BUILDING ENERGY DEMAND RESPONSE SIMULATION FOR AN OFFICE TOWER IN NEW YORK

M. Malato Lerer[1], G. Carrilho da Graca[2], P.F. Linden[3]
[1]NaturalWorks, [2]University of Lisbon, Portugal, [3]University of Cambridge, UK

ABSTRACT

This paper presents a building energy simulation study of the impact of electrical peak demand reduction strategies in a large office tower in New York that has extensive use of daylight responsive dimmable ballasts, and under floor air distribution systems (UFAD). The complexity and large size of the building imposed careful simplification of the simulated geometry in order to make the simulations and results analysis manageable. The simulations were used to predict the building energy demand profile and test different control strategies that minimize degradation of indoor conditions while achieving a significant and stable demand reduction during four-hour midday periods in the warmer months of the year.

INTRODUCTION

During the last decades, widespread use of mechanical cooling systems has resulted in increased difficulty for electrical utilities in guarantying reliable electricity supply in the warmer periods of the summer days. In these critical periods of high demand or supply contingencies, demand side management may play a key role in enhancing grid stability and supply quality, reducing the risk of blackouts (IEA, 2005). By definition, Electricity Demand Response (DR) is any action taken by consumers to reduce their electrical demand by a minimum amount during a predefined period, either as a response to a direct request from the utility or to the market price of electricity (NYISO, 2010 & ConEd, 2010). A summary of the performance of DR programmes in the U.S. in the hot summer of 2006 (Hopper et al., 2007) shows that the impact of DR under critical situations is relevant to grid stability resulting in a reduction in overall electrical system load of up to 2.3% (compared to the projected system load without DR). Most DR requests, or large electricity cost variations, occur in the warmer periods of spring and summer weekdays. In most cities around the world, office buildings are the largest electricity consumers in these periods, making them the main source DR related demand side management.

From the customer point of view, identifying strategies that allow for a significant and consistent demand reduction during DR events without a noticeable impact on indoor conditions is an essential first step in order to commit to a DR scheme. Building energy simulation is a suitable tool for testing DR strategies, typically in the following sequence:

1. Obtain a typical energy demand profile from an appropriate characterisation of the building and its energy systems.
2. Test different control strategies and predict their impact on electrical demand.
3. Negotiate the level of intervention in a DR scenario with the building manager to define internal setpoint adjustments and sensible equipment or spaces that cannot be subject to DR actions.

The present analysis focused on locally available incentive-based DR programs (ConEd, 2010 & NYISO, 2010). For the utilities these programs allow for more effective planning, from the building energy management point of view these programs can be very demanding. Still, lessons learned from the stringent tests imposed by these programs are easily adaptable to the less severe demand reduction requirements of other programs. After a review of local existing DR programs it was decided that the analysis would focus on following common program characteristics:

- DR events associated with high cooling loads happen typically during the afternoon (lasting 4 hours, in the period 14 – 18 h), when the outdoor air temperatures are higher, the solar radiation effects are stronger, and indoor spaces have accumulated heat from morning use.
- DR events can be partially forecasted, creating the opportunity to precool the building in the hours that precede the event. Predictions of high external air temperatures are good indicators (often, in these cases, the utility will contact the DR customers before the DR period).

The achieved energy demand reduction (DR Performance) is calculated on an hourly basis from a reference energy demand profile (called Customer Baseline Load, CBL) (NYISO, 2010). The CBL is calculated for each event, based on the average hourly electrical energy consumption from the previous ten days, choosing the five days with the highest load. Reference loads for the DR period are calculated from the average of these five days. DR performance is then calculated in an hourly basis for the DR event duration, as the difference between the CBL and the actual load.

The DR optimization case studied in this paper is a newly built 52-storey office tower, located in Manhattan, NY. The building has a few innovative features, such as exterior shading by ceramic rods, automatic control of internal shades, digitally controlled and automatically dimmable ballasts and an air conditioning based on Under Floor Air Distribution system (UFAD). The basic floor geometry is similar for most floors, still, different internal loads and occupation schedules create the need to simulate a large portion of the floors.

