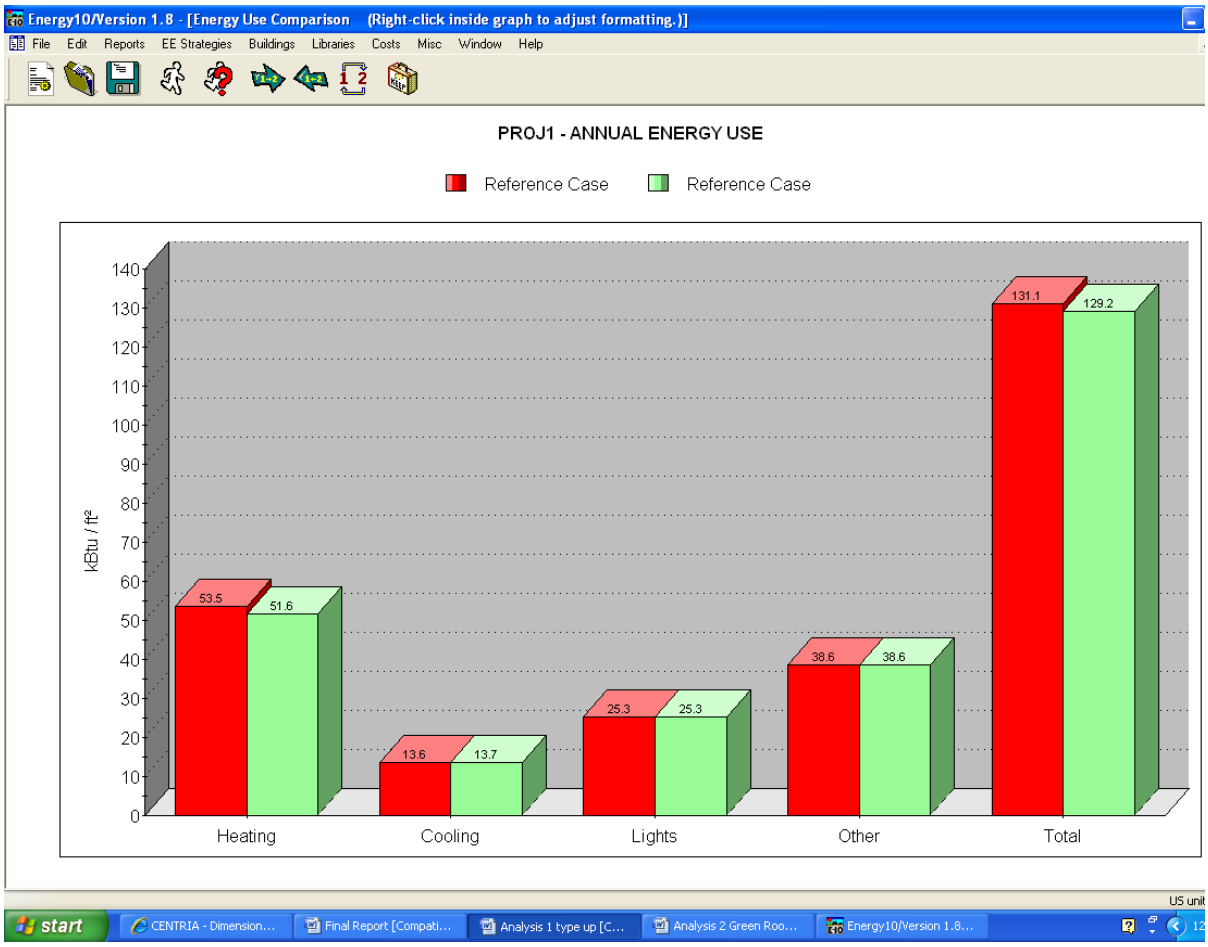

Fig 12

Analysis 2: Green Roof Implementation

Issue 2:

The roof is a regular built up roof with no general real problem, but with a green roof replacement, Plaza East could benefit in many ways.

Analysis:

Green roofs will be researched to be in place of the current built up roof. Adding a green roof to a project can have multiple advantages. It is expected to cost more than the original roof designed for Plaza East, but the cost savings, in the long run, could be much better. With a green roof you can have a higher LEED accreditation, reduced energy costs, and extended roof

life. A new structural system was planning on being designed for the building, making it easier to add the additional loads a green roof entails.

