What is the Future of Demand Side Management? Studying the Interaction of Energy Efficiency, Demand Response, Energy Storage, Renewables, and Electric Vehicles

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ABSTRACT

Utility demand side management (DSM) programs have existed in California for over 30 years, with well-publicized success. Yet the future delivery of these programs is uncertain as policies and new technologies promise to alter the consumption of energy. Policies targeting reductions in greenhouse gas (GHG) emissions associated with energy generated for use in buildings, rely on significant increases in energy efficiency, demand response, and renewables (namely PV). The resultant reduction in site energy consumption would not only reduce GHG emissions, but could reduce the building's peak demand and change the strategies employed to manage load. Alternatively, customer demand for, and adoption of, building level energy storage and electric vehicles could alter traditional energy consumption patterns, providing new opportunities for DSM. This paper will present the findings of a study designed to better understand the interactions of these technologies and their impact on future DSM programs.

A series of parametric building energy simulations were performed to gain an understanding of future load shapes and assess the opportunities presented. The simulations were run across multiple building types (commercial and residential), climate zones, and building vintages (retrofit and new construction). To frame the problem, the different DSM technologies were simulated at various levels, as well as in various combinations. In total nearly 8,000 load shapes were developed, each a unique representation of a potential building of the future. The key findings from this study are presented in this paper, with an emphasis on the impacts to peak demand and DSM opportunities.

Introduction

Regulatory initiatives, new technologies, and changing consumer behavior are coalescing to change how energy management and technologies are used by buildings in the future. To meet the Zero Net Energy (ZNE) goals established by the California Public Utilities Commission (CPUC) aggressive levels of energy efficiency (EE) must be coupled with distributed generation (DG) technologies, demand response, and storage capabilities. With the abundance of solar resources in Southern California and its declining costs, photovoltaic (PV) arrays are expected to be the prevalent DG technology. An increased push to leverage the smart grid and demand response (DR) is also expected. Southern California is anticipated to have many early adopters of plug-in electric vehicles (PEVs). Finally, advances in energy storage unit (ESU) technologies and the potential benefits they bring are likely to accelerate their adoption. If related policy goals are achieved and these resources are adopted, there will be unprecedented changes in how energy is consumed and generated. This project attempts to explain how these resources may interact and, thus, impact building energy consumption. This understanding is crucial to better define expected impacts from DSM programs and to plan future IDSM programs

Methodology

To gain an understanding of how these variables will impact building energy consumption, a series of simulations was designed and executed. These simulations were created to systematically examine scenarios, understanding how they individually, as well as in concert, impact energy consumption and building load shapes. In total 1300 simulations were performed to gain an understanding of how these variables perform individually and interactively. The DOE 2.2 energy simulation model was used to perform these building energy simulations.

To understand the impact of these measures, collectively called integrated demand side management (IDSM), multiple building types, climate zones, and vintages were selected. Simulations were performed for a new building (2005 Title 24 compliant[1]) and a building that would be retrofit (pre-1978 vintage). Additionally, three California climate zones were modeled; coastal (CEC zone 6), inland (CEC Zone 10), and desert (CEC Zone 15). Four building types were selected to reflect a broad range of market segments, the buildings modeled were; Single Family Home, Big Box Retail, Small Office, and Sit Down Restaurant. In an effort to provide meaningful results, this paper will focus on a small subset of the results, providing directional findings on impacts to DSM programs.

For the purposes of these simulations, the 2005 Database for Energy Efficiency Resources (DEER) defined building input files were used. DEER defines operating schedules, occupancy schedules, baseline technologies, building orientations, and many other parameters that impact the building's performance. Within California, the DEER models are accepted as reasonable assumptions for baseline buildings and are used to quantify savings for utility incentive programs. All IDSM measures were implemented to the DEER input files, and are discussed in the following section. To facilitate comparisons, the DEER model geometries (i.e. building shapes and orientations) were not modified.

Energy Efficiency Measures

For each of the building types, three different packages of EE measures were applied. These were designated EE25, EE40, and EE70, with the target savings being 25%, 40% and 70%, although these percentages were only roughly achieved. 70% savings were particularly difficult to achieve within the constraints of the project. To maintain consistency across the permutations, EE measures which impacted the physical shape, or orientation, of the buildings were not included.

