Multifamily Audit and Retrofit Case Study

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Performance Systems Development

Types of Audits

- Online
- On-site with checklist
- Information audit
  - General guidance on work scope
  - Rough cost estimates
- Installation or "investment" audit
  - Specific work scope
  - Detailed cost info
  - Generally done with money on the table

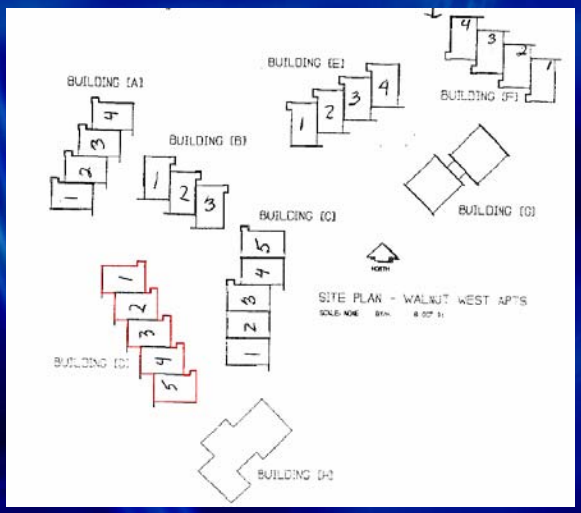
The Multifamily Investment Audit Process

1. Utility bill analysis
2. Site inspection with comprehensive visual and diagnostic investigation utilizing performance testing
3. Energy model calibrated development
4. Energy improvement measures and scenarios
5. Estimate costs
6. Financial analysis

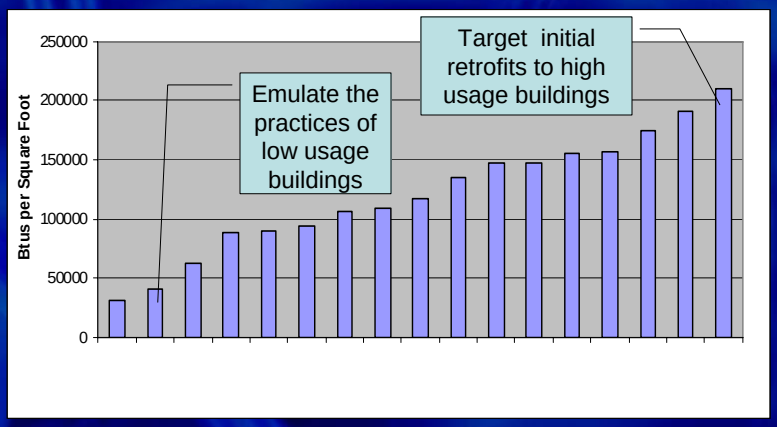
Walnut West Bldg Description

- Bldg description
  - 25 apt units in the 6 townhouse clusters
    - Individual gas furnaces and DHW tanks
  - 6 apt units in the 1 3-story apt building
    - Master heat and DHW from central boiler
  - 4 apt units in the old converted farmhouse
    - Master heat and DHW from central boiler

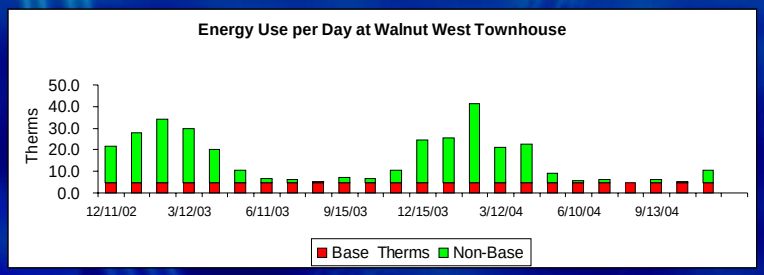
Walnut West Layout



Typical Energy Usage Intensity Benchmarking Data (NYC)



Building level billing analysis



- Aggregation of data tenant and master accounts
- Mechanisms for addressing missing data
  - Sampling
  - Similar units
  - Time

