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COMPUTER - ASSISTED ENERGY SIMULATION OF THE BLACK ROCK FOREST CENTER FOR SCIENCE AND EDUCATION

BLACK ROCK FOREST CONSORTIUM
Cornwall, NY

New York State
Energy Research and Development Authority

NOTICE

ENERGY SIMULATION OF BLACK ROCK FOREST CENTER FOR SCIENCE AND EDUCATION, USING THE COMPUTER PROGRAM DOE-2.1E

Prepared for:

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I. SUMMARY

Steven Winter Associates, Inc. (SWA) simulated the Black Rock Forest Center for Science and Education on the computer program DOE-2.1E. The analyses were performed in support of the design work by Fox & Fowle Architects, PC and Gerard Associates Consulting Engineers, PC. New York State Energy Research & Development Authority co-funded the project. The purpose of the simulation was three-fold:

- Ascertain energy saving opportunities within a unified design that results in small first cost increments.
- Recommend building details that reduce the probability of moisture condensation.
- Achieve thermal comfort and good IAQ.

The Base design is 34%-36% more energy-efficient than a Code-compliant building, depending on the HVAC system used in the Code-compliant design. Because it has a laboratory, the building is assumed to use much electricity for experiments, and also for data processing. This electricity use is constant in all analyses, and because of its magnitude it obscures the comparison between designs. If the electricity used by computers and laboratory equipment is not included in the calculation, the Base design is 43%-46% more energy efficient than a Code-compliant design, depending on the HVAC system used in the Code-compliant design.

With some further improvements, the design can save 37%-38% over the code-compliant building (47%-49%, without considering the electricity used by computers and laboratory equipment).

The Base design uses wall and roof details that reduce the risk of moisture condensation. It provides ASHRAE Standard 62 outside air rates, which are higher than required by Code, resulting in better IAQ. Further optimization of this design is possible and recommended in this study, and will result in some additional benefits in energy use and environmental areas.

Concept:

The guiding idea for the building was to achieve a high level of energy efficiency and good indoor air quality, at a relatively small increase in first cost. To this end, the following strategy was pursued:

- Site the building with the long axis on an east-west direction, to take advantage of solar heat during winter, and to easily protect against solar heat during summer.
- Place most windows on south and north facades, for reduced solar gain in summer, increased solar gain in winter, and good cross-ventilation.
- Specify high-R glass, with high visible transmittance, but with low shading coefficient. Protect the windows on the south facade with wide overhangs and awnings.

- Specify the opaque portion of the building envelope with higher thermal integrity, and with lower probability of moisture condensation.
- Specify efficient lighting, with controls to take advantage of daylight.
- Because of the good envelope, and because of the efficient lighting, obtain lower peak loads. Primary heating/cooling equipment, fans, ducts and pipes are reduced.
- Provide a highly efficient HVAC system, using geothermal heat pumps.
- Provide ASHRAE Standard 62 outside air rates.

Siting is an important first step for an energy-efficient design. A building of elongated shape, with the long axis on the east-west direction, can be easily designed to minimize heat gains in summer and to maximize them in winter. This is achieved by placing most glass on the south facade, where it can be protected with overhangs and awnings during summer; yet these shading devices allow most solar energy to penetrate into the building during winter. (Cooling minimization requires very wide shading devices; increasing winter solar gains, and increasing the amount of daylight received at all times, requires no shading devices, or very narrow ones. Thus there exists an optimum width for overhangs and awnings.)

Windows on the north facade play a positive role too, because a) they allow daylight in the north section of the building; and b) they allow effective cross-ventilation.

All glass has high visible transmittance and low shading coefficient. High visible transmittance allows good visual contact with the outdoors, and increases the opportunity for daylighting. Low shading coefficient reduces cooling loads during summer. Since a low shading coefficient results in lower peak cooling load, the size of the cooling system (and also the length of the relatively expensive geothermal wells) is reduced.

The windows have low U-value. These windows save energy, improve comfort during winter, and also allow the diffusers to be kept away from the perimeter. Placing the diffusers at the interior partition walls frees valuable space at windows and reduces the cost for ductwork.

Another important factor in designing an energy-efficient building is the area of windows, and their distribution on facades. The Base Case design started with windows on the south facade as 17% of the gross wall area (first and second floor, not including the stairwell, which is fully glazed). Parametric analyses were then performed and found that increasing the window area up to 22% further reduces the energy use.

The building envelope was conceived with high thermal integrity -- a non-trivial task given the need to build with steel studs (for fire-protection purposes). The wall is well insulated, to reduce heat loss, to increase comfort, and to reduce the risk of moisture condensation. SWA assisted the Architect to develop a detail which can accomplish these goals in a cost-effective manner. The recommendation was to specify thermally-broken metal studs by Tri-Chord. Typical steel studs create cold strips on the interior gypsum board. In buildings without winter humidification, these strips result in increased energy use, but usually do not create further problems. However, if a space is likely to be humidified during winter (e.g., because of a fish-tank, or during experiments, as may be the case in this building), moisture will condense on the gypsum board and even on

studs. Dirt streaks, mold and rusting can occur. The Tri-Chord studs, with their thermally-broken design, reduce the likelihood of moisture condensation. They also reduce the heating energy use.

A well-insulated envelope removes the need to run ducts close to the perimeter, because the surfaces of windows and walls are warmer in winter. Thus, money is saved in lower first cost for HVAC distribution. A well-insulated, well-shaded envelope, in conjunction with an energy-efficient lighting system, also reduces the amount of air required to meet the peak loads. Lower cfm result in smaller fans and ducts, further reducing HVAC costs. Finally, the size of the primary heating and cooling equipment is decreased (heat pumps and associated geothermal wells), further reducing first costs. In turn, the reduction in HVAC costs is used to offset the increase in the cost of the envelope.

Simulation Model

SWA simulated the building using a 16-zone model on an extended version of DOE-2.1E running on UNIX computers. The relatively large number of zones for this small building (8,400 ft^2) was required to account for variations in function, schedules and azimuth. Such a detailed model gives increased confidence in results, and allows more informed decision-making during the design process.

Method

SWA closely collaborated with the Black Forest Consortium (William Schuster, Ph.D., Executive Director), with Fox & Fowle Architects (Sylvia Smith, AIA, Principal; and Leslie Lewis) and with Gerard Associates Consulting Engineers, PC (Jeff Pfeiffer, PE) in developing an energy-efficient, cost-effective design. Mark Watson provided input from NYSERDA. Because of the commitment of all team members to these goals, all energy-efficient strategies recommended at the initial brainstorm meeting were incorporated in principle in the design from the beginning. As a result, the DOE-2 analysis had the advantage of starting with a Base Case that was proven to be 34%-36% more energy-efficient than a similar, code-compliant design. Simulations were then performed a) to enhance the energy efficiency of the design, to the extent possible; and b) to quantify the increase in energy use, should some of the energy-efficient features not be implemented because of budget constraints. Specifically, the analyses were as follows:

- the highly efficient Base Case
- the code-compliant building, which represents typical practice (two types of HVAC system)
- window parametrics (glass types, window area, shading devices)
- opaque wall analysis
- lighting analysis
- circulation and geothermal pump analysis
- siting analysis (building rotated by 90°)

Findings

The Base Case building, which incorporated from start the recommendations for an energy-efficient design, has 36% lower energy cost than a similar building that merely complies with the New York State Energy Conservation Construction Code. This Code-complying building has the same geometry as the Base Case design, but differs in the energy efficiency of its components. It has less insulated walls, less insulated windows, and glass with higher shading coefficient; it has no overhangs and awnings; it also uses more electric lighting. The Code-complying building uses the same type of HVAC system as the Base Case design -- a water loop heat pump (SEER= 9.3, HSPF = 12.97), but the energy source for the heat pumps is not geothermal; rather, it is provided by a cooling tower and a boiler (AFUE=80%). If the comparison is made against similar building which complies with the Code and which uses the more common rooftop DX/furnace system, the Base Case has 34% lower energy cost than the Code-complying case.

Energy-Efficient Strategies (EES) Incorporated in the Base Case Design

The highly efficient Base Case building has the following features:

- Oblong shape, with long axis on the east-west direction
- Most windows placed on the south facade, minimal glazing on the east and west facades
- Cardinal LoE^2-172 clear glass for windows (Ucog=0.25, SC=0.37, VT=0.72) shaded on the south facade with overhangs 2.0 feet deep (second floor) and with awnings 2.0 feet deep (first floor)
- Wall with thermally-broken Tri-Chord steel studs and insulating sheathing (R-overall=21.27)
- Roof with structural insulated panels (R-overall= 22.7), eliminating the possibility of air intrusion through the more typical fibrous insulation
- Geothermal heat pumps (SEER=14, HSPF=12.6) for heating, cooling and DHW
- Variable speed for the pump in the building circulating loop
- Air-to-air heat recovery, 75% efficient
- ASHRAE Standard 62 ventilation rates (20 cfm/person)
- CO_2 sensors to modulate the outside air according to occupancy
- Efficient lighting, using electronic ballasts and T-8 lamps (1.8 watts/sq.ft. labs; 1.5 watts/sq.ft all others)
- Occupancy sensors in offices
- Daylight dimming system in all perimeter spaces

The following additional energy-efficient strategies were studied to examine whether the Base Case design could be improved, and also to assess how much would the energy use increase if some EES were not implemented.