The portion of the building that will by subject to DR is occupied by the New York Times (NYT), floors 2 to 22. The building has a central heating/cooling plant. Heating is provided by a co-generation plant. Chilled water is provided by five compression chillers and one absorption chiller (using waste heat from the co-generation plant). Cooling towers are located at the building roof. A Building Management System controls and monitors the systems and energy consumption. This facility will greatly contribute to the implementation and evaluation of DR strategies. As expected, the co-generation plant cannot be used as a Demand Reduction resource, since it is base-loaded.

The aim of this study was to perform different simulation tests in order to identify a control strategy for the different systems that allows for a consistent reduction in the electrical demand without significant effects on thermal comfort. The simulations where performed in the open tool EnergyPlus (DOE-LBNL, 2010). The size and complexity of the building required careful and effective simulation simplification approach that will be discussed in the next section.

A SIMPLIFIED APPROACH FOR THERMAL SIMULATION OF LARGE BUILDINGS

The combination of currently available thermal simulation software and hardware processing power allows for increasingly complex simulations that often have a very large number of thermal zones. In the case of the office tower analysed in this paper, simulating the whole building without considerable geometric simplification would lead to over five thousand thermal zones. Clearly this approach is extremely time consuming in all phases of the process: data input, calculation, analysis and the iterations of these three phases that typically occur during a simulation. Thankfully, as is often the case with office buildings, the building under analysis has a periodic and symmetric geometry that allows for considerable simplification. Ideally one should be able obtain an accurate simulation result with a minimum number of thermal zones. This minimization speeds up the simulation and makes data analysis more feasible. The authors experience shows that, the increased control over the quality of the results allowed by the simplified model, largely compensates the small errors caused by the simplifications.

Simplification of overall geometry

To simplify the overall building geometry the following procedure was used:

1. Identify any periodic features in the building geometry, typically a floor that is repeated. This floor will be the base of the simulation model.
2. In the floor that is repeated check to see if it is possible to further reduce the simulation model to a slice of the floor or just one side if the floor is symmetric.
3. Construct the base model of the final minimal building portion obtained (typically a single floor or a portion of a single floor).
4. Construct a simplified model of the building and surrounding buildings so that solar shading and reflection effects are modelled.
5. Define the set of simulations and result aggregation that is required to characterize the whole building.

In order to minimize errors due to incorrect heat fluxes in the surfaces where the partial model interacts with the rest of the building model adequate boundary conditions must be selected. Typically, the two options are: adiabatic or periodic. For horizontal boundaries, floors and ceilings, often the best option is to use periodic boundary conditions, linking the middle of the floor slab with the middle of the ceiling slab. For vertical boundaries, linking slices or the two sides of a floor, often the best option is to use adiabatic boundary conditions. Finally the overall simulation result is obtained by summing the results of a minimal set of partial simulations of the floor or subfloor model (step 5 above).

Thermal zoning criteria

Within the selected periodic building portion the minimum number of thermal zones should be defined. Generally the simulation model will have fewer zones than the building but in some cases a single building zone may be divided into tow or more zones in order capture envelope effects or the core areas of typical open space offices. In order to reduce the number of thermal zones only internal surfaces that are subject to thermal gradients should be modelled explicitly. All other surfaces should be integrated into thermal mass surfaces (this type of simulation object is linked in the thermal model but is not modelled explicitly in the geometry). In most situations this approach greatly reduces the number of thermal zones by grouping adjacent rooms or offices with similar internal gains and HVAC systems.

In the current case, it was found that the majority of the floors present an equivalent geometry; therefore there was an opportunity to reduce the number of geometric models. The HVAC and lighting systems are also very similar among floors. However, the occupation and equipment installed, and the periods of use, present some diversity. Therefore, the common geometric model was modelled under different internal loads conditions and usage patterns. The results for the whole building are obtained from a reduced set of simulations by interpolation and extrapolation.

THERMAL SIMULATION MODEL

Building Geometry

The tower office analysed in this paper is shown in figures 1 and 2. Tower floors are mostly open space, with glazed partitions increasing the availability of natural light to closed spaces (meeting rooms). Most floors are symmetric along the building North-South axis (true North is rotated 29º to East). The floor general layout is repeated through the tower height. Each floor has a dedicated Air Handling Units (AHUs), feed by a fresh air pre-treatment central unit. The basic model consists of half floor that can be rotated and translated to represent any floor of the tower. The thermal zoning of the half floor is presented in figure 1.

