NAVIGANT

Energy Efficiency / Demand Response Plan: Plan Year (6/1/2012-5/31/2013)

Appendix to Fast Track Memo: Economic Redevelopment

FINAL

Presented to
Nicor Gas

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1.1.1 ERP-01 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-01
Verification Method: Onsite M&V, Engineering File Review, and Billing Analysis

Navigant's evaluation of this project consisted of an engineering file review, billing analysis, and onsite verification activities. Navigant's evaluation verified the annual energy savings to be 6,623 therms, resulting in a project realization rate of 0.77, summarized in Table **Error! No text of specified style in document.**-1.

The primary reason for the difference in the ex-ante and research findings gross savings is that the energy model used to calculate ex-ante savings overestimated the gas savings due to heating system measures.

Table Error! No text of specified style in document.**-1: ERP-01 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Increase venting and balance steam heating system (same set-point across building)	1,907	1,449	0.76
Insulate all exposed DHW pipes (basement, garages, storage spaces) to R-4.5	1,993	1,653	0.83
Lower DHW temperature to lowest allowable by code	280	280	1.00
Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board	2,337	1,776	0.76
Insulate all exposed steam pipes (basement, garages, storage spaces) to R-6	2,134	1,622	0.76
Total	**8,650**	**6,780**	**0.78**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-01 Customer implemented energy efficiency measures at their multifamily housing facility with a project completion date of 12/1/2012. The project was completed as part of the ERP because the facility was located in a TIF district.

NAVIGANT

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and review of the project files:

- Building description: Multifamily facility built in the 1920s
- Walls: Brick with air gap; minimal air sealing
- Roof: Minimal insulation
- Windows: 10-15 years old; double-paned; vinyl frame
- Unbalanced steam distribution system
- No insulation on steam pipes
- No insulation on DHW pipes
- Minimal air sealing in basement
- DHW Temperature Setting: 130°F

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: Increase venting and balance steam heating system

The IC used the following algorithm to calculate gas savings from this measure:

$$Therms\ Saved = (1 - \%\ Lacking\ Steam) * Heating\ days * Temp\ Increase * Avg\ Therms\ per\ HDD$$

Algorithm Parameter	Value	Unit	Source/Description
% Lacking Steam	50	%	Portion of the building not receiving adequate steam
Heating days	142.02	Days (equivalent)	212 heating days*67% to account for time the boiler is not in use during the heating season
Temp Increase	3	°F	Assumed; temperature increase required to deal with imbalance of steam heating system
Avg Therms per HDD	8.95	therms/HDD	Linear regression of degree days to therms used
Therms Saved	1,907	therms	Calculated; excess therms required to heat the rest of the building

Source: Navigant's analysis of project files

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Measure: Insulate all exposed DHW pipes to R-4.5

The technical assistance team used a pipe insulation calculator[1] to estimate the energy loss factor associated with poorly insulated pipes. The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Pipe\ Length * \frac{Loss\ Factor}{Avg\ Boiler\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source/Description
Pipe Length	491	feet	Measured onsite
Loss Factor	2.76	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	68	%	Assumed
Therms Saved	1,993	therms	Calculated

Source: Navigant's analysis of project files

Measure: Lower DHW temperature to lowest allowable by code

The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Avg\ Summer\ Gas\ Use * 12\frac{months}{year} * \%\ DHW\ Savings * 0.8$$

Algorithm Parameter	Value	Unit	Source/Description
Avg Summer Gas Use	636	therms	Utility gas bills
% DHW Savings	4.6%	%	Modeled results from Nicor ERP and Energy Savers
0.8	0.8	-	Assumed ratio of DHW to avg summer gas use
Therms Saved	280	therms	Calculated

Source: Navigant's analysis of project files

Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board

The IC estimated the gas savings from this measure based on Energy Savers audit reports. The following was included in the analysis file provided by the IC:

"Energy Savers basement air sealing measure is based on the R-value of insulation in rim joists and typical infiltration values for this type of basement. Their formula has been tuned from utility bill monitoring of dozens of similar buildings. As a further constraint, we benchmark total air sealing energy

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[1] http://www.wbdg.org/design/midg_design_echp.php

savings to be at most 30% of gas usage; a typical anecdotal limit to potential; with limited information on this building, a very conservative portion of this leakage (15%) has been attributed to the basement."

The ex-ante savings calculation estimated the annual gas savings due to this measure at 2,337 therms.

Measure: Insulate all exposed steam pipes (basement, garages, storage spaces) to R-6

The technical assistance team used a pipe insulation calculator[2] to estimate the energy loss factor associated with poorly insulated pipes. The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Pipe\ Length * \frac{Loss\ Factor}{Avg\ Boiler\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source/Description
Pipe Length	309	feet	Measured onsite
Loss Factor	5.18	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	75	%	Assumed
Therms Saved	2,134	therms	Calculated

Source: Navigant's analysis of project files

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed onsite verification activities at this site on June 27, 2013. The measure-level findings and analysis of the site visit are outlined below.

Billing Analysis: All space heating measures

Navigant interviewed the site representative to determine the validity of using billing analysis as a verification method. This interview revealed that no non-ERP energy efficiency measures were implemented at this site, no major changes were made to the building envelope or HVAC system besides the measures implemented as part of the ERP, and no gas leaks or other problems arose that would have affected the facility's gas usage. Navigant also acquired building tenancy data from the building's manager which showed a trivial change in average occupancy: 97.7% in the pre-implementation period and 97.5% in the post-implementation period. Thus Navigant executed a weather-normalized comparison of the pre- and post-implementation gas billing data to estimate gas savings due to the facility's heating system upgrades.

Navigant first calculated the 2011 and 2012 summer monthly gas use averages to determine the non-heating portion of the gas billing data. Separate averages for summer 2011 and summer 2012 were calculated to account for behavioral changes and the installation of non-heating system gas efficiency

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[2] http://www.wbdg.org/design/midg_design_echp.php

measures. Navigant performed a regression analysis of the heating portion of the gas billing data and monthly HDDs and found an R^2 of 0.99 and 0.75 for the pre- and post-implementation periods, respectively. The evaluation team calculated pre- and post-implementation weather-normalized gas consumption at 7.87 and 6.78 therms per HDD60, respectively. Thus, Navigant found a savings of 1.09 therms per HDD60 for the facility's heating system, resulting in 4,843 therms of savings for an average year using Chicago-O'Hare TMY3 weather data (4,449 HDD60s, excluding summer). Compared to 6,378 therms of combined ex-ante savings (all heating system measures), Navigant verified that the realization rate for all heating system measures is 0.76.

Measure: Increase venting and balance steam heating system

This multifamily facility, since it was built in the 1920s, uses steam distributed through a pipe network to transfer heat from the steam boiler to individual apartment units. This system was not originally designed for efficiency and did not provide even distribution of heat. By installing steam vents, the rate of steam flow to individual apartment units' radiators can be adjusted to prevent overheating in apartment units near the steam boiler and under-heating in apartment units far from the steam boiler.

Navigant verified new steam venting devices and radiator air vents to balance the steam distribution system, shown below in Figure 1.

Figure 1: ERP-01 Steam Vents
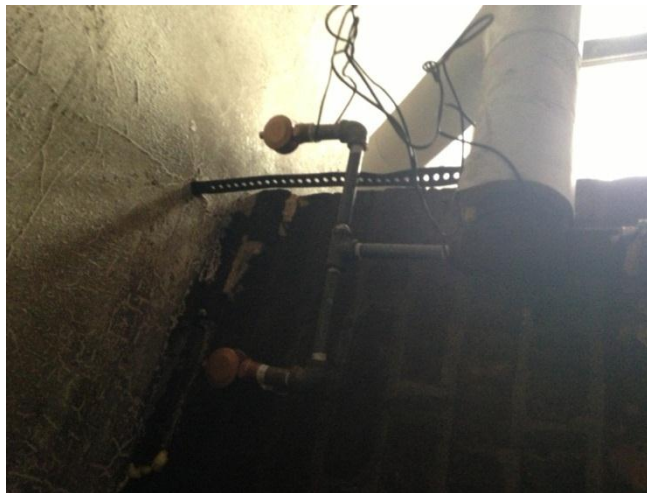
Source: Navigant's onsite verification on July 27, 2013

Navigant performed a gas billing data analysis (summarized in the previous section) on all measures related to the heating system of this facility. Based on the billing analysis, Navigant verified that the annual savings for this measure are 1,449 therms.

Measure: Insulate all exposed DHW pipes to R-4.5

Navigant verified that approximately 491 feet of DHW pipes were insulated, with a segment of the insulated pipes shown below in Figure 2.

Figure 2: ERP-01 DHW Insulation

Source: Navigant's onsite verification on July 27, 2013

Navigant identified the DHW boiler as an A.O. Smith HW-420 932 with 82% nameplate efficiency.

Replicating the algorithm used in the ex-ante savings calculation with the originally used pipe length and loss factor and a DHW boiler efficiency of 82%, the research findings annual savings for this measure are 1,653 therms.

Measure: Lower DHW temperature to lowest allowable by code

Navigant observed the DHW temperature setting to be 125°F. The Illinois TRM specifies a baseline DHW temperature setting at 135°F. According to documentation in the analysis file[3], there was a 10°F turn-down. Therefore, Navigant made no adjustments, and the research findings annual savings for this measure are 280 therms.

Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board

Navigant verified thorough ceiling air sealing, spray foam over window and wall leaks, and rigid foam board over rim joists in the basement of the facility.

Navigant performed a gas billing data analysis (summarized above) on all measures related to the heating system of this facility. Based on the billing analysis, Navigant verified that the annual savings for this measure are 1,776 therms.

Measure: Insulate all exposed steam pipes (basement, garages, storage spaces) to R-6

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[3] "Nicor Gas ERP Energy Calculations – 101 Harvey – Verification.xlsx" → "Other ECM Calcs" tab

Navigant verified that approximately 309 feet of steam pipe insulation was installed as part of the project. Navigant identified the steam boiler as a Weil-McLain Model 88 Series 2 boiler (model 1288). The nameplate efficiency for this steam boiler is 85.6%[4].

Navigant performed a gas billing data analysis (summarized above) on all measures related to the heating system of this facility. Based on the billing analysis, Navigant verified that the annual savings for this measure are 1,622 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Navigant does not have any recommendations based on evaluation of this project.

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[4] Weil-McLain Specifications of the 88 Series 2 Commercial Gas Oil Boiler (http://weil-mclain.com/en/weil-mclain/pd-88-series-2-commercial-gas-oil-boiler/)

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1.1.2 ERP-02 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-02
Verification Method: Onsite M&V and Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review and onsite verification activities performed by a Navigant engineer on June 27, 2013. Navigant's evaluation verified the annual energy savings to be 779 therms, resulting in a realization rate of 1.00, summarized in Table Error! No text of specified style in document.**-2**.

