

# TOWARDS A WORKSHOP METHODOLOGY FOR INVOLVING NON-EXPERT STAKEHOLDERS IN THE INTERACTIVE SOUND DESIGN PROCESS: CONNECTING HOUSEHOLD SOUNDS AND ENERGY CONSUMPTION DATA

Yann Seznec

KTH  
Royal Institute of Technology  
Stockholm, Sweden  
yannse@kth.se

Sandra Pauletto

KTH  
Royal Institute of Technology  
Stockholm, Sweden  
pauletto@kth.se

## ABSTRACT

Sonic interaction design and sonification have the potential to provide new ways to display and interpret data and information. Data from a number of domains have been sonified: astronomy, finance, health, security, and many more. However in recent years, research in auditory displays has highlighted the importance of using participatory methods to include stakeholders, often users who are not experts in sound, in the design loop. This raises the question of how to discuss sound with participants who may not be familiar with it, and how to discuss links and relationships between sound and the specific domain which is the focus of the design. In this paper we propose a methodology for a participatory workshop with stakeholders that could be applied to a variety of domains. We describe how we have deployed this methodology in a workshop that aimed to explore attitudes to both sound and energy usage in the home environment, and discuss what can be gained from such an approach.

## 1. INTRODUCTION

The *Sound for Energy*<sup>1</sup> project is aiming to explore the relationship between sonic interactions and energy consumption in the home environment. We are approaching this from a number of different directions with a goal of developing novel interfaces that address resource use through sound. With this long term aim in mind, our initial focus is to develop a deep understanding of attitudes to both resource use and sound environments in the home. Exploring this area presents a unique challenge, as sound and energy are not generally associated with each other in people's minds. Whilst there is certainly an opportunity to improve the existing sonic aesthetic or further explore the affordances presented by sound design and auditory displays [1], we propose that there is a possibility to reveal a more nuanced and complex understanding of the existing and potential links between sound and resource use through participatory activities with users. In order to begin this process we have developed a framework for a user workshop which attempts

to elicit responses that go beyond casual attitudes to both sound and energy and help inform a future set of designs.

## 2. BACKGROUND

A great deal of work and analysis has been done in the field of Sustainable Interaction Design [2], particularly with regards to how interaction design can be used to encourage specific behaviour changes in individuals [3, 4]. However more recently this type of work has been criticized for relying too heavily on displaying data and for reinforcing existing gender dynamics by designing for a so-called "Resource Man" [5]. This can result in what has been termed a "knowledge-action gap" [6], where users are unable (or unwilling) to use the available data to make informed decisions [7]. Additionally, existing literature indicates that household relationships with resource management technology such as smart metres can be fraught and problematic, with early gains in efficiency often being lost in the longer term [8]. This can be seen as a being a result of the technology clashing with existing structures in the household and not being designed with actual household environments and the people living in them in mind.

Comparatively little research within this field has so far focused on sonic interaction design specifically (see [9, 10] to name a few). This work is often applied to voice-activated control systems [11] or audio feedback in the form of warning sounds. However researchers have identified an unpopulated design space in the domestic soundscape for novel sonic interactions (e.g.[12]). There is therefore potential to develop novel sonic interactions that can address issues related to sustainable behaviour by harnessing existing domestic sound behaviours and attitudes.

More generally, environmental sound, and any potential designed sound to be embedded in it, can be a particularly difficult topic to explore within a workshop setting with non-expert users, as we pay little overt attention to everyday environmental sounds and arguably often lack the vocabulary to fully describe thoughts and feelings related to sound [13, 14, 15].

The workshop methodology described in this paper is therefore a contribution to establishing exploratory design activities that can effectively produce useful design material and respond to issues of interaction design, sound, and, in this particular case, energy use.

<sup>1</sup><https://soundforenergy.net>



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### 3. WORKSHOP STRUCTURE

The aim of the workshop was threefold:

- To explore existing attitudes to sound in the home environment
- To explore attitudes to resource use, leveraging examples described in existing literature
- To explore, via a speculative approach, how these two concepts could be linked

The order of these three aims is deliberate, and was reflected in the resulting structure. By foregrounding the issue of sound in the workshop we implicitly framed the discussions of resource use that followed as something that could be addressed (or illustrated) through sound. The first two aims also focus on exploring existing attitudes to sound and resource use respectively, while the third aim speculates about a connection between these areas in the close future rather than in the present. This allows us the participants to imagine connections between the main topic unburdened by practical limitations.

