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Impact of energy use information resulting in behavioural change

A report prepared for **Beacon Pathway Limited**

by

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IMPACT OF ENERGY USE INFORMATION RESULTING IN BEHAVIOURAL CHANGE

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1. BACKGROUND

Beacon would like to carry out a search on studies that have been conducted identifying whether information on energy usage or ways of improving energy has resulted in behavioural change.

The objective of this study is to provide Beacon with a greater insight into understanding if households who can monitor their actual energy use details will change their behaviour to reduce their energy consumption.

2. EXECUTIVE SUMMARY

A substantial amount of research has been conducted internationally on optimising information feedback channels to prompt home owners to reduce their energy consumption. Some of these studies deal in particular with real-time energy consumption display technologies. However, very little research has been conducted to quantify the energy savings from technology which improves information of instant energy consumption alone. Instead, most studies investigated intervention packages which included smart metering and display technologies. It is therefore somewhat difficult to assess what impact the display units alone would have on consumer behaviour.

A group of studies explored the impact of integrating energy display technology into thermostats[i]. The focus of many of the existing projects, in particular in the US, was on peak demand shifting rather than on reduction of electricity consumption.

In summary, most studies found that there are measurable electricity use reductions in homes with instant energy display technologies. Savings were reported to be generally between 5% and 15%.

Many of the studies and conversations during this project also suggested that in order to fulfil the true potential of smart metering technology, it needs to be integrated with time-of-use (TOU) electricity pricing options which are not yet in place for the New Zealand residential consumer.

3. BRIEF SUMMARIES OF SOME INDIVIDUAL STUDIES:

3.1 MM Research, New Zealand Cent-a-meter survey

The Cent-a-meter has been distributed by Island Power Pty Ltd (an Australian company) in Australia and New Zealand since January 2004 and May 2004 respectively. The company had sold over 9000 units as of October 2004. A US launch is planned in 2005.

MM Research conducted a phone survey in 2004 of 207 New Zealand users of the systems.[ii] The survey found that over two thirds of respondents had changed their energy consumption behaviour as a result of the Cent-a-meter. However, surprisingly only one-third of respondents stated that their power bill had reduced since then. The amount of electricity consumption reduction was not covered in the survey. 92% of respondents were so satisfied with the Cent-a-meter that they recommended it to others.

The response rate of the survey was 76.7%. Although this rate is comparatively high, it is likely that the sample selection skews the results somewhat positively, i.e. users who refused to participate in the survey may be more likely to have less positive experiences than the ones who participated.

3.2 Darby: international survey

A very useful paper is the report by Darby at Oxford University.[iii] Darby undertook a literature review of 38 studies of consumer feedback effectiveness, and broadly categorises the feedback into three forms:

1. direct feedback – available on demand (learning by looking or paying)

2. indirect feedback – raw data processed by the energy provider and sent out to customer (learning by reading and reflection)

3. inadvertent feedback – learning by association (social learning in the community context etc).

Only the first of these covers technologies of interest to this report. Direct feedback technologies include direct displays, interactive feedback via a PC, smart meters, trigger devices/consumption limiters, prepayment meters, self-meter reading, meter readings with and advisor and cost plugs.

Twenty-one of the investigated studies are in this group. The following table shows the energy savings found in these programmes:

Savings	Direct feedback studies (n=21)	Indirect feedback studies (n=13)	Studies 1987-2000 (n=21)	Studies 1975-2000 (n=38)
20%	3		3	3
20% of peak			1	1
15-19%	1	1	1	3
10-14%	7	6	5	13
5-9%	8		6	9
0-4%	2	3	4	6
unknown		3	1	3

These findings suggest that energy savings of around 10% could be expected. The highest savings were found for table-top interactive cost and power display units, smart card readers for prepayment and an indicator showing the cumulative cost of operating and electric cooker. Direct feedback with some form of advice for consumers to save energy gave savings in the region of 10% in four programmes aimed at low income households.

The 21 direct feedback studies varied in respect to sample size, housing type, additional interventions, feedback frequency and duration.

3.3 Stein: technology review for Southern California Edison

Southern California Edison commissioned a report on display technology assessment in 2004.[iv] The Information Display Pilot project was in particular designed to investigate the impact of display units in combination with dynamic electricity pricing signals, a situation different from New Zealand at the moment.

