

**Assessment of  
Energy Efficiency  
and  
Customer-Sited Generation Investments  
in the Southern Loop**

**Prepared for  
Vermont Electric Power Company, Inc.**

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## EXECUTIVE SUMMARY

Served by Central Vermont Public Service Company, (“CVPS” or “Central Vermont”), Vermont’s “Southern Loop” stretches from southwestern to southeastern Vermont. CVPS and Vermont Electric Power Company (“VELCO”), the state’s transmission utility,<sup>1</sup> have found from previous analysis that reliability solutions in this area are needed imminently at current loads, and that reliability needs intensify under continued load growth. CVPS used a distributed utility planning (“DUP”) scoping tool to assess potential for additional energy efficiency, referred to here as Demand Side Management (“DSM”), to defer need for transmission and distribution (“T&D”) upgrades.<sup>2</sup> Preliminary analysis in 2004 found that, while additional DSM could not solve immediate reliability problems, there may be enough economically achievable potential to defer the need for subsequent T&D investment to meet future reliability needs. In 2005, CVPS and VELCO engaged Optimal Energy, Inc (“OEI” or “Optimal”), and its subcontractors Green Energy Economics Group, Vermont Energy Investment Corporation (“VEIC”), Conservation Services Group, eWorks, David Grimason, and Richmond Energy Associates to gain better estimates of the potential costs of and contributions from distributed resources to meet the region’s future reliability needs.

This report presents the results of an in-depth analysis of the economically achievable potential for efficiency and customer sited generation – that is, the realistically achievable electricity savings and generation costing less than the conventional generation, transmission, and distribution resources they would avoid. It finds that VELCO and CVPS can expect to achieve cost-effective energy efficiency investments to reduce yearly winter peak load and energy requirements by 32 megawatts (“MW”) and 174 gigawatt-hours (“GWh”) by 2017 on the Southern Loop.<sup>3</sup> These savings are virtually identical to the demand and energy savings identified by Central Vermont’s initial scoping analysis. While the magnitude of the economically achievable efficiency potential found in this study does not differ markedly from that identified in the scoping analysis, both its composition (more residential winter demand savings, less commercial winter demand savings) and timing (more savings sooner) have changed.

For customer-sited distributed generation (“DG”), the report evaluated both solar photovoltaic (“PV”) and combined heat and power (“CHP”) options. The report found that PV is not a cost-effective option for the Southern Loop, although a limited program could reduce summer demand by 4.1 MW and provide 5.5 GWh/yr in energy savings. The report also conducted an assessment of a limited number of CHP opportunities, finding that 2.1 MW of winter demand reduction and 11.6 GWh/yr of CHP would be cost effective. Were CHP to be pursued beyond the societal cost-effectiveness, the assessment

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<sup>1</sup> Subsequent to the commencement of this study, VELCO was reorganized such that the transmission system assets are now owned by Vermont Transco, LLC with services provided by VELCO. See Docket No. 7174, Order of June 20, 2006. As used in this report, VELCO shall refer to Vermont Transco, LLC.

<sup>2</sup> The DUP DSM scoping tool, developed by Optimal Energy, Inc. in 2003, allows a utility to input loads by customer segment and obtain a “first cut” estimate of likely achievable potential.

<sup>3</sup> Note that some of this achievable energy efficiency potential is already planned to be achieved in the Southern Loop through on-going efficiency initiatives delivered by Efficiency Vermont.

indicated that CHP could provide up to 10.4 MW of winter demand reduction and 91 GWh/yr.

Based on the analysis results, cost-effective Southern Loop DSM and customer-sited DG could provide 34.1 MW of winter demand reduction and 185.6 GWh per year of annual energy use reduction, depending on the type and scale of initiatives selected.

The report also sets forth the methodology used to refine estimates of localized electricity savings from additional energy efficiency investment, and to assess potential contributions from customer-sited solar photovoltaic (“PV”) and combined heat and power generation. The report includes conceptual descriptions of the kinds of market strategies that would need to be designed and deployed to procure both additional DSM savings and generation from locally-sited PV and CHP, as well as budgets for these initiatives. The final section of this report contains findings and conclusions on the potentially economically achievable potential contributions by energy efficiency and customer-sited PV and CHP toward meeting future reliability needs in the Southern Loop.

## **1 PROJECT OVERVIEW**

This analysis of demand-side management, solar PV, and CHP options takes place within a context of reliability and capacity concerns across the Southern Loop. These three customer-sited resources have the potential to defer the need for certain investments to address those concerns. This section provides summaries of the technical and policy background, project scope, analysis results, and methodology.

### **1.1 BACKGROUND**

This report assesses the potential for investments in end-use energy efficiency savings and customer-sited generation to reduce growing peak loads in southern Vermont. As is the case in northwestern Vermont, the Southern Loop is an area where persistent growth in demand for electricity is outstripping the capacity of existing distribution and transmission facilities to serve it. Unlike northwestern Vermont, however, reliability needs in the Southern Loop are driven primarily by continued growth in winter peak demand due to the predominance of the ski industry and related services. This study examines the contributions that a targeted, aggressive and sustained campaign to increase energy efficiency investment and customer sited generation could make during the next ten years to reduce peak loads in six sub-load-zones of the Southern Loop. The costs of achieving additional electricity savings and customer-sited DG were estimated and compared with the generation, transmission and distribution costs they would avoid. The resulting estimates of costs and electricity contributions form the basis for potential resource configurations that VELCO and CVPS will develop and compare to identify and analyze the most economical solutions to the Southern Loop’s reliability needs. The analysis considers impacts through 2026 of distributed resource programs that begin in 2007 and end in 2016.

Vermont's Southern Loop is a 66-mile, 46 kilovolt ("kV") transmission line running from Bennington to Brattleboro with a current peak demand (in winter) of about 120 megawatts ("MW"). The area consists of six sub-zones designated as follows: Bennington; West; Bromley; Stratton; East; and Brattleboro. Total annual energy sales are approximately 587 gigawatt-hours ("GWh"). There is a 69-kV line that supplies the Brattleboro area, and both the 69-kV and 46-kV lines are fed by 115-kV lines terminating in Bennington and Brattleboro (CVPS 2006). Over the past decade, peak winter demand has grown by about 0.5 percent annually, and energy use by about 1.3 percent annually, although this growth has seen two separate peaks (one in 1998-99 and one more recently in 2004-2005). There are about 27,000 single-family residential customers, 3,700 multifamily dwellings, and 5,700 commercial and industrial ("C&I") customers. "Industrial" customers include ski areas (with a combined peak load of 15 MW), hospitals, lumber yards, wood products manufacturers, plastics manufacturing, and food processors. There is only limited combined heat and power production, and no distributed generation.

In the mid-1980's Central Vermont proposed that a third 46 kV transmission source be connected to the Southern Loop near its center. The Vermont Public Service Board (the "Board" or "PSB") reviewed the application and determined that, on a probabilistic basis, the company had not made a sufficient case for the need for the new source. The Board directed the company to implement aggressive load management and to analyze the reliability need based on the probability that the facility would need reinforcement in order to provide adequate service.

Over the ensuing twenty years Central Vermont, now in combination with Efficiency Vermont, Vermont's energy efficiency utility ("EEU"), has managed peak loads through aggressive pricing programs and energy efficiency targeted at lowering peak winter energy consumption. CVPS reduced and managed load growth with DSM programs throughout the 1990s, emphasizing fuel-switching, high-efficiency snowmaking equipment, and aggressive load management contracts and mandatory time-of-use ("TOU") pricing for large customers and voluntary TOU pricing for small customers. Since 2000, Efficiency Vermont continued and expanded efficiency investment statewide, including in the Southern Loop.

Despite these efforts at reducing load, additional solutions are needed to deal with five core issues (CVPS 2006):

- General reliability exposure to an unplanned loss of a transmission line or a transformer. Such a loss may cause unacceptably low voltage in Southern Vermont at as little as 45 percent of peak demand, which the Southern Loop experiences 66 percent of the time;
- Reliability exposure specifically in Brattleboro to the unplanned loss of a transmission line or a transformer;
- Reliability exposure to a long-term loss of the Vermont Yankee nuclear power plant's transformer;

- Future demand growth, which may exceed the capability of the Southern Loop to operate properly even with all facilities in service;
- Future problems in the wider regional transmission system; and

Local load reductions may have different levels of effectiveness for each of the above five core issues.

While the creation of the statewide energy-efficiency utility, Efficiency Vermont, relieved Vermont's distribution utilities of the obligation to procure system-wide DSM in 2000, they were left with the responsibility to integrate DSM into their T&D planning. To meet least-cost planning requirements, Vermont statutes and regulation still obligate distribution utilities to demonstrate that any proposed "wires" solutions constitute the lowest-cost alternatives among a full range of potential resource configurations, which must include localized DSM and DG options. The regulatory landscape for transmission and distribution planning in Vermont changed again in 2005 with the passage of Act 61, which amended Title 30, Chapter 5 of the Vermont Statutes Annotated ("V.S.A."). VELCO now has the obligation to identify in its transmission planning process, the demand or supply parameters that generation, demand response, energy efficiency or other non-transmission strategies would need to address the identified reliability deficiencies. *See* 30 V.S.A. § 218c(d). Act 61 requires Vermont's transmission utilities, including VELCO, to identify T&D issues in advance (through a 10-year T&D plan) and quantify the extent to which DSM, distributed generation, and combined heat and power can defer or alleviate those problems. VELCO and CVPS commissioned this study as an integral part of their effort to meet this new responsibility.

### **1.1.1 Study Objectives and Scope**

The study estimates the reductions in winter and summer peak load and annual energy requirements that could be achieved by highly aggressive initiatives targeting key residential, commercial and industrial markets in the six planning zones. These initiatives would extend and expand on programs Efficiency Vermont ("EVT") is now implementing statewide.<sup>4</sup> To achieve these aggressive load reduction goals, the study contemplates a large ambitious investment campaign over a decade, using the most aggressive proven market implementation strategies to acquire widespread participation by all market sectors: Such strategies would necessarily include:

- Sustained marketing to consumers, retailers, builders, contractors, and equipment suppliers;

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<sup>4</sup> Note that the EEU budget was adjusted by Order of the Board dated August 2, 2006. This Order increased the 2006 funding level from a capped amount of \$17.5 million to \$19.5 million, and establishes funding levels of \$24 million and \$30.75 million for 2007 and 2008, respectively. This amounts to incremental funding for the EEU of \$21.75 million over this period (the "2006 EEU budget adjustment"). At this time, specifics on how the 2006 EEU budget adjustment will be deployed to procure incremental DSM are not known. As a result, when referred to in this report, references to the EEU budget refer to the budget in existence prior to the announcement of the 2006 budget adjustment.

- Extremely attractive financial incentives to customers, offering them extraordinarily favorable financial returns on their investment in efficiency retrofits and distributed generation investments, and covering the full incremental cost for new construction/renovation measures;
- Comprehensive technical and information services for market participants; and
- For some market segments, complete customer service delivery from initial contact through project completion (including measure installation).

The analysis considered opportunities in the residential and nonresidential sectors separately in each of the six zones of the Southern Loop. In contrast to VELCO's previous analysis for the Northwest Reliability Project ("NRP") and Central Vermont's preliminary DUP scoping analysis for the Southern Loop, this analysis did not employ a "top-down" approach applying generic technology characterizations to sector-level sales forecast. For this analysis, Optimal built up estimates from customer- and project-level experience by Efficiency Vermont and CVPS, and on-site surveys for a sample of individual nonresidential customers. To achieve maximum participation and market penetration, the study developed a set of aggressive conceptual designs for market initiatives with budgets to sustain their continued success over the next decade.

The analysis specifically sought to ensure that the estimates of potential peak demand savings are realistic, considering how difficult it may be to convince most consumers and businesses to replace inefficient existing equipment or choose high efficiency options in new construction. This aggressive campaign would pursue comparatively high levels of peak load and energy reductions, considering the history of energy efficiency programs in Vermont and other places in the nation. The analysis recognized this by lowering projected penetration rates to levels below that achieved by selected "best practice" programs where full funding has been available, ensuring a more conservative analysis.

All the technologies and market intervention strategies contemplated in the analysis have proved effective in Vermont, throughout New England, more broadly in the Northeast, and beyond, especially in California where DSM and distributed supply have figured prominently in that state's efforts to meet its pressing resource needs. This long and successful history of procuring large quantities of cost-effective energy-efficiency in Vermont provides a strong basis for confidence in the estimates developed here. An important source of uncertainty, however, is the fact that no utility has ever sustained such large distributed resource commitments for so long in so many markets simultaneously and actually achieved the relative magnitudes of peak demand savings projected over the next decade as indicated in this report.

## **1.2 OVERVIEW OF ANALYSIS RESULTS**

The study estimates savings both from an aggressive campaign in the target zones and those expected to materialize due to statewide programs already underway by Efficiency Vermont. The impacts of existing programs are implicitly included in the base case forecasts VELCO and CVPS are using to assess the need for upgrading transmission and distribution capacity. The net impact of the achievable contributions projected here is the

difference between this targeted campaign (which includes efficiency savings anticipated from Efficiency Vermont in the Southern Loop) and the projected savings from existing EVT efforts under its 2006-8 contract (exclusive of program activities associated with the 2006 budget adjustment).

**1.2.1 Demand and Energy Savings Impacts**

Table 1.1 presents estimated electric impacts from investments in efficiency, photovoltaics, and combined heat and power throughout the Southern Loop. These are expressed as cumulative annual peak-load and energy contributions through 2016. This refers to the total impact of energy efficiency, solar photovoltaics, and the limited assessment of combined heat and power that could occur in each year (e.g., the net reduction in forecasted load that year), taking into account savings from all prior year activities that are still generating savings (or capacity, in the case of PVs and CHP), as well as the current year. Projected outcomes are expressed in terms of winter and summer peak demand and energy savings during the summer and winter peak and off-peak periods.

**Table 1.1 Electric Impacts from Cost-Effective Investments in DSM, Solar PVs, and CHP**

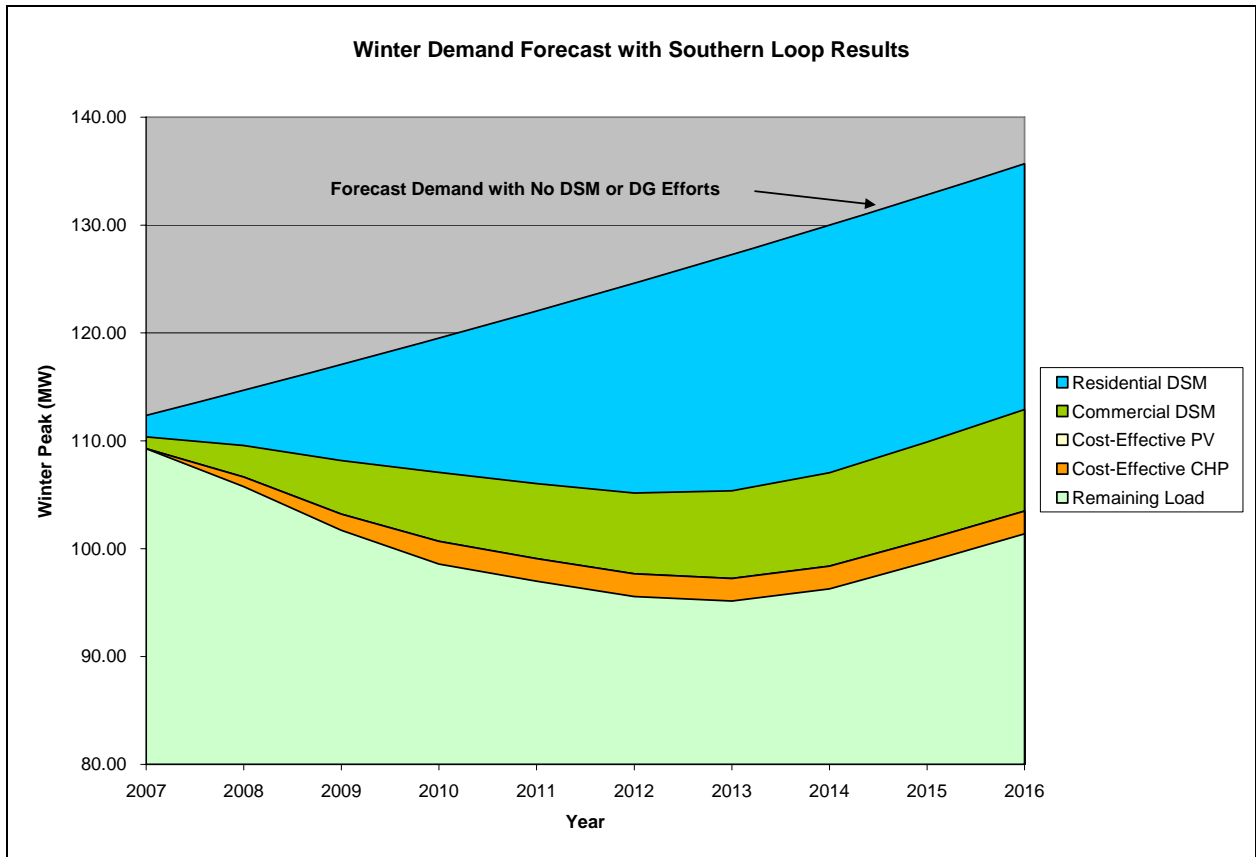
	<b>Winter Peak Demand Reduction (MW)</b>	<b>Annual Energy Use Reduction (MWh/yr)</b>
Residential DSM	22.8	97,894
Commercial DSM	9.4	76,137
Photovoltaics	--	--
Combined Heat & Power	2.1	11,600

These results are presented graphically, by year, in Figure 1.1 and Figure 1.2. These graphs present a simplified demand and energy forecast with no DSM, PV, or CHP activities for comparison, based upon average historical growth rates per zone provided by CVPS (and not including system-wide DSM provided by Efficiency Vermont). The initiatives are assumed to commence in 2007, and each year’s cumulative energy and demand savings represent those accomplished by the initiatives at the end of each year. The graph depicts that by 2016, the Residential DSM efforts could reduce about 17 percent of the forecast winter peak demand. Commercial DSM could reduce the peak load by about 7 percent, and analyzed cost-effective CHP could reduce the winter peak by another 1.5 percent.

Looking at the changes in Winter Peak demand over time, the DSM initiatives could (through aggressive direct install and retrofit efforts), lower system peak demand from current levels and keep peak demand below current levels. The initiatives would yield a minimum winter peak in 2013 of about 95 MW, but the peak would slowly grow again from that point to 101 MW by 2016.

