Erratic Appliances and Energy Awareness

We are exploring how to increase energy awareness through critical interaction design by creating objects that in various ways expose issues related to energy consumption. To raise energy from not only being a technical solution in everyday life, we try to find new ways of relating to energy in design and to uncover the properties of energy as design material. To learn more about how energy can be made more present in product design, we have been re-designing a series of everyday objects around the theme of 'Erratic Appliances'. As household energy consumption increases, the appliances start to behave strangely. These appliances are also meant to embody relations between one's actions and often rather negative global effects of energy consumption.

Anders Ernevi
Samuel Palm
Johan Redström
Interactive Institute RE:FORM studio
anders.ernevi@tii.se
samuel.palm@tii.se
johan.redstrom@tii.se

INTRODUCTION

While often at the forefront of trying to expand consumption and material welfare, designers are now increasingly facing the issue of how to achieve the opposite. And hopefully, just as industrial design once helped to introduce the range of electrical home appliances we almost can-not live without today, design can now play a role in raising consumer awareness of energy use and of the consequences of over-consumption.

Thinking about design and its relation to energy use in products, the importance of energy as a material building the object does not seem to translate into the way we think about its design. Certainly we notice if the electricity needed is not there, and thus we do acknowledge it as basic material building the thing and how we expect it to present itself to us as we use it, but it is nevertheless hidden to us. Consider, for instance, just the energy needed for maintaining stand-by modes: estimations made by the Swedish Energy Authority (STEM) show that products such as computers, television sets, mobile phone chargers and other electronic appliances on standby in a common household consume as much as 300 – 700 kWh of electricity per year [6].

Whereas our concern for the styling of everyday electronic objects seems to be ever increasing, electricity is often something that we simply assume will be provided and it is only in situations of lacking outlets, batteries running low, or power failures that we consciously acknowledge its presence - or rather, its absence. Unfortunately, this difference seems to exist also in how we work with the design of such objects: whereas the furniture fashion market continuously presents new lamps, this is, with respect to the energy technology, often a matter of creating yet another form or shade – ie., another way of presenting and packaging a light bulb, as we tend to take the standardised electricity distribution for granted. In many ways, the way we relate to electricity in design is an example of what Borgmann once described as the division of design into separate engineering and aesthetic branches [1].

Maybe it is not that strange that users of electrical appliances have a hard time relating to their energy consumption, as so much seems to have been done to hide such issues away in the way we use and experience them. And maybe it is not that strange that designers of electronic objects have a hard time relating to the electrical 'material' they use, as it has not been considered alongside other materials to be used in design, but as a practical problem to be 'solved'. The increasing interest in sustainable design and consumer awareness could, however, represent an interesting opportunity to revisit such questions.

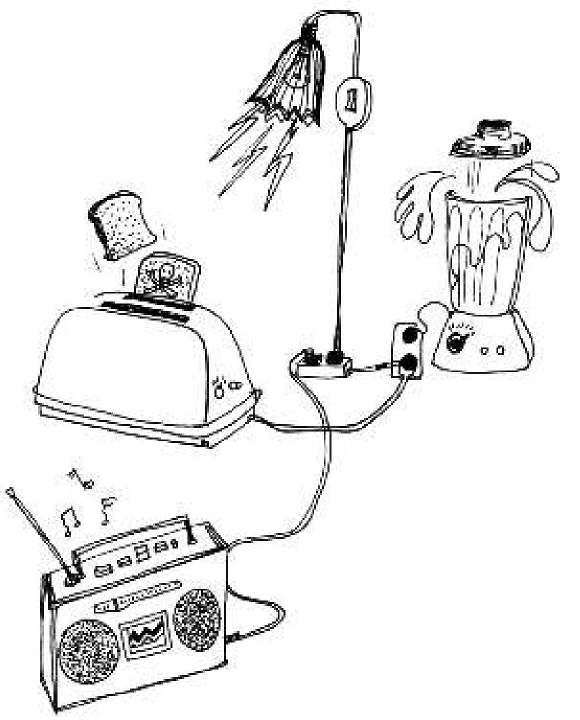

Figure 1: Crazy kitchen appliances. (Illustration by Ulrika Löfgren).