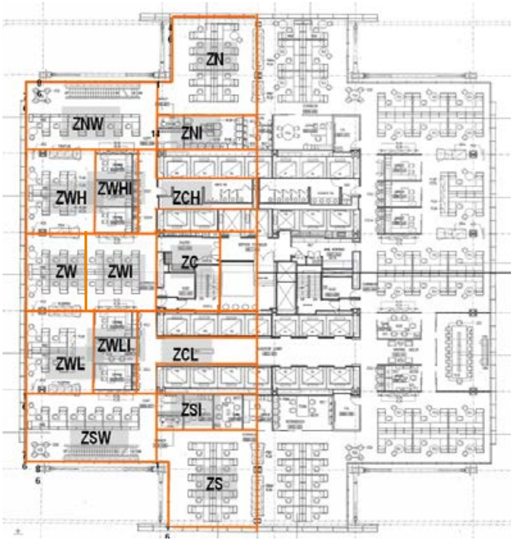


Figure 1 – Typical Floor Plant; Half Floor Zoning.

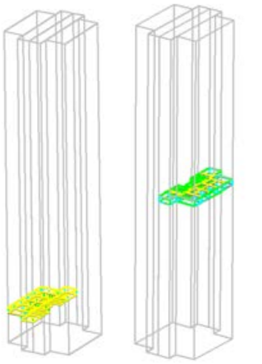
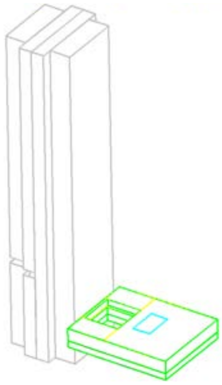


Figure 2 – Examples of rotation and translation of half floor model: 5th floor West half, 26th floor East half.



2 zone model of podium with skylight and courtyard.

The base of the tower is a podium (floors 2, 3 and 4) with a central courtyard and a skylight. This geometry was not modelled explicitly. Podium simulations were produced from standard half tower floors models with an extra thermal load that hourly reproduces the heat gains through the skylight and the windows that face the courtyard.

Construction

The building has a heavy concrete structure; internal partitions are mostly lightweight. Lightweight raised floors and suspended ceilings provide supply and outflow plenums, respectively. The facade is glazed, except between the suspended ceiling and the next floor's elevated floor (opaque insulated elements composed of 5 cm rock wool core coated in both sides by aluminium sheets). The curtain glass facade uses extra-clear low-iron, low-emissivity double glazing. Interior fabric shades are automatically controlled to prevent glare and direct solar incidence. An external shading skin made of white ceramic rods contribute to reduce direct solar incidence in the facade, while diffusing light to the interior (approximately 250 000 ceramic rods are distributed over the facade). Rods are unevenly distributed over each floor height allowing for unobstructed view at eye level.

Lighting and daylight

Daylighting is an essential feature of the building. The combination of glazed facade with open space increases daylight penetration. Digitally addressable dimmable ballasts automatically reduce artificial light according to available daylight. Lights levels on each zone can also be reduced by central BMS.

HVAC

The building uses a central plant with production and fresh air pre-treatment combined with floor level AHU. Conditioned air is introduced in the spaces using an Under Floor Air Distribution system (UFAD) with swirl diffusers (approximately one per workstation). Fan powered perimeter boxes allow for adjustable airflow in the facade zone.

The working principle of UFAD is similar to Displacement Ventilation (DV): air is introduced at low level, rising as it absorbs heat from the space, and is removed at high level. It is better than traditional DV systems in dealing with large loads due to increased mixing. These systems are not correctly described by the conventional well-mixed room air assumption, therefore the UCSD UFAD model was used within EnergyPlus (Lin and Linden, 2005). This model defines two sub-zones in each space, a lower occupied zone, and an upper zone, each assumed to have uniform temperature. The thermostat controls the lower, occupied zone.

