National Association for State Community Services Programs

NASCSP 2023

WINTER TRAINING CONFERENCE
April 3 – 7 | Arlington, VA

MISSION POSSIBLE
Restoring Hope

Audit-Related Quality Assurance Issues and Remedies

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OAK RIDGE National Laboratory

Top 10 Audit Related Quality Assurance Issues and Remedies

Prepared for 2023 NASCSP Winter Training Conference

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

Introduction and Purpose

Intro: Bill Eckman

- Program Manager – ORNL-SCEP
- Structural design/construction since 2001
- Building performance/efficiency since 2008
- Former: crew member, energy auditor/inspector, trainer, curriculum developer, business owner, consultant, multifamily auditor, operations and maintenance trainer….

Image 1: Bill Eckman photo – January 2019

Learning Objectives

- List common audit data gathering and input errors
- Define strategies for identifying common audit errors using audit software
- Define strategies for limiting common audit data errors through standardized processes

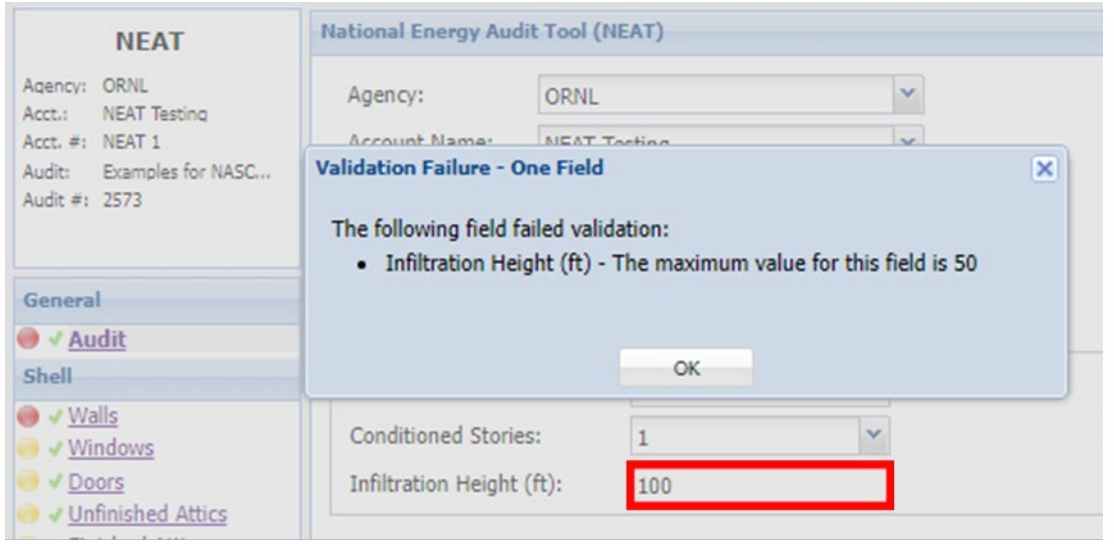


Figure 1: Error message resulting from likely input error in WAv10

The Bigger Purpose of This Session

Improve QA Performance

- **>80% of reviewed audits scoring low (0) in THREE or more categories**
- Cost-effective energy-conservation retrofits are the foundation of the WAP
- **Computerized energy audits** analyze the cost-effectiveness of *multiple retrofit and package options*
- ~50% of reviewed audits exhibit issues with HVAC systems modeling
- >50% of reviewed audits exhibit issues with building envelope modeling

Purpose of QA Processes

- Accurate energy audits
- Technical program compliance
- Statutory program compliance
- The right retrofits
- Cost-effective retrofits

QA Concern #1: Work Orders (88%)

No Work Order(s) provided

- Why it is an issue:
  - Provide details and instructions
  - Link to SWS or other specs
  - Clear communication with installation staff

Measures on WO not in Audit

- Why it is an issue:
  - Measure not tested for compliance (cost-effective)
  - Whole package cost-effectiveness not checked
  - Regulatory requirements not met

Funding Source(s) unclear

- Why it is an issue:
  - Different requirements by funding source
  - Programmatic compliance not met

Work Orders help direct field work and track actual costs

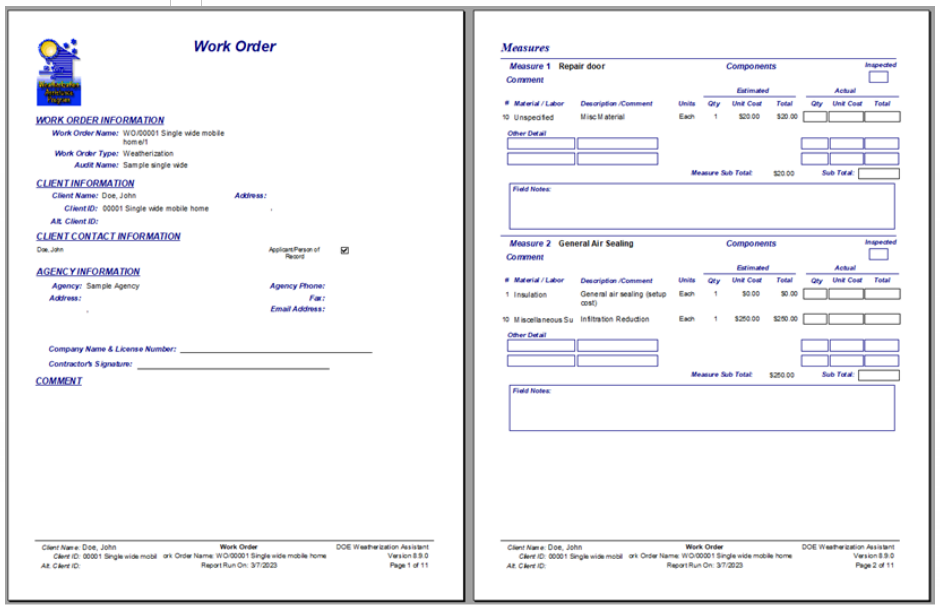


Figure 2: Example Work Order from WAv8.9

QA Concern #2: Health and Safety Measures (68%)

HSM not entered

- Why it is an issue:
  - Total weatherized unit costs not captured
  - Materials may not be allocated/order
  - Health & Safety non-energy impacts not captured

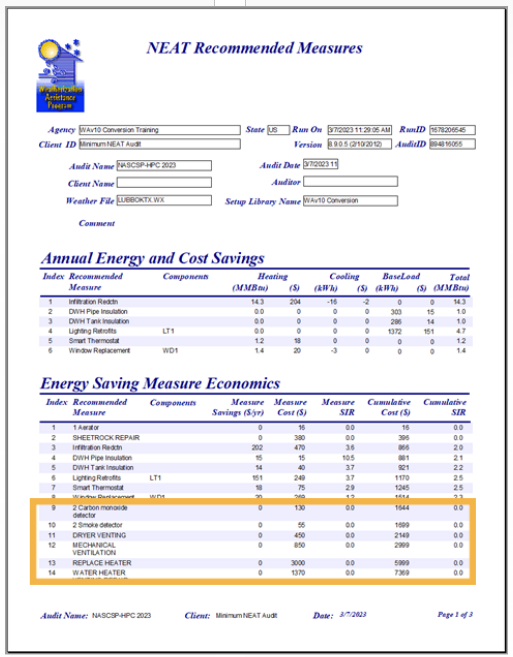
Measures miscategorized as HSM instead of IRM

- Why it is an issue:
  - Different requirements for HSM vs. IRM
  - Whole package cost-effectiveness not checked
  - Potential disallowed costs

HSM requirement not met

- Why it is an issue:
  - Possible disallowed costs
  - Potential non-energy impacts not realized

HSM not included in whole-building SIR



NEAT Recommended Measures

Annual Energy and Cost Savings

Index	Recommended Measure	Components	Heating (MMBtu)	Heating ($)	Cooling (kWh)	Cooling ($)	BaseLoad (kWh)	BaseLoad ($)	Total (MMBtu)
1	Infiltration Reductn		14.3	204	-16	-2	0	0	14.3
2	DWH Pipe Insulation		0.0	0	0	0	303	15	1.0
3	DWH Tank Insulation		0.0	0	0	0	286	14	1.0
4	Lighting Retrofits	LT1	0.0	0	0	0	1372	151	4.7
5	Smart Thermostat		1.2	18	0	0	0	0	1.2
6	Window Replacement	WD1	1.4	20	-3	0	0	0	1.4

Energy Saving Measure Economics

Index	Recommended Measure	Components	Measure Savings ($/yr)	Measure Cost ($)	Measure SIR	Cumulative Cost ($)	Cumulative SIR
1	1 Aerator		0	16	0.0	16	0.0
2	SHEETROCK REPAIR		0	380	0.0	396	0.0
3	Infiltration Reductn		202	470	3.6	866	2.0
4	DWH Pipe Insulation		15	15	10.5	881	2.1
5	DWH Tank Insulation		14	40	3.7	921	2.2
6	Lighting Retrofits	LT1	151	249	3.7	1170	2.5
7	Smart Thermostat		18	75	2.9	1245	2.5
8	Window Replacement	WD1	20	269	1.3	1514	2.3
9	2 Carbon monoxide detector		0	130	0.0	1644	0.0
10	2 Smoke detector		0	55	0.0	1699	0.0
11	DRYER VENTING		0	450	0.0	2149	0.0
12	MECHANICAL VENTILATION		0	850	0.0	2999	0.0
13	REPLACE HEATER		0	3000	0.0	5999	0.0
14	WATER HEATER		0	1370	0.0	7369	0.0