ENERGY AWARENESS AND INTERACTION DESIGN

If we consider a lack of energy awareness to be, at least in part, related to the design of our electronic appliances then the obvious question is to what extent we could use design to promote reflection and critical questioning. With respect to such objectives, work in the area of critical design provides an interesting perspective. Whereas critical design is often aimed at presenting alternatives to existing main-stream design, it can at times also be seen as a way of passing on questions about use to users. Using strategies borrowed from e.g., contemporary art such as de-contextualisation, de-familiarisation, fragmentation and other ways of creating a resistance towards easy acceptance and use, design can be used to make 'users' reflect upon objects, their functions and how we relate to them [2,3].

Another strand of related work can be found under the heading of 'captology' and the study of, in particular, computers as persuasive technologies (eg. [4]). Unlike critical design, such work has often been based on a human-computer interaction (HCI) perspective and so it represents a different strategy compared to the sometimes rather art-oriented work in critical design. Of course, other design methods are required to address the need for sustainable development as well, but with respect to an initial attempt at raising energy awareness through interaction design, such critical approaches provide an interesting perspective.

In architecture and urban planning, issues of sustainable development and energy consumption and their presence in the everyday living environment, has been explored to a significant degree, including experiments with 'green architecture', self-sustaining systems, alternative ways of harvesting and conserving energy, new materials, etc. There is also work explicitly working with expressions of technology in relation to energy, such as Toyo Ito's "Tower of Winds" in Yokohama Japan. In interaction and technology design, however, such issues are less developed especially with respect to expressions in use.

In a project called 'Static!', we are exploring critical design strategies as a way of creating objects that resist easy use with respect to energy use. The way we have approached how energy seems to be hidden in appliances is by considering it to be a design material, thus trying to expose its properties as such [5]. In practice, this means that we try to find expressions and aesthetics typical of this material, and then re-design existing appliances in ways that expose these properties. These processes, however, work in the opposite direction as well: that we try to learn more about how we might think about energy as material through experiments with how the dependency on energy more present in the object. Thus, our objective is twofold: on one hand, we aim to make energy-related issues more present to users as they engage with an appliance; on the other, we aim to develop knowledge about the properties of energy as material in design.

ERRATIC APPLIANCES

As part of the Static! project, we are developing a series of design examples around the theme of 'Erratic Appliances' (see Figure 1). The Erratic Appliances are meant to embody consequences of energy use in terms of starting to behave strange as consumption increases. While these appliances can be seen as 'visualisations' of energy use and how it changes over time as we turn our electronic appliances on and off, their erratic behaviours also introduce aspects of risk and indeterminacy with respect to use and usability. As such, they are meant to question the perception of an often very distant relation between one's actions and the large-scale negative effects of increasing energy use. Doing so, however, they are meant to be somewhat humorous as well in order to raise the questions but not necessarily to provide the answers.

The appliances we have re-designed have been centred on the home environment, and particularly the kitchen, since it is a place where we use many electronic products in a fairly concentrated space, and where we frequently turn things on and off as we shift between different activities. Since the behaviour of any given appliance will depend on the overall energy consumption of the local electrical system it is connected to (such as an apartment), they are also meant to introduce questions of choice, ie. that users need to make choices of what things to use and when. For instance, turning on the oven could mean that the radio and the blender will not work properly. Considered as a system of appliances, they are meant to embody such questions related to the limitations of energy resources and need for us to make choices of what to use and when as we can not rely on a continuous and unlimited access to electricity.

Design sketches

As a starting point, we created a series of design sketches illustrating how different appliances could be re-designed to become erratic. Doing so, we focused on how to find connections between energy use and possible changes in behaviour as the re-design has to be more than random to be able to fulfill the role of promoting reflection. Thus, we tried to look for examples where the logic behind the functions of the given appliance could be affected and changed as it comes to depend on fluctuations in energy consumption. Ideally, the 'erratic-ness' must expose how the appliance depends on energy as a material building its normal appearance in use. This, in turn, means that we eventually have to dig rather deeply into how the appliance has been made to expose such relations between the materials building the thing and how it appears in use. Below, we present some of our early ideas for re-designs:

Washing machine

A modern washing machine is based on a set of programs, sensors and actuators that help optimise washing with respect to selected temperature, program, amount of laundry, and so on. Thus, many things can go wrong as it becomes erratic with respect to energy use: spinning rates, water temperature and program structure might be altered as a result of the connection to variations in the overall energy consumption in the local electrical system. And so circumstances will determine what combination of programs, temperatures, etc. will actually be used in each case and how our laundry will come out in the end. One could hope that solid knowledge of when and how the overall energy consumption changes would help one predict when and how to wash what. But then again, you would never know.