The details of each of the efficiency measure packages varied by building type, climate zone, and vintage. To provide an understanding of the types of measures employed, the details for the Single Family Home are listed below.

Retrofit Baseline:

- Wall insulation: R5.4
- Roof insulation: R11.83
- Roof absorptance: 0.88
- Window U-value = 1.23
- Window shading coefficient: 1.00

[1] 2005 Title 24 is designated as the reference code for the CPUC ZNE goals. Also, the 2005 DEER models, based on 2005 Title 24, were the most widely accepted models available at the time of this work.

- Lighting power: 1 W/ft²
- Equipment power: 0.37-0.91 W/ft²
- Cooling EER: 8.4
- Furnace efficiency: 80%
- Fan power: 0.365 W/cfm

New Construction Baseline:

- Wall insulation: R10 for zone 6, R 15.8 for zones 10 and 15
- Roof insulation: R28 for zone 6, R36 for zones 10 and 15
- Roof absorptance: 0.58
- Window U-value = 0.67 for zone 6, 0.57 for zones 10 and 15
- Window shading coefficient: 0.91 for zone 6, 0.46 for zones 10 and 15
- Lighting power: 1 W/ft²
- Equipment power: 0.32-0.81 W/ft²
- Cooling EER: 10.85
- Furnace efficiency: 80%
- Fan power: 0.292 W/cfm

EE 25:

- Increase wall insulation to R16 (This meets current code requirements in some climates)
- Increase roof insulation to R36 (This meets current code requirements in some climates)
- Decrease roof absorptance from 0.58
- Upgrade windows to U-value = 0.3, SC =0.2 (Solarban 60, dark green, fiberglass frame)
- Reduce installed lighting power by 25%
- Reduce equipment power by 25%
- Improve cooling EER to 14
- Improve heating efficiency to 90%
- Reduce fan power to 0.292 W/cfm

EE 40:

- Increase wall insulation to R25
- Increase roof insulation to R50
- Decrease roof absorptance to 0.40
- Upgrade windows to U-value = 0.22, SC =0.2
- Reduce installed lighting power by 50%
- Reduce equipment power by 35%
- Improve cooling EER to 15
- Improve heating efficiency to 92%
- Reduce fan power to 0.292 W/cfm

EE 70:

- Increase wall insulation to R25
- Increase roof insulation to R50
- Decrease roof absorptance to 0.40
- Upgrade windows to U-value = 0.22, SC =0.2
- Reduce installed lighting power by 75%

- Reduce equipment power by 55%
- Improve cooling EER to 20
- Improve heating efficiency to 95%

Demand Response

For each building, DR strategies were employed on the peak day of the year. The peak day was defined as the hottest day of the year, when participation in DR programs would be most beneficial to the utility. These dates were identified by SCE, and were September 25 for climate zone 6, September 17 in climate zone 10, and August 5 in climate zone 15. When the DR event was triggered, the actions were:

- Increase cooling setpoint to 78°F from 74°F
- Reduce lighting power by 15% (of peak, not of current schedule value).

Both of these strategies are currently promoted through SCE's programs and adopted by SCE's customers. They were selected for inclusion in this study to represent likely DR strategies for each of the buildings modeled.

Distributed Generation

A PV solar array was used to offset the remaining electricity consumption over the course of a year. The array was sized to provide the amount of electricity the building consumed with the EE70 efficiency measures applied, i.e. to achieve ZNE at the EE70 level. Given that the exercise was to simply understand the performance of the buildings when achieving ZNE goals, no considerations of cost or additional loads (e.g. PEV) were made in sizing the array.

Energy provided by the PV array was used first to meet any building load. If the array could meet the building load and had excess energy available, it was fed back to the grid as a negative load on the grid.

Energy Storage

An ESU was applied to the building. Very few ESUs exist in the market today, and as a result the DOE2.2 engine does not have built in capabilities to model this technology. Through discussions with subject matter experts in SCE's Advanced Technologies Organization all characteristics of the ESU's performance were developed, with additional consideration given for the constraints of the modeling software. The ESU was specified to have a maximum charge or discharge rate equal to 15% of the building's peak demand, with a storage capacity equal to seven hours at that rate.