Figure 3: WAv8.9 Recommended Measures report with Health and Safety measures

QA Concern #3: Foundations (56%)

Foundation type confusion and double entry

- Why it is a concern:
  - Miscalculation of existing space conditioning (heating/cooling) energy use
  - Inaccurate savings for foundation and/or HVAC retrofits
  - Inaccurate cost and materials estimates

Examples:

- Floor over a conditioned basement entered as non-conditioned (insulation added)
- Perimeter and/or area do not agree with footprint
- Less exposed wall than modeled

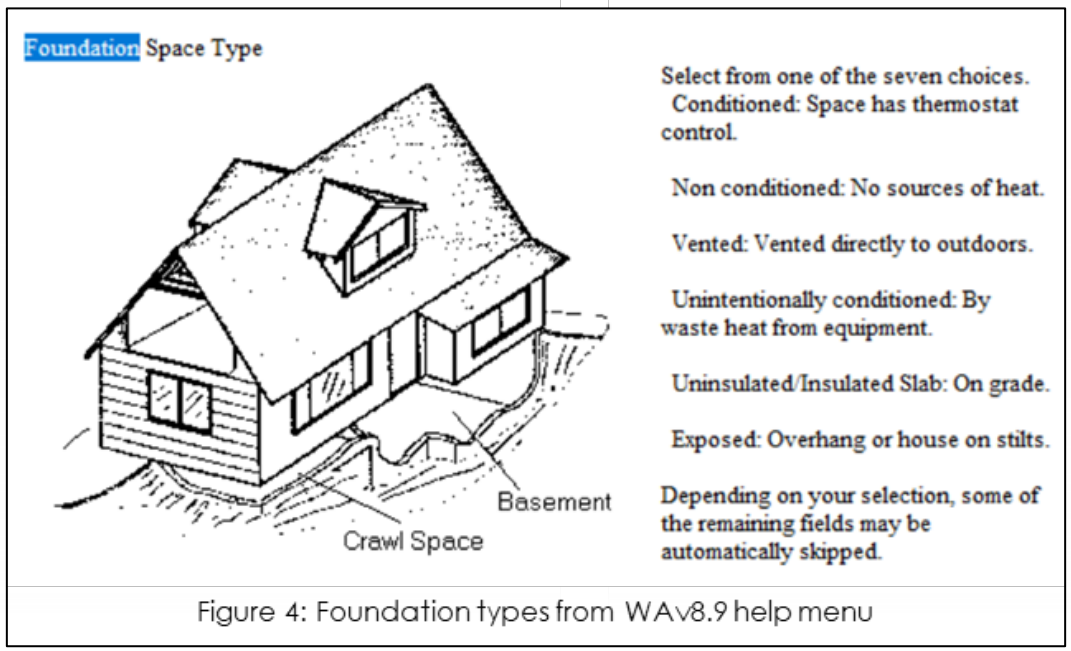


Figure 4: Foundation types from WAv8.9 help menu

QA Concern #4: Attics (54%)

Attic area larger than conditioned area

- Why it is a concern:
  - Miscalculation of existing space conditioning (heating/cooling) energy use
  - Inaccurate savings for attic insulation and/or HVAC retrofits
  - Inaccurate cost and materials estimates

Examples:

- Total attic area not within +/-10%
- Incorrect existing insulation depth/R-value input
- Missing finished attic elements

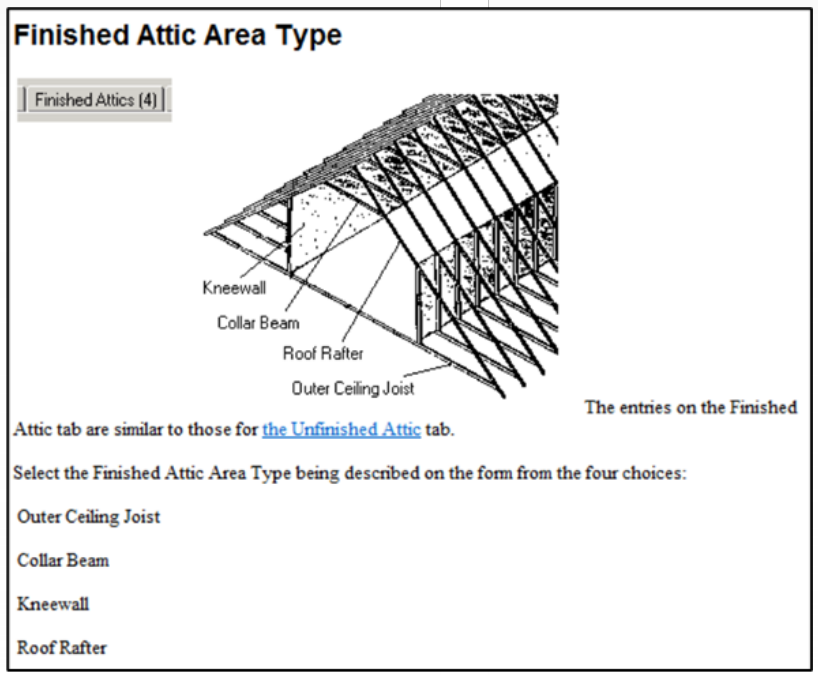


Figure 5: Finished Attic area types from WAv8.9 help menu

QA Concern #5: Doors and Windows **(54%)**

Window Shading %

- Why it is a concern:
  - Miscalculation of solar exposure
  - Inaccurate solar gain (summer/winter)
  - Inaccurate savings from window retrofits and/or HVAC retrofits

Examples:

- Summer vs. winter shading
- Auditor adjustment for orientation (e.g. North)

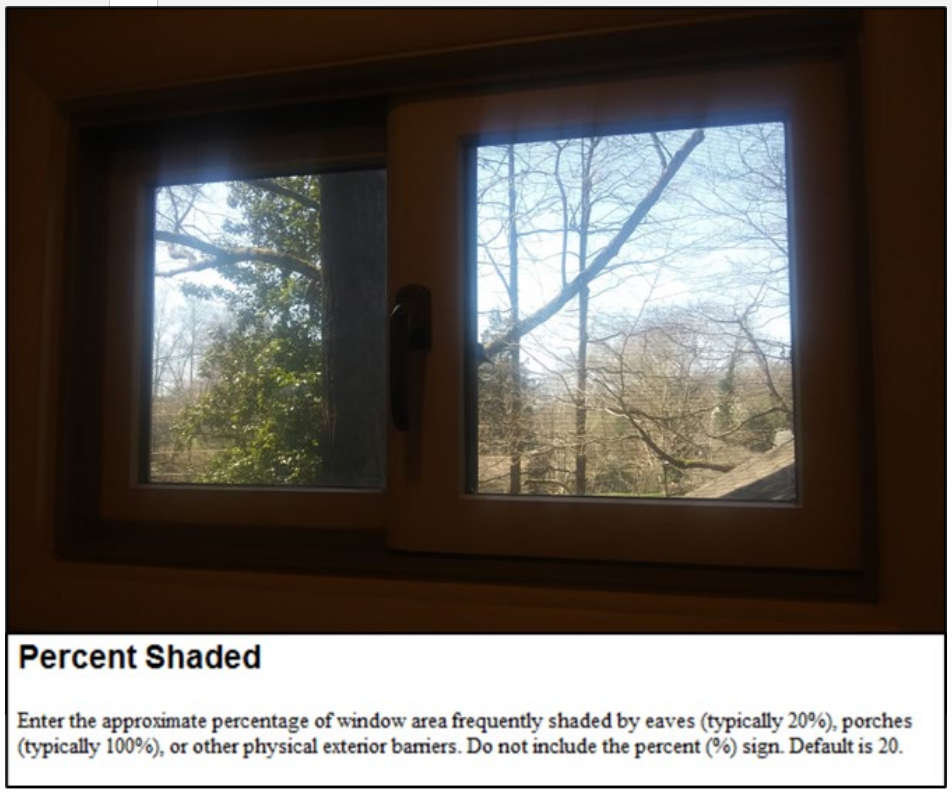


Figure 6: Example window with shading by trees (winter)

QA Concern #6: Ducts (53%)

Duct sealing included with air sealing

- Why it is a concern:
  - Less funds available for air and duct sealing
  - Miscalculation of energy use and savings
  - May impact HVAC delivered efficiency

Duct sealing/insulation on WO but not audit

- Why it is a concern:
  - Miscalculation of energy use and savings
  - Missing total unit costs/savings in cost-effectiveness test

Figure 7: Example of duct sealing

QA Concern #6: Ducts [BONUS] (53%)

Sealing/Insulation in conditioned space

- Why it is a concern:
  - Possible overstatement of savings
  - Potential disallowed measures/costs
  - Miscalculation of HVAC energy/savings

Uninsulated ducts not input

- Why it is a concern:
  - Miscalculation of HVAC delivery efficiency
  - Missed energy savings opportunity
  - Potential unintended moisture/durability concerns when paired with cooling system changes