Table Error! No text of specified style in document.**-2: ERP-02 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joints with rigid foam board	779	779	1.00
Total	**779**	**779**	**1.00**

*Source**: Project files and Navigant's analysis*

PROJECT SUMMARY

The ERP-02 Customer implemented energy efficiency measures at their multifamily housing facility with a project completion date of 12/1/2012. The project was completed as part of the ERP because the facility was located in a TIF district.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and/or review of the project files:
- Building description: Multifamily facility built in the 1920s
- Walls: Brick with air gap; minimal air sealing
- Minimal air sealing in the basement
- Roof: Minimal insulation
- Windows: 10-15 years old; double-paned; vinyl frame

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joints with rigid foam board

The IC estimated gas savings from this measure based on an inverse energy model developed by Energy Savers of five similar vintage and construction type multifamily buildings. The model takes building usage and envelope data, and backs out infiltration and air sealing savings. Using this model, a regression analysis on these five data points resulted in 41 therms saved per residential unit. Therefore, for this 19-unit building, the ex-ante savings were 779 therms.

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed onsite verification activities at this site on June 27, 2013. The measure-level findings and analysis of the site visit are outlined below.

Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joints with rigid foam board

Navigant visually verified thorough ceiling air sealing, spray foam over window and wall leaks, and rigid foam board over rim joints in the basement of the facility. An example of the basement air sealing is shown in Figure 3.

Figure 3: ERP-02 Air Sealing

Source: Navigant's onsite verification on July 27, 2013

Navigant could not perform a billing analysis on this project due to lack of pre-implementation gas billing data.

Navigant considers the Energy Savers methodology of using modeled results from five similar buildings, normalized to the number of apartment units, to be reasonable. Therefore, the research findings annual savings for this measure are 779 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Navigant does not have any recommendations based on evaluation of this project.

1.1.3 ERP-03 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-03
Verification Method: Onsite M&V and Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review and onsite verification activities performed by a Navigant engineer on June 27, 2013. Navigant's evaluation verified the annual energy savings to be 19,720 therms, resulting in a realization rate of 0.90, summarized in Table Error! No text of specified style in document.-3.

The primary reason for the difference in the ex-ante and research findings gross savings is that the ex-ante savings calculations for multiple measures do not apply accurate boiler efficiencies. The steam boilers' efficiencies were verified via combustion analysis testing, but the ex-ante savings calculation for other measures dependent on the steam boiler efficiency did not use verified efficiency parameters. In addition, while the IC accurately adjusted the DHW boiler efficiency retroactively in the "Verification Changes" line item for one measure, they did not adjust this value in the savings calculations for other measures dependent on the DHW boiler efficiency.

The secondary reason for the difference in the ex-ante and research findings gross savings is that the IC's energy model calculated energy savings using parametric runs without considering the interactive effect of multiple measures. Specifically, the IC's energy model calculated savings from basement air sealing using an inefficient boiler despite the boiler also being tuned-up as part of this project and the related savings separately captured.

Table Error! No text of specified style in document.**-3: ERP-03 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Air sealing basement windows, rim joists, doors	1,786	1,415	0.79
Tune-up and control improvement to existing boiler	1,706	1,352	0.79
Install new DHW boiler (>95%+ eff.)	2,077	997	0.48
Replace boiler room vent with mechanical louver	255	0	0.00
Insulate all remaining uninsulated steam pipes	5,098	4,346	0.85
Insulate all remaining uninsulated DHW pipes	2,013	2,333	1.16
Repair/replace all failed steam traps	8,505	7,770	0.91
Air seal apartment units: baseboard, windows, doors	1,765	1,507	0.85
Verification changes (see below)	-1,335	N/A	N/A
Total	**21,870**	**19,720**	**0.90**

PROJECT SUMMARY

The ERP-03 Customer implemented energy efficiency measures at their 35-unit multifamily apartment building with a project completion date of 1/12/2013. The project was completed as part of the ERP because the facility was located in a TIF district.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The IC used an energy model calibrated to billing data to estimate existing baseline gas usage. This baseline model included the following inputs:
- Windows: Single pane, U-0.95, SHGC = 0.95
- Walls: Brick with air gap; minimal air sealing
- Roof: 75% R-38 blown-in cellulose
- Boiler: 67% efficiency
- No insulation on steam pipes
- No insulation on DHW pipes
- Minimal air sealing in basement

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: Air sealing basement windows, rim joists, doors

This measure consists of the use of two-part spray foam and rigid foam board (for larger gaps) to seal all leaks in the basement envelope (primarily window frames, rim joists, and doors). The IC used a TRACE 700 energy model to compare the energy use of the baseline case versus an efficient case with the air sealing measure. The energy model reduced the garage infiltration rate from 1.7 air changes per hour (ACH) in the baseline case to 0.8 ACH in the air sealing case. The energy model output was an estimated annual gas savings of 1,786 therms.

Measure: Tune-up and control improvement to existing boiler

This measure includes the installation of new boiler controls including a cutout control on two boilers located at this site. In addition, a professional contractor completed the following steps in tuning the boiler: (1) measure combustion efficiency, (2) optimize air flow, (3) optimize burner input, (4) clean and inspect burners/chamber/HX, (5) check venting, (6) visually inspect piping/insulation, (7) check safety control, (8) verify adequate combustion air.

The IC used a TRACE 700 energy model to compare the energy use of the baseline case versus including the boiler tune-ups. The energy model used a boiler efficiency of 67% and 70% in the baseline and boiler

tune-up cases, respectively. The ex-ante savings calculation estimated the annual gas savings due to this measure at 1,706 therms.

Measure: Install new DHW boiler (>95%+ eff.)

The IC used a TRACE 700 energy model to compare the energy use in the baseline case and the energy use including the new DHW boiler. The energy model used a boiler efficiency of 70% and 95% in the baseline and new DHW boiler cases, respectively. The ex-ante savings calculation estimated the annual gas savings due to this measure at 2,077 therms.

Measure: Replace boiler room vent with mechanical louver

The IC estimated the gas savings from this measure based on a TRACE 700 energy model. The ex-ante savings calculation estimated the annual gas savings due to this measure at 255 therms.

Measure: Insulate all remaining uninsulated steam pipes

This measure consists of insulating existing steam piping (R-6) where current insulation is failing, inadequate, or missing. The technical assistance team used a pipe insulation calculator[5] to estimate the energy loss factor associated with poorly insulated pipes. The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Pipe\ Length * \frac{Loss\ Factor}{Avg\ Boiler\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source/Description
Pipe Length	811	feet	Measured onsite
Loss Factor	4.4	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	70%	%	Assumed efficiency of steam boiler
Therms Saved	5,098	therms	Calculated

Source: Navigant's analysis of project files

Measure: Insulate all remaining uninsulated DHW pipes

This measure consists of insulating existing DHW piping (R-4.5) where current insulation is failing, inadequate, or missing. The technical assistance team used a pipe insulation calculator[6] to estimate the energy loss factor associated with poorly insulated pipes. The gas savings for this measure were calculated via the following algorithm:

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[5] http://www.wbdg.org/design/midg_design_echp.php
[6] http://www.wbdg.org/design/midg_design_echp.php

$$Therms\ Saved = Pipe\ Length * \frac{Loss\ Factor}{Avg\ Boiler\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source
Pipe Length	693	feet	Measured onsite
Loss Factor	2.76	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	95%	%	Assumed efficiency of DHW boiler
Therms Saved	2,013	therms	Calculated

Source: Navigant's analysis of project files

Measure: Repair/replace all failed steam traps

This measure consists of repairing or replacing 52 failed steam traps. The ex-ante gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = \frac{\#\ Traps * Steam\ Loss * DRF * OpHrs * \frac{therms}{100\ lbs}}{Boiler\ eff} * (1 - Other)$$

Algorithm Parameter	Value	Unit	Source/Description
# Traps	52	traps	Number of steam traps
Steam Loss	15	lb/hr	From: http://uesystems.com/tech_support_charts_steam_loss.asp
DRF	0.5	-	Derating factor (TRM)
OpHrs	1880	hours	Based on 8 hours/day during heating season
Therms/100 lbs	0.01	Therms/lbs	Conversion factor
Boiler eff	75%	%	Steam boiler efficiency
Other	0.13	-	Fraction of heating savings captured in other measures
Therms Saved	8,505	therms	Calculated

Source: Navigant's analysis of project files

Measure: Air seal apartment units: baseboard, windows, doors

This measure consists of sealing the baseboards with foam and caulk, caulking around the storm windows, and weather-stripping the rear doors. The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = \#\ of\ Units * Savings\ per\ Unit * (1 - \%other)$$

Algorithm Parameter	Value	Unit	Source/Description
# of Units	35	Apartment units	Onsite
Savings per Unit	58	Therms	Energy Savers model
%other	13.1%	%	Modeled results; Usage saved by previous measures
Therms Saved	1,765	Therms	Calculated

Source: Navigant's analysis of project files

Verification changes

The IC adjusted the final savings results due to the verified DHW boiler efficiency of 82% (originally assumed at 95%). This adjustment resulted in a change in the reporting savings of the "Install new DHW" measure and was calculated via the following algorithm:

$$Verification\ Changes = Savings\ from\ new\ DHW * \frac{eff_{baseline} - eff_{EE\ verified}}{eff_{EE\ assumed} - eff_{baseline}}$$

Algorithm Parameter	Value	Unit	Source/Description
Savings from new DHW	2,077	Therms	Energy Model
$eff_{EE\ verified}$	82	%	Combustion analysis test results located in project files
$eff_{EE\ assumed}$	95	%	Assumed
$eff_{baseline}$	70	%	Assumed
Verification	-1,080	Therms	Calculated

Source: Navigant's analysis of project files

Additionally, the project did not replace the boiler room vent with a mechanical louver, resulting in a 255 therm reduction in savings.

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Due to the complexity of this project, Navigant explored the opportunity of using billing analysis to compare the pre- and post-implementation gas usage to determine annual gas savings. Based on an onsite interview with the property manager, Navigant learned that a condensate leak was found after the project was implemented which skewed the gas use for a portion of the post-implementation period. Thus, billing analysis is not a reasonable method for calculating gas savings.

Navigant performed onsite verification activities at this site on June 27, 2013. The findings of the site visit are outlined below.

Measure: Air sealing basement windows, rim joists, doors
Measure: Tune-up and control improvement to existing boiler

During onsite verification, Navigant verified thorough ceiling air sealing, spray foam over window and wall leaks, and rigid foam board over rim joists in the basement of the facility. Navigant was only provided access to one of the two tuned-up boilers which was identified as a Weil McLain Model LGB-16 Series 2 Boiler, matching the invoice in the project files.

Without blower door testing, Navigant was unable to verify the reduction in infiltration rate to the basement assumed by the energy model but considers these assumptions reasonable. The energy model assumed a steam boiler efficiency of 67%; however according to the combustion analysis results from the steam boiler tune-up verification documentation in the project files, the pre- and post-tune-up efficiencies were 79.05% (average of 79.9% and 78.2%) and 82.3% (average of 82.2% and 82.4%), respectively.

Since the savings calculations of the air sealing and boiler tune-up measures are dependent on each other, Navigant considers it best practice to apply both measures in a parametric energy model comparison. Navigant applied 79.05% boiler efficiency and 1.7 ACH infiltration rate in the baseline case and 79.05% boiler efficiency and 1.7 ACH infiltration rate in the energy efficient case, and resulting savings were 2,767 therms or a realization rate of 0.79 (ex-ante savings were 1,785 therms for air sealing and 1,706 for the boiler tune-ups). Navigant applied this realization rate to both measures in the Executive Summary to report the research findings savings per measure.