The ESU was operated such that it was charged from the grid during night hours (starting at 10 p.m. and continuing until 5 a.m.), reaching full charge if possible.

During the day, if the PV array could meet the building load and had excess power available, then the excess power was used to charge the storage system, if it was not fully charged. If excess power remained, it was then fed back to the grid.

If the PV array could not meet the entire load on the building, and the ESU had energy available, the ESU would contribute toward meeting the building's load. Only when the PV array and ESU could not meet the building's load, was energy drawn from the grid.

Plug-In Electric Vehicle

PEV charging stations were modeled for each building. A unique schedule of vehicle charging load was developed for each building type. The schedules and other assumptions were developed in collaboration with subject matter experts within SCE's PEV group. Vehicle charging occurred every day except for the Small Office where it occurred only Monday through Friday. Details of the PEV charging inputs are shown in Table 1.

Table 1. Electric Vehicle Load (kW)

Hour	Big Box Retail	Small Office	Sit Down Restaurant	Single Family Home
1	0	0	0	1.1
2	0	0	0	0.5
3	0	0	0	0.5
4	0	0	0	0.5
5	0	0	0	0.5
6	0	0	0	0.5
7	0	0	0	0.3
8	12	0	0	0
9	18	6	0	0
10	30	16.1	0	0
11	24	8.2	0	0
12	24	0	18	0
13	60	0	36	0
14	36	18	18	0
15	36	12.3	12	0
16	48	0	12	0
17	72	0	18	0
18	96	0	24	0
19	90	0	36	0
20	60	0	36	0
21	48	0	36	0
22	0	0	18	3.9
23	0	0	12	3.9
24	0	0	0	2.3
# of charging stations	20	3	6	1

Results

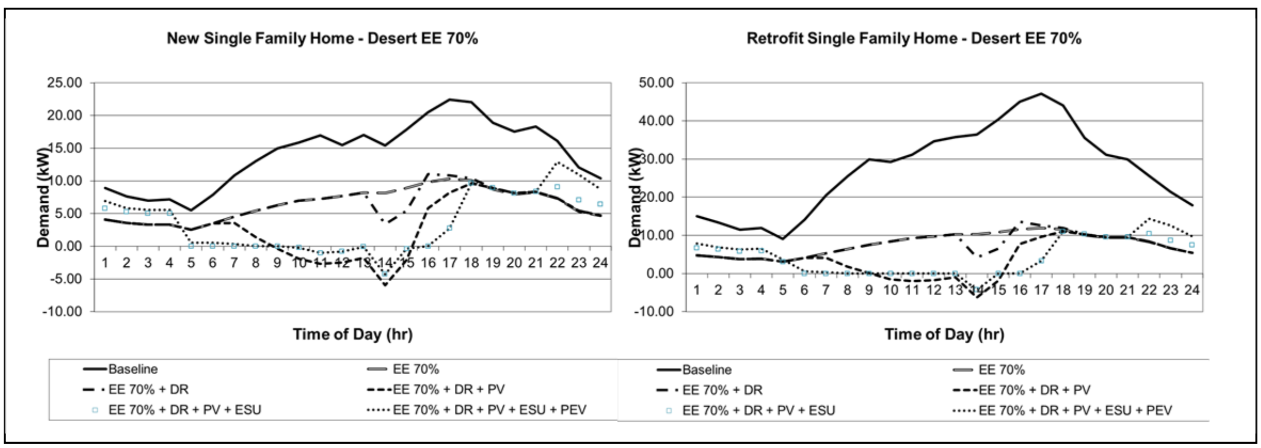
Given the high number of simulation results developed, a representative selection is presented in this paper. This section shows only the results of the buildings in climate zone 15 (desert) since this area is expected to see relatively more growth (new construction) and also is an area with significant peak demand (driven by cooling needs). The impact to load shapes is discussed, as well as the impact on peak demand.

Single Family Home

In 2008, residences accounted for 25,000 MW of demand, 32% of total California electricity consumption, and 36% of California's natural gas consumption (CPUC 2008). Typically residential customers are the largest customer class for a utility and are the target of many DSM programs. Given the prevalence of customers and overall magnitude of consumption, it was important to understand how residential consumption may change.