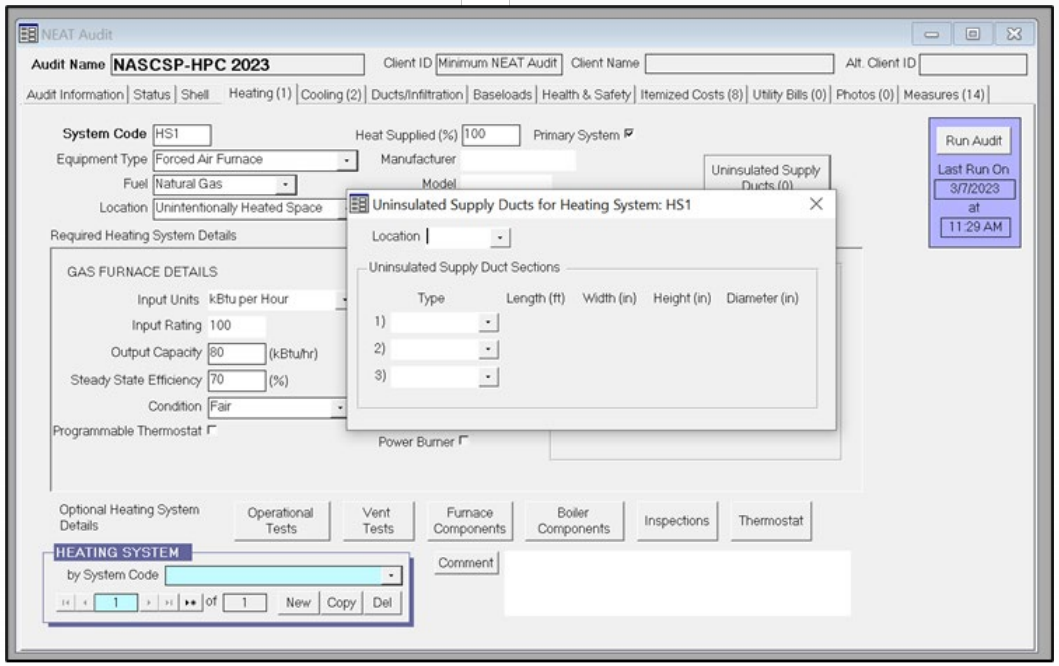


Figure 8: Blank uninsulated ducts input in WAv8.9

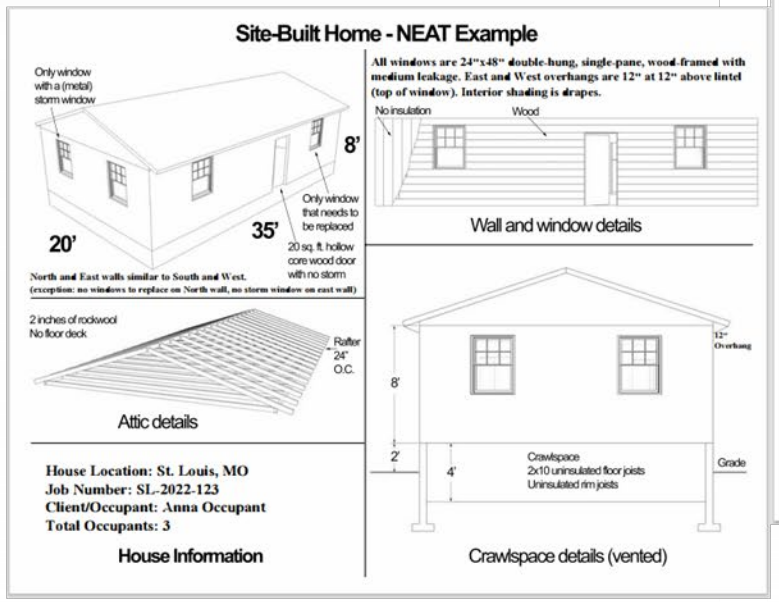
QA Concern #7: Walls (51%)

Inaccurate wall surface area(s)

- Why it is a concern:
  - Miscalculation of heating/cooling loads
  - Miscalculation of insulation measure savings and costs
  - Miscalculation of HVAC retrofit savings

Examples:

- Wall areas not within +/-10% of actual



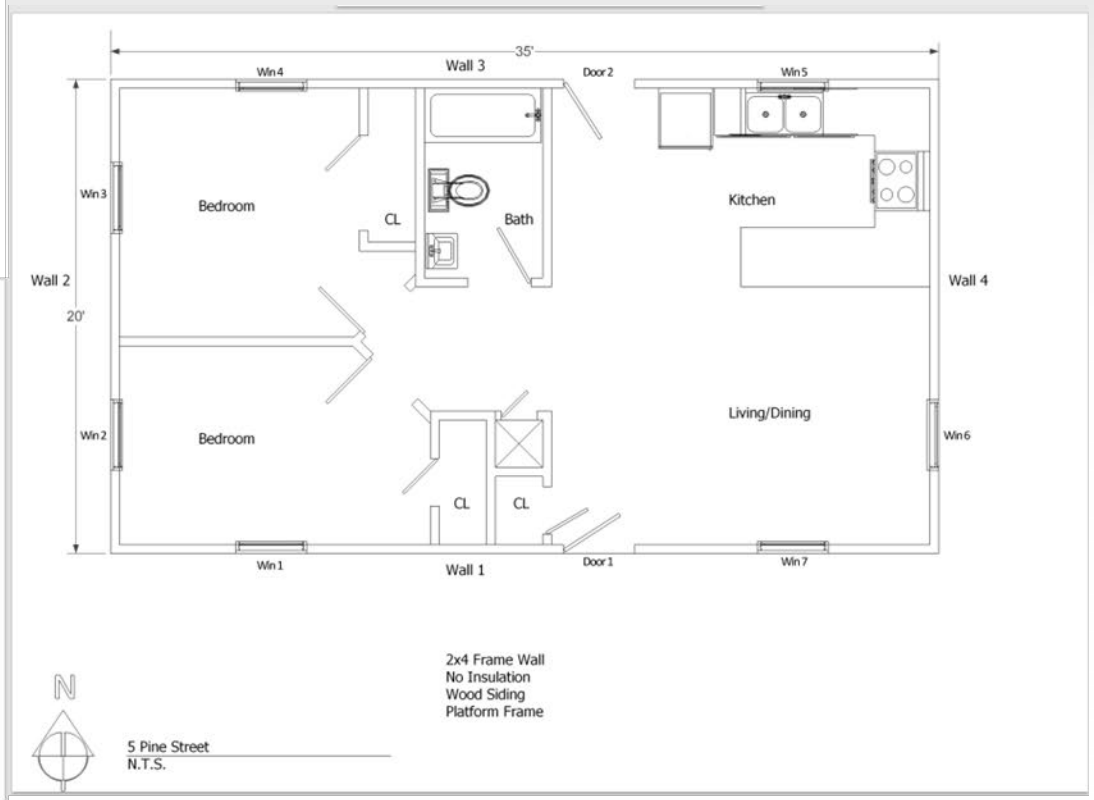


Figure 9: Example simple ranch house layout and elevations

QA Concern #8: Baseloads (49%)

Elec DHW input and EF not appropriate

- Why it is a concern:
  - Miscalculation of existing energy use
  - Miscalculation of energy and cost savings
    - Equipment replacement
    - Other DHW baseload measures
  - If paired with social cost of carbon, miscalculation of emissions savings and added non-energy impacts

Examples:

- Input 4500kW vs. 4.5kW
- EF = 0.45 vs. 0.93

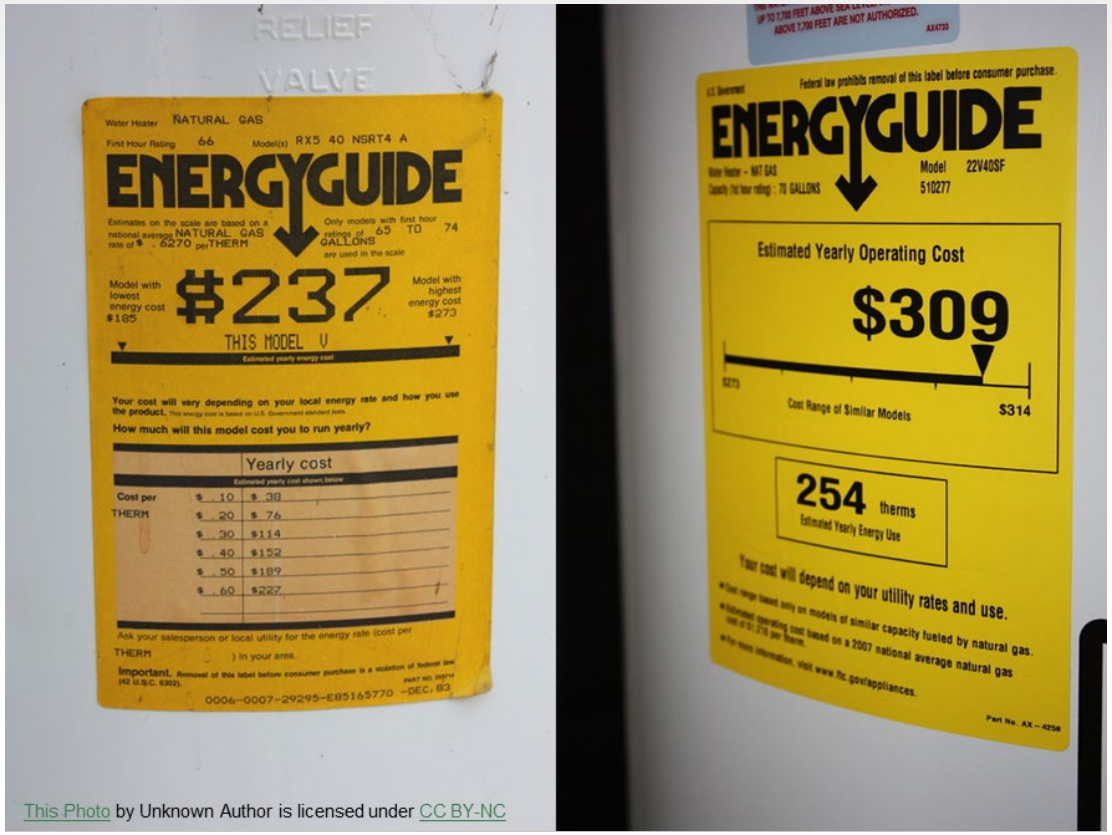


Figure 10: Example water heater energy guide labels

QA Concern #9: Ventilation (42%)