Expectations:

After the analysis of the first cost and time saving issues, the money and time saved will be put forth to pay for the green roof addition to the building. With the green roof the initial cost will be higher, but money is expected to be saved in the future from the green roof's long life capabilities.

Outcome:

A green roof consists of living vegetation installed atop of a building. With the application of green roofs, many advantages can be gained including: storm water runoff reduction, improvement of air quality, sound absorbing and insulating properties, increase life expectancy of rooftop waterproofing, reduce urban heat island effect, increase habitat for birds and butterflies, provide attractive views for other people, and insulating a building reducing heating and cooling costs.

With a green roof addition to Plaza East, they can help manage the storm water by mimicking a variety of hydrologic processes normally associated with open space. Plants absorb the water into their roots and promote evapotranspiration allowing them to prevent much storm water from leaving the roof and entering the runoff stream. With this effect, green roofs greatly reduce the risk of flooding, sewer overflows, and subsequent discharges. Water does not run off these roofs until the entire roof is saturated, which happens hours after peak flow for a storm. For short duration storms, green roofs have been shown to reduce cumulative annual runoff by 50%. GreenGrid's Intensive (8-inch) system retained 93% of a 1-inch rainfall that occurred in 15 minute intervals and its Extensive (4-inch) system retained 72%. With Plaza East having such a large parking lot, this aspect can help manage a costly retention and detention system for Plaza East. It can also give some habitat back to the birds and other animals that were taken from the area.

Green roofs can help with noise reduction and tests have been shown to reduce indoor noise pollution from outdoor contributors by 10 decibels. Plaza East is not in a very noise impacted area, well at least not for the time being. As time goes on the area should begin to grow and when it does the noise levels are sure to increase. Having a green roof could be a good way to prepare for that.

The roof of Plaza East is very simple built-up roof and changing to a green roof can increase its life expectancy. This is based on the fact that the roof membrane is protected from ultraviolet radiation, extreme temperature fluctuations, ozone, punctures and other physical damage. Built up roofs can average around 20 to 25 years for life expectancy. Green roofs can have the life expectancy up to or more than 40 years, however green roofs in Berlin have shown to protect roofs up to 100years.

The urban heat island effect comes from roads and building rooftops absorbing heat during daylight hours and then radiating it back into the atmosphere causing further warming. This effect has been shown to actually change weather patterns in some large cities. For some of these large cities the factors can result in a 6 to 10 degree temperature difference. Green roofs help lower this effect and because urban area in DC and Virginia is only growing, it is a good idea to get as many green roofs built as possible. Covering dark conventional roofs with green roofs can significantly reduce the temperature above the roof. Green roofs have been shown to out-perform white or reflective roof surfaces in reducing the ambient air temperature. If sufficient urban surfaces are covered, this cooling (and attendant improvement of air quality) can have significant positive effects on human health, especially for the young and elderly in congested urban areas.

Green roofs do not only look nice but are very energy efficient. They can increase the value of condominiums, apartment complexes, office buildings, as well as help save money through heating and cooling costs. A traditional black rooftop can reach up to 180^{o}F when the outside air temperature reaches 80^{o}F. This has a drastic effect on the energy used to cool the building. The additional layers of the green roof help mediate the extreme temperature differences; annually from 212^{o}F to 95^{o}F and daily from 140^{o}F to 59^{o}F. Green roofs have been

shown to reduce the heating and cooling costs from 25% to 50% for the floor directly below the roof and can also slow down a buildings heat gain or loss.

Energy demands have been threatening the power supply of our country and the world. With the oil prices doing nothing but rising, the industry must look into better ways for sustainability and green roofs are an easy fix to help with that. Governments are giving cities different incentives to increase sustainability for their building. Some include financial, technical, educational incentives along with tax credits and avoidance of fees assessed for impervious surface cover.

For my analysis I will use Energy 10 software, the same software used for the building envelope energy analysis, to show a few benefits that can be seen by using a green roof. It was recommended I just try and simulate the top floor space because Energy 10 was used for smaller scale projects and a green roof is said to predominately affect the top floor. How the building information was put into the program can be seen in **Analysis 1: Building Envelope Investigation**.