Whilst in our workshop we focused on energy use in the home, the structure proposed here is agnostic to any one specific application area. In practice the second aim could be replaced with any topic that a researcher is attempting to link to sound.

In practical terms, the workshop was split into three distinct sections, which we refer to as *tasks*: a first task involving the sketching of a soundscape on the basis of present attitudes and experiences; the formulation of a response to a specific resource-use scenario; and finally a speculative design fiction exercise.

A first iteration of this kind of workshop took place on a university campus in Stockholm in December 2021. Nine participants (5 male and 4 female) took part, who were students and employees from the university. The workshop was scheduled to be 3 hours long. Participants were asked to split into three groups and, after a short introduction to the project, began the first task.

#### 3.1. Task 1: Personal attitudes to sounds

For this first task, the users were given a prompt and asked to discuss it and take notes in response. This was kept deliberately short, around 10 minutes. The aim of the prompts was to ask the participants to explore three feelings (not necessarily in relation to sound) in the home: a feeling of coziness, which might be associated with feeling relaxed, within a familiar environment, with feeling secure; a feeling of frustration, which might be associated with things not working properly or being annoying; and the feeling of fun which might be associated with playfulness, excitement, happiness. We were interested in these feelings because in this project our goal is to create sonic interaction designs that embed well in the house, perhaps producing feelings of coziness and fun, while avoiding feelings of frustration.

The prompts were written on pieces of paper and given to each group: *Imagine and describe a cozy/frustrating/fun situation in the house. Are you alone or with others? Would there be conversations, what kind? In which room? What would you and others be doing? What time of day is this? What is it like outside?* Following the short group discussion, the groups were then asked to attempt to illustrate these situations through the sketch of a soundscape. As participants were not expert in sounds, we thought that it would be beneficial for them to first conjure up these situations in their mind, and only afterwards consider which sounds in the house they might

associated with them. The groups were provided with an array of everyday objects that could make a variety of sounds, as well as access to the online BBC Sound Library web interface<sup>2</sup>, which enables users to search a wide library of sounds and add them together to form a layered mix. The resulting soundscapes were then performed and a short discussion ensued.

#### 3.2. Task 2: Testing scenarios around resource usage

This section of the workshop was based on existing literature about existing attitudes to energy consumption (and resource use more generally) in the home. During this task the groups were each given a scenario drawn from existing literature around the usage of smart metres. The scenarios were for the most part based and adapted from results from interviews performed by Hargreaves and colleagues as part of a longitudinal study on smart metre usage (or lack thereof), which appeared to indicate a number of problems with how the technology is adapted, and in many cases slowly abandoned by users. [8].

The scenarios were as follows:

##### Scenario 1: Family A

*Parent:* How long were you in that shower?!

*Child:* I dont know, I didnt keep track! Does it matter?

*Parent:* It all costs money, you know! Hot water isnt free.

*Child:* I dont think it would make any difference to be a few minutes less, you probably wouldnt even notice.

*Parent:* I just feel like we could all be taking shorter showers. Why use hot water we dont need?

##### Scenario 2: Husband and wife

*Husband:* We got the smart meter one year ago. It was a novelty then, so we checked it regularly, but we dont use it much now. We have a good idea of what it is going to show anyway.

*Wife:* It was in the living room at first, but then we rearranged up the house and it was getting in the way in the living room, so Nick has it in his office.

*Husband:* I spend an awful lot of my time in the office so its sort of monitored most daytimes now at least, but less in the evenings of course.

*Wife:* We changed the way we used some electricity after getting the meter, and I think those changes will stay, because we dont think about it these days. Its part of life now to make sure that youre not using too much power, and were all aware of it.

##### Scenario 3: Family B

*Father:* Julie you must turn the TV off.

*Julie:* But it is turned off!