Comprehensive Visual Inspection

- Physical measurement of the building
- Occupant and operator interviews
- Observations of problems
  - Energy
  - Non-Energy
- Initial diagnosis
- Record probable solutions

People

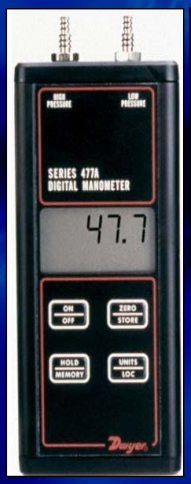
- Occupant behaviors
  - Thermostat operation
  - Moisture production
  - Ventilation
  - Cleaning
  - Windows left open
  - Smoking
- Operator
  - Schedules
  - Problem reports
  - Maintenance issues

Performance Testing

- Combustion safety and efficiency
  - All gas appliances
- Air leakage testing with Blower doors
- Duct testing
- Infrared Imaging (combined with blower door)
- Moisture and IEQ (air and wood)
- Optional: Hobo meters

Combustion Safety and Efficiency

Air Leakage Testing



Duct Testing

Duct Hunting Season

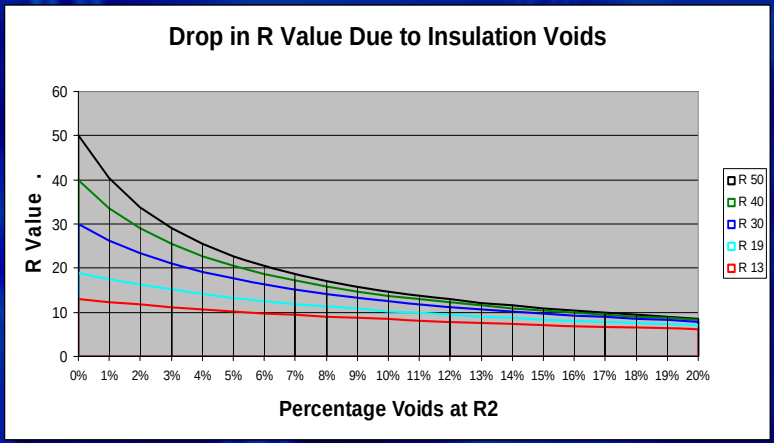
Bath Fan Testing

Infrared Imaging

- Used by itself and in combination with blower door
- Visual information on:
  - Insulation voids
  - Air flow
  - Moisture in materials
- Great sales tool!

Insulation Quality

Translate IR Images into R Value Impacts



IEQ – Indoor Environmental Quality

- Hazard control – Radon, Lead, VOC's, Dust
- Combustion
- Ventilation
- Smoking

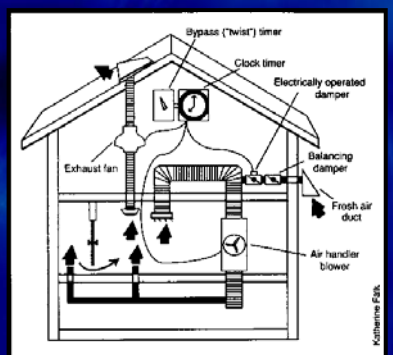


Figure 1. Integrating ventilation with a central forced-air heating system.

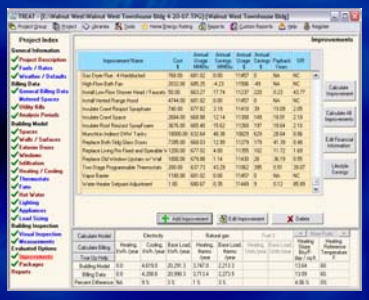
Moisture

Home Performance with Energy Star

- A whole-house approach to improving the energy efficiency of existing homes
- Differentiated local contractors
- Evaluate and implement performance-tested improvements
- Test out process = quality assurance

