and Buildings Strategy*. London: HM Government.

Summary of Sprint 1

Using the PETSEL with a timeline approach makes it easier to understand the heat pump transition in both structural and temporal terms. PETSEL shows how political, economic, technological, social, environmental, and legal forces affect each other. The timeline shows how these forces have changed and depended on each other over the years. They show important lock-ins, including gas infrastructure and policy delays, as well as turning points, like RHI and BUS. The strength is in linking policy history to systemic change, even while it might make complicated relationships easier to understand. This combination strategy does a good job of showing how the UK heat pump landscape has changed over time.

Problems Statement of Sprint 1

We want to find out what the best way to heat and cool homes in 2035 is, when most homes utilize high-efficiency heat pumps. We will focus on how this technology can make people more comfortable and healthy indoors, as well as how it can make a big difference in energy efficiency and the environment. We will look more closely at how heat pumps can help make living spaces more adaptable and durable, so that they can meet the demands of future generations. We will also look at how governments, energy companies, and housing authorities are involved in pushing and regulating these changes. This will make sure that using heat pumps not only meets the need for eco-friendly heating and cooling, but also helps build communities that are ready for the future.

Signals

Noises

- Early work on **refrigeration/heat transfer**
- developed the first practical heat-pump
- **GSHPs** and electrically driven compression heat pumps became more practical

- Online debates & homeowner complaints about heat pump, space, or upfront cost.
- Small-scale experimental technologies (e.g. hybrid heat pumps, shared ground loops).
- Advocacy groups pushing social media campaigns, but not mainstream awareness.

Weak Signals

- **RHI** (2014 domestic launch): First dedicated policy for renewable heat.
- **Growth of MCS** (Microgeneration Certification Scheme) creating a standardised installer base.
- Early niche adopters in **eco-conscious households in London suburbs.**

- Public perception shift: More neutral/positive press coverage; heat pumps mentioned in home-buying advice.
- London Borough pilots (e.g. Camden, Hackney) testing heat networks with heat pumps.
- Growth of skilled workforce programs (training colleges in Greater London offering heat pump installer courses).
- Property developers starting to market “heat pump-ready homes.”

Strong Signals

- UK **Net Zero 2050 law (2019)**: Put decarbonisation of heating firmly on policy agenda.
- **Declining cost of heat pump tech globally** (esp. in Scandinavia).
- **Recognition in London Environment Strategy** (2018) that fossil heating must be phased out.

- Boiler Upgrade Scheme (2022, grant increased 2023): Making upfront cost competitive.
- Future Homes Standard (2025): Gas boiler ban in new builds → inevitable lock-in of heat pumps.
- Clean Heat Market Mechanism (2025 launch): Forcing supply chain to pivot.
- Record installations (2023–2024): 250k+ heat pumps certified UK-wide → shift from niche to mainstream.
- Net Zero strategy updates repeatedly highlight heat pumps as central to UK’s energy transition.

Past till 2020

Present 2021 - 2025

European Heat Pump Association (EHPA) (2022) *Heat Pumps in Renovation Update 2022: The Most Flexible Technology When Renovating Any Kind of Building.* Brussels: EHPA.

Signals

Boiler Upgrade Scheme (BUS)

Applicable in England and Wales. This scheme provides an upfront subsidy of £7,500 for both air-source and ground-source heat pumps for residential and small non-residential installations. The scheme runs from 23 May 2022 to 31 December 2027. The budget for the 2025/26 fiscal year is £295 million.

The government provides subsidies to encourage

The Clean Heat Market Mechanism (CHMM)

It takes effect on April 1, 2025, and will run until at least 2029. It is not a household subsidy, but rather an annual "clean heat quota" obligation for fossil fuel boiler manufacturers: boiler manufacturers must match their boiler sales with "credits" earned from installing their own or purchased heat pumps, and failure to meet these requirements will result in civil penalties. This mechanism aims to "force the boiler industry chain to shift production capacity, channels, and services toward heat pumps," and is currently the UK's most direct policy tool influencing manufacturing investment decisions.

The government ask companies to reduce cost

Zero-Rated Value Added Tax (0% VAT) - Energy-Efficient Material Installation

From April 1, 2022, to March 31, 2027, the installation of "energy-efficient materials" (including heat pumps) in residential buildings will be subject to 0% VAT (after which the reduced rate will revert to 5% under current legislation, unless further extended). This significantly reduces overall costs for residents and indirectly increases the certainty of manufacturers' order forecasts.

The government cuts taxes to encourage

On April 30, 2025, the government announced an additional £5m to continue the Heat Training Grant until March 2026, expanding the installation and operation and maintenance talent pool and alleviating the talent bottleneck facing industry expansion.

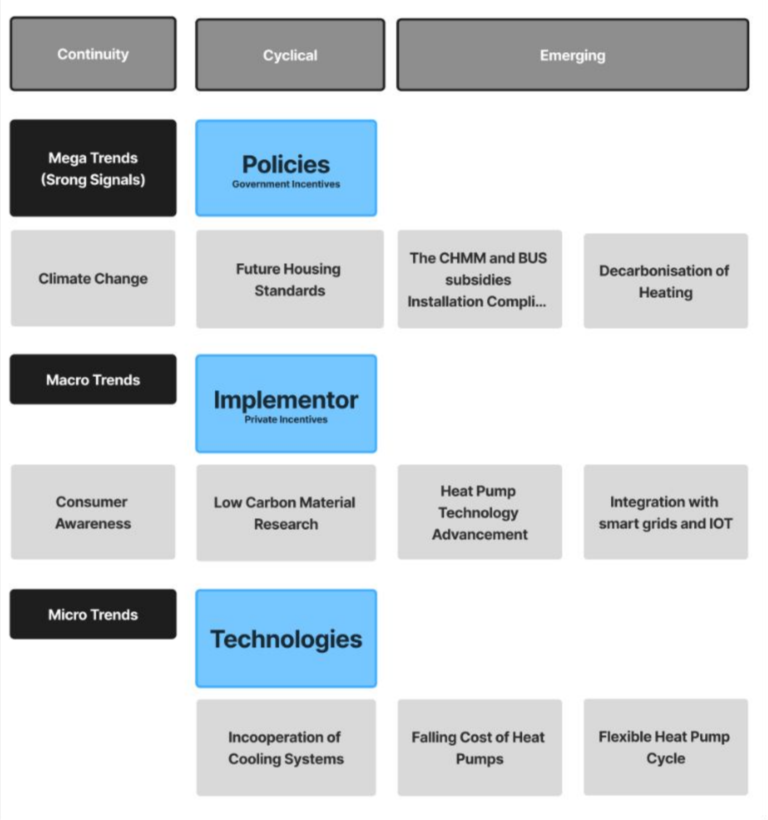
Government training of technical personnel

Government are seeking views on proposals and draft statutory instrument to improve ecodesign and energy labelling legislation to increase the performance of space heating products.

Government raises standards for space heating products

National Grid ESO (2022) *Future Energy Scenarios*. Warwick: National Grid ESO.

Trends

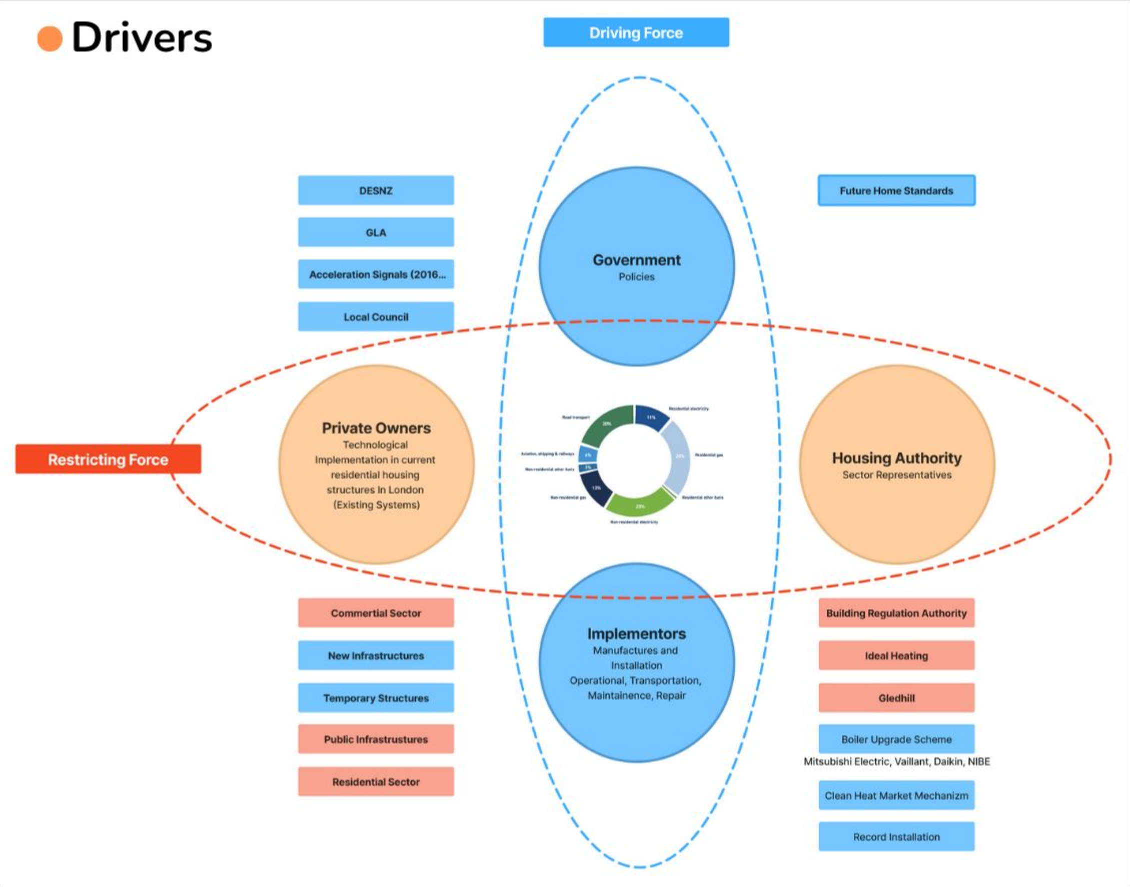


The government is promoting industry development through policies and subsidies, while companies are continuously innovating in low-carbon materials and intelligent technologies. Technically, this is reflected in cost reduction, functional integration, and system optimization. Overall, policy guidance, market momentum, and technological advancement have jointly promoted the popularization and development of heat pumps.

Sprint 2-Signal, Trends, Driver, Wildcard

Sayce, S., Wilkinson, S., Armstrong, G. and Organ, S. (eds.) (2022) *Resilient building retrofits: Combating the climate crisis*. Taylor & Francis.

Sprint 2-Signal, Trends, Driver, Wildcard



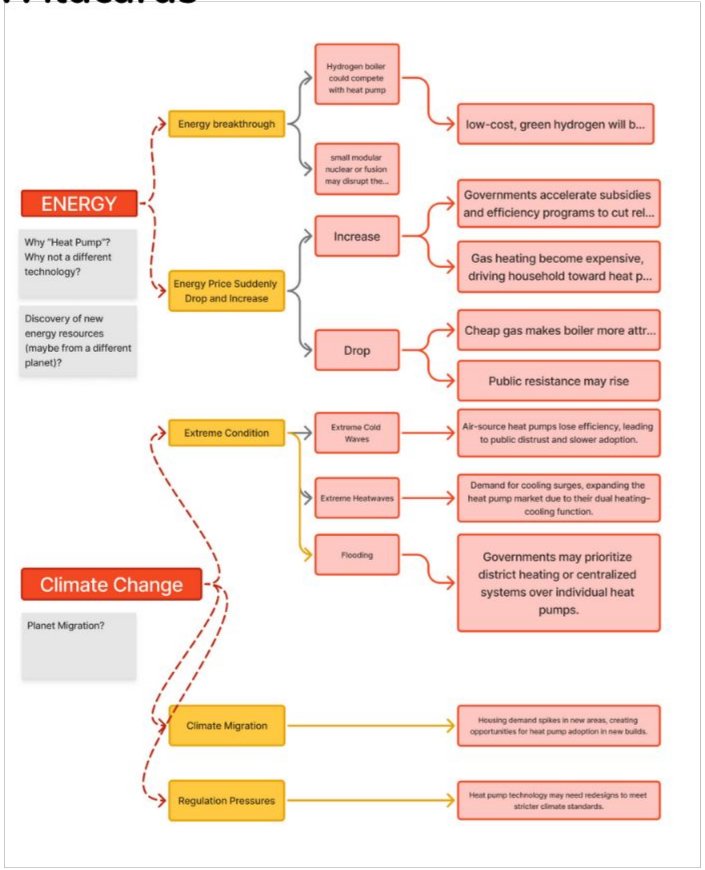
Why are we doing this?