*Father:* Its not properly turned off, youve just put it on standby. That keeps using some energy.

*Julie:* How much could it possibly be using? And that means I have to turn it on at the TV.

*Father:* Go look at the smart meter Julie. You can see the difference it makes.

<sup>2</sup><https://sound-effects.bbcrewind.co.uk/search>

*Julie:* Mum moved it into your office, remember?

*Father:* Yeah Im trying to teach her this stuff too.

*Mother:* Excuse me? Teach me about what? Why dont you worry about the time you spend hoovering the car? That takes energy too

*Father:* Well, the meter says that my hoovering for a week uses less than a TV left in standby mode for a week.

*Mother:* Yeah, but the hoovering is much more annoying.

Participants were asked to discuss the scenarios in their groups and then present the results of their discussion with the larger group.

### 3.3. Task 3: Design fiction

The primary method for exploring connections between sound and, in this case, energy consumption was speculative design fiction, as previously used by Pauletto and others [16]. Each group was provided with a blank New York Times newspaper and instructed to imagine a front page in 100 years time, with a focus on energy efficiency and sound. The groups were encouraged to put aside concerns about realism or practicalities and consider possibilities from an imaginative standpoint. They were asked to imagine titles, short text, images and if possible accompanying sounds. Magazines and other imagery was provided in case they wanted to cut out pictures to include.

Three specific areas on this speculative future newspaper were open for a imagined stories from the past, present and future (from the perspective of the year 2121). The first is in answer to the question: What has *already been done* in the area of sound and energy today (in 2121) that causes headlines? The second is: What do you *want to be done* in the near future?, i.e. what is not been done right now but you would like to. What headlines would these ideas create? The third is What was *not done* in the past that caused a scandal?, i.e. think about what was not done that people in the future think you should have done, and that will cause their reaction.

Each group was thus tasked to design their newspaper by filling it in with text and imagery explaining and illustrating their speculative future and then present it for discussion.

## 4. RESULTS

### 4.1. Task 1: Results

#### 4.1.1. Group 1

This group was tasked with the “frustrating” situation. They described feelings of frustration resulting from losing something, clashing with other household members about lifestyle, and being overwhelmed by notifications. They approached the soundscape aspect of the task by finding sounds that represented objects being broken, doors being opened and closed, ringing phones, tap dripping, and digital sonic feedback indicators. These sounds were all primarily found on the BBC Sound Library mixer system, and were played back simultaneously.

#### 4.1.2. Group 2

This group was assigned a “fun” situation, and they approached this by attempting to create the sounds of a social evening with

#### Task 1: Personal attitudes to sounds

- Discuss a situation in the home in small groups
- Design and create a soundscape to describe it
- Listen and discuss



#### Task 2: Testing scenarios

- Discuss home energy usage scenarios in groups
- Present discussion to the larger group



#### Task 2: Design fiction

- In small groups, imagine a future scenario combining sound and energy usage
- Create a newspaper from the future illustrating this situation, how it arose, and what could happen

Figure 1: Overall structure of the workshop

friends playing board games. In order to recreate this soundscape they used music played back on Spotify, a recording of a cafe, and they crinkled a plastic bag to create the sound of eating snacks.

#### 4.1.3. Group 3

The third group represented the “cozy” situation. They imagined a party night where it was raining outside, during Christmas season, eating snacks, and drinking wine and glogg. They played rain sounds from the BBC sound library, Christmas songs from Spotify, and during the playback of these sounds the group simulated a conversation in order to represent the social interactions of the party.

### 4.2. Task 2: Results of Energy Scenario Discussions

#### 4.2.1. Group 1

Group 1 described their scenario as “a small argument between a child and their parent about using the hot water in the shower too much”. In response to whether they felt that the scenario was “believable”, the group members said that it could be familiar within certain cultural or economic conditions (areas with expensive scarce resources), but that in countries like Sweden this may be less familiar due to relatively few energy constraints.

#### 4.2.2. Group 2

The second group described their scenario as being a discussion between a husband and wife with regards to a smart metre in the house, and how their use of it has changed. They thought the level of tension was minimal: “we thought there wasn’t actually that much tension...the couple seem to really agree that the smart metre isn’t that important right now...it’s that thing they did before”.

