CRITICALLY REVIEWING SMART HOME TECHNOLOGY APPLICATIONS AND ENERGY DIGITALIZATION TRENDS IN EUROPE

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Prof. Benjamin K. Sovacool, University of Sussex and Boston University

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The salience of smart home technologies (SHTs)

The number of home connected devices sales growth by 17% per year across the European Union

Smart home technologies had diffused to 17.5 percent of households globally and generated expected revenues of $84.2 billion in 2022

22.5 million smart homes systems installed in Europe alone or 9.9% of European households have a smart system installed.



It is forecasted a growth of ~30% a year, or 284 million smart homes by 2028, with France, Germany, and the United Kingdom leading the European market.

SHTs will add $14 trillion of economic value to the global economy by 2030 and an additional $100 billion in operating profits across industry.

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Research design (Phase 1)

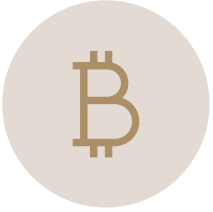
Semi-structured research interviews (n=31)



Government including national ministries and local governments.



Academic institutions such as Imperial College London and University of Oxford.



Private sector firms including energy suppliers such as Engie and Npower.



Civil Society and independent research societies: Energy Systems Catapult and Citizen Advice



Intergovernmental organizations such as the European Commission and the International Energy Agency



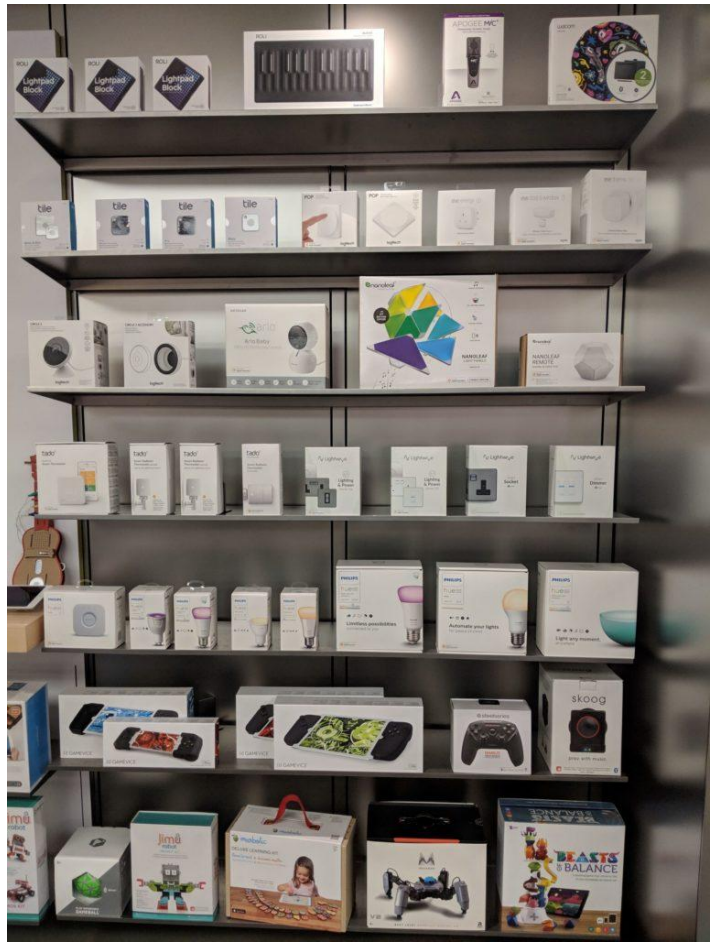
This was complemented with a review of the academic literature