Energy Modeling with TREAT

- Computer simulation of building energy use taking into account building characteristics, operations and weather for accurate prediction of savings
- TREAT
  - Verified hourly simulation
  - Integrated billing analysis
  - Scenario modeling
  - Savings tracking
  - Used by New York State to calculate savings in all retrofits of existing residential buildings



www.treatsoftware.com

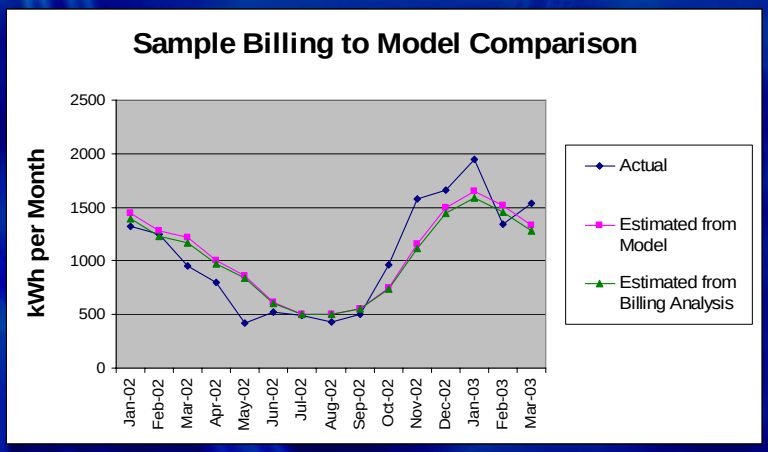
Quality Assurance For Savings Predictions

- Model Calibration
  - Baseload
  - Temperature Settings
  - Exceptions (low bills = 55ºF?)

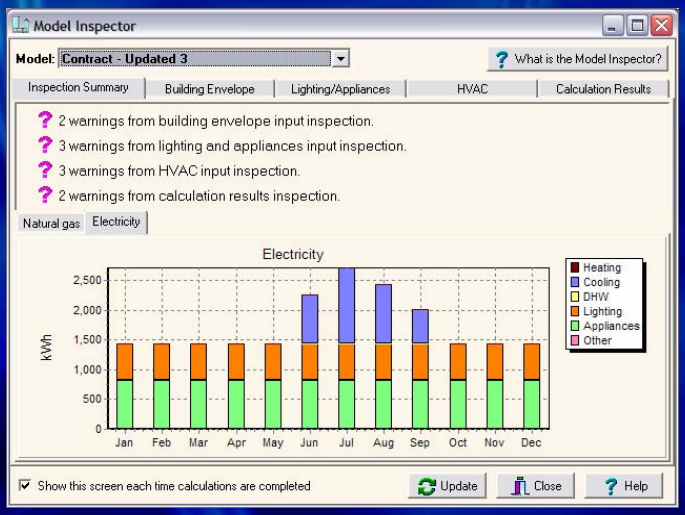
TREAT true-up screen compares the performance of the energy model to the actual bills

Calculate Model	Electricity			Natural gas		Fuel 3		More Fuels	
Calculate Billing / True Up Help	Heating, kWh /year	Cooling, kWh /year	Base Load, kWh /year	Heating, therms /year	Base Load, therms /year	Heating, Units/year	Base Load, Units/year	Heating Slope Btu/F-day / sq.ft.	Heating Reference Temperature F.
Building Model	0.0	4,619.0	20,291.3	3,747.0	2,213.3			13.64	60
Billing Data	0.0	4,208.8	20,998.3	3,713.4	2,273.9			13.09	60
Percent Difference	NA	9 %	3 %	1 %	3 %			4.06 %	0%