After **Fig 4** from the Building Envelope Investigation some of the steps change. Looking at the drawings I saw R values for the roof and the façade. Stated before, I calculated the average window area for each side of the building faces and used an amount of an existing window in the Energy 10 library that closely resembled that number. I used the same method for the architectural concrete panels to come up with an R value of 10 for the walls and R value of 18 to 19 for the roof, as seen on the drawings. After detailing building 1, be sure to enter into the building pull down menu again and copy building 1 to building 2. After this is done I shall change the roof R-values and solar absorption values to resemble a green roofs values; changing solar absorption from .6 to .2 as recommended. Changing the R-value was much more difficult. I used the cross section below (**Fig 13**) to construct a layered roof in Energy 10. The resulting R-Value being 30.75.

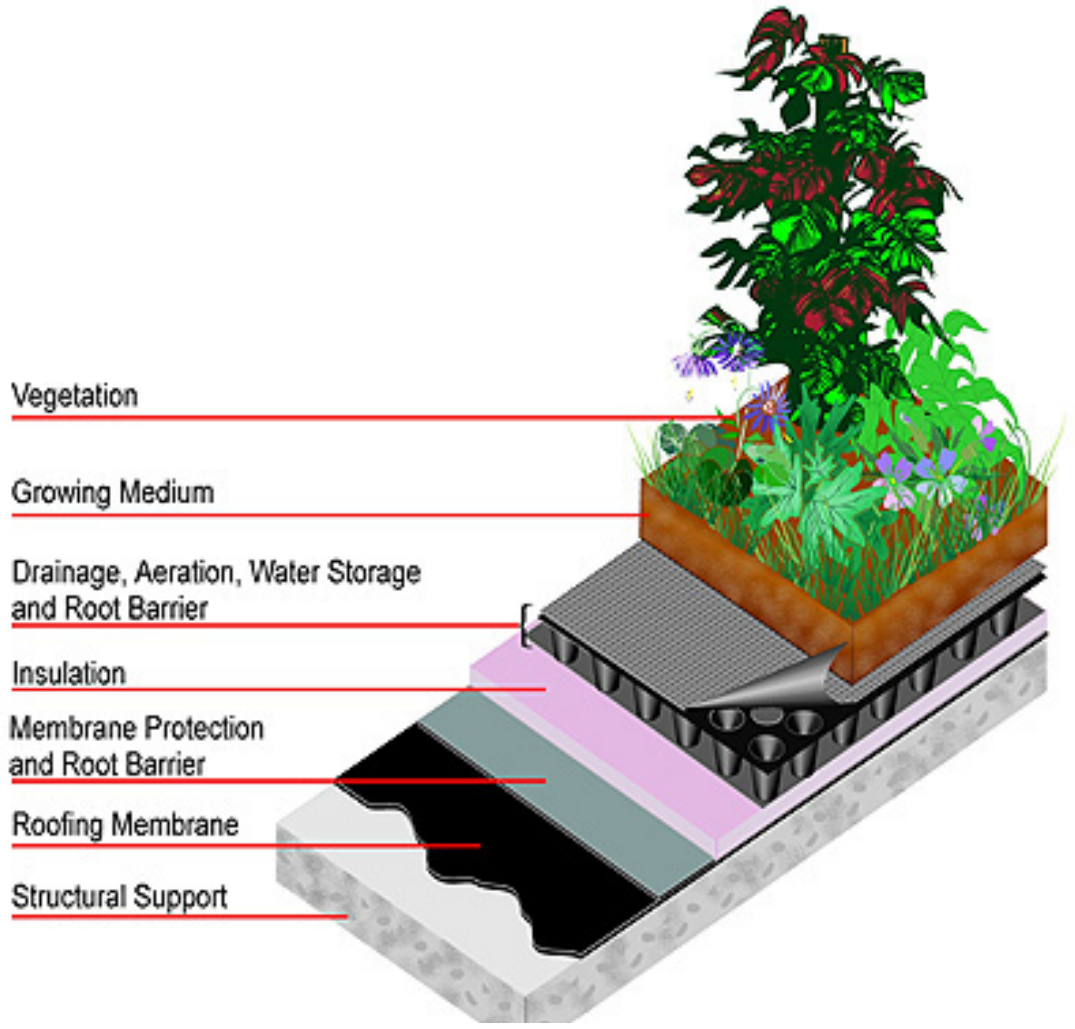

Fig 13

Then leaving everything else at default for both simulated buildings you can run the simulation. To run the energy simulation you simply click on the Misc window and then simulate (**Fig 14**). After this another box will appear and you click “ok”. The first window you see is the Annual Energy Use graph, building 1 in red and building 2 in green (**Fig 15**). As seen 4.5 kBtu/ft^2 in heating, 0.1 kBtu/ft^2 in cooling, and 0.2 kBtu/ft^2 in the category “Other” is saved over a year.