For SCE, much of the growth of new homes is expected to be in the desert area. With this in mind, the results of the simulations for climate zone 15 are shown in Figure 1. It is important to note that the DEER model contains 4 homes, with differing orientations. The DEER model homes also vary in size, making an average hard to determine. Therefore, the aggregate of all 4 homes is shown in Figure 1.

Figure 1. Single Family Home Load Shapes



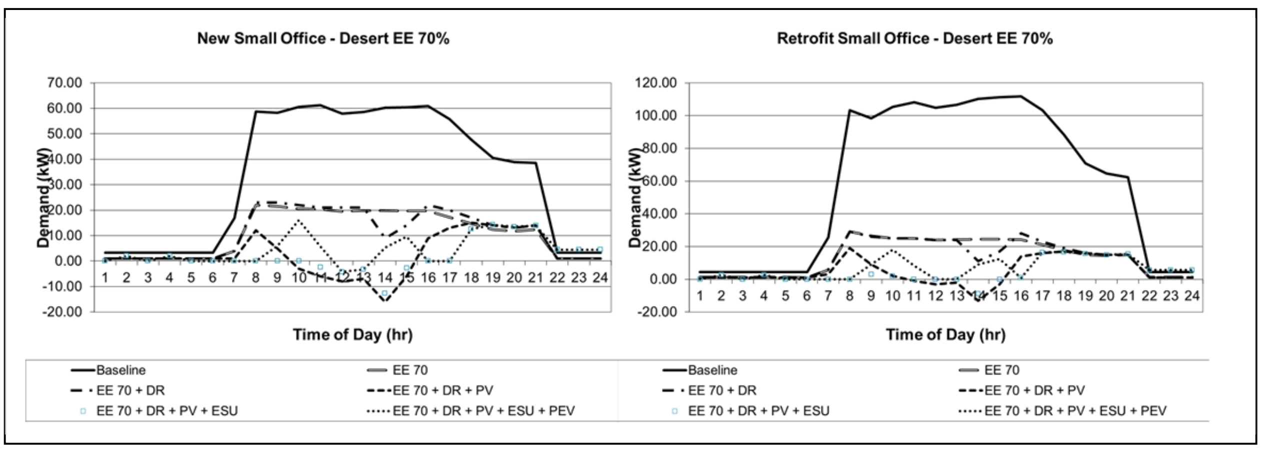
The left side of Figure 1 shows the impact that the IDSM measures would have on a new home. It is clear from this figure that the implementation of EE mainly changed the magnitude of the load shape, with minimal change to the shape of the profile (some smoothing occurs). The implementation of DR is shown to achieve the 15% reduction, but at the price of a small rebound (increase) in load immediately following the event. As noted previously, the PV was sized to achieve ZNE, which caused the home to generate more energy than consumed at points, as clearly shown by the negative demand values. When the ESU was added to the home model, the ability of the storage to smooth out the load shape is clearly seen, keeping the grid supplied energy to a minimum. Energy was consumed with the ESU off-peak, when the ESU was charging. The addition of the PEVs added slightly to the base load and created a secondary peak around 10 pm. However, most of the impacts associated with this new load were mitigated by the other measures, as represented by the minimal change in load shape when compared to the model without the PEV (EE70% + DR + PV + ESU).

The right side of Figure 1 shows the impact that the IDSM measures would have on an existing home. Similar to the new home, the biggest change from implementing EE was in the magnitude of the load shape. However, in the retrofit homes, it can be seen that EE had a greater impact on the shape of the load shape, causing a more gradual, less steep, ascent to the peak demand. The implementation of DR had no difference in impact on the retrofit building, when compared to the new one, the 15% load drop is achievable, with the penalty of a slight rebound. The results associated with PV, ESU, and PEVs mirror those of the new home. The PV again made the home a generator at times, coincident with the peak demand of the baseline home. The ESU provided the capability to smooth the profile and lessen the load on the grid for most of the day. Finally, PEVs created a new peak at 10 pm, but were largely mitigated through the other measures.