What we asked

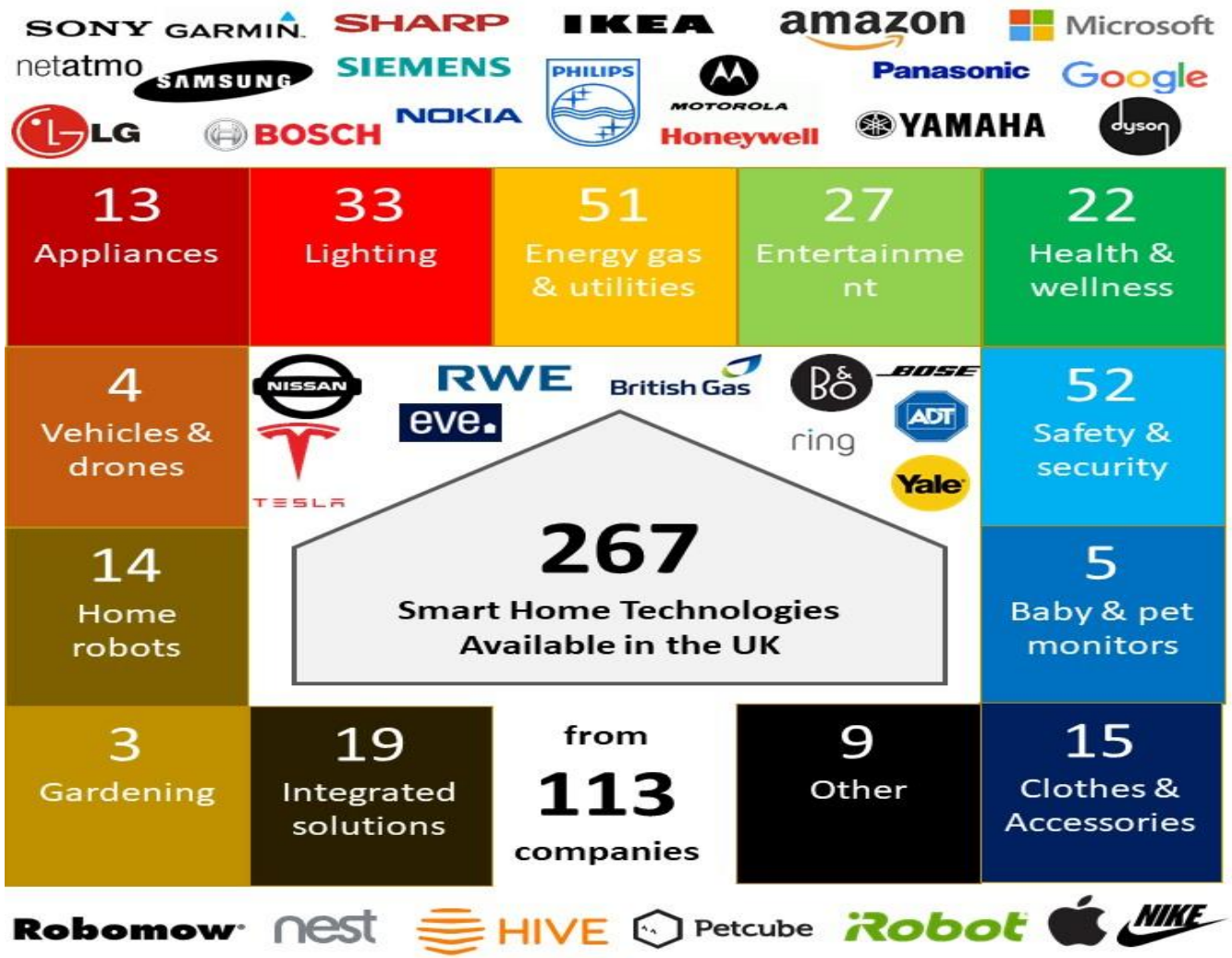
1. How does one define smart home technologies (SHTs)? What are they?
2. What technologies or options for SHTs are available here in the UK and Europe?
3. Are smart home technologies becoming the default option?
4. What are their biggest benefits?
5. What are their biggest barriers?
6. What business models have the most promise?
7. What policy recommendations do you suggest?

Map of the stores we visited (n=37)





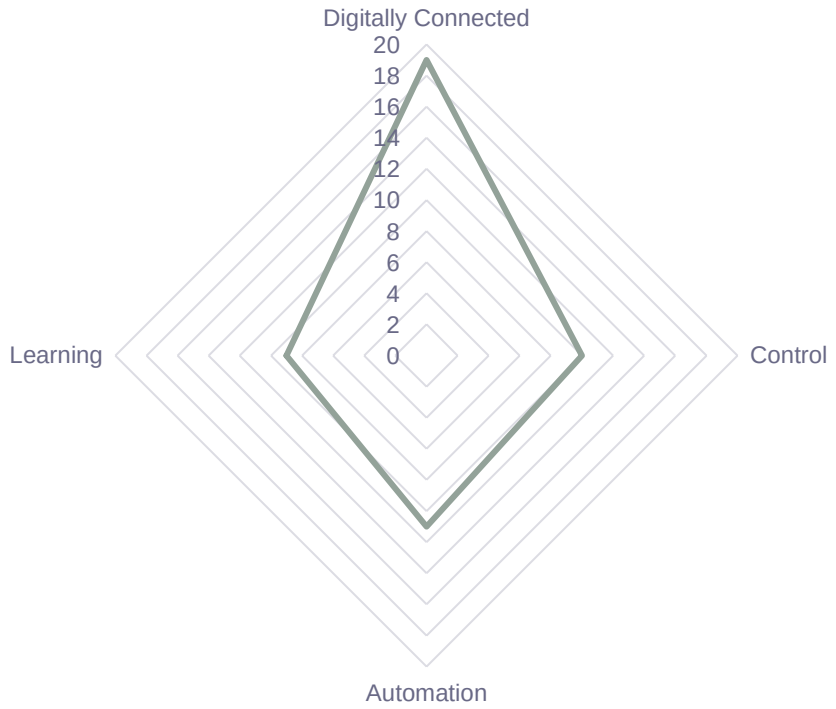
Our first finding: a broad variety of SHT suppliers