Outdoor Air

The outdoor air rate is based on ANSI/ASHRAE Standard 62.1-2007 recommendations for office buildings, given by the sum of occupant outdoor air rate (2.5 L/s.person) and area outdoor air rate (0.3 L/s.m^2). In the simulation, the maximum of 67 occupants in a half floor (1036 m^2) was considered for outdoor air definition. This is approximately 50% of the outdoor air rate capacity of the AHU.

Exterior shading

Exterior horizontal ceramic cylindrical rods cover part of the facades and contribute to shade the extensive glazed surface. EnergyPlus does not model curved surfaces such as cylinders and so the ceramic rod was represented as two long surfaces running along the facade with an X shape cross-section (see figure 3). Each of the 2 surfaces that compose the cross model is characterized by visible and solar reflectance of 40% and all radiation is reflected as diffuse.

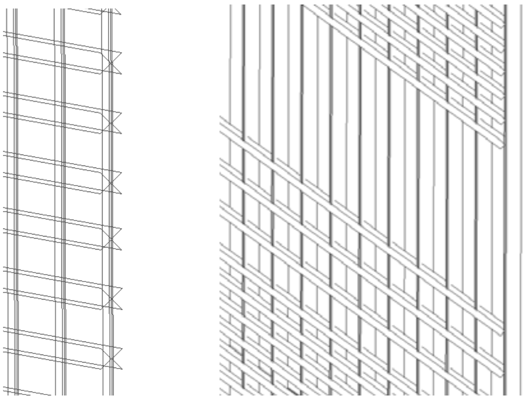


Figure 3 – Cylindrical ceramic rods representation; left: detail of the X shape cross section; right: rods distribution over each facade and open stripe at floor eye level.

The neighbourhood buildings are also modelled to take in account the effect of shading and reflections. The source for this modelling was the digital urban 3D model of the New York City provided within the project scope. Significant tall buildings are located mostly east and northeast from the NYT building. Not every construction was modelled. Building surfaces were selected according to the ability to shade or reflect solar radiation, considering both their relative position to the NYT building, distance and height.

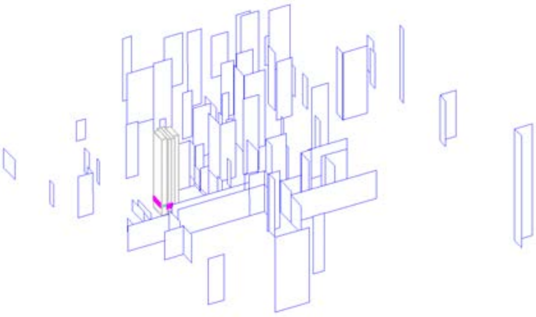


Figure 4 – Model representation of surrounding buildings, S-SW view.

Internal Gains

The building occupation schedule is complex, resulting from several different users within the NYT company and tenants. Office floors follow a typical daytime schedule, whereas Newsroom floors stay open until 2 am. For Newsrooms, the typical internal load due to occupation, lighting and electric equipment, during the morning period, is between 22 and 29 W/m^2, depending on the floor. For office floors, there is a greater difference variation between 19 and 34 W/m^2.

In the early simulation phase very little difference was found between simulation results for high and for low floors. This unexpected result triggered a detailed investigation on the impact of floor height was performed, analysing the solar incidence and the floor energy demand, for floor models with the same internal gains, located in the 6th floor and 26th floors. We found that, from floor 6 upwards, the impact of floor height is minimal, since shading and reflection from neighbourhood is much reduced. Although this is a highly glazed building, the energy demand of the different office floors are mostly associated to internal loads.

Whole building simulation

The fact that the total electrical demand was found to be mostly associated to floor use, with very little difference deriving from location (only 3% difference in total electrical demand from floor 6th to floor 26th when applying the same internal loads), allowed for the use of an extrapolation criteria based on internal load.

All Newsrooms have similar internal loads, ranging between 22 and 29 W/m^2. For these floors we consider that electrical demand for a given floor is proportional to its internal gains by a "Floor Factor" (close to 1):

$$\text{Floor Factor} = \frac{\text{floor internal load at 9am}}{\text{typical floor internal load at 9am}} \qquad (1)$$

The electrical demand (lights, electrical equipment and HVAC, as calculated by EnergyPlus simulations) is then extrapolated (proportional, to the test case demand, by the factor defined).