Small Office

Small Offices are a common building type, and given their relatively low energy density, are likely candidates to achieve ZNE. Additionally, within SCE's service territory, Small Offices will receive Edison SmartConnect™ meters, and will be targeted by new IDSM offerings facilitated by the advanced meter infrastructure. For these reasons, the Small Office was selected for this study. The simulation results for climate zone 15 for both new construction and retrofit are shown in Figure 2.

Figure 2. Small Office Load Shapes



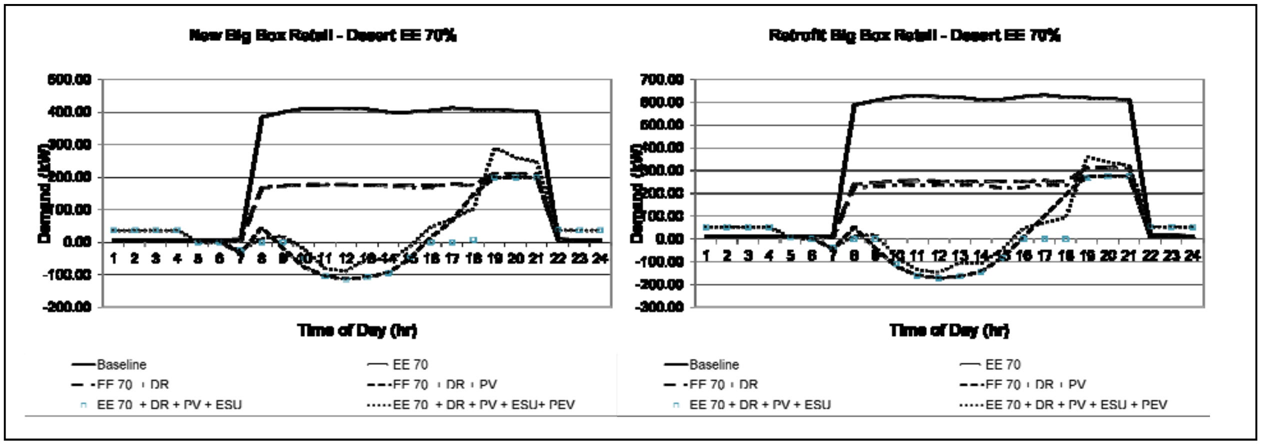
The left side of Figure 2 shows the impact that the IDSM measures would have on a new office. Similar to the home, it is clear that the EE measures did not shift peak, but simply served to reduce load throughout the day (with some smoothing occurring). Again, the implementation of DR strategies allowed for peak demand savings, with a slight rebound penalty. With the 70% level of efficiency achieved, the addition of PV caused the new office building to generate more electricity than it consumed during peak times. The inclusion of the ESU provided smoother energy consumption, making the building close to zero load throughout most of the non-charging period. Finally, given the charging schedule of the PEVs in an office building (added load in the morning and afternoon); two distinct day time peaks could be seen in the building's load shape.

The right side of Figure 2 shows the impact that the IDSM measures would have on an existing office building. Comparing the new office to the retrofit office, the impacts of the various measures and their interactions were consistent. Interestingly, the magnitudes of peak demand, as well as load shapes, were very similar once the EE70 level was obtained, despite the significant difference in baseline peak demand magnitude.

Big Box Retail

Big Box Retail is another building type that is commonly seen as a viable candidate to achieve ZNE, given the space available for renewables and the relatively low energy density. For this reason, this building type was selected to be a part of this study. For consistency across building types, the results for climate zone 15 are shown in Figure 3.

