

Factors Affecting the Impact of Energy Efficiency Incentives

-Issue Paper Eight-

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Preface

The Energy Sector Sustainability Table (ESST) was established in 2005 as a multi-stakeholder advisory mechanism - including senior representatives from governments, industry, and civil society – created by the Government of Canada to provide advice on how best to meet the energy needs of Canadians so as to improve the environmental and economic sustainability of energy systems in Canada and to make recommendations on short-and long-term sustainable energy objectives.

Energy efficiency was identified as key priority for the ESST so the Table established the Energy Efficiency Working Group (EEWG). The EEWG is a committee of industry, government and civil society experts mandated to provide the ESST with an expert perspective on energy efficiency in Canada. The EEWG has produced several products including its Energy Efficiency in Canada Foundation Paper, a series of issue papers, and a final report summarizing the key conclusions and recommendations that resulted from the EEWG's work.

This issue paper is one in a series of a total of eight issue papers. The paper, as well as all other EEWG products, was prepared by the EEWG in conjunction with Marbek Resource Consultants and Dr. Michael Margolick.

To access other EEWG documents or for more information about the Energy Sector Sustainability Table and its Energy Efficiency Working Group, please visit: <http://www.sst.gc.ca>

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1. INTRODUCTION

While energy efficiency is widely accepted as an effective strategy for reducing energy consumption, the effectiveness of energy efficiency programs and policies and in particular, energy efficiency incentives, is influenced by a number of behavioural and economic factors. Developing an understanding of these factors will increase the likelihood of designing better programs and implementing better policies.

This short paper informs the discussion on behavioural and market factors that affect the results (and thus the cost-effectiveness) of energy efficiency incentives. It defines four key effects and explores them in the context of sector-specific examples. The four effects are the:

- Free rider effect;
- Spill-over effect;
- Rebound effect; and,
- Leakage effect.

Further consideration is given to lessons for portfolio planning, for the planning, design and implementation of energy efficiency programs, and for their evaluation. Evaluation is a crosscutting theme in this paper. Results of evaluations are crucial to our appreciation of these effects as is the development of approaches to credibly conduct such evaluations. Clear evaluation frameworks with clear objectives are required for the appropriate interpretation of these effects in the broader policy context (i.e. not simply from a narrow program effectiveness perspective). A strong clear framework starts with the identification of clear objectives, includes the development of metrics or indicators, setting targets, and establishing a measurement approach. The objectives established at the beginning form the basis for the entire process. Considering energy efficiency incentives, it is possible to consider various policy objectives including:

- Energy intensity – focus on increases in technological efficiency;
- Energy use – focus on the reduction in overall energy use;
- Equity – focus on subsidizing / rewarding positive behavioural patterns; and,
- Market transformation – focus on overall market direction and progress as opposed to specific programmatic efficiency gains.

Much of the focus in the evaluation literature is on the effectiveness of programs for improving energy intensity or more specifically, programmatic cost-effectiveness. Recent work particularly in leading jurisdictions such as California has begun to shift towards consideration of market transformation and reducing energy use as the over-riding objectives. In considering the literature drawn upon for this paper, it is important to consider estimates of the various effects in the context of the appropriate evaluation framework and objectives. It is also important to note that the effects discussed are not predictable in any real sense. With the exception of possibly the rebound effect, these effects are highly dependent on individual technologies, program design and circumstance and can only be assessed based on past experience and empirical evidence.

This paper draws on the initial scoping research for this topic undertaken by Alberta's Climate Change Central as well as various scholarly articles, consultant studies and institutional documents.

2. KEY CONCEPTS & DEFINITIONS

There are a variety of ways of categorizing the various factors. For the purposes of this paper, we have chosen to distinguish four main types, with a series of sub-categories, representing different manifestations. These are shown in Table 2.1 and discussed in the following sub-sections.

Table 2.1
Types of Factors Affecting the Impact of Energy Efficiency Programming

| Type | Sub-Category |
|------------|----------------------|
| Free Rider | Full |
| | Partial |
| | Moral Hazard |
| Spill-Over | Participant |
| | Market |
| | Free Drivers |
| Rebound | Direct – Own Price |
| | Direct – Cross Price |
| | Indirect (Income) |
| | Economy-Wide |
| Leakage | Activity Shifting |
| | Life Cycle |

2.1 FREE RIDERS

A free rider is a program participant (i.e. one who claims an incentive or otherwise actively participates in program) who would have invested in efficiency improvements even in the absence of the program. If the program has little or no influence on the decision to engage in energy efficiency, energy savings from the actions or purchases by this group of customers cannot be credited to the energy efficiency program. Thus, as free ridership increases, the cost-effectiveness of the energy efficiency program decreases. The literature distinguishes between full and partial free riders (Violette et al. 2001) as well as moral hazard:

- **Full free riders.** These participants would have installed the exact energy efficiency measures at the same point in time had a program not been offered.
- **Partial free riders.** These participants would have undertaken some, but not all of the energy efficiency measures; or, would have undertaken all of the measures but at a later point in time.
- **Moral hazard.** This sub-category of effect refers to individuals that, knowing or suspecting that an energy efficiency program will be implemented, delay the application of energy efficient measures in order to obtain the subsidy associated with the program. In addition to the regular free rider loss of value, the effectiveness of the program is further eroded by the time during which the energy efficiency measure was delayed.

The literature also gives some consideration to the measurement of “pure” free ridership. Estimates of pure free ridership exclude those individuals / entities who, despite being free riders in a real sense, are influenced by previous program experience. Pure free ridership is discussed primarily in the context of commercial / industrial programs with regards to cumulative program effects, and ultimately market transformation. Surveys have shown that some commercial / industrial entities’ energy efficiency investments were influenced to a greater degree by previous program experience than by their experience in the year for which the program was being evaluated.

As illustrated by the concept of pure free ridership, the impact of free ridership on program effectiveness and its consideration as having either a positive or detrimental effect, ultimately depends on the program objective and subsequently what is (or ought to be) tracked, measured, evaluated and rewarded.¹ Resource acquisition initiatives involve participant-focused evaluations whereas market transformation requires market-focused evaluations (“market progress reports” instead of “program evaluations”). Market penetration, not the number of net rebates, is tracked. Measurements for both strategic interventions are still based on the relationship between what happened with and what would have happened without the intervention. For participant-focused evaluations, the issues are usually categorized as problems in determining free ridership and spillover and, in almost all cases, trying to determine this based on the motivations and characteristics of the participants. For market transformation initiatives, the effect of the intervention is determined by the actual penetration in the marketplace “with the program,” and the baseline penetration expected “without the program.” Incentives in this sense assist in overcoming the risk premium associated with new technologies, preparing the market through increased production capacity and building political will.