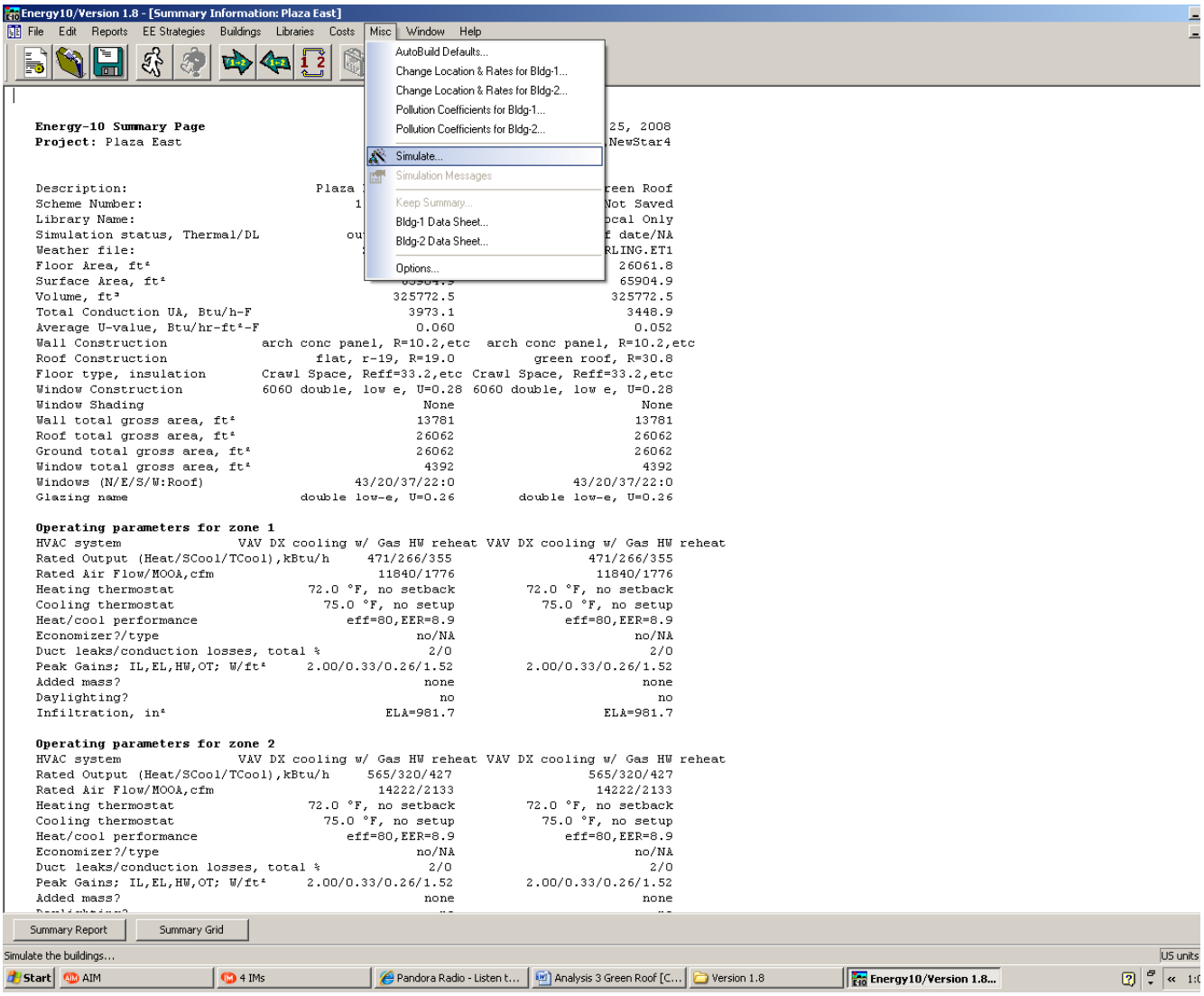
Energy10/Version 1.8 - [Summary Information: Plaza East]
File Edit Reports EE Strategies Buildings Libraries Costs Misc Window Help
AutoBuild Defaults...
Change Location & Rates for Bldg-1...
Change Location & Rates for Bldg-2...
Pollution Coefficients for Bldg-1...
Pollution Coefficients for Bldg-2...
Simulate...
Simulation Messages
Keep Summary...
Bldg-1 Data Sheet...
Bldg-2 Data Sheet...
Options...
Energy-10 Summary Page
Project: Plaza East
Description: Plaza
Scheme Number: 1
Library Name:
Simulation status, Thermal/DL ou
Weather file:
Floor Area, ft²
Surface Area, ft²
Volume, ft³
Total Conduction UA, Btu/h-F
Average U-value, Btu/hr-ft²-F
Wall Construction arch conc panel, R=10.2,etc arch conc panel, R=10.2,etc
Roof Construction flat, r-19, R=19.0 green roof, R=30.8
Floor type, insulation Crawl Space, Reff=33.2,etc Crawl Space, Reff=33.2,etc
Window Construction 6060 double, low e, U=0.28 6060 double, low e, U=0.28
Window Shading None None
Wall total gross area, ft² 13781 13781
Roof total gross area, ft² 26062 26062
Ground total gross area, ft² 26062 26062
Window total gross area, ft² 4392 4392
Windows (N/E/S/W:Roof) 43/20/37/22:0 43/20/37/22:0
Glazing name double low-e, U=0.26 double low-e, U=0.26
Operating parameters for zone 1