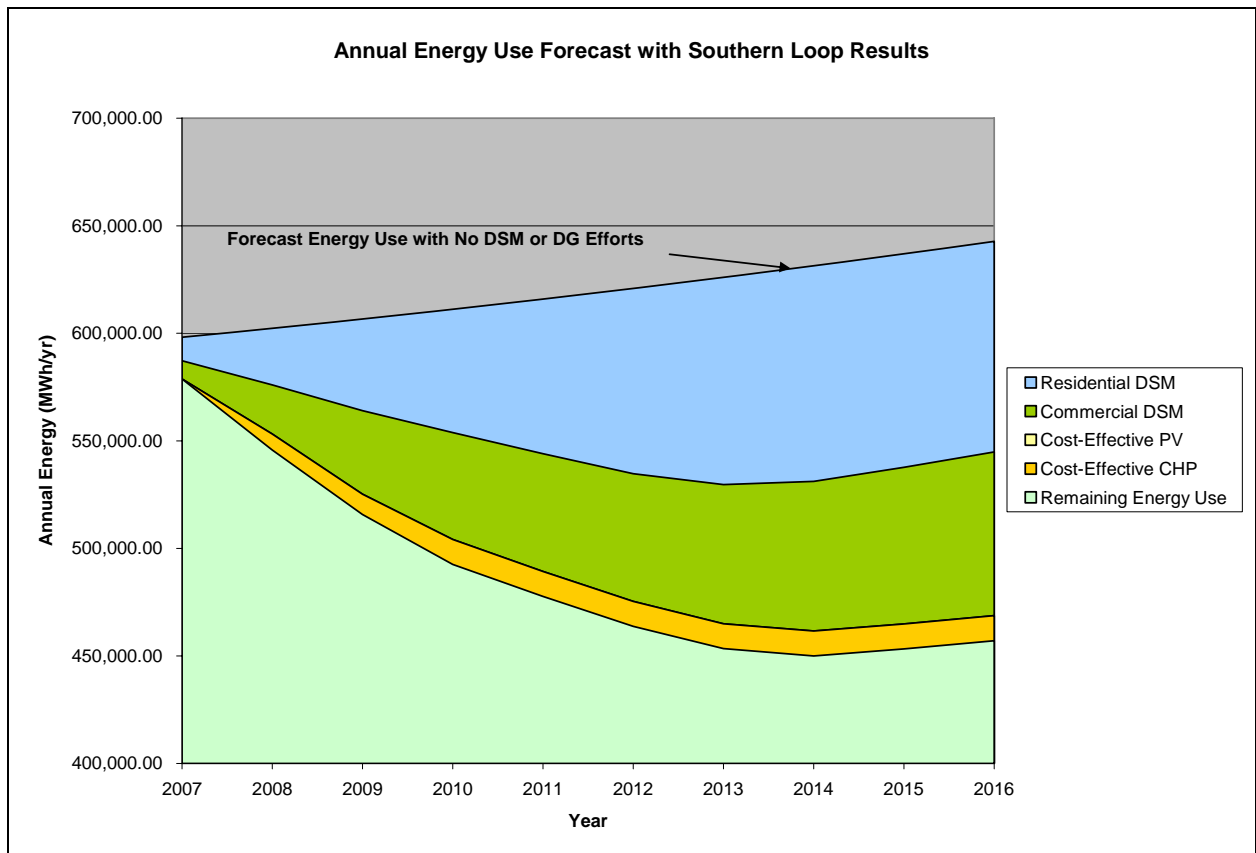
With regard to energy use, residential and commercial & industrial DSM could yield about 15 and 12 percent reductions in energy use, respectively, with potential contributions of 2 percent from and cost-effective CHP.<sup>5</sup> Annual energy use could be lowered to about 450 GWh per year across the Southern Loop in 2014, but would increase to about 457 GWh per year by 2016.

**Figure 1.1** Southern Loop Analysis Results Compared to Simplified Winter Demand Forecast



<sup>5</sup> Stated otherwise, PV and CHP are local sources of generation that meet needs locally. When viewed in this light, actual peaks are higher by the amounts of PV and CHP assumed to be in service and on-line.

**Figure 1.2 Southern Loop Analysis Results Compared to Simplified Energy Use Forecast**



Output Tables T1 through T14 present the cumulative annual winter peak kW load reductions through 2016 by initiative in each of the six load zones. The residential sector provides the largest amount of winter demand and energy savings, and the C&I sectors the largest amount of summer demand savings. In both the residential and C&I sectors, the retrofit market segment provides the majority of the demand savings. The analysis considered impacts through 2026 of initiatives that begin in 2007. The cumulative annual values account for timing effects from efficiency measures installed over the analysis period, such as expiration of shorter-lived measures and changes in savings during the lifetimes of installed measures due to underlying changes in baseline efficiency levels.

Projected electricity savings are above and beyond what would occur naturally in the marketplace in the absence of any change in anticipated future market intervention due to Efficiency Vermont’s ongoing efforts supported by the Energy Efficiency Charge (“EEC”) at the levels in effect prior to the 2006 budget adjustment. These projected savings are subtracted from the sales forecast to produce estimates of the resulting loads in each planning zone.

### 1.2.2 Economic Impact

Full implementation of the initiatives outlined here would require a budget of \$108.4 million over ten years; \$91.7 million for DSM and \$6.7 million to achieve the limited cost-effective CHP potential. Implementation of a limited solar PV initiative, if selected, would cost an additional \$10 million. Efficiency Vermont is anticipated to spend \$13.3 million in the Southern Loop over the same ten year horizon, based upon its current contract (without taking into account any incremental spending associated with the 2006 Budget Adjustment). All budget dollar figures are reported in 2006 real dollars; present values (for cost-benefit analysis) are listed in 2006 real dollars, calculated with a real discount rate of 6.8%. Table 1.2 presents economic information about the projected contributions from the targeted initiatives. More detailed information is presented in Output Tables T16 and T17.

The analysis indicates that all the targeted initiatives taken together could result in:

- \$69.35 million in *utility* (VELCO and CVPS) net present value benefits;
- \$89.82 million in societal present value costs;
- \$63.6 million in societal net present value benefits;
- A societal benefit-cost ratio of 1.71; and
- a net societal cost of \$(79.68)/kW-year per kW of winter peak demand contribution for DSM, and \$(32.83) for limited cost-effective CHP, after subtracting from distributed resource total costs the savings from avoided electric energy and non-electricity cost savings

**Table 1.2** Potential Costs and Benefits of DSM and Cost-Effective CHP

INITIATIVE	Total Societal Costs (PV)	Total Value of Electricity Savings (PV)	Net Benefits (PV)	Benefit/ Cost Ratio	Net Cost Per Winter Peak kW
Direct Install	\$51,473,145	\$61,859,501	\$10,386,357	1.20	\$73.58
Efficient Products	\$224,553	\$13,520,322	\$13,295,769	60.21	(\$417.98)
Home Performance	\$1,379,351	\$2,029,298	\$649,947	1.47	\$61.75
HVAC	\$526,172	\$2,099,105	\$1,572,933	3.99	(\$142.07)
Low Income	\$11,680,011	\$12,639,665	\$959,694	1.08	\$114.17
Res New Construction	(\$1,188,924) <sup>6</sup>	\$1,394,701	\$2,583,625	-1.17	(\$1,206.03)
Commercial Direct Install	\$6,089,086	\$16,345,055	\$10,255,969	2.68	(\$297.30)
Large C/I Retrofit	\$8,309,261	\$18,487,670	\$10,178,409	2.22	(\$297.90)
C/I Lost Opportunity	\$10,070,540	\$24,457,235	\$14,386,694	2.43	(\$366.68)
C/I New Construction	\$290,488	\$584,631	\$294,193	2.01	(\$290.86)
<b>DSM TOTALS</b>	<b>\$89,820,560</b>	<b>\$153,417,187</b>	<b>\$63,596,623</b>	<b>1.71</b>	<b>(\$79.68)</b>
Cost-Effective CHP	\$7,682,082	\$9,942,437	\$2,260,354	1.29	(\$32.83)
<b>COST-EFFECTIVE INITIATIVES TOTAL</b>	<b>\$97,502,642</b>	<b>\$163,359,624</b>	<b>\$65,856,977</b>	<b>1.68</b>	

Economic benefits are the monetary value of the electric energy and peak demand savings, which reflect updated estimates of the wholesale market value of generation, and estimates of avoided transmission distribution capacity costs previously approved by the Board for DSM cost-effectiveness analysis by Efficiency Vermont. These electric avoided costs are included in both the societal and utility cost-effectiveness tests. Included in the societal but not the utility tests are the Board-approved values for environmental externalities. Not accounted for in this analysis is the comparative risk adjustment to reflect the risk-mitigating advantages of energy-efficiency resources which, while recognized by the PSB, provides a conservative estimate of benefits. These risk advantages include the ability to acquire resources in stages, and the tendency of efficiency savings to vary directly both with hourly load fluctuations and cyclical and secular economic trends.

### 1.3 OVERVIEW OF ANALYSIS APPROACH AND METHODOLOGY

While the results of this study have corroborated the forecast of the Distributed Utility Planning DSM Scoping Tool, the overall reliability of the DUP Scoping Tool estimates was unknown. In addition, VELCO and CVPS sought to evaluate customer-sited generation alternatives, specifically solar photovoltaic and combined heat and power

<sup>6</sup> Benefit-cost ratio (“BCR”) calculations typically presume that there will be positive costs. For this analysis, any fossil fuel, operation and maintenance, or water savings are treated as negative costs; i.e., credits to program costs. In the case of RNC, the bulk of the energy savings stem from fossil fuel reductions, and the value of these savings are greater than actual measure costs. Consequently, the accounting results in negative costs and, hence, a negative BCR. Cost-effectiveness for this analysis is therefore determined by BCRs either greater than one or less than zero.

resources, which were not addressed by the DUP Scoping Tool. Consequently, the study needed to address key issues:

- Refinement of the assumptions inherent in the Scoping Tool – such as efficiency measures and their savings and costs – and a better understanding of current energy efficiency levels in Southern Loop residences and businesses;
- Addressing changes in the energy market through the use of more current electricity, fossil fuel, and other avoided costs;
- Ensuring that all DSM measures – particularly fuel-switch measures – meet the societal cost-effectiveness test;
- Capturing DSM savings faster by emphasizing aggressive retrofit initiatives over time-of-replacement and new construction initiatives; and
- Addressing customer-sited DG options in the residential, commercial, and industrial sectors.

The study's analysis approach and methodology were developed to strategically address these issues at a high level.

### **1.3.1 Reviewing the DUP Scoping Tool Results**

As a first step at estimating the DSM potential CVPS used the Distributed Utility Planning (DUP) Scoping Tool, developed for the Vermont Department of Public Service. Based on the number of residential customers and commercial and industrial electricity sales data in the transmission-constrained area, this tool scales the results from two Vermont 2003 achievable potential studies to provide a preliminary estimate of the DSM potential over 10 years.

The preliminary findings from the DUP Scoping Tool indicated that enough additional DSM could not be implemented to potentially resolve immediate transmission reliability problems, but that incremental DSM investments may defer need for subsequent transmission investments to meet reliability needs in the future. Overall, the tool estimated that over a 10-year timeframe, DSM could provide 25.8 MW of Winter peak demand reduction at the customer meter (29.4 MW at generation) and energy savings of 136 GWh per year (cumulative) at the meter, or 20 percent of forecast demand and energy use. The DUP Scoping Tool also helped identify the most likely energy end-uses and sectors to provide significant savings.

### **1.3.2 Developing a Southern Loop-Specific DSM Analysis**

While the DUP Scoping Tool provided a general sense as to the potential magnitude of DSM savings, CVPS and VELCO needed more geographically-specific results. The DUP Scoping Tool relies upon the most recent Vermont statewide DSM potential study, but the Southern Loop has substantially different characteristics from the rest of the state:

- Load in two of the analysis zones is dominated by ski areas, which make them and the Southern Loop as a whole winter-peaking, unlike the rest of the state and the region;
- A significant portion of the residential load comes from ski condominiums, with more electric heat than the statewide average and different occupancy rates and tenant/landlord relationships;
- Different mixes of large commercial and industrial customers than the statewide average; and
- Declining sales in the small and medium commercial market.

To provide a determination of potentially achievable DSM savings, a more current analysis more specific to the Southern Loop area was required. CVPS and VELCO engaged Optimal Energy Inc., Vermont Energy Investment Corporation and Green Energy Economics Group to assist in a detailed analysis of potential efficiency, renewable and cogeneration options. The analysis team developed a methodology to “ground” the initial statewide analysis with direct field experience and stratified site visits. For example, Efficiency Vermont has experience implementing the Home Performance with ENERGY STAR® program in the Southern Loop. The project database and field experience provided information on baseline technologies and systems (e.g., electric space heat and electric domestic hot water systems). Working with CVPS and Efficiency Vermont, refinements were made to establish counts of homes with electric space heat, domestic hot water and appliances and to reflect installations that have occurred in the Southern Loop, both prior to and by Efficiency Vermont.

For the commercial and industrial sector, site visits were conducted for many of the large customers (with demand greater than 100 kW) and to a stratified sample of smaller accounts. Of the 140 large commercial and industrial accounts, 44 locations were visited to assess efficiency opportunities and another 10 have completed projects through Efficiency Vermont. The sites visited represented 61 percent of the large C&I MWh energy use. The efficiency opportunities at the visited sites were then applied to the other large C&I customers of the same building or facility type. For the small to medium commercial and industrial customers walkthroughs were conducted at more than 50 locations. The information found from the walkthroughs was used to refine general assumptions, such as baseline equipment, for the customers with similar building types.

### **1.3.3 Evaluating Generation Options**

The analysis also assessed the generation potential for photovoltaic systems and combined heat and power. For photovoltaic systems, basic information on the number and type of electric accounts for each area was used as a basis for developing scoping estimates of potential summer and winter peak capacity savings, annual electric generation and associated costs. Further inputs to the analysis included average available roof space by account type, average applicability, average costs and annual output, and summer and winter peak capacity coincidence factors. For combined heat and power, the analysis team developed a survey instrument to capture information on thermal and

electric loads at a wide range of facilities, including minimum, average, and maximum loads, type of heat distribution (e.g., hot water, low pressure steam, high pressure steam), and coincidence hours between heat and electric loads. These survey results were translated into general measure characterizations, matching loads to generation technologies with associated costs, fuel use, and other operation and maintenance characteristics.

### **1.3.4 Development of Initiatives to Achieve Savings or Generation**

Based on the results from the DUP scoping analysis and Efficiency Vermont's experience in the Southern Loop area, the study team developed program concepts that would target the end uses and markets with high savings potential that could be acquired cost effectively. Generally, the team focused on two program types:

- Retrofit programs that would aggressively capture demand savings in the first four years, providing the demand reduction needed to respond to special needs such as offsetting high power costs and potentially deferring transmission upgrades; and
- Lost Opportunity projects that increase incentive offers above and beyond what Efficiency Vermont currently offers, and that make use of a more aggressive sales approach that leads to greater completion rates (Kleinman et al. 2006).

The residential initiative concepts evaluated were:

- Ski Area Residential/Multifamily New Construction
- Targeted High Use Residential Direct Install
- Appliance Turn-In
- Ski Area Fuel Switch
- Efficient Products
- Low Income (single- and multifamily)
- HVAC lost opportunity
- Home Performance with ENERGY STAR®

While the individual measures for the Appliance Turn-In initiative were cost-effective, the initiative as a whole (i.e., including other variable and fixed costs) were not; that initiative and its measures were dropped from the analysis. Overall, the residential initiatives were expected to require a budget of \$49.6 million over 10 years.

The commercial and industrial initiative concepts evaluated were:

- Small-Medium Commercial Direct Install
- Large Commercial & Industrial Account Management (Retrofit and Lost Opportunity)
- Enhanced Small-Medium C&I Lost Opportunity
- C&I New Construction

The estimated budget for these C&I initiatives is \$42.1 million.

The photovoltaic initiative builds on the foundation created by the participation of CVPS in the Vermont Solar and Small Wind Program. This is a low-overhead initiative that makes additional incentives available to residences, schools, ski areas, and businesses in the Southern Loop, taking advantage of the 2005 Energy Policy Act's tax provisions to make solar photovoltaic systems more affordable.

The combined heat and power initiative would establish clear interconnection policies, review pricing schemes, and provide design and financial assistance to residential, commercial, and industrial customers seeking societally cost-effective CHP applications.

## **2 DETAILED ACHIEVABLE POTENTIAL RESULTS**

This report provides results relative to two cost-effectiveness tests, the Societal and Electric Utility test. The Societal test compares the total costs and benefits to society – including customers and utilities. The Electric Utility test only compares the costs and benefits to the electric utility. The Net Benefits are equal to the benefits minus the costs and the Benefit/Cost ratio (“BCR”) is the benefits divided by the costs. Both tests are present valued to 2006 and in 2006 dollars. This report only presents DSM savings for which societal benefits are greater than societal costs. Solar PVs do not pass this test, and the report differentiates CHP savings by those that pass the societal test, and those that do not.

Societal costs include measure installed costs, deferral replacement credit for some retrofit measures, operation and maintenance costs (savings), fossil fuel costs (savings), fossil fuel environmental externality costs (savings), water costs (savings), and the administrative costs of delivering the efficiency initiatives. Where those items listed above produce cost savings, those items are counted as negative costs. Societal benefits include the avoided costs of producing electric energy, electric generating capacity, electric transmission and distribution capacity, electric environmental externalities, and risk mitigation benefits.

Electric Utility costs include financial incentives offered to customers to install measures and the administrative costs of delivering the efficiency initiatives. Electric Utility benefits include the avoided costs of producing electric energy, electric generating capacity, and electric transmission and distribution capacity.

This Southern Loop study finds that DSM and CHP could provide over 25 percent of the 2016 forecast winter demand (with the baseline assuming no DSM activity over that timeframe) and over 28 percent of the annual energy requirements for the Southern Loop (again, with the baseline assuming no DSM activity over that timeframe). Winter demand reductions from DSM vary significantly by load zone, from only 6.3 percent in Stratton up to 36 percent in Bennington. The DSM results of 32.2 MW of winter demand reduction represent a significant increase over Efficiency Vermont's projected savings of

8.7 MW over the same time period (based on the EEU budget without accounting for changes to result from the 2006 budget adjustment).

The evaluated cost-effective CHP opportunities are only estimated in the Bennington, East, and Brattleboro zones because completed survey responses were limited to those zones. It is likely some additional opportunities may exist in those as well as in other zones. While the solar PV analysis indicated summer demand savings across zones, winter demand savings are negligible.

This section summarizes the achievable potential results for DSM, solar PVs, and CHP. The following section (Section 3) reviews the approach and methodology used to develop these results.

## **2.1 OVERVIEW OF TARGETED RESOURCE PROCUREMENT**

Unlike most states, Vermont is fortunate to have a well-established infrastructure – the Energy Efficiency Utility -- with a proven track record of procuring strategic quantities of cost-effective energy-efficiency resources over the past six years. Efficiency Vermont has exceeded three-year goals under its last two performance contracts. VEIC, Vermont's EEU service provider, has contracted to provide even greater savings per dollar invested between now and 2008. It has delivered savings throughout Vermont, including in the Southern Loop. The Efficiency Vermont contract obligates the EEU to respond to requests for proposals ("RFPs") by any Vermont utility for targeted energy-efficiency investment in its service territory. The requesting utility has no obligation to contract with the EEU for targeted efficiency services; if it finds an EEU bid unacceptable, a utility is free to seek bids from other providers. Consequently, Efficiency Vermont offers VELCO and CVPS an efficiency provider of both first and last resort. As a first step in this direction, CVPS has engaged VEIC in a separate contract to develop preliminary proposals for first-stage implementation of expanded and accelerated energy-efficiency service delivery in one or more load zones of the Southern Loop.

Ongoing regulatory proceedings to implement changes in Vermont law regarding distributed-resource planning and procurement may influence Efficiency Vermont's capability to deliver energy-efficiency and customer-sited generation in the Southern Loop. Pursuant to Act 61, the PSB has raised the annual EEC to increase Efficiency Vermont's budget and associated electricity savings targets throughout the State. While details on specific implementation strategies are as yet unknown, this should raise the portion of economically achievable potential found by this analysis that Efficiency Vermont would be responsible for delivering in the Southern Loop. This in turn would reduce the amount of additional, or incremental, demand-side resource procurement that VELCO and CVPS would have to consider procuring beyond Efficiency Vermont's ongoing service delivery.

