

Peak Demand in the Brave New World of Building Decarbonization and Distributed Energy Resources

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ABSTRACT

In the world of “traditional” demand side management, the concept of peak demand has been relatively straightforward. In general, it refers to the highest electrical use in kilowatts (kW) delivered to a building (noncoincident peak). In aggregate, peak demand determines the capacity (kW) needed for the generation, transmission, and distribution systems serving buildings, as well as the amount of energy (kWh) that needs to be delivered. Before the rise of solar generation, the nonresidential buildings peak and grid system peak was relatively coincident. In states with a significant solar resource, efforts are focused on controlling “net demand” (total demand minus grid solar generation). With increased distributed energy resources (DERs) behind the meter (roof top solar) there is an increase in two-way energy flows between utilities and facilities. During peak exports to the grid, DERs strain the distribution system while simultaneously reducing transmission loads and reducing the need for generation when it is most abundant. These DERs may include onsite generation, energy storage, and load management systems which with “intelligent” controls and programming have the capability of significantly reducing a facility’s peak demand. Decarbonizing or electrifying space heating and water heating without storage and load management increases net demand peaks in the morning and evening. This paper will take a forward look at peak demand in the context of increased DERs, building decarbonization, emerging load management strategies, resilience, and energy bills.

Introduction

The specific definition of peak demand varies by context and purpose for which it is being identified. In most cases, the different definitions relate to the duration of the peak and the scale of the system that is being considered. The range of peak durations may be from a few cycles (e.g., inrush current to a motor) to a few days (California Public Utilities Commission (CPUC) metric of quantifying peak demand for demand side management programs). With these considerations, peak demand will be addressed more generically to focus on the relevant issues of this paper. Although many of the issues discussed in this paper have an emphasis on California by way of examples, there is nonetheless applicability to other regions as well.

Traditional Peak Demand

At the building level, peak demand is determined by the National Electric Code that regulates the size and peak demand capacities of electrical equipment. Upstream of the electric meter, peak demand is considered at the service line, transformer, distribution line, substation,

transmission line, and system operator or grid region. For the California Independent System Operator (CAISO), Figure 1 shows the peak demand in megawatts (MW) and the 24-hour demand profiles during the four seasons from 2015 to 2021. The Y-axis is normalized by the average peak demand for that season. These graphs represent “traditional” grid loads as they are “gross” as they are not off set by renewable generation. The peak demand for each year is shown to be about 5:00 PM that coincides with building peak cooling demand.

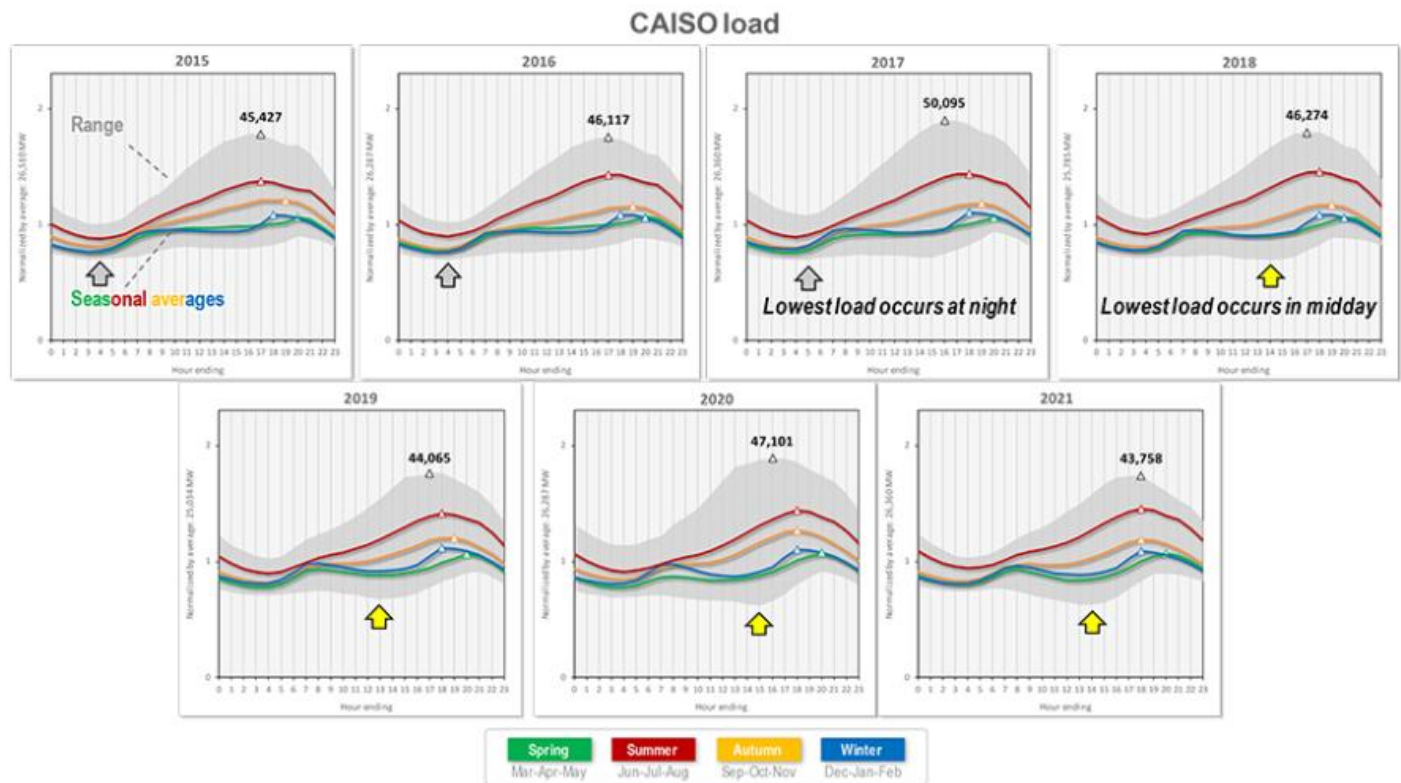


Figure 1. Gross CAISO peak demand in MW and normalized loads 2015-2021 for each season by hour. *Source: M. Rothleder, 2022*

There were various traditional methods that have been deployed to accommodate increasing peak demand. In general, peak demands were met by increasing generating resources (more fossil fuel and hydro power plants), building more transmission and distribution facilities, and increasing building electrical infrastructure. Peak capacity was considered to be essentially unlimited.