HVAC system VAV DX cooling w/ Gas HW reheat VAV DX cooling w/ Gas HW reheat
Rated Output (Heat/SCool/TCool),kBtu/h 471/266/355 471/266/355
Rated Air Flow/MOOA,cfm 11840/1776 11840/1776
Heating thermostat 72.0 °F, no setback 72.0 °F, no setback
Cooling thermostat 75.0 °F, no setup 75.0 °F, no setup
Heat/cool performance eff=80,EER=8.9 eff=80,EER=8.9
Economizer?/type no/NA no/NA
Duct leaks/conduction losses, total % 2/0 2/0
Peak Gains; IL,EL,HW,OT; W/ft² 2.00/0.33/0.26/1.52 2.00/0.33/0.26/1.52
Added mass? none none
Daylighting? no no
Infiltration, in² ELA=981.7 ELA=981.7
Operating parameters for zone 2
HVAC system VAV DX cooling w/ Gas HW reheat VAV DX cooling w/ Gas HW reheat
Rated Output (Heat/SCool/TCool),kBtu/h 565/320/427 565/320/427
Rated Air Flow/MOOA,cfm 14222/2133 14222/2133
Heating thermostat 72.0 °F, no setback 72.0 °F, no setback
Cooling thermostat 75.0 °F, no setup 75.0 °F, no setup
Heat/cool performance eff=80,EER=8.9 eff=80,EER=8.9
Economizer?/type no/NA no/NA
Duct leaks/conduction losses, total % 2/0 2/0
Peak Gains; IL,EL,HW,OT; W/ft² 2.00/0.33/0.26/1.52 2.00/0.33/0.26/1.52
Added mass? none none
Summary Report
Summary Grid
Simulate the buildings...
US units
Start AIM 4 IMs Pandora Radio - Listen t... Analysis 3 Green Roof [C... Version 1.8 Energy10/Version 1.8...

