## Introduction

For large commercial properties, developing an effective energy management plan to lower demand, shift demand, and control maximum energy consumption is complicated and nearly impossible to achieve optimally without the insights provided by a Real Time Energy Management (RTEM) system.

Time-variant electricity tariffs, such as time-of-use (TOU) pricing, in which electricity costs vary considerably from peak to off-peak periods, is becoming commonplace. Consequently, finding ways to reduce and shift demand, and control the hour of the day when high consumption occurs, is an essential component of strategic energy management.

Cost savings from demand management can significantly improve return-on-investment (ROI) and shorten payback periods.

## Time-Variant Tariff Example

Con Edison's business TOU[1] delivery rates are 29.38 cents/kWh during the on-peak hours from 8 a.m. to 10 p.m. between June 1 and September 30, and 1.08 cents/kWh during the off-peak hours from 10 p.m. to 8 a.m. and on weekends. For all other months, the TOU delivery rate is 14.47 cents/kWh during peak hours and the same 1.08 cents/kWh for off-peak hours. In comparison, the non-TOU standard delivery rate is 12.46 cents/kWh between June 1 and September 30, and 10.46 cents/kWh for all the other months.

For businesses on the TOU rate, reducing electricity consumption during the on-peak hours has a significant impact on lowering energy costs. An RTEM system provides an excellent way to monitor the time profile of electricity consumption, identify opportunities, and automate the demand reduction process to avoid incurring inadvertent and unplanned demand charges.

## Demand Delivery Charges

Electricity demand, measured in kW, is the aggregation of the building's electric loads that are operating simultaneously at any time throughout the day. The result is referred to as a load curve reflecting the property's profile of kW versus time (e.g., 15-minute interval, hourly interval). Peak demand is typically calculated by the utility based on the highest kW measured over a predefined duration, commonly 15 or 30 minutes, and detected during the monthly billing period.

A demand delivery charge is a source of revenue for utilities to offset capacity costs while maintaining generation and distribution capabilities to support expected demand.

[1] https://www.coned.com/en/save-money/energy-saving-programs/time-of-use

Demand delivery charges can account for a significant portion of electricity costs. The range of demand delivery charges could account for 30% to 70% of the total electricity cost in a monthly electricity bill. For a large commercial electricity customer in New York City, the cost of demand (e.g., cost per kW multiplied by kW demand) delivery can be routinely more than the cost of energy (cost per kWh multiplied by total kWh) during the summer season.

The cost of demand delivery charges varies throughout New York State. According to a survey of demand delivery charges conducted by the National Renewable Energy Laboratory (NREL)[2] in 2017, the average maximum demand charge for utilities within New York State is about $10/kW.

Limiting and reducing a building's maximum demand can significantly lower demand delivery charges for most, if not all, commercial utility customers on a TOU rate.

## Demand Management Strategies

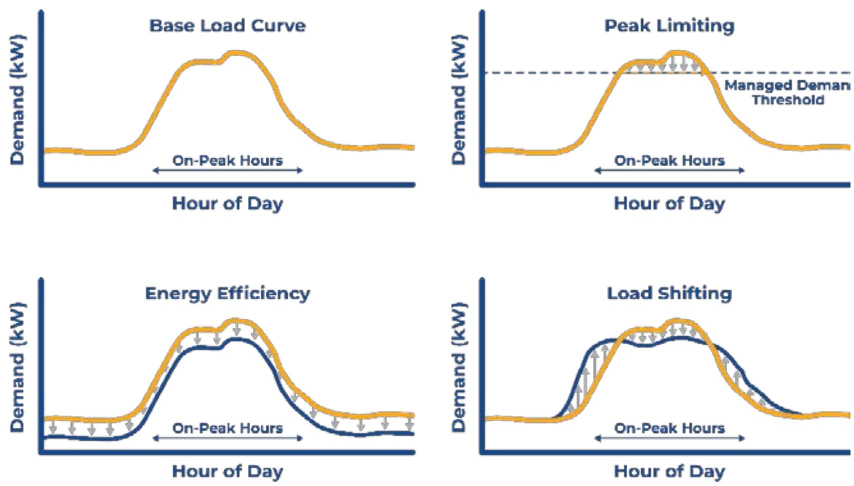
RTEM system and service providers have the expertise and capability to assist customers with demand management and tap into a significant source of cost savings.

This guide will discuss three demand management strategies:

- Energy Efficiency
- Peak Limiting
- Load Shifting

Figure 1 illustrates the three demand management strategies.