TV

A fully functional TV is perhaps not considered as functioning this or that way, apart from the fact that it shows moving pictures broadcasted from somewhere else. But, on a more profound level, distinguishing between a properly working TV and a broken one reveals a set of properties normally not considered in everyday use. For instance, the fact that the picture stays in place, that it does not roll or sway from side to side, is one of those criteria we have for describing a working television set - in this case, a problem with the synchronisation of the image. Or if the picture is not filling the screen properly (widescreen functions not considered) there must be something wrong with it in this case with the deflection. Thus, its complexity creates a vast space of possible ways to deteriorate.

On a more abstract level, TVs could perhaps be said to create a social place, a place where we watch and comment, laugh, or scream at the same things at the same time, though often at separate locations. The performance of these erratic TVs might be somehow connected to what is going on the building with respect to energy consumption, thus connecting the apartments in yet another fashion. Especially, it seems, two functions are related to what is going on: synchronisation and deflection. The deflection seems to relate to what is going in my neighbour's apartments: whenever they start using more and more energy, the picture on my TV becomes compressed, leaving black areas at the top and bottom of the screen as if my own space for consumption is reduced when others expand theirs. Another strange thing seems to relate to the way the synchronisation works: whenever I start using more energy, the picture starts rolling and swaying. Once, I went to ask my neighbour if their TV behaved the same way, and as I looked at it, it had large black areas at the top and bottom.

Iron

An iron is used to iron cloths and clothes. As this is done with heat and steam, an iron has user inputs such as setting the temperature and setting the amount of steam. These variables can give a foundation of what an erratic behaviour for the iron can be as they both depend on the use of energy. One suggestion would be that the temperature is connected to the overall energy consumption, the iron behaving like one individual in a herd of appliances. And so, if the overall consumption approaches some critical level making any single individual appliance start to rapidly increase its energy use, the other ones will follow until the whole herd is bolting. This means the user needs to be careful not to have to many other appliances being active at the same time, in order to keep the system in control. More specifically, it means that successful ironing requires an energy system in balance and harmony.

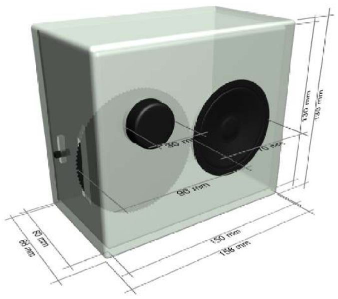

Figure 2: Early sketch of the Erratic Radio. (Drawing by Andreas Lykke-Olesen.)

Blender

A blender is for blending food, and its primary control is that of the spinning rate of the blade. Further, the blade spins in a direction so that the food is sucked downwards rather than pushed towards the top. Now, suppose that the rate as well as the direction of the spinning blade somehow depends on the energy consumption in the kitchen. To be able to control the blender, therefore, the user has to anticipate and adapt to fluctuations in the energy usage. The act of using the blender seems to have turned into a precise and delicate matter as one has to constantly adjust the control as to render the desired result and to avoid food being sprayed out of the device.

Setting out to explore energy as design material, thus working not only with resulting behaviours but also with how different functions were implemented physically, we started re-designing a fairly simple appliance: a radio (see Figure 2). Eventually, we might re-design and implement other appliances as well, but as an illustration of the concept our first prototype had to work also as an individual object and the radio seemed to be a good candidate also in this respect.

THE ERRATIC RADIO

The basic functionality of a radio is to be able tune in on a specific frequency, amplify the received signal and then play the result in an audible fashion. As such, it depends on energy as basic material in many different ways. With respect to interaction, what users normally control is what frequency the radio should be attuned to, the volume at which the sound should be played and whether the device should be switched on or off.