They commented on how the smart metre felt like more of a collector's object than something useful, and that they felt perhaps "too relaxed" about it. The group also commented on how the scenario reflected traditional gender roles, with the husband in control of the technology. One group member described the use of a smart metre in her own family home, pointing out that her family found it useful and that it did not cause tension or arguments.

#### 4.2.3. Group 3

The final group described their scenario as not being very believable, mainly because completely switching televisions off (rather than using standby mode) did not feel to them like standard practice: "...we talked about mostly about turning the TV off standby or turning off completely. And we decided that it wasn't that believable because no, we haven't heard about anybody asking anybody to switch it off properly, leaving it on standby is just the accepted way."

### 4.3. Task 3: Results of Design Fiction

#### 4.3.1. Group 1

This group's design fiction centred around the idea of buildings as "living beings". They imagined a future in which houses were sentient and had feelings. The issue from the past was therefore described as a decision by designers to not give buildings natural language processing abilities, which led to their inability to properly communicate their stresses. In terms of future developments, they described new modern houses that will allow for better communication, possibly linking to sustainability as the inhabitants can be told if their resource use is too high.



Figure 2: Excerpts of the Group 1 design fiction task

#### 4.3.2. Group 2

This group focused on the concept of "beautiful annoying sounds". They described a past where "annoying" sounds were used to communicate excess energy use (such as items left on standby). However in their present this has gone out of control and "neighbourhood tensions are at an all time high" due to the sheer amount of warning sounds. Therefore the story for the future is that the society is pinning hopes on finding "beautiful annoying sounds" that can be used as a warning whilst being sonically pleasing.

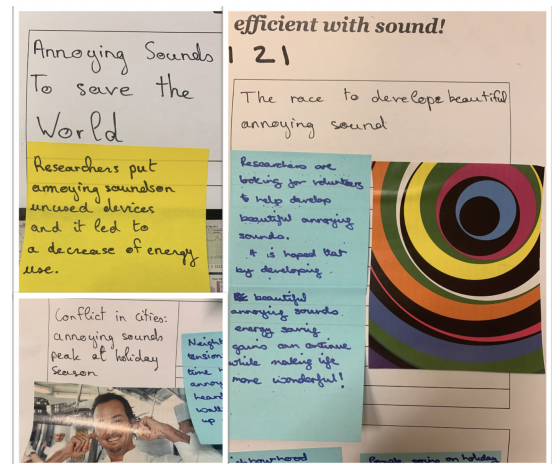


Figure 3: Excerpts of the Group 2 design fiction task

#### 4.3.3. Group 3

The third group developed the idea of a musically responsive house. In their speculative past the sonic feedback that had been developed for homes had become "horrible" and unlistenable, leading to users switching off the sounds. This then led to a standardised method of assigning sounds to items and actions, focusing primarily on musical feedback: "maybe a saxophone to the kettle and a piano to the fridge". This was linked directly to energy usage, with excessive energy usage having a negative impact on the musicality of the feedback. In their future, this was going to lead to a system of musical energy credits, with good usage being rewarded with credits that could be used for better musical feedback:

The more energy you consumed, the more bad the timing was, the more wrong the pitch was, and things like that. But if you've got a daily tune, there was also weekly charts for everybody. So you're trying to produce the best music which basically means keeping your energy consumption low, so you didn't get any, you know, so any wrong notes or something like the key or something like that...

## 5. DISCUSSION

The structure of the workshop was designed to elicit personal reflections on relationships to energy and sound in the home, and encourage creative thinking about how these concepts can be linked. This was the main motivation behind the order and specific nature of the exercises, and the results of the design fiction confirm this approach. All three design fictions incorporated fundamental sound design concepts (interactive music, responsive communication, and sonic feedback) and linked these directly and indirectly to energy usage. The discussions of the scenarios was fruitful and led to a number of insights, particularly regarding the personal contexts of energy usage.