Fig 14

Fig 15

Multiple other graphs can be seen from the Reports and Comparative Graphs menus. As seen from the results the green roof did not save as much on energy usage or energy cost as I anticipated. Tishman Speyer representative told me the original roof was $9 per square foot, when adding a green roof each value per square foot would increase up $8 to $12 per square foot (taken from Jay Britton, Project Manager of Prospect Waterproofing Company). Saving a total energy use of 4.8 kBtu/ft^2 and energy cost of 0.003 $/ft^2 accompanied with price shows the benefits do not outweigh the work involved with adding a green roof.

Original Roof: $\$9/ft^2 \times 26000\ ft^2 = \$234000$

Green Roof Best Case Scenario: $\$17/ft^2 \times 26000\ ft^2 - \$0.003/ft^2 \times 26000 = \$441220$ No Good!

Years needed to make money back: $441220 - $234000 = $207220 / $780 per year = 265 years and 8 months No Good!

Conclusion:

With the green roof alone or when included with a different building envelope, the energy usage savings and cost are not very significant. If the owner would like to go strictly with cost savings there seems to be no real reason to switch to a green roof for this project. But as listed before in the analysis, the green roof has many other attributes that go outside of energy usage savings and costs.

After noticing that neither the new envelope panels nor the green roof saved much energy individually, I've decided to go back into Energy 10 and apply both at the same time. If a green roof and a new façade were combined it may show a significant difference in energy savings and energy utility costs. The results of energy saved per year from using a Versawall and a Green Roof are seen in (**Fig 16 & Table 5**). The results of energy saved per year from using the Dimension Series panels and a Green Roof equaled (**Fig 17 & Table 5**).

Energy Savings from Façade and Green Roof vs Existing (kBtu/sqf)					
	Heating	Cooling	Other1	Total Energy Savings	Total Cost Savings ($/sqf)
Versawall and Green Roof	5.9	-0.2	0.3	6.0	$0.015
Dimension Series and Green Roof	6.2	-0.1	0.3	6.4	$0.028

Table 5

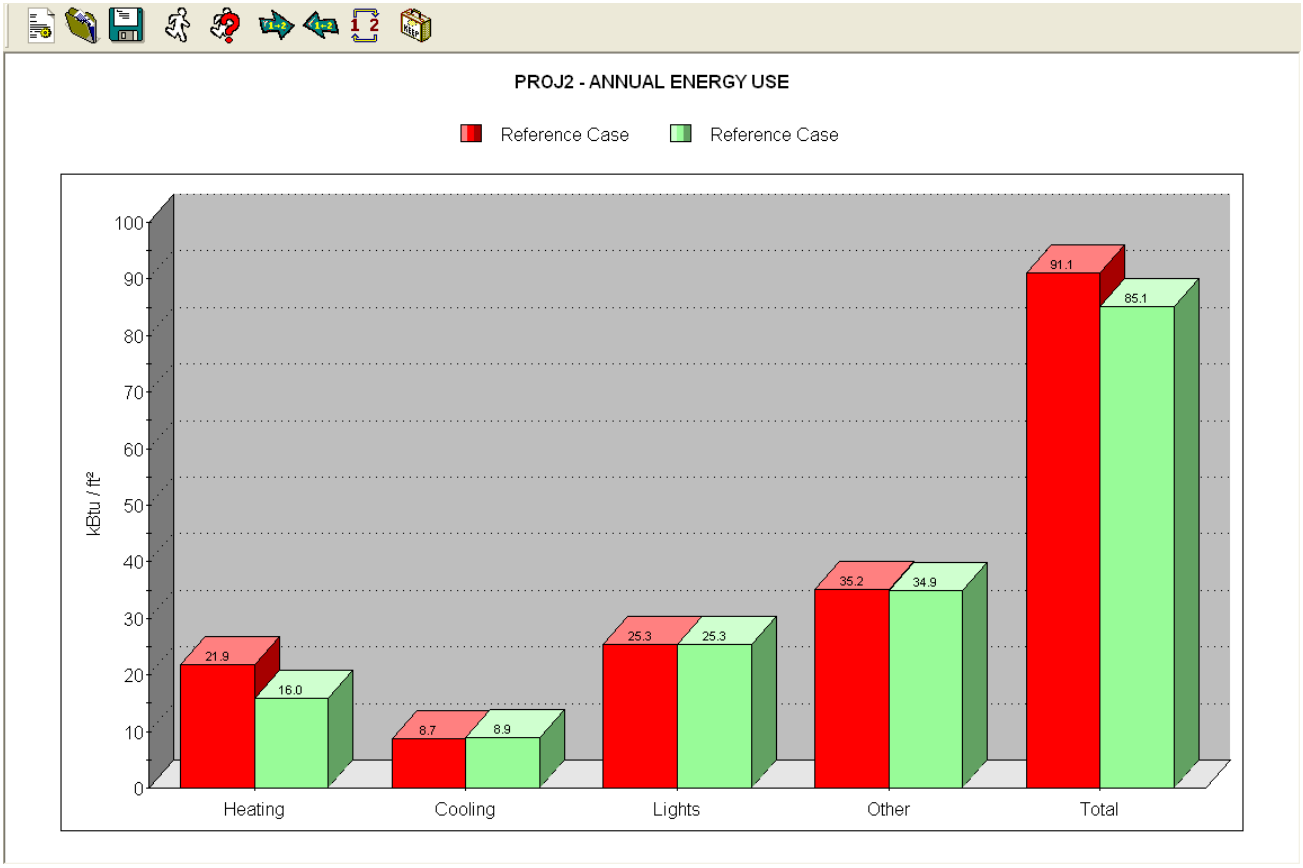
PROJ2 - ANNUAL ENERGY USE
Reference Case
Reference Case
kBtu / ft²
100
90
80
70
60
50
40
30
20
10
0
21.9
16.0
8.7
8.9
25.3
25.3
35.2
34.9
91.1
85.1
Heating
Cooling
Lights
Other
Total

