Cold Climate Case Studies: A Tale of Two Retrofits

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In this presentation

1. An integrated approach to retrofits
2. What matters most and why
3. Our Process in 2 case studies
4. Case 1: The Ely Retrofit
5. Case 2: The Superior Retrofit
6. Finding Opportunities

An Integrated Approach

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe." -John Muir

A house rarely needs "just one thing." And, preparing to "fix" one thing invariably affects other things, so it is better to come prepared to look for and understand the relationships elements have with one another in a building.

(Sound familiar?)

An Integrated Approach

What to consider:

Structure
Skin
Systems
Space
Stuff
Water and air
Living, breathing creatures
Money

An Integrated Approach

So much to consider:

Structure
Skin
Systems
Space
Stuff
Water and air
Living, breathing creatures
Money

Are there priorities even with an integrated approach?

What Matters Most (and why)

1. Safety.

2. Durability.

3. Energy.

What Matters Most (and why)

1. Safety

"Do no harm."

Take care of the people.

Solve problems that exist.

Do not create new ones.

What Matters Most (and why)

2. Durability

If it lasts, it costs less in the long run.

If it works, it costs less in the long run.

If it is good quality, it adds value and pleasure.

Improving what is already here usually has less negative environmental impact than building something entirely new.

What Matters Most (and why)

3. Energy

Energy efficiency usually increases comfort.

Reduced consumption reduces operating costs.

Addressing energy use can reduce household environmental impact.

Improving the energy efficiency of the building can mean occupants stay secure even when purchased energy is "out of service."

Approaching what matters most

1. Combustion Safety
2. Ventilation
3. Water Management
4. Air Management (Sealing)
5. Insulation

A word about Radon

TEST

The Process We Used

1. Definition of Goals
2. Assessment of Existing Conditions
3. Analysis of Energy Use/Energy Model
4. Schematic Recommended Approach
5. Modeled Recommended Approach
6. Design
7. Working with the Builder
8. Construction
9. Evaluation and Verification/Lessons

Ely, MN

- 9800 HDD
- 180 CDD
- 1970
- 1-story walk-out
- 3314 ft2
- Septic system
- Lakeshore
- Grid electricity
- Fuel oil
- Firewood

Ely 1. Goals

- Reduce household energy consumption
- Improve household “carbon footprint”
- Improve indoor air quality
- Reduce use of known pollutants
- Maintain most interior finishes
- Improve long term durability
- Fix water management problems

Ely 2. Existing Conditions

This is the "main entry."

Ely 2. Existing Conditions

- Big masonry chimney that leaked
- Wet basement
- Oil-fired boiler
- New 22.5 kW electric boiler for dual fuel
- Newer electric water heater
- Little opportunity for passive solar gain
- Roof, windows, and siding in need of replacement