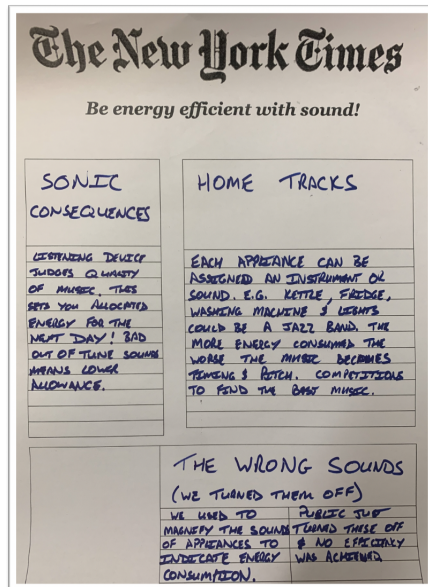


Figure 4: Group 3 design fiction task

### 5.1. Discussion of Task 1: the home environment and its sounds

This section served to guide non-expert participants towards thinking about sound and sonic interactions in home environments and how that might connect to different feelings in the house. They successfully created sound designs that reflected their thoughts on what the situations might represent, and for many of participants it was their first time working creatively with sound or even considering sound as a medium.

The takeup of the tools on offer was mixed, with only a few of the tangible sound making devices being used, and the BBC Sound Library Mixer being eagerly adopted by Group 1 in particular, but somewhat intimidating to Group 2.

### 5.2. Discussion of Task 2: Energy Scenarios

#### 5.2.1. Cultural context of energy usage

The discussion of the scenarios provided a practical way of exploring different attitudes to resource use, much of which are derived from social and cultural factors. This can include how much of a resource is actually available currently, or whether the resource was perhaps limited in the past and the attitudes remain despite a change in situation.

In response to Scenario 1, for example, one participant mentioned that water usage was an issue for his grandmother, but in practice was not an issue in other countries:

While I've lived in big city on the life, I can't really assume the scarcity part. But I do know from, for instance, my grandmother, who comes from a small village in Poland, her commenting on wastefulness, when I was just watering plants, or let tap running, for instance, or getting water and going away, still letting it run, and so on...because yeah, back in her village, they basically have to make physical wells to

get access to water, compared to here in Stockholm, where we literally have a large river going through the city.

Another participant, originally from India, felt that the scenario itself would be much more believable if it took place there, rather than in a northern European country:

Personally to me from India, it is very believable and it has happened. And so it's very familiar. But the tension comes from economic concerns. So you have to pay for water. And hot water is not supplied separately, we use heaters to heat the water, we consume electricity. So both these add additional financial constraints on the problem...But I don't know whether, if you remove the economic constraints from there, the parents will respond the same way. Because even India still has a deep conservation mentality where we don't want to waste stuff...So I don't know if you displaced that family to here how it would play out, maybe it might play out because of deep rooted mindsets. But in Sweden, I don't think this situation is very familiar me. But it comes from resource scarcity.

This led to questions regarding the scope of our research. From these discussions, it became evident that attitudes towards resource usage are culturally and socially specific, to the point where there will be specific attitudes towards energy consumption that may not be fully transferable even to other European countries. This indicates that we can attempt to widen our scope sufficiently to make any work relevant to a large area - perhaps European-wide - while also taking advantage of the particular context which we live in to explore specific concepts.

To a certain extent this same concept can be applied to the soundscape activity. The resulting sound designs that were generated by the participants will necessarily have been influenced strongly by their own cultural backgrounds as well as their current lifestyles (the focus on notification sounds being perhaps the most obvious illustration of this).

#### 5.2.2. Invisibility of resource use

Modern resource use is for the most part invisible. This has been discussed elsewhere by Lockton [17] and can be seen within a greater context of both general efficiencies as well as structural hierarchies that link wealth and privilege to more hidden resource usage.

This was raised specifically in the discussion about "standby modes" on different devices. Generally speaking the participants agreed that this was not an issue they had considered much, with perhaps one reason being that experientially the difference between standby and fully-off on modern devices is limited. This was not the case even just a few years ago:

That situation was slightly familiar when you had CRT TVs, because they took a while to turn on, especially if there was a humidity, so the screen would condense inside so then it would take a while for it to turn and for the picture to come up. But we get really frustrated waiting for that to happen, especially if you were like just wanting to watch something and you were like come on! So you would just leave it in



standby so that that doesn't happen. So then my dad would get annoyed.