No ASHRAE calc or details do not match

- Why it is a concern:
  - Unable to show/ensure programmatic compliance
  - May violate "do no harm" principle
  - Costs may be missed and/or disallowed

Examples:

- No calculation
- Occupants and/or other details don't match audit inputs

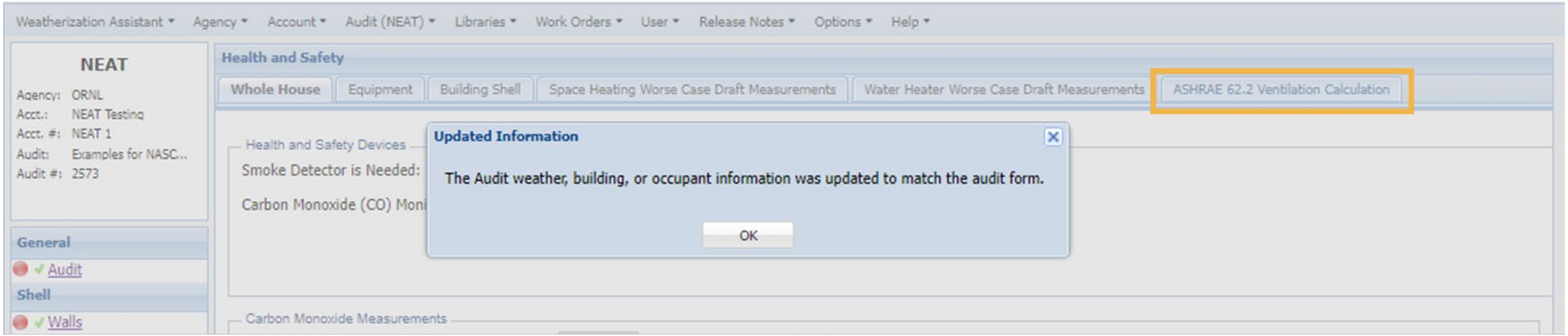


Figure 11: Mismatched data error message for ASHRAE 62.2 Ventilation Calculation in WAv10

QA Concern #10: Cooling (42%)

Cooling not included in model

- Why it is a concern:
  - Missing cooling energy savings for envelop retrofits
  - Missing cooling energy savings for air and/or duct sealing
  - Miscalculated existing energy use (additional problems with utility bill adjustment functions)

Examples:

- Window air-conditioners present, but not entered in model
- Central air-conditioner shown in photos, but not entered in model

Figure 12: Window/room air conditioners installed in residential building

QA Concern BONUS: Missing Documentation/Photos **(NA)**

Required photos/documents missing

- Why it is a concern:
  - Unable to verify existing conditions
  - Difficulty getting second opinion on inputs and/or retrofit additional costs
  - Unable to properly identify incidental repairs and health and safety conditions/costs

Examples:

- No photos of existing condition provided
- Missing Grantee-required combustion testing forms

Figure 13: Example detail photos documenting existing conditions

QA Concerns: Summary (88%)

Issue	Importance
Work Orders not included or mismatched	Provides details, specifications, and costing
Health and Safety Measures not eligible	Program compliance and allowed costs
Foundation entry confusion/doubled	Incorrect load, savings, and costs
Attic area larger than conditioned area	Increased load, cost, and savings
Window shading %	Inaccurate solar gain, load, savings, etc.
Duct sealing/insulation not modeled	Incorrect load, cost, and savings
Wall surface area not accurate	Incorrect load, savings, and costs
Electric Water Heater low efficiency input	Increased savings for retrofits
ASHRAE 62.2 calculation details do not match	Incorrect calculations and retrofits
Cooling not included in model	Decreased load/savings, missed opportunity
Photos/forms/documents missing	Verification of details and compliance

Part 2: Strategies for Limiting/Identifying Common QA Issues

Processes

- Field processes –
  - Forms
  - Standard sequence
  - Standard test methods
- **Software processes** –
  - Direct data entry
  - Cross-linked data
  - Included workflow/resources/calculations

Quality Control

- Review inputs
- "Sanity check" results
- Secondary review

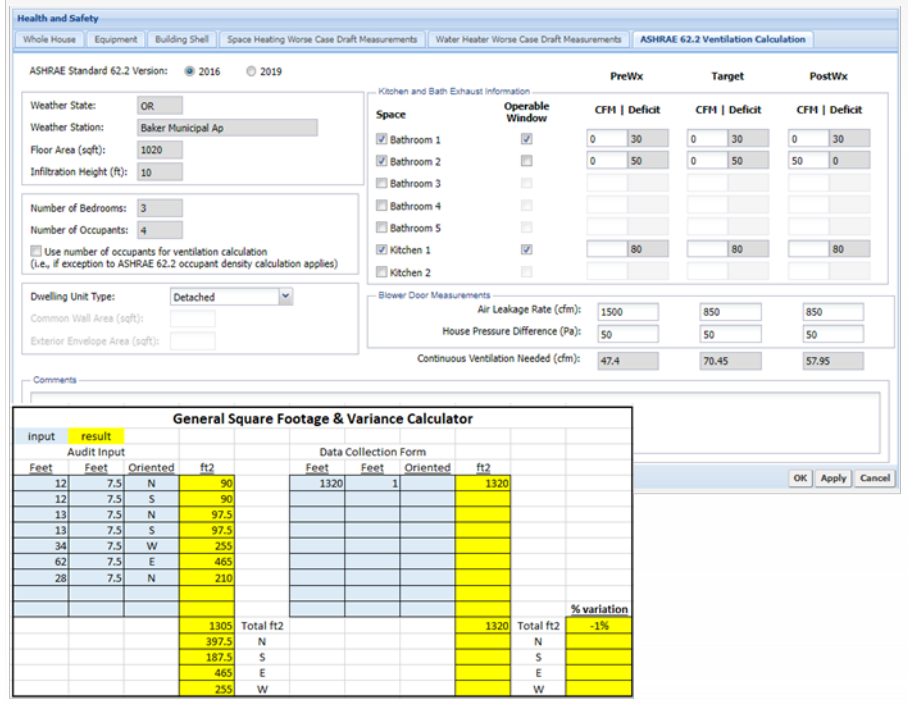


Figure 14: Quality Control tools for energy audits

Solutions #1: Work Orders (88%)

No Work Order(s) provided

- Why it is an issue:
  - Provide details and instructions
  - Link to SWS or other specs
  - Clear communication with installation staff

Measures on WO not in Audit

- Why it is an issue:
  - Measure not tested for compliance (cost-effective)
  - Whole package cost-effectiveness not checked
  - Regulatory requirements not met

Funding Source(s) unclear

- Why it is an issue:
  - Different requirements by funding source
  - Programmatic compliance not met

Use audit tool workflow → Generate WO(s) directly

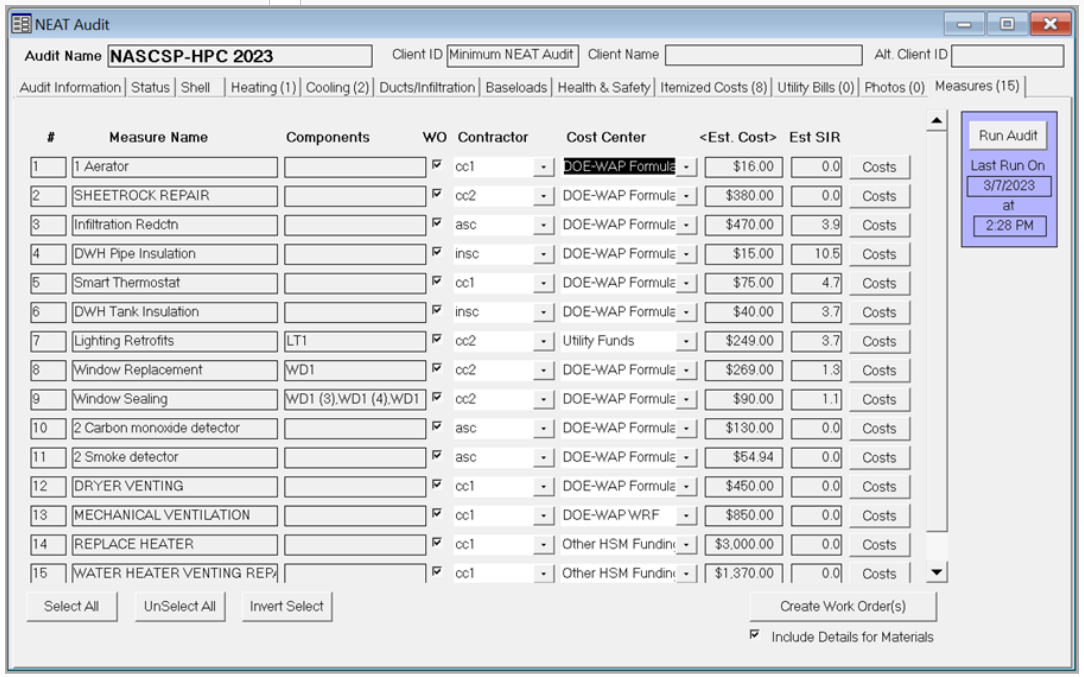


Figure 15: WAv8.9 Work Order Generation Form

Solutions #2: Health and Safety Measures (68%)

HSM not entered

- Why it is an issue:
  - Total weatherized unit costs not captures
  - Materials may not be allocated/order
  - Health & Safety non-energy impacts not captured