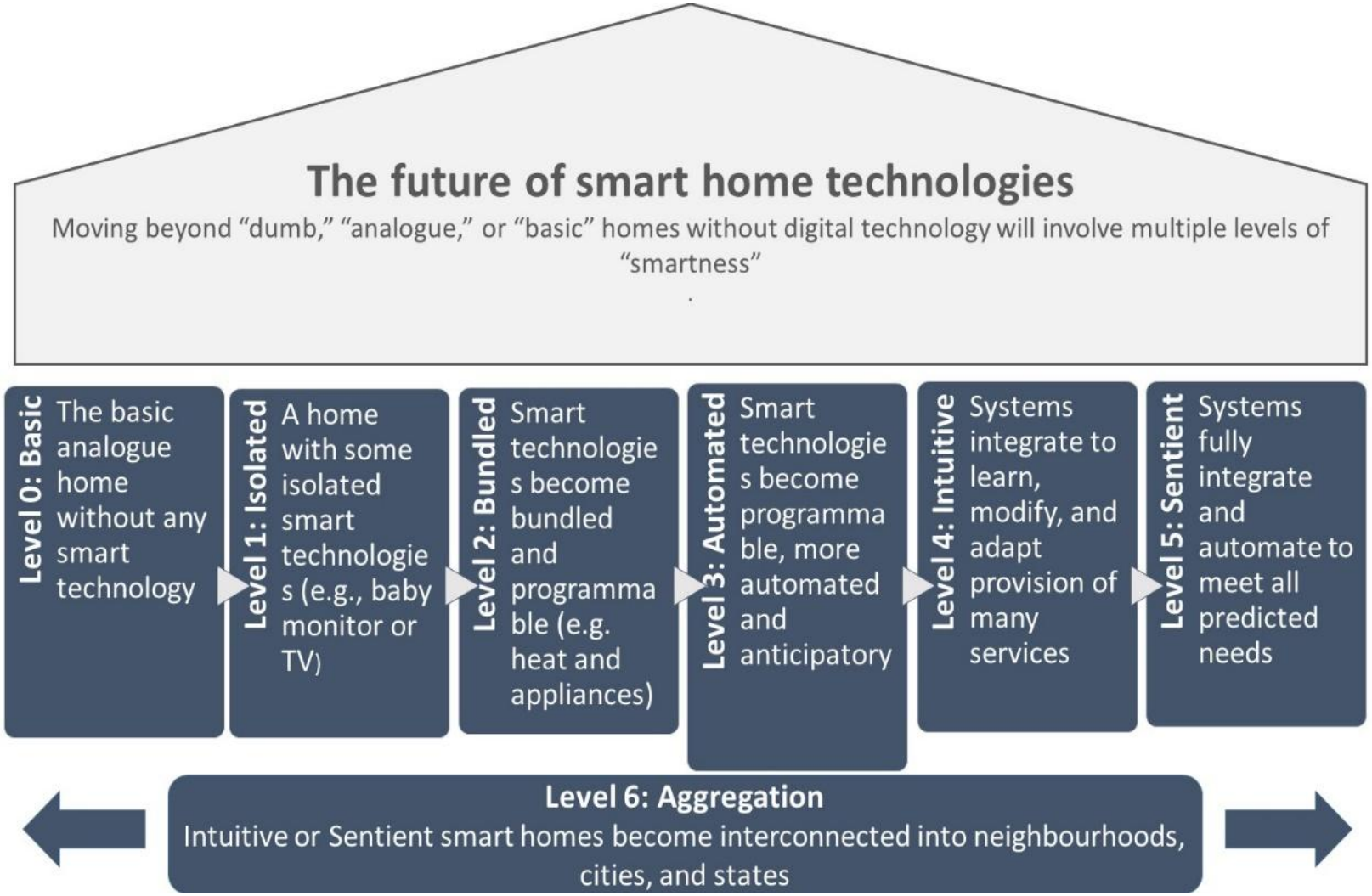
What smart home technologies are?

- There is no consensus on what smart home technologies are.
- From our research, we found that SHTs need to have at least 4 components.

- Digitally connected (19)
- They automate processes (12)
- Allow users remote control (10)
- SHTs have the capability of learning (9)



Our second finding: different levels of smartness



Finding 3: Plentiful benefits

Rank	Frequency by interview		Topic
1	25	80.65%	Energy savings
1	25	80.65%	Convenience and controllability
2	15	48.39%	Financial benefits and saving money
2	15	48.39%	System benefits for grids, networks, operators
3	14	45.16%	Environmental benefits including carbon, pollution, waste
4	13	41.94%	Aesthetics including style, design, feel, and fashion
5	11	35.48%	Health benefits and assisted living
5	11	35.48%	Social benefits including inclusion, networking, status
6	9	29.03%	Educational benefits and learning
6	9	29.03%	Entertainment including music, movies, streaming
6	9	29.03%	Safety and security
7	8	25.81%	Other enhanced experiences (e.g., shopping)
8	4	12.90%	Free services or promotional gifts

Table 1. Smart home technology benefits discussed by expert interview respondents (n=31)

Benefits

- Energy Services
- Convenience and controllability
- Financial benefits and economic savings

Quotes

- *The biggest or best potential for smart home technologies relates to reducing energy demand and better demand management"*
- "*Anything that makes you more comfortable and easier for you to get the outcome you want without having to consciously think about how to achieve that outcome."*
- *"Smart homes should increase the engagement of the consumer with different markets. That has huge potential savings for the customers*".

Finding 4: Emerging Risks

Rank	Frequency by interview		Topic
1	25	81%	Privacy, security and hacking
1	25	81%	Technical reliability, warranties, and obsolescence
2	24	77%	Usability, user acceptance and learning
3	23	74%	Elitism, incumbency, barriers to market, and erosion of democracy
4	20	65%	Uncertainty, lack of sharing, and difficulty monetizing benefits
5	15	48%	Interoperability and resilience
6	14	45%	Energy rebounds and wasteful consumption
7	9	29%	Loss of personal control and autonomy
8	8	26%	Resource intensity, materiality, and sustainability
9	7	23%	Lack of home ownership
10	6	19%	Cultural differences to global diffusion
10	6	19%	Poor connectivity, lack of standardization, and supply chains
10	6	19%	Corporate longevity, accountability, and consumer choice
11	5	16%	High cost
11	5	16%	Fear of new technology
12	2	6%	Social isolation and loneliness
13	1	3%	Health

Table 2. Smart home technology risks and barriers discussed by expert interview respondents (n=31)