These practices began to change with greater awareness of energy supply limitations caused by the OPEC (Organization of Petroleum Exporting Countries) oil embargo in 1973 (United States Department of State 2022). This threat to the business-as-usual supply side of energy delivery to buildings promulgated various national and state regulations to conserve and manage energy use by all energy-consuming sectors including buildings. This manifested building energy and appliance conservation standards to reduce both energy use and peak demand.

While energy conservation addressed energy shortage concerns, peak demand management was more nuanced. As energy use became more scrutinized, and with an increasing higher market penetration of air conditioning in warmer climates, an increasingly higher and narrower mid-afternoon energy peak demand with an accompanying lower load factor (average energy used as compared to peak demand) also began to emerge as air conditioning energy use drove peak demand. One of the hottest series of days in the past 20 years in California was during July, 2006 during which time the CAISO had its highest peak demand at 50,270 MW (CAISO 2021) driven by a heat wave across the Southwest. This compares to the average CAISO peak demand of 46,725 MW (CAISO 2019). Therefore, to ensure adequate supplies in California during the summer, at least 4,000 MW of additional capacity above the average peak was needed. In colder climates, peak demand occurs during the winter where electric heating systems dominate the building peak demands. In milder climates where gas heating is prevalent, the switch to electric heat pumps may cause a winter peak in addition to the existing summer peak.

Although energy efficiency was (and still is) an effective strategy in minimizing the growth in peak demand, there was still a need to build additional facilities and procure generation capacity to meet the growing peak demand. However, it became clear that it was more economical to manage the demand for energy rather than build more facilities that were only needed for a small number of hours that may infrequently occur. This resulted in time-of-use rate tariffs, demand charges (usually based upon the highest demand in any 15-minute period during each month), interruptible rate tariffs, and demand response programs that paid incentives for reducing load when grid capacity was constrained. By limiting the growth of new generating and T&D facilities, rates could be kept lower.

Figure 2 depicts four “traditional” demand response strategies used to reduce peak demand as seen by the grid. Some of these strategies require dynamic control of loads that ranged from simple remote switches on residential air conditioning compressors to sophisticated demand limiting energy management control systems (EMCS) for large buildings and campuses. When optimized, EMCS were effective in minimizing energy bills and maximizing demand response program incentives while having little to no impact on comfort, business operations, or occupant health and safety.

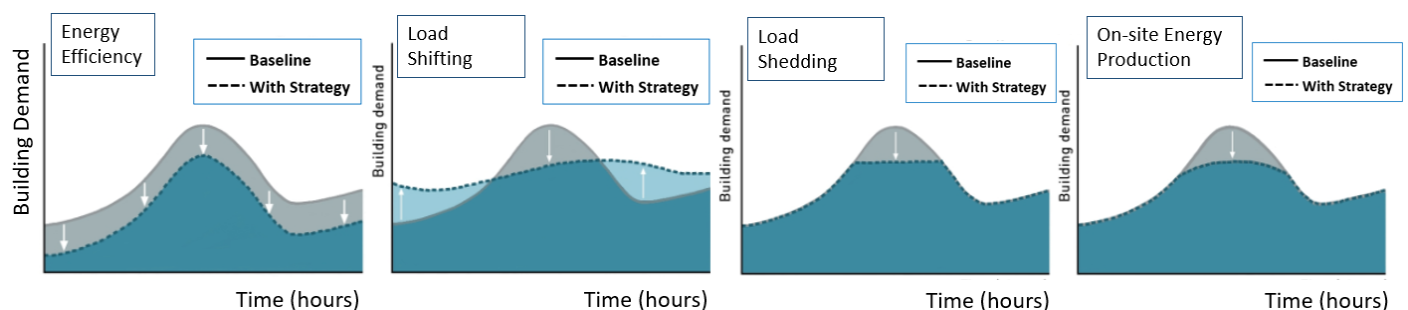


Figure 2. Overview of traditional demand response strategies to reduce peak demand. *Source:* Watt-Logic. 2021

Trends and Drivers for the Brave New World

In the past 15 years, there has been a wider recognition of climate change effects caused by GHG (greenhouse gas) emissions from energy production, transportation, and building operations. This promulgated federal, state, and local policies and legislation to address the impending effects of the climate crisis. There has been recognition that “traditional” peak demand management is still valid (with some updates) in addition to new strategies and tactics.

The strategy for the electric sector is to rely on more renewable and cleaner energy sources. In California, SB 100 requires all electricity sales to be from 100% renewable energy by 2045 (CPUC 2021). California (and other parts of the world) is making significant progress in decarbonizing their electric grid and is on track to meet this goal, mostly with solar photovoltaics along with hydro, wind energy and other renewable energy sources. During an increasing number of hours each year, renewable energy is causing the total generation available on the grid to exceed the total demand for electricity. On April 28, 2022, for the first time, California briefly met 100% of the demand with renewable energy.

The increasing impact on the net load (gross load minus renewable energy) for the CAISO is shown in Figure 3 where the increase in renewable energy (mostly solar) decreases the net load during the middle of the day but causes a steeper ramp as the sun sets and as residential consumers begin their energy consuming evening routines. This results in the infamous “duck curve” which causes the peak load to shift from 5:00 PM to 8:00 PM.