For office floors, the internal load ranged between 39 and 71 kW per floor. To cover all cases we simulated the two extremes load scenarios and, on an hourly basis, used linear interpolation to predict the demand. For the floors to be rented (23-27), which are not known in detail, an average internal gain value of 54 kW/floor was adopted, based in the office floors in use by the NYT. These floors are not subject to DR.

Energy demand components

In this analysis we focused on electricity use, since the main objective is to determine the electrical demand profile and the Demand Response strategies. The following electrical demand components were considered:

- *Electric equipment*: workstation and floor equipments; elevators and similar not considered;
- *Lighting*: floor automatically dimmable lights
- *HVAC*: chiller, AHU fans, perimeter boxes fans, cooling tower fan, pumps;

The chiller electrical demand is calculated from the VAV cooling coil demand in post processing, using a simple version of the EnergyPlus model Chiller:Electric:EIR (LBNL, EnergyPlus, 2010), implemented in a spreadsheet. The condenser entering temperature is a function of outside wet bulb temperature.

DEMAND RESPONSE STRATEGIES

Demand Response periods

To test the DR strategies, potential demand response periods must be identified. Hot days are usually local peak electrical demand periods for office buildings, due to air conditioning demand, and also potential DR event periods. We simulated a one year period of a representative portion of the building and analysed the correlation of cooling energy to three different environmental parameters: daily maximum Dry Bulb Temperature, daily maximum Wet Bulb temperature and daily average of total (beam plus diffuse) Solar Radiation. The variable that presented a better correlation to cooling energy was Dry Bulb Temperature, so this was chosen as the main environmental parameter for selection of critical periods.

Figure 5 shows the correlation between cooling energy and the three environmental parameters analysed and identifies two potential Demand Response event days: May 10th and July 1st.

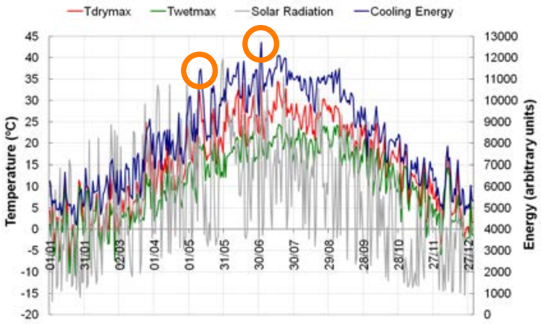


Figure 5 – Selection of potential DR days.

In this study, we performed a series of simulations in different phases, for refining the reference model and the DR strategies. Typical DR actions considered included reduction of indoor lighting setpoints, increase of cooling setpoint, reduction of fresh air and pre-cooling the building.

With the aim of achieving a consistent demand reduction over the DR period, two different approaches were tested:

- Progressive DR, where actions are applied successively and progressively.
- Simultaneous DR, where actions are applied simultaneously at the start of the DR event.

The Progressive DR strategy consists of:

14h00: Lights: reduction to 30% in Core, to 70% in PC interior zones and to OFF on PC perimeter zones.

Pre-cooling: Cooling supply air temperature is 12ºC during the morning and at 14h is increased to 14ºC.

Fresh Air: during the DR period the overall fresh airflow is reduced by 43%;

Thermostat: set point increases from 23.65 to 26ºC.

Fans: airflow capacity of perimeter boxes fans is limited to 30%.

16h00: pre-cooling supply air temperature increases to 15.3ºC.

17h00: Thermostats: In the East side of the building, cooling set point increases to 27 ºC. In the West side, no further increase in cooling setpoint takes place, since solar incidence will depreciate comfort conditions. HVAC system is shut off in the Office floors (in normal operation this occurs at 17h30).

18h15: System's recovery initiates.

The Simultaneous DR strategy consists of:

14h00: reduction of lights by 70% in Core, 30% in PC interior zones and to 100% on PC perimeter zones.

Pre-cooling: Cooling supply air temperature is 12ºC during the morning and at 14h is increased to 15.3ºC.