Another consideration influencing the relative importance of the free rider effect and also related to the overall policy objective, is the issue of equity. In a general sense, positive behaviour – behaviour which is consistent with current social and environmental policies – ought to be rewarded. If as opposed to taking a narrow view of program effectiveness, energy incentives are considered from a broader policy perspective, “free riders” could be considered as benefiting from a “green rebate”. This type of program might in time shift towards taxation of undesirable behaviour as market penetration of the technology and political saleability of regulation increased (a pull-push approach).

Free ridership varies with each sector, technology, jurisdiction and type of program and is also influenced by program implementation. Free ridership also changes over time in relation to business-as-usual technology adoption rates. The market penetration curve of a technology must therefore be taken into account when estimating future costs and benefits of energy efficiency incentive programs and care must be taken when comparing results between jurisdictions.

Estimation of free ridership can be costly and difficult. Uncertainty surrounding free ridership is a significant component of DSM savings uncertainty; however, as discussed in the California Evaluation Framework (TecMarket Works 2004), reducing the uncertainty associated with free ridership through additional studies can be expensive. The challenge is to find a way to attribute

¹ Sebold et al. (2001), pg.68

impacts either by comparison with a control group, or by estimating incremental impacts over a baseline (counter-factual) scenario. Three general approaches are used (Eto et al. 1995):

- Surveys
- Survey-based customer choice models
- Billing analysis using a comparison group.

Surveys and survey-based customer choice models yield direct estimates of free ridership whereas billing analysis incorporating a comparison group in principle controls for free ridership implicitly. The majority of free ridership estimates are based on surveys (Eto et al. 1995). Two propensities tend to reduce the accuracy of surveys (Vreuls 2005):

1. Respondents can exaggerate or underplay the influence a program had on their decisions, depending on their perception of expectations for the survey;
2. Respondents often have difficulty recalling and reconstructing the circumstances around the purchase.

These problems can be reduced but bias in self-reported data cannot entirely be eliminated.

2.2 SPILL-OVER EFFECT

Spill-over can be defined as energy efficiency improvements that occur due to program influence but which are not directly supported through a financial incentive or technical assistance (Vreuls 2005). Spill-over effects reduce the total cost of energy efficiency because they increase the energy savings generated with no increase in program costs. Given the tendency for individuals to make social comparisons and communicate through social networks (see EEWG's *Personal Drivers* paper), theoretically, spill-over effects could result from a chain reaction of communication – not just secondary but also third- and fourth- (etc.) order effects.

Increasing levels of spill-over are indicative of market transformation and likely correspondingly increasing support (or saleability) for a regulatory approach such as implementing minimum energy performance standards.

The literature distinguishes between three sub-categories of spill-over:

- **Participant spill-over.** Participant spill-over occurs when a participant of an energy efficiency program continues to adopt energy efficiency measures beyond the initial targeted measure. Skumatz (2006) makes the distinction between 'inside project spill-over' and 'outside project spill-over' which accounts for the timeframe during which the additional measures are implemented – inside project measures are undertaken concurrently with the incentive program whereas outside project measures are implemented at a later date.
- **Non-participant spill-over (including *free-driver effect*).** Non-participant spill-over refers to energy efficiency measures purchased or implemented by individuals outside the program (i.e. non-participants) that were inspired to undertake the measures ultimately as a result of the program (for example, because of program advertising or because more

energy efficient equipment is in the market as a result of program actions). What has been known as the *free driver effect* is also included in this category. The free driver effect refers to program participants inspiring non-participants to undertake energy efficiency measures. This can be a function of social comparisons and networking and the influence of participants on non-participants is not necessarily overt.

- **Market spill-over.** Market spill-over refers to the adoption of energy efficient products and services by program non-participants who implement measures as a result of the program's influence on the market (e.g. stock displacement/production changes). A program's influence on individuals and the market may be contained within the jurisdiction of the administering agency or may, in instances of highly successful programs, extend to external jurisdictions. For example, through the development of national level supply chain relationships, BC Hydro's seasonal LED (SLED) program resulted in substantial spill-over, transforming the seasonal lighting market across Canada (CEEA 2004). Further spill-over could result from upstream efficiency increases (or reductions in energy consumption) enabled by downstream changes in consumption patterns or technology (e.g. subsidies encouraging further innovation). These effects are sometimes referred to as indirect or induced market effects in market transformation literature (Skumatz 2006).

Spill-over has only relatively recently been recognized as having potentially significant positive impacts on policy / program effectiveness. Its measurement has thus only recently become a priority and as a result little data is available. In addition, measuring the spillover effect is difficult so the limited data available is often controversial. Currently, there is no consistent approach to spill-over in program impact evaluation. In the US: some states assume that free ridership and spill-over cancel each other out; others require impacts be calculated net of free riders and no spill-over is counted (though it may be estimated for informational purposes); one state does not discount for free riders but adds in spill-over; and, one state includes free riders and only participant spill-over.²

Methods for estimating spill-over include: comparisons of technology penetration between participating, non-participating but nearby jurisdictions, and isolated jurisdictions; surveys for participants and non-participants; discrete choice models; and, participant and non-participant billing analysis. These methods can impose high transaction costs and the results are not necessarily conclusive – for example, econometric analyses using billing data require datasets with the appropriate control variables in order to be considered valid analyses. A considerable difficulty is the presence of 'market noise.' The impacts of a particular program in a market filled with many implementers offering similar programs under different names with different incentive structures and marketing methods make estimating the influence of any particular program problematic. Customers may not be able to discern between the various programs operating in the marketplace, and may not accurately recall what influences various programs may have had on their decision processes or even remember the program in which they participated (TecMarket Works 2004).

² Violette, D. 2007. Perspectives on DSM Program Evaluation: DSM Informational Workshop, Public Utilities Commission. Summit Blue Consulting.