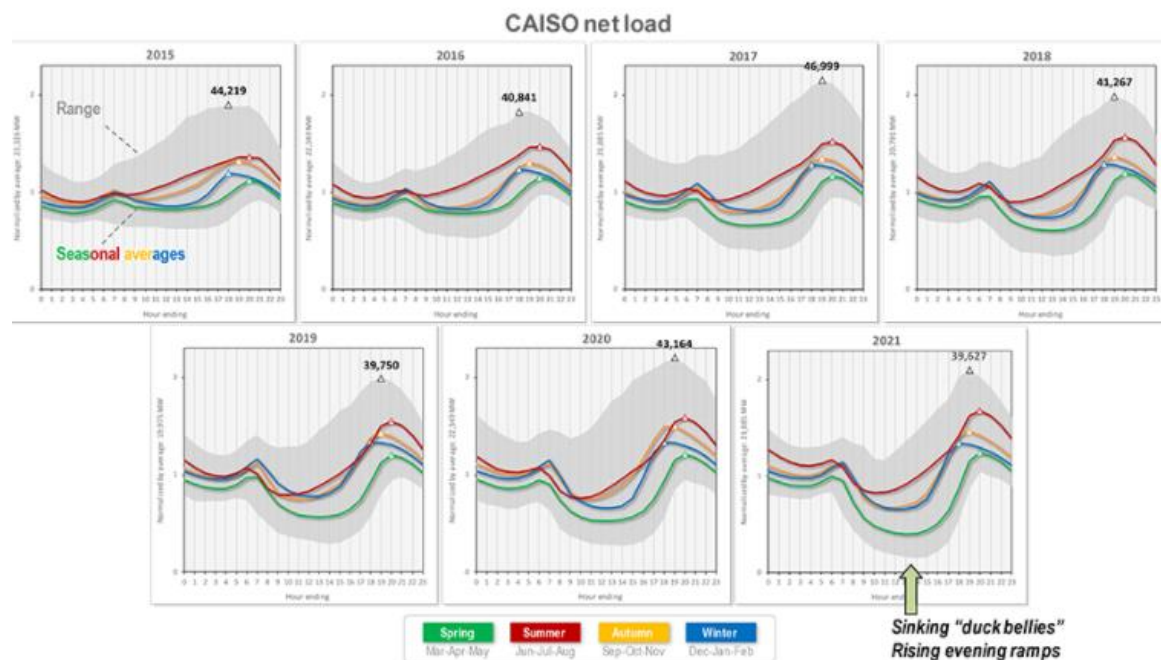


Figure 3. Net CAISO Peak Demand with Renewable Generation 2015-2021 for each season by hour. *Source:* M. Rothleder, 2022

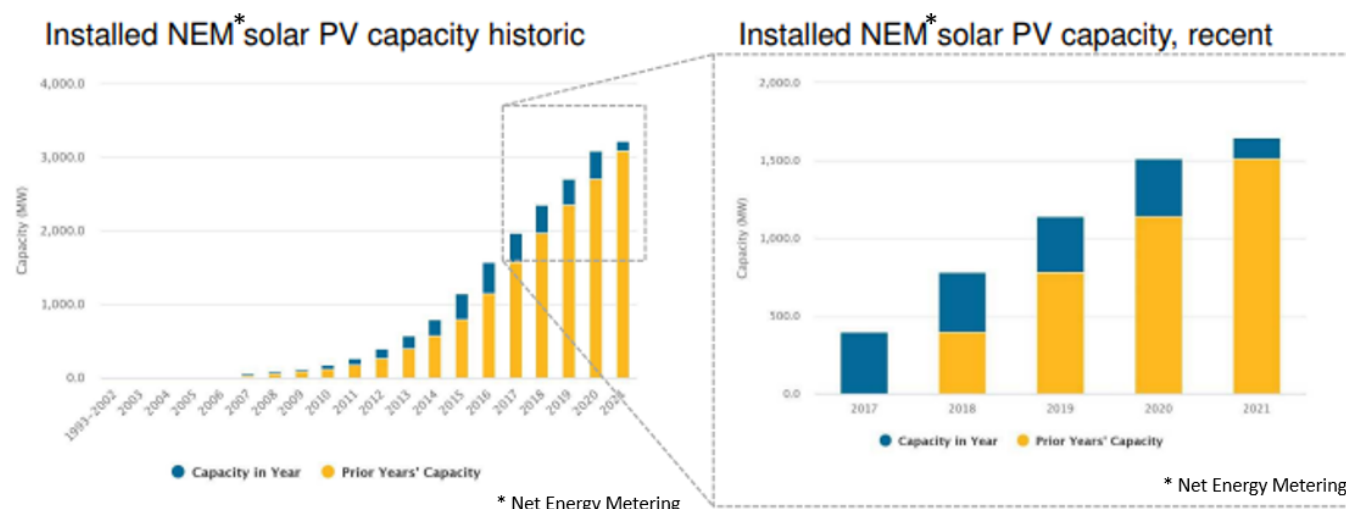
Figure 4 depicts California forecasted hourly source energy factors (Btu/kWh) which are closely correlated to GHG emissions from electricity generation. The “redder” areas indicate

higher levels of GHG emissions caused by higher levels of fossil fuel generation. As expected, the hours of the year with the least GHG emissions (“greener”) occurs when there is an abundance of solar energy generation. As the grid becomes less carbon intensive and as rooftop solar continues to increase, there will be more “green” hours throughout the year. Similar charts which also depict long-run marginal GHG emissions are available for other grid regions using the Cambium dataset (National Renewable Energy Laboratory 2022).