Run Code	Alterative Design Description	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Annual CO_2 Emissions (lbs)	Reduction in Annual CO_2 Emissions (lbs)
Base Case	As noted above	8,923	N/A	93,250	N/A
New York State Energy Conservation Construction Code Compliant Alternates					
ANYRQ	Model complying with New York State Energy Conservation Construction Code, water loop heat pump with cooling tower and boiler	13,874	(4,951)	127,696	(34,446)
ANYR1	Model complying with New York State Energy Conservation Construction Code, DX/furnace rooftop units	13,472	(4,549)	93,898	(647)
Architectural Design Alternates					
ALTA1	Rotate building to have the long axis on a north-south direction	9,163	(240)	96,301	(3,051)
ALTS1	Increase south window area by 10%	8,915	8	93,167	84
ALTS2	Increase south window area by 20%	8,907	16	93,085	166
ALTS3	Increase south window area by 30%	8,900	23	93,011	239
ALTS4	Decrease fixed glass area at south stairwell by 20%	8,917	6	93,206	44
Lighting, Shading, R-value Alternates					
ALT02	No daylighting dimming	9,409	(486)	97,878	(4,628)
ALT2A	Offices with 1.0 w/ft² lighting	8,794	129	91,866	1,384
ALT09	3'-0 overhang and awnings	8,832	91	92,239	1,012
ALT10	4'-0 overhang and awnings	8,837	86	92,274	976
ALT11	2'-6 overhang and awnings	8,833	90	92,245	(1,005)
ALT19	R19 steel studs, not thermally broken	9,120	(197)	(94,537)	(1,287)
Commercial Glazing Alternates					
ALT01	Double pane ¼" Viracon VE 1-85 glazing (no argon) SC=0.62 VT=0.76 U=0.31	9,089	(166)	94,608	(1,357)
ALT03	Double pane ¼" Viracon VE 1-2M glazing (no argon) SC=0.43 VT=0.70 U=0.29	8,968	(45)	93,483	(233)
ALT04	Double pane ¼" Viracon VE 1-2M w/ argon glazing SC=0.43 VT=0.70 U=0.24	8,897	26	93,071	179
ALT05	Double pane ¼" Interpane Super-E glazing (no argon) SC=0.46 VT=0.69 U=0.29	8,975	(52)	93,545	(295)
ALT06	Double pane ¼" PPG Sungate 1000 glazing (no argon) SC=0.44 VT=0.69 U=0.29	8,972	(49)	93,511	(260)
ALT07	Double pane ¼" Interpane ILE-174 glazing (no argon) SC=0.66 VT=0.74 U=0.31	9,042	(119)	93,983	(733)

Run Code	Alterative Design Description	Annual Energy Cost ($)	Annual Energy Cost Savings ($)	Annual CO_2 Emissions (lbs)	Reduction in Annual CO_2 Emissions (lbs)
ALT08	Double pane ¼" PPG Sungate 100 glazing (no argon) SC=0.59 VT=0.73 U=0.31	9,028	(105)	93,871	(621)
Residential Glazing Alternates					
ALTG1	Double pane ⅛" PPG Sungate 1000 (2) w/ argon glazing SC=0.44 VT=0.71 U=0.24	8,904	19	93,123	127
ALTG3	Double pane ⅛" Cardinal LoE² 178 (2) w/ argon glazing SC=0.68 VT=0.78 U=0.26	8,976	(53)	93,556	(305)
ALTG4	Double pane ⅛" Cardinal LoE² 178 (3) w/ argon glazing is used. SC=0.75 VT=0.78 U=0.26	8,993	(70)	93,657	(407)
ALTG5	Double pane ⅛" Guardian Performance Plus (2) w/ argon glazing SC=0.1 VT=0.70 U=0.28	9,002	(79)	93,731	(481)
ALTG7	Double pane ⅛" LOF Energy Advantage (2) w/ argon glazing SC=0.75 VT=0.75 U=0.29	9,021	(98)	93,901	(651)
ALT12	Double pane ⅛" Kolbe & Kolbe Cardinal LoE² 172 5/8" unit w/ argon SC=0.48 VT=0.72 U=0.40	9,004	(81)	93,591	(340)
HVAC System Alternates					
ALTW1	Two pumps with VSD for the building loop (one or two pumps on as needed)	8,885	38	92,587	663
ALTW2	One geothermal well pump with variable speed drive.	8,782	141	90,782	2,468
More Energy-Efficient Design					
INT01	ALTS3, ALT2A, ALT11, ALTW2 Most spaces with 1.0 w/ft² lighting 2'-6" overhang and awnings. Increase south window area by 30%. One geothermal well pump with variable speed drive.	8,540	383	8,813	84,437

Conclusions

- The computer simulation ALTA1 quantifies the reduction in energy cost obtained by having the long axis of the building in the east-west direction instead of the north-south direction ($240/year). This no-cost strategy is part of the Base Case design. Note that the reduction is fairly small because the building is highly energy efficient. Further, the north-south orientation for the long axis would result in higher costs for the HVAC equipment, due to higher size of heat pumps, of larger ducts, and of larger geothermal wells.

- The Base Case design has very good performance, since it already incorporates an energy efficient envelope, energy efficient lighting, and energy efficient HVAC system.

- The simulations of larger window areas on the south facade indicate that modest energy savings can be achieved. The savings are not sufficient to justify the added cost for larger window areas; however, they do indicate that the Architect can increase this area for other reasons (aesthetic, functional) and reap a small additional energy bonus in the process. For instance, a larger window area will allow more visual contact with the outdoors.

- The best energy performance is obtained by the following glazings:

  - ALT04, ¼" Viracon VE 1-2M glazing with argon (SC=0.43, VT=0.70, U=0.24)
  - ALTG1, ⅛" PPG Sungate 1000 (2) glazing with argon (SC=0.44, VT=0.71, U=0.24)
  - Base Case, ⅛" Cardinal LoE^2-172 glazing with argon (SC=0.47, VT=0.72, U=0.25).

  Other glass has good energy cost performance, including the ⅛" glass used in ALTG3 (Cardinal LoE^2-178, SC=0.68, VT=0.78, U=0.26) and the commercial glasses of ALT03 and ALT06. Ideally, though, the glass will have U-value 0.26 or below, to ensure optimal comfort at perimeter, and to reduce the potential for moisture condensation.

- The 2'-6" overhang on the south facade outperforms both the 2'-0" overhang and the 4'-0" overhang, and has practically the same energy use as the 3'-0" overhang. Thus, if first cost considerations permit, we recommend that the 2'-6" overhang be used. Note that the energy analysis was performed by increasing both the overhang width, which provides protection for second floor windows, and the width of shading devices above the first floor windows. If, for structural reasons, the shading devices that protect the first floor are maintained at 2'-0" width, then only half of the energy savings of this alternate will be attained.

- The glass area at the south stairwell can be decreased by 20% without significant effect on energy use.

- The R-value of the wall, including air films, is lowered from R-21.27 for thermally-broken studs to R-14.70 for typical steel studs. The steel stud walls that are not thermally broken increase the energy cost by a relatively small amount, given the highly efficient HVAC system. The detrimental effect of steel studs without thermal breaks is more significant in moisture condensation than in energy cost. We recommend that the thermally-broken steel studs by Tri-Chord be retained.

- The daylight dimming system yields significant cost savings and should be retained. An alternate system could yield similar energy savings, if the occupants are motivated. In this system, the ballasts are non-dimming. The occupancy sensor can only turn the lights off. A person has to press the light switch to turn the lights on. (See Section III for further details.)

- Further energy savings opportunities can be achieved if the lighting system can be designed with less than 1.5 w/ft^2 in office areas (1.0 w/ft^2 is achievable with indirect lighting).

- Variable speed pumps on one of the goethermal wells, if technically feasible, could further reduce the energy use.

If the following improvements were made, the design would be 37%-38% more efficient than the Code-Compliant buildings:

- South windows 30% larger
- Overhangs and awnings 2'-6" wide
- Variable speed pump for one geothermal well
- Most areas with 1.0 w/ft^2 (except laboratories, entry, living quarters)

Finally, occupant behavior can greatly affect the energy cost of the facility. For instance, opening the windows during cool and warm weather (combined with turning the heat pumps off) can further reduce the cooling energy use.