2.3 REBOUND EFFECT

The rebound effect (also termed the snap-back or take-back effect) refers to the increase in energy demand resulting from an effective reduction in energy cost caused by energy efficiency improvements. As a result, increases in energy efficiency do not achieve their technical potential and in the extreme, could theoretically result in a net increase in energy consumption (a condition termed “backfire”). The rebound effect is an extension of the “Law of Demand” which states that if effective costs decline, consumption generally increases (the extent of this reaction is a function of the price-elasticity of product / service demand). In this context, cost is not limited to financial cost, but may also include time, risk or discomfort (VTPI 2007).

The rebound effect can be divided into four sub-categories (Dimitropoulos & Sorrell 2006):

- **Direct own price effects.** Direct effects include increased service / commodity consumption resulting from decreases in cost as a function of effective energy price. This increase in consumption offsets the savings achieved through efficiency improvement. Direct effects can stem from an initial actual or perceived inadequacy in the level of service provision, particularly in the context of low-income consumers. For example, a low-income household may raise the thermostat following a drop in the monthly cost of heating resulting from the installation of a high-efficiency furnace, as the energy efficiency savings allow the household to afford a higher comfort level. Alternatively, having purchased a highly fuel-efficient personal vehicle, an individual may increase their road travel in terms of vehicle kilometers travelled while remaining within their previous transportation budget. An additional consideration often included in the direct effect is the concept of a psychological license to consume. Because one has already undertaken an action to offset the negative implications of consumption, the ‘guilt’ (disincentive) associated with consumption is reduced / negated.
- **Direct cross-price effects.** These effects involve the substitution of a more energy intense form of service / commodity for an initial form due to changes in relative (out-of-pocket) expenses (cross-price effect). For example, an individual might use their fuel efficient vehicle because it is now less expensive than transit (this cost difference might be due to hidden subsidies).
- **Indirect (income) effects.** With lower energy bills, more income is available to spend on additional (or higher amenity) services and commodities which may be more or less energy intensive than the initial service / commodity. The services and commodities on which this additional disposable income is spent will vary depending on the prior income level (basic goods versus luxury services), with air travel being an example of the high end (Schipper & Grubb 2000).
- **Economy-wide effects.** A reduction in the real cost of energy services as a result of energy efficiency gains may have a ripple effect in the economy. This ripple effect could lead to adjustments in both price and quantity for a wide spectrum of goods and services with energy-intensive sectors gaining at the expense of less intensive sectors (Dimitropoulos & Sorrell 2006). In addition to these market effects, economy-wide effects include transformational effects which, while more subtle, are possibly in the

long-term the most influential (Herring 2006). Transformational effects influence the direction and pace of technical change and innovation. As costs drop, new goods and services are introduced and new mass markets are created.

Rebound effects are sometimes further differentiated on the basis of whether they are short- or long-term, based on the duration of the cost difference. Generally, long-term rebound is larger as people may not initially change their habits or purchase technology.

An important consideration is that the rebound effect does not necessarily manifest itself in the physical expansion of service demand but may be embodied in increases in amenity or the quality of service provided (Wirl 1997). For example, despite improvements in engine efficiencies, North American automobiles throughout the 1990s maintained fairly steady vehicle fuel consumption efficiencies while ancillary features and engine power increased.

Economy-wide effects are the most difficult to estimate and the question of energy efficiency's causal influence is among the most contentious of rebound debates. It is evident that energy consumption has and continues to increase in established markets. What remains less clear is the role that energy efficiency plays in stimulating economic growth. In considering transformational effects one must assess the extent to which energy efficiency is an enabler versus a causal force; new mass markets may be made possible by energy efficiency improvements but are largely a function of the human propensity to consume goods and services. This suggests that influencing personal decision-making through changing cultural mores (see *Personal Drivers* paper) is a necessary complement to investment in technical energy efficiency improvements. Ontario's promotion of a "conservation culture" is an example of such an effort. An additional consideration in this context is the relative cost of energy versus time, and the tendency in established economies to substitute energy for time.

The extent of the rebound effect is in part a function of income. This is relevant in terms of the socio-economic characteristics of groups targeted by policies and programs, but also in the context of interpreting results. For example, given that the average income in the US is higher than in Canada, it would be expected that the rebound effect in Canada would be greater. This should be considered when interpreting results from different jurisdictions.

2.4 LEAKAGE

Leakage is defined as an increase in consumption due to activity outside the affected jurisdiction or due to upstream or downstream modifications in the product life-cycle (in this context leakage can be described as negative spill-over). Generally, leakage occurs due to loop-holes in the applied policy and/or unanticipated changes in product life-cycle that result in either no change or an increase in the consumption / production of the limited quantity.

Leakage may result from:

- **Activity shifting.** For example, instead of producing more efficient vehicles in response to a subsidy program, automobile manufacturers whose production lines for fuel-efficient vehicles were fully utilized could shift their inventory of vehicles such that the jurisdiction with the subsidy gets more fuel efficient vehicles while other (unregulated /

un-incented) jurisdictions get fewer such vehicles as a result (i.e. the net production of fuel efficient vehicles – or the average fleet fuel efficiency – remains constant).

- **Changes in production / life-cycle.** For example, if the use of a more efficient downstream fuel required greater upstream processing (and energy consumption), the net effect of the requirement could be a greater absolute use of energy despite a possible increase in the technical efficiency at the end-use level.

Leakage can occur as both a producer and consumer phenomenon. For example, cross-border gas purchases may increase in response to a provincial / state gas tax.

3. SELECTED EXAMPLES

Free ridership, spill-over, the rebound effect and leakage are at different stages of research on their effects and magnitude. The quantity and quality of studies vary a great deal and no consistent research has been identified for any of the concepts. The question of rebound has tended to attract primarily academic attention whereas the free rider and spill-over effects have been mainly a preoccupation for utilities and program administrators. While there are a wide range of reported values for each concept, not all of them are based on sufficient sample sizes or on robust or consistent methodologies.