Measures miscategorized as HSM instead of IRM

- Why it is an issue:
  - Different requirements for HSM vs. IRM
  - Whole package cost-effectiveness not checked
  - Potential disallowed costs

HSM requirement not met

- Why it is an issue:
  - Possible disallowed costs
  - Potential non-energy impacts not realized

Use audit tool Defined Measures Library (or similar)

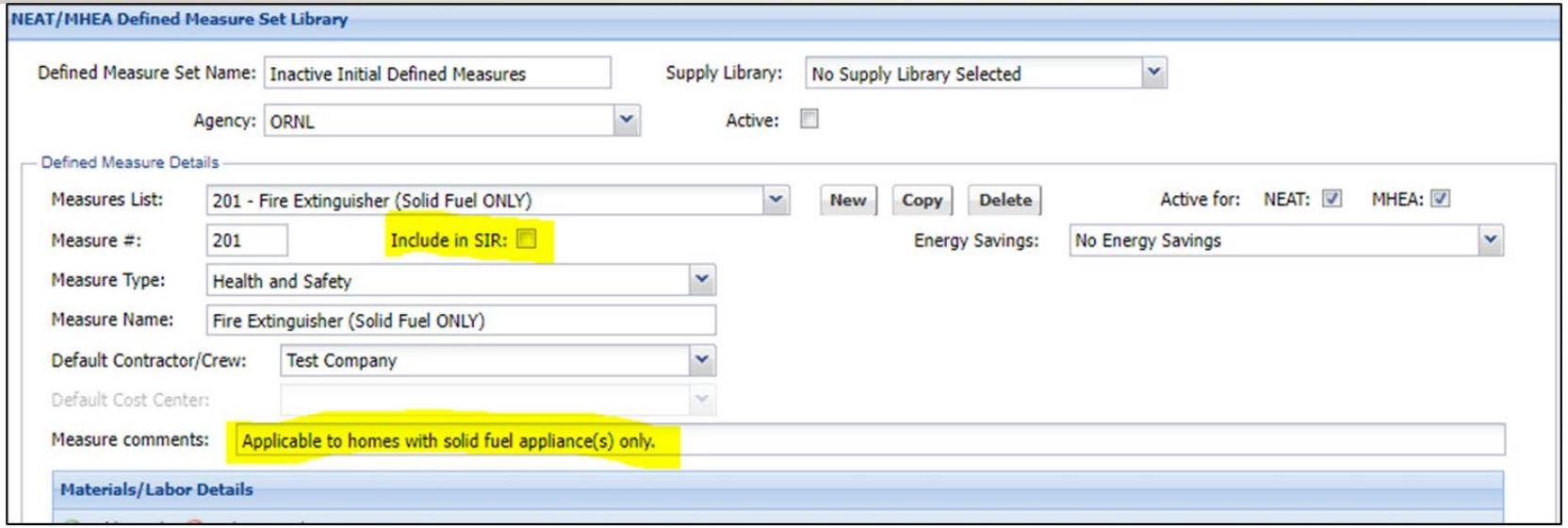


Figure 16: Example custom Health and Safety Measure in WAv10 Defined Measure Library

Solutions #3: Foundations (56%)

Foundation type confusion and double entry

- Why it is a concern:
  - Miscalculation of existing space conditioning (heating/cooling) energy use
  - Inaccurate savings for foundation and/or HVAC retrofits
  - Inaccurate cost and materials estimates

Examples:

- Floor over a conditioned basement entered as non-conditioned (insulation added)
- Perimeter and/or area do not agree with footprint
- Less exposed wall than modeled

Use help to define foundation spaces/assemblies prior to entry

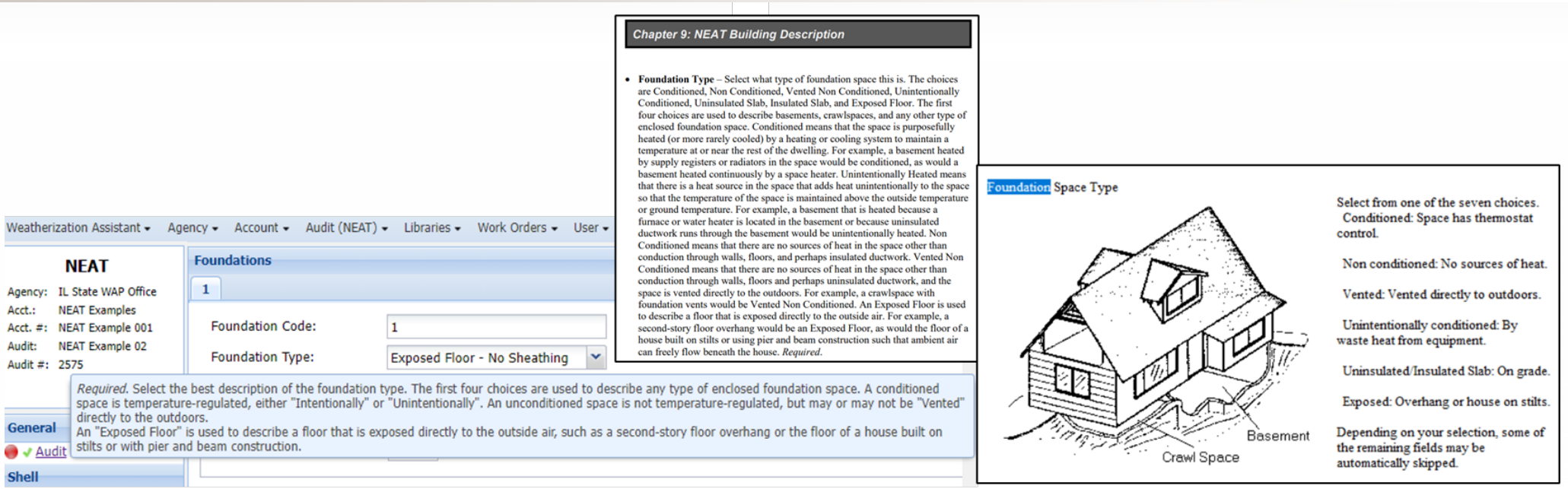


Figure 17: Example WAv10 Tool-tip, WAv8.9 Help, and WAv8.9 User Manual

Solutions #4: Attics (54%)

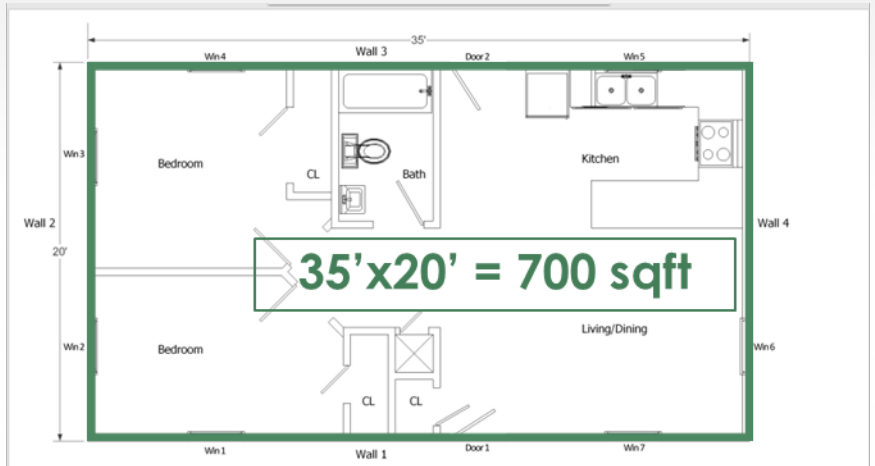
Attic area larger than conditioned area

- Why it is a concern:
  - Miscalculation of existing space conditioning (heating/cooling) energy use
  - Inaccurate savings for attic insulation and/or HVAC retrofits
  - Inaccurate cost and materials estimates

Confirm total area against floor area or layout
AND
Show calcs in Comments

Examples:

- Total attic area not within +/-10%
- Incorrect existing insulation depth/R-value input
- Missing finished attic elements



General Square Footage & Variance Calculator

input result

Audit Input Feet	Feet	Oriented	ft2	Data Collection Form Feet	Feet	Oriented	ft2
12	7.5	N	90	1320	1		1320
12	7.5	S	90				
13	7.5	N	97.5				
13	7.5	S	97.5				
34	7.5	W	255				
62	7.5	E	465				
28	7.5	N	210				
							% variation
			1305 Total ft2				1320 Total ft2 -1%
			397.5 N				N
			187.5 S				S
			465 E				E
			255 W				W

2x4 Frame Wall
No Insulation
Wood Siding
Platform Frame

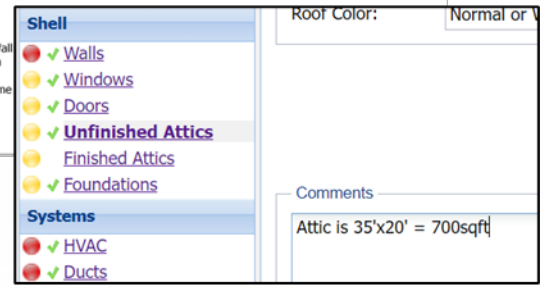


Figure 18: Example Layout, Area Comparison Calculator, and In-audit comments

Solutions #5: Doors and Windows (54%)