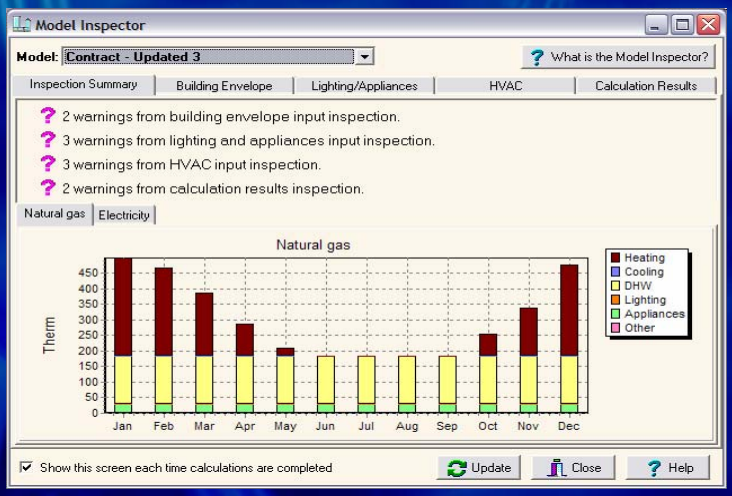
TREAT Accuracy



Electrical Energy End Uses



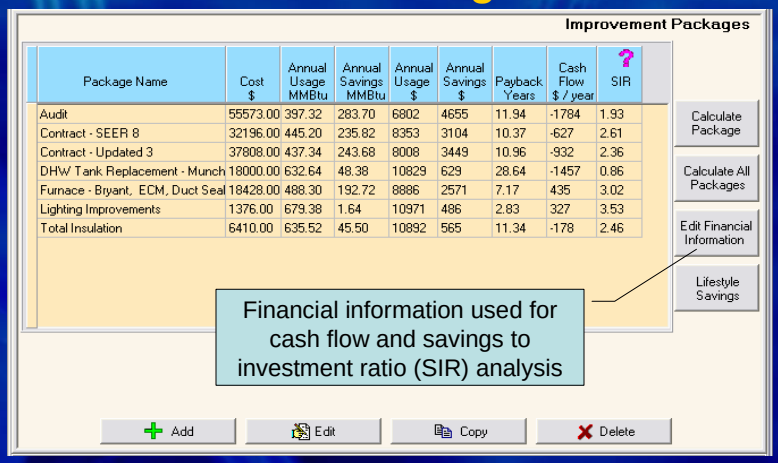
Gas End Uses



Improvement Analysis

Improvement Name	Cost $	Annual Usage MMBtu	Annual Savings MMBtu	Annual Usage $	Annual Savings $	Payback Years	SIR
Gas Dryer Flue - 4 Hardducted	768.00	681.02	0.00	11457	0	NA	NC
High-Flow Bath Fan	2032.00	685.25	-4.23	11506	-49	NA	NC
Install Low Flow Shower Head / Faucets	50.00	663.27	17.74	11237	220	0.23	43.77
Install Vented Range Hood	4744.00	681.02	0.00	11457	0	NA	NC
Insulate Crawl Rimjoist Sprayfoam	740.00	677.82	3.19	11418	39	19.09	2.05
Insulate Crawl Space	2684.00	668.88	12.14	11308	149	18.01	2.18
Insulate Roof RimJoist SprayFoarm	3676.00	665.40	15.62	11260	197	18.64	2.10
Munchkin Indirect DHW Tanks	18000.00	632.64	48.38	10829	629	28.64	0.86
Replace Both Sldg Glass Doors	7395.00	668.03	12.99	11279	179	41.39	0.48
Replace Living Rm Fixed and Operable W	1200.00	677.02	4.00	11355	102	11.72	1.69
Replace Old Window Upstairs w/ Wall	1000.00	679.88	1.14	11430	28	36.19	0.55
Two-Stage Programmable Thermostats	200.00	637.73	43.29	11062	395	0.51	39.07
Vapor Barrier	1180.00	681.02	0.00	11457	0	NA	NC
Water Heater Setpoint Adjustment	1.00	680.67	0.35	11449	9	0.12	85.89