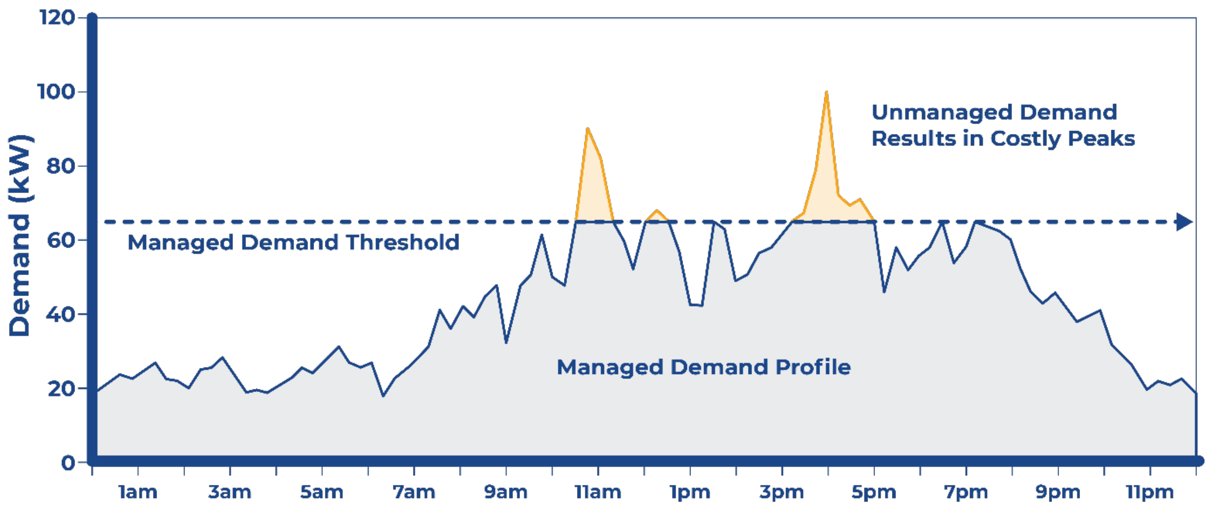
*Figure 1. Demand Management Strategies*




[2] http://www.cleanegroup.org/ceg-resources/resource/nrel-demand-charges-storage-market/

A demand management strategy starts with determining what a building's demand should be to maintain building operations, including an appropriate level of margin. This value becomes the managed demand threshold for the building, as illustrated in Figure 2.

*Figure 2. Illustration of a Building's Unmanaged vs. Managed Demand*[3]




The first step in demand management is to characterize the time profile of a building's electricity consumption, ideally identified by each major electricity-operated plant and piece of equipment. An RTEM system, with the requisite meters, delivers fine interval time-series data to provide insights into the load profiles of the building, along with the constituent plants and equipment. Additionally, real-time monitoring permits the forecasting of impending demand peaking in time for remedial actions before incurring expensive new demand delivery costs.

Additionally, RTEM data, when analyzed in consideration of the building's control schedules, will identify any unnecessary concurrent operation of plants and equipment that results in higher and more costly kW demand. Building operators using this information can ensure that scheduling of major loads within the building is well coordinated with no redundancies.

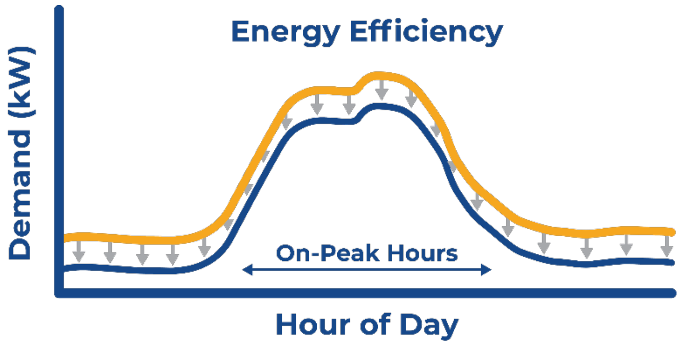
## Energy Efficiency Strategy

The energy efficiency strategy lowers a building's energy consumption (e.g., kWh) with the intent to also realize a notable reduction in the building's maximum demand (e.g., kW).

[3] http://www.cleanegroup.org/wp-content/uploads/Demand-Charge-Fact-Sheet.pdf

Figure 3 illustrates the demand reduction profile resulting from energy efficiency measures.

*Figure 3. Demand Reduction Using Energy Efficiency*




Identifying energy efficiency opportunities is a fundamental capability of an RTEM system; however, not all energy efficiency measures that reduce kWh consumption will also result in significant and dependable demand reduction and the accompanying utility bill cost savings. If dependable demand reduction is a necessary element of an energy efficiency project, an RTEM system is often necessary to provide the existing load curves of the candidate measures to select one with demand that coincides with the property's high-demand hours or that consumes a large amount of energy during the on-peak hours of the time-variant tariff.