Ely 3. Analysis

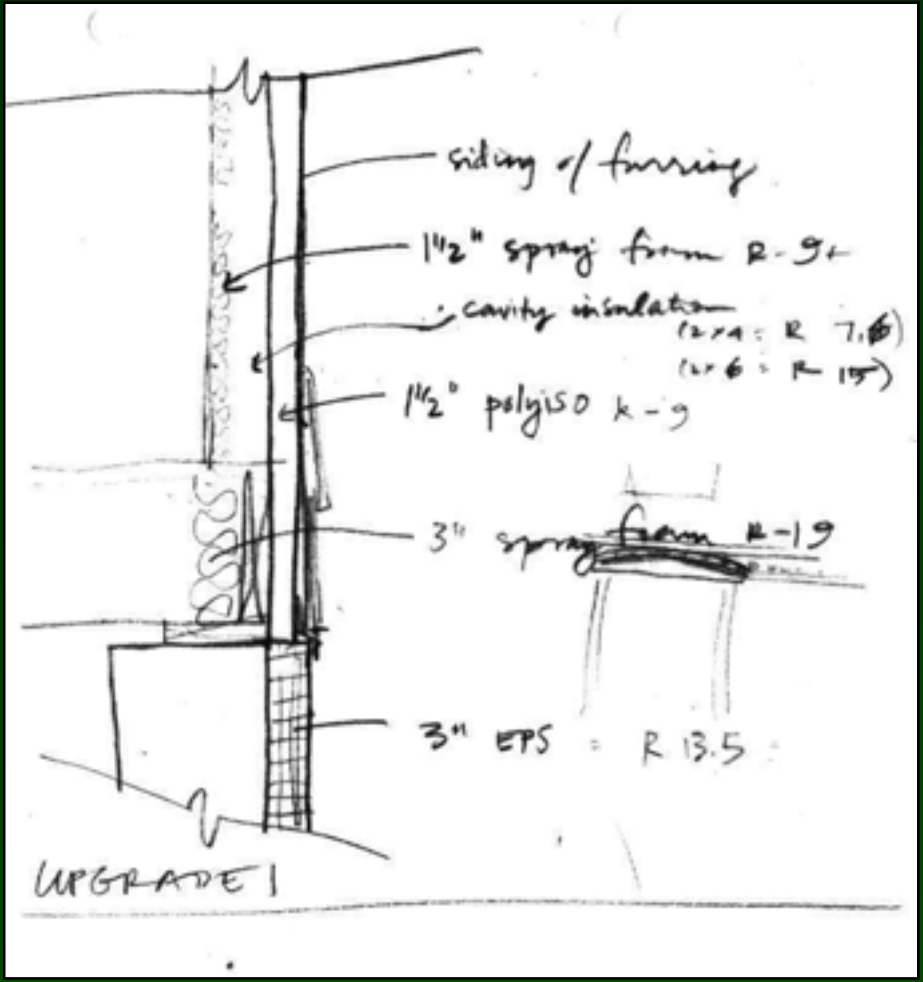
- Blower door test and infra-red imaging
- REM Design baseline energy model
- Energy consulting
- Existing energy bills
- Exterior approach the obvious choice:
  - Fix bulk water problems
  - Owner wanted to keep interior finishes
  - Exterior finishes at end of useful life