Hour																									
Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
1	4282	4245	4229	4231	4269	4314	4333	4336	3239	2087	1787	1717	1694	1725	1816	2024	3537	4399	4399	4398	4397	4395	4379	4357	
2	3719	3704	3694	3698	3713	3730	3739	3736	1590	734	625	603	600	617	647	736	1391	3757	3759	3758	3757	3757	3751	3735	
3	2751	2743	2738	2740	2754	2764	2768	1701	477	223	188	179	178	182	190	250	776	2668	2720	2721	2720	2716	2710	2703	
4	1271	1268	1267	1268	1271	1274	1220	402	76	15	4	0	0	0	0	8	112	1097	1320	1321	1318	1300	1288	1283	
5	853	850	849	849	851	853	469	90	25	7	4	5	2	1	4	23	132	643	1075	1074	1051	988	936	924	
6	1560	1545	1543	1542	1545	1529	645	172	92	72	63	60	61	61	71	121	313	980	2022	2323	2009	1849	1716	1645	
7	3412	3409	3408	3407	3409	3411	2712	939	375	193	169	156	156	162	178	270	614	1510	3780	3894	3740	3591	3472	3449	
8	3994	3982	3976	3977	3990	3995	3751	1370	415	237	212	212	213	224	256	409	939	3291	4227	4222	4193	4095	4043	4031	
9	4591	4548	4506	4506	4545	4595	4566	1758	298	145	116	70	123	162	238	522	1475	4672	4732	4725	4694	4643	4619	4601	
10	4439	4416	4402	4409	4433	4458	4466	2622	578	371	309	305	306	321	362	631	3321	4540	4534	4533	4525	4508	4491	4477	
11	4803	4749	4722	4718	4751	4809	4842	4479	1614	1143	1123	1076	1072	1106	1212	1700	4836	4900	4901	4901	4901	4900	4886	4833	
12	4354	4312	4290	4296	4321	4384	4416	4420	2980	1918	1648	1551	1526	1611	1769	2068	4455	4463	4463	4462	4461	4458	4431	4400	

Figure 4. California Long-Run Marginal Hourly Source Energy (Btu/kWh) Assuming Compliance with California’s Goal of 100% Carbon-Free Energy Sales by 2045 *Source: CEC 2020*

In this brave new world, buildings have been recipients of a significant growth of new DER technologies including on-site solar energy generation, and an emergence of electrical energy storage devices (batteries, either stationary or in vehicles), thermal energy storage, in heat pump water heaters, and advanced demand response that can facilitate further decarbonization. These DERs can support many of the “traditional” peak demand strategies as well as facilitate new strategies. Figure 5 shows the growth in on-site customer solar installations in California. Similar growth has been observed with batteries as well.



1. Source: California Distributed Generation Static, available at: <https://www.californiadgstats.ca.gov/charts/nem> (data through June 2021).

Figure 5. Growth in customer (behind the meter) solar installation in California. 2021. Source: California Distributed Generation Statistics 2021.

Another trend is the increase in building energy code requirements for DERs. The California Energy Commission (CEC) Building Energy Efficiency Standards, Title 24, Part 6 began requiring renewable energy systems for all new homes in 2020 and will require renewable energy with batteries in many nonresidential buildings in 2023. To increase the utilization of available renewable energy and for buildings to be more “grid harmonized,” the 2022 Title 24 expanded demand response capabilities to allow for a “load up” or increase building loads when excess energy is available on the electric grid. Other Title 24 grid harmonization strategies is the requirement for building capabilities to maximize the consumption of the onsite solar generated energy to minimize exports to the grid and to require buildings to have flexible loads that can respond to the operational needs of the grid.

Challenges and Opportunities

Looking forward to the brave new world, there are several emerging challenges and opportunities to address building and grid peak demand that leverage and go beyond “traditional” peak demand strategies. While many cost-effective technologies have emerged in recent years to address these new challenges, there are nonetheless many issues that need to be resolved. The following is an identification of some of these challenges and potential opportunities.

Intermittency of Renewable Energy

One of the key challenges to reaching the 100% renewable electric sales from the grid is the intermittency of many renewable energy resources. Generation from solar, wind, and hydro are not available on a continuous basis and fluctuate on a diurnal, seasonal, and year-to-year basis. Solar energy availability diminishes when the solar incidence angle is low (winter in the

Northern Hemisphere and early and late in the day) and isn't available after sun sets on the western edge of the country as solar resources are (currently) limited to terrestrial installations. Wind energy generators in the US have been primarily limited to terrestrial locations where wind is generally available but is nonetheless not 100% constant. Energy from hydro is more constant but can vary from year-to-year, especially in California where the availability of run-off water from the snowpack is becoming more unpredictable with climate change. To meet climate goals, the trend is for the grid to increase its reliance on intermittent renewable energy sources such as wind and solar as they are often cheaper than fossil fuel generation (Mathis 2021).

Therefore, new strategies are required to reach 100% renewable energy sales from intermittent generation sources as there will be periods when there is either insufficient renewable energy or, conversely, an excess of renewable energy required to meet building loads. These peak demand problems may also be localized due to renewable generation limitations and/or transmission and distribution limitations as there may be too much or not enough capacity that limits utilization of available renewable energy in certain locations of the grid.

The necessity to maximize renewable energy use requires that intermittent generation be better aligned with loads, and vice versa. Current net building demand does not match the current availability of renewable generation. The mismatch of demand and renewable generation can be lessened with optimally controlled building DERs (US DOE Office of Energy Efficiency and Renewable Energy, 2019) to shed, shift, and shape building loads using both traditional and emerging strategies to better track available intermittent renewable energy. In addition, grid-side DERs as well as off-shore solar and wind generators may have applicability to also improve the availability of renewable energy.

Overgeneration by Renewable Energy Sources

Higher levels of renewable energy resources will be required to meet a 100% clean grid. However, this will increase the occurrences of energy production exceeding demand. Unless all available renewable energy is usefully utilized when generated or stored for later use, it will not only make it more difficult to meet decarbonization goals, but it will also cause congestion on the grid that may prevent additional renewable energy from being deployed and utilized. At present, the renewable generators are generally requested to curtail their generation and/or are required pay (negative pricing) for continuing to generate and feed energy into the grid (CAISO 2017).