Vermont's infrastructure for procuring the customer-sited generation analyzed in this study is far less evolved. Efficiency Vermont is currently confined to providing limited technical assistance to customers considering PV and CHP opportunities, and the

Vermont Small Wind and Solar Program provides limited financial incentives. Aforementioned regulatory changes under consideration may well expand and strengthen the market strategies employed to encourage customers to undertake solar and combined heat and power investments. If not, VELCO and/or CVPS would need to develop and participate in new arrangements building on existing services for fielding initiatives to stimulate customer-sited generation in the Southern Loop. Costs for the development of these services for the limited cost-effective CHP potential are included in this report, and the report section on PVs estimates the costs associated with a possible, limited PV initiative.

## 2.2 RESIDENTIAL ENERGY EFFICIENCY ACHIEVABLE POTENTIAL

The analysis found that the residential sector of the Southern Loop offers the greatest achievable potential to reduce winter demand, accounting for 22.8 MW of the 32.2 MW reduction. The higher share of winter demand savings can be attributed to current residential sector shares of electric space heat, electric domestic hot water (“DHW”), incandescent lighting, and “leaky” building envelopes. Table 2.1 summarizes the cumulative energy and demand savings for the six proposed residential Southern Loop initiatives. By 2016, the residential initiatives provide about 56 percent of all of the cumulative energy savings and about 39 percent of the summer demand savings. The proportionally smaller summer demand impacts from the residential initiatives is not surprising given residential energy use patterns (i.e., with the exception of space cooling, residential energy use is low during a summer day when the summer peak occurs).

These estimates represent increases over the 4.4 MW of winter demand reduction, 3.6 MW of summer demand reduction, and 26,800 MWh per year of energy savings that Efficiency Vermont would likely secure in the Southern Loop residential sector over the same time horizon based its budgets in effect prior to the 2006 budget adjustment.

**Table 2.1 Cumulative Residential Initiative Savings in 2016  
All Initiatives, Aggregated across All Zones**

Savings Indicator	Savings	Percent of 2016 Forecast
<b>Energy Savings</b>	97,894 MWh/yr	15.2%
<b>Winter Demand</b>	22.77 MW	16.8%
<b>Summer Demand</b>	9.11 MW	--

Table 2.2 shows the cumulative energy and demand savings from each of the six proposed initiatives in 2016. Over half of the energy and demand savings come from the Direct Install (“DI”) Initiative and over three-quarters from the combination of the Direct Install and Efficient Products Initiative, as the DI initiative is very aggressive, residential new construction rates are relatively low, and the Efficient Products initiative would cover the full incremental cost of energy-efficient appliances for Southern Loop customers.

**Table 2.2 Cumulative Residential Initiative Savings in 2016  
By Initiative, Aggregated across All Zones**

<b>Initiative</b>	<b>Energy Savings (MWh/yr)</b>	<b>Winter Demand (MW)</b>	<b>Summer Demand (MW)</b>
<b>Direct Install</b>	56,557	14.41	5.83
<b>Efficient Products</b>	24,654	3.49	1.17
<b>Home Performance</b>	2,259	1.00	0.03
<b>HVAC</b>	1,599	0.74	0.82
<b>Low Income</b>	11,651	2.94	1.19
<b>New Construction</b>	1,737	0.24	0.08
<b>Total</b>	<b>98,457</b>	<b>22.82</b>	<b>9.12</b>

Examining the 2016 savings impacts by zone in Table 2.3 shows that Bennington has the largest cumulative energy and demand savings in 2016, followed by East and then West. These three zones represent 70% of the cumulative energy and winter demand savings and 68% of the cumulative summer demand savings. The relatively low savings opportunities found in the Stratton and Bromley zones, as compared to the others, are the result of the relatively small number of residential customers, the nature of the housing stock and the type of residential accounts found in these two zones. While ski condominiums tend to have a higher incidence of electric resistance space heating than single-family detached residences, for example, they also are much harder to convert to a fossil fuel source due to their physical and legal limitations.

**Table 2.3 Cumulative Residential Initiative Savings in 2016 (All Initiatives, By Zone)**

<b>Zone</b>	<b>Energy Savings (MWh/yr)</b>	<b>Winter Demand (MW)</b>	<b>Summer Demand (MW)</b>
<b>Bennington</b>	26,175	5.10	2.41
<b>Brattleboro</b>	20,171	4.60	1.84
<b>Bromley</b>	2,032	0.48	0.19
<b>East</b>	22,756	5.35	2.14
<b>Stratton</b>	6,531	1.56	0.62
<b>West</b>	20,229	4.80	1.91
<b>Total</b>	<b>97,894</b>	<b>21.89</b>	<b>9.11</b>

Table 2.4 summarizes the 10-year budgets for each residential sector initiative. The 10-year budget for the residential sector initiatives is \$49.6 million, with the DI initiative accounting for more than half of that budget. This represents an increase in spending of \$41.5 million over Efficiency Vermont's estimated budget of \$8.1 million over the same time horizon.<sup>7</sup>

<sup>7</sup> Assuming level funding based on current Efficiency Vermont contract and budgets in effect prior to the 2006 budget adjustment.

**Table 2.4 Residential Sector Cumulative 10-Year Initiative Budgets**

<b>Initiative</b>	<b>TOTAL</b>
<b>Residential Direct Install</b>	
Financial incentives	\$ 19,856,613
All other program costs (variable and fixed)	\$ 6,675,162
Total expenditures	\$ 26,531,775
<b>Efficient Products</b>	
Financial incentives	\$ 1,677,527
All other program costs (variable and fixed)	\$ 1,867,114
Total expenditures	\$ 3,544,641
<b>Home Performance</b>	
Financial incentives	\$ 403,718
All other program costs (variable and fixed)	\$ 736,179
Total expenditures	\$ 1,139,897
<b>HVAC</b>	
Financial incentives	\$ 756,879
All other program costs (variable and fixed)	\$ 748,988
Total expenditures	\$ 1,505,866
<b>Low Income</b>	
Financial incentives	\$ 7,213,171
All other program costs (variable and fixed)	\$ 2,776,179
Total expenditures	\$ 9,989,350
<b>Res New Construction</b>	
Financial incentives	\$ 3,661,404
All other program costs (variable and fixed)	\$ 3,235,505
Total expenditures	\$ 6,896,908
<b>TOTAL RESIDENTIAL</b>	
Financial incentives	\$ 33,569,311
All other program costs (variable and fixed)	\$ 16,039,126
Total expenditures	\$ 49,608,438

Table 2.5 summarizes the cost-effectiveness of each residential sector initiative. The net benefit calculation subtracts societal costs (including measure and initiative costs, but deducting any maintenance or non-electric resource savings such as fossil fuels or water) from societal benefits (including avoided energy and capacity costs and externalities).

**Table 2.5 Residential Sector Initiative Societal Cost-Effectiveness**

<b>INITIATIVE</b>	<b>Net Benefits</b>	<b>Benefit/ Cost Ratio</b>	<b>Net Cost Per Winter Peak kW</b>
Direct Install	\$10,386,357	1.20	\$73.58
Efficient Products	\$13,295,769	60.21	(\$417.98)
Home Performance	\$649,947	1.47	\$61.75
HVAC	\$1,572,933	3.99	(\$142.07)
Low Income	\$959,694	1.08	\$114.17
Res New Construction	\$2,583,625	-1.17	(\$1,206.03)

The Efficient Products initiative yields the highest level of net benefits, followed by DI and Residential New Construction. (The Efficient Products initiative is able to leverage a high number of benefits at relatively low cost because consumers only face incremental costs to energy efficiency, and the initiative operates with high economies of scale.) The benefit-to-cost ratio is the relative fraction of benefits to costs; a negative benefit-to-cost ratio for the residential new construction initiative indicates that the sum of maintenance and non-electric resource savings are greater than measure and initiative costs. (One initiative, Appliance Turn-In, was deleted from the analysis because it provided negative net benefits and a benefit-to-cost ratio of less than 1.0).

Table 2.5 also highlights the net societal cost per Winter peak kW reduction for each initiative. The net societal cost deducts the avoided energy cost benefits from the total societal cost, and then divides the remaining costs by the levelized Winter peak kW reduction. For three initiatives, this net societal cost is negative (because fossil fuel, water, and maintenance savings are counted as “negative costs” rather than benefits). In other words, even if there was no value to reducing winter peak loads, these initiatives would still provide net benefits.

Table 2.6 shows these same calculations from the utility perspective, which focuses only on utility costs (incentives and initiative costs) and utility benefits (avoided electric energy and capacity costs). The Residential New Construction initiative is not cost-effective from the utility perspective.

**Table 2.6 Residential Sector Initiative Utility Cost-Effectiveness**

<b>DISTRIBUTED RESOURCE CATEGORY</b>	<b>Net Benefits</b>	<b>Benefit/ Cost Ratio</b>	<b>Net Cost Per Winter Peak kW</b>
Direct Install	\$35,684,347	2.77	(\$108.96)
Efficient Products	\$9,733,789	4.76	(\$268.70)
Home Performance	\$951,845	2.08	\$21.20
HVAC	\$872,573	1.81	(\$12.49)
Low Income	\$3,759,578	1.50	\$13.88
Res New Construction	(\$3,794,102)	0.22	\$2,138.66

More detailed results for the residential sector are presented in Tables 1-7, 12, and 15-24 of the Output Tables section.

### **2.3 COMMERCIAL AND INDUSTRIAL ACHIEVABLE POTENTIAL**

The analysis found that the commercial and industrial (C&I) sector offers less potential to reduce winter peak demand than the residential sector. Much of the winter peak demand in the C&I sector is associated with mountain operations at ski areas; site visits conducted of Southern Loop businesses found very low use of electric space heat and electric DHW, with the exception of larger low-income housing stock and lodging. Because the analysis focused on retrofit opportunities for ski areas rather than potential expansions, and there are a limited number of cost-effective retrofit measures for snowmaking or ski lift operations, the analysis yielded limited winter peak demand achievable potential (see discussion on methodology in Section 3.4). Major ski area expansion is not included in this analysis; it is assumed that should that expansion occur, the Southern Loop C&I New Construction Initiative would achieve demand and energy savings that are additive to this achievable potential study.<sup>8</sup> The net load growth from large new projects will include the effect of energy efficiency driven by Act 250 considerations and Efficiency Vermont programs targeted at lost opportunities.

Table 2.7 summarizes the cumulative energy and demand savings for the proposed C&I Southern Loop initiatives. By 2016, The C&I savings account for about 45 percent, 30 percent of the winter demand savings, and 70 percent of the summer demand savings. The high level of cooling, refrigeration, and daytime lighting in the C&I sector accounts for its high percentage of summer peak reduction.

These energy and demand savings represent increases over estimated Efficiency Vermont efforts over the same time period that would yield 4.3 MW of winter demand savings, 5.5 MW of summer demand savings, and 32,818 MWh of annual energy savings (under the EEU budgets in effect prior to the 2006 budget adjustment).

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<sup>8</sup> Note that CVPS' current forecast anticipates a probability of significant ski area expansion, but not as a certainty.

**Table 2.7 Cumulative Commercial and Industrial Initiative Savings in 2016  
All Initiatives, Aggregated across All Zones**

<b>Savings Indicator</b>	<b>Savings</b>	<b>Percent of 2016 C&amp;I Forecast</b>
<b>Energy Savings</b>	76,137 MWh/yr	12%
<b>Winter Demand</b>	9.42 MW	7%
<b>Summer Demand</b>	14.1 MW	N/A

Table 2.8 summarizes the achievable potential by C&I initiative. The C&I Lost Opportunity initiative provides the most savings, capturing opportunities for equipment replacement at C&I facilities, as well as remodeling, and renovation projects for commercial facilities. This initiative provides significant savings from larger C&I customers who replace equipment at failure or end-of-life. Based upon past trends, with the exception of possible ski area expansion (which falls outside of this analysis), very little C&I new construction is anticipated during the 10-year time horizon.

**Table 2.8 Cumulative Commercial & Industrial Initiative Savings in 2016  
By Initiative, Aggregated across All Zones**

<b>I Initiative</b>	<b>Energy Savings (MWh/yr)</b>	<b>Winter Demand (MW)</b>	<b>Summer Demand (MW)</b>
Commercial Direct Install	14,324	2.20	3.30
Large C&I Retrofit	27,792	3.09	3.10
C&I Lost Opportunity	33,294	4.04	7.57
C&I New Construction	727	0.09	0.17
<b>TOTAL</b>	<b>76,137</b>	<b>9.42</b>	<b>14.14</b>

Table 2.9 summarizes the C&I sector's achievable potential by Southern Loop load zone. Brattleboro and Bennington offer the majority (more than 60 percent) of the winter demand savings.

**Table 2.9 Cumulative Commercial & Industrial Initiative Savings in 2016 (All  
Initiatives, By Zone)**

<b>Zone</b>	<b>Energy Savings (MWh/yr)</b>	<b>Winter Demand (MW)</b>	<b>Summer Demand (MW)</b>
<b>Bennington</b>	23,072	2.8	4.5
<b>Brattleboro</b>	26,362	3.13	4.75
<b>Bromley</b>	482	0.07	0.05
<b>East</b>	7,468	0.94	1.43
<b>Stratton</b>	2,559	0.35	0.30
<b>West</b>	16,194	2.13	3.16
<b>Total</b>	<b>76,137</b>	<b>9.42</b>	<b>14.19</b>

The 10-year budget for the four C&I initiatives of \$43 million is broken out in Table 2.10. More than half of the spending would occur through the C&I Lost Opportunities program. This budget is \$37.8 million more than Efficiency Vermont is forecast to spend in the Southern Loop over the same time period (a total of \$5.2 million prior to the 2006 budget adjustment).

**Table 2.10 C&I Sector Cumulative 10-Year Initiative Budgets**

	<b>TOTAL</b>
<b>Commercial Direct Install</b>	
Financial incentives	\$ 3,287,363
All other program costs (variable and fixed)	\$ 1,783,101
Total expenditures	\$ 5,070,464
<b>Large C/I Retrofit</b>	
Financial incentives	\$ 6,075,774
All other program costs (variable and fixed)	\$ 1,712,971
Total expenditures	\$ 7,788,745
<b>C/I Lost Opportunity</b>	
Financial incentives	\$ 22,758,636
All other program costs (variable and fixed)	\$ 5,696,801
Total expenditures	\$ 28,455,437
<b>C/I New Construction</b>	
Financial incentives	\$ 601,418
All other program costs (variable and fixed)	\$ 172,882
Total expenditures	\$ 774,300
<b>TOTAL C&amp;I SECTOR DSM BUDGETS</b>	
Financial incentives	\$ 32,723,191
All other program costs (variable and fixed)	\$ 9,365,755
Total expenditures	\$ 42,088,946

Table 2.11 summarizes the cost-effectiveness of each C&I sector initiative. The C&I sector provides slightly more societal net benefits (\$34.9 million) than the residential sector (\$28.9 million).

**Table 2.11 C&I Sector Initiative Societal Cost-Effectiveness**

<b>INITIATIVE</b>	<b>Net Benefits</b>	<b>Benefit/ Cost Ratio</b>	<b>Net Cost Per Winter Peak kW</b>
Commercial Direct Install	\$10,255,969	2.68	(\$297.30)
Large C/I Retrofit	\$10,178,409	2.22	(\$297.90)
C/I Lost Opportunity	\$14,386,694	2.43	(\$366.68)
C/I New Construction	\$294,193	2.01	(\$290.86)

The societal benefits provided by all initiatives except for C&I New Construction are fairly equal. The benefit-to-cost ratios are fairly robust (in that the net benefits exceed the

net costs by a factor of two or more). Also, the net societal cost per winter peak kW reduced is negative for all initiatives.

Table 2.12 shows this same calculation from the utility perspective. For the electric utility, the C&I initiatives provide lower net benefits (\$22.8 million) than the residential initiatives (\$35.6 million), primarily because of the importance of winter demand reduction generated by the residential DI initiative (providing T&D capacity benefits). The benefit-to-cost ratio for both the C&I Lost Opportunity and New Construction initiatives drops as fossil fuel and other resource savings are not considered from a utility perspective; this also affects the utility’s net cost per winter peak kW reduction.

**Table 2.12 C&I Sector Initiative Utility Cost-Effectiveness**

<b>DISTRIBUTED RESOURCE CATEGORY</b>	<b>Net Benefits</b>	<b>Benefit/ Cost Ratio</b>	<b>Net Cost Per Winter Peak kW</b>
Commercial Direct Install	\$10,384,096	3.25	(\$296.59)
Large C/I Retrofit	\$9,960,103	2.55	(\$288.01)
C/I Lost Opportunity	\$2,441,744	1.13	\$61.42
C/I New Construction	(\$9,140)	0.98	\$162.46

More detailed results for the commercial and industrial sector are presented in Tables 8-11, and 13-24 of the Output Tables section.

## **2.4 NON-COST-EFFECTIVE DSM POTENTIAL**

Because the cost-effectiveness test used statewide transmission and distribution (“T&D”) avoided costs (see Section 3.1.3.3 for a more detailed discussion), VELCO and CVPS requested an analysis of additional achievable potential should the local T&D avoided costs be slightly higher. The project team separately evaluated the set of energy efficiency measures with societal benefit-cost-ratios between 0.95 and 1.0. This approximates an increase in T&D avoided costs by 5 percent.

The analysis indicated that another 1.5 MW of winter peak demand, 0.95 MW of summer peak demand, and 9.6 GWh of annual energy savings could be cost-effectively achieved through the DSM initiatives. This represents an increase in the DSM achievable potential of about 4.7 percent in winter peak demand and 5.5 percent in energy, close to the tested 5 percent increase in T&D avoided costs.

## **2.5 SOLAR PHOTOVOLTAICS**

The solar photovoltaic analysis evaluated achievable potential from a five-year initiative that would address the residential sector and three C&I subsectors: schools, ski areas, and other commercial buildings. Schools and ski areas were targeted as visible and likely

receptive sectors to solar PV installations; residential and the remaining commercial sector were targeted based upon past performance of the Vermont Small Wind and Solar program. The intent of the analysis was to develop an estimate of the achievable solar PV potential based upon a limited utility budget.

None of the solar PV achievable potential meets the societal or utility cost-effectiveness tests. The solar PV initiative's net societal benefits are negative \$36 million, and net utility benefits are negative \$6 million. Its societal benefit-to-cost ratio is 0.24 and utility benefit-to-cost ratio is 0.52. Because it does not provide winter demand benefits, the analysis does not yield a net cost per winter kW reduction (or supply).

A limited implementation of solar PV technology could generate 5,534 MWh annually and provide 4.1 MW of summer capacity. The initiative is not estimated to provide any winter demand savings, as the PV systems will generally not generate power at the time of the utility winter peak (i.e., in the late afternoon or early evening of a winter day, typically during snowmaking operations as well).

The solar PV demand projected here are greater than the installed solar PV capacity, because the analysis provides demand savings *at generation*, taking into account line losses. Because solar PV generates power on-site, it effectively offsets a greater amount of remote generation because remote generation needs to overcome line losses.

The estimated budget for this five-year initiative would be \$10 million, leveraging a total investment of approximately \$38.8 million. This would substantially increase the amount of solar PV capacity in Vermont.