Figure 3. Big Box Retail Load Shapes

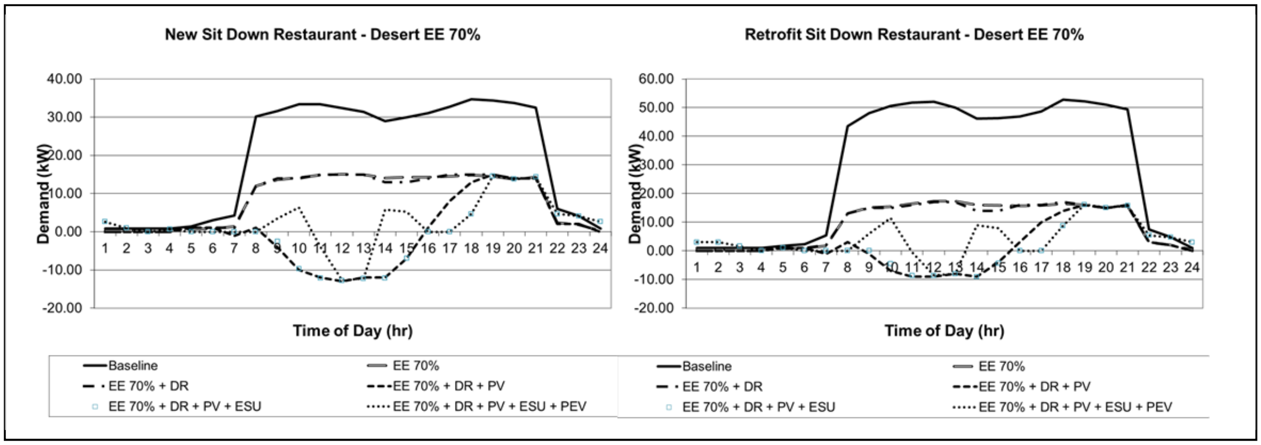


The new Big Box Retail results are shown on the left side of Figure 3 and the retrofit results are shown on the right side. In both building vintages, it is clear that achieving the EE70 level significantly reduced the peak load, without altering when the energy was used. For the new building, the introduction of a DR strategy did not result in much impact. In the retrofit building the DR strategy lowered overall consumption throughout the day, not only during the peak period. These results were unexpected and were likely a result of the buildings overall energy consumption (i.e. lighting and HVAC likely did not represent a significant portion of the building consumption, thus a DR event targeting them was not as impactful on total demand). As was expected, the introduction of a PV system resulted in these buildings, both new and retrofit, becoming generators during peak. The charging schedule of the ESU resulted in greater consumption overnight, but provided benefit by reducing the amount of consumption during the day (as seen by the consumption line not exceeding zero until the late afternoon). The introduction of the PEVs resulted in slightly less generation feeding back into the grid, greater overall consumption, and an increase in the new building peak which occurs in the late afternoon/early evening period.

Sit Down Restaurant

A Sit Down Restaurant was selected as a building type less likely to achieve ZNE, but one that presents an interesting issue. If the definition of ZNE includes off-setting gas energy with renewable generation, restaurants are likely to be significant generators. This study did not include off-setting gas, but still provides insight into the changes to load shapes associated with restaurants, which would be further exacerbated by off-setting gas. The results are shown in Figure 4.

Figure 4. Sit Down Restaurant Load Shapes



From Figure 4, it is evident that the IDSM measures had similar impacts on the two vintages, with the only result being a reduction in the magnitude of the load. As was seen in all the other building types, achievement of the EE70 level reduced the magnitude of the peak load without significantly changing the shape of the load shape (some smoothing occurred again). DR was seen to be effective in both the new and retrofit vintages and did not experience the rebound effect seen in other building types. The PV was sized to only off-set the electricity usage and still made the building a generator during most of the day. Clearly, if gas usage were off-set, the building would be a relatively large generator (typically, restaurants use more gas than electricity, significantly increasing the size of PV needed). The ESU served to reduce some consumption from the grid in the late afternoon, but could not completely eliminate the need for grid supplied electricity. It was also seen that the ESU was able to be charged before the end of the overnight charging period. The PEVs caused the building to draw from the grid during the peak charging times, creating two new peaks coinciding with the charging times.

Peak Demand

Load shapes allow for an understanding of not only when energy is used, but also the magnitude. This section goes into greater detail on the magnitude of peak demand and how it was impacted. The peak demand for each building type, climate zone, and vintage are shown in Table 2. The scenarios were selected to show the impacts of EE on building peak, as well as the impact of the other measures on a representative efficient building. The representative efficiency level selected, EE70, was modeled to allow the buildings to achieve ZNE. The peak demand shown was calculated at 3 pm on the previously identified peak demand days.