Fresh Air: during the DR period the overall fresh airflow is reduced by 43%;

Thermostats: cooling set point increases from 23.65 to 26ºC in the West half of the building, and to 27ºC in the East half of the building.

Fans: Airflow capacity of perimeter boxes fans is limited to 30%.

17h00: HVAC system is shut off in the Office floors (in the normal operation this occurs at 17h30).

18h15: System's recovery initiates.

RESULTS

Whole building energy demand

The typical Newsroom demand profile is presented in figure 6 and the full building profile is shown in figure 7.

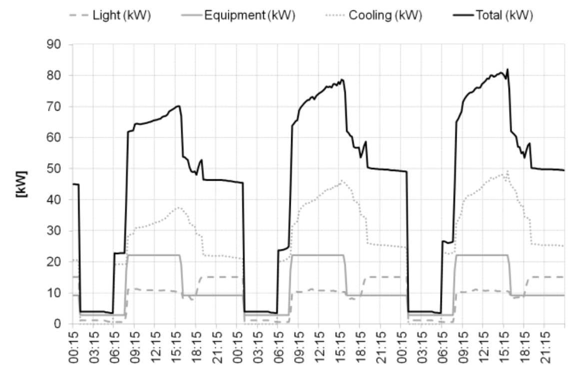


Figure 6 – Demand profile components for a typical Newsroom floor (May 8-10).

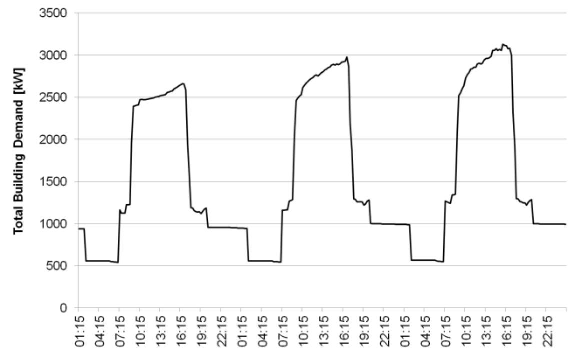


Figure 7 – Demand profile for the building – floors 2 to 27 (May 8-10).

Comfort Analysis

In order to access the impact of DR actions and different pre-cooling strategies in occupants thermal comfort (ANSI/ASHRAE, 2004), a PMV analysis was performed for representative perimeter zones, located on both sides of the typical floor and facing different orientations.

The less favourable comfort conditions are achieved for a southwest facing zone, as expected. In the May DR period, the maximum Fanger PMV is 0.7 (1 corresponds to "slightly warm" in the ASHRAE thermal sensation scale), while without DR actions the maximum is 0.4. For the July DR period, the maximum Fanger PMV in this zone is 0.9, while even without DR actions the maximum is 0.8 (due to the impact of solar gains in the radiant temperature of the space). Figure 8 and 9 show, on the left axis, two simulation results for total electrical demand:

(A´) the energy demand for the building in the DR day, in case no actions were taken to reduce load.

(F) the Energy Demand resulting from the DR actions implementation (sequential actions).

On the right axis shows the PMV values, averaged for the facade zones (typical Newsroom floor), as resulting from baseline control (A´) and from the DR progressive strategy (F).

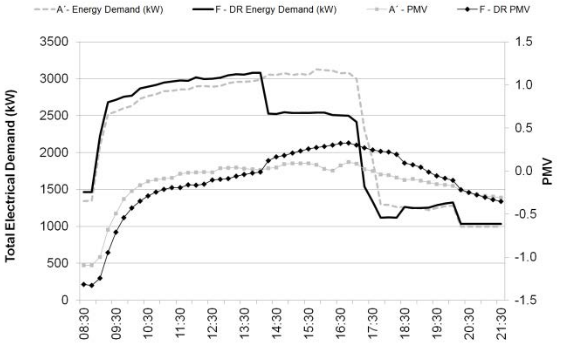


Figure 8 – Electrical demand profile for the building and PMV averaged for facade zones (May 10).