The report lists a series of existing display technologies in the US. There are currently about 10 different systems available with several tens of thousands of units installed. Costs for these systems range between US$50 and a few hundred US dollars. The main difference between the systems is the communication mode between the sensor and display units. Most of the units are currently only adapted to show energy cost at constant cost rates, but manufacturers claim that they can be easily modified for TOU rates. Modifying them to account for non-regular dynamic rates would require major redesigns.

The study investigates the combination of electricity consumption display units in combination with a feedback technology alerting the consumer of high price TOU periods. The technology used in this project was adopted from an alert device for stock market prices. It consisted of a glass orb, which glowed at different colours in response to the instant electricity price. Participants in the study found the technology appealing and engaging.

The report also quotes various international studies which have evaluated electricity savings following the installation of display technologies.

3.4 Storm: 231 Danish households

A three year Danish study[v] of 231 households on effects of various energy saving measures found that a set of intervention measures, including portable electricity meters, resulted in energy savings of between 12% and 14%. However, the impact of the portable electricity meters was considered to be only 5% of the total savings, which would equate to savings of only 0.6%. It was noted that the meters certainly had a high impact initially, but the novelty effect quickly wore off. The study authors also believe that the meters functioned as triggering mechanisms for purchasing low energy appliances. This means that although the meters had little long-term effect on everyday consumer behaviour, they nevertheless had long-term benefits because of the modified purchasing behaviour.

To be able to assess and design DSM activities, and to establish aggregate DSM plans for the whole of Denmark, the management and planning tool Save X was developed in 1997. The program was used to calculate the Benefit/Cost Ratios (BCR) in the table below.

DSM activities	**Use of resources of the society [Euro per saved kWh]**	**Use of resources of the utility [Euro per saved kWh]**	**BCR of the utility**	**BCR of the society**	**Realised savings in relation to a saturated market [%]**
Book of recipes	0.04	0.02	2.49	1.74	12
Leaflet "Better Electricity Practices"	0.05	0.05	1.01	1.29	11
Transportable electricity meter	0.05	0.05	1.02	1.30	1
Reading of meters	0.06	0.04	1.24	1.08	10
CFL's	0.07	0.03	1.55	0.92	25
Residential consultant	0.13	0.08	0.58	0.47	3
Measuring cup	0.14	0.10	0.50	0.43	2
Monthly newsletter	0.30	0.30	0.16	0.21	27

3.5 Hutton: US and Canada

A study conducted in Canada and the US[vi] in the mid-1980s found savings of 4-5% in Canada, but no savings in the US. The study also found that although the users of the systems tended to refer to the display less frequently after the first few months, the energy savings ceased once the display systems had been removed.

3.6 Wood: 44 households in the UK

A UK study[vii] of 44 households in 2003 found that displaying cooking energy consumption only reduced it by 15%. If only post-event information was provided (monthly bills) the cooking energy dropped only by 3%.

3.7 Hunter: 125,000 households in Northern Ireland

Northern Ireland Electricity[viii] installed keypad meters in 125,000 households and analysed the impact on energy consumption. With appropriate training customers reduced energy consumption by 11%. Also when no dedicated training was provided customers still achieved 4% savings.

A small pilot study started in New Zealand market last year in conjunction with Genesis Energy. The pilot involved more than 80 homes in the Wellington and Waikato regions.[ix] The small, easy-to-use Liberty meter replaces the customer's existing meter and provides access to a wide range of information. The technology allows instant prepayments at any time and includes a 'friendly credit', which enables continued electricity use if the available credit runs out in the dead of night or outside normal business hours.

3.8 Van Houwellinger: 50 Dutch households

A Dutch study[x] of 50 households in the Netherlands from 1984-85 found that in-home gas consumption display devices reduced the energy consumption by 12%. The authors suggest that providing a target for energy achievements – 10% energy savings in this case – in combination with the technology was an important component of the programme.

3.9 Other studies

In Norway customers with feedback reduced energy use by about 9%.[xi] (Although there were several references to the Norwegian experience with the technology it was not possible to obtain more detailed information on this work within the short timeframe.)

Substantial research has also been conducted in commercial and industrial feedback evaluation. However, the decision making processes leading to energy behaviour changes in residential buildings are quite different. Therefore the results from these commercial and industrial applications can not be extrapolated.