Measure: Install new DHW boiler (>95%+ eff.)

Navigant visually identified the new DHW boiler as a Lochinvar CWN270PM boiler. Navigant verified that the IC correctly applied the nameplate efficiency of this boiler (82%) in the reported "Verification Changes" (see above) for this measure, resulting in a research findings annual savings of 997 therms.

Measure: Replace boiler room vent with mechanical louver

Navigant determined that this measure was not implemented as part of this project. The ex-ante savings calculation properly negated the savings due to the lack of implementation of this measure in the "Verification Changes" line item (see above). Thus, the research findings annual savings of this measure is zero therms.

Measure: Insulate all remaining uninsulated steam pipes

Navigant visually verified insulation on all steam pipes, as shown in Figure 4.

Figure 4: ERP-03 Steam Pipe Insulation

Source: Navigant's onsite verification on July 27, 2013

The ex-ante savings calculation for this measure assumed 70% steam boiler efficiency. Navigant considers the steam boiler efficiency to be 82.1% based on the combustion analysis results in the project files. Replicating the ex-ante savings algorithm with the verified steam boiler efficiency of 82.1%, the research findings savings for this measure are 4,346 therms.

Measure: Insulate all remaining uninsulated DHW pipes

During onsite verification, Navigant visually verified new insulation on all DHW pipes and identified the new DHW boiler as a Lochinvar CWN270PM boiler with a nameplate efficiency of 82%. The IC originally assumed 95% efficiency and properly adjusted the gas savings of the "install new DHW boiler" measure within the "Verification Changes" line item. Navigant determined that the IC did not apply this efficiency adjustment to the "insulate all remaining uninsulated DHW pipes" measure. Replicating the ex-ante savings algorithm with the verified DHW boiler efficiency of 82%, the research findings savings for this measure are 2,333 therms.

Measure: Repair/replace all failed steam traps

Navigant verified numerous repaired or replaced steam traps (example in Figure 5) during onsite verification activities.

Figure 5: ERP-03 Steam Trap

Source: Navigant's onsite verification on July 27, 2013

Navigant also reviewed the steam trap invoices in the project files and verified that 52 steam traps were repaired or replaced. The ex-ante savings algorithm used 75% steam boiler efficiency; however, based on Navigant's review of the combustion analysis results of the steam boilers, a boiler efficiency of 82.1% should have been used instead. Replicating the ex-ante savings algorithm with the verified steam boiler efficiency of 82.1%, the research findings savings for this measure are 7,770 therms.

Measure: Air seal apartment units: baseboard, windows, doors

Navigant was not able to visually verify air sealing in apartment units because the units were occupied with tenants during the site visit. The IC estimated the gas savings per apartment unit using Energy Savers modeled results. Navigant did not find documentation of the IC's assumed steam boiler efficiency in the ex-ante savings calculation. The IC assumed steam boiler efficiencies of 70% and 75% for the ex-ante savings algorithms of other measures that also depend on the steam boiler efficiency.

Based on Navigant's review of the combustion analysis results of the steam boilers, the verified boiler efficiency is 82.1%. Navigant adjusted the savings attributed to this measure by multiplying the reporting savings by the ratio of the reported efficiency (assumed to be 70%) to the new steam boiler efficiency (82%). The research findings savings for this measure are 1,507 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: The IC did not use consistent boiler efficiencies in the savings algorithms for multiple measures dependent on the same boiler.

> **Recommendation**: Navigant recommends that the IC establish consistent boiler efficiency inputs for measures dependent on the same boiler.

Finding: The IC's energy model calculated energy savings using parametric runs without considering the interactive effect of multiple measures.

> **Recommendation**: Navigant recommends that the IC run their energy model comparing one pre-implementation to one post-implementation case (with all measures built in) when multiple measures are dependent on each other.

1.1.4 ERP-04 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-04

Verification Method: Onsite M&V, Engineering File Review, and Billing Analysis

Navigant's evaluation of this project consisted of an engineering file review, billing analysis, and onsite verification activities. Navigant's evaluation verified the annual energy savings to be 7,522 therms, resulting in a project realization rate of 0.41, summarized in Table Error! No text of specified style in document.-4.

The primary reason for the difference in the ex-ante and research findings gross savings is that the ex-ante energy model overestimated the gas savings due to heating system measures. Navigant calculated the research findings energy savings for these measures by conducting a utility gas billing analysis to compare the pre- and post-implementation time periods.

Table Error! No text of specified style in document.-4: ERP-04 Savings Summary

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Replace roof (R-39), air seal	5,462	2,106	0.39
Tune-up and control improvement to existing boiler	3,875	1,494	0.39
Insulate DHW pipes (R-4.5)	1,090	1,090	1.00
Air sealing basement windows, rim joists, doors	2,664	1,027	0.39
Turn down DHW heater temperature to 120°F	358	0	0.00
Air seal apartment units: baseboard, windows, doors	2,449	944	0.39
Increase main steam line air vents; balance heating	2,234	861	0.39
Total	**18,131**	**7,522**	**0.41**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-04 Customer implemented energy efficiency measures at their 56-unit multifamily apartment building with a project completion date of 12/1/2012. The project was completed as part of the ERP because the facility was located in a TIF district.

NAVIGANT

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and/or review of the project files:
- Building description: Multifamily facility built in the 1920s
- Walls: Brick with air gap; minimal air sealing
- Roof: Minimal insulation
- Windows: 10-15 years old; double-paned; vinyl frame
- Unbalanced steam distribution system
- No insulation on steam pipes
- No insulation on DHW pipes
- Minimal air sealing in basement
- 72% efficient steam boiler
- DHW temperature setting: 135°F

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: Replace roof (R-39), air seal

This measure consists of air sealing all penetrations, and at all adjacent walls, with two-part spray foam and then insulating the cavity with blown-in cellulose to R-39. The IC used an eQuest model to calculate the energy savings due to this measure. The model assumed the facility's roof had a baseline R-value of R-2. The ex-ante savings calculation estimated the annual gas savings due to this measure at 5,462 therms.

Measure: Tune-up and control improvement to existing boiler

This measure includes the installation of new boiler controls to include a cutout control and to improve short cycling. In addition, a professional contractor completed the following steps in tuning the boiler: (1) measure combustion efficiency, (2) optimize air flow, (3) optimize burner input, (4) clean and inspect burners/chamber/HX, (5) check venting, (6) visually inspect piping/insulation, (7) check safety control, (8) verify adequate combustion air.

The IC used an eQuest model to calculate the energy savings due to this measure. The model used a baseline boiler efficiency of 72% and a tuned-up efficiency of 80%. The ex-ante savings calculation estimated the annual gas savings due to this measure at 3,875 therms.

Measure: Insulate DHW Pipes to R-4.5 (1,090 therms)

The IC used an eQuest model to calculate the energy savings due to this measure. The model used a baseline DHW pipe insulation R-value of R-1 and post-implementation DHW pipe insulation R-value of R-4.5. The ex-ante savings calculation estimated the annual gas savings due to this measure at 1,090 therms.

Measure: Air sealing basement windows, rim joists, doors (2,664 therms)

The IC used an eQuest model to calculate the energy savings due to this measure. The model used a baseline basement infiltration rate of 0.10 cfm/ft² and a post-implementation basement infiltration rate of 0.078 cfm/ft². The ex-ante savings calculation estimated the annual gas savings due to this measure at 2,664 therms.

Measure: Turn down DHW heater temperature to 120˚F (358 therms)

The IC used an eQuest model to calculate the energy savings due to this measure. The model used a baseline DHW temperature setting of 135˚F and a post-implementation DHW temperature setting of 120˚F. The ex-ante savings calculation estimated the annual gas savings due to this measure at 358 therms.

Measure: Air seal apartment units: baseboard, windows, doors (2,449 therms)

This measure consists of sealing baseboards with foam and caulk, caulking around the storm windows, and weather-stripping the rear doors. The IC estimated energy savings using energy modeling results from an Energy Savers report[7]. The ex-ante savings calculation estimated the annual gas savings due to this measure at 2,449 therms.

Measure: Increase main steam line air vents; balance heating (2,234 therms)

The IC estimated the gas savings based on literature. The following was included in the analysis file provided by the IC:

"Reference: Cost Effective Boiler System Retrofits; Lobenstein, Hewett, and Katrakis; Consulting-Specifying Engineer February 2010.

This article was written based on empirical M&V of a steam retrofit measure performed by the Center for Energy and Environment in Minneapolis. They found between 5-10% savings for increasing the size of main line air vents in buildings where the heat delivery distribution was uneven. **We simply take the conservative 5%** end of the range to show SOME savings for an improvement in this building. This also fits within the average estimate for energy savings per housing unit for this type of property as provided by CNT's Energy Savers program."

The ex-ante savings calculation estimated the annual gas savings due to this measure at 2,234 therms.

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Billing Analysis: All space heating measures

Navigant interviewed the site representative to determine the validity of using billing analysis as a verification method. This interview revealed that no non-ERP energy efficiency measures were

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[7] "301 N Oak Park Report.pdf" in the project files

implemented at this site, no major changes were made to the building envelope or HVAC system besides the measures implemented as part of the ERP, no gas leaks or other problems arose that would have affected the facility's gas usage, and the number of tenants did not change between the pre- and post-implementation periods. Navigant also acquired building tenancy data from the building's manager which showed a trivial change in average occupancy: 97.9% in the pre-implementation period and 97.2% in the post-implementation period. Thus Navigant executed a weather-normalized comparison of the pre- and post-implementation gas billing data to estimate gas savings due to the facility's heating system upgrades.

Navigant first calculated the 2011 and 2012 summer monthly gas use averages to determine the non-heating portion of the gas billing data. Separate averages for summer 2011 and summer 2012 were calculated to account for behavioral changes and the installation of non-heating system gas efficiency measures. Navigant performed a regression analysis of the heating portion of the gas billing data and monthly HDDs and found an R^2 of 0.99 and 0.88 for the pre- and post-implementation periods, respectively. Navigant subtracted the post- from the pre-implementation period heating gas consumption to actual HDD60 factors to find a savings of 1.44 therms per HDD60 for the facility's heating system. Multiplied by the annual HDD60s from TMY3 data (4,449 HDD60s for Chicago-O'Hare, not including summer), the resulting savings are 6,423 therms for an average year. Compared to 16,684 therms of combined ex-ante savings (all heating system measures), Navigant verified that the realization rate for all heating system measures is 0.39.

Measure: Replace roof (R-39), air seal

During onsite verification, Navigant did not have access to the roof area to visually verify the upgraded roof. The site representative confirmed that the roof was replaced with R-39 insulation and air sealing.

Navigant performed a gas billing data analysis (summarized in the section above) on all measures related to the heating system of this facility. The billing analysis revealed a realization rate of 0.39 for all heating measures. Navigant verified that the annual savings for this measure are 2,106 therms.

Measure: Tune-up and control improvement to existing boiler

Navigant confirmed with the site representative during the site visit that two Weil-McLain Model LGB-18 Series 2 boilers were tuned-up.