## **2.6 COMBINED HEAT AND POWER**

The combined heat and power initiative evaluated opportunities in both the residential and C&I sectors. The analysis developed an estimate of different types of CHP options:

- Customer-Sited, Customer-Owned: In this case, CHP systems would be sized to match a customer's thermal (i.e., heating) load to maximize hours of operation of the CHP system. Use of waste heat generated by the CHP system would be maximized, but electricity output (both in terms of capacity and energy) would be limited to a customer's thermal energy requirements.
- Customer-Sited, Utility-Owned: In this case, the CHP system could be sized to optimize electrical output to meet the needs of not only the host facility, but also surrounding facilities. Such a CHP system would generate surplus waste heat (i.e., in excess of the host facility's thermal energy requirements).

The analysis of the limited number of completed surveys (see the methodology description in Section 3.6) and extrapolation to similar facilities found that customer-sited/customer-owned CHP that also meets the societal cost-effectiveness test could offset 2.1 MW of winter capacity, 1.7 MW of summer capacity, and 11,600 MWh of

annual energy generation. This CHP capacity would be secured over a four-year period with a total budget of \$6.7 million. Table 2.13 indicates the relative cost-effectiveness of the CHP. The net societal benefits are \$2.7 million and the societal benefit-to-cost ratio is 1.35. The net cost per winter peak kW is negative; this is due both to reductions in fuel costs by switching to either waste or purchased biomass, as well as accounting for the value of the energy generated by the CHP systems. These net costs per winter peak kW are less expensive than some of the residential sector DSM initiatives but more expensive than the C&I sector DSM initiatives.

**Table 2.13 C&I Sector Initiative Societal Cost-Effectiveness**

<b>DISTRIBUTED RESOURCE CATEGORY</b>	<b>Net Benefits</b>	<b>Benefit/ Cost Ratio</b>	<b>Net Cost Per Winter Peak kW</b>
Combined Heat & Power	\$2,698,433	1.35	(\$11.68)
Non Cost-Effective CHP	(\$14,982,021)	0.81	\$373.47

The analysis of a limited number of non-cost-effective CHP opportunities shows greater potential – 8.3 MW of winter capacity, 6.1 MW of summer capacity, and 90,957 MWh of displaced electricity generation. The lack of cost-effectiveness may be attributed to costs of available fuels in the Southern Loop (e.g., propane, distillate fuel oil); the cost-effective CHP either uses industrial by-products as fuel sources (e.g., wood chips, biogas) or biomass-fired steam boilers.

### 3 APPROACH AND METHODOLOGY

While the results of this study have corroborated the forecast of the Distributed Utility Planning DSM Scoping Tool, the overall reliability of the DUP Scoping Tool estimates was unknown. In addition, VELCO and CVPS sought to evaluate customer-sited DG alternatives, specifically solar photovoltaic and combined heat and power resources, that were not addressed by the DUP Scoping Tool. Consequently, the study needed to address key issues:

- Refinement of the assumptions inherent in the Scoping Tool – such as efficiency measures and their savings and costs – and a better understanding of current energy efficiency levels in Southern Loop residences and businesses;
- Addressing changes in the energy market through the use of more current electricity, fossil fuel, and other avoided costs;
- Ensuring that all DSM measures – particularly fuel-switch measures – meet the societal cost-effectiveness test;
- Capturing DSM savings faster by emphasizing aggressive retrofit initiatives over time-of-replacement and new construction initiatives; and
- Addressing customer-sited DG options in the residential, commercial, and industrial sectors.

The study's analysis approach and methodology were developed to strategically address these issues at a high level.

### **3.1 ANALYSIS FRAMEWORK**

The analysis team developed a tiered methodology to supplement the team's knowledge of local conditions with site visits. Because the team consisted of Efficiency Vermont staff and was complemented by CVPS staff, the team already possessed a great deal of information about local conditions.

The scope of the study consisted of the following:

- Reviewing DUP DSM Scoping Tool results to identify areas for evaluation
- Account for new technologies since the development of the DUP DSM Scoping Tool (e.g., Super T8 lighting systems);
- Account for new avoided costs
- Review of Efficiency Vermont or CVPS experience with customers to inform estimates of costs, savings, and current levels of use of a wide range of energy efficiency technologies;
- Site visits of Southern Loop customers to further inform estimates of costs, savings, and technologies in use, as well as to develop potential energy efficiency packages for larger customers;
- Review of existing data on use of combined heat and power in the Southern Loop and development and implementation of a survey instrument to collect data needed to develop an estimate of CHP potential;
- Develop methodology to estimate available roof or other areas for photovoltaic installations, and associated capacities and costs;
- Analysis of DSM, CHP, and PV potential using Optimal Energy's Portfolio Screening Tool to determine cost-effectiveness, overall achievable potential, and supply options; and
- Consolidation of results into a written report.

#### **3.1.1 Markets, Measures, and Initiatives**

The analytical methodology makes distinctions between markets, measures, and initiatives. Energy efficiency measures are the technology options themselves, although measure characteristics (i.e., costs and savings) depend upon the market in which the technology is applied. Initiatives are implementation efforts with strategies tailored to specific markets and measure packages. This section defines measure, market, and initiative to structure the methodology discussions that follow.

From the perspective of this report, markets are the arenas in which decisions are made affecting energy use. Broadly, there are two different markets – existing buildings (whether homes, offices, retail stores, or industrial facilities) and new construction. Owners of existing homes or business facilities are faced with different decisions than

potential owners of new homes or business facilities, particularly when evaluating costs of different options that would affect energy use.

However, the existing building market can be subdivided into three “submarkets” – retrofit, purchase/replacement, or remodel/renovation:

- **Retrofit Opportunities:** In this “market,” home or business owners have existing equipment that provide needed lighting, heating, cooling, refrigeration, or other services. While this equipment may not use energy efficiently or may have other disadvantages (e.g., age, reliability, product quality), the owner has the option of continuing to use this equipment. When considering energy efficiency, a home or building owner must compare the benefits of new equipment against the full cost of installation.
- **Equipment Purchase or Replacement:** In this case, the home or business owner makes a decision to install new equipment, due to equipment failure, expansion, performance concerns, or other drivers. In the case of a home owner, this could be the replacement of a failed refrigerator or clothes washer, or the purchase of a chest freezer (in addition to the freezer box of a refrigerator). For a business, this could be the replacement of a failed motor or purchase of new production equipment to expand plant capacity. Typically, the window of opportunity (in terms of time) to influence the energy efficiency of this decision is very narrow, much narrower than in the retrofit market. And success in this market relies heavily upon the efforts of retailers (for retail products), design professionals (particularly engineers), and trade allies (e.g., contractors, vendors, suppliers).
- **Remodel/Renovation:** This market is similar to equipment purchase or replacement, but affects an entire system, or multiple systems, within a given home or building. For example, a renovation effort could allow for a switch from one type of space cooling system to another (e.g., furnace to boiler, package rooftop units to a chilled water system). This market also has the opportunity to evaluate system interactions, such as how reducing waste heat from lighting in a refrigerated warehouse also reduces refrigeration load, allowing the installation of smaller compressors.

One energy efficiency measure may have very different characteristics depending upon the market. In the residential sector, a homeowner would evaluate the full cost of a new ENERGY STAR® refrigerator when considering the replacement of an old, inefficient, but serviceable unit; for a new home, or someone in the market for a new refrigerator anyway, the cost of the ENERGY STAR® unit is only the additional cost above a standard-efficiency unit. The energy and demand savings also differ – the savings for a retrofit are compared to the old, inefficient unit (at least until the homeowner would have needed to replace the unit at the end of its life), while the savings for new construction or replacement are compared to a new, standard unit.

Finally, “Initiatives” are strategies – sometimes competing – that affect energy-related decisions in each of these markets. Sometimes there is a clear mapping of initiative to

market – for example, the Commercial Direct Install initiative deals exclusively with retrofit projects in existing business (small- to medium-sized) facilities. However, there can be overlapping initiatives, as in the case of the residential Direct Install and Home Performance with ENERGY STAR® initiatives. The analysis takes into account these competing initiatives by de-rating the number of participants in each.

### **3.1.2 Measure Characteristics**

The evaluation of energy efficiency measures is not only a function of market, but is also a function of methodology. There are two basic approaches to determining the energy efficiency (or generation) potential of an efficiency measure: “bottom-up” or “top-down.”

- The “Bottom-up” approach determines initiative savings by developing savings information for a specific measure (e.g., the installation of one compact fluorescent lamp), and then multiplying those costs and savings by the number of lamps installed through the initiative’s time horizon. The bottom-up approach determines costs by taking the cost of each measure and multiplying by the number of installed measures.
- The “Top-down” approach determines initiative savings by forecasting total electric energy sales over the analysis time horizon, and then determines what percentage of those sales may be offset by the installation of a given energy efficiency measure in each year. The top-down approach develops costs relative to energy savings, and then multiplies that “cost per energy saved” by the measure’s energy savings each year to determine each year’s installed costs.

In the Southern Loop analysis, the residential sector DSM and combined heat and power initiative calculations use the bottom-up approach, the Large C&I retrofit initiative uses a hybrid, and the remaining C&I initiatives and the solar PV initiative use a top-down approach. Regardless of approach, all methodologies need to develop factors for the following measure characteristics:

- **Applicability** is either the number of customers eligible for a given measure (bottom-up) or the fraction of the end-use level sales for each building type that is attributable to equipment that could be replaced by the high efficiency measure (top-down). In a top-down example, for packaged air conditioners it is the portion of total building type cooling electrical load consumed by packaged systems).
- **Feasibility** is the fraction of the applicable number of customers or end-use sales for which it is technically feasible to install the high efficiency technology. Numbers less than 100% reflect engineering or other technical barriers that would preclude adoption of the measure. Feasibility is not reduced for economic or behavioral barriers that would reduce penetration estimates. Rather, it reflects technical or physical constraints that would make measure adoption impossible or ill advised.
- **Turnover** is the number or percentage of existing equipment that will be naturally replaced each year due to failure, remodeling, or renovation. This only applies to

replacement/purchase and remodel/renovation markets. In general, turnover factors are assumed to be 1 divided by the measure life. (e.g., assuming that 10% (1/10) of existing stock of equipment is replaced each year for a measure with a 10 year estimated life.)

- **Baseline Adjustment** adjusts the savings downward in future years for retrofit measures to account for the fact that newer, standard equipment efficiencies are higher than older, existing stock efficiencies.
- **Savings Fraction** is used only in the top-down approach, and represents the percent savings (as compared to either existing stock or new baseline equipment for retrofit and non-retrofit markets, respectively) of the high efficiency technology. Savings fractions are calculated based on individual measure data and assumptions about existing stock efficiency, standard practice for new purchases, and high efficiency options.
- **Annual Net Penetrations** are the difference between the Base Case measure penetration underlying the VELCO zonal forecasts and the measure penetrations that could be achieved with maximum sustained efficiency initiatives. In a bottom-up approach, these penetrations are the number of installed measures each year (net of freerider and spillover effects). In a top-down approach, these are percentages of the total economic potential savings achieved for each measure for each year.

### 3.1.3 Initiative Cost-Effectiveness Screening

Neither all measures nor all initiatives are included in the results of this analysis. In many cases, the costs of technology installations – either the technology costs themselves, or the costs of implementing the initiative strategies – are higher than their benefits. In those cases, the measures or initiatives fail to meet a cost-effectiveness test, and their associated energy and demand savings are removed from the analysis results.

#### 3.1.3.1 Cost-Effectiveness Tests

This report uses two cost-effectiveness tests, the Societal and Electric Utility test, but excludes measures and initiatives only on the basis of the Societal test. The Societal test includes the total costs and benefits to society – including customers and utilities. The Electric Utility test only includes the costs and benefits to the electric utility. The Net Benefits are equal to the benefits minus the costs and the Benefit/Cost ratio is the benefits divided by the costs. Both tests are present valued to 2006 and in 2006 dollars.

Societal costs include measure installed costs, deferral replacement credit for some retrofit measures, operation and maintenance costs (savings), fossil fuel costs (savings), fossil fuel environmental externality costs (savings), water costs (savings), and the administrative costs of delivering the efficiency initiatives. Where those items listed above produce cost savings, those items are counted as negative costs.

Societal benefits include the avoided costs of producing electric energy, electric generating capacity, electric transmission and distribution capacity, electric environmental externalities, and risk mitigation benefits.

Electric Utility costs include financial incentives offered to customers to install measures and the administrative costs of delivering the efficiency initiatives.

Electric Utility benefits include the avoided costs of producing electric energy, electric generating capacity, and electric transmission and distribution capacity.

### 3.1.3.2 Net Cost per Winter Peak kW

For calculating the Societal and Utility Net Cost per Winter Peak kW, costs are net of some benefits. For the Societal Net Cost per Winter Peak kW, the societal costs are net of all societal benefits except for transmission and distribution benefits. For the Utility Net Cost per Winter Peak kW, the utility costs are net of electric energy and generating capacity benefits, but not electric transmission and distribution capacity benefits.

### 3.1.3.3 Value of Electric Energy and Demand Savings

The electric avoided costs are comprised of four energy periods, summer generating capacity, and transmission and distribution capacity. The transmission and distribution avoided costs used for this analysis are the same as currently used in the DPS statewide screening tool used by Efficiency Vermont. All avoided costs are stated in 2006 dollars at the generator.

The energy and summer generating capacity avoided costs used in this analysis are derived from the December 2005 avoided costs developed by ICF Consulting for the Avoided Energy Supply Component Study Group (“AESC”). The energy avoided costs in the AESC study were not stated at the generator. Transmission losses were removed so that values used in this analysis are expressed at the generator. Note that the DPS has proposed that these avoided costs be approved by the Board for use by the EEU in program and measure screening.<sup>9</sup>

The AESC summer generating capacity avoided costs did not include a reserve margin. A 20 percent reserve margin was added to the AESC avoided costs for this analysis.

See the table below for the electric avoided costs used in this analysis.

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<sup>9</sup> At this time, the Board has yet to approve the use of the new avoided costs by the EEU. These avoided costs are the subject of an ongoing workshop review process.

**Table 3.1 Electric Avoided Costs (2006 \$, at generation)**

	Energy (\$/kWh)				Capacity (\$/kW-yr)	
	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	Summer Generating Capacity	T&D Capacity
<b>2006</b>	0.0871	0.0718	0.0804	0.0607	44.71	149.45
<b>2007</b>	0.0895	0.0738	0.0837	0.0619	50.78	149.41
<b>2008</b>	0.0748	0.0597	0.0727	0.0505	77.04	149.38
<b>2009</b>	0.0611	0.0485	0.0573	0.0401	82.36	149.42
<b>2010</b>	0.0526	0.0421	0.0491	0.0350	85.94	149.47
<b>2011</b>	0.0541	0.0437	0.0503	0.0366	89.69	149.51
<b>2012</b>	0.0556	0.0453	0.0515	0.0382	93.60	149.44
<b>2013</b>	0.0561	0.0459	0.0521	0.0386	93.81	149.37
<b>2014</b>	0.0567	0.0464	0.0528	0.0391	94.19	149.29
<b>2015</b>	0.0572	0.0470	0.0534	0.0396	94.56	149.21
<b>2016</b>	0.0578	0.0475	0.0541	0.0400	94.94	149.13
<b>2017</b>	0.0594	0.0492	0.0563	0.0418	94.35	149.09
<b>2018</b>	0.0612	0.0509	0.0585	0.0437	93.75	149.00
<b>2019</b>	0.0630	0.0527	0.0609	0.0456	93.16	148.93
<b>2020</b>	0.0648	0.0546	0.0633	0.0477	92.58	148.84
<b>2021</b>	0.0655	0.0551	0.0641	0.0483	93.00	148.77
<b>2022</b>	0.0662	0.0557	0.0649	0.0490	93.43	148.69
<b>2023</b>	0.0670	0.0563	0.0658	0.0497	93.86	148.62
<b>2024</b>	0.0677	0.0568	0.0666	0.0504	94.29	148.54
<b>2025</b>	0.0684	0.0574	0.0675	0.0511	94.72	148.47
<b>2026</b>	0.0692	0.0580	0.0683	0.0518	95.16	148.40
<b>2027</b>	0.0699	0.0586	0.0692	0.0526	95.60	148.32
<b>2028</b>	0.0707	0.0592	0.0701	0.0533	96.04	148.24
<b>2029</b>	0.0715	0.0598	0.0710	0.0541	96.48	148.16
<b>2030</b>	0.0723	0.0604	0.0719	0.0548	96.92	148.09

### **3.2 USE OF DUP SCOPING TOOL**

As a first step at estimating the DSM potential CVPS used the Vermont Distributed Utility Planning Collaborative Demand-Side Management Scoping Tool (the “Scoping Tool” or “DSM Scoping Tool”), developed for the DPS.

#### **3.2.1 Scoping Tool Overview**

The Vermont Distributed Utility Planning Collaborative Demand-Side Management Scoping Tool (“Scoping Tool”) models the energy savings potential and costs of demand-side measures in a targeted service area with minimal user input. Within the “targeted area,” users need only to enter the number of residential customers and commercial and industrial electricity sales data by building type. The tool can accommodate more regionally-specific information (such as the amount of electric space heat or electric

domestic hot water heating) if such information is available. The tool is based on two detailed studies on the potential of demand-side management in the State of Vermont, the “Power to Save” economic potential study and the VELCO Northwest Reliability Project’s DSM assessment.<sup>10</sup> This tool uses the library of measures, the measure assumptions, and the results of these studies to calculate the potential savings and costs for a targeted area.

### **3.2.2 Results for the Southern Loop**

The preliminary findings from the DUP DSM Scoping Tool indicated that additional demand side management could not resolve immediate transmission reliability problems, but may in combination with other investment strategies defer the need for subsequent transmission investment to meet reliability needs in the future. The DUP Scoping Tool analysis used certain assumptions, including a 0 percent penetration of energy efficiency measures (beyond statewide “baseline” efficiency levels) and the results of a 1999 survey effort to identify the amount of electric space heat or electric domestic hot water heating. Overall, the tool estimated that over a 10-year timeframe, DSM could provide 25.8 MW of Winter peak demand reduction at the customer meter (29.4 MW at generation) and energy savings of 136 GWh per year (cumulative) at the meter, or slightly over 20 percent of forecast Southern Loop demand and energy use. The DUP Scoping Tool also helped identify the most likely energy end-uses and sectors to provide significant savings.

### **3.2.3 Residential Results**

The DUP Scoping Tool analysis projected 13.0 MW of winter peak demand savings (14.8 MW at generation) in the residential sector (compared to 22.8 MW winter peak savings estimated by this report). Table 3.2 shows the top ten residential efficiency measures predicted to provide the most winter peak MW savings potential (at the customer meter). Because space heat and DHW fuel-switching and lighting measures account for 73 percent of the residential winter peak MW savings, the DUP tool analysis is highly sensitive to estimates of electric heat use and its cost-effectiveness.

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<sup>10</sup> “Assessment of Economically Deliverable Transmission Capacity from Targeted Energy-Efficiency Investments in the Inner and Metro-Area and Northwest and Northwest/Central Load Zones,” Optimal Energy, Inc., prepared for VELCO, 2003.