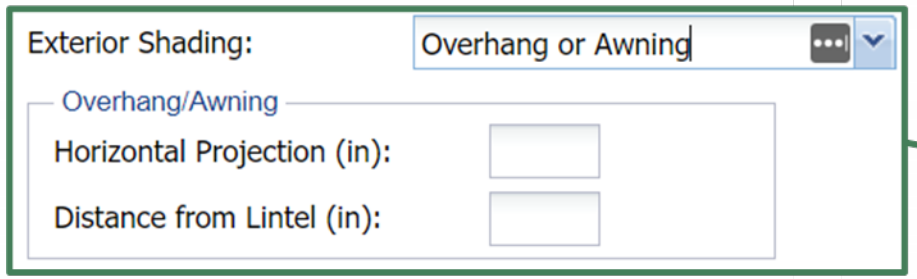
Window Shading %

- Why it is a concern:
  - Miscalculation of solar exposure
  - Inaccurate solar gain (summer/winter)
  - Inaccurate savings from window retrofits and/or HVAC retrofits

Shading % no longer used in WAv10 –
now defined by directly confirmable/measurable details

Examples:

- Summer vs. winter shading
- Auditor adjustment for orientation (e.g. North)



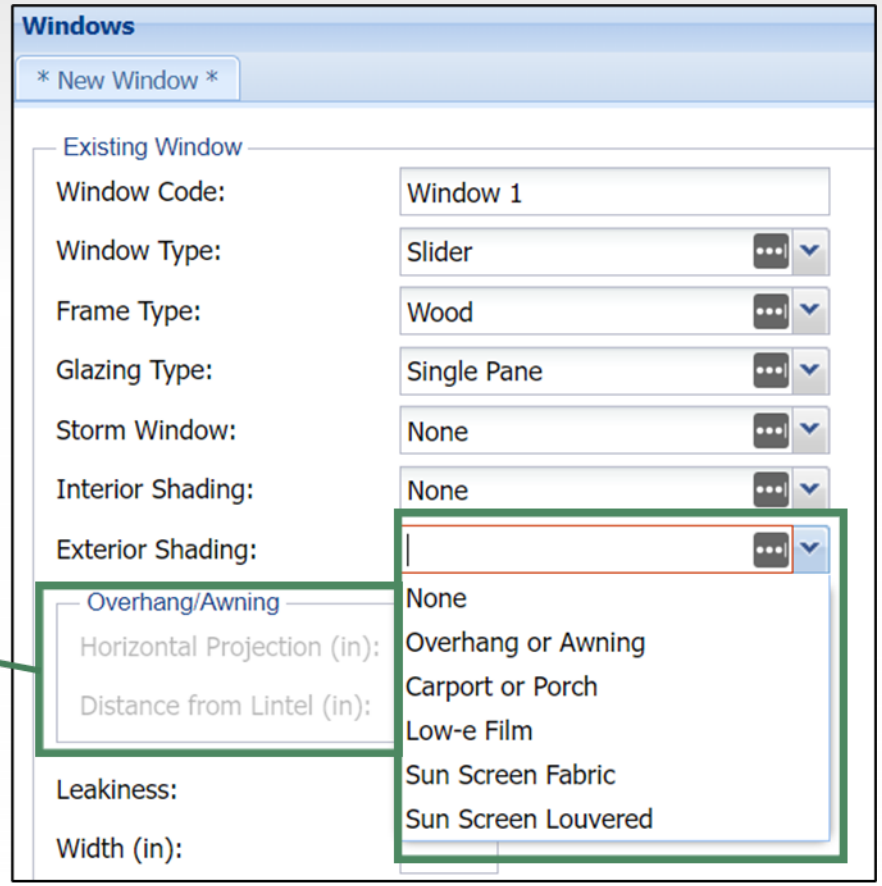


Figure 19: WAv10 Windows Form with exterior shading details

Solutions #6: Ducts (53%)

Duct sealing included with air sealing

- Why it is a concern:
  - Less funds available for air and duct sealing
  - Miscalculation of energy use and savings
  - May impact HVAC delivered efficiency

Duct sealing/insulation on WO but not audit

- Why it is a concern:
  - Miscalculation of energy use and savings
  - Missing total unit costs/savings in cost-effectiveness test

Use standard workflow and separate duct sealing inputs

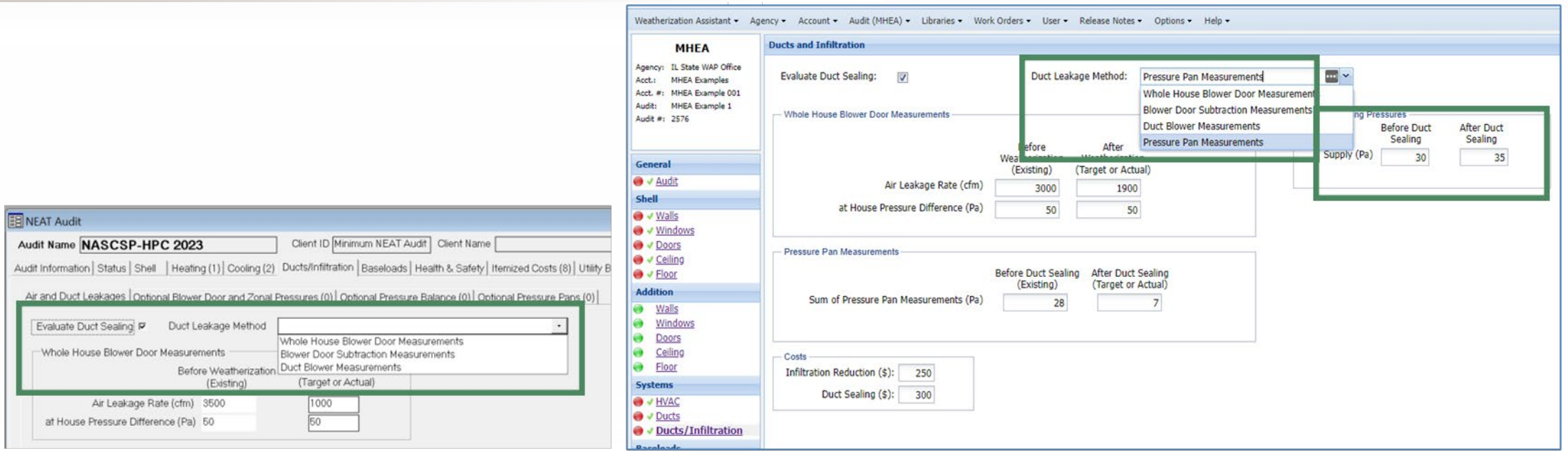


Figure 20: Example Duct sealing input options - WAv8.9 (NEAT) and WAv10 (MHEA)

Solutions #6: Ducts[BONUS] (53%)

Sealing/Insulation in conditioned space

- Why it is a concern:
  - Possible overstatement of savings
  - Potential disallowed measures/costs
  - Miscalculation of HVAC energy/savings

Uninsulated ducts not input

- Why it is a concern:
  - Miscalculation of HVAC delivery efficiency
  - Missed energy savings opportunity
  - Potential unintended moisture/durability concerns when paired with cooling system changes

Ducts form provides added flexibility/QC options (WAv10)

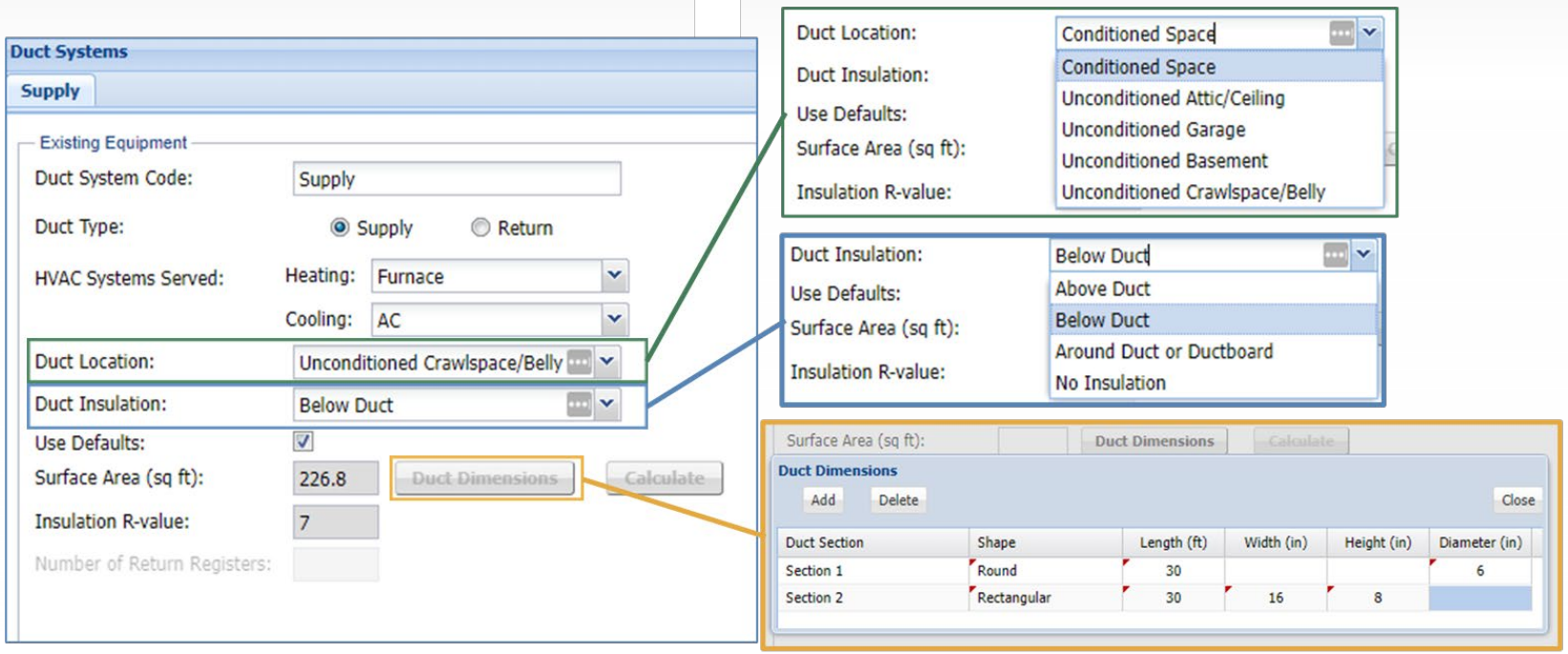


Figure 21: Example inputs on the WAv10 Ducts Form

Solutions #7: Walls (51%)