4. OTHER TRENDS AND CONSIDERATIONS

4.1 Dynamic pricing

The trend internationally is towards smart metering in combination with TOU electricity tariffs. Most of the previous studies were conducted with flat or non-dynamic rates. They are therefore compatible to the current New Zealand situation. It could be argued that with a dynamic pricing structure the electricity savings would be even more pronounced.

4.2 Current trends in the electricity industry overseas

A current debate between energy supply companies is around the question of how smart metering technologies might be used to maximise commercial advantage. Smart or intelligent metering technologies are playing a central role in opening up what have previously been monopolistic markets.

It is recognised that if the domestic market is to be opened up to full competitive pressures, new metering technologies will need to be able to control flows of utility services with an unprecedented degree of sophistication down to the level of the individual household.[xii]

There is frequent discussion in the industry and at policy level about whether real time consumer pricing needs to be implemented in New Zealand. Proponents say that only when real time pricing is offered to the end user a true wholesale electricity market will lead to energy efficiency and peak demand improvements. A key New Zealand player is Energy Intellect Ltd, a Wellington based company which offers advanced metering technologies mainly to commercial and industrial consumers.

Victoria Australia last July mandated the roll out of interval metering for all their 2,200,000 customers.[xiii]

4.3 The implementation process

It is generally acknowledged that both during the design and the implementation stages of smart energy technologies the communication between designers and those outside the design process is essential. One approach to facilitate this process is the Constructive Technology Assessment (CTA), a concept developed in the Netherlands. In an Austrian case study employing this approach interesting perceptions were uncovered; architects considered the importance of information communication technology quite low in sustainable residential buildings. Quite often the fact was stressed that with highly efficient buildings the additional efficiency gains from sophisticated controls were small. Smart home experts in turn were not interested in architectural solutions.[xiv] The saving potential would obviously be quite different in existing New Zealand houses which consume significant amounts of energy.

4.4 Making the feedback attractive

An interesting concept in the context of energy display technologies is the premise of Calm Technology. It is based around the ability of people to process information at the periphery almost as effectively as when they focus on it. A typical example is car engine sound; during normal driving the driver does not consciously listen to the noise of the engine but rather listens to the radio or has a conversation. But as soon as the engine makes unusual noises the attention shifts. In a similar way people are able to, for example, process information about their power consumption in a peripheral manner bypassing the need to focus on display readings or access the internet on a PC. The challenge is to design the technology to be able to do that. Calm Technology, which would both encalm and inform, was the vision of Mark Weiser and John Seely Brown of Xerox PARC.[xv]

4.5 Alternatives to technical devices

Instant energy consumption feedback using new technologies is only one means of providing information to the consumer in order to influence his or her energy consumption behaviour. More traditional channels have also found to be successful and the benefits of each alternative should be weighed up against each other. As Roberts et al[xvi] put it: “However, it seems reasonable to conclude that there is no systematic evidence that metering-based techniques necessarily produce a greater impact on consumer energy use than well-designed billing information developments. Bearing in mind the likely differences in costs and potential speed of introduction between the two different approaches, this is important.”

Also Darby[xvii] concludes that consumer feedback is a necessary but not sufficient condition for achieving the energy savings reported in the studies evaluated. “The range of savings, as well as the accompanying detail, shows the importance of factors such as the condition of housing, personal contact with a trustworthy advisor when needed, and the support from utilities and government which can provide the technical, training and social infrastructure to make learning and change possible.”

Often instant display technologies are used in combination with detailed monthly billing records. Studies in the 1970s, when instant feedback was technically not available, found that daily feedback has an impact on heating and cooling and continuous feedback affects other energy uses.[xviii]

4.6 Unintended consequences of smart display technologies

Many of the studies found the largest impact in connection with heating and air conditioning devices. In New Zealand existing homes approximately one third of the energy is used for heating, suggesting a significant savings potential. However, although heating energy is large, New Zealand houses are comparatively cold at international standards. It would therefore have potentially detrimental health impacts if smart metering technologies would prompt home occupants to reduce current heating levels even further.