In Figure 6, the highest frequency of negative pricing LMPs (Local Marginal Pricing) occurrences are in areas of the country where renewable energy is generated primarily by wind (Seel et al 2021).

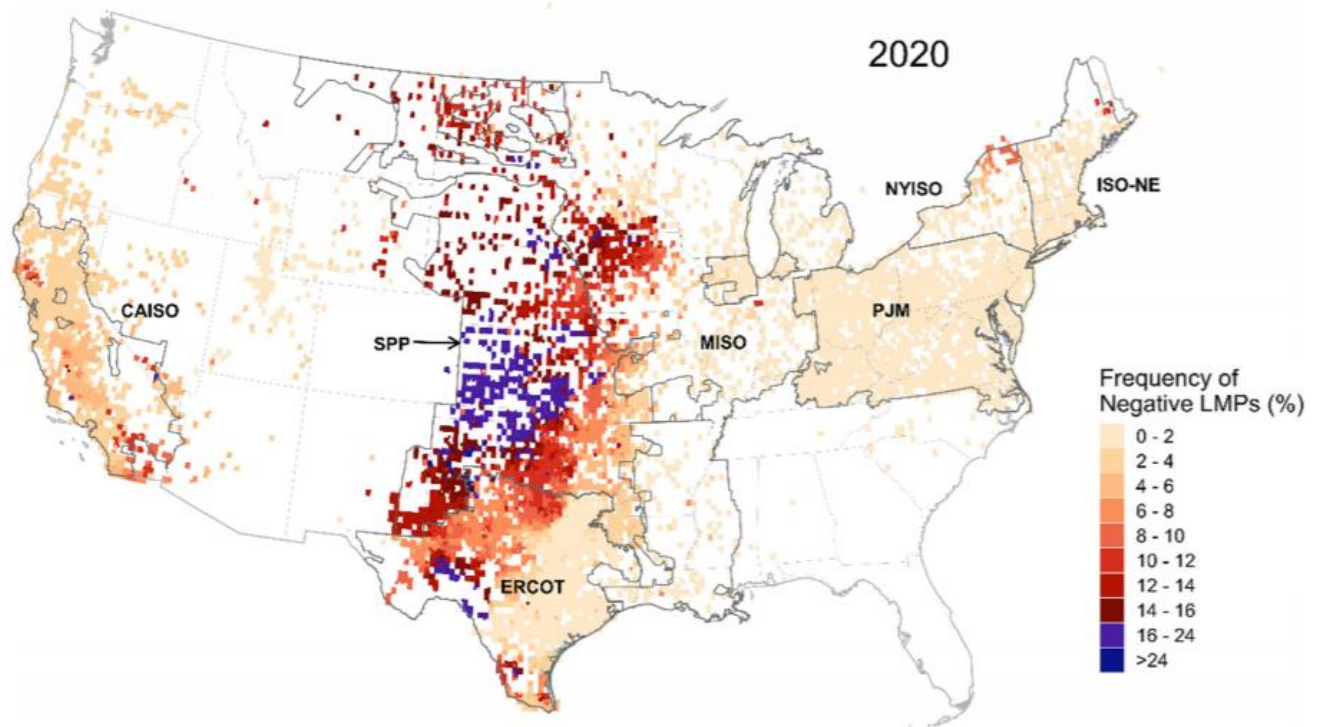


Figure 6. Frequency of negative locational marginal prices at nodes in 2020. *Source:* Seel et al 2021

One program to address overgeneration was developed in Texas where energy providers offer “free nights and weekend plans” (Constellation Resources, LLC. 2022) with higher rates during weekdays to encourage shifting load to times when there is excess renewable energy from wind generators.

However, there is currently no demand response strategy, program, nor rate tariff to address the overgeneration of renewable energy at the retail level in California. Pilot projects were conducted by California electric utilities to utilize the “overgeneration” or “excess generation” of renewable energy (Olivine 2020). However, currently, there are no programs available to California utility customers despite the enabling capabilities required in Title 24.

To encourage more grid harmonization and self-utilization of onsite renewable generation, the CEC has requirements in the 2022 Title 24, Part 6 Joint Appendices includes “future proofing” for batteries and heat pump water heaters to have the capability of increasing energy use when the appropriate demand response signal is received.

Managing DERs to reduce peak demands

As previously described in this paper there is an increasing uptake of DERs in buildings that have a critical role in reducing peak demand. The recognition of the potential for DERs as a solution are being recognized in policies, incentive programs, and codes and standards. However, there is insufficient direction and instruction on how DERs should be operated to reduce peak demand, GHG emissions, energy use, and energy bills.

One example of this lack of direction was realized in the evaluation of the advanced energy storage systems subscribed under the Self-Generation Incentive Program (SGIP). The study highlighted the importance of coordination between the grid and storage system operators and their potential to inadvertently impact peak demand and GHG emissions if not operating in harmony (Itron, 2020). Instead of being used to support load shifting to relieve stress on the grid and reduce GHG emissions, batteries were operated to achieve the opposite effect. As a result of that study, changes were made to the program to ensure better grid-harmonized battery controls that also resulted in lower GHG emissions (Verdant, 2021).

This example sheds light on the fact that DERs can be valuable grid and building assets or can cause unintended results that may increase peak demands on the grid and the building. Therefore, what can be done to ensure the operation of DERs so that they optimize GHG reductions, energy bill savings, reduce energy use, and reduce the need for additional generation, transmission and distribution facilities?