Table 2. Peak Demand by Building and Scenario (kW)

	Climate Zone and Vintage	Baseline	EE 25	EE 40	EE 70	EE 70 + DR	EE 70 + DR + PV	EE 70 + DR + PV +ESU	EE 70 + DR + PV + ESU + PEV
Single family home	CZ 06 retrofit	12.83	3.41	2.79	1.86	1.00	-7.00	-6.81	5.44
	CZ 06 new	8.75	2.999	2.532	1.63	1.00	-7.00	-6.62	5.64
	CZ 10 retrofit	19.40	6.14	5.08	3.65	2.00	-6.00	-4.75	7.50
	CZ 10 new	9.927	5.886	5.017	3.61	2.00	-4.00	-2.82	9.43
	CZ 15 retrofit	40.37	16.37	13.99	10.83	6.55	-1.85	0.00	0.00
	CZ 15 new	17.83	13.31	11.44	8.91	5.42	-2.08	-0.39	-0.39
Small Office	CZ 06 retrofit	73.04	36.45	30.17	16.04	11.00	-12.00	-12.06	0.19
	CZ 06 new	45.22	27.75	22.93	12.21	8.00	-9.00	-8.85	3.41
	CZ 10 retrofit	85.82	41.74	34.61	18.76	11.00	-5.00	-1.40	10.86
	CZ 10 new	51.02	32.02	26.42	14.35	8.00	-8.00	-5.40	6.85
	CZ 15 retrofit	111.16	51.63	43.02	24.41	17.00	-3.00	0.00	12.25
	CZ 15 new	60.46	41.07	34.30	19.75	14.00	-6.00	-2.73	9.52
Big Box Retail	CZ 06 retrofit	536.58	284.82	285.48	220.02	179.00	-167.00	-167.22	-131.22
	CZ 06 new	355.89	237.68	214.95	149.32	126.00	-123.00	-122.82	-86.82
	CZ 10 retrofit	574.85	305.83	304.98	234.02	206.00	-36.00	0.00	36.00
	CZ 10 new	377.10	252.56	228.97	159.64	153.00	-24.00	0.00	36.00
	CZ 15 retrofit	612.09	331.96	329.27	252.42	224.00	-82.00	-82.15	-46.14
	CZ 15 new	399.62	271.27	247.75	173.86	168.00	-49.00	-49.08	-13.08
Sit Down Restaurant	CZ 06 retrofit	31.25	21.00	18.23	14.95	7.00	-18.00	-18.20	-5.95
	CZ 06 new	21.70	12.58	10.43	7.27	6.00	-18.00	-18.03	-5.78
	CZ 10 retrofit	42.75	20.42	17.22	12.08	11.00	-6.00	-4.16	8.09
	CZ 10 new	28.75	17.98	15.45	11.03	10.00	-7.00	-4.62	7.64
	CZ 15 retrofit	46.33	25.18	21.98	15.82	14.00	-4.00	-4.31	7.94
	CZ 15 new	29.95	20.08	17.85	14.33	13.00	-7.00	-6.97	5.29

Single family home. As stated previously, it is important to note that the Single Family Home model actually included 4 homes, and the results presented are the aggregate of all 4 homes. The baseline peak demand was clearly a function of vintage and climate zone, with the highest peak seen in the retrofit desert home (CZ 15), likely due to significant HVAC loads. For all retrofit homes, introducing even EE25 levels resulted in significant, roughly 60% or greater, peak demand reductions. For new homes, the reduction was not quite as great, given the more efficient baseline. As the EE level was increased, the peak demand continued to diminish, however not in a linear fashion. This finding highlights the indirect relationship between EE and demand. DR was clearly beneficial in all scenarios, reducing peak significantly. The percent demand savings seen varied by vintage and climate zone as a result solely of climatic differences, as occupancy schedules were identical. As seen in Figure 1, adding the amount of PV required to achieve ZNE clearly makes these buildings generators during the conventional peak period. The ESU reduced the amount of generation at peak, by using some PV generation to charge, but did not bring any home back to a net user during peak. However, the PEV did cause significant peak loads to be seen, in most cases, even with all the other IDSM measures serving to reduce load.