- CLIMATE CHANGE
- Environmental Emergencies
- Summer Cooling Needs
- Residential Carbon Emission (10%)

The government is promoting the widespread adoption of heat pumps through policies, subsidies, and housing standards. Manufacturers and implementers are accelerating the implementation of the technology through production, installation, and maintenance. However, the main obstacles for private owners are the difficulties and high costs of retrofitting older homes, as well as the limitations of housing authorities in enforcing regulations. Overall, the development of heat pumps is driven by policy and the market, but also constrained by practical technical and institutional challenges.

Sprint 2-Signal, Trends, Driver, Wildcard

Wildcards



Futures?

- **Plausible Future**

  Adaptable System Technology

- **Preferable Future**

  By 2050

  Aim-To Achive Net Zero Emissions

- **Probable Future**

  Hybrid Technology for Heating and Cooling

  Effective Implementation of High Efflciency

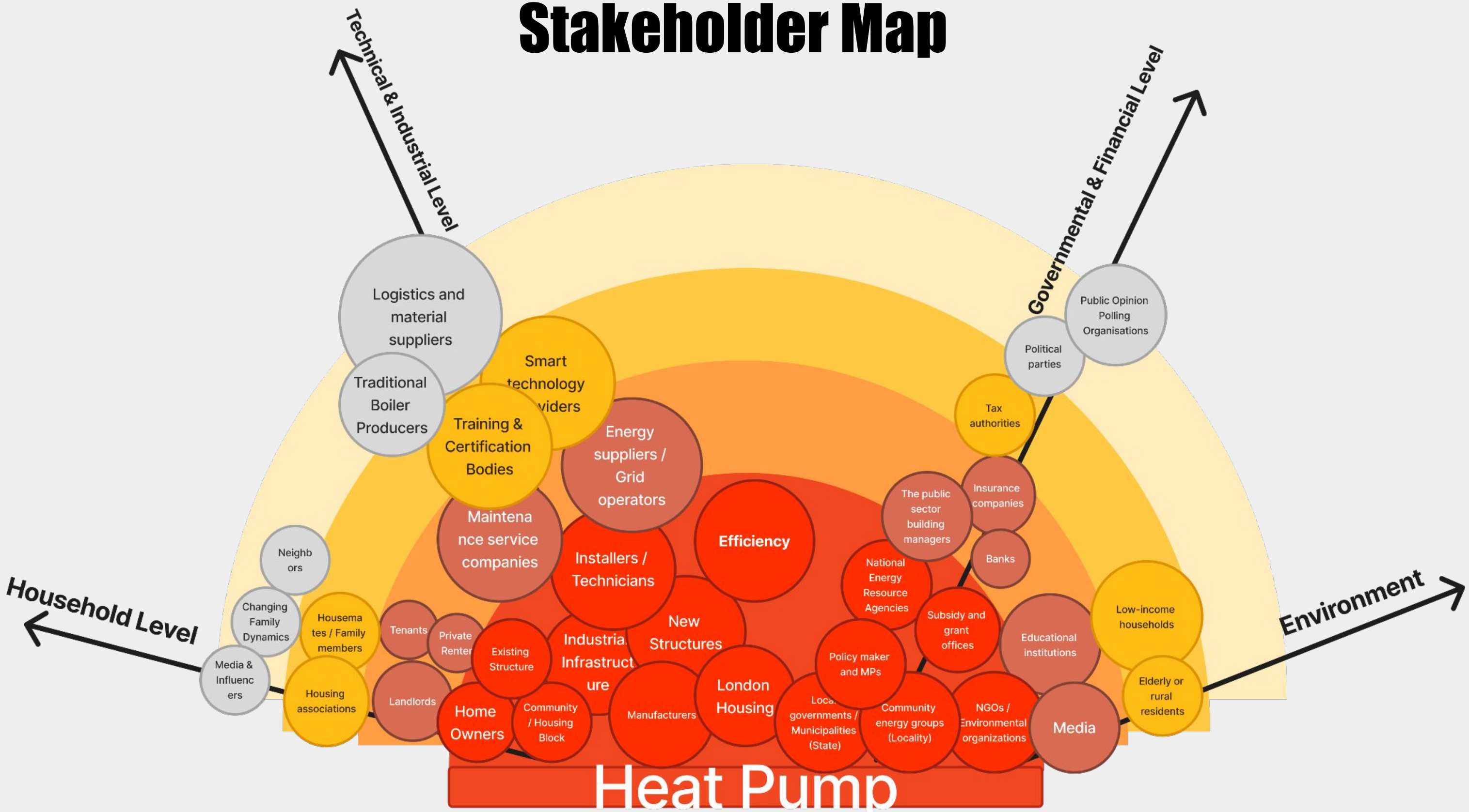
  District Heating

Problems Statement of Sprint 2

Achieving the UK's 2050 net zero target requires a rapid and systemic transition from **fossil-fuel-based heating to low-carbon alternatives** such as heat pumps. However, the retrofit of **existing residential buildings** presents complex, **context-dependent challenges that resist** standardized**,** top-down solutions. We aim to understand the challenges of **adaptability** as a critical design principle for a resilient, equitable, and future-ready heating transition. Framing heat pump deployment as a socio-technical **system**, we argue that adaptability must be embedded at multiple levels: **technical (e.g., modular and hybrid systems), infrastructural (e.g., grid-responsive controls), policy (e.g., evolving incentives), and** behavioral **(e.g., consumer pacing and engagement).** An adaptable approach enables multiple retrofit pathways across diverse housing typologies and user profiles, while allowing for iterative development through feedback loops, performance monitoring, and localized learning. By aligning heat decarbonization efforts with principles of long-term flexibility, distributed agency, and co-evolution of systems and users, we attempt to outline a **framework for sustainable design futures in residential heating transitions.**

Sprint 4-Stakeholder map, Gameplay, Analysis

Stakeholder Map



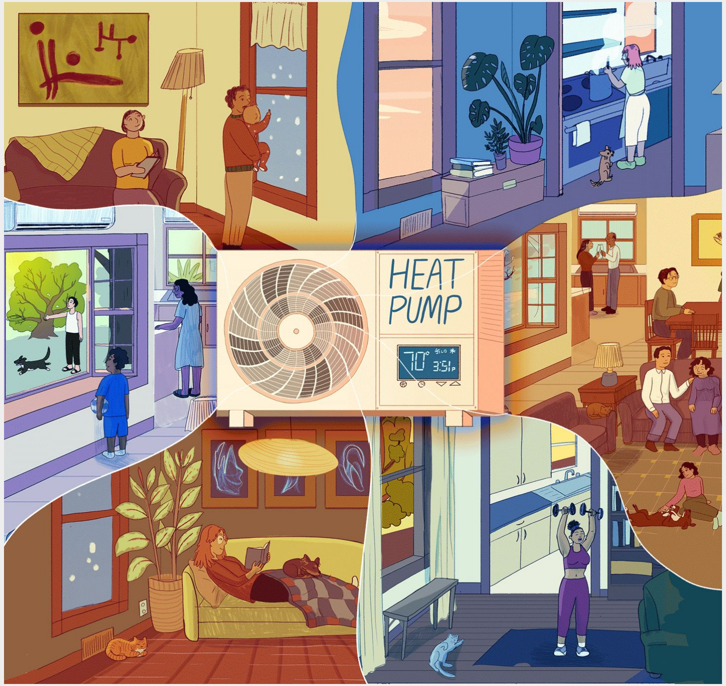
Homeowners at the Heart of Change

Why Homeowners Matter Most

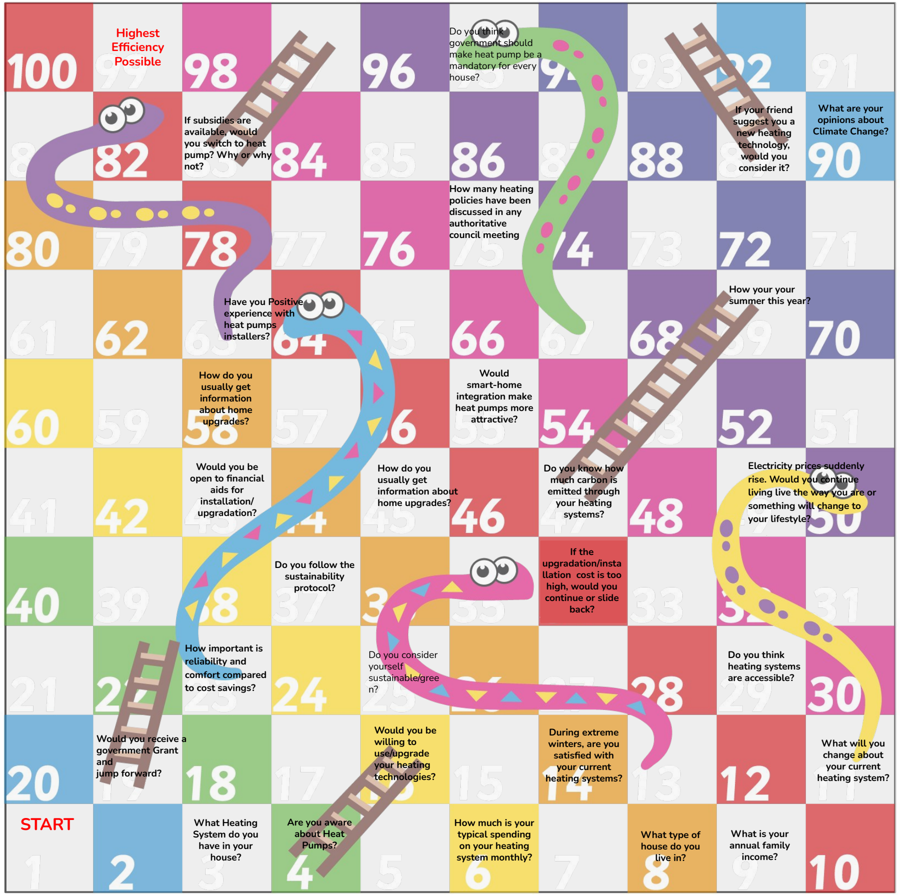
- **Most Affected:** Directly impacted by government energy policies and housing regulations.
- **Largest Group:** Represent the highest share of potential adopters of heat pumps across the UK.
- **Direct Users:** Live with the technology daily — influencing comfort, energy bills, and overall satisfaction.

What We Want To Unlock

- **Understand Pain Points:** Identify barriers homeowners face in adopting heat pumps.
- **Map Opportunities:** Explore incentives, support systems, and innovations that can accelerate adoption.
- **Co-Design Futures:** Develop homeowner-centered strategies for efficient, scalable installation of heat pumps.
- **Inform Policy & Practice:** Provide insights to local authorities, housing associations, and policymakers for sustainable roll-out.



Sprint 4-Stakeholder map, Gameplay, Analysis



Game Rules

Roll the dice ↣ players move forward the number of squares.

Landing on a square:

Regular square ↣ nothing happens, just wait for your next turn.