The answer is not straightforward and requires knowledge of several real-time data inputs including building loads, carbon content of the energy supplied by the grid and the building, capacity of energy storage system (both electrical and thermal), utility rates, building occupant comfort, and the building operator's level of sophistication and/or willingness to be engaged with their building operations. However, even with a well-intentioned building operator at the helm of the most sophisticated interoperable building energy management control system, there is no readily available optimized sequence of operations in common use.

The starting point of optimizing peak load management should always be energy efficiency as it will not only reduce energy use and GHG emissions, but it will also have added effect of reducing the size, capacity and first costs of DERs. Other traditional approaches include demand limiting and load shifting strategies to minimize demand charges and reduce the reliance of fossil fuel peaking power plants. A key emerging strategy is to increase the self-utilization of onsite renewable energy generation by matching building load profiles with renewable generation availability. While much of this can be achieved with batteries or thermal storage, there are round-trip charging and discharging losses that need to be considered even though they may have a net positive impact on energy bills and GHG emissions.

While there are significant opportunities to modify building loads and energy production, there are also opportunities to address this issue on the supply side. For example, in 2021, Southern California Edison (SCE) went on-line with a 400 MWh grid-side battery storage system to reduce the reliance on gas peaking power plants that reduce GHG emissions by 33% (St. John 2015). Another supply side battery was installed at PG&E's Moss Landing substation using a 730 MWh Tesla battery (Lambert, 2022).

Interoperability, Monitoring, and Communications Between Buildings and the Grid

Managing the peak demands of both buildings and the grid has become more complex and critical as electric energy is increasingly flowing in both directions, the number of grid-connected DERs have increased, and the optimization needs to be balanced between energy bills, GHG emissions, grid harmonization, and building occupant health, comfort, and safety. This requires sophisticated monitoring and control capabilities that, ideally, would use non-proprietary open protocols that allow for full interoperability. However, the US market has only

partially embraced this approach despite the emergence of open end-to-end (substation to device) protocols such as the IEC (International Electrotechnical Commission) standard 61850 (Shadle 2017). At the same time, cybersecurity and resilience issues become increasingly vital as more open communication channels are deployed (ICF 2016).

Digital energy management and control systems (EMCS) have been utilized in buildings for the last four decades to manage energy use and, perhaps most importantly, peak demand as demand charges for many buildings became the dominant portion of a commercial building's energy bill. To manage peak demand, EMCS were programmed to limit demand by shedding non-essential or lower-priority building loads as demand peaks rose to pre-determined levels. As demand response programs were first offered to commercial building operators, it was relatively simple to modify and adapt EMCS to respond to grid operators' needs to reduce load on an event-driven basis. Traditional EMCS systems may be further enhanced to address current and future needs by installing additional sensors, controls points, and control algorithms to include DER management. For full optimization, an EMCS requires capabilities to monitor and control all building connected DERs, have rate data (time-of-use rates, demand charges and/or critical peak pricing and real time pricing tariffs), and carbon content of grid electricity (real-time and day ahead forecasted). In California, this real time data, as well as demand response notices, will be available from the MIDAS (Market Information Demand Automation Server) at <https://midasapi.energy.ca.gov>.

Figure 7 depicts the “traditional” connection between the electric grid and buildings with minimal communication and 1-way flows of electricity. To better address peak demand, GHG reduction, and facilitate the management of DERs, there will need to be a smarter grid that is able to accommodate 2-way flows of electricity and have robust 2-way communications with buildings and DERs as shown in Figure 8.

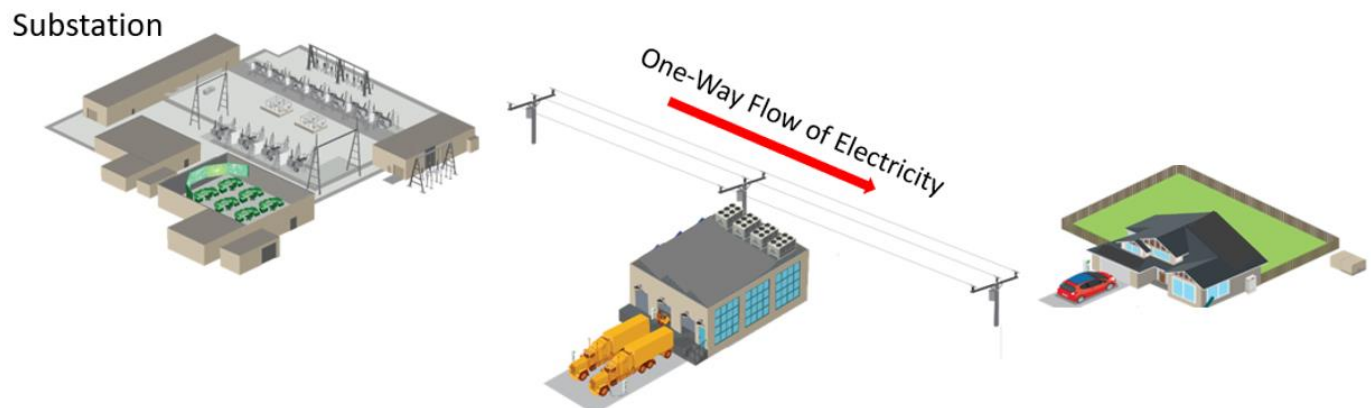


Figure 7. “Traditional” Electric Grid Intersection with Buildings and DERs. *Source:* SCE 2021