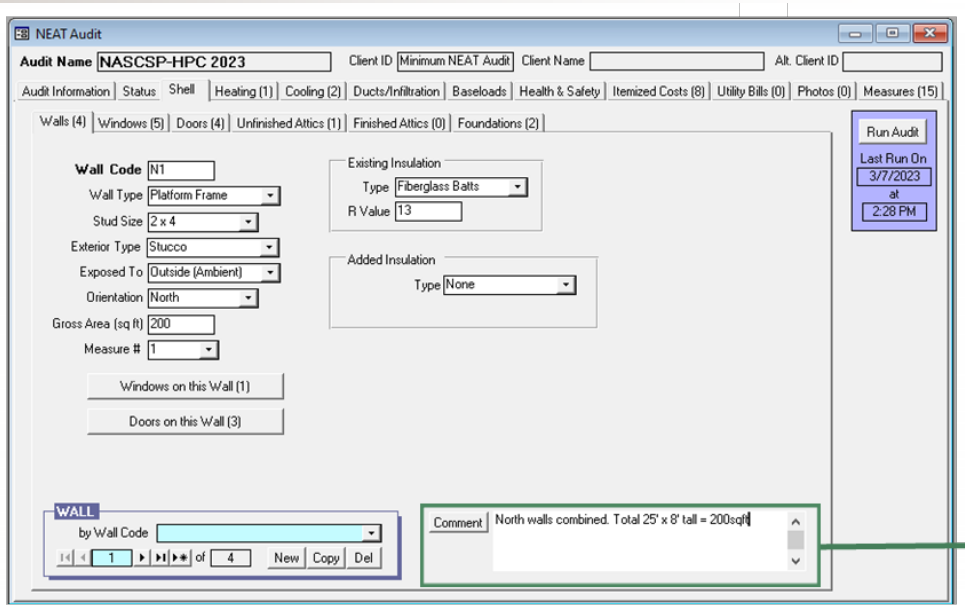
Inaccurate wall surface area(s)

- Why it is a concern:
  - Miscalculation of heating/cooling loads
  - Miscalculation of insulation measure savings and costs
  - Miscalculation of HVAC retrofit savings

Examples:

- Wall areas not within +/-10% of actual

Include details in Comments
Use summary spreadsheet for QC check



General Square Footage & Variance Calculator

input result

Audit Input					Data Collection Form				
Feet	Feet	Oriented	ft2		Feet	Feet	Oriented	ft2	
12	8	N	96		100	8		800	
10	8	N	80						
2	8	N	16						
1	8	N	8						
25	8	W	200						
25	8	S	200						
25	8	E	200						
									% variation
			800	Total ft2				800	Total ft2
			200	N					N
			200	S					S
			200	E					E
			200	W					W

North walls combined. Total 25' x 8' tall = 200sqft

Figure 22: Examples of WA Wall Comments and Area Calculator

Solutions #8: Baseloads (49%)

Elec DHW input and EF not appropriate

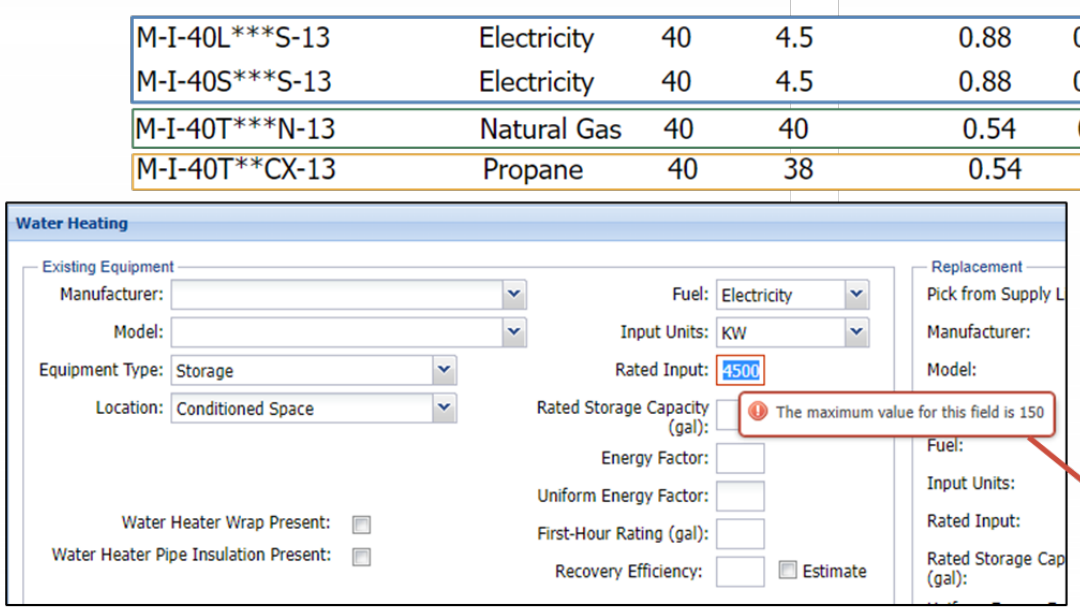
- Why it is a concern:
  - Miscalculation of existing energy use
  - Miscalculation of energy and cost savings
  - If paired with social cost of carbon, miscalculation of emissions savings and added non-energy impacts

Use default and/or input range check for QC

Examples:

- Input 4500kW vs. 4.5kW
- EF = 0.45 vs. 0.93

M-I-40L***S-13	Electricity	40	4.5	0.88	0.98
M-I-40S***S-13	Electricity	40	4.5	0.88	0.98
M-I-40T***N-13	Natural Gas	40	40	0.54	0.76
M-I-40T**CX-13	Propane	40	38	0.54	0.76



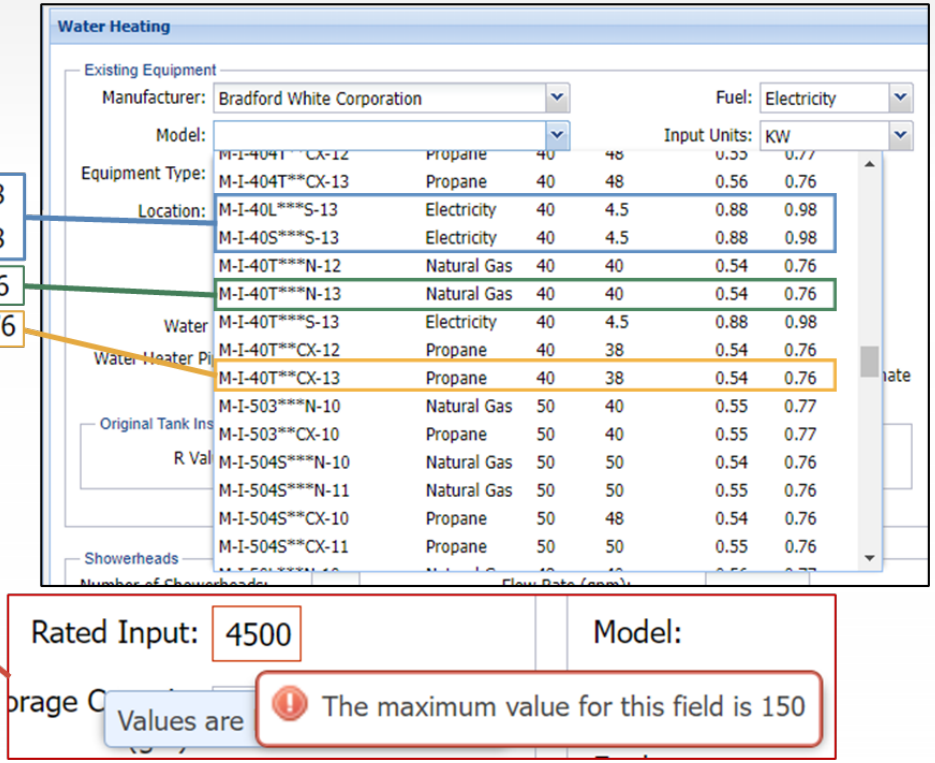


Figure 23: Examples of Water Heater input range check and Default Values in WAv10

Solutions #9: Ventilation (42%)