Increased use of smart technologies may also have adverse effects on the household energy consumption. An extensive study by the Swiss Federal Office of Energy concluded that additional standby consumption may add up to 657 kWh per year, or 16% of an average Swiss household's energy use[xix] (NZ has an average consumption of about 10,000 kWh, and base load contributes up to 10%).[xx]

5. OPEN QUESTIONS

During this study a number of further questions arose which seem to be covered in a significant amount of literature. Some of the issues have been touched on in the previous section; however, they could not be satisfactorily covered within the scope of this small study.

Open questions include:

- What are the possible technical and market obstacles for implementing smart information technologies?
- What are suitable business models including end-users, supply companies, lines companies, public agencies and Beacon?
- How likely is it that New Zealand will adopt TOU pricing in the residential sector and what are the implications at a national level? What are the significant issues for regulators and industry?
- What coincidental benefits or problems does the technology have from a consumer point of view?
- How does the impact of smart technology compare to other information feedback channels?
- What is the importance of the format of the display interface for influencing consumer behaviour?

6. REFERENCES

[i] Levy, R. (2002). "Meter Scoping Study: Final Report for the California Energy Commission", Levy Associates, 2805 Huntington Road, Sacramento, California.

[ii] MM Research (2004). "Cent-a-meter Survey for Power Save Marketing Ltd", November 2004.

[iii] Darby, Sarah (2000). "Making it Obvious: designing feedback into energy consumption". Environmental Institute, University of Oxford, 2000.

[iv] Lynn Fryer Stein (2004). "Final Report: California Information Display Pilot Technology Assessment". Prepared for: Mark Martinez, Southern California Edison, prepared by Primen Inc. Boulder, CO 80302, December 21, 2004.

[v] Storm Sorensen, Maria (1999). "The effect of electricity saving measures in the residential sector", *ECEEE Proceedings*, Panel 1-23.

[vi] Hutton, R., Bruce, Gary A., Mauser, Pierre Filiatrault and Olli T. Ahtola (1986). "Effects of Cost-Related Feedback on Consumer Knowledge and Consumption Behavior: a Field Experimental Approach," *Journal of Consumer Research.* 13:327-336 (quoted in ref. iv).

[vii] Wood, G. and M. Newborough (2003). "Dynamic Energy-Consumption Indicators for Domestic Appliances: Environment, Behaviour and Design", *Energy and Buildings* 35:8 (quoted in ref. iv).

[viii] Graeme Hunter, NIE presentation (2004). Quoted in ref. iv.

[ix] Metering International (2004) (http://www.metering.com/archive/mi_4_2004/14_1_1.php).

[x] Van Houwellinger, Jeannet H. and W. Fred Van Raaij (1989). "The Effect of Goal-Setting and Daily Electronic Feedback on In-Home Energy Use", *Journal of Consumer Research* 16:98-105.

[xi] See ref. iv.

[xii] Guy, Simon and Marvin, Simon (1995). "Pathways to 'Smarter' Utility Meters: the Socio-Technical Shaping of New Metering Technologies", Electronic Working Paper No 23, Centre for Urban Technology, Department of Town and Country Planning, University of Newcastle upon Tyne.

[xiii] www.esc.vic.au.

[xiv] Rohracher, H. (2002). "Smart homes and energy efficiency: Constructive technology assessment of ICT use in sustainable buildings", *ACEEE Summer Study 2002*.

[xv] Weiser, Mark and John Seely Brown (1996). "The Coming Age of Calm Technology", Xerox PARC (October 5, 1996).

[xvi] Simon Roberts and William Baker (2003). "Towards effective energy information improving consumer feedback on energy consumption". A report to Ofgem Reference, Contract no: Con/Spec/2003/16.

[xvii] Darby, S. (2000). "Making It Obvious: designing feedback into energy consumption". Appendix 4 of Boardman and Darby, *Effective Advice*, Environmental Change Institute, University of Oxford.

[xviii] McClelland and Cook (1979). Quoted in ref. iv.

[xix] Aebischer, B. and A. Huser (2000). *Networking in Private Households: Impacts on electricity consumption*. Bern: Swiss Federal Office of Energy. Quoted in ref. xiv.

[xx] Isaacs N., Amitrano L., Camilleri M., Pollard A. and Stoecklein, A. (2002). *Energy Use in New Zealand Households: Report on the Year 6 Analysis for the Household Energy End-use Project (HEEP)*, BRANZ Ltd, Judgeford, November 2002.