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Witness:	Sarah J. Darby, Environmental Change Institute, University of Oxford

SOUTHERN CALIFORNIA GAS COMPANY

ADVANCED METERING INFRASTRUCTURE

CHAPTER V

ESTIMATED CONSERVATION IMPACT OF PROVIDING DAILY GAS INFORMATION TO CUSTOMERS

Errata to

Prepared Direct Testimony

of

Sarah J. Darby

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I. INTRODUCTION

The purpose of my testimony is to present evidence for the potential conservation impact of using AMI technology and making timely usage information available to customers. The focus is on how customers change their behaviour in relation to information feedback.

II. SUMMARY

The Southern California Gas Company (SoCalGas) proposes communication technologies and supporting systems to provide online next-day gas usage information and also in-premise display information for their customers. The total conservation impact from these information presentation tools will depend on the scope for conservation in customers' homes, the quality of feedback and the level of customer participation in a feedback programme.

On the basis of the research literature regarding the impact of feedback on heating- and cooling-related behaviour, I estimate an average conservation impact of approximately 5% per participating household from the adoption of AMI and regular use of next-day feedback on the SoCalGas website. This saving would result from changes in routine behaviour and resetting of controls.

A second option ~~under consideration~~ proposed by SoCalGas is a dedicated in-home display. My estimate of the conservation effect from adoption of AMI with display-based feedback is 10%. The higher figure results from the information being more easily accessible than it is when online: the consumer does not have to go and seek it out.[1]

Over 75% of households in southern California are estimated to have Internet access[2]; the display-based feedback would be the default option for those who are not online. In-premise displays and web-based feedback are not mutually exclusive and can be complementary.

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[1] SoCalGas witness Mr. Olmsted discusses the capabilities of the available AMI technologies, including responses to SoCalGas AMI technology RFP. Several gas AMI technology vendors propose communications capabilities that will communicate with home information gateway devices or home area network (HAN) display devices.

[2] Nielsen figures for local internet penetration, Q4 2006

I have estimated the overall conservation impact of web-based and display-based feedback on the assumption that initial participation levels will be 6.5% of the customer base for each. This gives a total conservation impact of **just under 1%** in the first year for those customers with the arrangements in place for next-day feedback. If participation were then to increase at a rate of an additional 1% per year, this total would rise to approximately **1.6%** of total gas consumption 5 years after the start of the rollout, averaged over the customer base.

There are potential further savings from investment in energy efficiency measures and low-carbon technologies, once customers' interest and commitment are engaged more fully, but these are likely to be accounted for elsewhere.

Approximately 40% of gas consumption in homes in the SoCalGas territory is used for space heating and 47% for water heating. These two end-uses offer the main potential for conservation.

Estimates for the conservation effect of web-based and display-based feedback are based on the studies summarised in the Attachments. They can only be a guide to what is possible. The outcome for SoCalGas customers will depend to some extent on how the feedback is implemented and supported, and on the overall drive towards fuel conservation in California. However, the trend over recent years has been for domestic energy users to show increased concern about their usage and about its environmental impact, and to expect greater access to timely information.

III. BACKGROUND

The California Energy Efficiency Strategic Plan sets targets for deep energy reduction and envisages a 'rapid evolution in both technology and customer behaviour to make energy efficiency "a way of life" among Californians by 2020' (pp.2-3). Visual displays of real-time or near-real-time energy use are seen as part of this evolution (p.17), enabling households to manage their energy use more effectively and to reduce emissions through changes in behaviour and adoption of low-carbon technologies and efficiency measures.

This testimony deals with the potential for energy conservation resulting from adoption of AMI by the Southern California Gas Company. It relates to the likely impact of improved feedback on customer behaviour.

AMI can provide energy usage information to both customer and utility on a defined, regular basis. By doing so, it can improve the quality of feedback to both, which can lead to better understanding of how to manage and to conserve fuel. Data from an AMI also provides a shared point of reference in the event of complaints or requests for advice.

IV. THE RESEARCH LITERATURE ON ENERGY FEEDBACK

Several of the studies on energy information feedback that were reviewed for this testimony were conducted before advanced metering was available. However, they are still relevant because these studies involved changes in the energy user's information environment of the type proposed by SoCalGas, i.e., more timely, accurate information, comparisons of energy usage with previous periods, and identification of consumption goals or benchmarks.