Bundling Improvements into Packages



Package Name	Cost $	Annual Usage MMBtu	Annual Savings MMBtu	Annual Usage $	Annual Savings $	Payback Years	Cash Flow $ / year	SIR
Audit	55573.00	397.32	283.70	6802	4655	11.94	-1784	1.93
Contract - SEER 8	32196.00	445.20	235.82	8353	3104	10.37	-627	2.61
Contract - Updated 3	37808.00	437.34	243.68	8008	3449	10.96	-932	2.36
DHW Tank Replacement - Munch	18000.00	632.64	48.38	10829	629	28.64	-1457	0.86
Furnace - Bryant, ECM, Duct Seal	18428.00	488.30	192.72	8886	2571	7.17	435	3.02
Lighting Improvements	1376.00	679.38	1.64	10971	486	2.83	327	3.53
Total Insulation	6410.00	635.52	45.50	10892	565	11.34	-178	2.46

Financial information used for cash flow and savings to investment ratio (SIR) analysis

Improvement Interactions

- Avoid predicting savings that are more than 100% of current energy use!!!
- Typical types of interactions
  - Lighting with heating and cooling
  - Insulation and heating
  - Windows and cooling
- Simulation modeling captures the impact of these interactions

Solving Split Incentives

- Tenant pays some or all of the bill but does not invest
- Capturing energy savings makes it worthwhile to convert to central metering
- Energy efficiency reduces the risks of central heating, cooling and hot water metering
  - Reducing loss reduces risk
- Requires high trust level

Walnut West Meter Scenarios

- Pre
  - Each apt on individual ng meter, meter is for heat, DHW, cooking, and dryer (optional)
- Post
  - Each apt keeps individual elec meter
  - Each apt keeps individual ng meter for DHW , cooking, and dryers (optional)
  - New meter for heat only, owner pays heat bill

Recommendations

Improve building air tightness & insulation

- Spot air sealing for penetrations through crawlspace ceiling and inside apartments where plumbing enters wall cavities
- Insulating and air sealing the crawl space
- Insulating the band joist and rim joist below the insulated roof
- Air sealing around window cases, caulking older windows

Sealing air leaks with spray foam and board materials

Weatherizing the AC Sleeve

Party Walls

Reduce fuel for heating and cooling and increase comfort by:

- Replacing old inefficient furnaces with high-efficiency condensing furnaces with new thermostats
- Install new high SEER air conditioning equipment
- Sealing leaky supply and return ductwork
- Installing larger opening return grills
- Install louvered grill in mechanical room door providing combustion air. (Only if existing furnaces remain)
- Replacing the old sliding glass doors with new Energy Star rated models.

Duct Sealing

High efficiency gas furnace

- **Secondary heat exchanger**
- **94+% efficient**
- **ECM Motors!!!**

SEER Seasonal Energy Efficiency Ratio

- 1970s-era: 4.5-8.0
- Minimum allowed 200513.0
- Energy Star qualified (2004) 12.0
- Best commercially available 16-18

Thermostats

Programmable thermostats can save 5-15% annually versus a constant temperature setting

Reduce fuel for domestic hot water by:

- Insulating any piping in unconditioned spaces
- Replacing old shower heads and faucets with low-flow models

DHW Replaced On Failure

Reduce electric baseload consumption by:

- Replacing old refrigerators with Energy Star™ rated models.
- Replacing incandescent fixtures with Energy Star™ rated fluorescent fixtures.

Energy Star refrigerators

- 50% less electricity than 10 year old models
- 40% less than pre-2001 standard
- 10% less than current standard
- Online lists

Lighting

Control Moisture Levels by:

- Replacing damaged exterior window trim
- Installing a vapor barrier in the crawl space
- Replacing bathroom exhaust fans with new higher capacity whisper models on a timer.
- Hard ducting all clothes dryers and replacing the outside termination that is restricting exhaust flow.

Moisture Problems

External Moisture Deterioration

Health & Safety Issue

Contracting

- Early feedback on installation
- “Testing out”

Test Out Finds Mistakes