**Table 3.2 Top Residential Measures from DUP Scoping Tool**

<b>Top 10 Measures</b>	<b>Program</b>	<b>Winter Peak Savings (MW)</b>	<b>% of Total</b>
ESH Fuel Switch	Retrofit	3.76	29%
DHW Fuel Switch	Retrofit	2.81	22%
Dryer Fuel Switch	Retrofit	1.36	10%
Clothes Washer (E-Star)	Retail	0.41	3%
1 <sup>st</sup> Refrig Early Retirement	Retrofit	0.40	3%
Ceiling Fan	Retrofit	0.40	3%
Torchiere	Retrofit	0.39	3%
CFL (Screw-Base)	Retail	0.34	3%
Hard-wired indoor fixture	Retrofit	0.28	2%
Torchiere	Retail	0.28	2%

Source: DUP Scoping Tool Results

### **3.2.4 Commercial and Industrial Results**

The DUP Scoping Tool analysis also yielded 11.7 MW of winter demand reduction (as compared to this report's estimate of 9.4 MW). Table 3.3 shows the top 15 commercial and industrial measures predicted to provide the most winter peak MW savings potential (again at the customer meter). As with the residential results of the DUP Scoping Tool, electric space heat and water heat fuel switch and efficient lighting provide the bulk of the estimated efficiency savings. Table 3.4 provides the commercial and industrial achievable potential savings by building type and indicates which energy end-uses dominate (electric heat and lighting in most cases). Comparisons of actual Southern Loop electric heat use and inefficiency in existing lighting to the DUP Scoping Tool assumptions would be needed to estimate the accuracy of this efficiency potential estimate.

**Table 3.3 Top Commercial & Industrial Measures from DUP Scoping Tool**

<b>Top 15 Measures</b>	<b>Winter Peak Savings (MW)</b>	<b>% of Total</b>
Heat Fuel Switch – Resistance	2.06	20%
HE fixtures/design Tier I	1.84	18%
Heat Fuel Switch – HP	1.14	11%
WH Fuel Switch	0.70	7%
CFL – interior	0.69	7%
Specular Reflectors	0.58	6%
Retrocommissioning	0.48	5%
EMS/Controls – HEAT	0.42	4%
Integrated Building Design	0.31	3%
High Performance Glazing - HEAT	0.27	3%
Occupancy on/off	0.26	3%
T8 lamp/ballast	0.21	2%
Heat pump water heaters WH	0.21	2%
Commissioning	0.20	2%
Industrial Process	0.15	1%

Source: DUP Scoping Tool Results

**Table 3.4 Commercial and Industrial Savings by Building Type**

<b>Building Type</b>	<b>Winter Demand Savings (MW)</b>	<b>% of Total</b>	<b>Savings Dominated by</b>
Retail	2.12	20%	Space heating, then light.
Education	1.98	10%	Lighting, then space heat
Office	1.80	17%	Space heating & lighting
Health	1.32	13%	Space heating & lighting
Lodging	0.99	10%	Space heating
Restaurant	0.80	8%	Water heating, then light.
Industrial	0.64	6%	Indoor lighting, then misc.
Grocery	0.60	6%	Indoor lighting
Warehouse	0.09	1%	Indoor lighting
Agriculture	0.02	0%	Ventilation

Source: DUP Scoping Tool Results

### **3.2.5 Comparison of Scoping Tool Results to Efficiency Vermont Activities**

A review of Efficiency Vermont activity in the Southern Loop between 2000 and 2005 suggested that the DUP Scoping Tool assumptions would need to be checked against actual field conditions. Efficiency Vermont’s 5-year efforts (March 2000 through September 2005) yielded claimed winter demand savings (at generation) of 5.9 MW and annual energy savings of 30 GWh (at generation). The single largest measure category contributing to winter demand reduction was energy-efficient snowmaking at the ski areas, comprising 3 MW of the demand reduction and 6.6 GWh of energy use reduction. Table 3.5 shows the remaining contributions to winter demand reduction by measure category.

**Table 3.5 Efficiency Vermont Winter MW Savings in the Southern Loop by Measure Category**

<b>Measure Category</b>	<b>Winter Demand Savings (MW)</b>	<b>Percent of Total</b>
Light Bulb/Lamp	0.71	12.18%
Lighting Hardwired Fixture	0.55	9.43%
Space Heat Fuel Switch	0.28	4.76%
Industrial Process Efficiency	0.26	4.42%
Refrigeration	0.25	4.32%
Lighting Efficiency/Controls	0.23	3.91%
Compressed Air	0.19	3.28%
Cooking and Laundry	0.11	1.96%
Motor Controls	0.10	1.73%
Other Fuel Switch	0.08	1.40%
Hot Water Fuel Switch	0.07	1.16%
Ventilation	0.04	0.61%
Hot Water Efficiency	0.02	0.42%
Design Assistance	0.02	0.36%
Motors	0.02	0.28%
Space Heat Efficiency	0.01	0.23%
Air Conditioning Efficiency	0.01	0.19%
Thermal Shell	0.01	0.11%

Source: Query of Efficiency Vermont database 2000-2005

Efficiency Vermont’s efforts do suggest that electric heat and lighting opportunities have contributed to winter demand reduction; however, electric heat fuel switching has not played as great a role for Efficiency Vermont as in the DUP Scoping Tool analysis. Additionally, industrial process efficiency and refrigeration each provided demand savings equal to space heat fuel switching, two measure categories not estimated by the DUP Scoping Tool analysis to provide significant potential.

**3.2.6 Research Questions Resulting from the DUP Scoping Tool and Efficiency Vermont Reviews**

The review of the Efficiency Vermont track record in the Southern Loop suggested the possibility that site conditions in the Southern Loop residential and C&I sectors might differ, perhaps significantly, from the assumptions in the DUP Scoping Tool. Specific questions identified to address in the Southern Loop Analysis included:

- Given the Southern Loop avoided costs and fossil fuel avoided costs, are fuel switch measures cost-effective with actual, not DUP Scoping Tool, assumptions?
- Given Efficiency Vermont’s project experience, both in identifying fuel switch opportunities and in completing fuel switch projects, are the residential electric space and DHW heating saturation rates still applicable?
- Again, given Efficiency Vermont’s project experience, how should the DUP Scoping Tool’s assumptions for commercial and industrial electric space and DHW heating

measures be revised? What percent of the potential has Efficiency Vermont already realized?

- How accurate are the DUP Scoping Tool's estimates of baseline efficiency levels for both residential and commercial/industrial lighting? What are new technologies not included in the DUP Scoping Tool that should be incorporated in the Southern Loop analysis?
- What are the industrial energy efficiency measures that should be included in the Southern Loop Analysis? Should they be general measures, or measures specific to Southern Loop industries?

### **3.3 RESIDENTIAL ENERGY EFFICIENCY ACHIEVABLE POTENTIAL**

The residential analysis is based on developing and aggregating savings and costs from individual measures installed in existing and new homes in the Southern Loop. For any given measure, savings are the product of the penetration of that measure over the analysis period times the measure's respective per unit savings – annual kWh, summer kW and winter kW. The penetration of a measure is a function of either its planned replacement or installation – at or near the end of its useful life or during new construction – or its accelerated retirement or replacement. The analysis estimates measure penetrations both with and without the more aggressive Southern Loop efforts in place. Costs are defined at both the measure level (per unit installed costs and utility incentives) and at the initiative level (staff, marketing, program tracking and reporting, etc.)

Measures include a mix of efficient technologies (e.g., high efficiency appliances), improved practices (air conditioning charge and airflow), and fuel switching activities (space and water heating and gas-burning appliances). Many of the measures analyzed are currently being promoted by Efficiency Vermont, though several of the proposed initiative designs, i.e., implementation strategies, are not currently being pursued by Efficiency Vermont.

#### **3.3.1 Residential Sector Market**

There are a total of 35,200 homes in the six load zones comprising the Southern Loop area with Bennington the largest at 9,180 homes and Bromley the smallest at 734 (Table 3.6). Of these homes, 5,810, or approximately 16.5% of the total, are low-income occupied. Single family dwellings comprise 69% of the homes and multifamily 31%. Based on a 1999 survey by CVPS the electric space heat saturation in existing homes is estimated to be 5.1% and the electric hot water saturation is estimated at 40%. Space and water heater market shares for other fuels are derived from the recently completed statewide residential appliance saturation survey ("RASS"). The estimate of new

construction starts is based on extrapolating the actual number of new homes built in Windham and Bennington counties from 2000 -2004.<sup>11</sup>

**Table 3.6 Residential Housing Characteristics**

Zone	All customers	Non-low-income customers	Low-income	Annual New Homes	Electric DHW	Electric Space Heat	Oil Heat	Kerosene Heat	LP Heat
Bennington	9,180	7,267	1,913	80	3,675	468	5,509	475	1,390
Brattleboro	6,983	6,193	790	51	2,795	356	4,190	361	1,058
Bromley	734	651	83	5	294	37	440	38	111
East	8,291	7,354	937	60	3,319	423	4,975	429	1,256
Stratton	2,431	1,924	507	21	973	124	1,459	126	368
West	7,581	6,001	1,580	66	3,035	387	4,549	392	1,148
<b>Aggregate</b>	<b>35,200</b>	<b>29,390</b>	<b>5,810</b>	<b>283</b>	<b>14,090</b>	<b>1,795</b>	<b>21,123</b>	<b>1,822</b>	<b>5,331</b>

3.3.1.1 Residential Electricity Use

Approximately 40% of all electricity consumed in the Southern Loop is by residential customers. Table 3.7 shows this consumption by load zone. Seventy percent of all residential electricity use is consumed in just three load zones. Within the Southern Loop, annual residential electricity usage has increased an average of 2% in recent years.

**Table 3.7 Residential Electricity Use Characteristics**

Zone	MWh	% of Total	Annual Growth Rate (1998 – 2004)
Bennington	54,781	23%	2%
Brattleboro	41,437	18%	2%
Bromley	6,762	3%	1%
East	54,839	23%	2%
Stratton	20,467	9%	3%
West	55,207	24%	2%
<b>Aggregate</b>	<b>233,493</b>	<b>100%</b>	<b>2%</b>

Source: CVPS

3.3.1.2 Past Energy Efficiency Efforts

Going on its seventh year of operation as Vermont’s efficiency utility, Efficiency Vermont has achieved some notable successes. Efficiency Vermont has both attained significant energy and demand reductions and has permanently changed the market for efficient products and services in the state. If not for these market changes, most of the proposed residential goals for the Southern Loop project would need to be reduced.

While Efficiency Vermont continues to be a nationally recognized leader in the energy efficiency field, there remains significant untapped efficiency potential for the Southern

<sup>11</sup> [www.housingdata.org](http://www.housingdata.org)

Loop Initiatives. This is a function of both the past focus of Efficiency Vermont programs and the difficulty in getting new technologies to fully penetrate the market.

For example, Table 3.8 shows, for certain critical residential measures, the number that customers purchased and/or had installed through Efficiency Vermont programs in the Southern Loop. Through the end of 2005, Efficiency Vermont has had some success in promoting ENERGY STAR fixtures and compact fluorescent lamps (“CFLs”), with nearly 60,000 purchased in the Southern Loop through the end of 2005. This translates into slightly less than 2 efficient lighting products per home. An analysis done in mid-2005 of EVT program efforts in the Southern Loop identified CFLs as the single largest source of winter demand savings, representing nearly 24% of all residential and C&I savings.

In comparison, the proposed Southern Loop Efficient Products Initiative estimates that approximately 14 CFLs will be purchased per residential customer over the ten-year time frame of the initiative. While this is an aggressive goal, it reflects the dramatic drop in CFL prices, considerably improved product quality, the greater number of CFL lamp types available, and an increase in the number and type of retailers that now stock and promote the product.

**Table 3.8 Efficiency Vermont Measure Installations Through 2005**

<b>Measure</b>	<b>Number purchased/installed</b>
CFLs	50,135
Hard-wired fixtures	8,484
Space heat fuel switch	32
Hot water fuel switch	53

While Efficiency Vermont has demonstrated success in promoting efficient lighting products, it has been less successful in tapping the market for space and hot water fuel switching. Efficiency Vermont results for these measures reflect, in part, the greater focus of its programs on lost opportunity and market transformation activities. In addition, even with large customer incentives, there remain significant customer capital cost barriers to overcome, particularly for space heat fuel switching.

### **3.3.2 Markets and Measures Analyzed**

In the residential analysis, individual measures are bundled into seven proposed initiatives. The same measure may be promoted through more than one initiative reflecting the different opportunities that a program administrator has to influence consumer selection. Table 3.9 maps the proposed residential initiatives against the opportunities they address. Note that some initiatives pursue both markets. Under an Efficient Products initiative, appliance sales typically occur for replacement purposes. However, CFL sales are often a combination of sales to replace failed incandescent lamps and customer purchases to remove and replace operating incandescent lamps. Similarly,

central air conditioner installations in the HVAC initiative will be a mix of both replacements of failed units and installations in homes that did not already have central cooling.

**Table 3.9 Proposed Residential Southern Loop Initiatives**

<b>Initiatives</b>	<b>Opportunity Type</b>
Efficient Products	Lost Opportunity
Turn-In	Retrofit
Residential New Construction (“RNC”)	Lost Opportunity
HVAC	Lost Opportunity
Home Performance	Retrofit
Direct Install	Retrofit
Low Income	Retrofit

In the analysis, many measures are characterized by the type of housing stock where they are installed. For some measures, assumed savings and cost vary depending on whether it is installed in a new home, existing home, or low-income dwelling. Further, for many measures different single family and multifamily cost and savings are assumed. In total, over 170 individual measure/market combinations were analyzed. Finally, water heater measures are further characterized by whether they are installed on a timer-controlled water heater or an uncontrolled water heater. Table A-2 in Appendix A lists all of the measures examined and their estimated costs and savings.

While this analysis examined a comprehensive set of measures, the list was not exhaustive. The analysis focused on technologies and practices that are currently available and that could be pursued at a local level within the areas served by the Southern Loop. As a result, this analysis excluded technologies which are not yet fully commercialized, e.g., heat pump water heaters, or for which a more regional or national strategy would be necessary to influence the market for the product, e.g., consumer electronics.

### **3.3.3 Methodology**

The residential analysis uses a “bottom-up” methodology. The principal measure attributes are its cost, assumed incentive, and energy and demand savings. Other measure inputs include:

- applicability factor – the number of households where a measure could be applied
- measure lifetime – used to determine the turnover rate for lost opportunity replacement measures, i.e., their applicability factor

- feasibility factor – an adjustment to the applicability factor that accounts for often physical, technological or other constraints that prevent the complete replacement of a less efficient baseline technology by a proposed measure.

Housing characteristics include number of dwellings by type, current heating and hot water fuel, and end-use or measure saturations. Finally, for each proposed measure penetration estimates are developed to determine the incremental impact of the proposed Southern Loop program efforts.

The measure and penetration rate screening tool inputs, including applicability and feasibility factors, are described more fully below.

#### 3.3.3.1 Measure Cost and Savings Characteristics

The large majority of measures were characterized using information from the Efficiency Vermont Technical Reference Manual (“TRM”). The TRM is used by Efficiency Vermont and by the DPS to determine per unit savings impacts and lifetimes of measures installed through Efficiency Vermont programs. These estimates are informed by both national and local data sources, including on-going evaluations of Efficiency Vermont programs by the DPS. The TRM also includes measure costs that were used in this analysis. Using the TRM provides both savings estimates that are Vermont-specific and that are disaggregated at a level necessary for this analysis. For example, the TRM provides different space and water heating fuel switching savings estimates depending on what fossil fuel is being used. These savings estimates have been informed by several years of actual Efficiency Vermont program experience.

Demand impacts were developed for each measure by adjusting the energy savings estimates based on end-use load shapes. Southern Loop end-use load shapes were developed using a proprietary data base developed by eShapes. The database assigns a kWh value, relative to each major end use, for each of the 8,760 hours of the year, based on geographic location, building type, combination of space heating and water heating fuel, and whether there is air conditioning. Data from the closest geographic location of Albany, NY were used for this analysis. The Southern Loop costing period definitions were then used to determine the proportion of energy use that fell into a given costing period bin. Coincidence factors were then developed for summer and winter peak periods through examination of the average and peak values assigned to the respective bins. Table A-3 in Appendix A provides the coincidence factors used in the residential savings analysis.

#### 3.3.3.2 Measure Incentives

To achieve the significant savings from the proposed portfolio of residential initiatives, incentive levels were set at or above current Efficiency Vermont program offerings. For most measures, incentives were set equal to 50 to 100 percent of the incremental cost of the measure. For new construction and fuel switch measures this results in large per

measure incentives. Such incentives can be justified given the lost opportunity considerations in residential new construction and the high capital cost hurdle involved in convincing a home owner to replace their space or water heating equipment. Table A-1 in Appendix A lists the incentive assumptions for most of the measures analyzed, in terms of percentage of incremental cost.

#### 3.3.3.3 Measure Applicability and Feasibility Factors

The theoretical maximum number of a measure that can be installed is defined and constrained by several considerations that are expressed as an applicability factor. This factor considers current saturations of the baseline technology, turnover of that technology as a function of normal replacement cycles defined by measure lifetime, and the future installation of the technology in homes that did not already have it. For this analysis, current saturations of technologies were defined by a combination of billing analysis and the results from the Vermont residential appliance saturation survey. As noted above, measure lifetimes are typically provided in the TRM.

Feasibility factors are used to adjust the number of measures that can realistically replace a baseline technology due to physical, technological or other impediments. For example, the number of water heaters that can have a tank wrap installed is limited by the location of the tank – there must be sufficient clearance between the tank and any adjacent walls to allow the wrap to be installed. Feasibility factors, when used, were estimated based on past program experience with the measures.

#### 3.3.3.4 Measure Cost-Effectiveness

Before developing total savings in the residential sector, measures that do not meet the societal cost-effectiveness test need to be removed from the analysis. The list of analyzed measures that failed the cost-effectiveness test and were removed from the analysis are:

- Hot tub fuel switch (from electric to fossil fuel);
- Domestic Hot Water fuel switch to:
  - Kerosene (instantaneous, both controlled and uncontrolled accounts)
  - Propane (instantaneous and direct-fired, both controlled and uncontrolled accounts, and indirect-fired, controlled accounts)
  - Oil (direct-fired, both controlled and uncontrolled accounts)
- Dishwasher upgrade (retrofit)

#### 3.3.3.5 Program Penetrations

For most retrofit measures a series of penetration curves were developed for each zone that yielded an 80 percent penetration of the measure, where applicable and feasible (see Appendix A, Tables A-6(a) through A-6(f)). These penetrations estimated the total expected program impacts, including any baseline measure installations that would have

occurred in the absence of the Southern Loop initiatives plus any program spillover that occurred, but for which incentives were not paid. Table 3.10 shows that program implementation is staggered, with efforts in the Bennington and Brattleboro zones starting in 2008.

**Table 3.10 Retrofit Measure Penetrations**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
<b>Aggregate</b>	4.1%	8.6%	13.5%	13.6%	13.6%	13.3%	9.2%	4.1%	0.0%	0.0%
<b>Bennington</b>	0	0.01	0.03	0.06	0.12	0.29	0.2	0.09	0	0
<b>Brattleboro</b>	0	0.01	0.03	0.06	0.12	0.29	0.2	0.09	0	0
<b>Bromley</b>	0.075	0.15	0.225	0.2	0.15	0	0	0	0	0
<b>East</b>	0.075	0.15	0.225	0.2	0.15	0	0	0	0	0
<b>Stratton</b>	0.075	0.15	0.225	0.2	0.15	0	0	0	0	0
<b>West</b>	0.075	0.15	0.225	0.2	0.15	0	0	0	0	0

For lost opportunity programs, implementation activities continued through 2016. Measure penetrations were developed based on relevant program experience by Efficiency Vermont and others. Similarly, baseline measure penetrations were also developed using information from Efficiency Vermont program efforts, national data sources (e.g., state level ENERGY STAR appliance market share estimates developed for the Department of Energy (“DOE”)), and the residential appliance saturation survey.