In 2006 I carried out a review of some 35 papers and reports in the literature on energy feedback in the residential sector for the UK Department of Environment, Food and Rural Affairs[3]. I concluded that

> *Indirect feedback [that is, feedback that is processed in some way before reaching the energy user]… is usually more suitable than direct feedback [immediately available to the user] for demonstrating any effect on consumption of changes in space heating, household composition and …investments in efficiency measures…*

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[3] Darby S (2006) *The effectiveness of feedback on energy consumption. A review for DEFRA of the literature on metering, billing and direct displays.* Environmental Change Institute, University of Oxford http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback.pdf and http://www.defra.gov.uk/environment/climatechange/uk/energy/research/pdf/energyconsump-feedback-appendix.pdf

Savings have ranged from 0-10%, but they vary according to context and the quality of information given. Historic feedback (comparing with previous recorded periods of consumption) appears to be more effective than comparative or normative (comparing with other households, or with a target figure)…

Persistence of savings will happen when feedback has supported 'intrinsic' behaviour controls – when individuals develop new habits – and when it has acted as a spur to investment in efficiency measures…As a rule of thumb, a new type of behaviour formed over a three-month period or longer seems likely to persist – but continued feedback is needed to help maintain the change and, in time, encourage other changes.

Dr. Corinna Fischer, a psychologist working at the Free University of Berlin, recently reviewed the same literature and also some German-language studies.[4] She found that feedback stimulates energy savings that are usually between 5-12%, provided that there is some motivation to conserve. She concludes that

'*With all due care because of data restraints, there are reasons to identify some likely features for successful feedback (meaning, both effective in stimulating conservation and satisfying to households). Such feedback*

- *is based on actual consumption*
- *is given frequently (ideally, daily or more)*
- *involves interaction and choice for households*
- *involves appliance-specific breakdown [the review relates to electricity]*
- *is given over a longer period [prolonged period]*

[4] Fischer C (2008) Feedback on household electricity consumption: a tool for saving energy?. *Energy Efficiency* **1** (1), 79-104

- *may involve historical or normative comparisons (although these [i.e., normative comparisons] are appreciated by households, the effects are less clear [than for historical comparison])*
- *is presented in an understandable and appealing way*.'

I concur with Dr. Fischer's conclusions. For the SoCalGas situation, the most important characteristics are actual, frequent consumption feedback information over a long (continuing) period of time, interactivity, comparisons with consumption in previous periods and presentation in a user-friendly format. I would also argue that more than one option for mode of feedback is desirable, in order to engage as many customers as possible; and more than one metric for feedback (for example, allowing customers to choose between cost or energy units, and to select time periods for comparison and goals or benchmarks).

V. RESEARCH DIRECTLY RELEVANT TO THIS TESTIMONY

There are not many fully-documented trials of feedback carried out with large numbers of people in 'normal' conditions, and those that exist have shown a range of conservation impacts, as indicated above. For this testimony, I selected four case studies of 'indirect' feedback that seemed most relevant to the SoCalGas situation, in that they relate to gas usage and use a computer-based interface with the customer. These case studies are summarized in Attachment SD-1.

I also selected ~~eight~~ twelve studies and reports that deal with more direct feedback modes (where the end-user has instant access to the consumption data), where space- and water heating are included among the end-uses. These are summarized in Attachment SD-2. The main point is that the feedback in these trials included relatively high energy loads, which do not change rapidly from moment to moment and which lend themselves to next-day feedback more than to real-time feedback.

The only instance in the English-language literature of a trial of next-day feedback on domestic gas consumption alone, given via a dedicated display rather than online, produced 12%

savings against a baseline and 10% against a control group for the duration of the experiment[5]. The feedback was given for the previous day's consumption in relation to a 10% conservation target. However, a year after the displays had been removed, consumption had reverted to the same level as that in the control groups: feedback needs to be integrated into the energy system, not offered as a temporary expedient.

We have evidence of durable or sustainable change – that is, changed habits – in the available studies, and we have evidence that people who monitor their energy usage also tend to have a more active interest in installing long-lasting efficiency measures and low-carbon technologies.[6]

Some of the selected research shows the combined effect of feedback and advice. Feedback information may prompt energy users to seek advice and it can also be used to check that the advice is productive. A study of low-income households in West Lothian in Scotland demonstrated that basic feedback from self-meter-reading gave average savings of 11% within three months from behaviour change when it was combined with personalised advice; there were further savings from energy efficiency measures which were installed later[7]. In Germany, participants in the Home Resource Account programme have averaged 5% gas savings per year over a period of four years when given graphical online feedback on their meter readings in combination with online or phone advice, including advice on improving the efficiency with which their central heating pumps work[8]. This indicates something of what is possible with motivated participants over an extended period. The participants in this scheme do not have smart meters but record their meter readings on the HRA website whenever they wish. A third

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[5] Van Houwelingen, JH and van Raaij, WF (1989) The effect of goal-setting and daily electronic feedback on in-home energy use. *Journal of consumer research* **16**, 98-105.