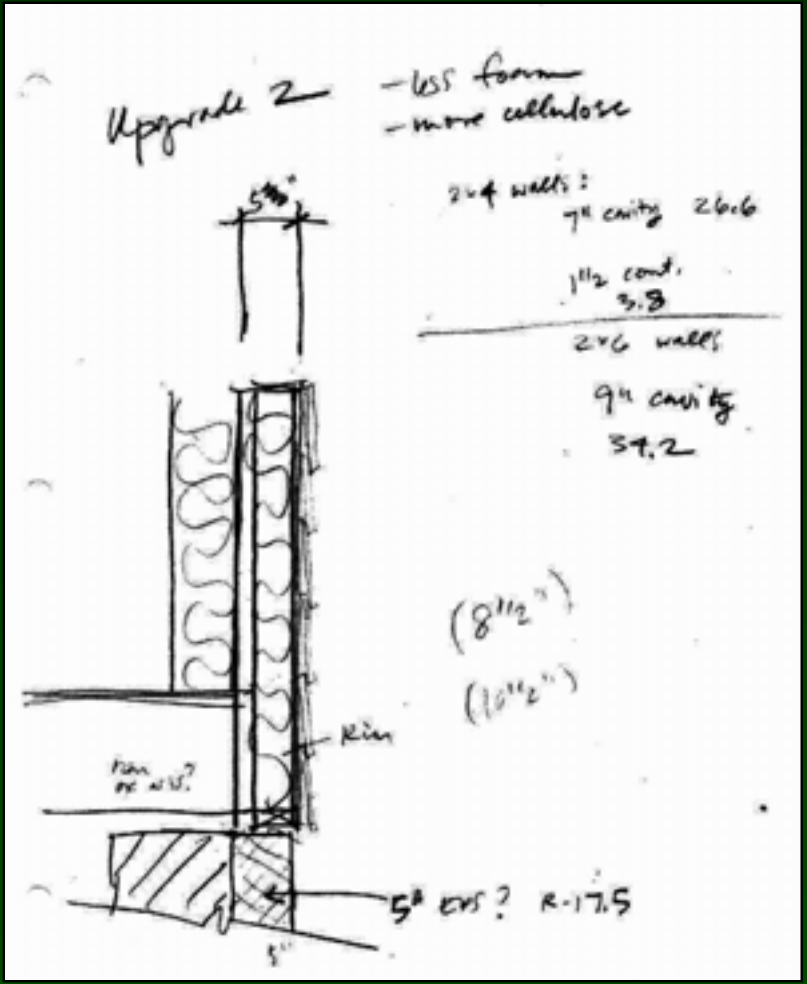
Ely 4. Schematic Approach

- Integrated Thinking
- Maintaining Priorities
- Exploring Ideas
- Conceptual

- Intuitive, but with basis in experience

Ely 4. Schematic Approach





Ely 4. Schematic Approach

- HRV and balanced ventilation system
- Remove masonry chimney
- Reduce eaves and simplify roof lines
- Comprehensive air sealing
- Exterior foundation insulation
- Exterior/cavity wall insulation
- Attic and interior ceiling insulation
- New windows
- Create one entry at east gable end

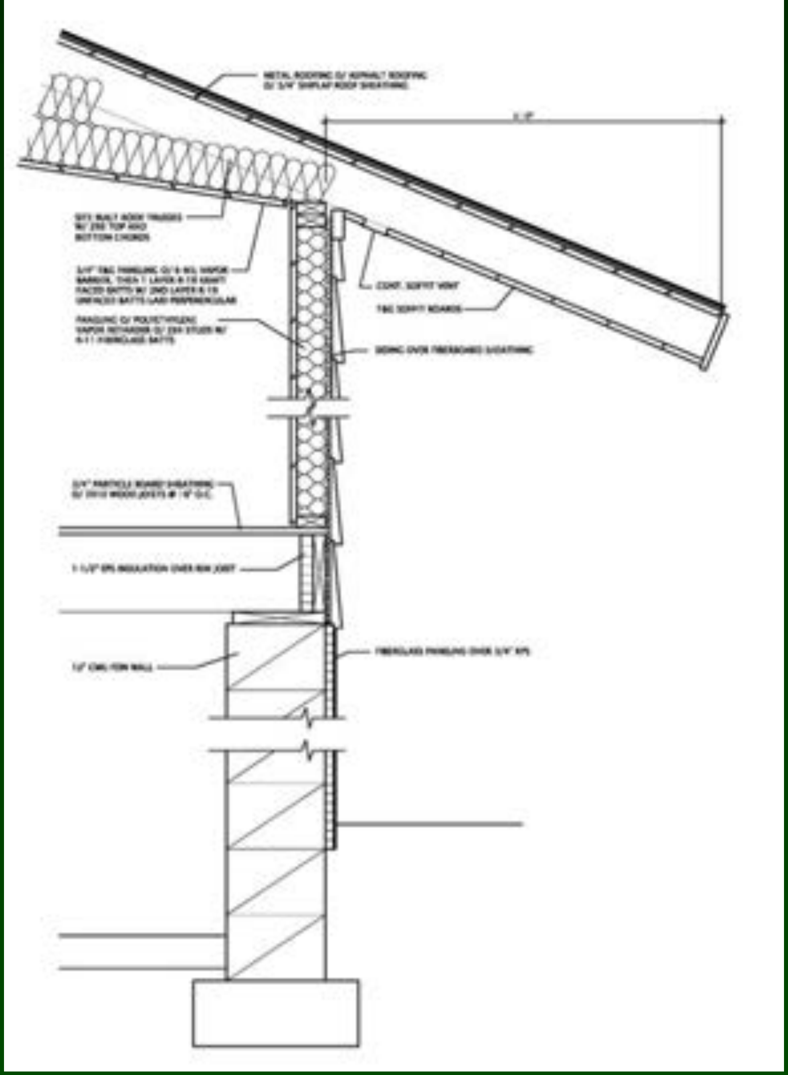
Ely 5. Modeled Approach

- Foundation and rim: R-18 (4” EPS)
- Framed walls: R-34 (9” dense packed cellulose)
- Windows: U-0.19 (Duxton tri-pane)
- Two attic conditions: R-40 and R-60