Emerging Risks

Privacy, Security and Hacking

Technical reliability, warranties, and obsolescence

Usability, user acceptance and learning

Quotes

- "At the highest levels of smartness, homes are especially most vulnerable to hacking and security breaches. So it's a paradox, the smarter your home is, the more vulnerable you become."
- *"We need to expect in smart systems that we will have problems from time to time, because they are clever, complex, and require expert knowledge, we need to keep our expectations realistic, and always have a plan B*."
- "*Smart home technologies require user learning, but learning isn't limited to users. System operators and business facilitators also have to learn, so do regulators, learning occurs across all of these [actors]"*

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Finding 5: Eight Policy recommendations

Rank	Frequency by interview		Topic
1	18	58.06%	Consumer protection, privacy, data security
2	16	51.61%	Restrictions or configurations to ensure low-energy or low-carbon
3	12	38.71%	Stronger regulations for energy services or Internet of Things
4	11	35.48%	Provide research, innovation, and learning
5	8	25.81%	Remove barriers and encouraging market competition
5	8	25.81%	Provide knowledge, information and evidence
6	7	22.58%	Set standards (marketing and advertising plus technical)
7	6	19.35%	Address poverty, equity, and vulnerability
7	6	19.35%	Promote interoperability and upgrades
7	6	19.35%	Redirect efforts to other policy areas
8	5	16.13%	Mandate and ensure consumer benefits

Table 3. Smart home technology Policies to accelerate their uptake discussed by expert interview respondents (n=31)

Policy Recommendations

Consumer protection, privacy, data security

Restrictions or configurations to ensure low-energy or low-carbon

Stronger regulations for energy services or Internet of Things

Quotes

- *"Stronger consumer protection and regulation is a must, regulation to protect consumers is essential."*
- *Some smart home technologies have some massive wastes of energy…The sustainability thing is scary for me, how much energy is been used and sits in the background?*
- *"Essentially we need policies around improving communication protocols between devices such as easy to use and set ups"*

Finding 6: Most Promising business models

Rank	Frequency by interviews		Business model
1	19	61.29%	Energy services provision (electricity, heat)
2	14	45.16%	Household data and surveillance capitalism
3	9	29.03%	Bundling and integration of services
3	9	29.03%	Subscription models and digital platforms (e.g., Netflix, AirBnB)
4	7	22.58%	Health care
4	7	22.58%	Convenience or accessibility
5	6	19.35%	Demand response
5	6	19.35%	Security and safety
6	5	16.13%	Capturing savings (economic, energy, time, emissions)
6	5	16.13%	Prosuming, peer-to-peer trading and/or Blockchain
7	4	12.90%	Mobility, EVs, and V2G
7	4	12.90%	New advertising channels
8	3	9.68%	Pay as you go
9	2	6.45%	Coupling with retrofits
9	2	6.45%	Insurance models

Table 4. Smart home technology business models mentioned by expert participants (N=31)

Most Promising business models

Energy services provision (electricity, heat)

Household data and surveillance capitalism

Bundling and integration of services

Quotes

- *" With the energy as a service model, the incentive is on the energy supplier to make your home energy efficient, instead of been on the home owner or home renter."*
- "*The real value we are dealing with right here is information; is the data. So, we might move away from the business model where we are selling energy, to a little bit closer on how a lot of services online are now working. Where we are getting Facebook and all of that supposedly for free, but paying with our data"*
- "*I see whole home solutions as the most attractive business case, as they can bundle or integrate solar photovoltaic with say smart appliances, home energy management systems, batteries/storage and electric vehicles*

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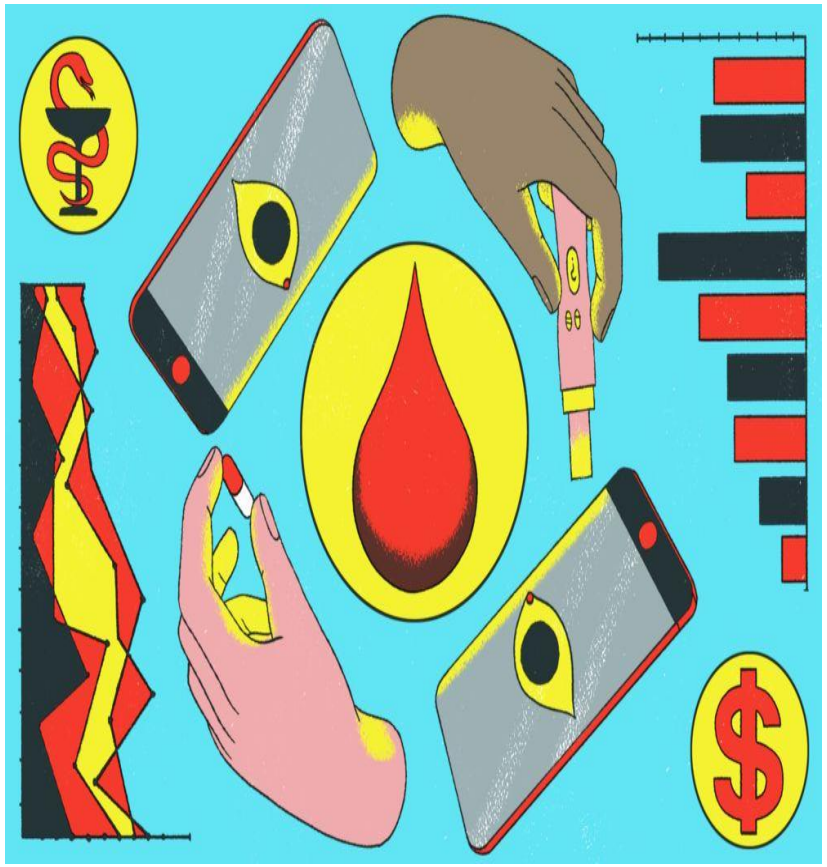
RESEARCH DESIGN (PHASE 2):