"Question" square ↣ the player (or group) must answer the interview question before staying on that square.

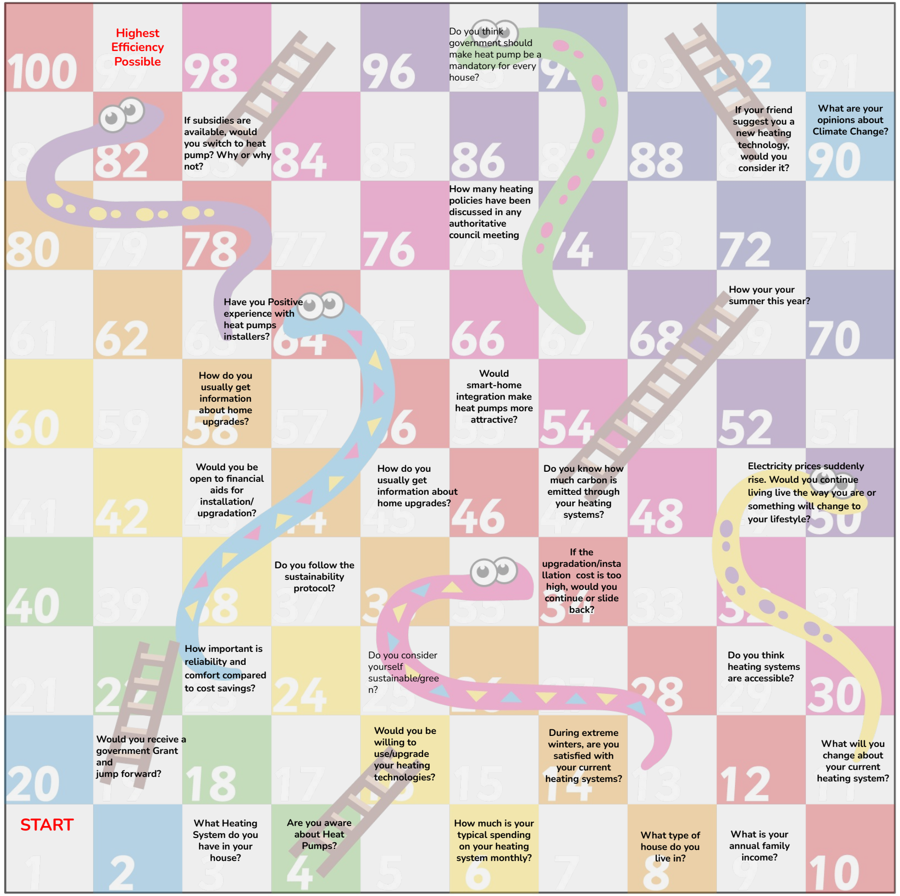
Snake ↣ slide back to the lower square (represents a barrier).

Ladder ↣ climb up to the higher square (represents an opportunity).

How Questions Work

1. If a player lands on a question square, the facilitator (or game leader) reads aloud the question from the playbook/legend.
2. The player answers based on their real-life perspective (as a homeowner), or the group can discuss.
3. After answering, they remain on that square until their next turn.

Sprint 4-Stakeholder map, Gameplay, Analysis



Achievements

1. Playful Learning & Visualization

Turned the complex issue of heat pump adoption into a fun, accessible, and visual experience through the metaphor of "ladders" (opportunities) and "snakes" (barriers).

2. Question Design Encouraging Critical Reflection

The board includes multi-layered questions about technology, economy, policy, and user behavior, promoting reflection on both personal and systemic factors.

3. Methodological Innovation

Combines qualitative research with gamification, bridging social research and design practice as a participatory co-design tool.

Failures

1. Weak Logical Progression

Some questions lack clear progression, mixing personal reflections with macro policy issues.

2. Undefined Player Roles

The absence of defined roles (e.g., homeowner vs policymaker) limits the depth of insights.

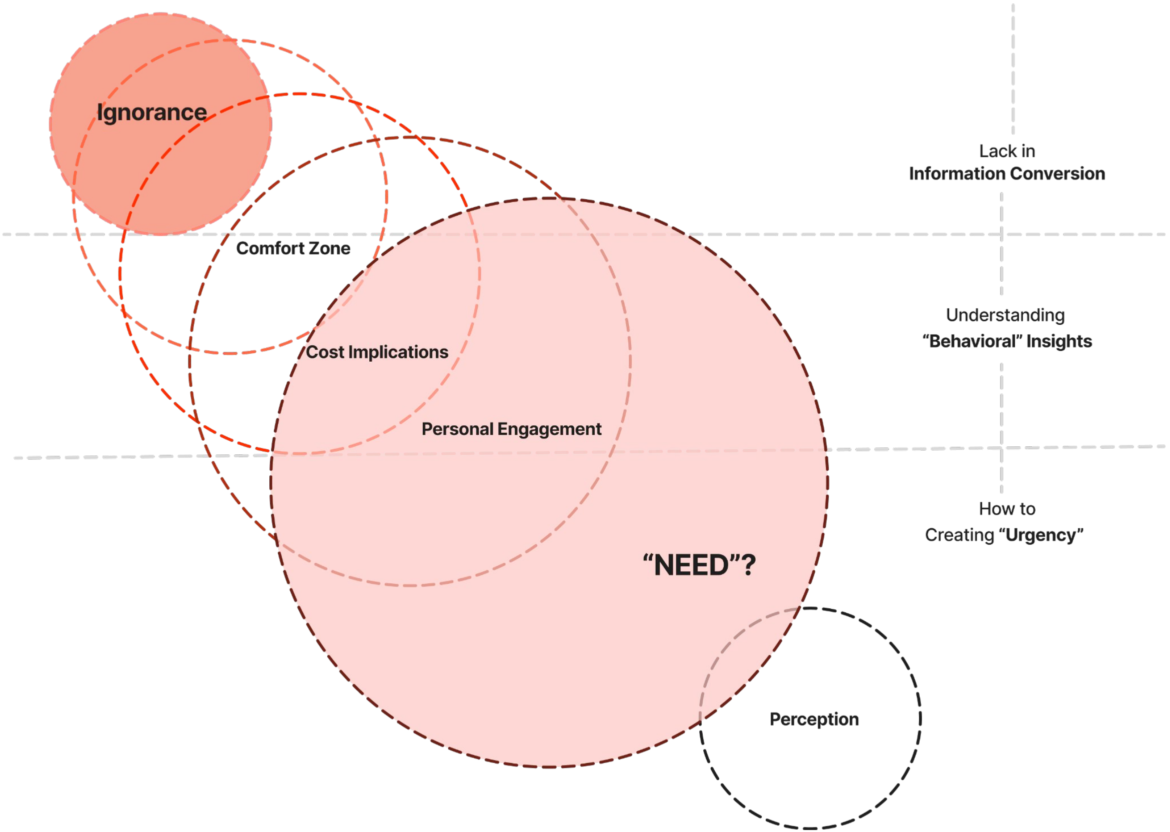
Playing

Sprint 4-Stakeholder map, Gameplay, Analysis

Sprint 4-Stakeholder map, Gameplay, Analysis

Game Analysis

Potential Methodology



Painpoint

Ignorance:

Lack in interpretative information leads to public not being aware about the concerns of this (energy and heating) sector.

Promotion of information on media, interactive platforms is not prominent for people to be aware of the existing policies, concerns or global trends.

Comfort: Cost: Commitment

People are not open to changes considering it requires personal effort, and there is no "need" or urgency as of now.

Cost of change is not readily affordable for a large middle-class mass."Want" is not enough.

The commitment to be involved in Installation, maintenance, and uncertain future constraint seems too much for too little.

Need

The urgency for Climate Change seems a controversial topic with opinions on both wings.

People like "Sustainability" but not necessary practice it.

Sprint 4-Stakeholder map, Gameplay, analysis

Summary of Sprint 4

The Heat Pump Snakes & Ladders Game is an interactive research tool that lets players look into how people feel about climate change and sustainable heating and cooling systems. The game turns complicated socio-technical discussions into a fun and interactive format that makes players think about their own choices, their knowledge of policies, and their responsibility to the environment. It shows how social perception, financial incentives, and technological literacy affect the use of heat pumps by asking questions about real-life problems and chances. The project successfully shows how gamification can get people involved, start conversations, and help them learn together about energy transition and home well-being. However, the structure and data collection need to be improved.

Problem Statement of Sprint 4

The Problem Statement for Sprint 4 is that as the transition to low-carbon heating speeds up, users, especially homeowners, will play a key role in shaping an energy future that is open to everyone and can adapt to their needs. The success of heat pump adoption relies not only on technical efficiency but also on emotional acceptance, behavioral adaptability, and the collaborative creation of significant domestic experiences. Our research examines the evolution of residential environments into participatory systems, wherein design serves as a conduit among policy frameworks, technological infrastructures, and the intimate dimensions of daily life. Through visual and narrative mapping, we examine the progression of households through various stages—awareness, decision-making, adoption, and co-design—each indicative of evolving dynamics between humans and technology. We want to use ideas from social practice theory, systems design, and speculative futures to come up with design strategies that promote collective agency, emotional resilience, and situated learning during the heat transition. This approach reimagines home heating not just as a technical upgrade, but as a process of adaptation, negotiation, and shared imagination that leads to long-term solutions.

TOPIC

HIGH EFFICIENCY HEAT PUMPS

Using system for both heating and cooling

Group 6:

Varun, Somya, Xiao, Charles

A Design Futures Methodolody for Adaptive Low Carbon Heating in London

Image source: https://www.technologyreview.com/2024/01/08/1085105/heat-pumps-decarbonizing-homes-manufacturing-breakthrough-technologies/

ASSUMED STATEMENT

Preferable Future

Social Challenge:
Adoption and Awareness

Long-Term Scale 2050

Human | **Technology** | **Nature**

Rural-Urban London Dwellings

Problem Statement

Achieving the **UK's 2050 Net Zero** target necessitates a rapid transition from **fossil-fuel-based heating to low-carbon** alternatives such as **heat pumps**. However, the **retrofit of existing residential buildings** remains a complex, context-dependent challenge that resists standardised, top-down implementation. Current approaches often overlook the importance of **adaptability** as the capacity of systems, policies, and users to evolve in response to changing technical, infrastructural, and social conditions. Without embedding adaptability as a guiding design principle, efforts to decarbonise residential heating risk becoming rigid, inequitable, and unsustainable over time. There is, therefore, a critical need to understand how adaptability can be operationalised across technical, infrastructural, policy, and behavioural dimensions to support a more resilient and inclusive heating transition. We attempt to outline a **framework for sustainable design futures in residential heating transitions,** for accelerated implementation at a societal level, and thus, **stabilising the issues of Climate Change.**

Breaking Down the Topic

What is a Heat Pump? | Why do we want High Efficiency? | Who "Needs" It?

"Heat Pumps could bring down global CO2 emissions by half a gigaton by the end of this decade."