GOALS:

- Air tightness goal 2.4 ACH50 (50% reduction)
- 65% reduction in heating energy
- 50% reduction in total energy use

Ely 6. Design



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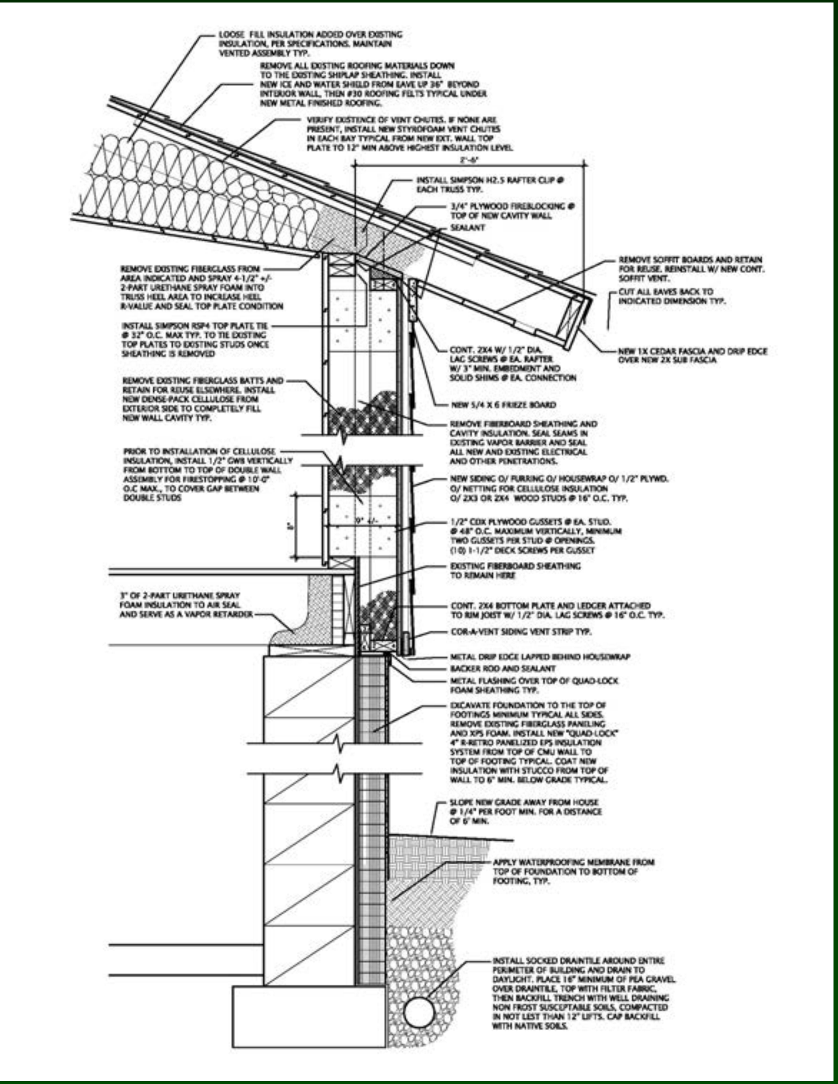