II. ANALYSIS OF BUILDING CHARACTERISTICS FOR BLACK ROCK FOREST CENTER FOR SCIENCE AND EDUCATION

General information on building geometry, internal loads and HVAC systems used for the "Base Case Model" analysis is provided below:

A. GENERAL INFORMATION

The Black Rock Forest Center for Science and Education is a two story research center. The cellar adds a third level.

Location:

Cornwall, New York

Expected Date of Construction:

1998

Building Area (as simulated on DOE-2.1E):

8,400 sq. ft. (approximate)

Number of Floors:

2 floors plus cellar

B. BUILDING OCCUPANCY PATTERNS

B.1 Functional Uses

The number of occupants and the occupancy schedules assumed in the energy analysis are listed below by function. The number of occupants is not the maximum allowed by code; rather, it is the maximum assumed for equipment sizing and energy use analyses.

B.1.a. Offices (includes the Data Center)

Assumes total of four people (one per office) at peak occupancy.

B.1.b. Computer Area

Assumes two people at peak occupancy.

B.1.c. Labs

Assumes 20 people per lab at peak occupancy.

B.1.d. Meeting Room

Assumes five people at peak occupancy.

B.1.e. Living Quarter

Assume one person at peak occupancy.

B.1.f. Mechanical Room

Assume one person at peak occupancy.

B.1.g. Stairs

Assumes one person at peak occupancy.

B.2 Occupancy Time Periods

B.2.a. Offices (includes the Data Center)

All year

Weekdays	Midnight-8:00 a.m.	0%
	8:00 a.m.-9:00 a.m.	50%
	9:00 a.m.-10:00 a.m.	100%
	10:00 a.m.-12:00 p.m.	33%
	12:00 p.m.-1:00 p.m.	100%
	1:00 p.m.-6:00 p.m.	33%
	6:00 p.m.-Midnight	0%
Weekend, Holiday	All hours	0%

B.2.b. Computer Area

All year

Weekdays	Midnight-8:00 a.m.	0%
	8:00 a.m.-10:00 a.m.	100%
	10:00 a.m.-12:00 p.m.	33%
	12:00 p.m.-6:00 p.m.	100%
	6:00 p.m.-Midnight	0%
Weekend, Holiday	All hours	0%

B.2.c. Labs

All year

Mon, Tue, Fri	Midnight-8:00 a.m.	0%
	8:00 a.m.-9:00 a.m.	50%
	9:00 a.m.-12:00 a.m.	10%
	12:00 p.m.-2:00 p.m.	0%
	2:00 p.m.-5:00 p.m.	10%
	5:00 p.m.-6:00 p.m.	5%

	6:00 p.m.-Midnight	0%
Wed, Thu	Midnight-8:00 a.m.	0%
	8:00 a.m.-9:00 a.m.	50%
	9:00 a.m.-12:00 a.m.	100%
	12:00 p.m.-2:00 p.m.	0%
	2:00 p.m.-5:00 p.m.	100%
	5:00 p.m.-6:00 p.m.	5%
	6:00 p.m.-Midnight	0%
Weekend, Holiday	All hours	0%

B.2.d. Meeting Room

All year

Weekdays	Midnight-9:00 a.m.	0%
	9:00 a.m.-11:00 a.m.	100%
	11:00 a.m.-1:00 p.m.	33%
	1:00 p.m.-5:00 p.m.	100%
	5:00 p.m.-Midnight	0%
Weekend, Holiday	All hours	0%

B.4 Building Environmental Conditions

The schedules reflect temperatures that are assumed to be average for each area.

HEATING SCHEDULE

Office, Computer Areas, Labs, Meeting Room

All Year

Weekday	Midnight-7:00 a.m.	65
	7:00 a.m.-6:00 p.m.	72
	6:00 p.m.-Midnight	65
Weekend, Holiday	All hours	65

Living Quarter

All year

Weekdays	Midnight-6:00 a.m.	68
	6:00 a.m.-8:00 a.m.	72
	8:00 a.m.-5:00 p.m.	65
	5:00 p.m.-10:00 p.m.	72
	10:00 p.m.-Midnight	68

COOLING SCHEDULES

Office, Labs, Meeting Room

All Year

Weekday	Midnight-7:00 a.m.	120
	7:00 a.m.-6:00 p.m.	78
	6:00 p.m.-Midnight	120
Weekend, Holiday	All hours	120

Computer Area

All Year

All day	All hours	76

Living Quarter		
All year		
Weekdays	Midnight-8:00 a.m.	76
	8:00 a.m.-5:00 p.m.	120
	5:00 p.m.-10:00 p.m.	78
	10:00 p.m.-Midnight	76

C. BUILDING ENVELOPE

C.1 Exterior Walls

The total wall area is 6,341 ft².

The total opaque wall area is 5,274 ft². The total window area is 1,066.32 ft².

The overall R-value of the opaque wall is 21.27 (hr·ft²·F)/Btu and U=0.047 Btu/(hr·ft²·F). The calculations account for thermal bridging effects.

The overall R-value of the entire wall, including windows which are 16.8% of the wall area, is 10.98 (hr·ft²·F)/Btu and U= 0.091 Btu/(hr·ft²·F).

Opaque Wall Construction:

- Exterior air film
- Wood siding (or stone at base)
- 1" extruded polystyrene (R-5)
- ½" plywood
- 6" Tri-Chord stud with R-19 batt insulation @ 16" o.c.
- 5/8" gypsum wallboard
- Interior air film

The New York State Energy Conservation Construction Code requirement for the entire wall (opaque and windows) is U=0.26 Btu/(hr·ft²·F). This relatively high U-value applies to calculations where thermal bridging is taken into account.

Therefore, the exterior wall complies with the Code.

C.2 Windows

Double-pane, ⅛" glass, mounted in wood frame with 7/8" air space filled with argon gas, from Kolbe & Kolbe. The glass is Cardinal LoE²-172. The frame is assumed to be 2" wide.

$U_{\text{center-of-glass}} = 0.25$
$U_{\text{unit}} = 0.4$
Shading Coefficient Glass = 0.47
Visible Transmittance Glass = 0.72

C.3 Roof

The total roof area for the building is 3,616 ft^2.

The roof layers are:

- Exterior air film
- Asphalt Shingles
- Felt paper
- ½" plywood
- 4" polystyrene
- ½" plywood
- Interior air film

The roof R-value is 22.7 ($hr \cdot ft^2 \cdot F$)/Btu and the U-value is 0.044 Btu/($hr \cdot ft^2 \cdot F$). The roof complies with the Energy Code.

D. MECHANICAL AND ELECTRICAL SYSTEM

D.1 Primary Heating and Cooling System

A water loop heat pump system provides heating and cooling in the building. Heating and cooling energy is extracted from geothermal wells, with a depth up to 500 feet. The heat pumps have a cooling EER of 14.0 and heating COP of 3.7. CO_2 sensors modulate the amount of outside air.

D.2 Domestic Hot Water

Domestic hot water is generated from a water/water heat pump.

D.5 Lighting

D.5.a. Offices (includes the Data Center) **- 1.5 w/ft^2**

All year		
Weekdays	Midnight-8:00 a.m.	5%
	8:00 a.m.-9:00 a.m.	50%
	9:00 a.m.-10:00 a.m.	100%
	10:00 a.m.-12:00 p.m.	33%
	12:00 p.m.-1:00 p.m.	100%
	1:00 p.m.-6:00 p.m.	33%
	6:00 p.m.-Midnight	5%
Weekend, Holiday	All hours	5%

D.5.b. Computer Areas - 1.5 w/ft^2

All year		
Weekdays	Midnight-8:00 a.m.	5%
	8:00 a.m.-6:00 p.m.	100%
	6:00 p.m.-Midnight	5%
Weekend, Holiday	All hours	5%

D.5.c. Lab Areas - 1.8 w/ft²

All year

Weekday	Midnight-8:00 a.m.	5%
	8:00 a.m.-9:00 a.m.	50%
	9:00 a.m.-5:00 p.m.	100%
	5:00 p.m.-6:00 p.m.	50%
	6:00 p.m.-Midnight	5%
Weekend, Holiday	All hours	5%

D.5.d. Meeting Room - 1.5 w/ft²

All year

Weekdays	Midnight-9:00 a.m.	5%
	9:00 a.m.-11:00 a.m.	100%
	11:00 a.m.-1:00 p.m.	5%
	1:00 p.m.-5:00 p.m.	100%
	5:00 p.m.-6:00 p.m.	50%
	6:00 p.m.-Midnight	5%
Weekend, Holiday	All hours	5%

A continuous dimming system is located in all perimeter spaces.