Navigant performed a gas billing data analysis (summarized above) on all measures related to the heating system of this facility. The billing analysis revealed a realization rate of 0.39 for all heating measures. Navigant verified that the annual savings for this measure are 1,494 therms.

Measure: Insulate DHW pipes (R-4.5)

Navigant verified that all DHW pipes were insulated during onsite verification. Navigant identified the DHW boiler as a Laars Luna 100T199E3N boiler. Navigant considers the assumed 80% average efficiency to be reasonable; therefore the research findings annual savings for this measure are 1,090 therms.

Measure: Air sealing basement windows, rim joists, doors

Navigant verified thorough ceiling air sealing, spray foam over window and wall leaks, and rigid foam board over rim joists in the basement of the facility.

Navigant performed a gas billing data analysis (summarized above) on all measures related to the heating system of this facility. The billing analysis revealed a realization rate of 0.39 for all heating measures. Navigant verified that the annual savings for this measure are 1,027 therms.

Measure: Turn down DHW heater temperature to 120˚F

Navigant observed the DHW temperature setting at 140˚F. The ex-ante savings calculation assumed a 135˚F baseline setting per the Illinois TRM and an assumed 120˚F turn-down setting. Therefore, the research findings annual savings for this measure are zero therms.

Measure: Air seal apartment units: baseboard, windows, doors

Navigant was not able to visually verify air sealing in apartment units because the units were occupied with tenants during the site visit.

Navigant performed a gas billing data analysis (summarized above) on all measures related to the heating system of this facility. The billing analysis revealed a realization rate of 0.39 for all heating measures, resulting in a research findings annual savings of 944 therms for this measure.

Measure: Increase main steam line air vents; balance heating

This multifamily facility, since it was built in the 1920s, uses steam distributed through a pipe network to transfer heat from the steam boiler to individual apartment units. This system was not originally designed for efficiency and did not provide even distribution of heat. By installing steam vents, the rate of steam flow to individual apartment units' radiators can be adjusted to prevent overheating in apartment units near the steam boiler and under-heating in apartment units far from the steam boiler.

During onsite verification, Navigant verified new steam venting devices and radiator air vents to balance the steam distribution system.

Navigant performed a gas billing data analysis (summarized above) on all measures related to the heating system of this facility. The billing analysis revealed a realization rate of 0.39 for all heating measures, resulting in a research findings annual savings of 861 therms for this measure.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: Navigant's billing analysis revealed that the energy model used to calculate the ex-ante savings significantly overestimated savings from heating system measures.

> **Recommendation**: Navigant recommends that Nicor Gas review energy models' savings for projects with multiple heating system measures and, if possible, provide the IC with gas billing data to allow calibration of energy models to billing data.

1.1.5 ERP-05 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-05
Verification Method: Onsite M&V and Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review and onsite verification activities. Navigant's evaluation verified the annual energy savings to be 21,581 therms, resulting in a project realization rate of 0.88, summarized in Table Error! No text of specified style in document.-5.

The primary reason for the difference in the ex-ante and research findings gross savings is that the steam and DHW boiler efficiency values used in the ex-ante savings were lower than the nameplate values.

Table Error! No text of specified style in document.**-5: ERP-05 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Air sealing of basement window, rim joints, doors	566	566	1.00
Lower DHW Temperature to 120°F	83	0	0.00
Install a new power flame burner for steam boiler	4,385	3,586	0.82
Fully insulate all steam and DHW piping	3,654	3,466	0.95
Repair/replace all failed steam traps	15,912	13,942	0.88
Total	**24,600**	**21,560**	**0.88**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-05 Customer implemented energy efficiency measures at their 51-unit multifamily facility with a project completion date of 10/15/2012. The project was completed as part of the ERP because the facility was located in a TIF district.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and/or review of the project files:
- Building description: Multifamily facility built in the 1920s
- Walls: Brick with air gap; minimal air sealing

- Roof: Minimal insulation
- Windows: 15-20 years old; double-paned; vinyl frame
- No insulation on steam pipes
- No insulation on DHW pipes
- Minimal air sealing in basement
- DHW Temperature Setting: 140°F

Energy Efficient Conditions

Measure: Air sealing of basement window, rim joints, doors

The IC used an eQuest model and a TRACE 700 model to calculate the energy savings due to this measure. This energy model reduced the infiltration rate of the basement area from 0.140 cfm/ft² to 0.135 cfm/ft². The ex-ante savings calculation estimated the annual gas savings due to this measure at 566 therms.

Measure: Lower DHW Temperature to 120 degF

The IC used an eQuest model to calculate the energy savings due to this measure. The model reduced the DHW set-point temperature from 140°F to 120°F. The ex-ante savings calculation estimated the annual gas savings due to this measure at 83 therms.

Measure: Install a new power flame burner for steam boiler

The IC used the following algorithm to calculate gas savings from this measure:

$$Therms\ Saved = \frac{Boiler\ Cap * (parA * 6500 + parB) * \frac{0.025}{Boiler\ eff}}{100}$$

Algorithm Parameter	Value	Unit	Source/Description
Boiler Cap	4,763	MBH	Steam boiler capacity
Boiler eff	70%	%	Steam boiler efficiency
parA	0.416	-	Wisconsin Focus on Energy Evaluation Report
parB	-126.46	-	Wisconsin Focus on Energy Evaluation Report
Therms Saved	4,385	Therms	Calculated

Source: Navigant's analysis of project files

Measure: Fully insulate all steam and DHW piping

The technical assistance team used a pipe insulation calculator[8] to estimate the energy loss factor associated with poorly insulated DHW and steam pipes. The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Pipe\ Length * \frac{Loss\ Factor}{Avg\ Boiler\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source/Description
Pipe Length	217	feet	Measured onsite
Loss Factor	3.77	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	75%	%	Assumed
Therms Saved	1,091	therms	Calculated

Source: Navigant's analysis of project files

Algorithm Parameter	Value	Unit	Source/Description
Pipe Length	413	feet	Measured onsite
Loss Factor	5.09	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	82%	%	Assumed
Therms Saved	2,564	therms	Calculated

Source: Navigant's analysis of project files

The ex-ante savings calculation estimated the annual gas savings due to this measure at a combined 3,654 therms.

Measure: Repair/replace all failed steam traps

This measure consists of repairing or replacing 92 failed steam traps. The ex-ante gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = \frac{\#\ Traps * Steam\ Loss * DRF * OpHrs * \frac{therms}{100\ lbs}}{Boiler\ eff} * (1 - Other)$$

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[8] http://www.wbdg.org/design/midg_design_echp.php

Algorithm Parameter	Value	Unit	Source/Description
# Traps	92	traps	Number of steam traps. Count was reduced by 15% from original estimate to be conservative
Steam Loss	15	lb/hr	From: http://uesystems.com/tech_support_charts_steam_loss.asp
DRF	0.5	-	Derating factor (TRM)
OpHrs	1880	hours	Based on 8 hours/day during heating season
Therms/100 lbs	0.01	Therms/lbs	Conversion factor
Boiler eff	75%	%	Steam boiler efficiency
Other	0.08	-	Fraction of heating savings captured in other measures
Therms Saved	15,912	therms	Calculated

Source: Navigant's analysis of project files

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed onsite verification activities at this site on June 27, 2013. Navigant could not perform a billing analysis on this project due to lack of site-level gas billing data. The measure-level findings and analysis of the site visit are outlined below.

Measure: Air sealing of basement window, rim joints, doors

Navigant verified during onsite verification thorough air sealing of the basement windows, rim joints, and doors. Navigant did not perform blower door testing to verify the infiltration rate adjustment; however, Navigant considers the original infiltration assumptions reasonable. Thus, the research findings annual savings for this measure are 566 therms.

Measure: Lower DHW Temperature to 120 degF

Navigant observed the DHW temperature setting to be 135 ˚F. The ex-ante savings calculation assumed a baseline of 140˚F and a reduced temperature of 120˚F. The Illinois TRM specifies a baseline DHW temperature at 135˚F. Therefore, no temperature decrease from the baseline was observed, so the research findings annual savings for this measure are zero therms.

Measure: Install a new power flame burner for steam boiler

Navigant verified the power flame burner installation during the site visit, with the nameplate shown in Figure 6.

Figure 6: ERP-05 Power Flame Burner Nameplate

Source: Navigant's onsite verification on July 27, 2013

Navigant was unable to identify the source of the reported algorithm used to calculate for this measure. The IC assumed 70% steam boiler efficiency in the reported calculation. Navigant determined the actual steam boiler efficiency to be 85.6% based on identification of the boiler nameplate during onsite verification. Replicating the reported algorithm using the nameplate efficiency, the research findings savings for this measure are 3,586 therms.

Measure: Fully insulate all steam and DHW piping

Navigant visually verified insulation on all steam and DHW pipes during onsite verification, with an example shown in Figure 7. The onsite visit confirmed the reported lengths of 217 feet and 413 feet for the DHW and steam pipes, respectively.

Figure 7: ERP-05 Steam and DHW Pipe Insulation

Source: Navigant's onsite verification on July 27, 2013

Navigant identified the DHW boiler as a Laars PW0500IN09KACXX. The nameplate capacity of this boiler is 81%. Navigant identified the steam boiler as a Weil-McLain 1488 Natural Gas Boiler with a nameplate thermal efficiency of 85.6%.

Replicating the reported algorithms with the nameplate efficiencies, the research findings savings are 1,010 therms for the DHW pipes and 2,456 for the steam pipes, or a total of 3,466 therms.

Measure: Repair/replace all failed steam traps

Navigant identified numerous steam trap replacements during the site visit, with an example shown in Figure 8.

Figure 8: ERP-05 Steam Trap

Source: Navigant's onsite verification on July 27, 2013

Navigant identified more than 92 steam traps in an invoice located in the project files. The reported savings calculation assumed a steam boiler efficiency of 75%; however, Navigant identified the steam boiler as a Weil-McLain 1488 Natural Gas Boiler which has an efficiency of 85.6%. The evaluation team replicated the reported calculation using a boiler efficiency of 85.6%, and thus the research findings savings for this measure are 13,942 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: The IC did not use consistent boiler efficiencies in the savings algorithms for multiple measures dependent on the same boiler.

> **Recommendation**: Navigant recommends that the IC establish consistent boiler efficiency inputs for measures dependent on the same boiler.

1.1.6 ERP-06 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-06
Verification Method: Onsite M&V and Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review and onsite verification activities performed by a Navigant engineer on June 27, 2013. Navigant's evaluation verified the annual energy savings to be 4,902 therms, resulting in a realization rate of 0.84, summarized in Table Error! No text of specified style in document.**-6**.

The primary reason for the difference in the ex-ante and research findings gross savings is that Navigant used the Illinois TRM to calculate savings due to a boiler tune-up, rather than the IC's use of a Wisconsin Focus on Energy Evaluation Report. The secondary reason for the difference in savings is due to the steam and DHW boiler efficiency values used in the ex-ante savings being lower than the nameplate values.