### **3.3.4 Initiatives and Budgets**

Budgets were developed for each of the seven proposed residential initiatives. Budget inputs included incentives, staff and subcontractor labor, marketing, evaluation, and initiative tracking and reporting. While who ultimately implements any enhanced Southern Loop initiatives has yet to be determined, we developed initiative budgets assuming that any implementation efforts were incremental to current Efficiency Vermont program activities in the Southern Loop, and in the case of initiative evaluation, incremental to any DPS evaluation efforts.<sup>12</sup> One initiative – the Appliance Turn-In Initiative – was eliminated after the analysis concluded that the initiative failed the societal cost-effectiveness test. Although the individual measures of a potential Appliance Turn-In Initiative would be cost effective, the relatively small total magnitude of benefits provided by those measures does not warrant the administrative and managerial costs such an initiative would require for successful operation.

Provided below is a brief description and discussion of any key assumptions regarding program staffing, incentives and implementation for each initiative. More complete Initiative descriptions are included in Appendix C.

<sup>12</sup> Note that this analysis assumes Efficiency Vermont program efforts undertaken prior to the implementation of the 2006 EEU budget adjustment.

#### 3.3.4.1 Efficient Products

This program promotes the purchase of efficient (ENERGY STAR) lighting and appliances at retail. While the large majority of participants are residential customers, non-residential customers are not excluded. In the analysis, however, all customer savings were allocated to the residential sector. Most of the program's savings are from lighting (CFLs). In the past, most CFLs sold through Efficiency Vermont's program used instant rebates. More recently, Efficiency Vermont has been implementing joint negotiated cooperative promotions with manufacturers and retailers to obtain either wholesale or retail price reductions. These efforts have both increased the number of efficient lighting products sold and reduced the costs to do so. Proposed incentives are generally consistent with current program offerings, except for the proposed clothes washer rebate which is higher to more completely cover the incremental cost of the measure.

#### 3.3.4.2 Residential New Construction

This program promotes the construction of efficient new homes and the installation of efficient products within that home. In 2007, the recently implemented changes to the ENERGY STAR Homes specification will be fully in place. Builders and homeowners will be encouraged to exceed the ENERGY STAR Homes specifications, particularly for electric end uses. Given the low penetration of both electric space and water heating in Vermont new construction, most of the electricity savings from this program come from the installation of efficient lights (both CFLs and fixtures). Significant non-electricity energy benefits also accrue from this program. The proposed incentive levels exceed current Efficiency Vermont program offerings to attain higher initiative penetration rates.

#### 3.3.4.3 Home Performance

This program builds on current efforts by Efficiency Vermont to develop a sustainable contractor infrastructure that promotes and undertakes comprehensive whole house retrofit activities. Currently, EVT provides contractor training services. Homeowners bear the cost of any audit/assessment and Efficiency Vermont provides a 3 ½ percentage point interest rate reduction on any financed home improvements. In addition to the more typical Home Performance measures of insulation and air sealing, this initiative also seeks to encourage consumers to upgrade their dishwashers and clothes washers. Proposed initiative incentives are in addition to any current program interest rate reductions.

#### 3.3.4.4 HVAC

This program promotes both the purchase of high efficiency central cooling equipment and its proper installation. It also proposes to continue efforts to promote the purchase of furnaces with high efficiency blower fans. Note that recently passed efficiency standards in Vermont may remove the fan measure from consideration as an initiative offering.

#### 3.3.4.5 Direct Install

This program provides a means for homeowners to have a comprehensive home assessment and measure installation at a significantly reduced cost. As the program relies

on initiative staff or subcontractors to make services available, as opposed to contractors promoting this program through the Home Performance Initiative, much higher levels of participation are assumed. This is also the principal means that fuel conversions are promoted.

#### 3.3.4.6 Low Income

This program builds on current low income program offerings. The majority of the initiative budget is directed to fuel switching activities.

### 3.3.5 Residential Analysis Example

As an example of how the residential savings potential for a specific measure is calculated, we use clothes washers in the Efficient Products initiative as an example.

The size of the eligible market is defined by the current saturation for this technology (from the RASS) times the number of single family non-low income households. For single family dwellings this is:

$0.915$  (percent of clothes washers in homes)  $\times$   $29,390$  (single-family homes)  $\times$   $0.6901$  (percent of non-low-income homes) =  $18,558$  clothes washers in single-family, non-low-income homes

Of these, 40 percent are in homes with electric hot water:

$18,558 \times 0.4003$  (percent of homes with electric hot water) =  $7,429$  clothes washers with electric hot water

The Efficient Products program assumes that the large majority of efficient clothes washers are purchased at or near the end of the useful life of the standard unit they are replacing. The annual available market is then defined by the clothes washer turnover rate, which is the reciprocal of the measure life time:

$7,429 \times 1/14$  (percent of turnover) =  $531$  clothes washers with electric hot water purchased annually

As there are no assumed limitations to replacing a standard clothes washer with an efficient one, the applicability factor for this measure is set to 1.0.

From 2007 through 2016, “with program” market penetrations were estimated to increase from 70 percent (2007) to 79 percent (2016) based on extrapolating 2004 ENERGY STAR market share data for Vermont. The “with program” penetration determines what percentage of the annual eligible market is captured by the initiative. These penetration rates include both direct program participants and those spillover participants that have been influenced by the program, but do not avail themselves of the initiative rebate. For clothes washers, a 30% percent spillover factor was estimated to determine the proportion of initiative participants accepting rebates.

The baseline, or “no program”, penetration of efficient clothes washers was estimated to increase from 26 to 35 percent over the analysis period. These baseline penetrations were based on extrapolations of ENERGY STAR market shares in states that did not have efficiency programs.

The per unit savings estimate of 212 kWh/year was derived from the TRM.

### **3.4 COMMERCIAL & INDUSTRIAL ENERGY EFFICIENCY ACHIEVABLE POTENTIAL**

As with the residential sector analysis, the commercial and industrial (“C&I”) sector analysis sought to estimate the DSM potential based upon actual conditions in the Southern Loop, rather than the statewide assumptions used in the DUP Scoping Tool. While a full census of the 5,679 business accounts in the Southern Loop was beyond the scope of this study, the project team decided upon a tiered methodology based upon customer size. The team would estimate the savings for smaller customers using the same “top-down” analysis approach followed in the statewide potential study and the Northwest Reliability Project, but with modifications to the inputs based upon Southern Loop conditions. For larger customers, the project team would conduct a limited set of site visits to assess conditions at specific types of businesses, and then extrapolate analysis results across similar facility types. The project team selected a peak demand of 100 kilowatts (kW) as a dividing line between large facilities (a total of 156 electric accounts) and small to medium ones.

#### **3.4.1 Commercial and Industrial Sector Market**

The Southern Loop report analyzed the C&I sector according to 15 different building or facility types, identified by function. A 16<sup>th</sup> type, called unknown, was used for locations that do not have a readily-identified function. As seen in Table 3.11, there are a total of 5,679 commercial and industrial electric accounts in the Southern Loop area. Brattleboro, Bennington, and the West zones essentially share the largest number of accounts, each with about 26% of the total. Bromley has the least, with 43 accounts or about 1% of the total. A total of 53% of the accounts could not be categorized, and are thus labeled as unknown. Ignoring the unknowns, the majority of businesses are small offices, warehouses, and small retails.

**Table 3.11 Commercial and Industrial Building Types by Load Zone**

	Bennington	West	Bromley	Stratton	East	Brattleboro	Grand Total
Farm	9	5					14
Grocery	14	10			2	21	47
Health	37	16		1	15	60	129
Industrial	18	10			12	8	48
Large Office	9	9			3	20	41
Large Retail	34	32			15	34	115
Lodging	21	63	7	5	43	24	163
Multi Family	33	66	9	92	11	28	239
Restaurant	35	42		7	12	47	143
School	36	21		6	31	28	122
Ski Area			2	10	5		17
Small Industrial	52	48	2	21	31	118	272
Small Office	128	64	11	39	71	243	556
Small Retail	84	149		7	41	78	359
Unknown	941	773	11	68	521	696	3010
Warehouse	49	135	1	1	120	98	404
Grand Total	1500	1443	43	257	933	1503	5679

Both Bennington and Brattleboro have diverse C&I establishments, with the Brattleboro zone having more health and small C&I (offices and industrial facilities) and the Bennington zone having more retail and multifamily, and greater difficulty in identifying facility types. The West zone has high percentages of lodging, multifamily, and small retail establishments, and the East zone has high percentages of lodging and warehouses. The Bromley and Stratton zones have the ski areas in each zone, and consequently have high percentages of multifamily and lodging building types (associated with the ski areas).

**3.4.1.1 C&I Electricity Use**

Approximately 60% of the electricity in the Southern loop is consumed by Commercial and Industrial customers. Table 3.12 shows the percentage of electricity consumptions of each of the six load zones. The Brattleboro zone uses the most energy (36 percent), and Bromley the least (1 percent) By building type, 36 percent of all electricity is used by the industrial subsector (small and large facilities). Another 11% percent is used by the 53 percent of accounts that could not be categorized.

**Table 3.12 Commercial and Industrial Electricity Use**

Zone	MWh	% of Total
Bennington	99,219	27%
Brattleboro	131,158	36%
Bromley	4,444	1%
East	35,243	10%
Stratton	23,152	6%
West	71,181	20%
Grand Total	364,396	100%

### 3.4.1.2 Past Efficiency Efforts

As was discussed in the residential sector section, Efficiency Vermont has over five years of implementation experience in the Southern Loop, affecting all energy efficiency markets through its New Construction and Existing Facilities initiatives. Table 3.13 summarizes the Coincident Winter Demand savings documented by Efficiency Vermont resulting from installed projects between 2000 and 2005, a total of 4.7 MW of savings. The bulk of the coincident demand savings resulted from mountain operations efficiency improvements at the main ski areas in the Southern Loop, accounting for 3 MW of demand reduction. Because the C&I sector methodology does not address major ski area expansions (see below), Efficiency Vermont's past efforts have captured 1.7 net winter MW of demand savings that are comparable to the Southern Loop report results.

However, the site visits conducted as part of the Southern Loop results (see below) led the project team to revise DUP Scoping Tool assumptions about baseline conditions, particularly with regard to lighting. Those site visits also characterized industrial process efficiency opportunities based upon current (i.e., 2006) conditions at Southern Loop industrial facilities. On that basis, these past efficiency efforts are not anticipated to significantly reduce the remaining potential.

**Table 3.13 Commercial and Industrial Sector Winter Demand Savings by Efficiency Vermont**

<b>Measure Category</b>	<b>Winter kW Savings</b>
Industrial Process Efficiency	3142
Lighting Hardwired Fixture	398
Lighting Efficiency/Controls	228
Refrigeration	214
Compressed Air	193
Space Heat Fuel Switch	175
Motor Controls	101
Light Bulb/Lamp	80
Other Fuel Switch	77
Hot Water Fuel Switch	36
Design Assistance	21
Ventilation	17
Motors	17
Space Heat Efficiency	13
Air Conditioning Efficiency	11
Other	5
Space Heat Replacement	3
Thermal Shell	2
Hot Water Efficiency	2
Cooking and Laundry	1

### **3.4.2 Markets & Measures Analyzed**

Across the C&I markets, the analysis evaluated 58 different energy efficiency measures for 12 different building types. Table B-15 in Appendix B lists the measures considered and the following list presents the analyzed building types:

- Office
- Retail
- Grocery
- Warehouse
- Education
- Health
- Lodging
- Restaurant
- Agriculture
- Industrial
- Multifamily
- “Other”

Not all efficiency measures apply to all markets – for example, the Super T8 relamp/reballast measure was considered only for the retrofit market, while Super T8 fixtures were considered for the equipment replacement, remodel/renovation, and new construction markets. There are a total of 1,955 combinations of technology, building type, and market, each combination representing an individual measure. Optimal Energy also developed measure “packages” for the large C&I customers, consisting of site-appropriate combinations of these individual measures (with costs or savings adjusted based upon facility characteristics).

Optimal Energy developed individual technology cost and performance characteristics using public and private information sources, including the EVT Technical Reference Manual developed and continually updated and maintained at EVT since 2000. Also used were: VELCO forecast data; EIA Commercial Building Energy Consumption Survey (“CBECS”); California Energy Commission measure cost and savings database; publications from national organizations such as American Council for an Energy Efficient Economy (“ACEEE”), Lawrence Berkeley Laboratory (“LBL”), and New Buildings Institute (“NBI”); utility, statewide, and regional technology, baseline and market assessment studies for areas in the Northeast United States; and communications with manufacturers and vendors. Appendix B provides detailed measure-level analysis inputs and source notes.

### **3.4.3 Methodology**

The C&I analysis takes a “top-down” approach that begins with the total electric sales forecast for each Southern Loop load zone analyzed. In summary, the energy savings potential for each measure (percent of existing measure load) is multiplied by the existing

and forecast load attributable to that measure for each building type to arrive at measure potential. Below is described this process and the major assumptions and data sources used. Appendix B provides detailed measure-level analysis inputs and source notes.

### 3.4.3.1 Eligible Electric Sales

CVPS provided forecasted electric sales for all six Southern Loop load zones. The project team broke out each zonal forecast into new and existing construction vintage, and then further disaggregated those sales into 12 building types (10 commercial plus industrial and multifamily) and 9 end-use categories. The disaggregation of sales by building type relied on 2004 electric sales data from CVPS and the utility’s identification of customers by building type. Finally, the breakout by end-use relied on end-use-level energy intensities (kWh/sq. ft.) for each building type and 2001 end-use from Regional Economic Research (“RER”). The RER data is based on simulation modeling with upstate New York weather of prototypical buildings developed based on data from over 20,000 energy audits conducted in the U.S. Because of the differences in approach between small-medium and large C&I customers, Optimal also split the sales into three main categories:

- Current and forecast sales for small-medium C&I customers;
- Sales for large C&I customers in 2007 only, as a basis for estimating energy savings for the Large C&I retrofit initiative (see “Initiatives and Budgets,” below); and
- Current and forecast sales for those large C&I customer end uses that were not addressed by the Large C&I retrofit initiative.

Tables B-2 through B-13 in Appendix B show the disaggregated electric sales forecast for each zone by vintage, building type and end use, respectively.

### 3.4.3.2 Application and Development of Measure Level Factors for Small-Medium C&I Customers

The project team applied various technology factors to the forecasted building-type/end-use sales by year to derive the maximum achievable potential for each of the 1,955 separate measures for each of 10 years, as well as the measure packages for the Large C&I retrofit opportunities. As discussed in Section 3.1.2, the basic methodology for developing kWh savings by measure is summarized by the following equation. Section 5 provides an example of this method for a selected measure.

Annual Measure Maximum = Achievable Potential	New or Existing Building End Use kWh Sales Per Year	X Applicability Factor	X Feasibility Factor	X Turnover Factor	X Baseline Adjustment Factor (Retrofit only)	X Savings Factor	X Annual Net Penetration (Achievable - Base Case)
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There were several important gaps in the data required to hone our analysis for the Southern Loop energy efficiency potential. Missing were direct, on the ground, experience with baseline technologies from which pivotal efficiency savings calculations would be derived. The purpose of the site visits was to find out, at least anecdotally, baseline information/evidence on the following end uses:

- Lighting
  - Percentage of installed linear fluorescent lighting, percents of T-12, T-8, and T-5.
  - Percent of incandescent installations by building type.
  - CFL saturation including pin-based configurations.
- Space heat
  - Percentages of conditioned space heated with fossil fuels and/or electricity. Information on the type of electric space heat was especially important along with its prevalence in several building types.
- Domestic hot water
  - Percentages of hot water heated with fossil fuels compared to electricity. Good information on commercial use of electrically heated hot water has been a moving target over the years with changes in use patterns evolving by building type. Available data was considered out of date.

The project team also sought to get better information on the energy use distribution by end use in the following building types:

- Lodging – Use of incandescent lights was an area of particular concern. Part of this effort was to determine a baseline on the use of CFLs in guest rooms.
- Restaurants – Potential large users of electrically heated hot water. While new technologies, including water saving sprayers, have been coming on the market, it is not clear how many have been adopted by the foodservice industry.
- Small retail – Retail outlets, like many in Manchester, have traditionally been strongholds of incandescent lighting. Issues with dimming and spot focus have limited CFLs and linear fluorescents to ambient or valence lighting applications. With the rise of integrated metal halide track lights, OEI wanted to verify that the baseline lighting technology distribution assumptions were accurate.

While performing planned site visits to the above building types, we used every opportunity to explore, as well as vet, end-use baseline assumptions in around 70 non-scheduled locations. In some cases, this consisted of a walk-through from the eyes of a customer, but in most cases, the project team was guided by facilities staff and reviewed and recorded the nameplate data on as many of the main energy consuming systems as possible.

In each planned site visit the project team asked a series of questions, trying to meet with as senior a decision-maker as possible, but in most cases met with available facilities staff at the time of the visit. Other sections of this report show the results of the more detailed

site visits performed. The sample list below indicates the number and variety of the collateral sites that were visited.

#### 3.4.3.3 Development of Measure-Level Factors for Large C&I Customers

For large C&I customers (those with peak demand of 100 kW or greater), the project team conducted site visits to assess energy efficiency opportunities at a limited number of facilities. These site visits yielded approximations of end use breakdowns of electric sales and savings fractions for efficiency measure packages against each end use. Based on the savings fractions, project team staff developed rough estimates of project scopes and cost estimates, using either R.S. Means construction cost averages or Efficiency Vermont project history data. The site visits addressed issues related to applicability and feasibility of measure packages; project team staff took a fairly conservative approach to each facility, assessing opportunities that would be likely to meet customer cost-effectiveness requirements and would use proven technologies.

#### 3.4.3.4 Measure Incentives

The project analysis assumed fairly simplified incentive rules for the C&I initiatives. The assumptions were 50 percent of small to medium C&I customer retrofit projects, 62.5 percent of large C&I retrofit project costs, and 100 percent of the incremental cost of all equipment purchase/replacement, remodel/renovation, and new construction projects.

#### 3.4.3.5 Development of Measure Penetrations

As described above, penetration estimates reflect a higher level of certainty that they can be achieved than statewide estimates developed for the DPS. For interior lighting retrofit measures, a maximum cumulative penetration rate of 60% of eligible opportunities by the end of a decade was assumed. For all other retrofit end-uses a maximum cumulative penetration of 40% was assumed. This contrasts to program experience for some of the best retrofit programs in North America that have achieved around 80%, and various potential studies that estimate between 70-80% achievable penetration. However, it also recognizes that the comprehensive list of technologies considered goes beyond what most programs have strived to get installed in participating buildings. Tables B-34 and B-36 show base case and achievable penetrations for small-medium retrofit measures and notes describing the basis for these estimates.

The project team also assumed that large C&I customers did not achieve 100% of all identified energy efficiency options, but realized an average of 62.5% over a period of four years and then achieved an 80% penetration rate at the end of eight years. Again, this is comparable with the best retrofit programs in North America, and reflect a program design that aggressively pursues these opportunities at these large facilities.

Market driven (non-retrofit) measure penetrations are estimated individually by taking into account current baseline practices, pending and likely impacts of state and national

codes and standards, and experience of other North American programs. Tables B-33 and B-35 in Appendix B show base case and achievable penetrations for market-driven measures and notes describing the basis for these estimates.