D.6 Other Electrical Equipment

D.6.a. Offices (includes the Data Center) **- 1.0 w/ft²**

All year

Weekdays	Midnight-8:00 a.m.	10%
	8:00 a.m.-9:00 a.m.	50%
	9:00 a.m.-10:00 a.m.	100%
	10:00 a.m.-12:00 p.m.	33%
	12:00 p.m.-1:00 p.m.	100%
	1:00 p.m.-6:00 p.m.	33%
	6:00 p.m.-Midnight	10%
Weekend, Holiday	All hours	10%

D.6.b. Computer Areas - 2.5 w/ft²

All year

Weekdays	Midnight-8:00 a.m.	50%
	8:00 a.m.-6:00 p.m.	100%
	6:00 p.m.-Midnight	50%
Weekend, Holiday	All hours	50%

D.6.c. Lab Areas - 6.7 kw total

All year, except for summer peak days

Weekday	Midnight-8:00 a.m.	20%
	8:00 a.m.-9:00 a.m.	70%
	9:00 a.m.-1:00 p.m.	50%
	1:00 p.m.-2:00 p.m.	70%
	2:00 p.m.-5:00 p.m.	50%
	5:00 p.m.-6:00 p.m.	80%
	6:00 p.m.-Midnight	20%
Weekend, Holiday	All hours	20%

Summer peak days, Jun 1, Jul 26, August 30

Weekday	Midnight-8:00 a.m.	20%
	8:00 a.m.-9:00 a.m.	70%

	9:00 a.m.-1:00 p.m.	50%
	1:00 p.m.-2:00 p.m.	70%
	2:00 p.m.-3:00 p.m.	100%
	3:00 p.m.-5:00 p.m.	50%
	5:00 p.m.-6:00 p.m.	80%
	6:00 p.m.-Midnight	20%
Weekend, Holiday	All hours	20%

D.6.d. Meeting Room - 1.5 w/ft^2

All year

Weekdays	Midnight-9:00 a.m.	10%
	9:00 a.m.-11:00 a.m.	33%
	11:00 a.m.-1:00 p.m.	10%
	1:00 p.m.-3:00 p.m.	100%
	3:00 p.m.-5:00 p.m.	33%
	5:00 p.m.-6:00 p.m.	17%
	6:00 p.m.-Midnight	10%
Weekend, Holiday	All hours	10%

III. DESCRIPTION OF ALTERNATE ENERGY DESIGNS FOR BASE BUILDING

BASE CASE: Loads and systems as previously described.

New York State Energy Conservation Construction Code Compliance Alternates

Alternate NYRQ: In accordance with the New York State Energy Conservation Construction Code:

Wall and window R-overall = 5
Roof R= 20
Lighting offices = 2.4 w/ft^2
Lighting laboratories = 2.4 w/ft^2
No daylight dimming is assumed.
HVAC system using water loop heat system, cooling tower and boiler.
The heat pumps have cooling SEER = 9.3 and heating HSPF = 12.97. The boiler has 80% AFUE.

Alternate NYR1: In accordance with the New York State Energy Conservation Construction Code, as in Alternate NYRQ, but changing the HVAC system to a configuration which uses DX/furnace rooftop packaged units.

The DX units have 8.9 SEER.
The furnace has 78% AFUE.

Architectural Design Alternates

Alternate A1: Rotate the building to have the long axis on a north-south direction. The size of HVAC systems increases (heat pumps, geothermal wells, ducts). The energy use increases too, but because of the highly efficient glass and HVAC systems, this increase is not major. The alternate was run for didactic purposes.

Alternate S1: Same as Base Case, except the south windows glazing area increase by 10%. This alternate shows small energy savings over Base Case.

Alternate S2: Same as Base Case, except the south windows glazing area increase by 20%. This alternate shows small energy savings over Base Case.

Alternate S3: Same as Base Case, except the south windows glazing area increase by 30%. This alternate shows small energy savings over Base Case.

Alternate S4: Same as Base Case, except the stair fixed glazing area decreases by 20%. This alternate shows small energy savings over Base Case.

Lighting Shading, R-value Alternates

Alternate 02: Same as Base Case, except there is no daylighting dimming.
This alternate is presented to quantify the benefits of daylight dimming.

Alternately, motivated occupants could obtain similar energy savings by using an occupancy sensor that only turns the lights off. Thus, if a person walks into a room, the light is off. In the presence of good daylight, it is likely that the person would not turn the lights on. During the occupied period, the daylight will fluctuate, but the eye readily adapts. The person will interrupt the work and make the conscious decision to go to the light switch only if light levels became so low as to be bothersome.
It is recommended that daylight dimming, or the occupancy sensor strategy outlined above, be retained for implementation.

Alternate 2A: Same as Base Case, except the following spaces have 1.0 w/ft² instead of 1.5 w/ft² lighting density: office, gathering, toilet, data center, media, computer room.
This alternate is recommended for implementation.

Alternate 09: Same as Base Case, except there is a 3'-0 overhang.

This alternate is more costly than ALT11, yet achieves the same energy use. It is not recommended for implementation.

Alternate 10: Same as Base Case, except there is a 4'-0 overhang.

This alternate is more costly than ALT11, yet has higher energy use. It is not recommended for implementation.

Alternate 11: Same as Base Case, except there is a 2'-6 overhang.
This alternate is recommended for implementation.

Alternate 19: Same as Base Case, except typical 6" steel stud with R-19 batt insulation is used. The overall R-value of the opaque wall decreases from R-21.27 to R-14.70.

This alternate is presented with the sole purpose of quantifying the additional benefits (lower energy cost) achieved by using the thermally-broken studs of the Base Case.

The thermally-broken studs are useful in reducing the risk of moisture condensation and should be retained in the design.

Commercial Glazing Alternates

Alternate 01: Same as Base Case, except double pane ¼" Viracon VE 1-85 glazing is used.

$U_{\text{center-of-glass}} = 0.31$
Shading Coefficient = 0.62
Visible Transmittance = 0.76

This alternate has higher energy cost than the Base Case and is not recommended for implementation.

Alternate 03: Same as Base Case, except double pane ¼" Viracon VE 1-2M glazing is used.

$U_{\text{center-of-glass}} = 0.29$
Shading Coefficient = 0.43
Visible Transmittance = 0.70

This alternate only slightly increases the energy cost and could be implemented. However, the best performing glazings are presented in ALT04, ALTG1, and Base Case. In addition, the glazings noted above have lower U-value, and thus provide better comfort and have lower moisture condensation potential.

Alternate 04: Same as Base Case, except double pane ¼" Viracon VE 1-2M w/ argon glazing is used.

$U_{\text{center-of-glass}} = 0.24$
Shading Coefficient = 0.43
Visible Transmittance = 0.70

This alternate is recommended for implementation (See also ALTG1). Note that the Base Case glass is also energy-efficient and a good choice for implementation.

Alternate 05: Same as Base Case, except double pane ¼" Interpane Super-E glazing is used.

$U_{\text{center-of-glass}} = 0.29$
Shading Coefficient = 0.46
Visible Transmittance = 0.69

This alternate has higher energy cost than the Base Case and is note recommended for implementation.

Alternate 06: Same as Base Case, except double pane ¼" PPG Sungate 1000 glazing is used.

$U_{center\text{-}of\text{-}glass} = 0.29$
Shading Coefficient = 0.46
Visible Transmittance = 0.69

This alternate only slightly increases the energy cost and could be implemented. However, the best performing glazings are presented in ALT04, ALTG1, and Base Case. In addition, the glazings noted above have lower U-value, and thus provide better comfort and have lower moisture condensation potential.

Alternate 07: Same as Base Case, except double pane ¼" Interpane ILE-174 glazing is used.

$U_{center\text{-}of\text{-}glass} = 0.31$
Shading Coefficient = 0.66
Visible Transmittance = 0.74

This alternate increases the energy use and is not recommended for implementation.

Alternate 08: Same as Base Case, except double pane ¼" PPG Sungate 100 glazing is used.

$U_{center\text{-}of\text{-}glass} = 0.31$
Shading Coefficient = 0.59
Visible Transmittance = 0.73

This alternate increases the energy use and is not recommended for implementation.

Residential Glazing Alternates

Alternate G1: Same as Base Case, except double pane ⅛" PPG Sungate 1000 (2) glazing is used.

$U_{center\text{-}of\text{-}glass} = 0.24$
Shading Coefficient = 0.44
Visible Transmittance = 0.71

This alternate is recommended for implementation (See also ALT04). Note that the Base Case glass is also energy-efficient and a good choice for implementation.

Alternate G3: Same as Base Case, except double pane ⅛" Cardinal LoE^2 178 (2) glazing is used.

$U_{\text{center-of-glass}} = 0.26$
Shading Coefficient = 0.47
Visible Transmittance = 0.78

This alternate has higher energy cost than the Base Case and is not recommended for implementation.

Alternate G4: Same as Base Case, except double pane ⅛" Cardinal LoE^2 178 (3) glazing is used.