Certainly on many modern devices the resource gains from switching between standby and fully-off would now be marginal, so in some ways this difference in experience maps well onto energy usage. Nevertheless this discussion points to a fundamental tension in modern households - the use of energy has become increasingly invisible, even as the use of energy has grown considerably. Put another way, the hiding of the delivery of energy has outpaced the use of that energy.

This brought us to consider how can this be addressed specifically through sound. Some possibilities include making the data visible (or audible), raising the questions of why it is hidden, or potentially something that questions the structure more fundamentally. This points perhaps towards the adoption of adverse-arial/agonistic, political, or other activist design techniques[18].

### 5.2.3. Expanding resource interaction to different audiences

Smart metres and other resource tools are well documented as being primarily aimed at people, usually men, who consider themselves better informed and able to make decisions on the basis of their understanding of data often displayed through graphs. Such a person has been termed a "Resource Man" [5]. This was reinforced in the workshop by several discussions, which covered both the prominence of gender clichés in resource decisions (data-driven men vs. feeling-driven women) and the particularly difficult place occupied by children with regards to energy and sustainability.

From a child's perspective, since they're not directly affected by [energy costs], like they're not the ones paying for it, it doesn't directly affect them. So they're removed from the actual cause of the problem. And as a result, they feel entitled to little amount of to certain amount of comfort, whereas the parents have to pay for it. So it affects them directly, and therefore there's tension there.

What emerged from the discussions was that different gender relations to the household environment and current displays of consumption, as well as age should be considered in any new design promoting energy efficiency. Children in particular are in some ways stuck between a having little power and too much awareness, as the sustainability and climate change discussions are inescapable - children have inherited a situation over which they had no control. How can this be addressed? Are there perhaps interactions and/or interfaces that can bridge some of these gaps through experimental or playful design?

## 5.3. Discussion of Design Fiction

The three groups each took quite different approaches to this exercise, resulting in three distinct outcomes. We can broadly describe these as focusing on sound in terms of language and speech, sound design, and music.

The first group explored the concept of communication with home interfaces, specifically using language as a metaphor. Various positive and negative outcomes to this were discussed, with the primary focus being on natural language interface and how it can be related to a sense of character or emotion.

The second group built much of their design fiction on the idea of "the race to develop beautiful annoying sounds", which can both perform a specific function in terms of warning users about excessive energy use or other situations, whilst avoiding a sense of unpleasantness or other problems that can come from sounds warning about negative situations.

The third group took a musical approach, describing a future in which houses create dynamic musical sound systems in response to the resource use.

### 5.3.1. Character of sounds

Whilst the first group's idea focused primarily on language interfaces, which is likely to be outside the scope of our project, their exploration of the idea of character is worth analyzing. For example, this led to a further discussion amongst several workshop participants around the use of sound as a method of conveying information without words, looking instead at language prosody (as is often used in fictional media representations of robots e.g. wall-e). There would appear to be an opportunity to explore the use of characterful and potentially emotionally complex sound generation as a feedback or interaction within the home, particularly if it explicitly avoids language or explicitly referential approaches.

### 5.3.2. Context - Beautiful Annoying Sounds

The discussion around the possible overlap between "beautiful" and "annoying" sounds evolved to cover the idea of context, and how a single sound can take on a number of different characteristics depending on the situation. This is of course a fundamental challenge with regards to all sound design, and in particular sonic interface design. A number of directions could be explored in response to this, including both the content of sound and the interface that delivers the sound to the listener. What effect is the sound making device itself having on the user's perception and interpretation of the sound? And could the implementation of meaningful content choice on the part of the user through a personalization process influence their feelings on the interaction?

### 5.3.3. Humor and playfulness as an alternative to positive/negative reinforcement

The musical house concept (and to a certain extent the other design fictions) relied on the idea of negative sonic feedback - unwanted behaviour being represented with "bad" sounds. This raises an interesting question of what other types of relationships are possible between interaction and sonic feedback. One possible method to explore would be to use humor and/or playfulness as a potential bridge or alternative to the traditional positive/negative reinforcement dichotomy. An example could be experimenting with disruptive designs of existing feedback systems such as the smart meter. This would open up a number of avenues for creative design exploration of interface and sonic feedback that could perhaps also address the different modes of engagement of different age-groups.