The product of the above factors provides measure level kWh savings by year. These kWh savings are then applied to hourly load shape data to derive energy impacts by rating period. Separate RER hourly loadshape data were used for each of the 108 building type/end use combinations. Table B-32 in Appendix B shows the loadshapes.

#### 3.4.3.6 Refining Energy and Demand Savings Estimates

Appendix B Table B-22 shows the ratio of kWh savings to diversified kW impacts for each measure. Each measure kWh savings was divided by these ratios to produce summer and winter diversified peak demand savings. These diversified kW impacts were then multiplied by the coincident factors (in Table B-32) to estimate summer and winter coincident, diversified peak impacts.<sup>13</sup>

In addition to the direct measure impacts, a “cooling bonus” and “heating penalty” were calculated for all interior lighting and office equipment measures. These reflect the effects of reductions in waste heat generated within the building shell as a result of improved efficiency. The cooling bonus increases the kWh savings by 12% and the summer peak kW savings by 28% from reductions in cooling load. The heating penalty results in an increased use of fossil fuel for heating of 0.00175 MMBtu per measure kWh saved. These factors were calculated based on an ASHRAE method, taking into consideration Vermont weather characteristics, load profiles for lighting, cooling and heating, and typical existing HVAC efficiencies.<sup>14</sup>

#### 3.4.3.7 Eligible Stock, Measure Penetration Model and Measure Interactions

New measures can be installed in existing buildings either on an early retirement (retrofit) basis, at the time of natural replacement, or at the time of renovation or remodeling. To avoid double counting, our model tracks the eligible stock of equipment over time, based on the assumed measure penetrations for each existing construction market. For example, if 10% of existing lighting fixtures are retrofitted with high efficiency models in 2003, then only 90% of the original population of lighting remains eligible for efficiency upgrades in non-retrofit markets during 2004. However, assuming the fixtures had only a 5-year measure life, the original 10% of lighting fixtures would again become eligible for replacement in 2008 (five years after original installation date). Similarly, once a building is renovated or remodeled, the opportunity for retrofit is

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<sup>13</sup> Note that coincident factors in many cases are higher than typical because diversity is already included in the kW impacts they are applied to. Typically, “coincident factors” are the product of coincidence and diversity and are applied to undiversified connected load reductions.

<sup>14</sup> Rundquist, R., “Calculating lighting and HVAC interactions”, *ASHRAE Journal*, November 1993.

diminished until the end of the measure lives for those measures installed under the market-driven scenarios.

Some of the technologies modeled are mutually exclusive – that is one or the other could be installed, but not both. For example, standard metal halide high-bay fixtures can be replaced with pulse start metal halides or fluorescent high-bay fixtures. When two or more measures compete with one another, an estimate of the penetration of the measure offering the most per unit savings was first estimated. The penetration of the next competing measure is then estimated based on the remaining potential.

Individual measure savings are not additive. Because of interactions between measures, the total potential for all measures is less than the sum of individual measure opportunities. For example, installing window film to reduce cooling load will lower the savings opportunities for installing a high efficiency air conditioner because the air conditioner will not run as long as it otherwise would have. The total potential estimates take into account all the interactions between measures. This therefore represents the total savings achievable with maximum measure adoption. Note however, that if some measures were eliminated, the potential for remaining measures might increase depending on their original interactions with the removed measure. Appendix B Tables B-29 to B-31 provides interaction factors separately for existing and new construction measures.

#### **3.4.4 Initiatives and Budgets**

Budgets were developed for each of the four proposed C&I sector initiatives. Budget inputs included incentives, staff and subcontractor labor, marketing, evaluation, and initiative tracking and reporting. While who ultimately implements any enhanced Southern Loop initiatives has yet to be determined, we developed initiative budgets assuming that any implementation efforts were incremental to current Efficiency Vermont program activities in the Southern Loop, and in the case of initiative evaluation, incremental to any DPS evaluation efforts.

Provided below is a brief description and discussion of any key assumptions regarding program staffing, incentives and implementation for each initiative. More complete Initiative descriptions are included in Appendix C.

##### **3.4.4.1 Small & Medium Commercial Direct Install**

The initiative would facilitate direct installation of all retrofit measures, either by using a network of private contractors solicited to develop and manage measure installations; or by allowing customers to rely on their own contractors with construction management assistance from program technical staff. The initiative would cover all construction management and project facilitation costs and also underwrite all technical and design assistance for retrofit and replacement measures, as well as for retrocommissioning and commissioning, where appropriate.

#### 3.4.4.2 Large C&I Account Management

The initiative targeting large C&I existing customer facilities (i.e., the 150 customers with demand of 100 kW or greater) would promote high-efficiency, discretionary retrofit opportunities and equipment and system purchase at the time these events naturally occur, including equipment replacement upon failure, building remodeling and minor renovation activities. The program would attempt to capture comprehensive, system improvements when possible. However, it would also address single equipment improvements where the opportunity for more comprehensive upgrades is not available.

The Large C&I customer initiative is designed to establish direct relationships with each of these customers to maximize the capture of both retrofit and lost opportunity projects. The goal of these relationships is to integrate initiative staff into capital planning activities at each Large C&I customer. Being invited to participate at that level with each customer may and likely will require demonstrating value to each Large C&I customer beyond the scope of just obtaining electricity savings (e.g., finding resources to assist with power factor correction, demand management, and other resource impacts).

To do so, the Large C&I Customer initiative is designed to offer comprehensive services, including: design incentives to develop project specifications for retrofit projects; retro-commissioning services (i.e., facility building and process system “tune-ups”); other technical and design assistance on “market-driven” projects; financial incentives both for technologies and labor; and coordination services to assist consumers, design professionals, vendors and contractors to overcome various transaction barriers.

Where appropriate, technical and design assistance services would be provided either by program staff, outside contractors hired by the program, the consumers design team, or some combination of the three, depending on customer needs, and expertise. The initiative is designed to assist in: determining efficiency opportunities; analyzing efficiency opportunities in terms of costs and savings; identifying available products and vendors; contributing to design and specification documents; and procuring commissioning or retro-commissioning services and establishing scopes of work.

#### 3.4.4.3 Commercial and Industrial Lost Opportunity

The initiative targeting existing customer facilities would promote high-efficiency, equipment replacement at the time these events naturally occur, including equipment replacement upon failure, building remodeling and renovation activities. As with new construction efforts, financial incentives would be designed to cover the full incremental installed costs of efficient measures (i.e., the full labor and equipment installation costs for retrofit measures, and the incremental labor and equipment costs associated with replacement).

The initiative would cover the full incremental design costs for projects requiring redesign of existing facilities and systems. At the customer’s option, the initiative would reimburse costs related to: extra efforts undertaken by the customer’s designers/vendors,

added project facilitation and/or design management, the procurement of additional technical assistance, or engaging retrocommissioning and commissioning services. Initiative staff or subcontractors would provide services as appropriate if competitive solicitations are unsuccessful.

Measures would comprehensively address efficiency opportunities in existing buildings, including retrofit, renovation and remodel/replacement situations.

#### 3.4.4.4 Commercial & Industrial New Construction

The C&I new construction initiative would promote the installation of comprehensive efficiency measures using a systems approach that capitalizes on interactions between technologies serving multiple end-uses. For example, multiple building systems would be optimized, recognizing sizing and other interactions between systems.

The initiative would target all C&I new construction (new buildings or significant expansion) and major renovation. Major renovation is defined here as either a complete “gut-rehab,” or at a minimum complete replacement of the HVAC system. Other renovation opportunities would be included under the C&I Existing Construction initiative. The C&I new construction initiative will offer comprehensive services including: financial incentives both for measure costs and design and analysis costs; technical and design assistance; and coordination services to assist consumers, design professionals, vendors and contractors to overcome various transaction barriers.

Technical and design assistance services may be provided either by program staff, outside contractors hired by the program, the consumers design team, or some combination of the three, depending on customer needs, and expertise. They will assist in: determining efficiency opportunities; analyzing efficiency opportunities in terms of costs and savings; identifying available products and vendors; contributing to design and specification documents; and procuring commissioning services and establishing commissioning scopes of work.

The initiative would focus its research, marketing and outreach efforts to ensure it is aware of new construction opportunities as early as possible. Whenever possible it will seek to engage with the customer prior to selection of a design team and development of designs. Program staff will work collaboratively with customers as a full partner in the design team, and seek to influence designs comprehensively before any decisions are made regarding the building envelope, equipment and systems.

#### 3.4.5 Small to Medium Commercial Analysis Example

The following example shows the basic approach to estimating C&I potential, for a T8 fluorescent fixture installed in lieu of a T12 fixture at time of remodel in an office

building. Note the actual values were selected for illustrative purposes and do not necessarily represent the exact values in the analysis.

Parameter	Description	Value	Result
Building type/ end use electric forecast	Electricity sales for interior lighting for offices.	100,000 MWh	100,000 MWh
Applicability factor	% of interior office lighting energy use from linear fluorescent fixtures	x 80%	80,000 MWh
Feasibility factor	% of linear fluorescent fixtures that could be replaced with T8 technology	x 100% (all linear fluorescents could feasibly be replaced with T8s)	80,000 MWh
Turnover factor	% of existing office space that will naturally replace lighting as a remodel in given year	x 6.7% (typical T12 fixture life of 15 years would result in 1/15 or 6.7% replacement/year on average)	5,333 MWh
Savings fraction	% energy savings from shifting from T12 to T8 technology (represents weighted average for different fixture sizes and number of lamps)	x 20%	1,067 MWh
Net penetration	The increase in penetration of T8 fixtures as a result of the initiative. This is the achievable penetration – base case penetration. Assume achievable is 75% and base case is 65%.	x 10%	106.7 MWh

In this example, installing T8s in place of T12s in offices at the time of remodel offers 106.7 MWh of potential for the year in question. Note that because this technology market has largely been transformed already, base case penetration is already very high, and opportunities to expand it are limited. Given the above result, for this measure:

1. Demand impact =  $(106.7 \text{ MWh} * 1,000 \text{ kWh/MWh}) / 4000 \text{ kWh/kW} = 26.7 \text{ kW}$
2. Total incremental cost =  $(106.7 \text{ MWh} * 1,000 \text{ kWh/MWh}) * \$0.10/\text{kWh} = \$10,670$

### **3.4.6 Future Effects of Efficiency Vermont Programs**

The estimate of achievable potential in the Southern Loop, as described above, represents the total annual electrical energy and peak demand savings achievable as compared to

current and expected practice without any intervention. However, Efficiency Vermont currently provides efficiency services throughout the state, including in the Southern Loop. As a result, this analysis estimates the portion of the Southern Loop efficiency opportunities that Efficiency Vermont would likely capture given current activities and funding levels (exclusive of program additions to follow from the 2006 EEU budget adjustment).

A number of differences exist between Efficiency Vermont's projected statewide C&I performance and the opportunities existing within the Southern Loop. In the past few years, Efficiency Vermont has captured a fairly large portion of savings from ski area expansions, particularly related to snowmaking activity – which is reflected in the Efficiency Vermont projections for future C&I savings. Some of these large projects occurred in the Southern Loop. As discussed above, the analysis of energy efficiency potential did not include large ski area expansion projects because such expansions are only probabilities and would significantly skew the results. The forecast of Efficiency Vermont spending and savings in the Southern Loop similarly omits large ski area expansion projects to ensure a consistent comparison.

Efficiency Vermont has also captured high savings from commercial and industrial new construction activity statewide. However, Vermont has generally enjoyed fairly robust growth in the past 5 years, particularly in the northwestern part of the state. The Southern Loop data provided by CVPS forecasts very little new construction activity during the planning horizon. The forecast of future Efficiency Vermont efforts also adjusts for this.

The starting point for estimating the C&I efficiency savings Efficiency Vermont would likely capture within the Southern Loop, absent the effects of the 2006 EEU budget adjustment, is to assume that the current Efficiency Vermont savings goals and budgets (2006-2008) represent the future yield (\$/kWh saved) and funding level (level funding) throughout the planning period. We scaled the Efficiency Vermont statewide C&I savings projections to the Southern Loop assuming savings are in proportion to the 2004 C&I electrical consumption in the two areas (i.e., statewide and the Southern Loop).

For C&I new construction, the analysis makes three adjustments:

- First, it eliminates any large C&I new construction from Efficiency Vermont's new construction projected savings;
- Second, it adjusts the small and medium C&I new construction savings downward by the ratio of estimated new construction activity in the Southern Loop (0.25%/yr) to the estimated historic annual growth statewide from 2001 to 2004 (0.89%/yr);
- Finally, it scales the adjusted statewide new construction savings to the Southern Loop proportional to the Southern Loop 2004 C&I electric load relative to statewide 2004 C&I electric load.

For projected EVT residential savings and budgets in the Southern Loop, the analysis scales the statewide EVT savings and budgets proportional to the Southern Loop 2004 residential MWh sales relative to statewide 2004 residential sales. A portion of the EVT

multifamily savings from individually metered units was allocated to the residential savings estimate for the Southern Loop. That same amount of multifamily savings was excluded from the C&I savings estimate for the Southern Loop.

Output Table 18 presents the EVT projected costs and savings for the Southern Loop. Output Tables 19 to 24 show the EVT projected costs and savings by the six load zones of the Southern Loop.

### **3.5 PHOTOVOLTAICS**

Current installed photovoltaic capacity in Vermont is approximately 1 MW. Reflecting trends in other domestic and international markets, the demand for photovoltaic systems in Vermont is growing rapidly. The new installed capacity in 2006 is expected to exceed 250 kW. The installed costs for PV currently average ~\$8.00/Watt DC capacity. Due to tight supply conditions for modules, driven by a tight global market for high quality refined silicon feedstock, installed costs have been stable or increased slightly over the last year. This situation is likely to remain through 2007, after which increased global production capacity should allow for prices to resume their historic decline (which has averaged 2% to 5% per year).

Support for demand in Vermont has been provided by the Vermont Solar and Small Wind Incentive Program, and more recently (for systems installed and put into operation during calendar years 2006 and 2007) by federal tax incentives.<sup>15</sup> The incentives in Vermont currently cover approximately 20 to 25% of the initial installed costs for systems. The tax incentives further improve customer economics, so that the expected lifetime average costs for a PV system are approximately \$0.20 to \$0.25 per kWh. Therefore, even with incentives, photovoltaic electricity in Vermont remains at a premium above alternative energy costs. That said, customer demand, due to a variety of values that customers associate with photovoltaic power, is high. Evidence of this demand is provided by the fact that the last two rounds of incentive funds that have been made available have been fully reserved within relatively short time horizons.

An extension of the federal tax credits, along with a stable source of funding to support installed costs, should provide the opportunity for increased installer activity, leading to greater economy of scale and business efficiencies.

#### **3.5.1 Expected Trends**

Historic trends suggest that photovoltaic installations in Vermont will continue to grow at 20% or more annually. The level of development anticipated in the PV Options analysis presented in this paper is significantly higher than the anticipated baseline growth rate, particularly as the development would be concentrated specifically in the Southern Loop.

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<sup>15</sup> Note that CVPS has made contributions to the Vermont Solar and Small Wind Incentive Program as a part of its ratepayer benefits plans adopted in accordance with the requirements of the Board's Orders of June 13, 2002 and November 24, 2003 in Docket No. 6545.

A stable market commitment and signal will be required to focus industry attention on deploying systems in the Southern Loop. Vermont is fortunate to have a strong installer network and base to build upon in this regard.

In the first two rounds of funding for the Vermont Solar and Small Wind Incentive program four photovoltaic systems, with a total installed DC capacity of 9.6 kW have been installed for customers with zip codes matching those on the Southern Loop. There has been greater participation and installation in the broader CVPS territory, for example in the second round of the incentive program seven grid tied systems with a total capacity of 28 kW have been installed in the CVPS territory.

### **3.5.2 Markets and Measures Analyzed**

The photovoltaic effect converts light energy (photons) to electricity. Solar cells are composed of semi-conductor materials, carefully designed and manufactured so that when they are struck by light, electrons are freed to flow in an electrical circuit external to the solar cell. A number of different materials are used in the solar cells currently on the market, including single crystal silicon, polycrystalline silicon, amorphous silicon (no crystalline structure), copper indium diselenide, and cadmium telluride. For panel or flat-plate photovoltaics, manufacturers typically combine a number of solar cells, wired in parallel or in series in a single unit (solar module) which is designed to produce specific voltage and current under full sun conditions.

A typical photovoltaic system, as analyzed in this study, consists of an array of photovoltaic modules that produce direct current electricity. The electricity from the array is fed to an inverter that produces high-quality, grid compatible alternating current electricity. The AC electricity from the inverter is directly connected to an electric service panel, and is subsequently distributed to meet building loads or is fed back to the utility grid. Compliance with standards developed by the Institute of Electrical and Electronics Engineers (“IEEE”) assure the inverters used in this type of grid-tied photovoltaic system are not capable of unintentionally back-feeding the utility grid. Equipment requirements and safe installation practices are further addressed by Underwriter Laboratory listings, and the National Electric Code.

Photovoltaics rely on available sunshine and therefore produce intermittent electric power. They will produce electricity any time the sun is shining, but more electricity is produced when the light is more intense (a sunny day) and is striking the PV modules directly (when the rays of sunlight are perpendicular to the PV modules). The efficiencies with which commercially available solar cell convert energy from sunlight to direct current electricity range from 7% to 21% depending on materials and cell type. In Vermont a photovoltaic system with a rated peak output of 1 kW (DC) will produce approximately 1,000 kW hours annually and contain roughly 100 square feet of solar cells (12% cell efficiency)<sup>16</sup>.

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<sup>16</sup> Note that cells with higher or lower efficiencies produce the same amount of electricity per rated Watt of installed capacity. The efficiency of cells impacts the amount of space required to produce the rated output not the output itself.

The photovoltaic analysis in this study addresses the potential for distributed on-site solar electric generation using flat plate modules or building integrated photovoltaic systems. These systems produce electric power “behind the meter” and serve primarily to offset a customer’s electric load and energy consumption. At times of good sunshine and low on site demand, these systems will also feed electricity onto the grid.

This type of photovoltaic system (distributed, modular and flat plate) comprises virtually all of the solar electric systems deployed in Vermont today. It will almost certainly remain the dominant form of technology deployed for at least the near term (<5 years). While new technologies may emerge over the medium to longer term, the current market conditions and applicability led us to exclude options such as central photovoltaic power stations, and concentrating solar power technologies from this analysis.

As described above, photovoltaic systems are a modular, distributed generation, resource that can be deployed across the full spectrum of customer sites. The markets analyzed for this study include residential (single and multi-family), commercial and industrial. All of these customer classes provide opportunities for the deployment of photovoltaic systems. For the achievable potential estimate we narrowed the focus to a specific sub-set of applications including the residential single family, schools, ski areas, and other commercial building types.

### 3.5.3 Methodology

The process of identifying the potential for photovoltaic contributions towards meeting Southern Loop reliability concerns began by estimating the total potential for PV based on number of customers and assumptions about typical PV system size, applicability, and characteristics. This first level of the analysis quickly established an upper bound of what the PV resource could provide and the costs. Data used to estimate the number and type of customers per line segment are presented in Table 3.14

**Table 3.14 Customer Accounts by Line Segment**

	Residential	Mutifamily	Commercial	Industrial
Bennington	7,755	33	1,440	18
Brattleboro:	5,768	29	1,467	8
Bromley:	661	9	34	-
East:	7,413	11	910	12
Stratton:	2,115	102	165	-
West:	6,673	66	1,362	10
<b>Total</b>	<b>30,385</b>	<b>250</b>	<b>5,378</b>	<b>48</b>

Further inputs to the analysis included average available roof space by account type, average applicability, average costs and annual output, and summer and winter peak capacity coincidence factors. The first level of analysis estimates the upper bound of what the photovoltaic resource could provide and the costs. The information from Table 3.14 (above) was used as the potential customer base upon which PV systems could be deployed.