Our sources of primary data for this phase of the project were twofold: a nationally representative survey (with quantitative and qualitative questions) distributed in the United Kingdom (n= 1032 respondents)

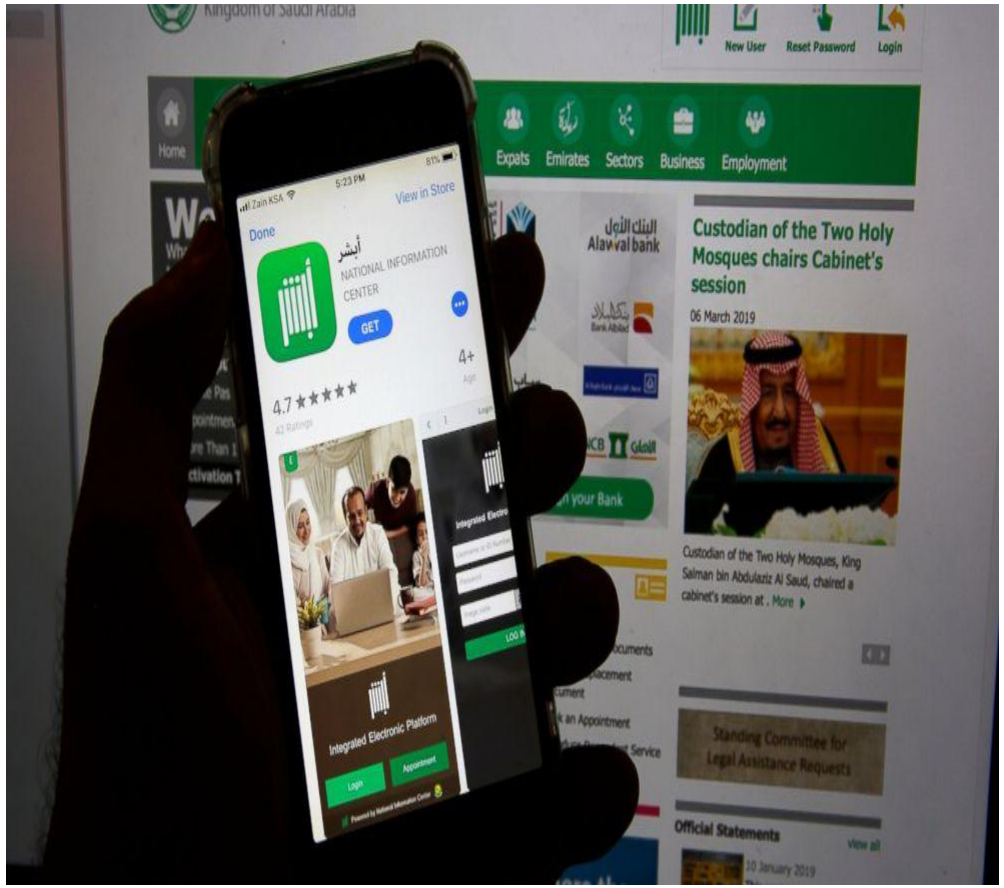
We also conducted three focus groups in London, Surrey and Manchester

Gender bias in the digital economy

- “Menstrual surveillance”