The majority of studies focus on the most directly observable manifestations of the effects, yet a broader understanding of these energy efficiency concepts is required to understand the effectiveness of policies and programs. While studies estimating free ridership have become increasingly sophisticated, the majority of evaluations provide estimates only for full free ridership. Furthermore, evaluations / studies often do not consider prior program influence or timing of investment, and the extent to which results are contextualized and qualified in meta-studies varies greatly.³ Similarly, studies of rebound particularly in the residential sector focus only on direct rebound. Spill-over estimates tend to shy away from market spill-over, preferring to focus on the more easily measured participant spill-over and free-driver effects.⁴

Where spill-over effects are considered, many evaluations now employ an attribution analysis which combines free rider and spill-over effects in one effectiveness metric, the net-to-gross-ratio (NTGR). Often, free ridership will be explicitly stated whereas spill-over must be derived from the NTGR. The majority of studies appear to define the NTGR as $1 - \text{free ridership} + \text{spill-over}$; however, different definitions are present in the literature.⁵ A danger in the use of the NTGR as an aggregate measure of program effectiveness is that some studies quote NTGR figures where the values represent a simple subtraction of free ridership from unity (e.g. free ridership of 48%; NTGR of 52%). This leads to the assumed inclusion (and devaluing) of spill-over, when in fact it has not been considered.

Leakage has yet to be substantively considered in the context of energy efficiency programming and policy and as such, our research did not yield any estimates from the literature. The lack of studies is also likely due to the effort required to undertake estimation and uncertainties associated with indirect mechanisms and effects.

In considering the examples in subsequent sections, it should be emphasized that all of these concepts – free ridership, spill-over, rebound and leakage – are dynamic, changing over time and with jurisdictional context.

³ For example, meta-studies may present results from different evaluations with varying numbers of participants in widely different contexts side-by-side, when direct comparison may be misleading. Study and evaluation results may also be summarized in terms of weighted averages or aggregate values which do not fully represent the variability by category (e.g. end-use). These results may be meaningful in the context of the specific evaluation, but are not necessarily suitable for direct comparison with other evaluations.

⁴ Often referred to in combination as “total spill-over”.

⁵ For example, see Skumatz (2006).

Furthermore, as noted earlier, estimation of these effects can be costly and difficult, and the self-reporting of results can be prone to bias. For this reason, it is important to consider the source and the methodology in deciding what weight to give to the various studies.

For clarity, free ridership is expressed as the percentage of the energy savings that would have been achieved without the program. Spill-over is expressed as the additional energy savings as a percentage of savings achieved by participants (e.g. a 20% spill-over rate would mean that 20% of a program's maximum achievement was achieved outside the context of (in addition to) the program. Net-to-gross-ratio combines free ridership and spill-over and indicates what percentage of the total possible savings from a program can be attributed to that program (causality). The rebound effect is expressed as a percentage of the total savings – for example if the rebound effect is estimated at 10 percent then 10 percent of the total savings from the energy efficiency measure were lost.

3.1 RESIDENTIAL

Estimates of effects in the residential sector are predominantly limited to full free ridership and direct rebound (Table 3.1).

Greening et al. (2000) indicate the number of studies on which their estimate is based, and provide an opinion on the quality of the estimate considering the correspondence of the results and the number of methodologies employed in their estimation.

Free ridership in residential programs varies widely; however it is possible to identify some items that are more susceptible to it. For example:

- Free ridership levels are higher where programs are targeted at items that have high non-energy related amenity (e.g. window retrofits). In such cases, the purchasing decision is largely influenced by factors other than cost, meaning that relatively small financial incentives have less effect, even if they are still collected.
- Free ridership levels are higher where programs are targeted at items that have reached mass market penetration and whose energy and cost savings are now reasonably well appreciated (e.g. CFLs). In such cases, the purchasing decision is already clear for many consumers, meaning that no additional financial incentive is needed, even though it is still collected.

Spill-over in the residential sector, particularly as concerns market transformation initiatives is thought to potentially be significant. The authors of the 2004 California Evaluation Framework suggest that “The level of free drivers may be extensive.” Further spill-over (both within project and market) could be expected. Unfortunately, little measurement of residential spill-over has been undertaken to date.

Space heating, space cooling and hot water heating tend to have greater potential than other end-uses for rebound; however, Schipper and Grubb (2000) suggest that saturation of service demand occurs fairly quickly indicating that there is a finite ceiling to the rebound. Schipper and Grubb (2000) place the income (indirect rebound) effect between five and fifteen percent. As discussed

briefly in Section 2.3, the magnitude of the rebound effect is proportional to the price-elasticity of service demand which in turn is a function of income. In general, the weight of evidence indicates that higher incomes are associated with lower rebound effect.

Table 3.1
Estimates of the Magnitude of Effects on Energy Savings in Residential Sector

| Reference | Free Rider | Spill-Over | Rebound |
|--|--------------------------|----------------------|-----------------------|
| <i>Various Studies / Reports</i> | | | |
| TecMarket Works (2004) Market transformation programs | | Large | |
| Itron (2003), Oregon Window Retrofit | 55% | | |
| Tachibana & Brattesani (2003) | 11% | | |
| Itron & Kema (2007) Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation | 28 – 59% ⁶ | 0 – 59% ⁵ | |
| Schipper (1996a, qtd. in Schipper & Grubb 2000) Domestic sector | | | Low |
| <i>OEB Total Resource Cost Guide (2005)</i> | | | |
| OEB (2005) TRC Guide – Assumptions & Measures List | 0 – 25% (Typically 10%) | | |
| OEB (2005) TRC Guide – Custom programs | 30% ⁷ | | |
| <i>Residential Sector Examples from the California Public Utilities Commission (2003)</i> | | | |
| CPUC (2003) Heating / Cooling Retrofit / Audit Programs | NTGR = 0.72 ⁸ | | |
| CPUC (2003) Fridge / freezer recycling | NTGR = 0.35-0.54 | | |
| CPUC (2003) Emerging technologies | NTGR = 0.82 | | |
| CPUC (2003) Other residential programs | NTGR = 0.8 | | |
| <i>Residential Sector Examples from Greening et al. (2000)</i> | | | |
| Greening et al. (2000) Space heating | | | 10 – 30% |
| Greening et al. (2000) Space cooling | | | 0 – 50% |
| Greening et al. (2000) Hot water heating | | | 10 – 40% ⁹ |
| Greening et al. (2000) Lighting | | | 5 – 20% ¹⁰ |
| Greening et al. (2000) Refrigeration | | | 0% ¹¹ |

⁶ The range accounts for variation by end-use. The average free ridership was 43% with a standard deviation of 9%. The average spill-over was 18 percent with a standard deviation of 17%. These statistics are indicative only of the extent of variation in values; some measures were implemented to a much greater extent than others providing much more data and likely resulting in more accurate free ridership and spill-over results. The aggregation of such results is problematic at best.

⁷ This value represents a default free ridership that must be applied to custom programs. The 30% value is based on studies commissioned by Enbridge and Consumers Gas (Summit Blue 2003; 2005).