The next step of the analysis was to define assumptions for a typical system in each of the four customer class types: residential single family, multi-family, commercial, and industrial. These assumptions and the calculated upper limit potential for the entire Southern Loop are presented in Table 3.15

**Table 3.15 Southern Loop Estimated PV Resource Potential**

<b>PV Summary Total</b>					
PV System Assumptions by Account Type					
	<u>Residential</u>	<u>Mutifamily</u>	<u>Commercial</u>	<u>Industrial</u>	<u>Totals</u>
Average Roof Space (ft <sup>2</sup> )	1,080	4,320	20,000	20,000	
Total Roof Space ft <sup>2</sup>	32,815,800	1,080,000	107,560,000	960,000	142,415,800
Applicability % of Roofs	20%	20%	20%	20%	
Solar Applicable Roof Space ft <sup>2</sup>	6,563,160	216,000	21,512,000	192,000	28,483,160
Average Space per kW DC (ft <sup>2</sup> )	100	100	100	100	
DC Capacity Potential kW	65,632	2,160	215,120	1,920	284,832
Summer AC Peak Coincidence	65%	65%	65%	65%	
Winter AC Peak Coincidence	20%	20%	20%	20%	
Summer AC Peak kW	32,849	1,081	107,668	961	142,558
Winter AC Peak kW	10,107	333	33,128	296	43,864
Average Annual kWh/DC Watt Installed	1000	1000	1000	1000	
Total Annual MWh	65,632	2,160	215,120	1,920	284,832
Average Installed Cost / DC Watt	\$ 8.00	\$ 8.00	\$ 7.50	\$ 7.50	
Total Investment	\$ 525,052,800	\$ 17,280,000	\$ 1,613,400,000	\$ 14,400,000	2,170,132,800

The findings indicate that even with conservative assumptions regarding square footage and applicability, a significant solar electric resource of more than 142 MW of summer peak capacity savings are available, although the cost of >\$2 billion effectively precludes acquiring this level of solar resource.

The next stage of the photovoltaic scoping analysis used the same methodology to estimate a more-limited potential, by line segment, for several market segments considered to be of particular interest for development of PV projects. These included residential, ski areas, schools, and other commercial. Table 3.16 provides an example of these results, illustrating the estimated potential for Schools in the Bennington area.

**Table 3.16 Example Line Segment by Project Type Results**

<u>Schools</u>	<u>Bennington</u>
Number in Zone	36
Average System Size DC kW	5
Applicability % of Schools	50%
Total DC kW	90
Summer AC Peak Coincidence	65%
Winter AC Peak Coincidence	40%
DC to AC Conversion Efficiency	77%
Summer AC Peak kW	69
Winter AC Peak kW	14
Average Annual kWh/DC Watt Installed	1000
Total Annual kWh	90,000
Average Installed Cost / DC Watt	\$ 7.50
Total Investment	\$ 675,000
75% Incentive Level Leverage	
To VELCO	\$ 506,250
To School	168,750

Note that the assumptions in Table 3.16 include an applicability factor of 50% for the installation of 5 kW systems on schools, resulting in a total of 18 school installations in the Bennington area. The analysis also assumes an average investment from the schools of ~\$9,400, and an investment by the transmission company of ~\$28,000 per system. The implicit projection in this analysis is that an incentive level of approximately 75% of installed costs is sufficient to prompt a 50% participation rate by the schools. This is a planning assumption, based on professional judgment that would need to be verified by further investigation of schools' willingness to participate.

We conducted similar analyses for installations in the residential, ski area, and other commercial market segments. These market segments were identified because they are likely to have different characteristics in terms of a "typical" project, and also because different levels of leveraged cost sharing may be applicable. The analysis examines the potential cost share needed to catalyze projects in each market segment.

For example, in Vermont, recent experience with the Solar and Small Wind incentive program activity indicates that sharing 20% to 25% of the installed costs for PV installations is sufficient to prompt private investment and development in the residential sector. On the other hand, as indicated above, it is likely that schools will require that a higher share of the costs (~75%) be borne by others before they can develop projects.

#### **3.5.4 Initiatives and Budgets**

Developing a five-year initiative to significantly increase the deployment of photovoltaic distributed generation in the Southern Loop territory can be quickly and efficiently accomplished by building upon and coordinating with the foundation created by the participation of CVPS in the Vermont Solar and Small Wind Incentive Program. The budget estimated in the PV options analysis conducted for this report estimates a total incentive budget of approximately \$10.4 million spread over a five year time horizon. The associated non-measure costs for the initiative are estimated at a total of \$635,000, varying between \$184,000 in year one and \$95,000 in later years. It is possible the initiative costs estimated for this report could be significantly reduced through coordination and cooperation with the statewide Solar and Small Wind Incentive Program.

### **3.6 COMBINED HEAT AND POWER**

Electricity generation through the use of steam or gas turbines or reciprocating engines is a process that also produces heat energy. Conventional electric utility generators are located far from potential users of this heat. Though some enhanced generation systems (such as combined-cycle power plants using both gas and steam turbines) optimize efficiency, much of this heat is rejected into the environment.

Combined Heat and Power is the generation of electricity in proximity to users of heat energy, and creation systems which can then use this heat. Potential uses of "waste" heat

include space and hot water heating, laundry, food processing, lumber drying, absorption cooling<sup>17</sup>, and others. By using this heat, CHP systems can attain efficiencies of 85 percent, as opposed to only 35 percent for electricity generation alone.<sup>18</sup>

Past studies elsewhere of CHP opportunities suggest that, extrapolating to Vermont, there are far more facilities in Vermont that could utilize CHP than the current set of installations. These prior studies relied upon certain criteria as a “first screening” for CHP feasibility assessment:

- Having a minimum electric demand of 20 kW;
- Having a minimum thermal load of 50 kW (or 170,000 Btu/hr);
- Simultaneously experiencing an electric load greater than 20 kW and a thermal load greater than 170,000 Btu/hr for at least 4,500 hours per year;<sup>19</sup> and
- Having a ratio of electric demand to thermal demand of 1.5 or less.<sup>20</sup>

The minimum electric demand establishes an immediate use for generated electricity (rather than relying solely upon net-metering and exporting electricity to the grid). The minimum thermal demand ensures a sufficient need for waste heat resulting from the electricity-generating process, and the coincidence of electric and thermal demand ensure adequate hours of operation to provide a return on investment. Typically, these systems are typically sized to meet 50 percent of the locations’ maximum thermal demand.<sup>21</sup>

The types of locations that generally seem to meet these criteria include:

- Food processing;
- Lumber and wood facilities;
- Pulp and paper facilities;
- Petroleum products;
- Educational facilities;
- Health care facilities;
- Lodging (particularly locations with cooling loads); and
- Apartments (also with cooling loads).<sup>22</sup>

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<sup>17</sup> Absorption cooling systems rely on a substance called a “dessicant” that absorbs the refrigerant. Heat is used to dry the dessicant (also called “recharging” the dessicant) so that it can absorb more refrigerant.

<sup>18</sup> Graham Major. 1995. *Learning from Experience with Small-Scale Cogeneration*. Centre for the Analysis and Dissemination of Demonstrated Energy Technologies.

<sup>19</sup> Graham Major. 1995.

<sup>20</sup> ONSITE SYCOM Energy Corporation. 1999. *Market Assessment of Combined Heat and Power in the State of California*. Prepared for the California Energy Commission.

<sup>21</sup> Graham Major. 1995.

<sup>22</sup> ONSITE SYCOM. 1999.

### **3.6.1 Expected Trends**

Vermont has at least two decades of experience with CHP projects. According to the U.S. Department of Energy's CHP Installation Database, as of May 2005 Vermont had completed 14 CHP projects providing a total of 36.5 MW of generation.<sup>23</sup> These projects span a wide range of generating capacity (60 kW to 20 MW), fuel sources (natural gas, propane, oil, wood waste, and methane) and technologies (steam turbines, combustion turbines, microturbines, and reciprocating engines). The facilities with CHP projects include:

- Pulp and paper, wood, or wood-processing facilities with a ready supply of "free" fuel (e.g., wood chips, sawdust) and a significant thermal load;
- Anaerobic digestion (at wastewater treatment facilities or dairy farms) that supply another "free" fuel source, biogas or methane;
- Educational or government institutions with district heating plants;
- Food processing plants with significant thermal loads;
- Health care facilities; and
- Other miscellaneous industries.

A list of CHP installations in the Southern Loop service territory is shown in Table 3.17.

### **3.6.2 Markets and Measures Analyzed**

The CHP analysis for the Southern Loop report applied an understanding of current and emerging CHP technologies to the Southern Loop's existing residential, commercial, and industrial building stock and heat systems. The technologies considered for the report included:

- Reciprocating engines;
- Steam turbines, powered by either fossil fuels (e.g., oil, propane) or biomass (i.e., wood chips);
- Gas turbines; and
- Microturbines.

Because CHP system economics are generally favorable for buildings that have significant year-round thermal loads, this analysis focused on facilities that meet those characteristics, including:

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<sup>23</sup> See <http://www.eea-inc.com/chpdata/States/VT.html>. Not all of the listed projects are currently in operation, and more recent projects (e.g., Audets Cow Power LLC, Omega Optical, and Brattleboro Retreat) are not listed.

**Table 3.17 Existing CHP Projects in Southern Loop Territory**

<b>Organization Name</b>	<b>Application</b>	<b>Connected Capacity (kW)</b>	<b>Notes</b>
Brattleboro Kiln Dry Company	Wood Products	380	Maximum output of 200 kW limited by thermal load
Omega Optical	Manufacturing	500	Unit does not net meter, only meets internal load of about 175 kW
Retreat Healthcare/ Brattleboro Retreat	Health Care	1,000	Maximum output of 450 kW, limited by thermal load
Allard Lumber	Wood Products	500	Unit is at end of useful life

Source: CVPS, 2006

- Pulp and paper, wood, or wood-processing facilities;
- Wastewater treatment facilities;
- Educational or government institutions;
- Food processing plants;
- Health care facilities; and
- Other miscellaneous industries.

To consider a wide range of options, the analysis also evaluated an emerging technology that ties into furnace heating systems, although households do not have a significant year-round heating load.

### **3.6.3 Methodology**

Consideration of CHP systems requires a detailed understanding of both electricity and thermal (heat) loads at any facility. The selection of CHP technology at a particular facility can be dictated not only by how much heat is needed, but also what kind of system is currently used to distribute that heat (i.e., steam, hot water, or forced hot air). Different CHP technologies also have different electricity generating characteristics.

#### **3.6.3.1 Commercial and Industrial**

Because this analysis was intended to provide an overview of CHP potential, rather than to evaluate specific CHP projects, the project team developed and implemented a CHP survey effort to commercial and industrial customers. Starting from a list of Southern Loop businesses and institutions that met the facility types listed above, OEI and CVPS staff contacted 26 different locations to complete the CHP survey (see Appendix D for

the survey instrument). Of these 26 locations, 8 facilities supplied the requested information.

OEI project team and LaCapra Associates staff reviewed the completed surveys to develop high-level estimates of potential CHP projects at each of these locations. These project estimates were based upon experience at other locations both in and outside of Vermont, including the Essex Junction Wastewater Treatment Facility and North Country Hospital in Newport. Once these project estimates were developed, the project team extrapolated results to other similar facilities, based upon either known electric or thermal loads.

### 3.6.3.2 Residential

In the case of residential applications, the OEI project team evaluated a specific residential-sector CHP technology. This technology uses a reciprocating engine that supplements home furnaces during the heating season. Air is forced through a heat exchanger (taking waste heat from the engine jacket and exhaust) before entering the furnace, which fires only if additional heat is needed. Each unit produces 1.2 kW at full load, the electric generating efficiency is rated at 22 percent, and the overall efficiency (electrical energy generated plus waste heat captured) is rated at 81 percent. The team developed a cost estimate based upon adding this system to a furnace replacement project (i.e., the incremental cost), and also estimated the electricity generation (demand and energy) and change in fossil fuel use. The team then projected the number of potential customers for this system based upon an estimate of forced-hot-air heating systems in the Southern Loop.

### 3.6.3.3 Cost-Effectiveness

The C&I project estimates and the residential application were then evaluated against the same societal cost-effectiveness test as applied to the DSM potential estimate. Only a limited number of the C&I project estimates passed the cost-effectiveness test.

### **3.6.4 Initiatives and Budgets**

Barriers to installation of CHP systems differ somewhat from DSM, but there are also a number of similarities. Unique barriers include grid interconnection requirements, net metering policies, pricing issues (including standby charges, utility asset recovery, and export pricing for “net metering”), fuel sources and prices, and permitting and siting issues. Barriers similar to DSM include first costs and financing availability, challenges and costs in developing projects, and performance uncertainties.

To address these barriers, the envisioned CHP initiative would:

- Establish a set of policies for CVPS around grid interconnection, net metering, and pricing that would both create a consistent understanding in the market and facilitate CHP project development.
- Provision of design and engineering incentives to overcome barriers to vendor or design engineer involvement, either by partnering with existing CHP resources (such as the Northeast CHP Application Center) or in-state expertise.<sup>24</sup>
- Provide funding to cover a portion of detailed project engineering services on CHP projects to reduce customer perceptions of risk that on detailed analysis projects will turn out not to be feasible, and 100 percent of the engineering services should the project go forward.
- Provide a financial incentive of 50 percent for C&I projects, and 100 percent of the incremental cost for residential projects.<sup>25</sup>

## **4 FINDINGS AND CONCLUSIONS**

This analysis found that customer-based energy-efficiency and distributed generation investments can contribute substantially to potential resource configurations for solving the Southern Loop’s reliability challenges over the next decade. However, neither efficiency nor customer-sited generation alone can completely relieve capacity constraints, either in the short term or the long term.

Achievable energy efficiency potential is an economically viable component of a resource configuration involving complementary supply alternatives such as generation and T&D investments. Combined heat and power generation can also make a substantial contribution toward relieving reliability constraints; 2.1 MW of the achievable potential

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<sup>24</sup> Note that the DPS has filed a proposal with the PSB to serve as Vermont’s CHP resource under 30 V.S.A. § 209(d).

<sup>25</sup> Note that an incentive equal to 100 percent of a project’s incremental cost is an aggressive incentive that may not be required to promote adoption of projects by participants.

was found to be cost-competitive with transmission and distribution. None of the 4.5 MW of achievable summer demand solar potential in the Southern Loop was found to be cost-effective when valued at avoided supply costs.

Aside from these quantitative findings that will inform VELCO's and Central Vermont's current planning, this analysis leads to broad conclusions that bear on future planning, development, and deployment of customer-based reliability solution .

This analysis confirms that a preliminary DUP DSM scoping tool can provide useful information to help determine whether further investigation of DSM alternatives to reliability problems is worthwhile. Such a scoping tool enables a utility to take a relatively low-cost first cut at the potential contribution from energy-efficiency in any zone of its network.

This analysis also reveals such DSM scoping analysis is not always sufficient for detailed analysis and planning needed to configure and initially compare reliability investment alternatives. More detailed analysis is sometimes needed to reflect actual end-use efficiency conditions and opportunities, especially when the area has already been and/or is likely to be served for a long time by pre-existing DSM programs and aggressive peak period pricing. The VELCO/CVPS analysis found greater but substantially different efficiency opportunities than uncovered by the preliminary analysis using the DUP scoping tool. One reason was the amount of time – three years – that had elapsed since the potential analysis underlying the Scoping Tool was completed. Significant differences in the customer mix and end-uses in the Southern Loop load zones relative to the statewide study were major contributors to the discrepancies between the DUP Scoping Tool estimate and the detailed analysis results. Efficiency markets had evolved considerably, and Efficiency Vermont had accomplished significant savings in key areas of opportunity identified by the scoping tool.

This analysis demonstrated that careful effort is required to properly synchronize and reconcile estimates of DSM potential with the utility's underlying load forecasts for sub-zones of the Southern Loop. Efficiency potential estimates are predicated on end-use analysis, whereas forecasts of loads on distribution substations are usually based on historical trends.

Two findings from this study confirm results of previous analysis and experience. First, the projected value of electric *energy* savings from end-use efficiency improvements approaches and sometimes exceeds the projected present worth of the entire societal and/or utility costs of the efficiency resources. This leads to net societal cost per kW-year of demand-side transmission and distribution capacity that can be negative, once the market value of energy savings are subtracted from total resource costs. This is consistent to the profile of generation solutions to reliability needs, where the market value of energy production is credited against the total cost of the supply. These findings are consistent with those reported in the NRP analysis of economically achievable demand-side transmission capacity. Now as then, the problem for transmission ratemaking and cost recovery is that these electric energy benefits accrue to the

distribution and customer side of the electricity system. This makes it difficult to equitably match DSM cost recovery with the distribution of cost responsibility.

Finally, the VELCO/CVPS analysis confirms what previous analysis of and experience with targeted DSM have shown: accelerated investment in energy-efficiency is far more likely to have a material effect on planned T&D investment several years into the future than in the very short term. This follows naturally from the fact that it takes time even for concerted DSM investment to reach a strategic scale with respect to anticipated T&D capacity investments.<sup>26</sup>

While these estimates of energy efficiency resource availability are a significant improvement relative to the original Scoping Tool analysis, additional work is necessary to design programs, provide information for program management, to monitor and evaluate the effectiveness of the investments and to design financing and cost allocation mechanisms if DSM is to be a part of the resolution of the area's reliability problems. Levels of customer incentives and delivery mechanisms can be adjusted to respond to program delivery monitoring results such as market penetration. Since the investments are intended to defer future capacity constraints from future load growth, the increase in background load growth net of the energy efficiency and large threshold growth, such as ski area or residential developments, can be monitored to guide program delivery changes and/or development of transmission facilities to maintain reliability.

In addition to the results of the *pro forma* economic analysis, the magnitude and timing of DSM investments must also be carefully monitored and evaluated during and after implementation. As the PSB noted in its 2002 Order regarding statewide energy efficiency funding: "The least-cost provision of ... [Vermont statutes] does not require that the Board always choose the option that has the lowest total life-cycle cost. It requires a reasonable balancing of all factors including the magnitude of the initial investment and the timing of those investments, to achieve the optimum long-term benefits to Vermont ratepayers without short-term costs that are unacceptable." *See* Docket No. 6777, Order of 12/30/2002, at 19.

Financing and cost allocation mechanisms will need to be developed to align the financial liability with the asset owners and to assign the costs in alignment with the benefits. For example, a distribution utility has difficulty raising capital for an asset owned by the customer; also, more benefits flow to customers with efficiency measures. Developing financing and cost-allocation mechanisms will be major challenges to successfully planning and deploying targeted efficiency and customer-sited generation investments in the Southern Loop. Overcoming these challenges poses considerable risks for realizing the achievable potential found in this study

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<sup>26</sup> In the case of the Southern Loop, the area has been and continues to be the subject of sustained DSM efforts that have already permitted CVPS and VELCO to prolong the useful life of the existing electric system and to defer otherwise necessary T&D investments.