$U_{\text{center-of-glass}} = 0.26$
Shading Coefficient = 0.75
Visible Transmittance = 0.78

This alternate has higher energy cost than the Base Case and is not recommended for implementation.

Alternate G5: Same as Base Case, except double pane ⅛" Guardian Performance Plus (2) glazing is used.

$U_{\text{center-of-glass}} = 0.28$
Shading Coefficient = 0.61
Visible Transmittance = 0.70

This alternate has higher energy cost than the Base Case and is not recommended for implementation.

Alternate G7: Same as Base Case, except double pane ⅛" LOF Energy Advantage (2) glazing is used.

$U_{\text{center-of-glass}} = 0.29$
Shading Coefficient = 0.75
Visible Transmittance = 0.75

This alternate has higher energy cost than the Base Case. It is not recommended for implementation.

Alternate 12: Same as Base Case, except double pane ⅛" glazing with 5/8" air space filled with argon gas from Kolbe & Kolbe.

$U_{\text{center-of-glass}} = 0.40$
Shading Coefficient = 0.48
Visible Transmittance = 0.72

This alternate is presented for comparison purposes only. The high U-value is incompatible with the duct design that keeps diffusers away from the windows.

HVAC System Alternates

Alternate W1: Same as Base Case, except that the building water loop has two pumps with VSD, each 50% of total capacity. At peak demand both pumps are working. During low-load periods only one pump is working.

This alternate saves some energy, but not enough to be implemented if payback is the primary consideration.

Alternate W2: Same as Base Case, except one of the geothermal well pumps has VSD.

Assuming that this alternate is technically feasible, it should be considered for implementation.

More Energy-Efficient Design

INT:01 Same as Base Case, except the following alternates are applied together:

ALTS3 - Increase south window by 30%
ALT2A - Most spaces with 1.0 w/ft² lighting (except laboratories, entry, living quarters)
ALT11 - 2'-6" overhang and awnings
ALTW2 - One geothermal well pump with variable speed drive

This interacted simulation is performed to indicate the potential for further energy savings (without making significant additional expenditures).

UTILITY RATE STRUCTURES

ELECTRICITY:

MONTHLY CHARGE:

Customer Charge	$ 15.15
Demand Charge	$ 9.20 per kW
Energy Charge	$ 0.05032 per kWh

NATURAL GAS:

First 200 cu. ft. or less	$ 6.17	
Next 9,800 cu. ft. (per 100 cu. ft.)		$ 0.6412
Next 490,000 cu. ft. (per 100 cu. ft.)		$ 0.5211
Additional Gas (per 100 cu. ft.)		$ 0.4865

$15.15/mo
$9.20/ kW Demand
0.05032 per kwh

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : BASE CASE : 7/8" KOLBE & KOLBE WINDOWS USING CARDINAL LoE2-172 w/ARGON SC=0.48 U=0.25 VT=0.72
WINDOW U=0.31

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6846	7613	2	7787	27279	752	19801	35646	0	105726

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9875	31	802	0	0	0	0	0	0	0	802
FEB	8506	29	718	0	0	0	0	0	0	0	718
MAR	8862	29	737	0	0	0	0	0	0	0	737
APR	7888	25	650	0	0	0	0	0	0	0	650
MAY	7881	31	701	0	0	0	0	0	0	0	701
JUN	9278	35	808	0	0	0	0	0	0	0	808
JUL	10175	35	852	0	0	0	0	0	0	0	852
AUG	9886	34	828	0	0	0	0	0	0	0	828
SEP	8561	34	762	0	0	0	0	0	0	0	762
OCT	7615	25	637	0	0	0	0	0	0	0	637
NOV	7332	26	627	0	0	0	0	0	0	0	627
DEC	9863	31	799	0	0	0	0	0	0	0	799
TOTAL	105726	35	8922	0	1	0	0	0	0	0	8923

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING :BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTRQ: NYS ENERGY CONSERVATION CONSTRUCTION CODE (WATER LOOP HEAT PUMP WITH BOILER AND COOLING TOWER)

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	19212	12959	3525	8340	29594	0	35503	35646	0	144780
NATURAL GAS (CCF)	1644	0	0	0	0	316	0	0	0	1961

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	13770	42	1103	470	262	0	0	0	0	0	1365
FEB	11844	41	995	348	198	0	0	0	0	0	1193
MAR	12280	40	1006	271	158	0	0	0	0	0	1164
APR	10245	37	873	69	49	0	0	0	0	0	922
MAY	10379	56	1053	31	25	0	0	0	0	0	1078
JUN	12178	58	1166	24	21	0	0	0	0	0	1187
JUL	14326	58	1278	26	22	0	0	0	0	0	1300
AUG	13704	58	1245	24	20	0	0	0	0	0	1265
SEP	11073	56	1092	24	20	0	0	0	0	0	1112
OCT	10550	37	890	65	47	0	0	0	0	0	937
NOV	10725	36	893	152	96	0	0	0	0	0	989
DEC	13700	43	1109	453	253	0	0	0	0	0	1362
TOTAL	144780	58	12702	1961	1172	0	0	0	0	0	13874

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTR1: NYS ENERGY CONSERVATION CONSTRUCTION CODE(DX ROOFTOP WITH FURNACE)

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	0	20260	0	14601	449	0	35503	35646	0	106460
NATURAL GAS (CCF)	6691	0	0	0	0	316	0	0	0	7008

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	7825	26	651	1236	661	0	0	0	0	0	1312
FEB	6919	26	606	1049	564	0	0	0	0	0	1170
MAR	7561	26	638	1020	548	0	0	0	0	0	1186
APR	7177	26	619	470	262	0	0	0	0	0	881
MAY	9122	48	921	342	195	0	0	0	0	0	1116
JUN	10718	53	1042	24	21	0	0	0	0	0	1063
JUL	11941	52	1101	26	22	0	0	0	0	0	1123
AUG	11680	47	1040	24	20	0	0	0	0	0	1060
SEP	10444	45	955	193	118	0	0	0	0	0	1073
OCT	8428	41	819	536	296	0	0	0	0	0	1115
NOV	6799	26	600	852	461	0	0	0	0	0	1061
DEC	7839	26	652	1231	659	0	0	0	0	0	1311
TOTAL	106460	53	9644	7008	3828	0	0	0	0	0	13472

35,310 for heating cooling fans + pumps

6691

$3199

$3655

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SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTS1: SOUTH WINDOWS INCREASE 10%

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6862	7615	2	7785	27277	752	19690	35646	0	105631

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9866	31	801	0	0	0	0	0	0	0	801
FEB	8499	29	717	0	0	0	0	0	0	0	717
MAR	8854	29	736	0	0	0	0	0	0	0	736
APR	7879	25	650	0	0	0	0	0	0	0	650
MAY	7871	31	700	0	0	0	0	0	0	0	700
JUN	9269	35	808	0	0	0	0	0	0	0	808
JUL	10165	35	851	0	0	0	0	0	0	0	851
AUG	9877	34	827	0	0	0	0	0	0	0	827
SEP	8555	34	761	0	0	0	0	0	0	0	761
OCT	7606	25	637	0	0	0	0	0	0	0	637
NOV	7324	26	627	0	0	0	0	0	0	0	627
DEC	9860	31	799	0	0	0	0	0	0	0	799
TOTAL	105631	35	8914	0	1	0	0	0	0	0	8915

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTS2: SOUTH WINDOWS INCREASE 20%

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6874	7626	2	7784	27275	752	19578	35646	0	105538

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9859	31	800	0	0	0	0	0	0	0	800
FEB	8492	29	717	0	0	0	0	0	0	0	717
MAR	8845	29	736	0	0	0	0	0	0	0	736
APR	7865	25	649	0	0	0	0	0	0	0	649
MAY	7863	31	699	0	0	0	0	0	0	0	699
JUN	9261	35	807	0	0	0	0	0	0	0	807
JUL	10157	35	850	0	0	0	0	0	0	0	850
AUG	9870	34	827	0	0	0	0	0	0	0	827
SEP	8551	34	760	0	0	0	0	0	0	0	760
OCT	7602	25	636	0	0	0	0	0	0	0	636
NOV	7316	26	626	0	0	0	0	0	0	0	626
DEC	9854	31	799	0	0	0	0	0	0	0	799
TOTAL	105538	35	8906	0	1	0	0	0	0	0	8907

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTS3: SOUTH WINDOWS INCREASE 30%

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6893	7631	2	7785	27277	752	19467	35646	0	105455