One interpretation of the radio, therefore, is that a primary aspect of its use is to select what to listen to. An erratic behaviour could imply that it tunes out, perhaps forcing users to listen to something else, somehow exposing issues of energy consumption as it does so. Or it could be that the user loses control over the volume of the sound. Such behaviours would not give the radio new modes of interaction as the controls as well as the output in terms of sound remains, but it would anyway fundamentally change the way it appears in use.

The behaviour that seemed most interesting to start exploring was the tuning in and out to specific frequencies, i.e., radio stations. To be tuned in is a vital quality of a radio, since if it is not able to correctly tune in, it will not be a very valuable appliance to its user. Such a behaviour would therefore be likely to be noticed.

The way this erratic radio tunes in to stations depends on the energy consumption in its vicinity. The way it does so is by listening not only to the frequencies of potential radio stations, but also to the frequencies around 50 Hz and the electromagnetic fields caused by electrical equipment. The amplitude of these low frequencies then affect how the radio tunes in and out to selected radio channels resulting in the radio tuning out as energy use increases. In terms of expressions in use, this means that the audio first will start to drift towards noise with slight increments in energy consumption, but as use it increases completely tunes out.

Prototype design

A radio selects stations using a narrow filter choosing a small part of the frequency spectrum. The tuning determines the centre frequency as the knob is turned. This filter consists of a fixed inductor (coil) in parallel with a variable capacitor forming a band pass filter, that is, a filter that only allows for a certain frequency band to pass. When selecting, for example, a station at 103MHz the filter is set to pass a narrow band around this frequency to the radio. This band contains the audio signal, which ranges from 10Hz to 10kHz, but moved to have the centre of 5kHz at 103MHz. This gives a frequency band of 102.995 to 103.005. The shifted up audio band is a very small fraction of the centre frequency, thus requiring a very narrow pass band of the selective filter. The narrowness of the pass band is the reason why a very slight alteration in the variable capacitance will cause the radio to lose its station or to select a completely different channel. What the rest of the radio does is to move the audio content of the selected channel back down from 103MHz±5kHz to 5kHz, that is, the regular audio band from 10 to 10kHz. This is then sent to the amplifier as a regular audio source.

In order for the radio to tune out and behave erratically, this centre frequency needs to be shifted. The 'erratic-ness' of the radio is thus created through hacking into the radio channel selection filter, allowing for a micro controller to slightly alter the frequency chosen. In order for the radio to react to energy usage a sensor has been devised, measuring the electrical fields around the radio. This provides a sense, not only for the actual consumption, but also for the electricity that surrounds us in our everyday life depending on where the artefact is placed. This kind of sensing does not provide accurate measurements of the consumption, but it gives the additional feature of mobile measurements.

The antenna for the erratic part of the radio has been minimised in relation to its optimum size. That is, it is still of quite substantial length compared to the antenna of a mobile phone. Antenna length is inversely proportional to operating frequency. Thus a mobile phone antenna working at a few GHz is much shorter than an antenna for FM radio of 100MHz. In the case of electrical field detection, the fundamental frequency of interest is 50Hz, resulting in an antenna with a corresponding length of several kilometres. There are examples of people who have built this kind of antennas. Most of these are loop antennas with a diameter of more than 4 metres. The American Navy has an ELF (Extremely Low Frequency) radio for communicating with submarines submerged at large depths. The antennae for that radio reach across a vast part of Wisconsin and Michigan respectively. For an unsuspicious looking object created as critical design this is not an option. The reduction in antenna size reduces the signal strength to the amplifying stages. To compensate for this, the gain of both stages has been maximised within reasonable limits. Since only signals of low frequency is of interest, the fact that reduced feedback in amplifiers limits high frequency response has no apparent relevance as long as the first few overtones of 100,150,200Hz or so are included.

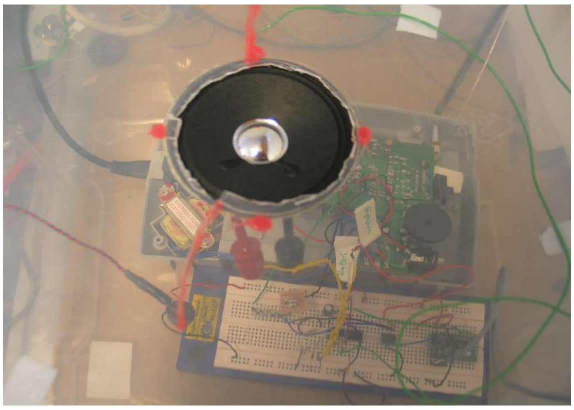

Figure 3: Testing technology on electronics prototype.