## 6. DISCUSSION: WORKSHOP METHODOLOGY

In this paper we have described a workshop methodology that addresses an issue common to many sonic interaction design and sonification projects: how to involve non-expert users in the design of new sonic interactions for a specific domain when they

have no knowledge about sound, and maybe not even about the application domain. It is likely that these stakeholders can therefore be confused or unsure about how these areas could intersect. Our workshop started from the type of experiences we wanted to invoke (or gently guide away from) with our design and asking people to conjure up situations that produced those feelings. With these in mind they could then successfully start to think of sounds associated with those situations and experiences. Having thought about feeling and sounds, we then switched the attention on to the application domain. With the support of literature we provided existing scenarios in that domain in which feelings of frustrations or satisfactions were described. This helped the participants bring together issues relevant to the application domain, their feelings towards it, and sounds that might be associated to those feelings. Finally, the design fiction aspect of the workshop allowed participants to fully explore and expand on the connections made in the first two parts of the workshop, with the freedom afforded by this speculative method.

A number of adjustments could be made to a future iteration of the workshop, especially one with a larger number of participants. For example, a more formalized cross-analysis between groups could prove useful, particularly on Tasks 1 and 3, giving the users the opportunity to assess each other's work and ideas and potentially generate deeper insights into the attitudes towards sound and energy. A more in-depth workshop could also expand to the development of initial prototypes that could then be evaluated using both qualitative and quantitative measures.

In the end, participants were able to formulate connections between areas that only three hours earlier seemed completely disparate. From the perspective of the researchers, this workshop has been very fruitful. The workshop has produced ideas (e.g. the “annoying-beautiful” sound concept) and opened up directions (e.g. humor and playfulness as an alternative to positive/negative reinforcement) that we would not have been able to consider. Overall, we believe that this “hybrid” methodology has been successful in allowing non-expert users to efficiently make connections between diverse areas and come up with very useful design material for researchers to develop on.

## 7. CONCLUSION

The workshop described in this paper provides a template for exploring issues shared by seemingly separate topics - in this case, sound and energy usage. By designing a workshop that places equal emphasis on discussions of (and hands-on experimentation with) sound alongside activities exploring resource use, we were able to elicit from the participants a dynamic and insightful analysis of the role that sound plays in everyday life, and extrapolate some potential directions and core concepts that can now be taken into account with regards to future designs.

## 8. ACKNOWLEDGMENT

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<sup>3</sup><https://soundforenergy.net>

<b>Task 1: The house as a sonic environment</b>	
Successful	All groups able to connect sound and sonic interactions in the house with different feelings
Mixed take up of sound tools	Little take up of physical sound objects (maybe more variety needed), some take up of digital tools, although intimidating for some
<b>Task 2: Energy scenarios</b>	
Areas discussed	Cultural context of energy usage
	Invisibility of resource use (e.g. standby vs. full off)
	Expanding resource interaction to different audiences (e.g. children, adults, older generations)
<b>Task 3: Design fictions</b>	
Three main emerging ideas	Buildings as living beings
	Potential of <i>beautiful-annoying</i> sounds
	Musical responsive house
<b>Final discussion</b>	
Main takeaways	Explore useful characteristics of different categories of sounds: voice (e.g. prosody), everyday sounds, and musical sounds
	Always consider how sound changes in context (e.g. beautiful-annoying sounds)
	Humor and playfulness as an alternative to positive/negative reinforcement