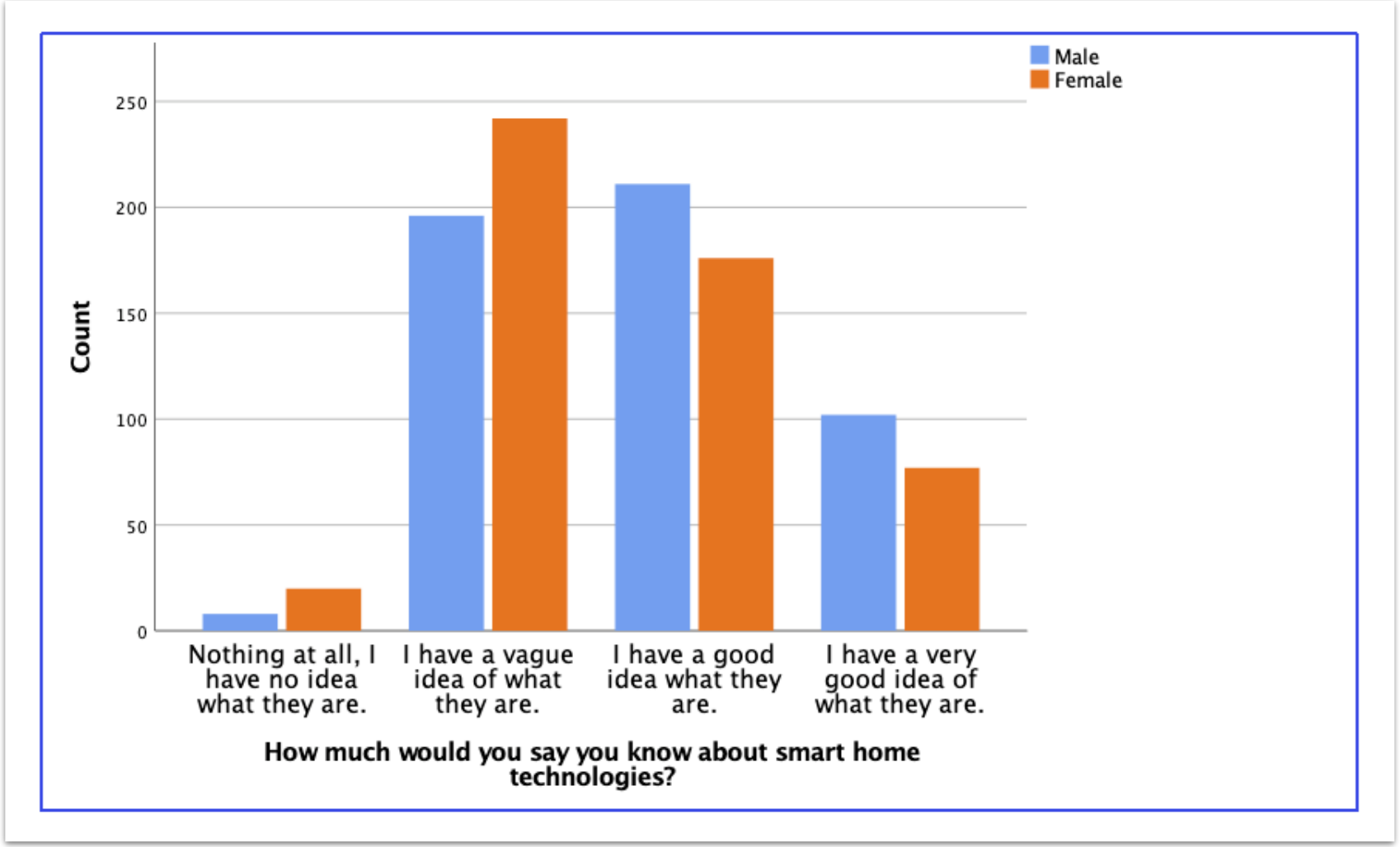
- Enhanced control



Knowledge as enabler of cyber abuse

- Victims feel they are less tech savvy than their abusers

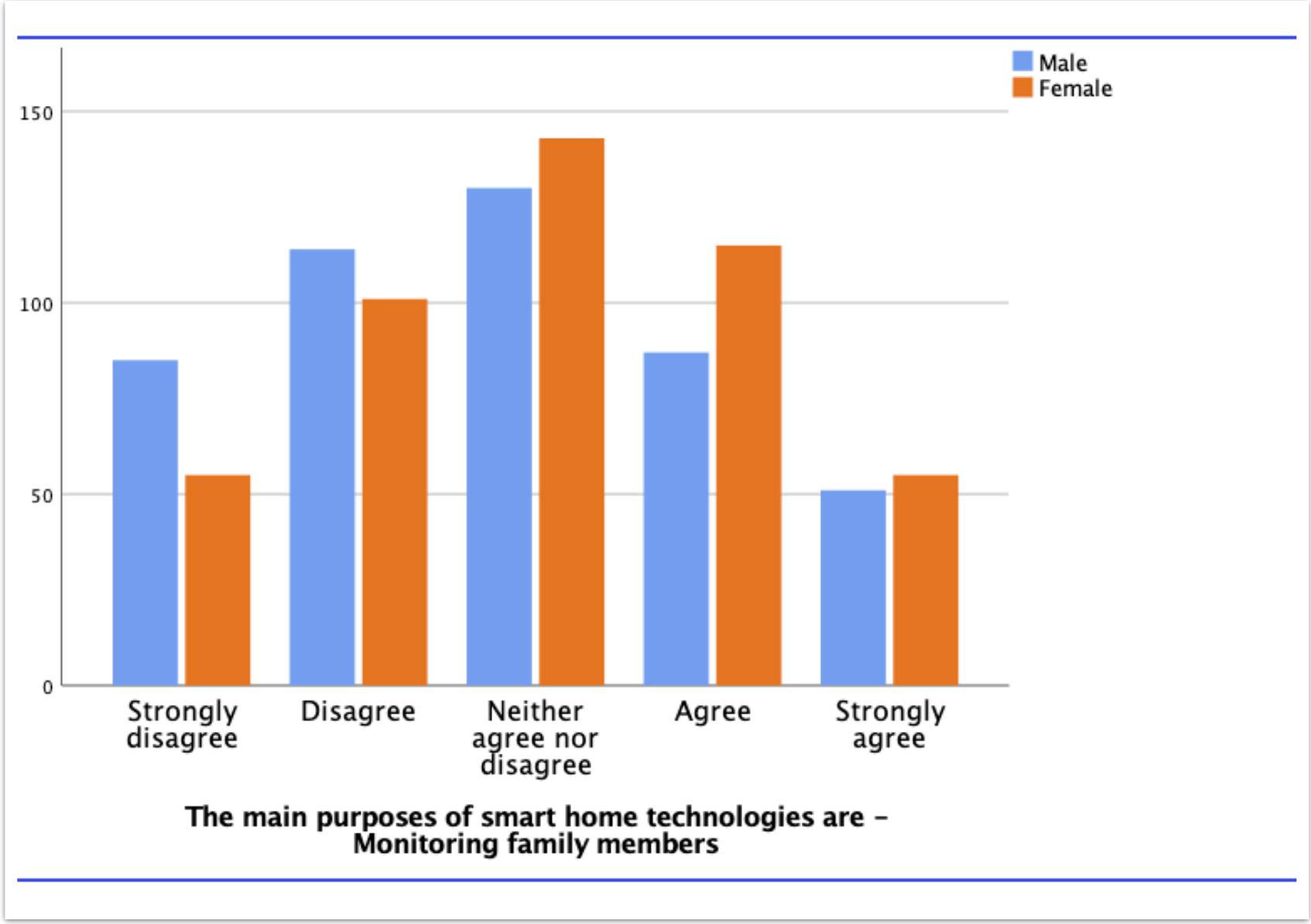
- Due to victims' lack of knowledge, abusers can typically access victim's digital accounts and devices and use them to control them