Table Error! No text of specified style in document.**-6: ERP-06 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Insulate all exposed steam pipes (basement, garages, storage) to R-6	1,993	1,845	0.93
Tune-up existing boiler	1,517	937	0.62
Insulate all exposed DHW pipes (basement, garages, storage spaces) to R-4.5	796	688	0.86
Lower DHW temperature to lowest allowable by code	197	79	0.40
Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board	1,353	1,353	1.00
Total	**5,855**	**4,902**	**0.84**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-06 Customer implemented energy efficiency measures at their 33-unit multifamily housing facility with a project completion date of 12/1/2012. The project was completed as part of the ERP because the facility was located in a TIF district.

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and/or review of the project files:

- Building description: Multifamily facility built in the 1920s
- Walls: Brick with air gap; minimal air sealing
- Roof: Minimal insulation
- No insulation on steam pipes
- No insulation on DHW pipes
- Minimal air sealing in basement

Energy Efficient Conditions

Measure: Insulate all exposed steam pipes (basement, garages, storage) to R-6

The technical assistance team used a pipe insulation calculator[9] to estimate the energy loss factor associated with poorly insulated steam pipes. The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Pipe\ Length * \frac{Loss\ Factor}{Avg\ Boiler\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source/Description
Pipe Length	212	Feet	Measured onsite
Loss Factor	7.05	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	75	%	Assumed
Therms Saved	1,993	Therms	Calculated

Source: Navigant's analysis of project files

Measure: Tune-up existing boiler

Navigant identified that the savings methodology for this measure used a Wisconsin Focus on Energy Evaluation Report. The ex-ante savings calculation estimated the annual gas savings due to this measure at 1,517 therms.

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[9] http://www.wbdg.org/design/midg_design_echp.php

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Measure: Insulate all exposed DHW pipes (basement, garages, storage spaces) to R-4.5

The technical assistance team used a pipe insulation calculator to estimate the energy loss factor associated with poorly insulated DHW pipes. The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Pipe\ Length * \frac{Loss\ Factor}{Avg\ Boiler\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source/Description
Pipe Length	202	feet	Measured onsite
Loss Factor	2.76	therms/ft lost	Pipe insulation calculator
Avg Boiler Efficiency	70	%	Assumed
Therms Saved	796	therms	Calculated

Source: Navigant's analysis of project files

Measure: Lower DHW temperature to lowest allowable by code

The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Avg\ Summer\ Gas\ Use * 12\frac{months}{year} * \%\ DHW\ Savings * 0.8$$

Algorithm Parameter	Value	Unit	Source/Description
Avg Summer Gas Use	447	therms	Utility gas bills
% DHW Savings	4.6%	%	Modeled results from Nicor ERP and Energy Savers
0.8	0.8	-	Assumed ratio of DHW to avg summer gas use
Therms Saved	197	therms	Calculated

Source: Navigant's analysis of project files

Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board

The IC estimated gas savings from this measure based on an inverse energy model developed by Energy Savers of five similar vintage and construction type multifamily buildings. The model takes building usage and envelope data, and backs out infiltration and air sealing savings. Using this model, a regression analysis on these five data points resulted in 41 therms saved per residential unit. Therefore, for this 33-unit building, the ex-ante savings were 1,353 therms.

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Due to the complexity of this project, Navigant explored the opportunity of using billing analysis to compare the pre- and post-implementation gas usage to determine annual gas savings. Based on an onsite interview with the property manager, Navigant learned that an underground gas leak was found after the project was implemented which skewed the gas use for a portion of the post-implementation period. Thus, billing analysis is not a reasonable method for calculating gas savings.

Navigant performed onsite verification activities at this site on June 27, 2013. The findings of the site visit are outlined below.

Measure: Insulate all exposed steam pipes (basement, garages, storage) to R-6

Navigant verified that approximately 212 feet of steam pipe insulation was installed as part of the project. Navigant identified the steam boiler as a Weil-McLain Model LGB-20 Series 2 boiler with 81% efficiency.

Therefore, replicating the algorithm used in the ex-ante savings calculation with the originally used pipe length and loss factor and a steam boiler efficiency of 81%, the research findings annual savings for this measure are 1,845 therms.

Measure: Tune-up existing boiler (1,517 therms)

Navigant identified the steam boiler as a Weil-McLain Model LGB-20 Series 2 boiler. During the site visit, the Navigant engineer interviewed the site representative who confirmed that a boiler tune-up was performed as part of the project. Navigant used the Illinois TRM algorithm for boiler tune-up to calculate savings due to this measure:

$$Therms\ Saved = \frac{N_{gi} * SF * EFLH}{eff_{pre} * 100}$$

Algorithm Parameter	Value	Unit	Source/Description
N_{gi}	2,000	kBTU/hr	Onsite and project files
SF	1.6%	%	Savings factor; reduction in gas consumption as a result of the tune-up; TRM
$EFLH$	2,050	Hours/year	Equivalent full load hours; TRM (Lodging in Zone 2 Chicago)
eff_{pre}	70%	%	Pre-implementation efficiency; project files
Therms Saved	937	therms	Calculated

Source: Navigant's analysis of project files

Nicor Gas Economic Redevelopment Program Evaluation
Appendix to Fast Track Memo

Using the algorithm specified by the TRM, the research findings annual savings for this measure are 937 therms.

Measure: Insulate all exposed DHW pipes (basement, garages, storage spaces) to R-4.5 (796 therms)

Navigant verified that approximately 202 feet of steam pipe insulation was installed as part of the project. Navigant identified the steam boiler as a Laars 0400C Natural Gas Boiler with 81% thermal efficiency.

Therefore, replicating the algorithm used in the ex-ante savings calculation with the originally used pipe length and loss factor and a steam boiler efficiency of 81%, the research findings annual savings for this measure are 688 therms.

Measure: Lower DHW temperature to lowest allowable by code (197 therms)

Navigant observed the DHW temperature setting to be 129 °F. The Illinois TRM specifies a baseline temperature of 135°F. The lowest temperature allowable by code is 120°F. Navigant used a temperature ratio to adjust the savings; therefore the research findings annual savings for this measure are 79 therms.

Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board (1,353 therms)

During onsite verification, Navigant verified thorough ceiling air sealing, spray foam over window and wall leaks, and rigid foam board over rim joists in the basement of the facility. Navigant considers the use of the Energy Savers model of five similar buildings to calculate savings due to this measure as reasonable. Thus, the research findings annual savings for this measure are 1,353 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: This project appeared to be accepted into the program without any documentation of the savings algorithms for multiple measures. Navigant acquired this documentation through follow-up contact with the IC.

> **Recommendation**: Navigant recommends that Nicor Gas require proper documentation of savings algorithms prior to accepting a project into the program.

1.1.7 ERP-07 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-07
Verification Type: Onsite M&V, Engineering File Review, and Billing Analysis

Navigant's evaluation of this project consisted of an engineering file review, billing analysis, and onsite verification activities. Navigant's evaluation verified the annual energy savings to be 3,501 therms, resulting in a project realization rate of 0.87, summarized in Table Error! No text of specified style in document.**-7**.

The primary reason for the difference in the ex-ante and research findings gross savings is that the ex-ante energy model slightly overestimated the gas savings due to heating system measures. Navigant calculated the research findings energy savings for these measures by conducting a utility gas billing analysis to compare the pre- and post-implementation time periods.

Table Error! No text of specified style in document.**-7: ERP-07 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Increase main steam line air vents; balance heating	2,000	1,720	0.86
Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board	1,820	1,565	0.86
Lower DHW temperature to lowest allowable by code	216	216	1.00
Total	**4,036**	**3,501**	**0.87**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-07 Customer implemented energy efficiency measures at their multifamily housing facility with a project completion date of 12/1/2012. The project was completed as part of the ERP because the facility was located in a TIF district.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and/or review of the project files:
- Building description: Multifamily facility built in the 1920s
- Walls: Brick with air gap; minimal air sealing

- Roof: Minimal insulation
- Unbalanced steam distribution system
- Minimal air sealing in basement

Energy Efficient Conditions

Measure: Increase main steam line air vents; balance heating

This multifamily facility, since it was built in the 1920s, uses steam distributed through a pipe network to transfer heat from the steam boiler to individual apartment units. This system was not originally designed for efficiency and did not provide even distribution of heat. By installing steam vents, the rate of steam flow to individual apartment units' radiators can be adjusted to prevent overheating in apartment units near the steam boiler and under-heating in apartment units far from the steam boiler.

The IC used an Energy Savers model to calculate the gas savings due to this measure. The ex-ante gas savings due to this measure was 2,000 therms.

Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board

The IC used an Energy Savers model to calculate the gas savings due to this measure. The ex-ante gas savings due to this measure was 1,820 therms.

Measure: Lower DHW temperature to lowest allowable by code

The gas savings for this measure were calculated via the following algorithm:

$$Therms\ Saved = Avg\ Summer\ Gas\ Use * 12\frac{months}{year} * \%\ DHW\ Savings * 0.8$$

Algorithm Parameter	Value	Unit	Source/Description
Avg Summer Gas Use	492	therms	Utility gas bills
% DHW Savings	4.6%	%	Modeled results from Nicor ERP and Energy Savers
0.8	0.8	-	Assumed ratio of DHW to avg summer gas use
Therms Saved	216	therms	Calculated

Source: Navigant's analysis of project files

Data Collection Findings and Analysis

Navigant performed onsite verification activities at this site on June 27, 2013. The measure-level findings and analysis of the site visit are outlined below.

Measure: Increase main steam line air vents; balance heating
Measure: Air seal basement ceiling, and major window/wall leaks with spray foam; insulate rim joists with rigid foam board

During the site visit, Navigant verified numerous steam vents connected to the steam distribution pipe network, with an example shown in Figure 9. Navigant also verified thorough ceiling air sealing, spray foam over window and wall leaks, and rigid foam board over rim joists in the basement of the facility.

Figure 9: ERP-07 Steam Vent
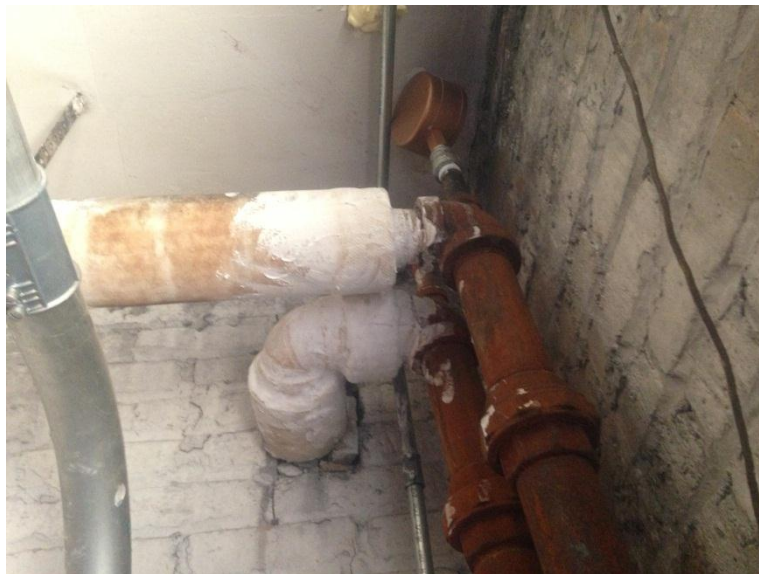
Source: Navigant's onsite verification on July 27, 2013

Navigant interviewed the site representative to determine the validity of using billing analysis as a verification method. This interview revealed that no non-ERP energy efficiency measures were implemented at this site, no major changes were made to the building envelope or HVAC system besides the measures implemented as part of the ERP, and no gas leaks or other problems arose that would have affected the facility's gas usage. Navigant also acquired building tenancy data from the building's manager which showed a trivial change in average occupancy: 96.4% in the pre-implementation period and 94.2% in the post-implementation period. Thus, Navigant executed a weather-normalized comparison of the pre- and post-implementation gas billing data to estimate gas savings due to the facility's heating system upgrades.