A project that upgrades a building's traditional lighting fixtures and lamps to LED technology would be an example of implementing an energy efficiency measure that also delivers predictable demand reductions (e.g., kW reduction.) The reduction in electricity demand is directly attributable to the reduction in the wattage needed to deliver the desired light level in the upgraded spaces. Wattage reduction also results in the lowering of electrical energy consumed (e.g., kWh reduction) by the LED lights.

The demand and energy reductions for the LED lighting project is the same when the lights are on, regardless of time of day, butwhen the building is on a time-variant tariff, the economic value of the energy savings differs greatly between on-peak and off-peak hours. The data from the RTEM system with a tariff engine would accurately calculate the energy savings delivered by the LED project.

Moreover, LED lighting could be dimmed to further reduce fixture and lamp wattage. The expense of installing advanced lighting controls to monitor and dim the LED wattage could be justified by maximum demand reduction during on-peak hours. The data gathered by the RTEM system makes the analysis straightforward.

Examples of common energy efficiency measures that would not guarantee demand reductions are:

- Raising the cooling setpoint for comfort air conditioning

- Reducing the hours in the “occupied hour” mode of the HVAC schedule
- Installing an economizer within the HVAC system (or repairing a broken economizer)
- Installing a variable-frequency drive (VFD) without limiting maximum frequency to less than 60Hz

Examples of common energy efficiency measures that will produce demand reductions are:

- Using lower horsepower-rated motors in fans and pumps
- Adopting higher efficiency air-conditioning plants such as chillers with a lower kW-per-ton rating or installing higher EER/SEER-rated rooftop packaged units
- Switching to higher lumens-per-watt light sources

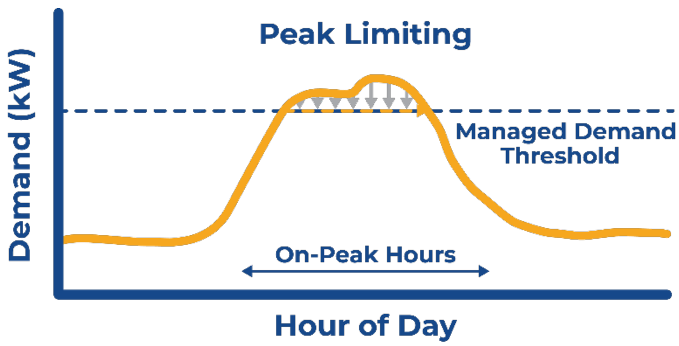
## Peak Limiting Strategy

The peak limiting strategy actively prevents a property’s electricity demand from exceeding the preset managed demand threshold (identified in Figure 2) by altering the building’s normal consumption profile during on-peak hours. An RTEM system is invaluable in helping the building operators to establish the managed demand threshold tailored to the building’s function, equipment/plants, and schedule.

Peak limiting can be implemented through load shedding, operating on-site generation measures, using energy storage measures, or any combination of these strategies. This guide will focus on the load-shedding strategy.

Limiting peak demand will also result in lower energy consumption. Figure 4 illustrates the profile of the demand reduction graphically using peak limiting strategy.

*Figure 4. Demand Reduction Using Peak Limiting*




Load shedding entails reducing or turning off loadsduring the on-peak hours to keep the aggregated demand below the preset level. The candidates for shedding should only be loads that can be reduced or turned off without affecting occupant safety, loads that will not lead to an unrecoverable impact on the building's operations, and loads that will not have a detrimental effect on the health of the equipment and plants.

Once a managed demand threshold for the building has been established, the building's real-time demand can be monitored to avoid exceeding the threshold. As real-time demand approaches the threshold, manual or automated load shedding can kick in to limit the peak demand.

An RTEM system's alarming and notification capabilities automate the warning of impending peak demand period and can also recommend shedding actions. An RTEM system can access a rich set of cloud-based data, such as forecasted temperature, humidity, and solar irradiance (for determining heat gain), to predict the building's demand trajectory in advance, with sufficient warnings to carry out planned and deliberate load limiting actions.

Planning for load shedding starts with the facility staff categorizing all major building loads into sheddable and not-sheddable categories. The distinction between sheddable and not-sheddable is very much tied to the building's critical functions. For commercial office buildings, examples of common sheddable loads are decorative lighting, general space lighting, and equipment associated with providing comfort heating and cooling, particularly in the common building areas. Allowing some common spaces to be a few degrees above or below comfort setpoints may be acceptable compared to activating an additional piece of HVAC plant or equipment that will trigger excessive penalties by exceeding the demand threshold. Examples of non-sheddable loads are security systems, often elevators and escalators, and emergency equipment needed to ensure occupant safety.