No ASHRAE calc or details do not match

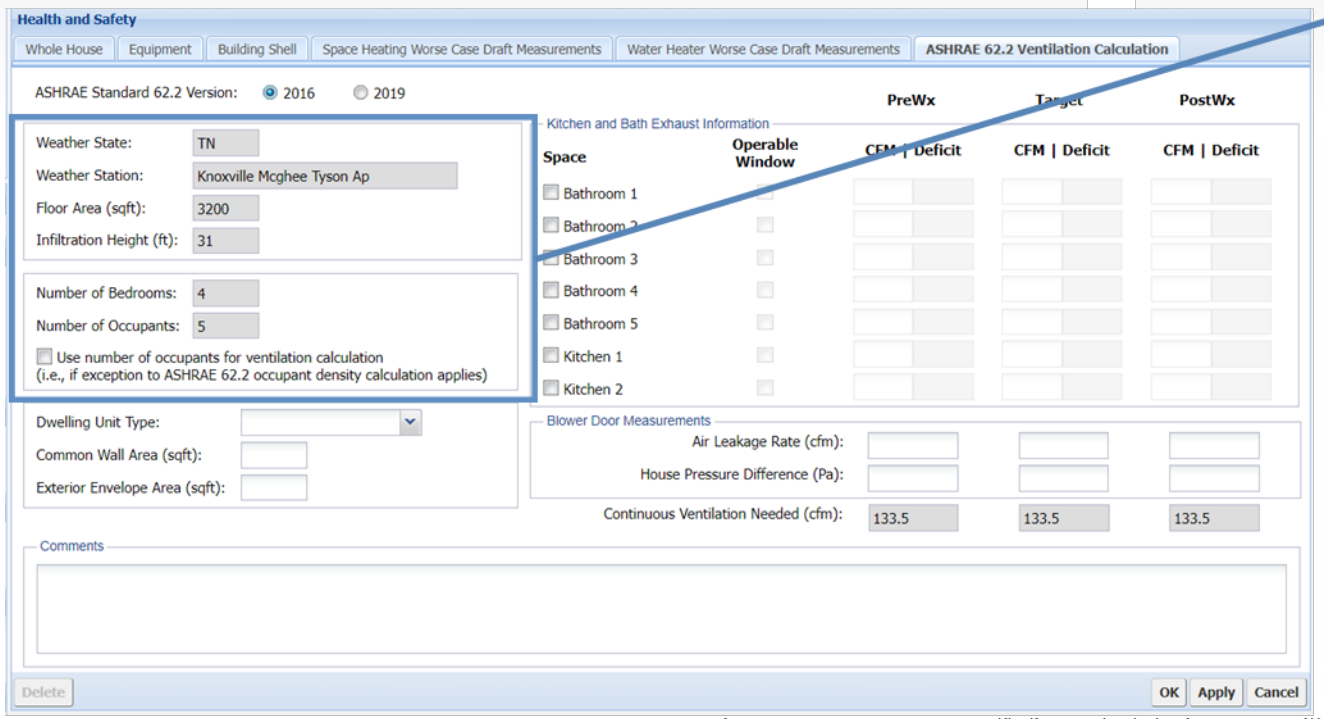
- Why it is a concern:
  - Unable to show/ensure programmatic compliance
  - May violate "do no harm" principle
  - Costs may be missed and/or disallowed

Examples:

- No calculation
- Occupants and/or other details don't match audit inputs

Use included calculator with linked datapoints (WAv10)

Linked datapoints shown in Gray



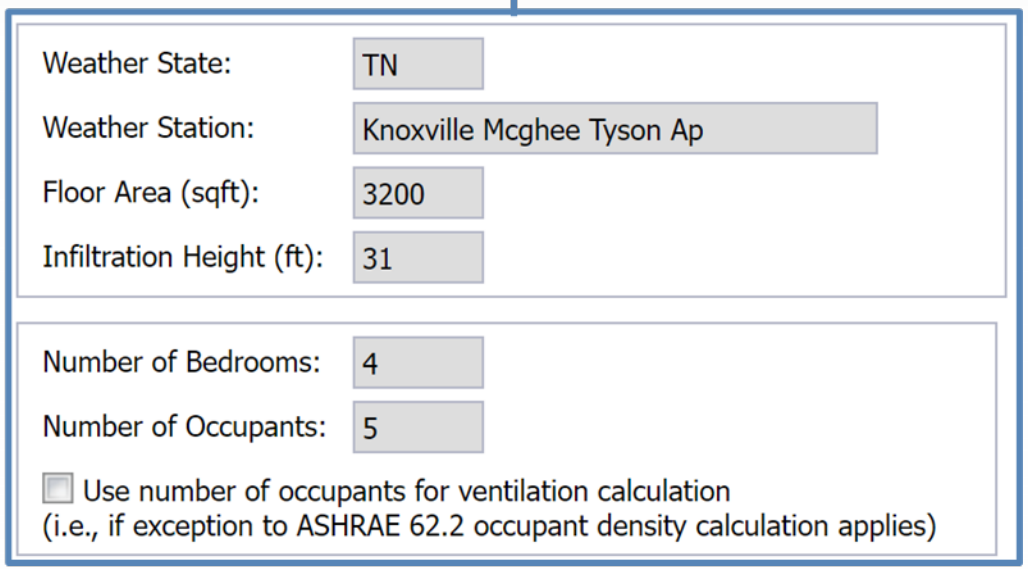


Figure 24: ASHRAE 62.2 Ventilation Calculator in WAv10 with linked datapoints grayed out

Solutions #10: Cooling (42%)

Cooling not included in model

- Why it is a concern:
  - Missing cooling energy savings for envelop retrofits
  - Missing cooling energy savings for air and/or duct sealing
  - Miscalculated existing energy use (additional problems with utility bill adjustment functions)

Examples:

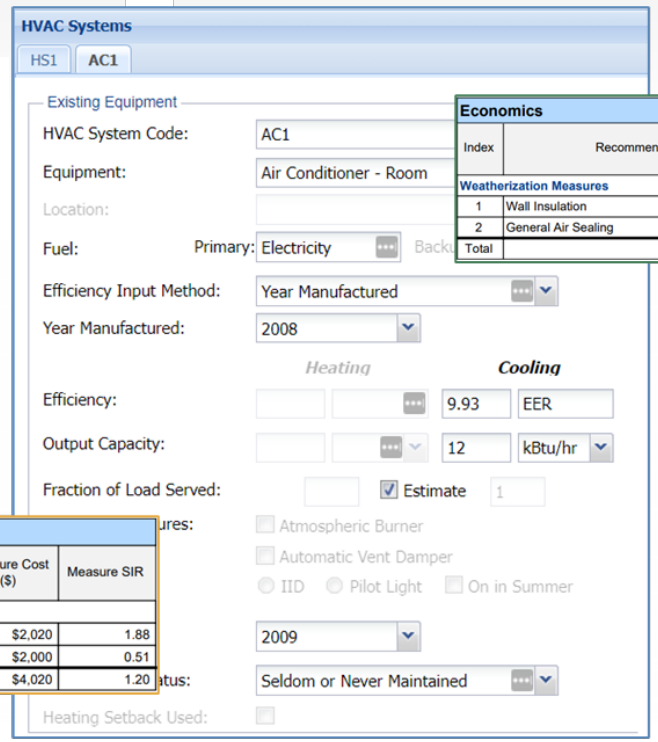
- Window air-conditioners present, but not entered in model
- Central air-conditioner shown in photos, but not entered in model

Use HVAC/Cooling inputs whenever applicable

Without AC entered:
Total Annual Savings = $358

Economics

Index	Recommended Measure	Components	Measure Savings ($/yr)	Measure Cost ($)	Measure SIR
Weatherization Measures					
1	Wall Insulation	WL1	$241	$2,020	1.88
2	General Air Sealing	Ducts/Infiltration	$117	$2,000	0.51
Total			$358	$4,020	1.20



Economics

Index	Recommended Measure	Components	Measure Savings ($/yr)	Measure Cost ($)	Measure SIR
Weatherization Measures					
1	Wall Insulation	WL1	$392	$2,020	3.04
2	General Air Sealing	Ducts/Infiltration	$127	$2,000	0.55
Total			$519	$4,020	1.80

With AC entered:
Total Annual Savings = $519
(+$161)

Figure 25: WAv10 simple AC input and results comparison

QA Solutions: Summary

Issue	Solution
• Work Orders not included or mismatched	• Software WO generation workflow
• Health and Safety Measures not eligible	• Create standard HSM in Defined Measures
• Foundation entry confusion/doubled	• Use Help/tips to define spaces before entry
• Attic area larger than conditioned area	• Record dimensions in notes - verify
• Window shading %	• Use updated inputs in WAv10
• Duct sealing/insulation not modeled	• Use Duct inputs in WAv10
• Wall surface area not accurate	• Record dimensions in notes – verify
• Electric Water Heater low efficiency input	• Use defaults and/or tool tip for sanity check
• ASHRAE 62.2 calculation details do not match	• Use embedded ASHRAE 62.2 calculator and linked datapoints
• Cooling not included in model	• Input Cooling equipment whenever applicable

The Bigger Purpose of This Session

Improve QA Performance

- **>80% of reviewed audits scoring low (0) in THREE or more categories**
- Cost-effective energy-conservation retrofits are the foundation of the WAP
- **Computerized energy audits** analyze the cost-effectiveness of *multiple retrofit and package options*
- ~50% of reviewed audits exhibit issues with HVAC systems modeling
- >50% of reviewed audits exhibit issues with building envelope modeling

Purpose of QA Processes

- Accurate energy audits
- Technical program compliance
- Statutory program compliance
- The right retrofits
- Cost-effective retrofits

QA Solutions BONUS: Missing Documentation/Photos

Missing documentation/photos

- Why it is a concern:
  - Unable to verify existing conditions
  - Difficulty getting second opinion on inputs and/or retrofit additional costs
  - Unable to properly identify incidental repairs and health and safety conditions/costs

Examples:

- No photos of existing condition provided
- Missing Grantee-required combustion testing forms

Who is using a photo management service/software?
What are you using?

Figure 13: Example detail photos documenting existing conditions

OAK RIDGE National Laboratory

Top 10 Audit Related Quality Assurance Issues and Remedies

Prepared for NASCSP 2023 Winter Training Conference

Bill Eckman – Oak Ridge National Laboratory

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