Navigant first calculated the 2011 and 2012 summer monthly gas use averages to determine the non-heating portion of the gas billing data. Separate averages for summer 2011 and summer 2012 were

calculated to account for change in tenants and the installation of the non-heating system gas efficiency measure (DHW temperature turn-down). Navigant determined the pre- and post-implementation weather-normalized gas savings to be 4.89 and 4.15 therms per HDD60 using actual weather data. Therefore, Navigant found a savings of 0.74 therms per HDD60 for the facility's heating system. The evaluation team multiplied this factor by 4,449 HDD60 (Chicago-O'Hare TMY3 data; excluding summer) resulting in 3,285 therms of savings for an average. Compared to 3,820 therms of combined ex-ante savings (all heating system measures), Navigant verified that the realization rate for all heating system measures is 0.86.

Measure: Lower DHW temperature to lowest allowable by code

During the site visit, Navigant verified the DHW temperature setting at 120°F. The research findings savings for this measure are 216 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Navigant does not have any recommendations for future projects based on this review.

1.1.8   ERP-08 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-08
Verification Method: Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review. Navigant's evaluation verified the annual energy savings to be 931 therms, resulting in a project realization rate of 0.99, summarized in Table Error! No text of specified style in document.-8.

The primary reason for the difference in the ex-ante and research findings gross savings is that Navigant used a different dataset of TMY3 weather data than what was used in the ex-ante savings calculation.

Table Error! No text of specified style in document.**-8: ERP-08 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Direct Fired Make-Up Air Units (x2 10,000 cfm, 92% eff)	940	931	0.99
Total	**940**	**931**	**0.99**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-08 Customer implemented energy efficiency measures at their industrial facility with a project completion date of 8/12/2012. The project consisted of the installation of two direct fire make-up air units to replace the existing infrared heaters. The project was completed as part of the ERP because the project had the potential to create jobs.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and/or review of the project files:
- Light industry facility
- Heating System Efficiency: 80%

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: Direct Fired Make-Up Air Units (x2 10,000 cfm, 92% eff)

The IC used the following algorithm to calculate gas savings from this measure:

$$Therms\ Saved = \frac{\sum Heat\ Load}{Baseline\ Efficiency} - \frac{\sum Heat\ Load}{EE\ Efficiency}$$

Algorithm Parameter	Value	Unit	Source/Description
Baseline Efficiency	80%	%	Baseline heating system efficiency
EE Efficiency	92%	%	Efficiency of energy efficient make-up air units
$\sum$ Heat Load	5,765	therms	See below
Therms Saved	940	therms	Calculated

Source: Navigant's analysis of project files

The IC ran an 8,760 hour annual analysis in Excel to calculate the annual heat load. At each hourly time-step where the outdoor temperature was below the supply temperature of 70°F, the model calculated the hourly heat load using the following algorithm:

$$Heat\ Load_i = 1.08 * Flow\ Rate_{max} * Air\ Flow\ \%_i * (Supply\ Temperature - Outdoor\ Temperature_i)$$

Algorithm Parameter	Value	Unit	Source/Description
1.08	1.08	Btu/cfm/°F	Constant
Flow Rate$_{max}$	10,000	Cfm/unit	Maximum outside air flow rate through the make-up air units
Air Flow $\%_i$	Varies per hour i	%	Ventilation requirements based on custom occupancy schedule
Supply Temperature	70	°F	Assumed
Outdoor Temperature$_i$	Varies per hour i	°F	Weather data
Heat Load$_i$	Varies per hour i	Btu	BTUs required to properly heat the facility

Source: Navigant's analysis of project files

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed an engineering file review of this project. The measure-level findings are outlined below.

Measure: Direct Fired Make-Up Air Units (x2 10,000 cfm, 92% eff)

Nicor Gas Economic Redevelopment Program Evaluation
Appendix to Fast Track Memo

Navigant reviewed the project files to verify the various assumptions used in the ex-ante savings calculation. Based on review of the make-up air unit invoice, Navigant identified a 92% efficiency rating and a 10,000 cfm supply flow rate per make-up air unit. Navigant also identified that the IC assumed a code-minimum baseline heating system efficiency of 80%. Navigant adjusted the ex-ante savings calculation to include TMY3 weather data from Chicago - O'Hare Airport, the closest geographical weather site to this facility.

Replicating the calculation using TMY3 weather data, Navigant verified the annual savings as 931 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: Navigant could not identify the baseline heating system equipment after following up with the IC.

Recommendation: Navigant recommends that the IC properly document all baseline conditions.

1.1.9   ERP-09 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-09

Verification Method: Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review. Navigant's evaluation verified the annual energy savings to be 9,619 therms, resulting in a project realization rate of 0.94, as summarized in Table Error! No text of specified style in document.-9.

The primary reason for the difference in the ex-ante and research findings gross savings is that the ex-ante energy model overestimated the gas savings due to heating system measures.

Table Error! No text of specified style in document.**-9: ERP-09 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Replacement of locker room AHUs with more efficient RTU that has an energy recovery wheel	10,267	9,619	0.94
Total	**10,267**	**9,619**	**0.94**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

Project ERP-09 implemented energy efficiency measures at their recreational facility with a project completion date of 01/01/2013. The project was completed as part of the ERP because this project is a non-profit or community-based entity and provides strong positive community impact.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified through review of the project files:
- Building description: Recreational facility built in the 1980s
- Floor area: 11,000 ft²
- Air-handler unit (AHU) Manufacturer and Model: RECOLD-AH 200C (supply air of 9,360 CFM)

Energy Efficient Conditions

This recreational facility is currently undergoing a series of major renovations of their entire HVAC system, as well as some plumbing, structural, and architectural improvements. However, this project specifically pertains only to a replacement of the facility's locker room air-handler unit (AHU) with a more efficient roof-top unit (RTU) that includes an energy recovery wheel. The energy recovery wheel

saves energy by maximizing usage of outside air (OA) and utilizing return air (RA) to meet the supply air (SA) requirement of 5,865 CFM to the space area.

Measure: Replace locker room AHUs with more efficient RTU with energy recovery wheel (10,267 therms)

The IC used eQuest building simulation to determine annual energy consumption from this measure by running 2 separate models, a baseline case with the old AHU and an efficient case with a new RTU with an energy recovery wheel feature in Table Error! No text of specified style in document.**-10**.

<div align="center">

Table Error! No text of specified style in document.**-10: Ex-Ante Savings Summary of Measure**

</div>

Run #	Scenario	Annual Natural Gas Consumption (therms)	Relevant Measure Description
1	Baseline	130,190	N/A
2	New Locker Room RTU; energy recovery wheel	119,923	Replacement of locker room AHUs with more efficient RTU that has an energy recovery wheel

<div align="center">

Source: Navigant's analysis of project files

</div>

The IC used TMY2 weather data, which may correspond to an earlier historical weather time-frame.

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed an engineering desk review of this project by analyzing the reasonableness of eQuest modeling inputs and assumptions and comparing modeled results to historical billing data.

Modeling Review: Replacement of AHU with more efficient RTU with energy recovery wheel

To gauge the reasonableness of the ex-ante annual energy savings, Navigant analyzed the eQuest models in the project files pertaining to each modeling sequence as described in Table Error! No text of specified style in document.**-10**. Navigant reviewed modeling inputs and determined that key measure parameters (i.e., RTU packaged gas furnace input and output capacity, SA CFM requirements) were being modeled in eQuest in agreement with project documentation (i.e., mechanical sheet, building drawings). The evaluation found that the new RTU manufacturer and model was Modine MPR20. Navigant noted that the minimum OA hourly schedule for the main packaged multi-zone systems serving the non-locker room space areas had set the fraction/design ratio to -999. The ex-post savings evaluation utilized the OA value in accordance with the mechanical sheets.

Billing Consideration: Replacement of AHU with more efficient RTU with energy recovery wheel

To gauge the reasonableness of the simulated annual energy savings, Navigant considered the historical energy consumption of this facility that pertained to the pre-installation time-frame.

However, energy consumption patterns at the site may have changed from pre- and post-installation due to other parameters (e.g., facility hours of operation changes) not explicitly listed in the project documentation.

The results of the re-run parametric models using TMY3 weather data for Chicago O'Hare International Airport, which was the closest geographical weather site to this facility, are summarized in the following table.

Table Error! No text of specified style in document.**-11. eQuest Model Simulation Summary**

Month	Simulated Consumption (therms) - Sequence 1	Simulated Consumption (therms) - Sequence 2
1	17,607	16,236
2	14,857	13,736
3	12,980	12,057
4	9,426	8,726
5	6,638	6,111
6	3,677	3,144
7	2,496	1,924
8	3,149	2,651
9	4,620	4,173
10	8,553	7,893
11	11,724	10,801
12	16,887	15,543
Total Annual Consumption	112,614	102,995
Total Annual Savings	-	9,619

Source: Navigant's analysis of project files

Therefore, the research findings annual savings for this measure are 9,619 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Navigant does not have any recommendations for future projects based on this review.

1.1.10 ERP-10 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-10

Verification Type: Engineering File Review

Table Error! No text of specified style in document.-12 summarizes the results of Navigant's engineering file review of this project. Navigant's evaluation verified the annual energy savings to be 18,375 therms, resulting in a project realization rate of 0.97.

The primary reason for the difference in the ex-ante and research findings gross savings is that the energy model used TMY2 instead of TMY3 weather data to calculate ex-ante savings.

Table Error! No text of specified style in document.**-12: ERP-10 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
Upgrade existing torn-off roof section with R-22	13,098	12,720	0.97
Upgrade rest of existing roof to R-22 with overlay	5,779	5,655	0.98
Total	**18,877**	**18,375**	**0.97**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

Project ERP-10 implemented energy efficiency measures at their warehouse facility with a project completion date of 03/01/2013. The project was accepted to the ERP because it will help create jobs.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions determined through review of the project files:
- Building description: Industrial warehouse facility with approximately 10% office space built in 1970
- Roof: Minimal insulation (assumed R-8 in modeling results), 116,138 ft^2 (area)

Energy Efficient Conditions

This warehouse facility underwent a major renovation that included new HVAC systems and upgrades to the lighting and envelope to comply with IECC 2009. However, this project specifically pertains only to the roof insulation as part of the envelope upgrade.