Sheddable load attributes need to be characterized and prioritized, whether load shedding occurs manually or automatically. Load characterization parameters include the magnitude of kW reduction, the time for the load to drop, the time for the load to recover, and the allowed sheddable duration (e.g., 15 minutes, one hour.)

An RTEM system can be set up to deliver step-by-step instructions for building operators to shed loads manually, to confirm the level of load reduction in real-time, and to instruct the operators to recover the load in a correct sequence after the shedding event. Additionally, the shedding process may also be automated using the RTEM system to dispatch commands to the building automation system or directly to various building systems.

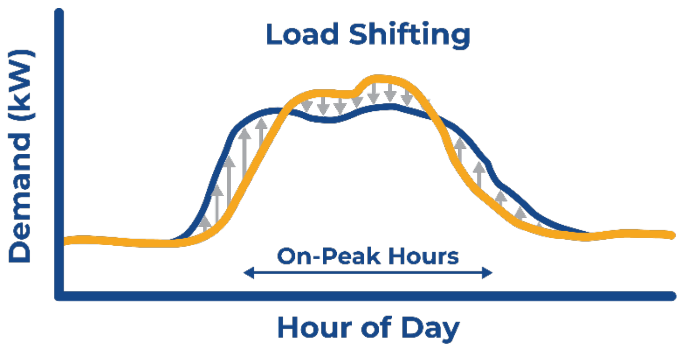
The RTEM system also serves an important function when the shedding event ends. Left unmanaged, the shredded loads may recover in an undesirable sequence, depending on conditions detected by the control terminals and automation systems, which could result in an excessive peak demand, and consuming extra energy unnecessarily as well as shorten equipment life.

## Load-Shifting Strategy

A load-shifting strategy shifts the building's highest consumption time period to before or after on-peak hours. Without relying on active energy storage measures or on-site generation, the load-shifting strategy also requires altering the building's normal consumption profile. An RTEM system allows the building operators to gain insights into the time profiles of each major load, such as lighting, comfort cooling, and ventilation, to identify and quantify candidate loads for shifting.

Figure 5 illustrates the profile of the demand reduction graphically using load shifting strategy.

*Figure 5. Demand Reduction using Load Shifting*




The simplest load shifting option is to change the building's schedule to operate outside of the on-peak hours. However, for commercial buildings, the high demand hours specified by the utility overlaps with common business hours, such as from 8 a.m. to 10 p.m. for Con Edison's electric TOU delivery rates. It is the cumulative effect of many buildings' consuming at their maximum level that initially causes the constrained condition for the utility and creates the on-peak and off-peak distinctions. Shifting a commercial building's schedule to operate between 10 p.m. and 8 a.m. is not practical for most businesses; however, changing some building equipment and plants to operate outside of the on-peak hours could avoid significant on-peak energy or demand costs.

A pre-cooling example is presented to demonstrate the load-shifting strategy. The building's existing comfort cooling system is used to cool the enclosed interior structure of the building envelope during off-peak hours. This can be achieved through advancing the start of the occupied mode in the comfort cooling schedule and also lowering the zone temperature setpoints. During the on-peak hours, the pre-cooled environment acts to maintain comfort without operating the mechanical cooling equipment as often, resulting in lower on-peak demand and on-peak energy usage for comfort air conditioning. Pre-cooling shifts peak loads while only requiring changing the control strategy and adjusting zone temperature setpoints. The RTEM system's automation and continuous monitoring capabilities ensure the building's critical functions, and the comfort of its occupants, are not dramatically impacted.

Pre-cooling can work as an effective load shifting strategy because most buildings configure an unoccupied mode (e.g., night setup mode) control for zone temperatures that does not take advantage of a building's thermal mass. During occupied hours, zone conditions are typically controlled at constant setpoints to maintain occupant comfort. During unoccupied times, the setpoints are raised and the equipment shuts off. This conventional HVAC control scheduling and setpoint control minimizes the storage of cooling energy in a building. The temperature of the buiding interior may become very warm during the unoccupied mode, which adds to the load of the building's comfort cooling equipment when cooling the interior to the comfort setpoint for the occupied model. Additionally, operating the building's comfort cooling plant during off-peak hours may also improve plant efficiency due to the generally lower ambient temperature to dissipate the plant's condenser heat.

A building's capacity for energy storage is highly dependent on building material and construction, HVAC system design, building function, occupancy schedule, and weather conditions. Improper pre-cooling control may actually result in a higher cost than staying with conventional control. Consequently, it is important for an effective load-shifting strategy using the building as energy storage to first characterize the building's thermal capacity and the associated variables. RTEM provides the analytic platform wherein the building's thermal capacity can be accurately modeled, allowing for the effects of changing conditions under varying weather factors to be predicted accurately. RTEM also monitors the efficacy of the control strategy in real-time to verify that the desired demand-shifting effect has been achieved.