⁸ CPUC defines NTGR as the net program load impact divided by the gross program load impact. Gross Savings * NTGR = Net Savings.

⁹ Greening et al. (2000) indicate that the hot water heating results (based on 5 studies) are considered inconclusive. Results are based on reports of increased shower length or the purchase of larger water heating units which indicate some indirect rebound effects but which cannot be measured.

¹⁰ Greening et al. indicate that the lighting results (based on 4 studies) are considered inconclusive.

¹¹ No rebound is reported in the authors' literature review (2 studies); however the result is indicated to be inconclusive. Anecdotal evidence suggests that consumers may shift fuel savings to increased consumption of durable good attributes (e.g. increased fridge volume or through the fridge ice cube / other features). Schipper & Grubb (2000) suggest that the trend towards increased size and amenity in refrigerators is correlated more closely with rise in income than with increase in technical efficiency.

3.2 COMMERCIAL / INDUSTRIAL

In the commercial sector, quantitative estimates exist for free ridership, spill-over and rebound. Table 3.2 summarizes a number of study results.

Free ridership estimates at a detailed end-use level were found to be highly variable; estimates tended to group more readily by fuel source or at a higher end-use level (i.e. process versus comfort measures). A review of 33 energy efficiency programs found that free ridership estimates ranged broadly from 0% to close to 50% with a simple average of 12% and a standard deviation of 11% over a one-year period (Eto et al. 1995). More recent work evaluating commercial and industrial programs found a large range (10 to 70 percent) of free ridership with levels depending on program type, previous program experience and target market (Summit Blue 2006). Historically, free ridership is thought to have been understated (Eto et al. 1995).

Estimates from 20 annual evaluations of U.S. commercial and industrial programs (two of which covered multiple programs) put spill-over in the range of 25 to 35 percent (Summit Blue 2006). Net-to-gross ratios provide a different perspective of spill-over showing net attribution ranging from 0.63 to 1.03 (i.e. in the latter case, spill-over more than compensated for free ridership resulting in greater than 100% attribution of savings).

The short-term direct rebound effect in the commercial and industrial sectors is generally small. Estimates for rebound from process efficiency improvements range from 0 to 20 percent while rebound from lighting efficiency upgrades is typically less than 2 percent. Greening et al. (2000) further estimate that the expansion in firm output resulting from the increased downstream demand as a result of effective price reductions is typically less than 2.5 percent. Observed results indicate that the commercial / industrial rebound effect – both direct and indirect – is small to moderate.

The results of Greening et al.'s (2000) literature review were inconclusive concerning the long-term aggregate rebound effect. The authors identified a large number of studies with a great deal of variability in their conclusions and suggested that any conclusions drawn would be tentative at best. They concluded that the range for long-run aggregate impacts and long-term indirect rebound effect was anywhere between zero and one hundred percent.

Table 3.2
Estimates of the Magnitude of Effects on Energy Savings
in Commercial and Industrial Sectors

| Reference | Free Rider | Spill-Over | Rebound |
|--|----------------------------|----------------------------|--------------------|
| <i>Various Studies / Reports</i> | | | |
| OEB (2005) Custom programs | 30% ¹² | | |
| CPUC (2003) Industrial / agricultural programs | NTGR = 0.70-0.96 | | |
| Jaccard (2006) | 50% - >60% ¹³ | | |
| Eto et al. (1995) Commercial sector | 0 – 50% | Not included ¹⁴ | <10% ¹⁵ |
| Schweitzer & Brown (2001) Residential / Commercial Sector – Market Transformation | | Pot. very substantial | |
| Summit Blue (2006), Wisconsin Light & Power Shared Savings Program Businesses (Program Wide) | 44% ¹⁶ | 34% | |
| | NTGR = 0.85-0.97 | | |
| Summit Blue (2006), Overall Estimates from Benchmarking Study, State Programs Commercial/Industrial | 10 – 70% ¹⁷ | | |
| <i>Select Examples from Summit Blue (2006) Benchmarking Study¹⁸</i> | | | |
| Summit Blue (2006), State Programs Commercial/Industrial | NTGR = 0.63-1.03 | | |
| | 41% | 4% (derived) | |
| Summit Blue (2006), California Standard Performance Contract Businesses (commercial / manufacturing) | NTGR = 0.63 | | |
| | 35-55% (over past 5 years) | | |
| Summit Blue (2006), NYSERDA Commercial / Industrial Performance Program Businesses | 30% | 27% (derived) | |
| | NTGR = 0.97 | | |
| Summit Blue (2006), Focus on Energy (Commercial programs, thermal energy) | 70% | | |
| Summit Blue (2006), Focus on Energy (Commercial programs, electricity) | 33% | | |
| Summit Blue (2006), Focus on Energy (Industrial programs, thermal energy) | 49% | | |
| Summit Blue (2006), Focus on Energy (Industrial programs, electricity) | 62% | | |

¹² Based on studies commissioned by Enbridge and Consumers Gas (Summit Blue 2003; 2005).

¹³ Jaccard refers to work undertaken by Joskow & Train (no references provided) as indicating free ridership rates in excess of 50%. He further refers to work undertaken by Loughran & Kulick (2004) which suggests that cost-effectiveness is reduced by free ridership in excess of 60%. Loughran & Kulick estimated first-year energy savings only, not energy savings over the lifetime of efficiency measures. Geller & Attali (2005, pg. 19) state "...it is inappropriate to judge whether or not utility DSM programmes have been cost-effective based on their study."

¹⁴ Only two of 31 programs in the study had explicitly included spill-over effects in their evaluation; fourteen others had included survey questions but did not calculate spill-over. None of the programs included spill-over (whether reported or not) in their final reported savings.

¹⁵ Five program evaluations concluded that there was no evidence of rebound; two estimated small amounts (<10%); five programs made provisions to measure rebound and then assumed it was negligible; and, 19 programs using billing analysis assumed that rebound was accounted for implicitly.

¹⁶ This estimate is for total free ridership. "Pure" free ridership – total free ridership less savings inspired by prior program experience is estimated at just over 35% with prior program induced savings of over 8%.

¹⁷ Free ridership rates for state programs range widely depending on program type and energy source.