Measure 1: Upgraded existing torn-off section (71,200 ft2) of roof insulation to R-20 using 4" extruded polystyrene (13,098 therms)
Measure 2: Upgraded rest of existing roof (50,600 ft2) to R-20 with overlay (5,779 therms)

The IC used eQuest building simulation to determine annual heating-end use energy consumption from these measures by running parametric runs in sequence of the measures listed above as shown in Table **Error! No text of specified style in document.**-13.

Table Error! No text of specified style in document.**-13. Ex-Ante Savings Summary of Measures**

Seq. #	Scenario	Annual Natural Gas Consumption (therms)	U-factor (Btu/h-ft2-^{0}F)	Relevant Measure Description
1	Baseline	112,456	0.120	N/A
2	Partial improved roof insulation	99,736	0.048	Upgrade existing torn-off roof section with R-20
3	Complete improved roof insulation	94,081	0.048	Upgrade rest of existing roof to R-20 with overlay

Source: Navigant's analysis of project files

Annual energy savings for each respective measure is a result of subtracting the annual energy consumption of the previous eQuest modeling sequence (i.e., savings for Measure 1 was determined by subtracting the modeled annual consumption from Sequence 2 from that of Sequence 1). The IC used TMY2 weather data, which may correspond to an earlier historical weather time-frame.

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed an engineering desk review of this project by analyzing the reasonableness of eQuest modeling inputs and assumptions.

Modeling Review: Roof insulation upgrade measures

To gauge the reasonableness of the ex-ante annual energy savings, Navigant analyzed the eQuest models in the project files pertaining to each modeling sequence as described in Table **Error! No text of specified style in document.**-13. Navigant reviewed modeling inputs and determined that key measure parameters (i.e., U-factor and square footage of roof area) were being modeled in eQuest in agreement with project documentation provided (i.e., inspection reports, building drawings, and technical specification sheets).

Navigant re-ran the parametric eQuest model runs using TMY3 weather data for Chicago O'Hare International Airport, which was the closest geographical weather site to this facility, to determine the re-simulated annual energy simulation, summarized in Table Error! No text of specified style in document.**-14**.

Table Error! No text of specified style in document.-14: eQuest Modeling Review Results

Scenario #	Scenario Description	Simulation Results - Annual Natural Gas Consumption (therms)	U-factor (Btu/h-ft2-^{0}F)	Square Footage of roof area with new insulation
1	Baseline	114,691	0.120	0
2	Partial improved roof insulation	101,971	0.048	71,200
3	Complete improved roof insulation	96,316	0.048	50,600

Source: Navigant's analysis of project files

Billing Consideration: Roof insulation upgrade measures

To gauge the reasonableness of the simulated annual energy savings, Navigant considered the historical energy consumption of this facility that pertained to the pre-installation time-frame. However, due to the significant renovations that would likely change the occupancy patterns for a new tenant, the evaluation team did not further consider the usage of billing data for savings analysis.

The results of the re-run parametric models using TMY3 weather data are summarized in Table Error! No text of specified style in document.-15.

Table Error! No text of specified style in document.-15: eQuest Model Simulation Summary

Month	Simulated consumption (therms) - Sequence 1	Simulated Consumption (therms) - Sequence 2	Simulated Consumption (therms) - Sequence 3
1	22,829	20,597	19,479
2	18,758	16,961	16,061
3	15,085	13461	12774
4	8,914	7,904	7,511
5	2,943	2543	2392
6	321	320	277
7	23	23	19
8	62	62	41
9	1,025	900	785
10	7,285	5,816	5,385
11	13,650	11829	11129
12	21,560	19,320	18,228
Total Annual Consumption	**112,456**	**99,736**	**94,081**
Total Annual Savings	**-**	**12,720**	**5,655**

The research findings annual savings for measures 1 and 2 are 12,720 therms and 5,655 therms, respectively. The slightly lower realization rate of 97% for this project is predominantly a result of usage of the ex-ante modeled savings being based off of TMY2 instead of TMY3 weather data.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: The energy model used to estimate ex-ante savings was based on the same operating parameters pre- and post-installation of the roof insulation.

> **Recommendation**: While not always possible depending on the project completion date, Navigant recommends, for future projects with major building operational changes that rely upon building simulation, that the IC obtain post-installation operating parameters and consider billing usage to inform the savings calculation.

1.1.11 ERP-11 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-11
Verification Type: Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review. Navigant's evaluation verified the annual energy savings to be 1,105 therms, resulting in a project realization rate of 0.94, summarized in Table Error! No text of specified style in document.**-16**.

The primary reason for the difference in the ex-ante and research findings gross savings is that the ex-ante savings estimation used an indoor heating temperature set point that was slightly higher than Navigant's interpretation of that value from the project files, resulting in a slight overestimation of savings.

Table Error! No text of specified style in document.**-16: ERP-11 Savings Summary**

Measure Description	Reported Savings (therms)	Verified Savings (therms)	Realization Rate
Upgrade roof insulation to R-20 using 2.5-3 inch poly-ISO insulation	1,175	1,105	0.94
Total	**1,175**	**1,105**	**0.94**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

Project ERP-11 implemented energy efficiency measures at their office/warehouse facility with a project completion date of 12/01/2012. The project was accepted to the ERP because the facility is located in a TIF district, and the project serves a nonprofit entity and will create jobs.

REPORTED SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines some baseline conditions identified through review of the project files:
- Total area of building's roof: 48,000 ft^2 (only 4,800 ft^2 was part of project scope)
- Heating System Efficiency: 75%
- Existing U-Factor: 0.15
- Heating temperature set-point: 70 ^{0}F

Energy Efficient Conditions

Measure: **Upgrade roof insulation to R-20 (1,175 therms)**

The IC used the following algorithm to calculate gas savings from this measure:

$$IF\ T_{db} < T_{balance}, THEN$$

$$Therms\ Saved = \frac{\sum_{h=1}^{8760}(U_{existing} \times Area \times [T_{heat} - T_{db,h}]) - \sum_{n=1}^{8760}(U_{proposed} \times Area \times [T_{heat} - T_{db,h}])}{Heating\ System\ Efficiency\ \times 100,000}$$

Algorithm Parameter	Value	Unit	Description
Roof Area (Area)	4,800	Ft^2	Area of roof that received roof insulation upgrade
Average zone balance point temperature (T$_{balance}$)	60	^{0}F	Assumed; Between 50 (for commercial) and 65 (multifamily)
Dry-bulb Temperature (T$_{db,h}$)	Varies	^{0}F	Varies hourly for an entire calendar year
Proposed U-Factor (U$_{proposed)}$	0.05	Btu/hr-ft^2-^{0}F	Corresponding to roof insulation of R-20
Existing U-Factor (U$_{existing)}$	0.15	Btu/hr-ft^2-^{0}F	Estimated value
Heating Temp (T$_{heat}$)	70	^{0}F	Presumed indoor heating temperature setpoint
Heating System Efficiency	75	%	Estimated value
Therms Saved	1,175	therms	Calculated; excess therms required to heat the rest of the building

Source: Navigant's analysis of project files

Natural gas savings result from reduced heat transfer due to an increased R-value (decreased U-Factor) when the heating system is presumed to be operational (i.e., when dry-bulb temperature is less than the balance point temperature).

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed an engineering file review of the files provided for this project. Based on this review, the evaluation team was able to verify assumptions and inputs in the reported savings calculation and gathered additional information used to calculate verified savings for the roof insulation measure.

According to the IC's site verification report dated 10/12/2012, this project originally called for tearing off portions of existing roof deck and installing 3" poly-ISO insulation, resulting in an overall R-25 value. However, the verification report revealed 2.5"-3" poly-ISO insulation was installed in a single layer resulting in an overall R-20 value. In addition, though the entire warehouse facility's roof area is 48,000 ft² only 10% of the overall facility roof (4,800 ft²) spanning the facility's lower office roof and new warehouse areas received the roof insulation upgrade. Navigant agrees with the values used for the baseline roof R-value estimation and the upgraded insulation R-value.

The evaluation team also discovered an energy audit report performed for this facility in February 2012 by an engineering firm identifying various energy efficiency opportunities. The audit report indicated that the facility's winter operating schedule is 5:30 AM – 4:00 PM, Monday – Friday and the temperature is set at 68°F during operating hours and setback to 62°F during non-operating hours. Further, this report reveals that the primary HVAC equipment found on-site are roof-top units (RTU) with gas furnaces. Table Error! No text of specified style in document.-17 represents the RTUs in the audit report that pertain to the space areas that had roof insulation upgrades.

Table Error! No text of specified style in document.-17: HVAC Equipment related to Roof Insulation

#	Manufacturer	Model #	Fan Capacity	Area served
RTU-9	Lennox	GCS16-120-270-1Y	6,400	New warehouse
RTU-10	Lennox	GCS16-120-270-1Y	6,400	New warehouse
RTU-11	Lennox	GCS16-120-270-1Y	6,400	New warehouse
RTU-12	Lennox	GCS16-120-270-1Y	6,400	New warehouse
RTU-13	Trane	YCD0603H0BE	2,000	Office Space
RTU-14	Trane	YCD0603H0BE	2,000	Office Space

Source: Navigant's analysis of project files

The evaluation team understands that these roof-top units include packaged natural gas furnaces and agrees with the original assumption of system efficiency of 75%.

Navigant agrees with the algorithm used to determine energy savings for this particular measure, but the project files do not support using an indoor heating temperature of 70°F. Since the energy audit report shows that the heating temperature during the winter season is 68°F, the evaluation team used this value and verified that the annual savings for this measure are 1,105 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: Navigant could not identify some of the baseline heating system characteristics after following up with the IC.

Recommendation: Because this particular project's savings is based on reduced heating consumption, the evaluation team recommends better documentation on key components of the heating equipment (e.g., capacity, efficiency) related to the roof insulation upgrades.

1.1.12 ERP-12 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-12
Verification Method: Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review. Navigant's evaluation verified the annual energy savings to be 7,375 therms, resulting in a project realization rate of 0.99, summarized in Table Error! No text of specified style in document.**-18**.

The primary reason for the difference in the ex-ante and research findings gross savings is that the ex-ante calculation used a DHW heater of 96% while Navigant's evaluation determined an efficiency of 95%.