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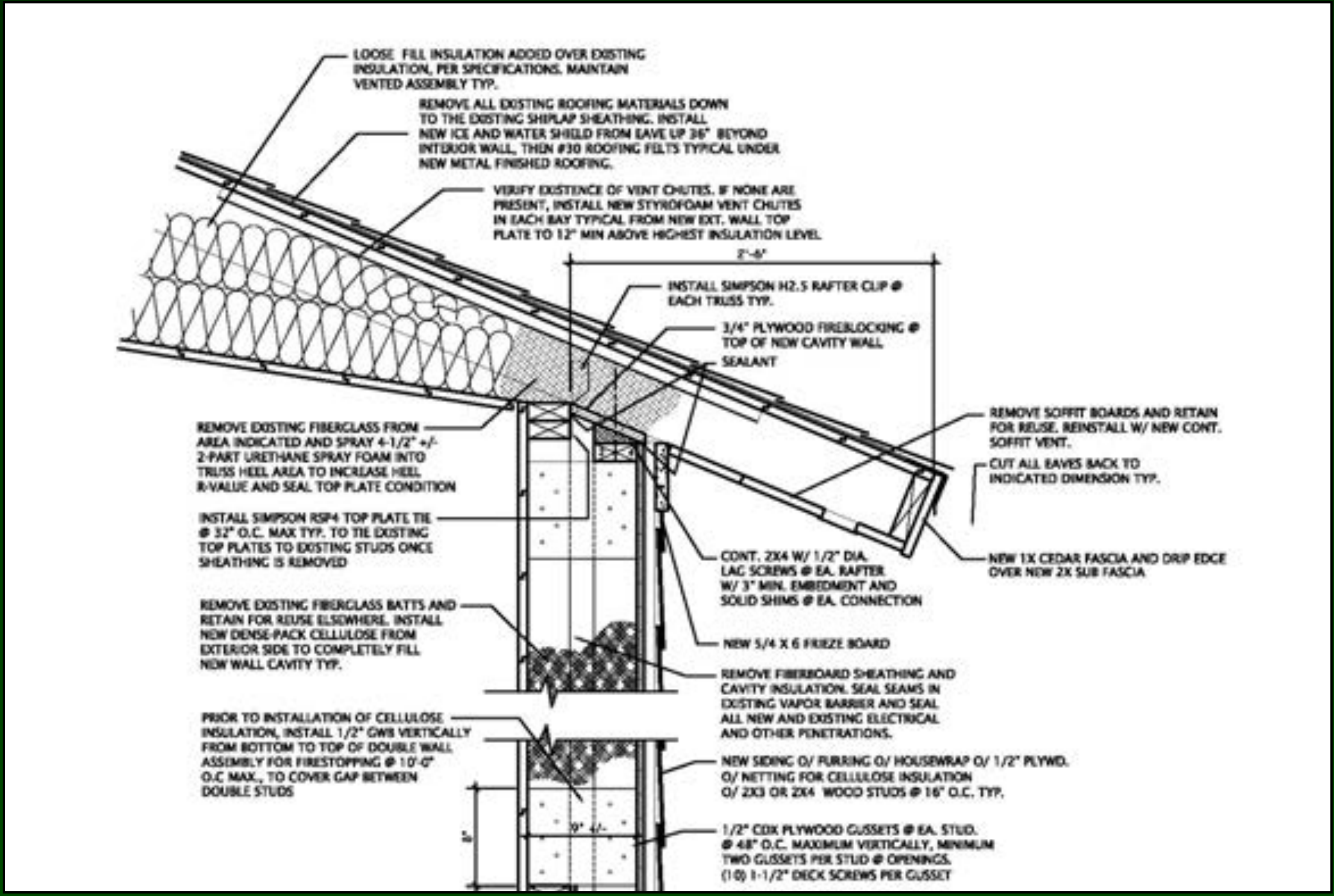