¹⁸ This select sample is illustrative of the range of results depending on program and energy type.

| Reference | Free Rider | Spill-Over | Rebound |
|--|------------|------------|------------------------|
| <i>Commercial Sector Examples from Greening et al. (2000)</i> | | | |
| Greening et al. (2000) Lighting | | | 0 – 2% |
| Greening et al. (2000) Process uses | | | 0 – 20% |
| Greening et al. (2000) Long-run aggregate impacts, long-term indirect rebound effect | | | 0 - 100% ¹⁹ |

3.3 TRANSPORTATION

Available estimates of economic and behavioural effects in the transportation sector only deal with the direct rebound effect. While examples of free ridership, spill-over and leakage exist, no quantification (or qualification) was identified in the literature. Unlike the residential, commercial and industrial sectors, energy efficiency programming is distinct from fuel/energy supply and the energy efficiency policy and programming structure is substantially different. In terms of private transportation, personal vehicles are the primary target of fuel efficiency programs.

The rebound studies presented in Table 3.3 relate to personal automotive transportation and measure the increase in vehicle kilometers (miles) travelled as a function of increased fuel efficiency. Small and Van Dender (2007) find that the literature is generally in consensus placing the long-term rebound effect in the range of 20 to 30 percent; estimates of short-term rebound effect are less uniform. Modelling efforts are not all necessarily consistent with regards to the parameters included or the methods by which they are included. This may account for some of the variation in results.

New evidence concludes that the rebound effect diminishes with income and to a lesser degree increases with the fuel cost of driving. Small & Van Dender (2007) indicate that rebound effects would be substantially reduced (estimates of 2.2 and 11 percent for short- and long-term, respectively) using exclusively the most recent 5-year data as opposed to the 30-year average.

¹⁹ Results were based on many studies with many approaches and were highly variable (inconclusive).

Table 3.3
Estimates of the Magnitude of Effects on Energy Savings in Transportation Sector

| Reference | Free Rider | Spill-Over | Rebound |
|---|------------|------------|---------|
| Greening et al. (2000) Long-term | | | 10-30% |
| Small & Van Dender (2007) Long-term (30-year avg.) | | | 22% |
| Small & Van Dender (2007) Short-term (30-year avg.) | | | 4.5% |
| Small & Van Dender (2007) Long-term (1997 – 2001) | | | 11% |
| Small & Van Dender (2007) Short-term (1997 – 2001) | | | 2.2% |

While no estimates of free ridership were identified in the literature, the effect clearly exists in the transportation sector. For example, it is widely agreed that the recent federal program providing transit pass tax rebates (subsidy to individual riders) suffers from substantial free ridership.²⁰

3.4 ALL SECTORS

Potential economy-wide effects include spill-over, rebound and leakage; however, the only quantified estimates in the literature are for the rebound effect as presented in Table 3.4. Even these values are to be considered as ball-park estimations – Greening et al. (2000) indicate that the result presented is based on one study (and a single methodology) and as such is inconclusive; they were unable in their extensive literature review to identify any global general equilibrium assessments of the effect of energy efficiency improvements on world energy markets. Geller & Attali (2005) set the upper boundary of the economy-wide effects at between one and two percent after reviewing a number of post-2000 studies.

Table 3.4
Estimates of the Magnitude of Economy-wide Effects on Energy Savings

| Reference | Change in Total Output Growth (Economy-Wide Rebound) |
|------------------------|--|
| Greening et al. (2000) | 0.5% |
| Geller & Attali (2005) | 1-2% |

²⁰ As mentioned earlier, depending on the evaluation framework and the stated objective of the program, free ridership may or may not be acceptable. If the objective is to reward transit users for doing the right thing, there is no disadvantage. On the other hand, if the objective is to achieve additional energy savings and reduce GHG emissions, a performance-based subsidy to operators (i.e. linked to transit ridership) would be more effective.

3.5 SUMMARY

In general, free ridership appears to feature prominently in residential, commercial and industrial sector energy efficiency programs, though the range of magnitude varies between sectors, programs and regions. The limited data on spill-over suggests that its impact is moderate; however, some experts believe that its potential impact is substantial. Measurements of NTGR also vary widely. As noted earlier, while by convention NTGR inherently incorporates free riders and spill-over, in practice this is not always the case.

The academic literature provides a variety of examples of the rebound effect. In their review of 75 studies, Greening et al. (2000) point to definitional (boundary) and methodology issues, limited data availability and the small number of studies as the major barriers to calculating definitive numbers for the different incarnations of the rebound effect. That said, they and others conclude that overall, the magnitude of the rebound effect appears to be small to moderate with the exact magnitude being a function of economic sector, location and end-use. Studies of energy efficiency improvements in OECD countries have found that most of the direct energy savings remain even after the direct rebound has been considered (Geller & Attali 2005; Greening et al. 2000). Schipper & Grubb (2000) further clarify that feedback effects are generally small in mature sectors of mature economies: "...lowering energy intensities almost always leads to lower energy use than otherwise."

4. IMPLICATIONS

The research on factors that influence the impact of energy efficiency incentive programs has implications for portfolio planning, program design, and evaluation.

4.1 PORTFOLIO PLANNING

- **Some types of incentive programs are more effective than others.** Some programs such as free hand-outs of common products (e.g. CFLs) are prone to high levels of free ridership. While such programs may be justified in creating awareness or generating early momentum for market transformation, other types of programs such as subsidies for retrofit audits or performance-based credits are likely to be more suitable.
- **Some types of product are more likely to attract free riders.** Products that have high levels of non-energy related amenity are likely to be associated with high levels of free ridership.
- **Balance the search for efficiency with efforts to improve conservation.** To counter the rebound effect, it may be necessary to develop programs that promote lower levels of activity or energy service (e.g. energy taxes, transportation demand management). This can be done while preserving or improving quality of life.
- **Develop a comprehensive market transformation strategy.** By combining programs into mutually supportive clusters and by targeting multiple market players, there are opportunities to minimize the negative effects of free ridership and rebound and maximize the opportunities for spill-over.
- **Design incentive programs to complement legislation.** Incentive programs can be used as temporary measures to build political will. Where an initiative is not yet politically saleable, incentives can increase receptivity and begin the process of market / social transformation which can be followed by regulation when the politics of the issue allow.
- **Experiment with different approaches and aim for spill-over.** In many cases, the ultimate effectiveness of programs may result from spill-over effects that, over time, truly transform the market.
- **Provide realistic forecasts of savings and costs.** Realistic estimates (preferably based on empirical data) should be used to predict free ridership and rebound, as well as spill-over and other benefits. These should be used in assembling credible estimates for cost of energy saved, and estimates for achievable energy efficiency gains. Statistics on market penetration of energy efficiency technologies can be a “first filter” to identify programs with potentially high free rider levels.