The actual positioning of the measuring antenna gives slightly different behaviours. If placed near an electrical outlet the measurement is more an actual measurement of changes in consumption that is, the change in the electrical field around the cable - whether there is a field in the cable or not. The electrical field does not change with current consumption, only the magnetic. Measuring magnetic fields however is a different ballgame requiring more sophisticated solutions. Inside a cable - at the surface of the copper in each conductor - the electrical field is 240V. This field diminishes with distance to the cable, but is constant whether the current drawn is in mA or A. In this way, the radio can only detect if a switch is pushed, filling the cable with 240V, causing the field around the cable to rise from 0V to a fixed value smaller than 240V. If placed more ambiently in the room, the radio presents an image of the fields your body is being exposed to, due to fields from various outlets and lamps in the room.

Battery operation has been chosen in order to present the clearest idea of the radio picking up fields in the air. Cables protruding from it might be suspected of faking functionality. The omission of a regular power supply including transformer and rectification also prevents the radio from setting off itself. Of course, batteries will eventually run out, rendering unpredictable effects before total silence. This however, should not be considered part of the "erratic experience".

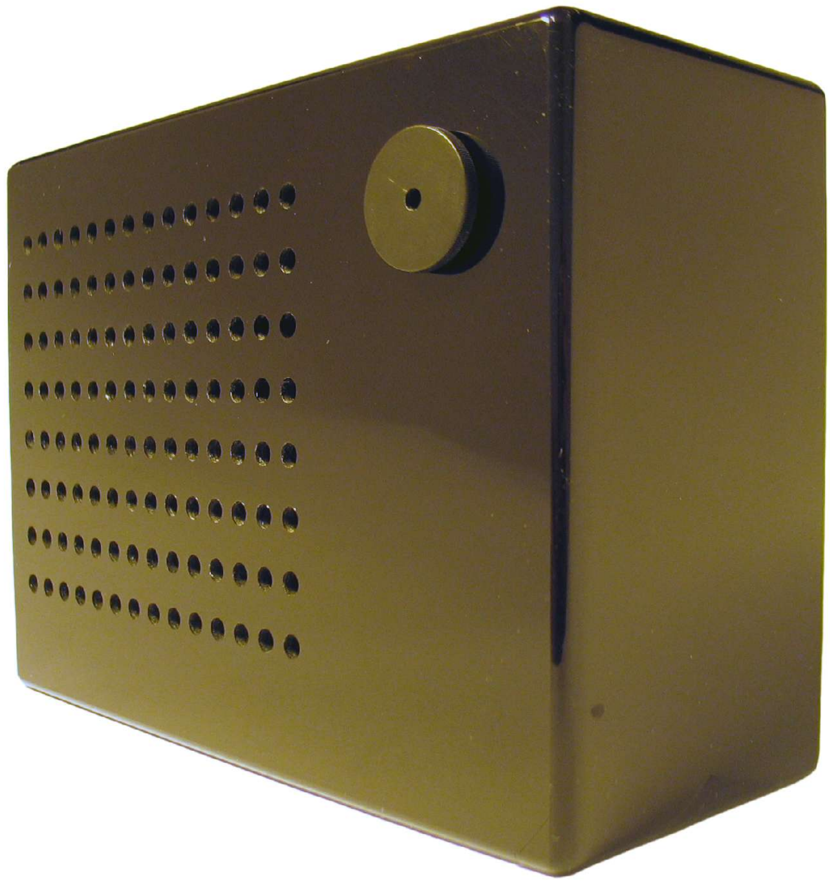

Figure 4: Final design of the Erratic Radio prototype.