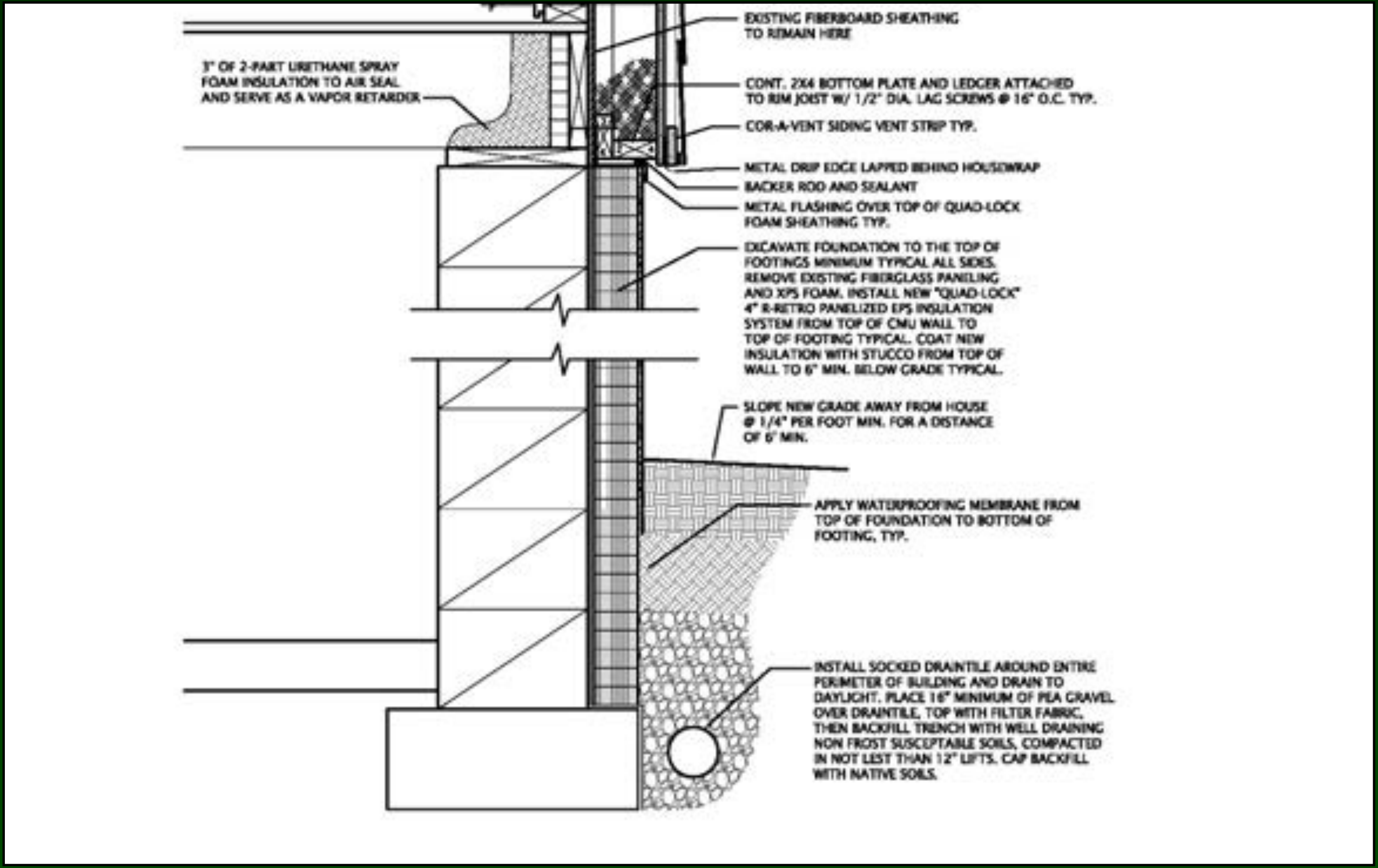
Ely 6. Design