Yannick Monschauer, "6 things to know about heat pumps"

Timelines

1850-1970	Mid 20th Century	1973	1990s	Early 2000s	2014-2016	2020-2025	Beyond
Breakthrough	Commercial Push	Oil Crisis	ASHPS	Policy Activation	Government Incentives	Social Implementation	Design Futures

TOPIC INTRODUCION

What it is

Gas-Fired Heat Pumps

↓

A **heat pump in 2025** is a reversible HVAC device that uses electricity to transfer thermal energy from ambient air, ground, or water into a home for heating, and reverses the flow to cool indoors during warmer months, **offering high efficiency and lower emissions.**

Primary Objective	Secondary Aspect	Tertiary Integration
Heat Pumps	High Efficiency	Heating & Cooling
Path Creation	Path Dependency	Path Breaking
Social-Culture	Technological	Climate Change
Economical	Ethical	Political

What we WANT

By 2060 "**heat pump**" may be defined as a **smart, adaptive thermal-exchange system** that not only transfers heat for space heating and cooling, but dynamically **integrates with renewable energy infrastructure, urban energy sharing networks, and climate-responsive materials to optimise comfort, efficiency, and sustainability.**

Concept Video Reference: https://youtu.be/6sSDXurPX-s?si=pb9J0g0KQTIZf8Aq

Barrier
(User)

Implementation-Focused

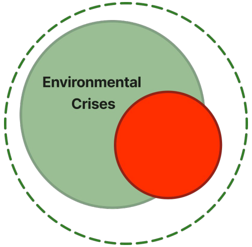
What
Who

Contextualizing

Social Challenge

In present times, **Heat Pump**s are central to UK's low- carbon strategy to achieve the **Net-Zero** transition, given that the fossil fuel heating dominates within the **"existing" homes**, producing about **17%** of **national emissions.** Thus, making **Social challeng (Key Barrier)** as the **Homeowners Adoption and Awareness.**

Prespectives

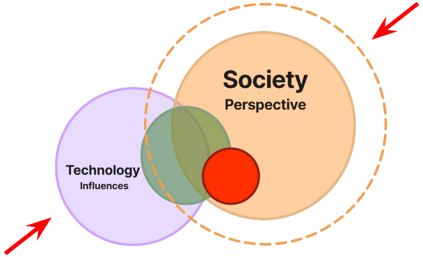


Policy-Design-User Intregration for the Environemnt

Where
When
Why

System-Level Prespective

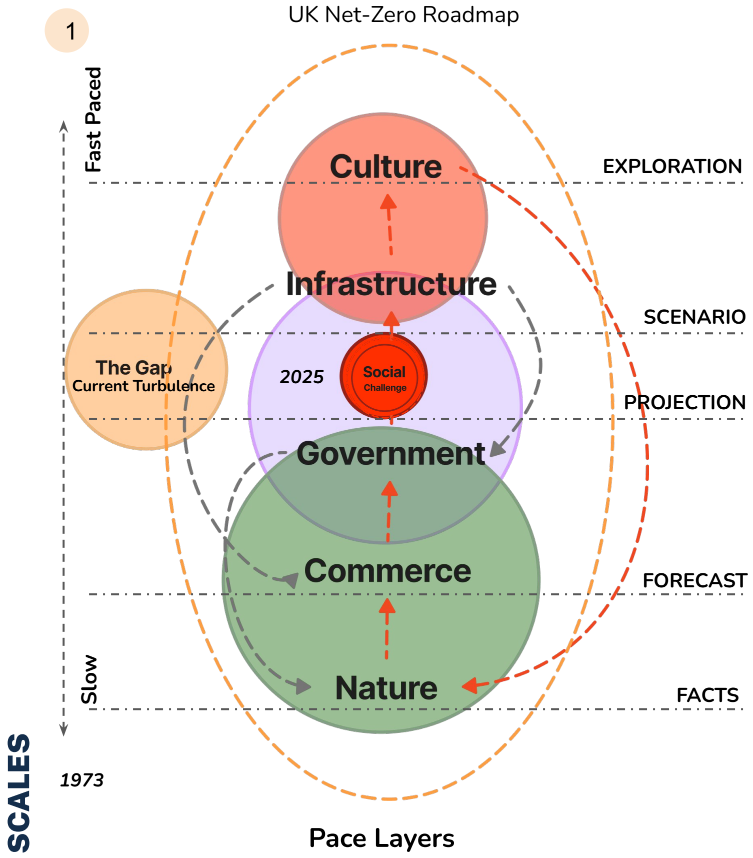
A clear link between its affected stakeholders where we treat **efficiency** not completely as a technical problem, but as a **design response to user behiviour and contextual condition.** ultimately the bigger aim is ho **stabalize the environmental crises** (Oil crisis) pushes us to pursue this study in the first place.



How

With such a varied **Domestic scene of London Dwellings**, it is essential to understand the **diverse typography** and **retrofit constraints.** With **User/Homeowners** at the center, we look at heating retrofit for its upfront costs, inconsistent existing policy support, and **limited consumer trust as the starting point** to achieve a **probable future solution.**

PROBLEM FRAMING



Pace Layers

2025-2050

Temporal Scales

As the starting point, **Nature** provides the clearest **factual evidence** and a slow-built foundation for **climate and ecological changes**. **Commerce and Policies** have been under development for over a decade regarding these topics. **Infrastructure** moves at a reasonable pace, where the **housing and energy networks** come to play, which must adapt to **new demands. Social value and norms** are **collective attitudes** towards **sustainability** and often slowest to move/change because they demand efforts at a personal level.

Something has already been started. How do we stabilise and facilitate the exponential growth of this social dimension? What is the integration of short-term actions and long-term systemic transformations?

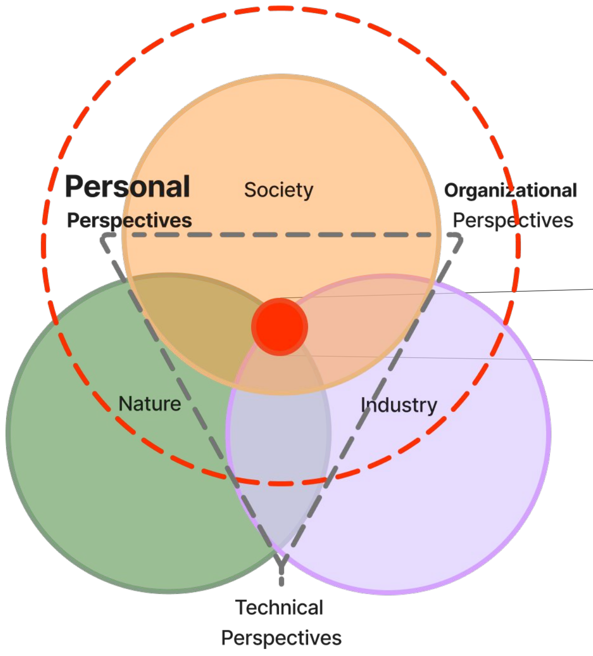
Why is it Important?

We are at a critical juncture in time where **stabilizing social systemic issues** is essential for achieving accelerated and sustainable results.

To move forward effectively, it is crucial to identify **where and how barriers (Social Structures) may become bottlenecks**, restricting the successful implementation of existing or newly developed **policies and technologies**.

Inspiration Source: Brand, S. (2008) 'Pace Layering: How Complex Systems Learn', *The Long Now Foundation*. https://longnow.org

IDENTIFICATION

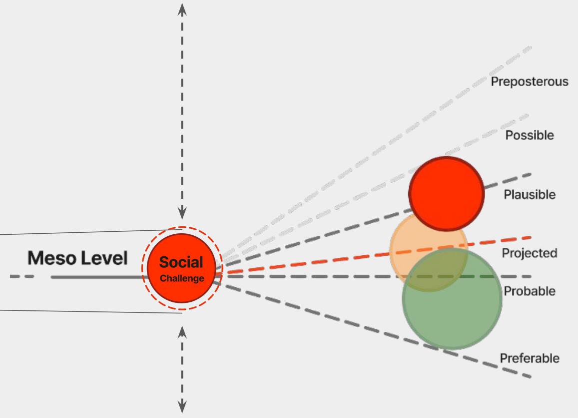


Represents Retrofit Complexity

Our Critical **(Meso) Context** Positioning

Understanding **Contextual Scales** &

Potential Guiding **Futures Narratives**



Context

Rural-Urban London Dwellings

We **strategically position user** to draw a systemic path for better **expansion** of already **existing** technology, and **effective implementation of policies**, to reform personal perspectives about **climate crises and sustainability**.

Concequences

2050

Plausible Future

Adaptable System Technology

Preferable Future

By 2050
Aim-To Achive Net Zero Emissions

Probable Future

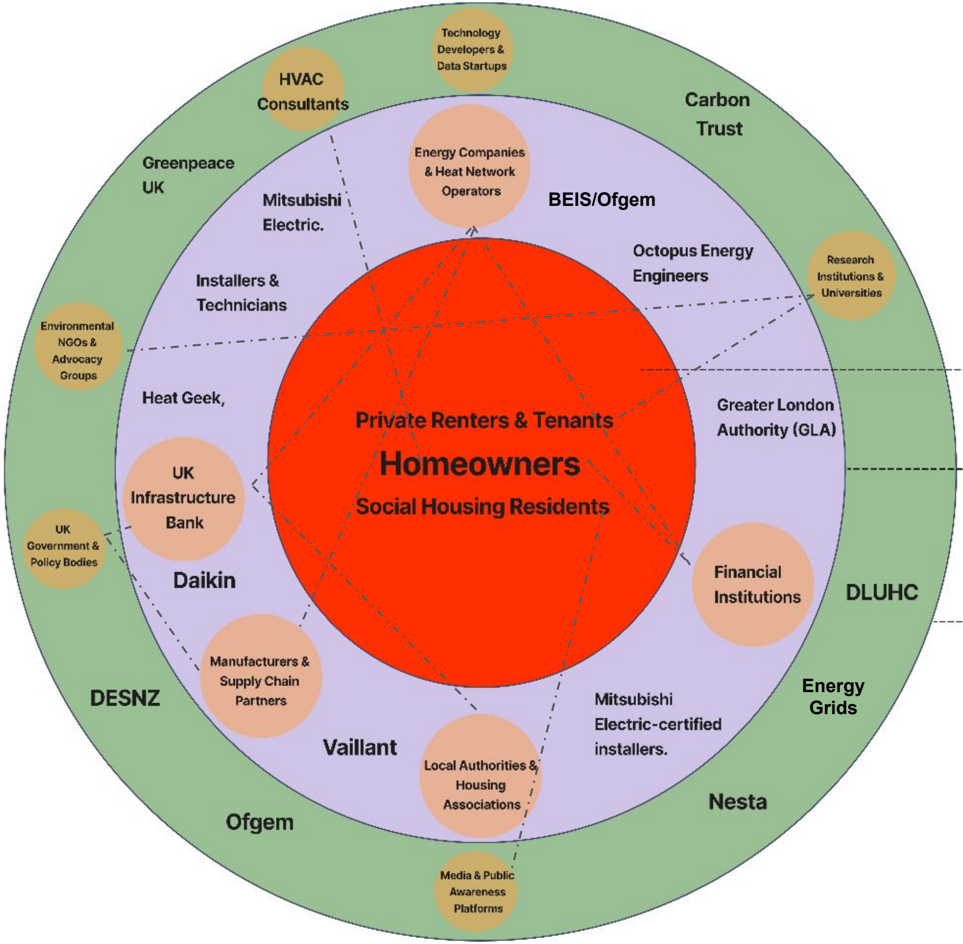
Hybrid Technology
for Heating and Cooling

Effective Implementation of High Efficiency

District Heating

Futures Prediction

STAKEHOLDER STUDY



Primary Stakeholders — Homeowners

These are the people living with the technology.
They experience the immediate benefits, frustrations, and daily realities of heat pump adoption

Secondary Stakeholders — Technology

Surrounding the users are those who make adoption possible.
They design, build, install, and maintain the systems — and in many ways, they act as the bridge between policy and people.

Tertiary Stakeholders — Nature

Finally, the outer layer consists of policy, research, and communication ecosystems.
These actors don't install or use heat pumps directly, but they define the conditions that make large-scale adoption possible.

RESEARCH QUESTION

"How can **user-centred adaptability** be **operationalised** through **design** and **policy frameworks** to accelerate equitable and efficient heat pump adoption in the **UK residential sector** by 2050?"

Why This Research Question Matters

Policy Relevance: Policy Relevance: UK low-carbon heating transition is critical to achieving 2050 net-zero targets.

Stakeholder Impact: Homeowners are obstructed by price, technicality, and lack of knowledge.

Design Futures Lens: A design-led approach is human-focused, rather than tech-focused — reframing homeowners' experience, trust, and relationship with heat pumps.