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9857	31	800	0	0	0	0	0	0	0	800
FEB	8485	29	716	0	0	0	0	0	0	0	716
MAR	8838	29	735	0	0	0	0	0	0	0	735
APR	7860	25	648	0	0	0	0	0	0	0	648
MAY	7854	31	699	0	0	0	0	0	0	0	699
JUN	9254	35	806	0	0	0	0	0	0	0	806
JUL	10149	35	850	0	0	0	0	0	0	0	850
AUG	9863	34	826	0	0	0	0	0	0	0	826
SEP	8540	34	759	0	0	0	0	0	0	0	759
OCT	7593	25	635	0	0	0	0	0	0	0	635
NOV	7308	26	626	0	0	0	0	0	0	0	626
DEC	9850	31	799	0	0	0	0	0	0	0	799
TOTAL	105455	35	8899	0	1	0	0	0	0	0	8900

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTS4: STAIR WINDOW DECREASES 20%

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6845	7576	2	7781	27270	752	19802	35646	0	105676

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9874	31	802	0	0	0	0	0	0	0	802
FEB	8508	29	718	0	0	0	0	0	0	0	718
MAR	8871	29	737	0	0	0	0	0	0	0	737
APR	7877	25	650	0	0	0	0	0	0	0	650
MAY	7874	31	700	0	0	0	0	0	0	0	700
JUN	9270	35	808	0	0	0	0	0	0	0	808
JUL	10168	35	851	0	0	0	0	0	0	0	851
AUG	9878	34	827	0	0	0	0	0	0	0	827
SEP	8552	34	761	0	0	0	0	0	0	0	761
OCT	7611	25	637	0	0	0	0	0	0	0	637
NOV	7326	26	627	0	0	0	0	0	0	0	627
DEC	9861	31	799	0	0	0	0	0	0	0	799
TOTAL	105676	35	8916	0	1	0	0	0	0	0	8917

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT01: VIRACON-VE185 SC=0.62 U=0.31 VT=0.76

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7131	7917	2	8650	27429	752	19736	35646	0	107265

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9992	32	813	0	0	0	0	0	0	0	813
FEB	8576	31	738	0	0	0	0	0	0	0	738
MAR	8953	30	750	0	0	0	0	0	0	0	750
APR	8088	26	668	0	0	0	0	0	0	0	668
MAY	8057	31	715	0	0	0	0	0	0	0	715
JUN	9425	36	821	0	0	0	0	0	0	0	821
JUL	10312	35	864	0	0	0	0	0	0	0	864
AUG	10029	34	841	0	0	0	0	0	0	0	841
SEP	8695	34	774	0	0	0	0	0	0	0	774
OCT	7722	26	649	0	0	0	0	0	0	0	649
NOV	7438	27	642	0	0	0	0	0	0	0	642
DEC	9973	32	814	0	0	0	0	0	0	0	814
TOTAL	107265	36	9088	0	1	0	0	0	0	0	9089

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT02: NO DAYLIGHT DIMMING

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6394	8059	2	7900	27463	752	24756	35646	0	110973

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	10112	32	820	0	0	0	0	0	0	0	820
FEB	8729	31	742	0	0	0	0	0	0	0	742
MAR	9208	31	767	0	0	0	0	0	0	0	767
APR	8541	27	698	0	0	0	0	0	0	0	698
MAY	8475	34	756	0	0	0	0	0	0	0	756
JUN	9862	38	863	0	0	0	0	0	0	0	863
JUL	10795	38	912	0	0	0	0	0	0	0	912
AUG	10467	37	885	0	0	0	0	0	0	0	885
SEP	9105	37	818	0	0	0	0	0	0	0	818
OCT	8070	28	685	0	0	0	0	0	0	0	685
NOV	7547	27	648	0	0	0	0	0	0	0	648
DEC	10058	31	814	0	0	0	0	0	0	0	814
TOTAL	110973	38	9408	0	1	0	0	0	0	0	9409

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT03: VIRACON-VE1-2M SC=0.43 U=0.29 VT=0.70

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7447	7410	2	7721	27175	752	19837	35646	0	105990

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9991	32	815	0	0	0	0	0	0	0	815
FEB	8610	30	729	0	0	0	0	0	0	0	729
MAR	9003	30	749	0	0	0	0	0	0	0	749
APR	7836	26	653	0	0	0	0	0	0	0	653
MAY	7825	31	696	0	0	0	0	0	0	0	696
JUN	9221	35	804	0	0	0	0	0	0	0	804
JUL	10148	35	849	0	0	0	0	0	0	0	849
AUG	9837	34	823	0	0	0	0	0	0	0	823
SEP	8501	33	756	0	0	0	0	0	0	0	756
OCT	7621	26	643	0	0	0	0	0	0	0	643
NOV	7421	27	638	0	0	0	0	0	0	0	638
DEC	9973	31	811	0	0	0	0	0	0	0	811
TOTAL	105990	35	8967	0	1	0	0	0	0	0	8968

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT04: VIRACON-VE1-2M ARG SC=0.43 U=0.24 VT=0.70

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6755	7523	2	7763	27243	752	19837	35646	0	105523

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9852	31	799	0	0	0	0	0	0	0	799
FEB	8498	29	716	0	0	0	0	0	0	0	716
MAR	8866	29	736	0	0	0	0	0	0	0	736
APR	7856	25	648	0	0	0	0	0	0	0	648
MAY	7857	31	698	0	0	0	0	0	0	0	698
JUN	9260	35	806	0	0	0	0	0	0	0	806
JUL	10159	35	850	0	0	0	0	0	0	0	850
AUG	9867	34	826	0	0	0	0	0	0	0	826
SEP	8542	34	760	0	0	0	0	0	0	0	760
OCT	7608	25	636	0	0	0	0	0	0	0	636
NOV	7306	26	625	0	0	0	0	0	0	0	625
DEC	9846	31	797	0	0	0	0	0	0	0	797
TOTAL	105523	35	8896	0	1	0	0	0	0	0	8897

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT05: INTERPANE-SUPER-E SC=0.46 U=0.29 VT=0.69

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7344	7492	2	7751	27216	752	19856	35646	0	106060

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9975	32	814	0	0	0	0	0	0	0	814
FEB	8587	30	728	0	0	0	0	0	0	0	728
MAR	8985	30	748	0	0	0	0	0	0	0	748
APR	7883	26	655	0	0	0	0	0	0	0	655
MAY	7853	31	698	0	0	0	0	0	0	0	698
JUN	9241	35	806	0	0	0	0	0	0	0	806
JUL	10161	35	850	0	0	0	0	0	0	0	850
AUG	9856	34	825	0	0	0	0	0	0	0	825
SEP	8531	34	758	0	0	0	0	0	0	0	758
OCT	7627	26	643	0	0	0	0	0	0	0	643
NOV	7413	27	638	0	0	0	0	0	0	0	638
DEC	9945	31	810	0	0	0	0	0	0	0	810
TOTAL	106060	35	8974	0	1	0	0	0	0	0	8975

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT06: PPG-SUNGATE-1000 SC=0.44 U=0.29 VT=0.69

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7410	7433	2	7732	27189	752	19856	35646	0	106021

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9985	32	815	0	0	0	0	0	0	0	815
FEB	8605	30	729	0	0	0	0	0	0	0	729
MAR	9000	30	749	0	0	0	0	0	0	0	749
APR	7855	26	654	0	0	0	0	0	0	0	654
MAY	7834	31	697	0	0	0	0	0	0	0	697
JUN	9229	35	805	0	0	0	0	0	0	0	805
JUL	10149	35	849	0	0	0	0	0	0	0	849
AUG	9844	34	824	0	0	0	0	0	0	0	824
SEP	8512	34	757	0	0	0	0	0	0	0	757
OCT	7621	26	643	0	0	0	0	0	0	0	643
NOV	7419	27	638	0	0	0	0	0	0	0	638
DEC	9964	31	811	0	0	0	0	0	0	0	811
TOTAL	106021	35	8971	0	1	0	0	0	0	0	8972

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT07: INTERPANE-ILE-174 SC=0.66 U=0.31 VT=0.74

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6979	8025	2	7907	27476	752	19768	35646	0	106557

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9904	31	807	0	0	0	0	0	0	0	807
FEB	8483	31	732	0	0	0	0	0	0	0	732
MAR	8844	30	744	0	0	0	0	0	0	0	744
APR	8070	26	665	0	0	0	0	0	0	0	665
MAY	8025	31	713	0	0	0	0	0	0	0	713
JUN	9370	35	817	0	0	0	0	0	0	0	817
JUL	10268	35	861	0	0	0	0	0	0	0	861
AUG	9980	34	838	0	0	0	0	0	0	0	838
SEP	8668	34	773	0	0	0	0	0	0	0	773
OCT	7678	26	646	0	0	0	0	0	0	0	646
NOV	7378	27	637	0	0	0	0	0	0	0	637
DEC	9885	32	808	0	0	0	0	0	0	0	808
TOTAL	106557	35	9041	0	1	0	0	0	0	0	9042

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT08: PPG-SUNGATE-100 SC=0.59 U=0.31 VT=0.73

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7206	7842	2	7837	27359	752	19784	35646	0	106430