The main purpose of smart home technologies to monitor family members

- Digital technologies can provide the sense of being ever-present in the victim's life

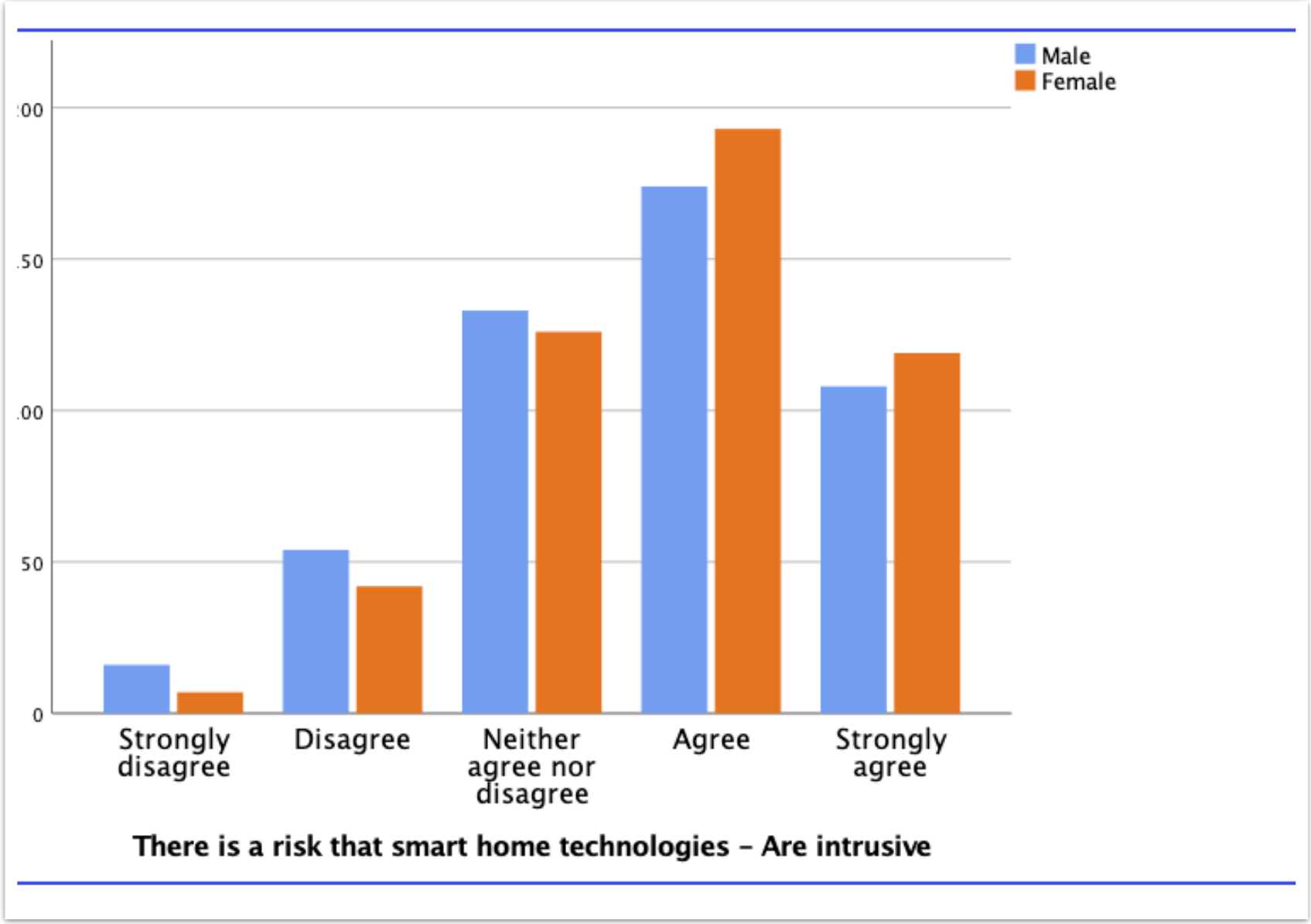
- Perpetrators could slip small tracking devices into their victim's clothes or use smart security locks to either lockout or lock-in their victims. Abusers could use location-based services, parental tracking or other safety services to track their victims