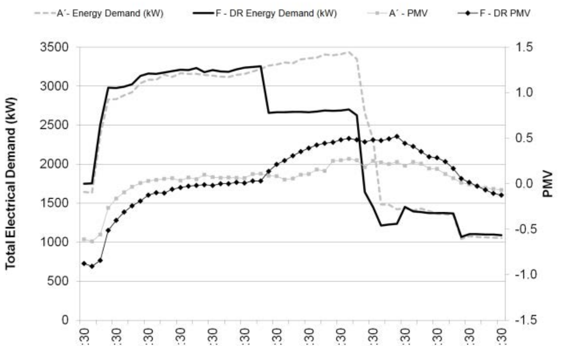


Figure 9 – Electrical demand profile for the building and PMV averaged for facade zones (July 1).

Demand reduction achieved

Figure 10 and 11 present the DR results for the two strategies considered, including three lines:

(A) the CBL baseline, based on the demand from previous days.

(A´) the energy demand for the building in the DR day, in case no actions were taken to reduce load.

(F) the Energy Demand resulting from the DR actions implemented.

The actions proposed allow for a consistent demand reduction during the DR event. The minimum hourly value of demand response (compared to the CBL) occurs during the first hour of the DR period, since in the following hours the accumulated effect of the solar gains and exterior temperature in the CBL increases and therefore the impact of the HVAC related DR actions also increases. The last hour of the demand period corresponds to a steep reduction in the baseline demand, due to the closing time of the offices, at 17h. The challenge is to keep the absolute value of the electrical demand shed for the building, even with a drop of approximately 50% in the CBL profile. The DR actions proposed create a fluctuation in the demand shed, seen at the end of the DR period. However, as the analysis is hourly, it is possible to maintain an approximately constant shed during the entire DR period.

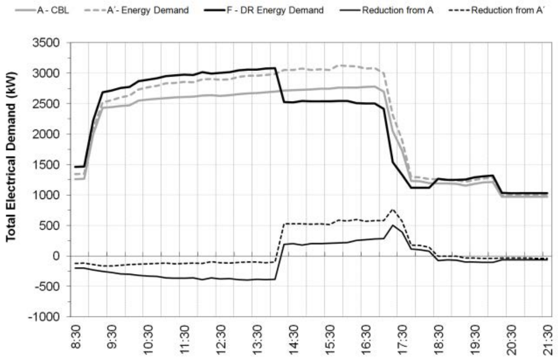


Figure 10 – Progressive DR Demand profile for the building (May 10).

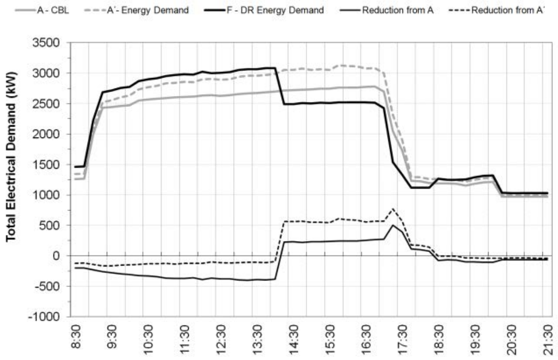


Figure 11 – Simultaneous DR Demand profile for the building (May 10).

For the July period, the results are similar. However, the demand is higher and the reduction achieved is more significant. A summary of the results is presented in tables 1 and 2.

Table 1 – Demand Reduction achieved in May 10

During DR Period (4 hours, from 14h to 18h)	Progressive Actions		Simultaneous Actions	
Baseline	A	A´	A	A´
Total Energy Reduction (%)	10%	19%	10%	19%
Minimum DR (kW)	193	422	227	422
Average DR (kW)	239	521	219	501

Table 2 – Demand Reduction achieved in July 1

During DR Period (4 hours, from 14h to 18h)	Progressive Actions		Simultaneous Actions	
Baseline	A	A´	A	A´
Total Energy Reduction (%)	14%	22%	16%	24%
Minimum DR (kW)	349	601	359	611
Average DR (kW)	373	659	427	713

The accuracy of the analysis presented could be improved by using a shorter time-step for weather data, as discussed by Hensen (1999). In the case of present study, a higher frequency of weather data would affect specially the quantification of light dimming controls and electrical demand. In a smaller extent, the precision would improve also in the solar gains related phenomena, since the time constant of building elements contributes to reduce the impact of short-term variations of solar radiation (wind data is not particularly relevant in the analysis performed; temperature and humidity are generally sufficiently well described by average hourly values).