[6] Darby 2006 as in footnote 1; Darby S (2006) Social learning and public policy: lessons from an energy-conscious village. *Energy Policy* **34**, 2929-2940; CO2 Online, a German website offering personal energy advice in conjunction with meter readings; Harrigan MS and Gregory JM (1994) Do savings from energy education persist? Alliance to Save Energy, Washington DC; Staats H, Harland P and Wilke HAM (2004) Effecting durable change: a team approach to improve environmental behaviour in the Netherlands. Enviornment and Behaviour 36 (3), 341-367

[7] Annual reports of the West Lothian Energy Advice Project; referred to in Darby S (1999) *Energy advice – what is it worth?* Proceedings, European Council for an Energy-Efficient Economy, III.05

[8] CO2online.de, accessed July 2008. Home Resources Account

example, that of the ‘Ecoteams’ in the Netherlands, shows what is possible with neighbourhood groups of motivated individuals: weather-adjusted gas savings of 20% against baseline were achieved during the first year of the programme and three years after the programme began, savings were still at 16% against the baseline[9]. There is more information on these three programmes in Attachment SD-2.

Attachment SD-2 includes summaries of the conservation impact of three pay-as-you-go systems. This payment method intrinsically involves a degree of feedback to the customer, but these programmes also included in-premise displays. The~~y~~ systems produced substantial conservation effects of up to 20%, though it is not known whether some of this was due to self-disconnection by customers from their electricity supply.

In summary, the evidence from these selected studies is that gas conservation and electric space- and water-heating conservation have resulted from both ‘indirect’ and ‘direct’ feedback; that durable effects have been measured~~,~~; and that the effect of feedback can be enhanced by combining it with advice and/or community initiatives.

VI. SCOPE FOR SAVINGS AMONG SOCALGAS CUSTOMERS

The scope for savings will be affected by factors such as initial consumption levels (how much scope is there for reductions in usage without sacrificing comfort?); ability and willingness to invest in energy efficiency measures or low-carbon technologies; and tenure (is the customer in a position to make alterations to the property or the gas appliances?).

SoCalGas workpapers[10] give eight principal end-uses for natural gas in dwellings, with varying scope for demand reduction. They are:

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[9] Staats, Harland and Wilke as in footnote 4.

[10] 2006 California Gas Report workpapers, redacted. Prepared by the Gas Company. P117.

1. Space heating (39% of residential gas consumption in California)[11] . This will vary according to location but conservation gains can be made in the short- and long-term through behavioural and physical changes such as
    - improving furnace efficiency or replacing old, inefficient furnaces;
    - turning the central heating thermostat down in winter: a rule of thumb is that a reduction of 1°C (1.8°F) leads to a reduction in consumption of around 10%;
    - heating less of the building – turning off heaters or shutting vents in unused rooms;
    - heating it for less time, e.g. use of timer to switch off and setback at night and during absences from home;
    - using area-specific thermostats to control heating better in different areas of the building;
    - improving the insulation of the home (this would also have the effect of keeping the building cooler in summer and reducing air-conditioning loads);
    - building and refurbishing for solar gain in winter.

There appears to be a price-response effect at work in conservation of space heating. When comparable trials of feedback via an in-premise display were carried out in Newfoundland and British Columbia[12], the Newfoundland householders with electric space heating reduced their demand by 20% compared with the control group. In British Columbia, where electricity is much less expensive than in Newfoundland, comparable figures were 3% and 2%. This could be relevant at a time of rapidly rising gas prices.

2. Water heating (47% of residential gas use). Potential conservation measures include
    - insulating the water tank;
    - installing low-flow taps and shower heads

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[11] California Statewide Residential Appliance Saturation Study. Final Report, June 2004

[12] Mountain, DC (2007) real-time feedback and residential electricity consumption: British Columbia and Newfoundland and Labrador pilots. Mountain Economic Consulting and Associates Inc., Ontario

- using less hot water day by day, e.g. shorter showers
- turning down the water tank thermostat to 140ºF/ 60ºC
- replacing the water heating system either with solar water heating or with a more efficient tank-less system. It is estimated that installing solar water heating could reduce natural gas demand in homes for water heating by 50-75%.[13]

3. Cooking (10% of residential use). We have no research data on use of feedback specifically for gas cooking; only for the real-time displays that were tried with electric cookers, where the volunteer users saved an average of 14%.[14] There is no suggestion that this would be separately available to SoCalGas customers, so any savings here would come from increased general awareness of consumption. Cooking would be likely to show up in the feedback if data were available three or four times a day, as proposed by SoCalGas, but might otherwise be 'lost in the noise' of daily data.