Small office. The Small Office was less driven by the climate conditions, with slightly less variation seen between climate zones, but again the impacts of building efficiency codes can be seen in the difference between new construction and retrofit. Achieving EE25 levels again resulted in significant peak demand savings, for both new (roughly 40%) and retrofit (roughly 50% or more). Again, increasing EE results in greater demand savings, but the savings levels do not directly correlate. Generally, the percent savings was greater in the retrofit buildings for all levels of EE. DR was successful in reducing peak load for all buildings modeled, with a maximum reduction seen in the new Office building in climate zone 10 (44% reduction). Again, the PV made the building a generator during the peak periods. The variance in generation is a function of Table 3 only being a snapshot; climate zone 6 has less overall generation (given the remaining load), but has a greater amount feeding back to the grid due to the more mild climate reducing building load during the peak period. Similar to the homes, the ESU reduced the amount fed back and the PEVs resulted in the building being a consumer during peak periods, but not to the level of the baseline building.

Big box retail. The Big Box retail building had the greatest baseline peak demand of the buildings selected, yet the same patterns can be seen. EE served to greatly reduce peak demand, while DR reduced demand even further, but not nearly to the same percentage as seen in homes and Offices. PV resulted in the building becoming a generator, in all cases, and ESU generally reduced the amount fed back to the grid. Unlike the other buildings, the load from the PEVs is not always enough to cause the Big Box Retail to consume energy during the peak period, only in climate zone 10 did the building draw power from the grid during the peak when PEVs were present.

Sit down restaurant. Unsurprisingly, the restaurant was also seen to follow the patterns of the other buildings for the IDSM measures; EE and DR reduced peak demand and PV resulted in generation during peak. The ESU generally resulted in less energy fed back to the grid during peak, but in some cases it actually increased peak energy use. In all climate zones other than zone 6, the PEVs resulted in consumption during the peak period. Examining the amount of generation during peak indicates that climate zone 6 had the greatest amount of generation on-peak, thus the impact from PEVs was minimized.

Implications

The changing behaviors of customers, be it driven by policy or personal interest, has been shown via modeling to significantly reduce the amount of energy consumed, particularly during peak periods, and in some cases even change when it was used. When considering DSM programs, this has significant implications on what the future may hold. As buildings began to consume less energy overall (increase EE), the potential for DR was reduced, yet it was still a viable strategy to reduce stress on the electric grid. However, as PV is introduced, and buildings achieved ZNE, the load shapes were significantly changed. The buildings modeled became generators during the conventional peak period and began to consume most of their energy in the early evening and night, potentially creating a new peak period. This is a tremendous change from the traditional consumption pattern considered in DSM planning and needs to be factored into any long term thinking on DSM offerings. This change also presents issues for the electrical grid, which was not typically designed for two-way flow and in some cases requires reduced energy consumption at night to maintain reliability (e.g. night time cooling of transformers). Storage was modeled to be a viable means to further smooth load of the buildings, but in most cases the peak demand was simply shifted and energy continued to be fed back into the electrical system. Improved storage technologies, which can more intelligently charge could help mitigate these issues. Finally, PEVs when introduced in conjunction with all these other measures returned the load shape to some state of normalcy, or at least maintained an afternoon peak, but also presented their own difficulties. The PEVs created a second day-time peak which may be problematic. In this effort, the impacts of the PEVs were primarily mitigated, but only as a result of extremely aggressive IDSM strategies being employed in conjunction.

Conclusions

The results of this study do not provide a single “silver bullet” for how DSM programs will look in the future, or how to maximize savings while maintaining grid reliability. However, they do provide a directional understanding and underscore the need for greater consideration and knowledge of integrative effects of IDSM in long term planning. It is clear from this effort that as the various policy goals and customer interests take hold, the energy consumed will not be as great and will be at different times. Utilities will need to modify their program offerings to provide the most benefit to the customer and the electrical grid. Additionally, regulators will need to understand how these changes in consumption impact the ability of utilities to achieve goals established for energy efficiency programs. Finally, the potential for significant increases in the amount of electricity fed back into the grid is evident and will require greater examination to understand the true impact to the grid. This study only provides a brief look into what the future may hold for DSM programs, but it clearly shows that the future will be different.

References

[CPUC] California Public Utilities Commission, 2008. *California Long Term Energy Efficiency Strategic Plan*