4.2 PROGRAM PLANNING, DESIGN & IMPLEMENTATION

- **Clearly identify the overall objectives and framework for an initiative at the outset.** Sufficient time needs to be allocated to developing the program theory and identifying the problem for which the program is a part of the solution. The overarching objective of the policy or program is the lens through which its performance is assessed. The establishment of appropriate indicators and performance metrics as well as targets depends on this goal.
- **Reduce incentives to overestimate results.** Programs that reward participants on the basis of a percentage of their energy efficiency investment do not necessarily encourage effective programs. At the same time, calculations on the basis of results may encourage over-estimation. A balanced approach with third-party involvement in measuring results is most likely to encourage utility programs to be effective.
- **Design programs to minimize free ridership.** There may be methods by which the participation of free riders can be discouraged. For example, increasing the level of effort required with obtaining the subsidy / incentive may discourage free ridership. This would have to be balanced by consideration of the extent to which it also discouraged general participation in the program.
- **Move quickly to roll-out programs or compensate early action.** Once the possibility of a program is rumoured, it may be difficult to avoid the moral hazard effect. It is important therefore to minimize the impact by avoiding delays or by providing compensation for early action.
- **Benchmark program performance in terms of typical free ridership and spill-over values.** Consideration of performance results from other jurisdictions may provide insight as to whether a program is on track, or whether design or implementation deficiencies exist. Be careful to distinguish contextual factors over which there is little control from program design factors which may be improved.
- **Where possible, avoid using generic estimates.** All four effects change over time, and vary depending on sector, income level, end-use and a host of other factors. Providing generic rates to be used by energy efficiency programmers to estimate program impacts may lead to inaccurate and misleading performance expectations.

4.3 PROGRAM EVALUATION

- **Use a clear and robust evaluation framework with well-defined objectives and performance criteria.** Clear articulation of program goals makes the development of performance-based measurement criteria more straightforward and ensures all players are working towards the same goal and calculating effectiveness from the same perspective. The use of a robust evaluation framework across all energy efficiency programs ensures consistent application of techniques and provides a level basis on which to compare program effectiveness. Standardized methods for factor estimation can increase the affordability of implementation and ensure consistency of measurement technique and application across all programs.
- **Employ an integrated planning process.** Ensure that the results of previous program evaluations (ex ante and ex poste analysis of effects) feed into both portfolio planning and program design. Integrated planning processes allow for structured consideration of lessons learned.
- **Use credible and conservative estimates of factors.** Although it may be tempting to claim greater effectiveness and incremental impact, it is more important in the long run that energy efficiency program results be believed and relied upon. To maintain support for energy efficiency, both policy-makers and ratepayers must be able to trust that only effective energy efficiency measures are being pursued. This means using appropriate levels of free ridership and rebound and justifying those levels with accurate data. Use of third parties to evaluate results is another step that can be taken to enhance the credibility of estimates.
- **Use partial free rider estimates to obtain a more accurate understanding of program effectiveness.** To some extent, many participants are likely to be partial free riders (i.e. they will adopt the technology eventually). Employing techniques that provide a greater extent of differentiation between the types of free riders can allow for a greater understanding of program effectiveness in terms of long-term market transformation. For example, free riders induced by prior program participation may not represent ineffective program design. Rather, they may be illustrative of the long-term commitment to a program required for true market transformation.
- **Use a variety of approaches to estimate and test the effects.** There are no easy standard ways of measuring the various effects. Depending on the circumstances, some techniques (e.g. surveys, baseline scenarios, modelling, etc.) may be better than others, but often trial and error may be the only way to know. In addition, if employing techniques with known limitations, apply complimentary measures that assist in bounding the uncertainty.
- **Be aware of limitations to estimating effects and of the narrow perspective of many evaluations.** Policy makers and program designers are influenced by evaluation results and in particular criticisms of particular approaches. Awareness of the context within which the evaluation is conducted (i.e. the overarching objective of the program vs. the objective of your policy / program), as well as any potential bias is key. Free rider and

spill-over effects vary widely between regions, by sector and technology. In part this is due to veritable differences in social / market behaviour; in part it is due to differences in the methods by which they are accounted for. Very few studies provide the in-depth statistical analysis required to accurately compare results on an equal footing.

- **Consider partnering with other organizations and/or jurisdictions to invest in studies to assess effects, particularly those that are more indirect.** Estimation of the impact of behavioural and economic factors is expensive and complex. In addition to reducing the cost, partnering with other organizations and/or jurisdictions can allow for a more comprehensive assessment of high-level economy-wide effects which themselves often cross jurisdictional boundaries.
- **Research is required into the implications of leakage on program effectiveness.** Little information is currently available concerning the role of leakage on energy efficiency policy and programming. A greater understanding of the influence of this factor will enhance measurement of program effectiveness.
- **Focus research efforts on measuring spill-over.** Measurement of spill-over effects and free driver creation are two key areas of research given that the overall objective of energy efficiency initiatives is often market transformation. Better understanding of the causes and magnitude of spill-over effects could create more effective energy efficiency programs and provide a more holistic picture of actual energy saved.

5. KEY MESSAGES

- Free ridership is likely to occur in most programs but its magnitude will vary. It is possible to target programs to products and sectors of the market that are less susceptible to free riders and to design programs to minimize the effect, but it must be accounted for in ex-ante and ex-post evaluations.
- Spill-over is a real effect that can offset some free ridership. Ultimately enough spill-over means that the market is transformed and program interventions can be ratcheted up to the next level. Spill-over is also highly variable.
- The rebound effect will erode some of the energy savings from energy efficiency programs, but most of the savings are likely to remain. The effect needs to be considered in portfolio planning and offset by other programs that promote conservation.
- Leakage can also erode some savings. This can be minimized by harmonizing between jurisdictions or by taking a life-cycle approach to portfolio planning.
- Measurement of these effects is difficult and costly, however, the effectiveness claims of energy efficiency programs depends on the completion of credible evaluations. Organizations and jurisdictions should collaborate in developing evaluation best practices and in researching the impact of indirect and economy-wide effects.
- Judicious and informed consideration of results from evaluations is required. Program objectives, measurement and reporting techniques, parameters included and analytical depth vary widely; however jurisdictional comparisons of policy / program effectiveness can be informative. It is important to distinguish contextual factors over which there is little control from program design factors which may be improved.
- Behavioural and market factors should be considered in the context of the overall policy / program objectives and evaluation framework. Consideration should be given to multiple societal goals, including:
 - Increasing energy efficiency;
 - Promoting equity;
 - Market Transformation
 - Reducing energy consumption

6. REFERENCES

California Public Utilities Commission (CPUC). 2003. Energy Efficiency Policy Manual v2. Net-to-Gross Ratios Table. <<http://eega.cpuc.ca.gov/deer/Ntg.asp>>

Canadian Energy Efficiency Alliance. 2004. 2004 Survey of Utility DSM Energy Efficiency Programs in Canada – Results.