Using/misusing established circuits
Both the sensory input and the erratic output of the interactive features of this radio implement the notion of hacked or misused circuits well known to engineers. Here, what are normally regarded as problems are treated as features, enhanced to give quite another effect than the original intention of the circuit. Looking at the field sensor, it is basically two cascaded signal amplifiers with a very high total gain. When designing such amplifiers, electrical engineers strive to achieve as good a S/N (signal to noise ratio) as possible. This allows for a clean signal, which can later be processed with a minimum of noise. In this case, the (low frequency) noise is the only interesting part since it contains the electrical fields often heard as hum in a stereo of poor quality or with its inputs open. Therefore, that is just what has been done. Not only is the input not connected to any source, it has been equipped with an antenna in order to pick up the hum better. The amplitude of the hum is then extracted and sent to the microprocessor. When the amplitude rises above a predefined level the erratic output is activated causing the radio to behave inconsistently and lose its station.

The erratic output uses the otherwise unwanted effect of drift in components. In this case it is a more logical usage of technology, since the goal of the output of the artefact is a negative effect. It is a variable capacitor that sets the centre frequency of the narrow filter. If this component shows signs of drift over time, or with temperature, the radio would be really annoying. It would constantly have to be retuned. In a normal radio, this feature would render the product unusable. But, in this case it is the desired effect. So, a small electrically variable capacitor has been added in parallel to the tuning capacitor, adding to its total capacitance. As long as there is a constant voltage applied to this extra capacitor it just shifts the total value of the much larger tuning capacitor. Thus that one will only need to be tuned whenever a new station is selected.

Since the radio used is a regular in-production unit, its features has been carefully engineered, ensuring stable operation (see Figure 3). When the micro controller is allowed to change the voltage applied to the extra capacitor, its value changes and so does the total value of the tuning capacitor. The component drifts out of specification causing the radio to lose the station to which it was tuned. For the moment though, the radio just loses its station whenever the electrical field is larger than its calibrated value. Other, more advanced solutions could be imagined, such as having the stations gradually tuning out as the electrical field increases. Or, it could jump in and out in a random pattern.

Casing design
The erratic radio is built in black Plexiglass and is 230x170x100 mm (WxHxD). The decision to make it in Plexiglass was based on an early idea of making the case of the radio transparent. This idea was later discarded because in future use studies, we wanted the focus to be on the 'new' behaviour and not the difference in visual appearance. Trying to give it a more 'neutral' visual appearance, the intention behind its minimalist form is that it simply should look like a (stereo-) typical radio, i.e., that its design is based on a simple square box with turning wheels for adjusting the tuning and

volume, an on/of switch, an antenna mounted on top and holes for the speaker (see Figure 4 and 8). The one thing that is not in black is the antenna, which is in chrome metal.

Using the erratic radio

The technical description of the radio presents some ideas of what using the radio might be like but to further illustrate how it appears in use, we describe two situations below. The first exemplifies how it might react to its immediate environment. The second scenario illustrates how it behaves as it is moved through different energy fields.

Figure 5,6,7: Office scenario.

As you sit at your office, you switch on the radio and tune in the preferred station. Listening to the music for a while, you realise you need to turn on the light. Starting to turn on a series of desk lamps, the radio gets increasingly noisy as it shifts away from the selected frequency. Only by turning the lights off again, returning to the original state, will the radio work properly again (see Figure 5,6,7).

Having listened to the radio for some time, you feel the need for some food. As you move into the kitchen still trying to follow that show on the radio, it gets increasingly difficult to hear it. As you pass the refrigerator and the freezer, the radio loses its channel completely, leaving you with just white noise to listen to. When moving the radio around in the kitchen, its sound reflects how strong the electrical magnetic field is at its current location. In a way, it is like walking around some contaminated area with a Geiger-counter.

DISCUSSION

So far, our work has been focussed on in which ways we might make energy related issues more present and pressing, in the way we interact with and use everyday appliances. To do this, we have tried to 're-discover' energy as a material building the things. A central outcome of this approach, as we see it, is that it could help uncover design decisions that over time have become hidden under increasing technical perfection.

To be able to consciously use the properties of energy as material in design to craft objects that help users become more aware of their consumption habits, and consequences, we need to know the design material at hand. We need to understand how it works, how its properties relate to how we interact with and experience the thing. Obviously, the way we ask questions about a given technology will depend on what kinds of answers we are interested in, and so the questions we ask tell us as much about our understanding as does our answer. Whereas a typical question is "how can we ensure that this device will work for X hours while on the move?", we try to ask questions such as "in what ways can we express the ways in which this device depends on energy?". Thus, working with a different set of questions while re-designing existing electronic appliances helps us uncover hidden assumptions as our perspective has been shifted. In this way, this approach represents a complement to strategies based on developing increasingly energy-efficient technologies.