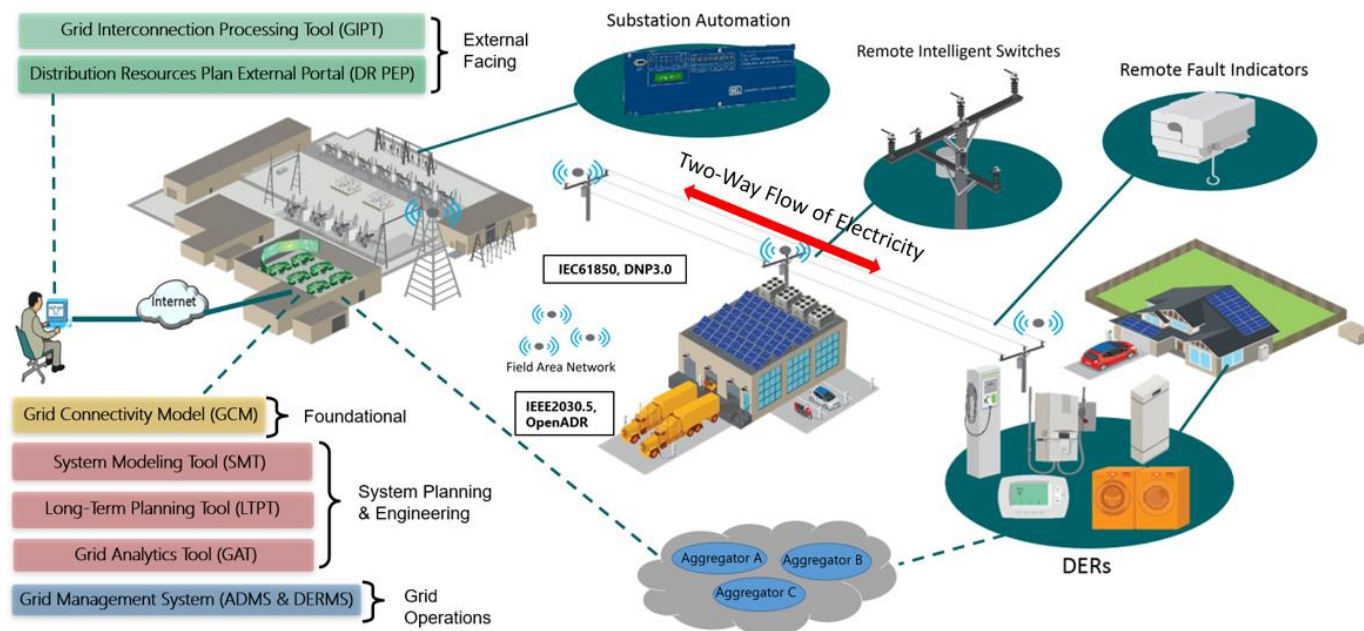


Figure 8. Future Smart Electric Grid Intersection with Buildings and DERs. *Source: SCE 2021*

Added Load from Building Electrification

Emerging policies and programs are aimed at increasing and continuing push to increase building electrification to reduce on-site and upstream GHG emissions. In some cases, these added electric loads have typical load profiles that have peak demands that coincide with current grid peak demand periods such as reheat in a VAV system for humidity and temperature control, and workplace electric vehicle charging. Matters are made worse if energy is used to charge energy storage devices such as batteries, TES systems, and heat pump water heater systems (the incorporate hot water storage) during these same peak periods. So, while it seems that electrification cannot be accommodated without large-scale building and grid upgrades, it can be seen in Figure 2 with load shifting, energy use can be increased without adding to peak demand by filling in the “valleys” or time of low demand. However, this will entail a significant amount of energy use being shifted to non-peak periods facilitated by intelligently programmed controls to optimize scheduling of loads and energy storage charging and discharging. Increased energy efficiency is essential for electrification and can be effectively deployed together (in warmer climates) to decrease summer peak demand when existing air conditioning systems are substituted for high-efficiency heat pumps that have lower summer cooling energy demands. Other HVAC demand side approaches can also minimize demand using heat recovery for reheat (including heat recovery chillers), reducing hot water supply temperatures, and by right-sizing variable capacity heat pumps.

Case Studies of Peak Load Reduction Strategies Harnessing DERs

Case Study #1 successfully addressed a potential peak demand problem within the Southern California Edison service area when a major generating resource (San Onofre Nuclear

Power Generating Station) unexpectedly went permanently off-line in 2013. This left two circuits in South Orange County without a large portion of its generating capacity. Rather than replace the generating capacity with new generating resources or new transmission facilities (both of which would have taken years or decades to complete), it was clear that the most expedient approach to addressing the impending peak load problem was to turn to demand-side solutions. In a novel approach, SCE solicited proposals for all potential demand-side solutions that would result in a measurable reduction in peak demand from the 2013 baseline. The proposal responses that were ultimately funded and deployed resulted in a relatively even mix of various decarbonization approaches that included energy efficiency (EE), distributed generation from photovoltaic solar generation (DG-PV), energy storage, and demand response (DR) as show in Figure 9. To date, this approach to peak demand reduction proved successful in avoiding overloads for these 2 constrained circuits.