<<http://www.energyefficiency.org/eecentre/eecentre.nsf/4abd5abcda04b6f4852569b8007716ed/d9a167e4480e7a4f852569b9001c7c69?OpenDocument>>

Dimitropoulos, J. and Sorrell, S. 2006. The Rebound Effect: Microeconomic Definitions, Extensions and Limitations. Working paper presented at the 29th IAEE International Conference, June 7 – 10, 2006, Potsdam, Germany.

Eto, J., Kito, S., Shown, L. and Sonnenblick, R. 1995. Where Did the Money Go? The Cost and Performance of the Largest Commercial Sector DSM Programs. Energy and Environment Division, Lawrence Berkeley National Laboratory, Berkeley, California. Document # LBL-38201.

Geller, H. and Attali, S. 2005. The Experience with Energy Efficiency Policies and Programmes in IEA Countries: Learning from the Critics (IEA Information Paper). ICE Consultants. URL: http://iea.org/textbase/publications/free_new_Desc.asp?PUBS_ID=1567

Greening, L.A., Greene, D.L. and Difiglio, C. 2000. Energy Efficiency and Consumption – The Rebound Effect – A Survey. *Energy Policy*, 28: 389-401.

Herring, H. (Lead Author), Cleveland, C.J. (Topic Editor). 2006. Rebound Effect. In: *Encyclopedia of Earth*. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). Published August 30, 2006; retrieved August 16th, 2007.

Itron. 2003. Existing Residential Single Family Window Retrofit Free Ridership. Prepared for the Energy Trust of Oregon. Portland, Oregon.

Itron & Kema. 2007. 2004/2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation. Prepared for California's Investor-Owned Utilities.

Jaccard, M.K. 2006. Shifting Rationales for Energy Regulation and Regulatory Dilemmas. Background paper for: "Views on Regulation" session of the 2006 annual conference of the Canadian Association of Members of Public Utility Tribunals (CAMPUT).

OEB. 2005. Board's Views on Stakeholder Comments on the Draft Guide to Total Resource Cost Analysis. Appendix A to letter from John Zych, Board Secretary, September 8, 2005. <www.oeb.gov.on.ca/documents/cases/RP-2004-0203/cdm_appendixa_080905%20.pdf>

Schipper, L. and Grubb, M. On the Rebound? 2000. Feedback Between Energy Intensities and Energy Uses in IEA Countries. *Energy Policy*, 28: 367-388.

Schweitzer, M. and Brown, M.A. 2001. Improving the Methods Used to Evaluate Voluntary Energy Efficiency Programs. Oak Ridge National Laboratory.

<http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=788572>

Sebold, F.D., Fields, A., Skumatz, L., Feldman, S., Goldberg, M., Keating, K. and Peters, J. 2001. A Framework for Planning and Assessing Publicly Funded Energy Efficiency. Pacific Gas and Electric Company. Study ID PG&E –SW040.

Skumatz, L.A. 2006. Evaluating Attribution, Causality, NEBs, and Cost-Effectiveness in Multi-family Programs: Enhanced Techniques. International Energy Efficiency in Domestic Appliances & Lighting Conference '06, London, UK, Session H2.

Sjim, J.P.M., Kuik, O.J., Patel, M., Oikonomou, V., Worrell, E., Lako, P., Annevelink, E., Nabuurs, G.J., and Elbersen, H.W. Spillovers of Climate Policy: An Assessment of the Incidence of Carbon Leakage and Induced Technological Change due to CO2 Abatement Measures. Netherlands Research Programme on Climate Change, Scientific Assessment and Policy Analysis. Report 500036002 (ECN Report: ECN-C-05-014).

<http://www.mnp.nl/en/publications/2004/Spillovers_Climate_Change.html>

Small, K.A. and Van Dender, K. 2007. Fuel Efficiency and Motor Vehicle Travel: The Declining Rebound Effect. *Economic Journal*, 28: 25-51.

Summit Blue Consulting (J. Erickson & S. Schare). 2006. Shared Savings Decision-Making Process Evaluation: Research Results. Prepared for Tracy La Haise, Wisconsin Power & Light.

Tachibana, D.L.O. and Brattesani, K.A. 2003. Seattle's Conservation Kit Program – Transforming the Residential Use of Compact Fluorescent Lighting. Energy Program Evaluation: Meeting Diverse Needs. Seattle, WA: National Energy Program Evaluation Conference, August 2003.

TecMarket Works. 2004. The California Evaluation Framework. Prepared for the California Public Utilities Commission and the Project Advisory Group.

<http://www.tecmarket.net/ca_eval_framework.htm>

Violette, D., Mudd, C. and Keneipp, M. 2001. An Initial View on Methodologies for Emission Baselines: Energy Efficiency Case Study. Information Paper prepared for the OECD Environmental Directorate and the International Energy Agency.

Victoria Transportation Policy Institute (VTPI). 2007. TDM Encyclopedia: Rebound Effects – Implications for Transport Planning. Updated August 2007.

<<http://www.vtppi.org/tdm/tdm64.htm>>

Violette, D. 2007. Perspectives on DSM Program Evaluation: DSM Informational Workshop, Public Utilities Commission. Summit Blue Consulting.

Vreuls, H. 2005. Evaluating Energy Efficiency Policy Measures & DSM Programmes. Sittard, International Energy Agency – Implementing Agreement on Demand-Side Management Technologies and Programmes: 173.

Wirl, F. 1997. The Economics of Conservation Programs. Kluwer Academic, qtd. in Herring (2006), Encyclopedia of Earth.