Sustainability: Resource and byproduct consideration ensures the transition avoids creating new problems (e.g., electricity consumption, reliance on rare earths).

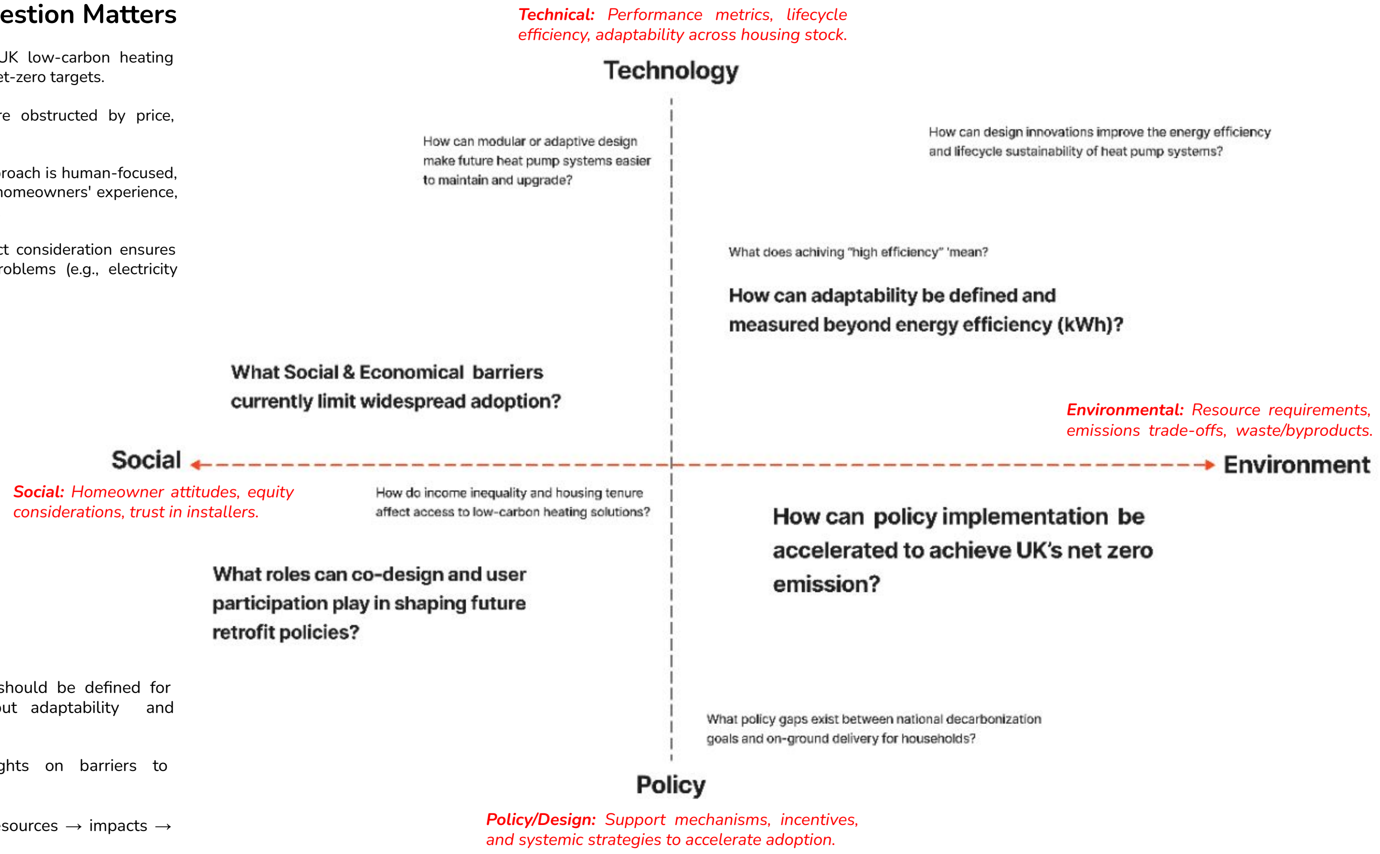
Knowledge Gaps

Lack of clarity on how “effiency” should be defined for future contexts (not just kWh, but adaptability and resilience).

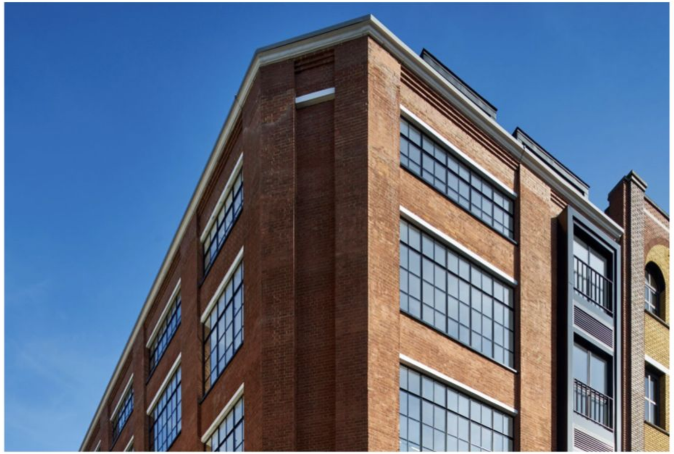
Limited homeowner-centered insights on barriers to transition.

Under-explored systemic view of resources → impacts → byproducts of heat pump scaling

SUB-RESEARCH QUESTIONS



CASE STUDY



Following is a case study taken from Heat Pump Association to illustrate the topic.

Summary

"With aspirations to **retrofit** its main sites, **£5 million** in funding unlocked a major opportunity to improve **air quality** around the borough whilst taking a big step towards meeting its **net zero pledge** by 2030." NIBE Energy Systems, 2024)

Results

"This transformation really highlights the benefits of combining multiple **technologies** to deliver **efficient**, **low-carbon** solutions. Whilst the full capacity could have been delivered using boreholes, which would have been a **less costly option,** the University welcomed the installation of **PVT** as an **innovative** and **space-saving** option.

The major project will save an estimated **500 tonnes** of **carbon** each year, and **9,460 tonnes** across the equipment's lifetime. It will also save **3,116,738 kWh** of gas-derived energy per year (equivalent to 70 heated homes) whilst improving local air quality.

The project is thought to be one of the world's largest **PVT projects,** and positions **UWL** as a leader in higher education for addressing the climate crisis. The project was recognised by the **Energy Managers Association's** (EMA) Energy Management Awards, receiving the Highly Commended designation in the **Decarbonisation** Project Category." NIBE Energy Systems, 2024)

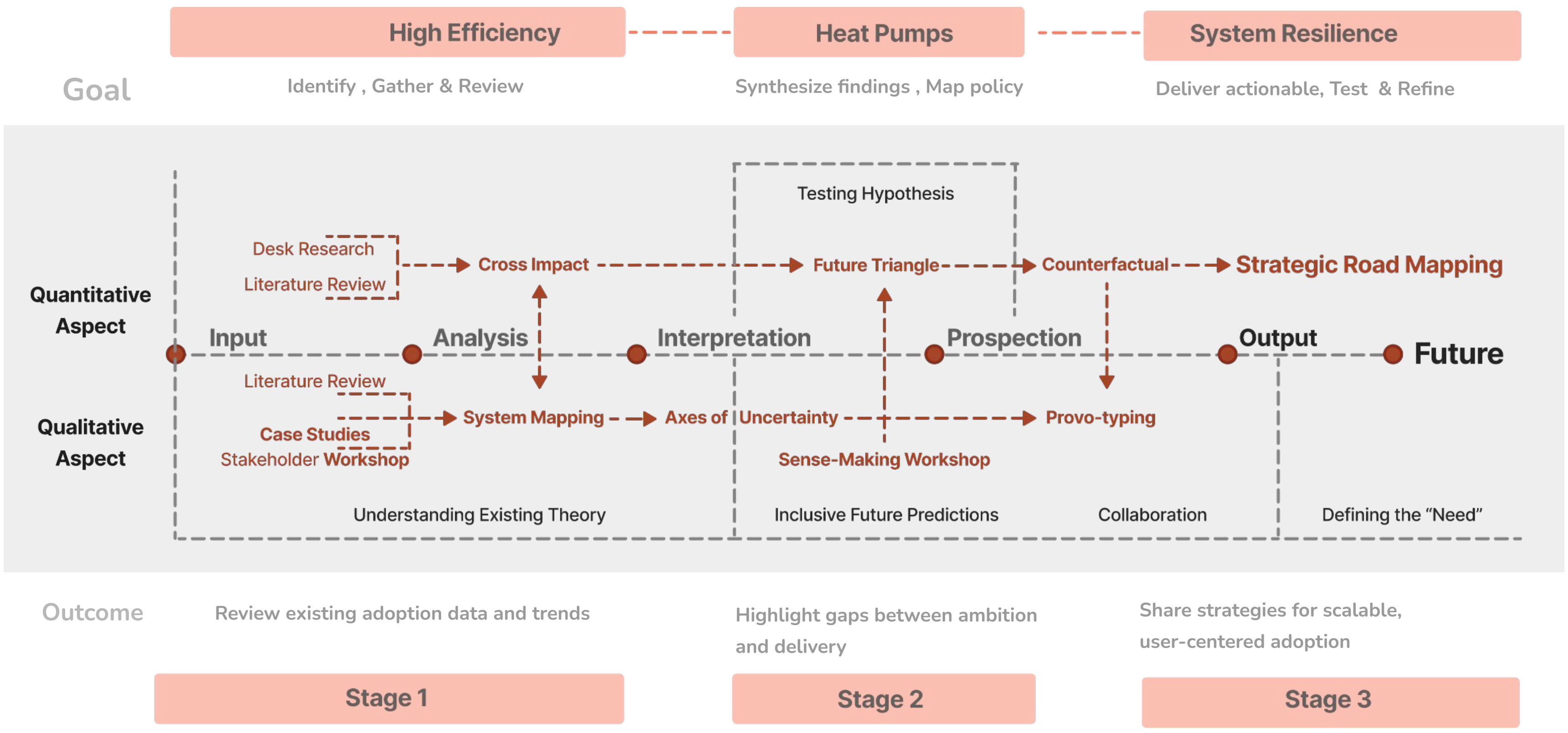
Background

"UWL contracted Ameresco as principal contractor and designer, who partnered with **NIBE Energy Systems** and **JKN Renewables**, Ltd. The first and main challenge was to design a **ground source heat pump (GSHP) system** for the university without disrupting the main car park on the campus to reduce the impact on students. This, in turn, resulted in an innovative solution, combining a **ground source heat pump system** working with boreholes and **solar PVT panels**. The designed system not only supplies **222 kW** of **PV electricity generation** but, crucially, acts as a collector system for the GSHP, capturing naturally occurring energy in the air to drive the heat pump process, and therefore reducing the number of boreholes required. (NIBE: University of West London, 2024) The old gas boilers previously heating the campus were replaced with **584 solar PVT** panels in combination with 34 169-meter boreholes to provide **900 kW** of heating and hot water throughout the site." (NIBE Energy Systems, 2024)

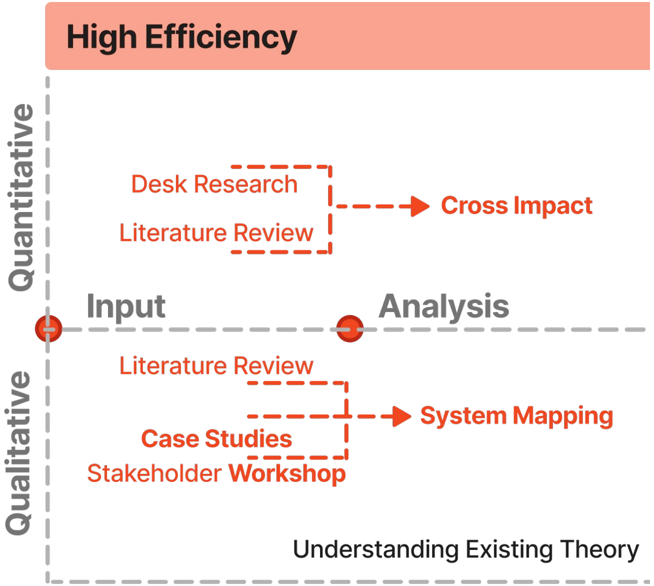
Heat Pump Association (n.d.) *NIBE: University of West London*. Available at: https://www.heatpumps.org.uk/nibe-university-of-west-london/

