DO IT YOURSELF METERING
A CASE STUDY

By Jonathan Sawdon Smith, co-founder and product development director of DIY Kyoto Ltd

With the slowness of UK regulators to agree on a standard for smart metering in the UK, and subsequent roll-out, a niche has formed to provide smart metering to end users who do not wish to wait for regulation to do so. This is the case study of the design and development of such a meter.

Our passion as a team was to reduce national energy consumption and in particular domestic energy reduction. When first coming together we brainstormed ideas for a product to help individuals to use less energy. Would it be an efficient kettle, a more sustainable fridge or some kind of smart thermostat? To aid our design efforts we conducted a large amount of user research, discussing with people their attitudes, habits and behaviours regarding their energy use. The overriding response we received from this was that people a) had no idea how much different appliances used and b) expressed an interesting in knowing. It then became clear that the product we should develop should inform people of their energy use in a continual manner. It was also clear that precise metering was not required, and that energy 'monitoring' would be sufficient to create behaviour change.

DESIGN CRITERIA

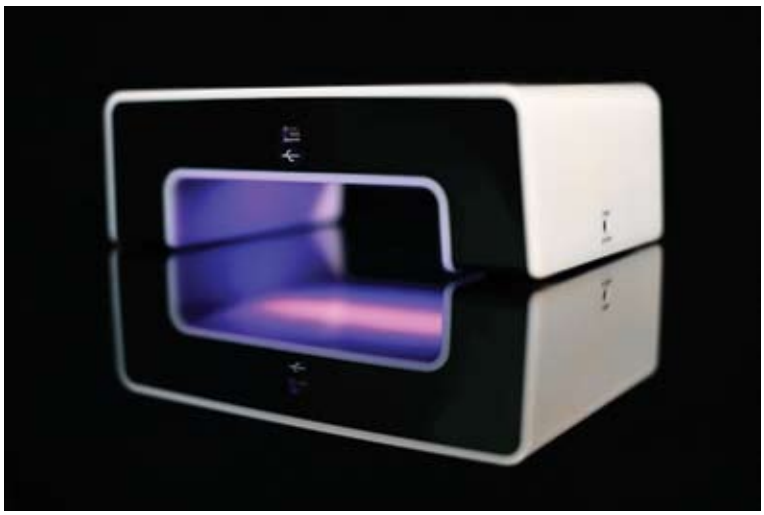
Once it was decided that an in-home energy monitor was going to be the first design, it was realised that this was an entirely new product category. The hardest question wasn't so much "How will it work?" as "What should it look like?" The existing LCD displays of digital meters were unappealing and it was crucial not to design yet another throw-away gadget that would become obsolete in a year's time. The design challenge was far from straightforward.

The following are examples of how certain criteria affected the development:

- Ease of installation
  It would be some time before utilities would professionally install smart meters on a large scale, and so it was important to develop a device that could be installed easily by an end user. It was very important that what was developed could be installed by ages 18 to 118. No expert skills or qualifications should be required for installation. We were particularly concerned about the sensor installation, knowing that meters can be situated in hard to reach and awkward places. We therefore designed a sensor that could be installed with only one hand.
- Simplicity of conveyed information
  During ethnographic research it became clear that the information provided had to be conveyed in such a way as to have relevance to a person in their home. Rather than replicate a digital desktop weather station cluttered with information, we restricted the display to a single category of information, with only one parameter been shown at any one time. We decided to provide a cost display, because this has a lot more relevance to a householder than kilowatt-hours or tons of carbon dioxide, which can be quite ambiguous to a lot of people.
  We also decided that the information needed to be bold and to be prominent within the domestic setting. The product needed to grab people's attention if they are to act on the information being displayed, particularly when large power changes were occurring. For this reason we decided to use an LED digit display, rather than a more subtle LCD. The digits were made to scroll when changing values purposely, a simple mechanism to further grab people's attention when power levels changed.
  We recognised that more in-depth levels of consumption information were important, such as energy use over time. Rather than complicate the display, we provided PC-based software for users to review their energy data in five-minute increments. This allowed us to keep the display simple and intuitive.
- User interaction
  We wanted to encourage people to engage with the display and to investigate their house personally, appliance by appliance. We considered it important for people to understand the varying amounts of energy consumed by different appliances. This led us to two key features. Firstly the display needed to be portable (which in itself led to requirements for a wireless link with the sensor, and

integrated battery pack). Secondly, the update rate of the display needed to be fast enough to provide the user with necessary feedback to determine the change in power as appliances are switched on and off.

Lastly, with our visual communication design background, we were acutely aware of the different ways people interpret information, the population being split between those that understand verbal information more easily (digits/numbers) and those that understand information in a more visual manner (colours/shapes). To cater for the visual side of the population, we implemented a colour light change functionality dependent on power usage, with colours fading from blue to purple to red depending on power consumption.



The second generation of Wattsons

- Contemporary design

  The key to making people change their behaviour, when it comes to energy use, is to expose them to their energy consumption information on a regular basis, if not continually. We therefore knew that whatever we designed had to be visually attractive if people were to voluntarily keep it on display. We could not design something that resembled an air conditioning or central heating remote control. This sort of device is likely be used once and then hidden in a drawer or back room.