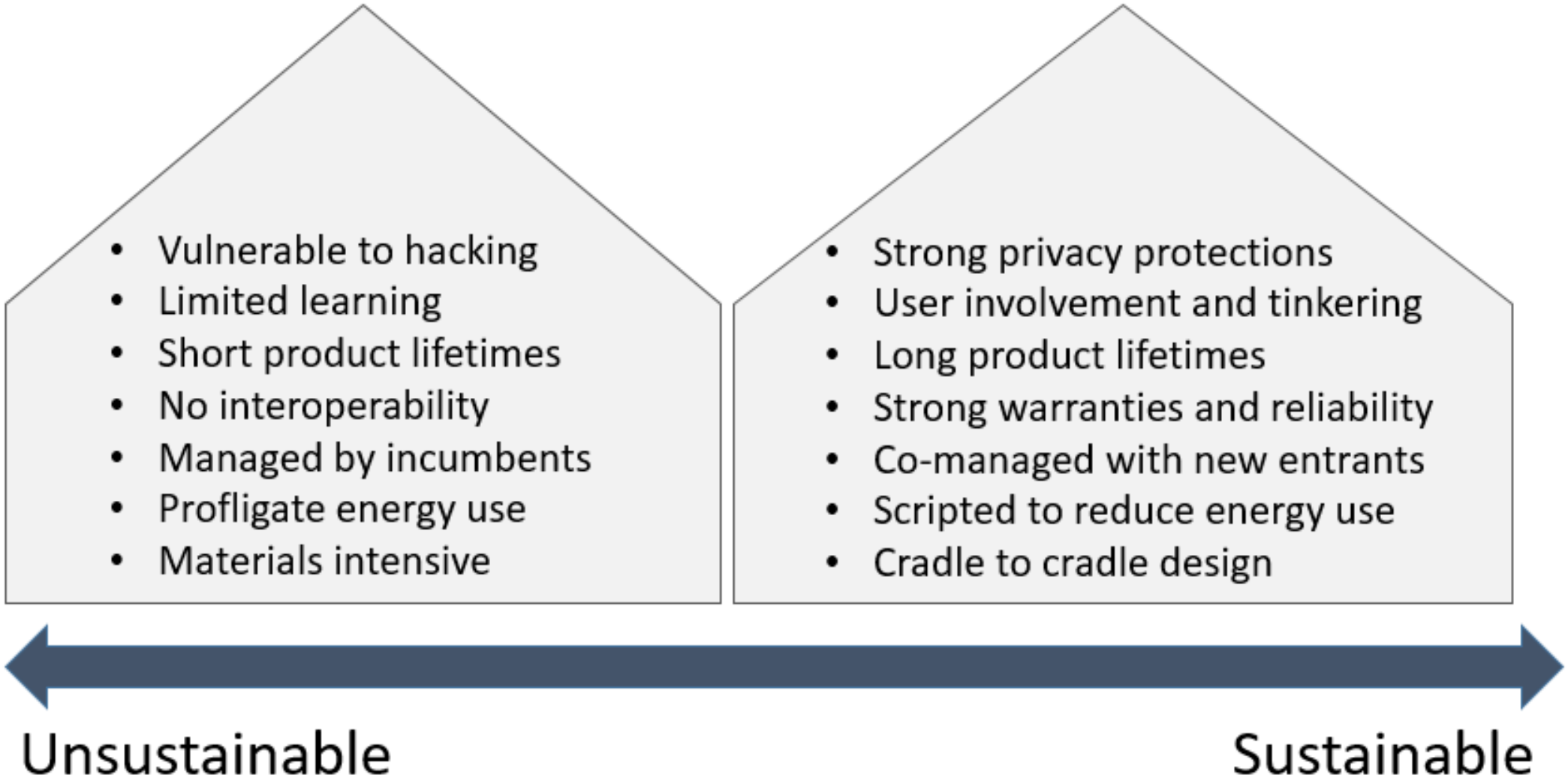
Are SHTs intrusive?

- Victims in this situation felt a condition of *unfreedom entrapment*

- Victims of Cyber abuse have felt their freedom threaten*: 'I would get over 100 abusive texts a day – I never felt free of him'*



Sustainability tradeoffs



Conclusions

- We need a more sophisticated understanding of how these technologies operate in the real world
- Further research ought to focus on developing regulatory frameworks addressing sustainability, energy systems and consumers protection
- Smart homes represent a bundle of different applications and degrees of smartness, all of which cascade into different business dimensions.
- Smart home technologies do not exist in a vacuum; our results show that knowledge, preferences, and perceptions remain mediated by gender as well as opportunities for abuse and violence (and conflict in the home)

Published research

1. Furszyfer Del Rio, D., Sovacool, B., Bergman, N., & Makuch, K. (2020). Critically reviewing smart home technology applications and business models in Europe. *Energy Policy*, 144. Link.
2. Sovacool, B. K., & Furszyfer Del Rio, D. D. (2020). Smart home technologies in Europe: A critical review of concepts, benefits, risks and policies. *Renewable and Sustainable Energy Reviews*, 120, 109663. Link.
3. Sovacool, B., Martiskainen, M. & Furszyfer, D.D Knowledge, energy sustainability, and vulnerability in the demographics of smart home technology diffusion. *Energy Policy* 112196 (2021). Link.
4. Sovacool, B. K., Furszyfer, D. D. & Griffiths, S. Policy mixes for more sustainable smart home technologies. *Environ. Res. Lett.* (2021). Link.
5. Furszyfer Del Rio DD. Smart but unfriendly: Connected home products as enablers of conflict. *Technol Soc* 2022;68:101808. Link.
6. Sovacool B, Furszyfer Del Rio DD, Martiskainen M. Can Prosuming Become Perilous? Exploring Systems of Control and Domestic Abuse in the Smart Homes of the Future. *Front Energy Res* 2021;9:707. Link.
7. Furszyfer Del Rio, DD, BK Sovacool and M Martiskainen "Controllable, frightening, or fun? Exploring the gendered dynamics of smart home technology preferences in the United Kingdom" *Energy Research & Social Science*. (2021). Link.
8. Furszyfer Del Rio, D, Sovacool, B. K & Griffiths, S "Culture, energy and climate sustainability, and smart home technologies: A mixed methods comparison of four countries". *Energy and Climate Change*. (2021). Link.

THANK YOU!!

Professor Benjamin K. Sovacool and Dr. Dylan D. Furszyfer Del Rio

B.Sovacool@Sussex.ac.uk

dfurszyfer@gmail.com