LITERATURE REVIEW

Source	Focus	Methods Used	Identified Gaps
Heat Pump Retrofit in London (GLA & Carbon Trust, 2020)	**What retrofit options exist in London's building stock; what policy & support needed at building level**	**Case studies** of 15 buildings; options-appraisals; fabric & energy efficiency assessment	Does not deeply explore homeowner perceptions or **behavioural barriers**; limited to London; less attention to **social equity**.
Energy Company Obligation (ECO3) Final Determination Report (Ofgem, 2023)	**Efficiency improvements** and heating/ low-carbon alternatives for **low-income/** vulnerable **households**; **policy obligations**	Scheme evaluation / **public reports**; **quantitative metrics** (bill savings, number of measures installed etc.)	**Less qualitative insight** on usability or homeowner satisfaction; limited in exploring **retrofit complexities** in **older housing** or heritage buildings.
Heat-Pump Net Zero Investment Roadmap (UK Govt, 202x)	**Forecasting need** and **scale** for heat pump installations; suitability analysis of UK housing stock	**Modelling**; suitability and cost comparisons; analysis of insulation and grid/electrical capacity	Future **deployment challenges** (finance, installers, public trust) less explored; **limited case study** or user feedback in many regions outside London.
"Quantifying National Space Heating Flexibility Potential..." (Halloran, Lizana, McCulloch, 2024)	Estimating how existing housing stock can provide demand **flexibility** when using heat pumps; **spatial variation** of usage	**Data analytics**; high spatial resolution modelling using historical heating consumption and temperature data	Technical modelling heavy; less on **social/policy levers**; doesn't deeply engage with homeowner decision factors.



METHODOLOGY PROPOSAL



Purpose: Review existing adoption data and trends : Stage 1

Input

1. Desk Research
(understanding technological efficiency quotient)

2. Literature Review
(theoritical gaps and stakeholder engagement)

3. Case Studies
(comparable retrofit adoption programs & equity- study of location, Retrofit scale, user typology)

4. Stakeholder Workshop

Key "Actors" insights to understand the challenges and opportunity in adoption of Heat Pump Technology, using **participatory mapping, by collecting lived experiences and narrative.** This will help us buil**d future scenarios,** feeding data for Axes of Uncertainty into the Analysis stage. This is crucial as it clarifies the current musts of **design and policy framework**.

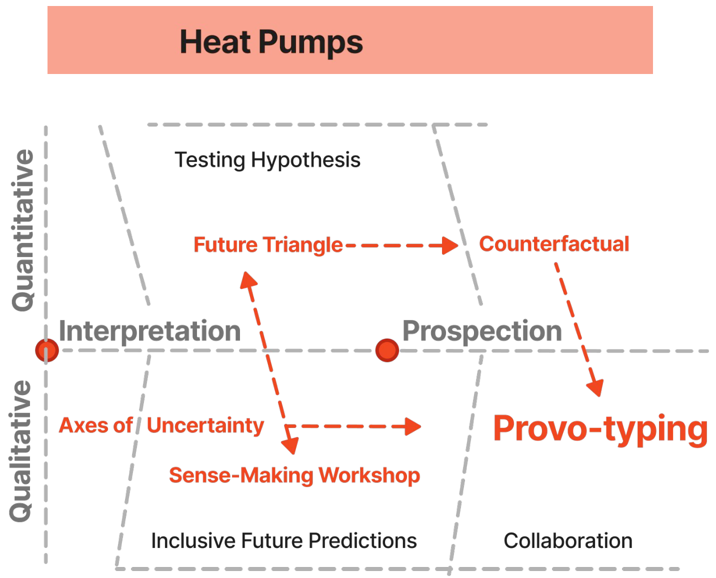
Analysis

5. Cross Impact

Building themes between behavioural adoption, policy intervention and socio-technical systems to understand the influences and potential impacts within the system of drivers. This includes Housing Typologies as well.

6. System Mapping

Workshop output can be structures into a **Map** to identify loops, dependencies, and potential poins to intervention. This foundation will be used for **Intrepretation** and **Scenario Development** Stage.



Highlights Gaps between ambition and delivery : Stage 2

Interpretation

7. Axes of Uncertainity

understanding **diverse housing typologies** as the **barrier** and key uncertainty towards shaping the **future of heat pumps** in existing **housing structures**.

8. Futures Triangle

to understand the essential **Drivers** shaping the **Possible futures** to understand **desired outcomes,** and begin to **identify preferred and alternative pathways.**

9. Sense Making Workshop

Testing Hypothesis

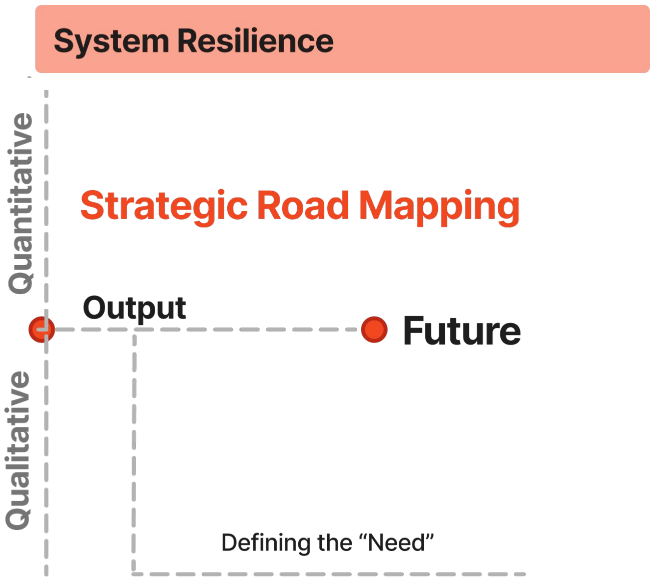
Prospection

10. Counterfractual

Evaluating resilience and adaptability of strategies under changing conditions by developing alternative scenarios

11. Provo-typing

To **test speculative concept technology and prototype policy** through **user feedback**



Scalable Plan of Actions with User- Centric Vision : Stage 3

Output

12. Strategic Road Mapping

Mapping the **Preferable direction** and reframing **“Inclusivity”,** integrating data from previous methods to design an **equitable adoption of heat pumps** in Lexisting London Dwellings.

Futures

Communicating the “need” to its usetr and potentially change presceptions and build a clear value proposition.

1. Ethical Framework

"Our research is guided by principles of **transparency, inclusivity, and responsibility.** Because our topic directly impacts **households, policies, and local communities,** ethical awareness is embedded at every stage of our process — from **data gathering** to **future speculation.**"

2. Inclusion Strategy

Methodology Phase	Potential Ethical Issue	Our Approach to Address It
Input (Desk Research, Literature Review, Stakeholder Workshop)	Risk of **bias** in data selection and representation of stakeholder voices	Use **multiple**, **diverse data** sources and ensure **equal** stakeholder representation in workshops (homeowners, installers, policymakers, social housing). Obtain informed **consent** for participation.
Analysis (Cross-Impact, System Mapping)	**Oversimplification** of complex relationships or **misinterpretation** of stakeholder influence	Apply **transparent** mapping criteria and **validate** findings through **peer review** or expert **feedback** sessions.
Interpretation & Prospection (Axes of Uncertainty, Futures Triangle, Provotyping)	**Ethical tension** in creating speculative futures — may reinforce bias or exclude **marginalized groups**	Facilitate **inclusive** futures workshops with **diverse participants**; encourage multiple possible futures (not one idealized vision). Use **ethical foresight** frameworks to avoid **techno-solutionism**.
Output (Strategic Roadmap)	Risk of policy recommendations **favoring privileged** groups or market actors	Test recommendations for **equity, accessibility, and affordability** impacts. Cross-check proposals with fuel-poverty and s**ocial justice** metrics before publication.

ETHICS

3. Data Ethics

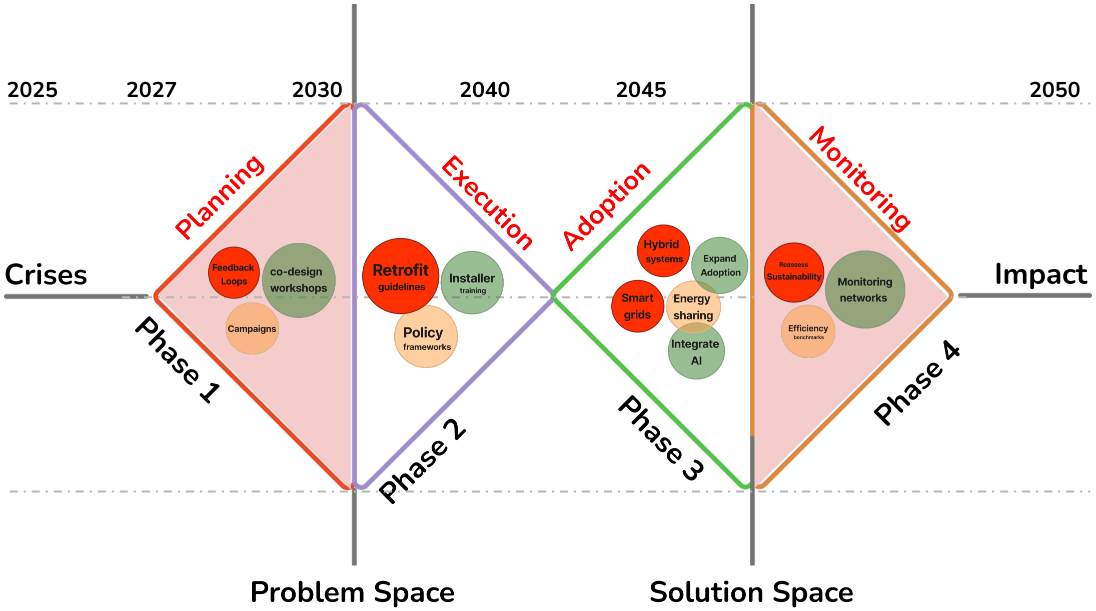
- All **qualitative data** (interviews, workshops) will be collected under informed **consent** and **anonymized.**
- Participants can withdraw at **any time** without consequence.
- Data stored **securely** and used only for **educational or research purposes.**
- Any secondary data follows **open-access and citation** ethics standards.

4. Design & Futures Ethics

- Avoid **technological determinism** — ensure **future scenarios** consider **social systems** and human agency, not **just innovation**.
- Use **counterfactuals and provotypes** responsibly — clarify they are **explorations,** not predictions.
- Prioritize **sustainability, justice, and well-being** in all imagined futures.

5. Reflection

Our **ethical** approach ensures that design methods do not just produce solutions,but also question whose futures are being designed and who benefits from them.By embedding ethics into each stage, our methodology stays accountable, equitable, and aligned with the principles of sustainable design futures.



OUTPUT

Strategic Roadmap for Heat Pump Transition (2025–2050)

Solving complex problems of **social variation** and **system adaptability**, pushing sustainability through technological advancement, is essential. **Implementation** of already existing policies, and defining the role of different stakeholders, is essential for the success, along with technology compensating for the barrier of Housing adaptability. The **uncertainty lies** in questioning the **"need" and "usefulness" of adopting this advancement at a personal social level.**

Design Council (2005) *A Study of the Design Process — The Double Diamond*. Available at: https://www.designcouncil.org.uk/sites/default/files/asset/document/ElevenLessons_Design_Council%20%282%29.pdf

Data analysis plan

Phase 1

Right now, the UK stands at a crucial transition point. We're shifting away from gas boilers — but awareness, affordability, and policy clarity remain barriers. Our journey begins here, with a mission to make heat pumps not just a policy mandate, but a public movement by focusing on **home owners of existing dwellings**

Phase 2-3

As awareness grows, we move into the decade of action with the **secondary and tertiary stakeholders**. Policies mature, communities adapt, and technology begins to evolve rapidly. This is when planning meets execution — where design thinking and systemic collaboration come alive.