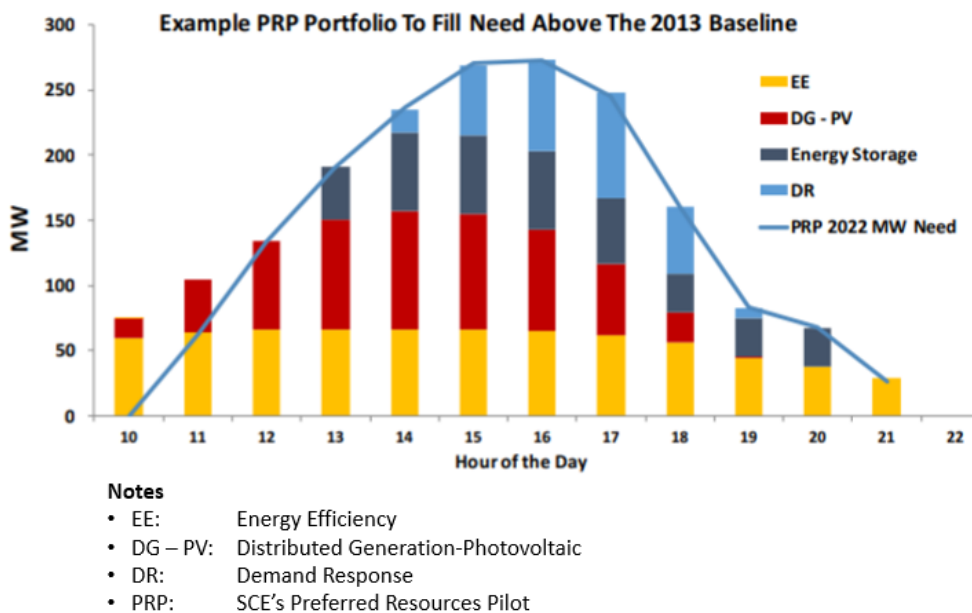


Figure 9. Peak Reduction Strategies Deployed SONGS Operation was Permanently Shut Down, *Source: DNV 2021.Clean Energy Summit 2021*

Case Study #2 is a project that was deployed at the University of California, Merced campus that has a 5,000 ton central chiller plant with a 2 million gallon chilled water thermal energy storage tank and a 4 MW solar generating farm. The objectives of this project to better integrate the renewable generation with the operation of the central plant to reduce peak demand from the grid and minimize excess on-site solar energy export to the grid by maximizing self-utilization of renewable energy. This project was supported by US Department of Energy, Building Technology Office through the Building Energy Efficiency Consortium, US-China Clean Energy Research Center (CERC-BEE).

The project involved an optimization analysis that minimized the marginal operating GHG emission rate and peak demand while maximizing on-site solar energy generation informed

by a complex set of mathematical models. The resulting optimization produced a peak demand reduction of 10 to 15%, reduced GHG emissions by 10%, increased on-site solar energy utilization from 72% to 99%, and reduced on-site generation exports from 8.9 to 0.2 MWh/day shown in Figure 10.

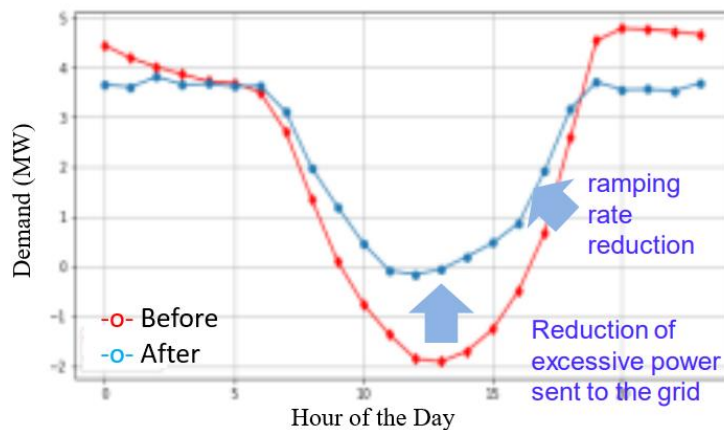


Figure 10. UC Merced Central Cooling Plant Peak Demand Reduction,
Source: Kim, D. 2022

Conclusions

The issues related with peak demand have transformed over the past few years and have become more complex and critical to building and grid decarbonization. The proliferation of DERs offers opportunities to both effectively manage peak demand and reduce GHG emissions if deployed intelligently with the appropriate objectives in mind.

While many of the peak demand strategies are new and emerging, many of the “traditional” building operation strategies and technologies can be enhanced and deployed to address current and future challenges. Building DERs have an opportunity to not only be beneficial to building owners by reducing costs and improving building operations, but also to support the electric grid (“grid harmonization”) by modifying building loads in response to the needs of the grid.

On the other hand, if DER operations are not controlled and deployed properly, the peak demand problem could be made worse. This could result in substantial costs to expand the grid’s capacity as well as a less resilient grid subject to loads that fluctuate more wildly than they do today.

Energy efficiency is essential to maximizing the impacts of DERs to reduce peak demands and decarbonizing buildings. Lower cooling and heating loads will allow for smaller and more efficient variable capacity electric heat pumps that will not only reduce energy bills, but also avoid building and grid infrastructure upgrades. In California where most of the heating is fueled by natural gas, the switch to right-sized high efficiency electric heating equipment is critical to avoid unnecessary electric resistance supplemental heating and minimize energy use when renewable solar energy is not available.

Ongoing study, research, and data gathering is required to manage the rapid change that is necessary to meet decarbonization goals. A significant amount of work has gone into the development of energy efficiency and building load management strategies, but more is needed, particularly as it relates to control strategies.

Specific recommendations include:

- Collect and analyze empirical data from as many case studies as possible to inform an optimized DER deployment strategy that can be scaled quickly to mitigate the climate crisis
- Continue to deploy traditional peak demand strategies such as energy efficiency, load shedding, load shifting, and demand response with appropriate enhancements to reflect the time-dependence of GHG and criteria pollution emissions, the expanding deployment of DERs, and emerging interoperability.
- Dynamically co-optimize building loads and DER operations to minimize GHG emissions as well as minimize peak demand charges and reduce consumption when peak energy rates are higher.
- Manage and control DERs to maximize the use of intermittent renewable generation that is available at the building and the grid.
- Standardize communications between the grid, DERs, and buildings to the extent possible while ensuring cybersecurity and resilience.
- Develop a portfolio of sequence of operations to optimize the control of DERs that building operators may deploy with available control systems and real-time data from sources such as MIDAS that provide rate, GHG emission, and demand response event data.
- Develop and deploy user-friendly residential EMCS that are as robust as large commercial systems to effectively manage DERs and peak demand.
- Consider incentive programs for building electrification that can be deployed to minimize peak demand to avoid grid infrastructure upgrades.
- Continue to develop codes and standards that require enabling technologies to facilitate the optimization of building operation that reduce peak demand, reduce GHG emissions, and increase grid harmonization and load flexibility.

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