4. Drying (4%). There is scope for reducing this consumption through line-drying. Again, data three or four times daily would be likely to show the impact of dryers.

5-8. Pool heating, spa heating, fireplaces and barbecues (very small proportions of overall consumption, but may be significant for the customers who use them). The first two of these lend themselves to solar heating technologies – a step involving investment but one that is becoming more likely in the light of recent policy on solar water

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[13] Del Chiaro B and Telleen-Lawton T (2007) Solar water heating: how California can reduce its dependance on natural gas. Environment California Research and Policy Center http://www.arb.ca.gov/cc/ccea/comments/jan/environment_california_swh.pdf

[14] Wood, G. and Newborough, M. (2003) Dynamic energy-consumption indicators for domestic appliances: environment, behaviour and design. *Energy and Buildings* **35**, 821-841

heating and the California Energy Efficiency Strategic Plan. Fireplaces and barbecues offer some prospect of incremental savings.

From the above, there is clearly substantial scope for gas conservation in the SoCalGas area. The question is how much of it can be realised through provision of gas usage and bill information feedback to customers, using AMI.

Table 1 summarises the findings from the most relevant research literature, dealing with feedback on gas consumption and/or space heating and cooling. Findings from the studies from which Table 1 is drawn are set out in more detail in the Attachments, as noted above.

Table 1: Summary of findings from the research literature on feedback to households*[15]

	Number of studies from which a figure for savings is derived	**Indicative figure for savings per participant**	**Range**
Indirect feedback, PC / web-based	4	5%	4 - 9%*
Direct feedback through a moveable in-premise display monitor or self-meter-reading	9	10%	1 - 20%
Pay-as-you-go metering with feedback	3	12%	5 - 20%

*The data for German homes show 5% savings year-on-year over a period of four years for a combination of self-monitoring, website use and availability of targeted advice.

[15] with the exception of the Carbon Trust trial of web-based feedback to SMEs.

The 5% and 10% indicative figures relate to savings in the short- to medium-term, mostly from behavioural change (change of habits) arising from increased awareness. Apart from the German CO_2 online example, ~~T~~they do not include any further conservation effects that may come about as householders become more knowledgeable about the options open to them and more likely to invest in energy efficiency and low-carbon technologies.[16] (These may be accounted for elsewhere, for example as a result of specific marketing programmes.)

VII. LIKELY PARTICIPATION IN A FEEDBACK PROGRAMME

Evidence on the effectiveness of feedback is mostly drawn from samples that are unlikely to be representative of the whole (especially in the early studies), and I had to make a judgement as to how much we could expect customers to take an interest in feedback. Participation in a utility-led, feedback-based conservation programme will depend to a large extent on customer motivation to conserve, and on the extent to which the utility engages them. The research literature shows that feedback is effective in two main ways. First, it builds awareness in people who have had a more or less fatalistic attitude to their energy bills, seeing them as something over which they have little or no control. This mindset is summarised in a recent study of householders in London:

> *Energy and power are not terms within the natural language of mainstream householders. Gas and electricity operate at the level of the subconscious within the home ... there appeared to be virtually no sense of being able to actively and significantly reduce energy consumption in the household.*[17]

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[16] Darby S (2006) Social learning and public policy: lessons from an energy-conscious village. *Energy Policy* **34**, 2929-2940

[17] Dobbyn, J and Thomas, J (2005) *Seeing the light: the impact of micro-generation on our use of energy.* Report to the UK Sustainable Development Commission. http://www.sd-commission.org.uk/publications/downloads/Micro-generationreport.pdf

For this group of people, response depends in the first instance on the extent to which the feedback seizes their attention. Once they are more aware of their consumption, they are in a position to start doing something about altering it. Once they have started experimenting, the feedback then tells them which actions and measures are most worthwhile.