Table 1: Summary of workshop's results

## 9. REFERENCES

- [1] M. Jeon, "Exploring Design Constructs In Sound Design With A Focus On Perceived Affordance," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 63, no. 1, pp. 1199–1203, Nov. 2019. [Online]. Available: <http://journals.sagepub.com/doi/10.1177/1071181319631340>
- [2] E. Blevis, "Sustainable interaction design: invention & disposal, renewal & reuse," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. San Jose California USA: ACM, Apr. 2007, pp. 503–512. [Online]. Available: <https://dl.acm.org/doi/10.1145/1240624.1240705>
- [3] C. DiSalvo, P. Sengers, and H. Brynjarsdottir, "Mapping the landscape of sustainable HCI," in *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*. Atlanta, Georgia, USA: ACM Press, 2010, p. 1975. [Online]. Available: <http://portal.acm.org/citation.cfm?doid=1753326.1753625>
- [4] J. Pierce and E. Paulos, "Beyond energy monitors: interaction, energy, and emerging energy systems," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Austin Texas USA: ACM, May 2012, pp. 665–674. [Online]. Available: <https://dl.acm.org/doi/10.1145/2207676.2207771>
- [5] Y. Strengers, "Smart energy in everyday life: are you designing for resource man?" *Interactions*, vol. 21, no. 4, pp. 24–31, 2014.
- [6] H. Brynjarsdottir, M. Hkansson, J. Pierce, E. Baumer, C. DiSalvo, and P. Sengers, "Sustainably unpersuaded: how persuasion narrows our vision of sustainability," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Austin Texas USA: ACM, May 2012, pp. 947–956. [Online]. Available: <https://dl.acm.org/doi/10.1145/2207676.2208539>
- [7] A. Kollmuss and J. Agyeman, "Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior?" *Environmental Education Research*, vol. 8, no. 3, pp. 239–260, Aug. 2002. [Online]. Available: <https://www.tandfonline.com/doi/full/10.1080/13504620220145401>
- [8] T. Hargreaves, M. Nye, and J. Burgess, "Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term," *Energy Policy*, vol. 52, pp. 126–134, Jan. 2013. [Online]. Available: <https://linkinghub.elsevier.com/retrieve/pii/S0301421512002327>
- [9] C. Leichsenring, J. Yang, J. Hammerschmidt, and T. Hermann, "Challenges for smart environments in bathroom contexts," in *Proceedings of the 1st workshop on embodied interaction with smart environments*, 2016, pp. 1–7.
- [10] K. Groß-Vogt, M. Weger, R. Höldrich, T. Hermann, T. Bovermann, and S. Reichmann, "Augmentation of an institutes kitchen: An ambient auditory display of electric power consumption." Georgia Institute of Technology, 2018.
- [11] A. Reddy, A. B. Kocaballi, I. Nicenboim, M. L. J. Søndergaard, M. L. Lupetti, C. Key, C. Speed, D. Lockton, E. Giaccardi, F. Grommé, *et al.*, "Making everyday things talk: Speculative conversations into the future of voice interfaces at home," in *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, 2021, pp. 1–16.
- [12] G. Oleksik, D. Frohlich, L. M. Brown, and A. Sellen, "Sonic interventions: understanding and extending the domestic soundscape," in *Proceedings of the SIGCHI conference on Human Factors in computing systems*, 2008, pp. 1419–1428.
- [13] G. Lemaitre, O. Houix, N. Misdariis, and P. Susini, "Listener expertise and sound identification influence the categorization of environmental sounds," *Journal of Experimental Psychology: Applied*, vol. 16, no. 1, p. 16, 2010.
- [14] V. Rosi, O. Houix, N. Misdariis, and P. Susini, "Investigating the shared meaning of metaphorical sound attributes: bright, warm, round, and rough," 2022.
- [15] M. Carron, T. Rotureau, F. Dubois, N. Misdariis, and P. Susini, "Portraying sounds using a morphological vocabulary," in *EURONOISE 2015*, 2015.
- [16] R. Bresin, S. Pauletto, J. Laaksolahti, and E. Gandini, "Looking for the soundscape of the future: preliminary results applying the design ction method," *c R*, p. 6.
- [17] D. Lockton, F. Bowden, C. Brass, and R. Gheerawo, "Powerchord: Towards ambient appliance-level electricity use feedback through real-time sonification," in *International Conference on Ubiquitous Computing and Ambient Intelligence*. Springer, 2014, pp. 48–51.
- [18] C. DiSalvo, *Adversarial Design*. The MIT Press, 2012.