One important difference is that the approach described here turns our attention away from strictly functional issues, towards questions of expressions in use and aesthetics. For instance, as a design example, the Erratic Radio illustrates that there are rather rich expressions available for designers. While it is certainly the case in this design, it is not necessary that the use of such expressions related to the use and misuse of technology have to be at the expense of usability and practical functionality. In this case, this shift away from ease of use is intentional, as we have tried to make it harder to think of energy and technology as something belonging in the background. But as we learn more about how these material properties relate to expressions in use, we can, of course, use it to create things with focus on usability as well.

There are of course a few things to be said about the potential use of the erratic radio. Would anyone stand it long enough to experience the effects on their behaviours regarding energy consumption? An important aspect in this context is that it increases focus to the object in question. Where a normal radio is ever-present in the background and quite invisible, the erratic radio constantly calls for attention either implicitly by the invoked need to manage energy consumption, or explicitly if one wants to override the effect and retune it to its station. This gives a different view on the erratic radio working in your home; although potentially annoying, it could still possess more value as an object as opposed to a regular radio because of its engaging qualities.

This might be comparable to the difference between a record player and a CD player, in that a record player requires the user to change sides manually, taking action in order to enjoy the music and thus making the whole listening experience more involving. It could be argued that these engaging qualities render the erratic radio an enjoyable artefact, much like the record player, as it requires attention. Presumably the attention is drawn towards playing with energy consumption patterns, enabling the user to reflect on his/her energy use. It is this reflection that makes the difference between it as an annoying object or as an enjoyable one, promoting experimentation and playfulness.

Figure 8: Layout of tuning, volume and power switch.

CONCLUDING REMARKS

With respect to how to use interaction design in order to bring certain questions forth in the way we use things, we have explored how to embody aspects of, for instance, *choice*, *distance* and *consequence*. The energy systems we live in are often enormous, intangible structures that are hard to grasp, and although aware that our actions might have effects also at a global scale such issues are often remote from our local experiences. To close this distance, or at least remind us of it, we have created things that respond more directly to local conditions. The way they do so have been inspired by some of the potential consequences of over-consumption: that things stop working properly and that over-consumption introduces aspects of indeterminacy and risk. Perhaps the central issue brought forward, however, is that of choice - that we as users will have to realise that limited resources require us to make choices with respect to what to do and when. And also in the future it makes us avoid using some energy powered appliances because of the time it will take to do all things in a sequence.

The next step in developing these erratic appliances is to present them to people through ‘user studies’ and exhibitions, and see to what extent and in what ways they may, or may not, promote reflection upon energy use. Obviously, these devices are not meant to replace existing designs and so the questions is not so much whether people would like to live them for extended periods of time, but what kinds of questions these devices make their users ask themselves.

ACKNOWLEDGMENTS

The authors would like to thank their colleagues in the Static! project in the Power and RE:FORM studios of the Interactive Institute. Special thanks to Margot Jacobs, Andreas Lykke-Olesen and Ulrika Löfgren for participation and ideas. This research has been funded by the Swedish Energy Authority (STEM).

REFERENCES

1. Borgmann, A. (1995). The Depth of Design. In: Buchanan, R. & Margolin, V. (Eds.): Discovering Design, The University of Chicago Press, Chicago, pp. 13-22.
2. Blauvelt, A. (Ed.) Strangely Familiar - Design and Everyday Life, Walker Art Centre, Minneapolis, 2003.
3. Dunne, A. (1999) Hertzian Tales; Electronic Products, Aesthetic Experience and Critical Design, RCA CRD Research Publications, London, 1999.
4. Fogg, B. J. (2002). Persuasive Technology: Using Computers to Change What We Think and Do. Morgan Kaufmann Publishers.
5. Redström. J. (2005). On technology as material in design. Forthcoming in: Design Philosophy Papers. Team D/E/S, Australia.
6. STEM (2005), Statens energimyndighet (the Swedish Energy Authority). www.stem.se