Fig 16

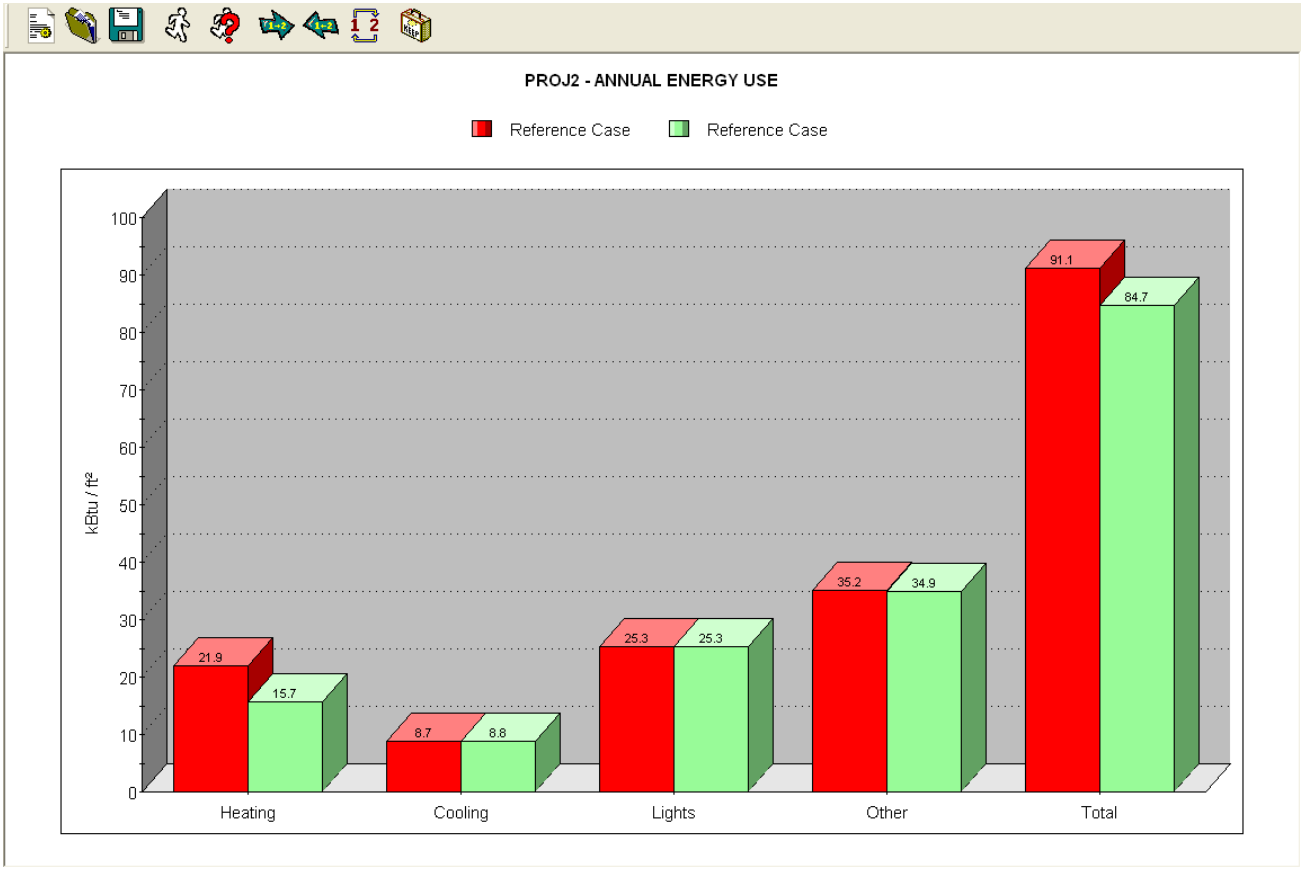
PROJ2 - ANNUAL ENERGY USE
Reference Case
Reference Case
kBtu / ft²
100
90
80
70
60
50
40
30
20
10
0
21.9
15.7
8.7
8.8
25.3
25.3
35.2
34.9
91.1
84.7
Heating
Cooling
Lights
Other
Total

Fig 17