  We needed to create a display that was contemporary in design and would compliment people's interiors, rather like a new piece of furniture. People needed to be proud of the display if it was to be of benefit.

  Design look and feel, as well as branding, were essential items for our intended channel to the consumer. Rather than produce a roll-out from a utility, we were required to target consumers and their tastes.

TECHNOLOGY CHOICES

The technology choices were influenced by four criteria:

- Cost:

  As previously mentioned, the unit was to be sold direct to the consumer: therefore we could not rely on a utility subsidy to keep the price competitive. Technology choice was therefore key to keeping the retail price affordable for the average consumer.

- Sustainability:

The raison d'être of our organisation is to reduce the environmental impact of humankind. We were therefore very conscious of incorporating sustainable design practice into the development of our product.

- Usability:
  Technology needed to be "plug 'n' play", with no special setup instructions requiring expert installation or compatibility issues with other devices.
- Cost of development:
  Due to minimal resources (we were three people starting out of a garage), development cost needed to be low. We chose technologies whose development tools were provided free or had a low subscription fee.
- Communication technology
  For the datacomms we chose a standard open band 433 Mhz transmission link between the sensor and the display. This allowed reduced development time due to be being able to use serial data communication and RF modules from external vendors. The range of modules allowed us flexibility amongst providers and also reduced certification costs.
  We created our own protocol for information transmission using a simplex connection (again to reduce cost). Other options such as Wi-Fi or Zigbee were discredited due to development time, complexity and cost. As always with our product, simplicity was the key.
- Processor selection
  Cost and power were two of the leading criteria for selection of processors, with functionality a close third. For the sensor electronics we chose the Silicon Labs C8051F33GM, as this device is known to have excellent debug tools available, a small form factor and special low power modes which have proved critical in maintaining battery life. An inexpensive price tag at sub $2 was the final selling point.
  For the main in-home display we had started out developing a design with the PIC18F87J50, primarily due to its USB compatibility. At a critical point in our development Microchip pulled this device from its range, and we had to implement some quick redesigns. Without another USB device

Wattson was designed to compliment a modern interior.

available in our price range, we chose to use another PIC, the PIC18F6527 with an external FTDI USB device. This configuration also gave us more flexibility over controlling the USB stack in debug environments. The 6527 also had the peripherals we required: timer modules for PWM LEDs, reasonable I/O source/sink currents and the wide voltage range essential for our battery-operated display.

- Casing
  We chose to make the casing from a sustainable material due to our company ethos. Due to the low production run forecast for the first product, each unit was hand-made and so we were able to use wood from a reclaimed source (in this case, old school science benches). This path was also chosen due to the lack of finance to invest in injection molding tools.

ROUTE TO MARKET

Rather than focus on a direct utility market channel where we would sell thousands of units to a single client, the company ethos demanded we target consumers directly, ie helping them to "Do It Themselves". This required very different marketing and distribution models to a typical meter manufacturer. Rather than attending utility metering tradeshows, we attended design and retail events. We didn't advertise in utility trade magazines, but used PR in domestic lifestyle magazines instead. Individual units could be bought from our website and from a large range of small independent design and eco stores. Being a new product category, we were required to educate both the consumer and the retailer on the benefits of in-home energy displays and what they can provide. The design of the product, its form, the buzz and marketing around the company, were all key elements in building the market we required.

- User behaviour
  One of the most rewarding points in the company history was the initial positive feedback from customers. The display was proving to have the desired effect: people were exploring their homes and gaining understanding they would otherwise never have had. One customer started to read books and listen to the radio after she learnt that television consumed so much more electricity. Another customer discovered that microwaves actually use more energy in displaying the time than in heating food. We received many anecdotes of families using the device and then making positive behaviour changes, children often providing the driving force behind them.

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USER IS KEY

Although this was the first product we developed and we have moved on in size and sophistication, the design process remains the same: the end user is the key factor in the design of the product, not the utility provider. We now conduct development projects for utilities on the basis that the experience of the end user is paramount and should be considered before all other factors. This helps to ensure that information is received gladly and understood easily by the customer, resulting in positive behaviour changes. This in turn contributes towards our ultimate goal: the reduction of energy consumption on a mass scale. MI

ABOUT THE AUTHOR: Jonathan Sawdon Smith is co-founder and product development director of DIY Kyoto Ltd, a London-based sustainable design and manufacturing company, and is responsible for all future product development. Jonathan holds a B.Eng in Electronic Engineering and an MA in Industrial Design Engineering. He has worked in the electronic and product design development sector for 15 years for companies based in the UK and in the United States.

ABOUT THE COMPANY: DIY Kyoto is a product design and manufacturing company formed in 2004 by three graduate engineers and designers. The ethos of the company is to provide individuals with the necessary information to help them reduce their impact on our planet and its natural resources. DIY Kyoto's flagship product is Wattson, a user-installed device that displays energy information in a simple, timely and understandable manner. DIY Kyoto use this experience to develop sophisticated and innovative energy-monitoring systems for utilities, including GPRS-based data retrieval.