Second, feedback acts as a tool for people who are already motivated to save energy. A psychologist evaluating a community trial of digital electricity real-time monitors in Wales noted that

> *The [monitors] had the most effect in households where discretionary electricity use was fairly high and they were motivated to reduce it for either environmental or cost reasons.*[18]

Something similar could be expected for those SoCalGas customers who are motivated by environmental and/or financial concerns, frequently online and comfortable with web-based interactive tools. Research carried out with 563 members of the SoCalGas online customer insight panel (a 51% response rate) showed 68% agreeing (38% strongly and 30% somewhat) that if their daily gas usage and cost were made available, it would influence their usage, with only 13% disagreeing. 47% of the panel said that they would prefer to have daily information on the SoCalGas website. This fits with the finding by a recent Pew Centre study that 41% of ICT users are either 'elite' or 'middle of the road' users who are at ease with the technology and value it[19]. On the combined SoCalGas and Pew figures, we could expect nearly 15% of all SoCalGas customers (51% response rate x 68% interest x 41% highly computer-literate) to show some interest in online feedback information at the outset of an AMI-related programme.

[18] Kidd and Williams, 2008

[19] Pew (2007) *A Typology of Information and Communication Technology Users*. Pew Internet and American Life Project, Washing DC, May 7 2007.

29% of the SoCalGas customer panel said that they would prefer daily feedback on an in-home display; however, this was an *online* panel. For those customers who are not online, a standalone display would be the default option.

I have estimated 13% participation in a feedback programme for the early days – a little lower than the 15% suggested by the customer insight panel and Pew data, but still a substantial level of interest. This 13% is divided into 6.5% of customers opting for online feedback and 6.5% for display-based feedback.

13% is higher than the Southern California Edison estimates of initial uptake of web-based feedback at 1% (with growth of 1% per year), and uptake of display-device-based feedback at 1% initially (with growth of 0.1% per year).[20] I believe the higher estimate is justified, based on the reasoning given above and on recent experience in northern Ontario, where Hydro One were recently able to roll out real-time electricity displays to 30,000 (20%) of their customers over a period of nine months, charging them $9 for postage and handling.[21]

SoCalGas is proposing measures as detailed in Chapter VI to encourage participation and conservation. All of these proposals could assist recruitment and effectiveness. It is worth noting that they would be introduced at a time when customers would be growing accustomed to real-time feedback on electricity consumption, and at a time when energy prices, environmental concern and expectations for high-quality information are rising.

Table 2 gives estimates of the initial conservation potential of an online feedback service, applying estimates of savings potential and participation (as discussed above) across the customer base.

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[20] Rebuttal testimony supporting Edison Smartconnect™ deployment funding and cost recovery. February 19, 2008. p12.

[21] Personal communication from the Director, Business Transformation, Hydro One. The conservation outcome is not established yet but is estimated to be in line with the findings of the pilot studies carried out by Mountain Consulting: that is, around 6-7%.

Table 2: Estimates of conservation potential from daily online feedback to SoCalGas customers

Feedback type	**% of customers participating**	**Savings potential (%)**	**Initial total conservation estimate (% of participants with 'smarted' meters)**	**Conservation estimate in Y5, assuming 1% participation growth rate per year**
Web-based	6.5	5	0.325	0.525
Display-based	6.5	10	0.65	1.05
Total conservation effect			**0.975**	**1.575**

VIII. WITNESS QUALIFICATIONS

My name is Sarah J Darby. I am a Research Fellow at the Environmental Change Institute, University of Oxford. The fellowship was awarded for the study of domestic energy feedback, with reference to the introduction of advanced metering, and is funded by the UK Research Councils' Energy Programme. I am a member of the evaluation team for the UK Demand Reduction Trials. I also contribute to the ECRIS project, part-funded by the Department of Business, Enterprise and Regulatory Reform, to develop tools to help people manage their energy usage better. This has led to the launch of the company ONZO.

I hold a BSc in Ecological Science from the University of Edinburgh, a postgraduate diploma in urban and regional planning from Oxford Polytechnic, and a doctorate from Oxford University. I began researching energy issues at the ECI in 1997, evaluating the effectiveness of energy advice programmes for low-income householders. In 2000 I wrote a paper that has been widely cited, '*Making it obvious: designing feedback into energy consumption*', in which I reviewed the evidence on how feedback affects energy consumption. In 2003 I completed a doctoral thesis on the topic of 'Awareness, action and feedback in domestic energy use'. Between 2003 and 2007 I contributed to research on policy and practice for low-energy housing and non-domestic buildings, including the ECI report *40% House* and background research for the Royal Commission on Environmental Pollution's 2007 report on the urban environment. In 2006 I carried out a further literature review on the effectiveness of feedback for the UK Department of Environment, Food and Rural Affairs.

This is my first testimony before the California Public Utilities Commission.

IX. NOTICE

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