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9943	32	810	0	0	0	0	0	0	0	810
FEB	8527	31	735	0	0	0	0	0	0	0	735
MAR	8901	30	747	0	0	0	0	0	0	0	747
APR	7981	26	662	0	0	0	0	0	0	0	662
MAY	7969	31	708	0	0	0	0	0	0	0	708
JUN	9338	35	814	0	0	0	0	0	0	0	814
JUL	10221	35	857	0	0	0	0	0	0	0	857
AUG	9939	34	834	0	0	0	0	0	0	0	834
SEP	8610	34	767	0	0	0	0	0	0	0	767
OCT	7672	26	646	0	0	0	0	0	0	0	646
NOV	7397	27	639	0	0	0	0	0	0	0	639
DEC	9927	32	810	0	0	0	0	0	0	0	810
TOTAL	106430	35	9027	0	1	0	0	0	0	0	9028

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT09: BASE CASE W/ 3'-0 OVERHANG AND AWNINGS ON SOUTH FACADE

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6791	7453	2	7419	26696	752	19818	35646	0	104579

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9791	31	796	0	0	0	0	0	0	0	796
FEB	8424	29	712	0	0	0	0	0	0	0	712
MAR	8786	29	731	0	0	0	0	0	0	0	731
APR	7769	25	642	0	0	0	0	0	0	0	642
MAY	7789	31	692	0	0	0	0	0	0	0	692
JUN	9165	35	799	0	0	0	0	0	0	0	799
JUL	10053	34	842	0	0	0	0	0	0	0	842
AUG	9766	33	818	0	0	0	0	0	0	0	818
SEP	8463	34	754	0	0	0	0	0	0	0	754
OCT	7535	25	631	0	0	0	0	0	0	0	631
NOV	7266	26	622	0	0	0	0	0	0	0	622
DEC	9769	31	793	0	0	0	0	0	0	0	793
TOTAL	104579	35	8832	0	0	0	0	0	0	0	8832

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT10: BASE CASE W/ 4'-0 OVERHANG AND AWNINGS ON SOUTH FACADE

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6813	7427	2	7408	26677	752	19894	35646	0	104619

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9804	31	797	0	0	0	0	0	0	0	797
FEB	8438	29	713	0	0	0	0	0	0	0	713
MAR	8800	29	733	0	0	0	0	0	0	0	733
APR	7762	25	643	0	0	0	0	0	0	0	643
MAY	7785	30	692	0	0	0	0	0	0	0	692
JUN	9157	35	798	0	0	0	0	0	0	0	798
JUL	10052	34	842	0	0	0	0	0	0	0	842
AUG	9764	33	818	0	0	0	0	0	0	0	818
SEP	8462	34	754	0	0	0	0	0	0	0	754
OCT	7536	25	632	0	0	0	0	0	0	0	632
NOV	7277	26	623	0	0	0	0	0	0	0	623
DEC	9780	31	793	0	0	0	0	0	0	0	793
TOTAL	104619	35	8837	0	0	0	0	0	0	0	8837

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT11: BASE CASE W/ 2'-6 OVERHANG AND AWNINGS ON SOUTH FACADE

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6772	7472	2	7426	26707	752	19807	35646	0	104586

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9787	31	796	0	0	0	0	0	0	0	796
FEB	8420	29	712	0	0	0	0	0	0	0	712
MAR	8780	29	731	0	0	0	0	0	0	0	731
APR	7782	25	643	0	0	0	0	0	0	0	643
MAY	7793	31	693	0	0	0	0	0	0	0	693
JUN	9168	35	799	0	0	0	0	0	0	0	799
JUL	10056	34	842	0	0	0	0	0	0	0	842
AUG	9770	33	819	0	0	0	0	0	0	0	819
SEP	8469	34	755	0	0	0	0	0	0	0	755
OCT	7535	25	631	0	0	0	0	0	0	0	631
NOV	7258	26	621	0	0	0	0	0	0	0	621
DEC	9765	31	792	0	0	0	0	0	0	0	792
TOTAL	104586	35	8833	0	0	0	0	0	0	0	8833

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT12: 5/8" KOBLE & KOBLE WINDOWS USING CARDINAL LoE2-172 W/ARGON SC=0.48 U=0.25 VT=0.72
WINDOW U=0.40

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7333	7600	2	7755	27222	752	19801	35646	0	106112

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9950	32	814	0	0	0	0	0	0	0	814
FEB	8555	31	736	0	0	0	0	0	0	0	736
MAR	8955	30	750	0	0	0	0	0	0	0	750
APR	7914	26	659	0	0	0	0	0	0	0	659
MAY	7899	31	702	0	0	0	0	0	0	0	702
JUN	9261	35	808	0	0	0	0	0	0	0	808
JUL	10172	35	852	0	0	0	0	0	0	0	852
AUG	9885	34	828	0	0	0	0	0	0	0	828
SEP	8552	34	761	0	0	0	0	0	0	0	761
OCT	7630	26	645	0	0	0	0	0	0	0	645
NOV	7399	27	639	0	0	0	0	0	0	0	639
DEC	9934	32	810	0	0	0	0	0	0	0	810
TOTAL	106112	35	9003	0	1	0	0	0	0	0	9004

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING :BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALT19: BASE CASE W/ R-19 STEEL STUDS

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	8607	7542	2	7702	27131	752	19801	35646	0	107185

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	10221	32	832	0	0	0	0	0	0	0	832
FEB	8769	32	757	0	0	0	0	0	0	0	757
MAR	9138	31	763	0	0	0	0	0	0	0	763
APR	7889	28	670	0	0	0	0	0	0	0	670
MAY	7883	31	701	0	0	0	0	0	0	0	701
JUN	9244	35	807	0	0	0	0	0	0	0	807
JUL	10173	35	852	0	0	0	0	0	0	0	852
AUG	9871	34	827	0	0	0	0	0	0	0	827
SEP	8535	34	758	0	0	0	0	0	0	0	758
OCT	7704	27	660	0	0	0	0	0	0	0	660
NOV	7589	28	660	0	0	0	0	0	0	0	660
DEC	10164	33	832	0	0	0	0	0	0	0	832
TOTAL	107185	35	9119	0	1	0	0	0	0	0	9120

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTG1: PPG-SUNGATE-1000-2 W/ARGON SC=0.44 U=0.24 VT=0.71

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6806	7539	2	7767	27250	752	19819	35646	0	105582

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9869	31	800	0	0	0	0	0	0	0	800
FEB	8509	29	717	0	0	0	0	0	0	0	717
MAR	8872	29	736	0	0	0	0	0	0	0	736
APR	7853	25	648	0	0	0	0	0	0	0	648
MAY	7860	31	699	0	0	0	0	0	0	0	699
JUN	9264	35	807	0	0	0	0	0	0	0	807
JUL	10160	35	850	0	0	0	0	0	0	0	850
AUG	9872	34	826	0	0	0	0	0	0	0	826
SEP	8546	34	761	0	0	0	0	0	0	0	761
OCT	7606	25	636	0	0	0	0	0	0	0	636
NOV	7309	26	626	0	0	0	0	0	0	0	626
DEC	9858	31	798	0	0	0	0	0	0	0	798
TOTAL	105582	35	8903	0	1	0	0	0	0	0	8904

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTG3: CARDINAL-LoE2-178-2 W/ARGON SC=0.68 U=0.26 VT=0.78

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6320	8138	2	7957	27548	752	19707	35646	0	106072

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9752	31	795	0	0	0	0	0	0	0	795
FEB	8360	30	716	0	0	0	0	0	0	0	716
MAR	8695	29	728	0	0	0	0	0	0	0	728
APR	8147	25	662	0	0	0	0	0	0	0	662
MAY	8061	32	716	0	0	0	0	0	0	0	716
JUN	9406	36	820	0	0	0	0	0	0	0	820
JUL	10285	35	863	0	0	0	0	0	0	0	863
AUG	10014	34	841	0	0	0	0	0	0	0	841
SEP	8690	35	776	0	0	0	0	0	0	0	776
OCT	7658	26	642	0	0	0	0	0	0	0	642
NOV	7242	26	623	0	0	0	0	0	0	0	623
DEC	9758	31	795	0	0	0	0	0	0	0	795
TOTAL	106072	36	8975	0	1	0	0	0	0	0	8976

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTG4: CARDINAL-LoE2-178-3 W/ARGON SC=0.75 U=0.26 VT=0.78

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6122	8295	2	8015	27647	752	19707	35646	0	106187