Phase 4

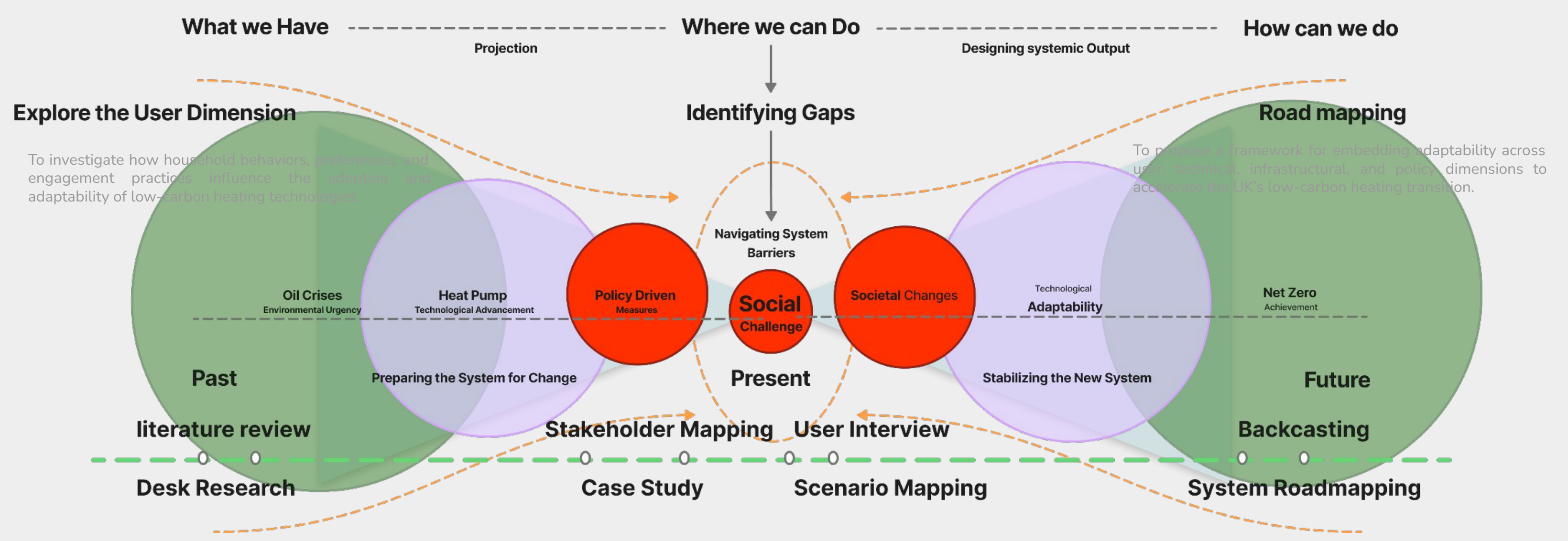
By this stage, the transformation is embedded in daily life of the homeowners. Heat pumps are no longer new technology — they're part of a smarter, cleaner, and more equitable energy ecosystem. Our focus shifts from deployment to long-term monitoring, refinement, and resilience.

Methodology & Impact

Our roadmap aligns with our chosen methodology, with a view of the design futures approach. It doesn't just predict potential outcomes, but it guides an adaptive system for implementation, which is a proactive, homeowner-centred transformation. Each phase supports iterative learning, making it reusable for other systems — from primary to tertiary stakeholders

Bridging Technology, Design, and Society in the Heat Pump Transition

METHOD JUSTIFICATION



Assess Policy Governance Implications

To analyze how policy frameworks and incentive schemes can support adaptive, user-centered retrofit pathways for residential heating transitions.

Implement

Transforming "the high efficiency of heat pumps" from a "technical issue" to a "design issue" - through the logical thinking of "user-centered, scenario adaptation, and system design", not only can the question of "how to make heat pumps more efficient through design" be answered, but ultimately the transformation from "efficient technology" to "efficient value that users can perceive" can be achieved.

Examine Technical and Infrastructural Adaptability

To identify how technical solutions (e.g., modular heat pumps, hybrid systems) and infrastructural mechanisms (e.g., grid-responsive controls) can accommodate diverse user needs.

Reference:Voros, J. (2003) ‘A generic foresight process framework’, *Foresight*

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“Crises Integrates Community”

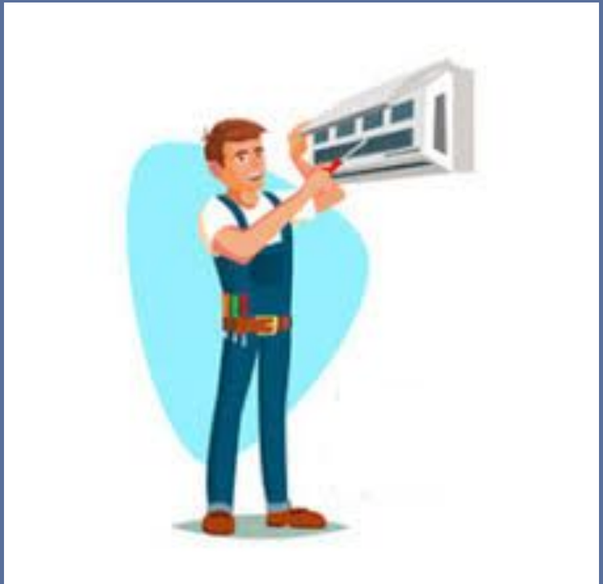
Thankyou

Varun, Somya, Xiao, Charles

TOPIC

HIGH EFFICIENCY HEAT PUMPS

Using system for both heating and cooling



Individual Work

Xiao Chen

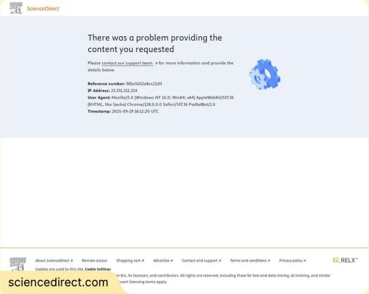
RCA ID: 10067313

Group 6

Literature Review

Q:Is Heat pump even the protenitial solution?
Or do we have a potential alternative?

Cost-optimization model to design and operate hybrid heating systems – Case study of district heating system with decentralized heat pumps in Finland
Author links open overlay panel



sciencedirect.com
Just a moment...
https://www.sciencedirect.com/science/article/pii/S0360544223016353
RCA Library

Summary: The paper "*Cost-optimization model to design and operate hybrid heating systems – Case study of district heating system with decentralized heat pumps in Finland*" presents people a cost-optimization framework to evaluate hybrid heating system. Some examples in this article show that it is a feasible method to reduce cost and carbon in the process by using integrating decentralized heat pumps into district heating, comparing with traditional heating system, which has higher efficiency. And the research highlights the potential of reducing carbon and improving efficiency in mix-system.

Reflection: The research was based on Finland, but it offer a methodological value for the UK in 2035, especially in combining district heat and heat pump to reducing carbon and energy safety. However, Finland has colder climate and stronger district heating tradition, which is quite different from UK. This research has not fully involved in cooling needs, building diversity and user behavior, which is important to UK. Thus, it is useful as a reference, not a answer.

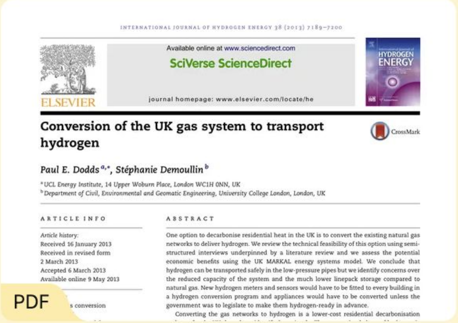
Individual Work

Savolainen, J., Syri, S. and Kirkerud, J.G. (2021) 'Cost-optimization model to design and operate hybrid heating systems – Case study of district heating system with decentralized heat pumps in Finland', *Applied Energy*, 288, p. 116623. doi:10.1016/j.apenergy.2021.116623.

Literature Review

Q:Is Heat pump even the protenitial solution?

Or do we have a potential alternative?



Conversion of the UK gas system to transport hydrogen

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 38 (2013) 7189–7200

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/he

ELSEVIER

HYDROGEN ENERGY

Conversion of the UK gas system to transport hydrogen

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ARTICLE INFO

Article history:
Received 16 January 2013
Received in revised form
2 March 2013
Accepted 6 March 2013
Available online 9 May 2013

ABSTRACT

One option to decarbonise residential heat in the UK is to convert the existing natural gas networks to deliver hydrogen. We review the technical feasibility of this option using semi-structured interviews underpinned by a literature review and we assess the potential economic benefits using the UK MARKAL energy systems model. We conclude that hydrogen can be transported safely in the low-pressure pipes but we identify concerns over the reduced capacity of the system and the much lower linepack storage compared to natural gas. New hydrogen meters and sensors would have to be fitted to every building in a hydrogen conversion program and appliances would have to be converted unless the government was to legislate to make them hydrogen-ready in advance.

Converting the gas networks to hydrogen is a lower-cost residential decarbonisation

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Summary: The author talk about the feasibility of converting the existing UK natural gas network to transport 100% hydrogen as a residential heating fuel. Their findings suggest that low-pressure pipes (especially those made of polyethylene) can safely carry hydrogen, but there are concerns around reduced capacity and reduced “line-pack” storage. They also find that converting appliances and meters across homes is a cost factor, but overall hydrogen conversion may represent a **lower-cost pathway** for residential heat decarbonisation compared to some alternatives under certain assumptions.

Reflection: This article has provide a alternative way of heat pump. However, this paper is from 2013, so its assumption, cost of hydrogen production, appliance conversion, safety regulation and alternatives may be outdated; By the way, the research focus on heating, which not include cooling and transfer in different situation.

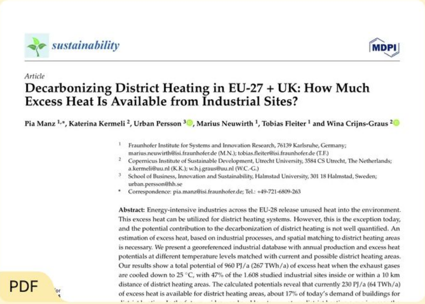
Individual Work

Dodds, P.E. and Demoullin, S. (2013) ‘Conversion of the UK gas system to transport hydrogen’, *International Journal of Hydrogen Energy*, 38(18), pp. 7189–7200. doi:10.1016/j.ijhydene.2013.03.070.

Literature Review

Q:Is Heat pump even the protenitial solution?
Or do we have a potential alternative?

Decarbonizing District Heating in EU-27 + UK: How Much Excess Heat Is Available from Industrial Sites?



sustainability

MDPI

Article

Decarbonizing District Heating in EU-27 + UK: How Much Excess Heat Is Available from Industrial Sites?