CONCLUSIONS

The motivation for contracting the dynamic energy simulations described in the present work was to understand the impact of different control strategies on the dynamic energy demand of the building and occupant comfort and to understand the adjustments that should be implemented to the BMS to implement these strategies.

The results indicate that, for the DR programs where a minimum value of demand reduction must be guaranteed for any day in an enrolment period, a (conservative) base value 150kW of demand reduction can be used. This corresponds to 4.3% of the peak building energy demand for the July period considered. The lessons learned from this work can also be used in daily load management, contributing to an improved energy cost management.

Early results from the current study were used by LBNL to get a first estimate of economic scenarios for DR programs. The analysis (Sila Kiliccote, 2006) used preliminary results of 400KW demand shed, considered the economic details of the DR programs in 2006 and, considering average of 2 events per year with 4 hours each, estimated the predicted annual savings that each program could represent for the NYT. The most lucrative program is the Installed Capacity Special Case Resource, as it pays monthly for the capacity, as well as during DR events, resulting in approximately $17600/year. However, as discussed in (Lee, et al., 2007), that corresponds to less than 1% of the estimated annual bill for electricity and therefore the economic incentive associated to DR is not significant. This result is not surprising, even from the NYT stakeholders' point of view: the main motivation for participating in DR programs is to contribute to improve reliability of the electrical system. This supports the idea that DR is typically done out of goodwill and not for economic reasons.

ACKNOWLEDGEMENT

This research was funded by the New York State Energy and Research Development Authority (NYSERDA), the Demand Response Research Center (drrc.lbl.gov) funded by the California Energy Commission, Public Interest Energy Research Program, under Work for Others Contract No.150-99-003, Am #1, by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

REFERENCES

International Energy Agency. (2005). Learning from the Blackouts - Transmission System Security in Competitive Electricity Markets. OECD/IEA.

NYISO Auxiliary Market Operations. (2010). Emergency Demand Response Program Manual (version 6.1).

Hopper N., Goldman C., Bharvirkar R., Engel D., The Summer of 2006: A Milestone in the Ongoing Maturation of Demand Response, The Electricity Journal, Volume 20, Issue 5, June 2007, Pages 62-75

Consolidated Edison, Inc. (n.d.). Retrieved in 2/12/2010 from www.coned.com

NYISO - New York Independent System Operator. (n.d.). Retrieved in 2/12/2010 from www.nyiso.com

U.S. Department of Energy. (2006). Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them - A Report to the United States Congress Pursuant to the Section 1252 Of the Energy Policy Act of 2005.

ANSI/ASHRAE. (2004). ANSI/ASHRAE Standard 55-2004 - Thermal Environmental Conditions for Human Occupancy.

ANSI/ASHRAE. (2007). ANSI/ASHRAE Standard 62.1-2007 – Ventilation for Acceptable Indoor Air Quality.

LBNL, EnergyPlus. (2010). Energy PLus Documentation: Getting Started with EnergyPlus, EnergyPlus Engineering Reference, Input and Output Reference.

Hensen, J. L. M. (1999). Simulation of building energy and indoor environmental quality – some weather data issues. Proceedings of the International Workshop on Climate data and their applications in engineering, 4-6 October, pages 1-15. Prague, Czech Hydrometeorological Institute.

Lee, E., Clear, R., Fernandes, L., Kiliccote, S., Piette, M. A., Rubinstein, F., et al. (2007). Daylighting the New York Times Headquarters Building, Commissioning Daylighting Systems, Estimation of Demand Response.

Y.J.P. Lin, P.F. Linden, A model for an under floor air distribution system, Energy and Buildings, Volume 37, Issue 4, April 2005, Pages 399-409.

Nicole Hopper, C. G. (2007). The Summer of 2006: A Milestone in the Ongoing Maturation of Demand Response. The Electricity Journal . Elsevier.

Sila Kiliccote, M. A. Piette (2006). Dynamic Controls for Energy Efficiency and Demand Response: Framework Concepts and a New Construction Study Case in New York. Proceedings of the 2006 ACEEE Summer Study on Energy Efficiency in Buildings.