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9714	31	791	0	0	0	0	0	0	0	791
FEB	8305	30	713	0	0	0	0	0	0	0	713
MAR	8662	29	726	0	0	0	0	0	0	0	726
APR	8218	25	664	0	0	0	0	0	0	0	664
MAY	8106	32	720	0	0	0	0	0	0	0	720
JUN	9452	36	824	0	0	0	0	0	0	0	824
JUL	10317	36	866	0	0	0	0	0	0	0	866
AUG	10068	35	847	0	0	0	0	0	0	0	847
SEP	8739	35	781	0	0	0	0	0	0	0	781
OCT	7674	26	645	0	0	0	0	0	0	0	645
NOV	7209	26	623	0	0	0	0	0	0	0	623
DEC	9721	31	793	0	0	0	0	0	0	0	793
TOTAL	106187	36	8992	0	1	0	0	0	0	0	8993

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTG5: GUARDIAN-PERFORMANCE-PLUS-2 W/ARGON SC=0.61 U=0.28 VT=0.70

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6787	7940	2	7876	27429	752	19837	35646	0	106271

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9874	32	807	0	0	0	0	0	0	0	807
FEB	8472	31	727	0	0	0	0	0	0	0	727
MAR	8831	30	739	0	0	0	0	0	0	0	739
APR	8022	26	660	0	0	0	0	0	0	0	660
MAY	8001	31	710	0	0	0	0	0	0	0	710
JUN	9359	35	816	0	0	0	0	0	0	0	816
JUL	10251	35	859	0	0	0	0	0	0	0	859
AUG	9962	34	836	0	0	0	0	0	0	0	836
SEP	8649	34	771	0	0	0	0	0	0	0	771
OCT	7661	26	642	0	0	0	0	0	0	0	642
NOV	7322	26	631	0	0	0	0	0	0	0	631
DEC	9863	31	804	0	0	0	0	0	0	0	804
TOTAL	106271	35	9001	0	1	0	0	0	0	0	9002

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : ALTG7: LOF-ENERGY-ADVANTAGE-3 W/ARGON SC=0.75 U=0.29 VT=0.75

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6517	8221	2	7981	27592	752	19752	35646	0	106464

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9809	31	801	0	0	0	0	0	0	0	801
FEB	8387	30	717	0	0	0	0	0	0	0	717
MAR	8733	30	734	0	0	0	0	0	0	0	734
APR	8183	26	667	0	0	0	0	0	0	0	667
MAY	8079	32	718	0	0	0	0	0	0	0	718
JUN	9433	36	822	0	0	0	0	0	0	0	822
JUL	10309	36	865	0	0	0	0	0	0	0	865
AUG	10040	35	844	0	0	0	0	0	0	0	844
SEP	8710	35	778	0	0	0	0	0	0	0	778
OCT	7681	26	644	0	0	0	0	0	0	0	644
NOV	7296	27	632	0	0	0	0	0	0	0	632
DEC	9801	31	799	0	0	0	0	0	0	0	799
TOTAL	106464	36	9020	0	1	0	0	0	0	0	9021

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : AA1: BUILDING AZ ROTATED 90 DEGREES

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7332	7872	2	8390	29445	752	19747	35646	0	109185

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	10231	31	823	0	0	0	0	0	0	0	823
FEB	8789	30	738	0	0	0	0	0	0	0	738
MAR	9078	30	753	0	0	0	0	0	0	0	753
APR	8273	26	673	0	0	0	0	0	0	0	673
MAY	8171	32	723	0	0	0	0	0	0	0	723
JUN	9587	36	831	0	0	0	0	0	0	0	831
JUL	10469	36	874	0	0	0	0	0	0	0	874
AUG	10198	35	855	0	0	0	0	0	0	0	855
SEP	8828	34	781	0	0	0	0	0	0	0	781
OCT	7794	26	647	0	0	0	0	0	0	0	647
NOV	7542	27	643	0	0	0	0	0	0	0	643
DEC	10221	31	820	0	0	0	0	0	0	0	820
TOTAL	109185	36	9162	0	1	0	0	0	0	0	9163

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : Aw1: THREE CIRC PUMPS

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6846	7612	2	7787	26527	752	19801	35646	0	104974

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9815	31	799	0	0	0	0	0	0	0	799
FEB	8452	29	715	0	0	0	0	0	0	0	715
MAR	8798	29	734	0	0	0	0	0	0	0	734
APR	7846	25	648	0	0	0	0	0	0	0	648
MAY	7805	31	697	0	0	0	0	0	0	0	697
JUN	9224	35	806	0	0	0	0	0	0	0	806
JUL	10120	35	849	0	0	0	0	0	0	0	849
AUG	9830	34	825	0	0	0	0	0	0	0	825
SEP	8494	34	759	0	0	0	0	0	0	0	759
OCT	7525	25	633	0	0	0	0	0	0	0	633
NOV	7254	26	623	0	0	0	0	0	0	0	623
DEC	9804	31	796	0	0	0	0	0	0	0	796
TOTAL	104974	35	8884	0	1	0	0	0	0	0	8885

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING : BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : Aw2: ONE VFD PUMP FOR WELLS

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	6846	7613	2	7787	24481	752	19801	35646	0	102928

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9875	31	802	0	0	0	0	0	0	0	802
FEB	8506	29	718	0	0	0	0	0	0	0	718
MAR	8862	29	737	0	0	0	0	0	0	0	737
APR	7565	25	634	0	0	0	0	0	0	0	634
MAY	7530	31	683	0	0	0	0	0	0	0	683
JUN	8930	35	791	0	0	0	0	0	0	0	791
JUL	9817	35	834	0	0	0	0	0	0	0	834
AUG	9519	34	809	0	0	0	0	0	0	0	809
SEP	8213	34	745	0	0	0	0	0	0	0	745
OCT	7273	25	620	0	0	0	0	0	0	0	620
NOV	6970	26	609	0	0	0	0	0	0	0	609
DEC	9863	31	799	0	0	0	0	0	0	0	799
TOTAL	102928	35	8781	0	1	0	0	0	0	0	8782

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING :BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : AA2: OFFICE LIGHTING 1.0 W/SF

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7039	7507	2	7735	27197	752	18278	35646	0	104157

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9772	31	794	0	0	0	0	0	0	0	794
FEB	8421	29	710	0	0	0	0	0	0	0	710
MAR	8758	29	729	0	0	0	0	0	0	0	729
APR	7729	25	639	0	0	0	0	0	0	0	639
MAY	7726	30	688	0	0	0	0	0	0	0	688
JUN	9135	34	796	0	0	0	0	0	0	0	796
JUL	10026	34	839	0	0	0	0	0	0	0	839
AUG	9742	33	816	0	0	0	0	0	0	0	816
SEP	8413	33	745	0	0	0	0	0	0	0	745
OCT	7471	25	627	0	0	0	0	0	0	0	627
NOV	7200	26	618	0	0	0	0	0	0	0	618
DEC	9758	30	791	0	0	0	0	0	0	0	791
TOTAL	104157	34	8793	0	1	0	0	0	0	0	8794

SUMMARY REPORTS OF ENERGY USE AND FUEL BILL

NAME OF BUILDING :BLACKROCK FOREST RESEARCH CENTER
MODEL DESCRIPTION : INT01: INTERACTED ALTERNATE

REPORT-1: ANNUAL ENERGY USE STATISTICS **********

FUEL TYPE	HEATING EQUIP.	COOLING EQUIP.	COOLING TOWER	FANS	PUMPS	DOMESTIC WATER	LIGHTING	MISC. EQUIP.	VERTICAL TRANS.	TOTAL FUEL USE
ELECTRICITY (KWH)	7013	7392	2	7376	23824	752	17986	35646	0	99992

REPORT-2: MONTHLY AND ANNUAL FUEL BILLS **********

MONTH	ELECTRIC KWH	ELECTRIC KW	ELECTRIC BILL ($)	NAT. GAS CCF	NAT. GAS BILL ($)	FUEL OIL GALLONS	FUEL OIL BILL ($)	STEAM MBTU	STEAM MBTU/HR	STEAM BILL ($)	TOTAL FUEL BILL ($)
JAN	9671	30	780	0	0	0	0	0	0	0	780
FEB	8318	29	703	0	0	0	0	0	0	0	703
MAR	8651	29	721	0	0	0	0	0	0	0	721
APR	7277	25	614	0	0	0	0	0	0	0	614
MAY	7259	30	661	0	0	0	0	0	0	0	661
JUN	8649	34	767	0	0	0	0	0	0	0	767
JUL	9533	34	810	0	0	0	0	0	0	0	810
AUG	9239	33	787	0	0	0	0	0	0	0	787
SEP	7949	32	718	0	0	0	0	0	0	0	718
OCT	7032	25	602	0	0	0	0	0	0	0	602
NOV	6757	25	594	0	0	0	0	0	0	0	594
DEC	9654	30	783	0	0	0	0	0	0	0	783
TOTAL	99992	34	8539	0	1	0	0	0	0	0	8540

45,607 for heat, cool, fans + pumps

A:\BLACKRCK.REP

State of New York
George E. Pataki, Governor

New York State Energy Research and Development Authority
William R. Howell, Chairman
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