Table Error! No text of specified style in document.**-18: ERP-12 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
CO_2 control in cardio, aerobic, spinning, and basketball rooms	5,693	5,693	1.00
(2) 95% Efficient, 400 MBH DHW heaters	1,794	1,682	0.94
Total	**7,487**	**7,375**	**0.99**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-12 Customer implemented energy efficiency measures at their fitness center facility with a project completion date of 10/1/2012. The project was completed as part of the ERP because it would put a building in use that was either vacant or underutilized.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by review of the project files:
- Building description: Fitness center

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: CO$_2$ control in cardio, aerobic, spinning, and basketball rooms

The IC used the following algorithms to calculate gas savings from this measure:

$$Therms\ Saved = \frac{\sum DCV\ Heating}{Heating\ Efficiency/100{,}000}$$

$$DCV\ Heating = (Ventilation\ Heating) \times (1 - \%Occupancy)$$

$$Ventilation\ Heating = 1.08 \times Outdoor\ Air\ Flow\ Rate \times Indoor\ Heating\ Setpoint \times T_{db}$$

$$Outdoor\ Air\ Flow\ Rate = 1400 \times 4 + 800 + 1400 = 7800\ cfm$$

Algorithm Parameter	Value	Unit	Source/Description
Heating Efficiency	75	%	Assumed; efficiency of the heating system
%Occupancy	Varies	%	Occupancy rate as a percent. From ASHRAE 90.1-2010 User's Manual page G46
Indoor Heating Setpoint	70	˚F	Assumed; temperature setpoint of heating system
T_{db}	Varies	˚F	Dry bulb temperature at a given time on a given day of the year. From Chicago weather data.
Therms Saved	5,693	therms	Calculated

Source: Navigant's analysis of project files

Measure: (2) 95% Efficient, 400 MBH DHW heaters

The technical assistance team used the following algorithm to calculate gas savings from this measure:

$$Therms\ Saved = \frac{Cap \times CF \times (\frac{Hours}{year}) \times 0.01 \times Eff_{base} \times (Eff_{new} - Eff_{base})}{OF}$$

Algorithm Parameter	Value	Unit	Source/Description
Cap	800	MBtu/hr	Heating capacity of units; verified by IC onsite
CF	0.25	-	Capacity factor; from ASHRAE 90.1-2010 User's Manual page G44
Hours/year	8760	Hours	Assumed
Eff_{base}	80	%	Efficiency of base unit; Assumed
Eff_{new}	96	%	Efficiency of new unit; Verified by IC onsite
OF	1.25	-	Oversize factor; Assumed
Therms Saved	1,794	therms	Calculated

Source: Navigant's analysis of project files

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed an engineering file review of this project. The measure-level findings and analysis of the file review are outlined below.

Measure: CO₂ control in cardio, aerobic, spinning, and basketball rooms

Navigant's engineering file review determined that the customer installed four CO_2 sensors for control in the following areas of the fitness facility: cardio, aerobic, and spinning rooms, as well as the basketball court. The evaluation team determined that the methodology and algorithm inputs were reasonable.

Navigant performed an engineering file review of this measure and verified that the annual savings for this measure are 5,693 therms.

Measure: (2) 95% Efficient, 400 MBH DHW heaters

Navigant's engineering file review determined that the customer installed two A.O. Smith BTH 400 commercial water heaters. The capacity of these water heaters is 400 MBtu/hr each, with nameplate thermal efficiency of 95% (see Figure 10 below). This was less than the 96% thermal efficiency used by the IC to calculate the therm savings for the measure. Using this efficiency with the original algorithm used, Navigant calculated the gas savings for this measure to be 1,682 therms.

Figure 10: ERP-12 Water Heater Nameplate

Source: LA Fitness – Nicor Gas ERP Verification Report.pdf

RECOMMENDATIONS FOR FUTURE PROJECTS

Navigant does not have any recommendations for future projects based on this review.

1.1.13 ERP-13 Project Review

Project Code: ERP-13
Verification Method: Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review. Navigant's evaluation verified the annual energy savings to be 4,402 therms, resulting in a project realization rate of 1.09, summarized in Table Error! No text of specified style in document.**-19**.

The primary reason for the difference in the ex-ante and research findings gross savings is that Navigant replicated the ex-ante savings using the eQUEST model created by the IC with TMY3 weather data. Navigant used the same parameters and determined the following research findings savings values.

Table Error! No text of specified style in document.**-19: ERP-13 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
(2) Boiler Tune-ups	2,129	2,321	1.09
Install Lochinvar-Armor hot water boiler 94% efficient	638	695	1.09
Replace boiler room vent with automatic louvered make-up air dampers, interlocked with burner controls	1,271	1,386	1.09
Total	**4,027**	**4,402**	**1.09**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-13 Customer implemented energy efficiency measures at their 49-unit multifamily housing facility with a project completion date of 1/1/2013. The project was completed as part of the ERP because the facility was a non-profit or community-based entity, provided housing solutions, and provided strong positive community impact.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following text outlines the baseline conditions identified by onsite verification and/or review of the project files:
- Building description: 49 unit Multifamily facility
- Building size: 65,000 square feet
- Heated by a steam boiler with radiators in each unit

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: (2) Boiler Tune-ups

The IC used an eQUEST building simulation with the following inputs to calculate savings for each measure.

Algorithm Parameter	Value	Unit	Source/Description
Baseline efficiency	0.72	-	Efficiency of existing steam boilers; Assumed
Post tune-up efficiency	0.76	-	Efficiency of steam boilers after tune-ups; Assumed
Therms Saved	2,129	therms	Calculated

Source: Navigant's analysis of project files

Measure: Install Lochinvar-Armor hot water boiler 94% efficient

The IC used an eQUEST building simulation with the following inputs to calculate savings for each measure.

Algorithm Parameter	Value	Unit	Source/Description
Baseline efficiency	0.72	-	Efficiency of existing water heater; Assumed
New unit efficiency	0.94	-	Efficiency of new water heater; See invoices and spec sheets
Therms Saved	638	therms	Calculated

Source: Navigant's analysis of project files

Measure: Replace boiler room vent with automatic louvered make-up air dampers, interlocked with burner controls

The IC used an eQUEST building simulation with the following inputs to calculate savings for each measure.

Algorithm Parameter	Value	Unit	Source/Description
Damper infiltration - existing	0.15	cfm	Damper infiltration of existing system; Assumed
Damper infiltration - new	0.00	cfm	Damper infiltration of new system; Assumed
Therms Saved	1,271	therms	Calculated

Source: Navigant's analysis of project files

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed an engineering file review of the project. Navigant verified the energy savings by developing an energy model based on assumptions from the ex-ante model and/or the project files, and an updated weather file representing TMY3 data. The measure-level findings and analysis of the engineering file review are outlined below.

Measure: (2) Boiler Tune-ups

This multifamily facility uses steam distributed through a pipe network to transfer heat from the steam boiler to individual apartment units. The customer had both of their steam boilers tuned-up from an assumed efficiency of 72% to an assumed efficiency of 76%.

Navigant verified the IC's inputs in the eQUEST model and reran the simulation with TMY3 data. Navigant verified that the annual savings for this measure are 2,321 therms.

Measure: Install Lochinvar-Armor hot water boiler 94% efficient

Navigant analyzed the building simulation performed by the IC and verified the water heater efficiency assumptions of 72% for the existing unit and 94% for the new unit.

The water heating unit installed was a Lochinvar-Armor 94% efficient unit. Navigant verified the IC's inputs in the eQUEST model, reran the simulation with TMY3 data, and verified the annual gas savings for this measure are 695 therms.

Measure: Replace boiler room vent with automatic louvered make-up air dampers, interlocked with burner controls

Navigant analyzed the building simulation performed by the IC and verified the damper infiltration assumption of 0.15 cfm for the existing system and zero cfm for the new automatic louvered system.

Navigant verified the IC's inputs in the eQUEST model, reran the simulation with TMY3 data, and verified the annual gas savings for this measure are 1,386 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: Navigant determined that the IC did not use a TMY3 weather file in their building simulation model used to calculate savings.

> **Recommendation**: Navigant recommends that the IC use TMY3 data when performing building simulations.

1.1.14 ERP-14 Project Review

EXECUTIVE SUMMARY

Project Code: ERP-14
Verification Method: Engineering File Review

Navigant's evaluation of this project consisted of an engineering file review. Navigant's evaluation verified the annual energy savings to be 4,970 therms, resulting in a project realization rate of 1.16, summarized in Table Error! No text of specified style in document.**-20**.

The primary reason for the difference in the ex-ante and research findings gross savings is that Navigant replicated the ex-ante eQUEST model using TMY3 data. Navigant used the same parameters and determined the following research findings savings value to be 4,970 therms.

Table Error! No text of specified style in document.**-20: ERP-14 Savings Summary**

Measure Description	Ex-Ante Savings (therms)	Research Findings Savings (therms)	Realization Rate
(2) Boiler Tune-ups	1,545	1,800	1.16
Replace boiler room vent with automatic louvered make-up air dampers, interlocked with burner controls	2,722	3,170	1.16
Total	**4,267**	**4,970**	**1.16**

Source: Project files and Navigant's analysis

PROJECT SUMMARY

The ERP-14 Customer implemented energy efficiency measures at their 54-unit multifamily housing facility with a project completion date of 1/1/2013. The project was completed as part of the ERP because the facility was a non-profit or community-based entity, provided housing solutions, and provided strong positive community impact.

EX-ANTE SAVINGS CALCULATION METHODOLOGY

Baseline Conditions

The following outline the baseline conditions identified by onsite verification and/or review of the project files:
- Building description: 54-unit Multifamily facility
- Building size: 65,000 square feet
- Heated by a steam boiler with radiators in each unit

Energy Efficient Conditions

The IC used the following methodology to calculate the ex-ante savings from which the incentive was paid to the customer.

Measure: (2) Boiler Tune-ups

The IC used an eQuest building simulation with the following inputs to calculate savings for this measure.

Algorithm Parameter	Value	Unit	Source/Description
Baseline efficiency	0.72	-	Efficiency of existing steam boilers; Assumed
Post tune-up efficiency	0.76	-	Efficiency of steam boilers after tune-ups; Assumed
Therms Saved	1,545	therms	Calculated

Source: Navigant's analysis of project files

Measure: Replace boiler room vent with automatic louvered make-up air dampers, interlocked with burner controls

The IC used an eQUEST building simulation with the following inputs to calculate savings for this measure.

Algorithm Parameter	Value	Unit	Source/Description
Damper infiltration South - existing	0.37	cfm	Damper infiltration of existing system; Assumed
Damper infiltration Humphrey - existing	0.51	cfm	Damper infiltration of existing system; Assumed
Damper infiltration - new	0.00	cfm	Damper infiltration of new system; Assumed
Therms Saved	2,722	therms	Calculated

Source: Navigant's analysis of project files

ANALYSIS & RESULTS

Data Collection Findings and Analysis

Navigant performed an engineering file review of the project. The measure-level findings and analysis of the engineering file review are outlined below.

Measure: (2) Boiler Tune-ups

This multifamily facility uses steam distributed through a pipe network to transfer heat from the steam boiler to individual apartment units. The customer had both of their steam boilers tuned-up from an assumed efficiency of 72% to an assumed efficiency of 76%.

Navigant verified the IC's inputs in the eQUEST model and reran the simulation. Based on the analysis, Navigant verified that the annual savings for this measure are 1,800 therms.

Measure: Replace boiler room vent with automatic louvered make-up air dampers, interlocked with burner controls

Navigant analyzed the building simulation performed by the IC and verified the damper infiltration assumption of 0.37 cfm for the existing system at the South location, 0.51 cfm for the existing system at the Humphrey location, and zero cfm for the new automatic louvered system.

Navigant verified the IC's inputs in the eQUEST model and reran the simulation. Using the building simulation parameters from the IC, Navigant verified the annual gas savings for this measure are 3,170 therms.

RECOMMENDATIONS FOR FUTURE PROJECTS

Finding: Navigant determined that the IC did not use a TMY3 weather file in their building simulation model used to calculate savings.

> **Recommendation**: Navigant recommends that the IC use TMY3 data when performing building simulations.