Pia Manz [1,*], Katerina Kermeli [2], Urban Persson [3], Marius Neuwirth [1], Tobias Fleiter [1] and Wina Crijns-Graus [2]

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Abstract: Energy-intensive industries across the EU-28 release unused heat into the environment. This excess heat can be utilized for district heating systems. However, this is the exception today, and the potential contribution to the decarbonization of district heating is not well quantified. An estimation of excess heat, based on industrial processes, and spatial matching to district heating areas is necessary. We present a georeferenced industrial database with annual production and excess heat potentials at different temperature levels matched with current and possible district heating areas. Our results show a total potential of 960 PJ/a (267 TWh/a) of excess heat when the exhaust gases are cooled down to 25 °C, with 47% of the 1.608 studied industrial sites inside or within a 10 km distance of district heating areas. The calculated potentials reveal that currently 230 PJ/a (64 TWh/a) of excess heat is available for district heating areas, about 17% of today's demand of buildings for

PDF

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Refelction: This paper is quite valuable and relevant for my group topic, which has show a substantial and under-used resource--industrial excess heat, especially in DH systems or hybrid systems. In situation of heat pump in the UK in 2035, it is feasible to combine with industrial excess heat, so that can have efficiency improvement and reduce cost of energy in heating process. However, assumptions about exhaust cooling to low temperatures may require advanced heat exchangers; spatial matching doesn't always translate to economic feasibility; DH expansion and low-temperature grid deployment are not guaranteed and depend heavily on policy, infrastructure, building stock.

Papapetrou, M., Kosmadakis, G., Cipollina, A., La Commare, U. and Micale, G. (2018) 'Decarbonizing district heating in EU-27 + UK: How much excess heat is available from industrial sites?', *Energy*, 153, pp. 582–594. doi:10.1016/j.energy.2018.04.126.

Literature Review

Summary of Literature Review

1. Government propose heating and building strategy, financial incentives and new efficiency standard to promote the transfer of low-carbon heating.

2. Heat pump (including hybrid systems) and hydrogen are highlighted as key solution, renovation project has show the flexibility of heat pump.

3. District heating decarbonization through industrial excess heat recovery and decentralized heat pumps improves efficiency and sustainability.

4. Repurposing the existing gas grid for hydrogen transport support a smoother transition without building new system.

Literature Review

Reflection of Literature Review

In the process of finding resource about my team topic *'High-Efficiency Heat Pump',* I learned that research should find balance between technological research and policy report. Academic article support detailed model, analyze of cost and long-term prediction, and government policy let me understand the 'difficulty' in applying in actual process. For the credibility of all resource, I first choose peer-reviewed journals and priority to official UK government strategies and recognized organizations like the Committee on Climate Change and National Grid ESO, which has authority and more transparent data. By critical reading, I learned some difference in emphasis, for example: some research focus on the potential of hydrogen technology, and some of them present the challenge of cost saving and building infrastructure. In my opinion, only receiving summary is not enough, which having to combine with comparing evidence across documents and reflected on possible biases, such as feasibility of industrial foundation and policy support, which will provide me better understanding in research.

Literature Review

Reference List & Padlet Link

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Padlet Link of Literature Review: https://rca.padlet.org/10067313/xiao-chen-s-reference-in-high-efficiency-heat-pump-chwmt8lzlgt9dej0

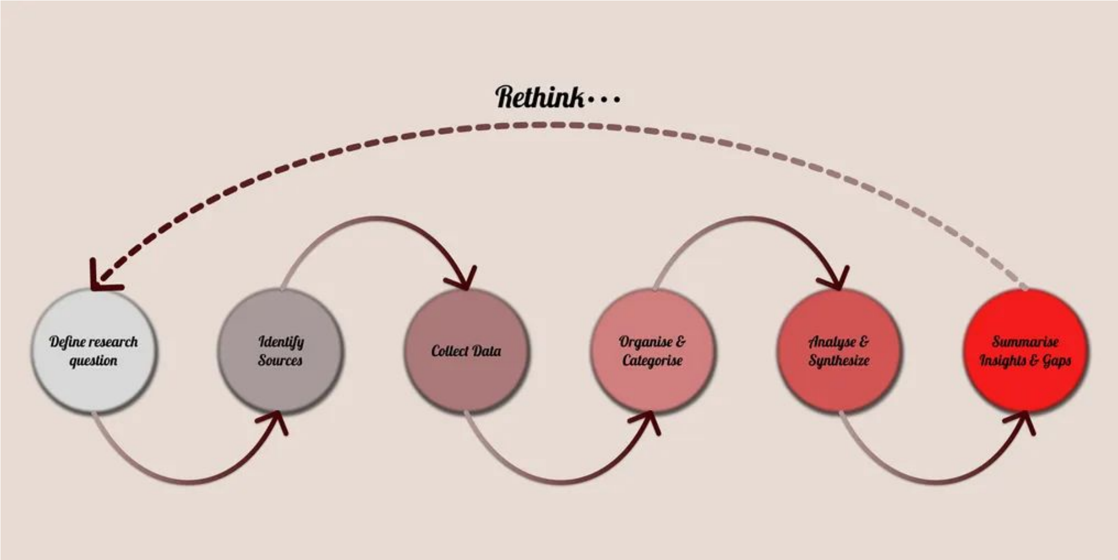
Method ToolKit Entry

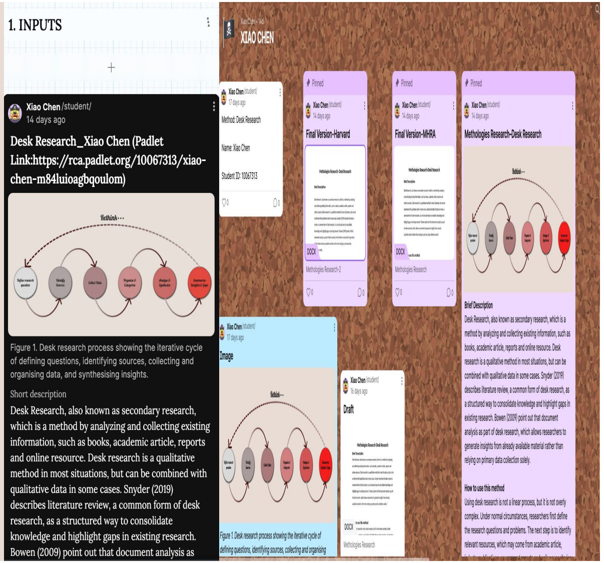
Method: Desk Research

4	Desk Research	Xiao Chen	https://rca.padlet.org/10067313/xiao-chen-m84luioagbqoulom

Individual Padlet Link of Method Toolkit:

https://rca.padlet.org/10067313/xiao-chen-m84luioagbqoulom





Individual Work

Method ToolKit Entry

Brief Description

Desk Research, also known as secondary research, which is a method by analyzing and collecting existing information, such as books, academic article, reports and online resource. Desk research is a qualitative method in most situations, but can be combined with qualitative data in some cases. Snyder (2019) describes literature review, a common form of desk research, as a structured way to consolidate knowledge and highlight gaps in existing research. Bowen (2009) point out that document analysis as part of desk research, which allows researchers to generate insights from already available material rather than relying on primary data collection solely.

How to use this method

Using desk research is not a linear process, but it is not overly complex. Under normal circumstances, researchers first define the research questions and problems. The next step is to identify relevant resources, which may come from academic article, industry publications, government reports and online repositories (Gash, 2000). Hart (2018) think this process involves more than just collection: it requires critical engagement, reflection, and interpretation. After identifying, data is collected and recorded systematically. Findings are organized and categorized to ensure clarity. Finally, insight are analyzed into a coherent conclusion and back to the first step to get more comprehensive understanding in further study. Flick (2014) notes that, “qualitative research is oriented towards analyzing concrete cases in their temporal and local particularity and starting from people’s expressions and activities in their local contexts”, which highlights why systematic interpretation is essential for the credibility of desk-based qualitative methods.

Method ToolKit Entry

Why use this method

Desk research can help researchers to gather wide range of information and build a foundation without starting from zero quickly. It includes the exploration of trends, historical development analysis and validation of assumption in an efficient way (Snyder, 2019). Bowen (2009) notes that desk research is often cost-effective and less time-consuming compared to primary research, while still offering rich insights when applied carefully. As Gash (2000) puts it, “literature searching is about finding information which is relevant to the subject of research and placing it within the context of what is already known”.

Why this method is relevant for Design Futures

Desk research play a key role in the study of Design Futures, the research about future always need to describe complex society systems, technology and culture. Desk research provide a systematic and interdisciplinary method to gather data, which is helpful for mastering trends in some weak signals, and finding gaps in current study, so that creating opportunities for the intervention of design. Snyder’s (2019) view point out that literature reviews reveal research chances underscores how desk research support futures projects by pointing to underexplored areas. Hart (2018) mentioned “Research Imagination” further highlight that desk research is not only realize current knowledges, but also can inspire new design possibilities.

Method ToolKit Entry

Limitation

Desk research has lots of strengths, but is also has limitation. Secondary data may lead to risk because of its outdated, incomplete or biased. Bowen (2009) warning that researchers have to evaluate the authenticity and credibility of text to avoid having same wrong conclusion. Gash (2000) also argues that desk research may copy mistakes and biases rather than challenge them without carefully filtrate. As Flick (2014) saying, desk research need reflective to reduce shortcomings.

Example

A typical example of desk research can be seen in Snyder's (2019) overview of literature reviews in business research. She argues that such reviews often have very large datasets; in one case of she discussed, a systematic review synthesised over 180 peer-reviewed article to consolidate fragmented insight into innovation management. This example show the feasibility of creating clear understanding where knowledge is dispersed across multiple studies by using desk research.

Similarly, Bowen (2009) demonstrate the value of document analysis by examining 54 public documents–including policy paper, reports and strategic plans–during his study of programme evaluation. His research shows that desk research can allow researchers evaluate situation by tracking institutional narratives, and without field investigation. In Design Futures research, similar approaches can be applied when analyzing foresight reports, technology assessments, or governmental white papers. For instance, some potential project may review government report and academic article to exclude noise and identify weak signal and trends for design interventions.

Method ToolKit Entry

Conclusion

In summary, desk research is a powerful and accessible method for collecting and analysing existing knowledge. It enables researchers to understand trends, identify knowledge gaps, and build a strong foundation for future studies. In Design Futures, this method supports informed and imaginative exploration by linking diverse sources of insight. Although secondary data may include bias or limitations, when applied critically and reflectively, desk research remains an essential tool for generating meaningful and forward-looking understanding in design practice.

Reference List

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- Flick, U. (2014) An Introduction to Qualitative Research. 5th ed. London: SAGE.
- Gash, S. (2000) Effective Literature Searching for Research. Aldershot: Ashgate.
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- Snyder, H. (2019) ‘Literature review as a research methodology: An overview and guidelines’, Journal of Business Research, 104, pp.333–339.

Statement Of Authorship & Contribution

Our group 6 worked together about topic “HIGH EFFICIENCY HEAT PUMPS: Using system for both heating and cooling”. We talked and exchange our ideas in the research process, and every member has own job.
My main tasks was **focusing on technology and research method,** which aim to explore the application and adaptation of heat pump system in real world by using research method of design and society. By using the methods like system mapping and timeline analysis, I have learned how to combine technology, human behavior and policy, which means to understand the connection and change between technology, society and environment perspective.
I also learned about how qualitative and speculative design methodologies can work together by mixing real-world analysis with thinking about the future. This process help me to transform vague research ideas to practical and flexible research method that base on evidence, and it can apply in reality and interdisciplinary cooperation.
Varun’s work were contribute the literature evaluation and theoretical framework, which is quite helpful for correcting errors in research process.
Somya worked on combining information together and communicating visually by making structured diagrams and charts to show data.
Charles did ethical reflection to make sure that our work is critical, which means its not imagination.
Through this research, I understand deeply that research methodology is not only tool of analyzing, but also speculative tool, which is significance for facing complex change and planning flexible future.

Statement Of Authorship & Contribution

Use of AI and Digital Tools

Throughout this project, I used AI-assisted platforms such as ChatGPT to refine research framing, improve clarity in writing, and explore methodological connections between socio-technical systems and design futures. I also used Miro for collaborative system mapping, Canva and Figma for visual synthesis, and Google Scholar for literature sourcing.
This tool play a role of analyzing deeply and visually in the research process, but all the key judgment and conclusion were made by me and my group members to ensure academic integrity.