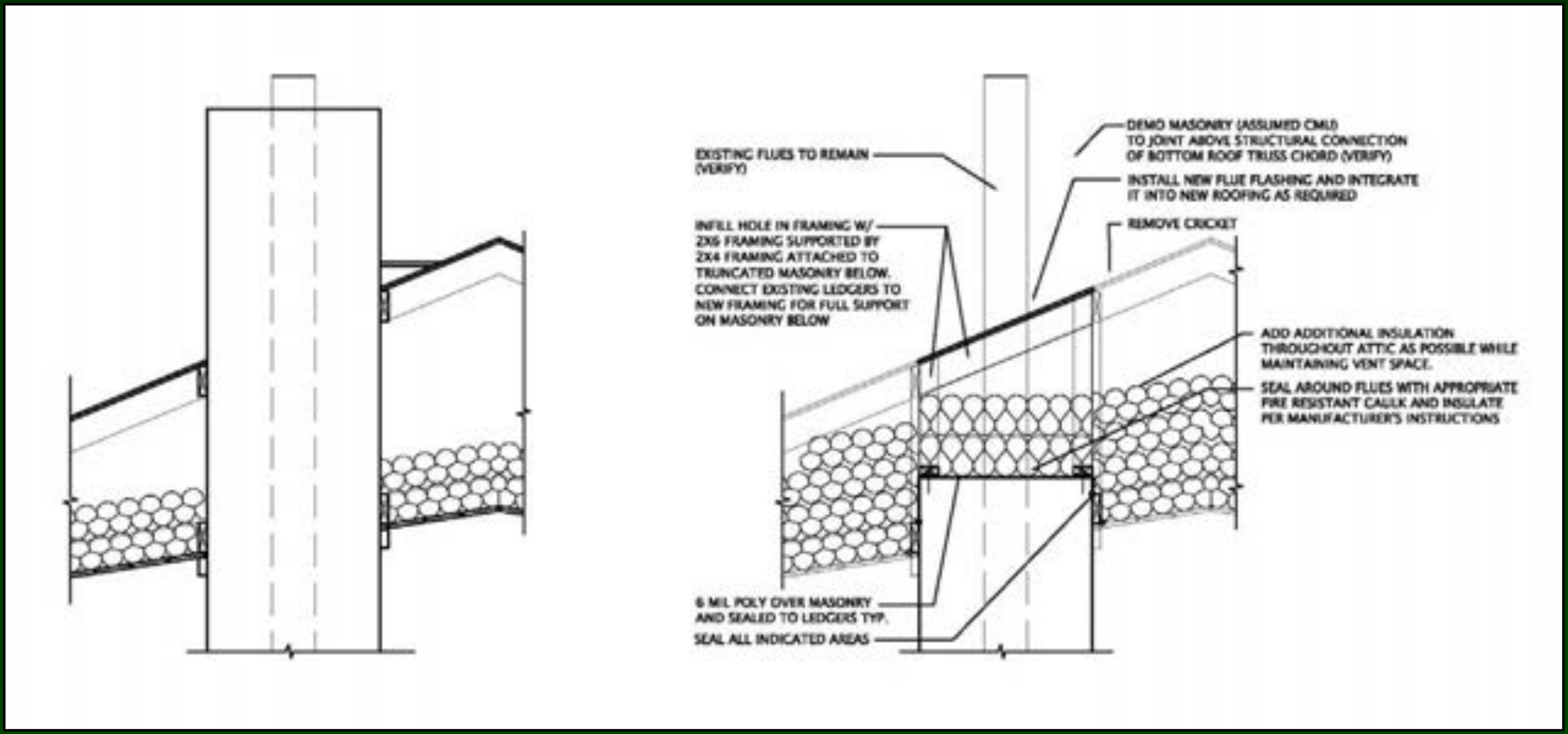

LOOSE FILL INSULATION ADDED OVER EXISTING INSULATION, PER SPECIFICATIONS. MAINTAIN VENTED ASSEMBLY TYP.
REMOVE ALL EXISTING ROOFING MATERIALS DOWN TO THE EXISTING SHIPLAP SHEATHING. INSTALL NEW ICE AND WATER SHIELD FROM EAVE UP 36" BEYOND INTERIOR WALL, THEN #30 ROOFING FELTS TYPICAL UNDER NEW METAL FINISHED ROOFING.
VERIFY EXISTENCE OF VENT CHUTES. IF NONE ARE PRESENT, INSTALL NEW STYROFOAM VENT CHUTES IN EACH BAY TYPICAL FROM NEW EXT. WALL TOP PLATE TO 12" MIN ABOVE HIGHEST INSULATION LEVEL.
2'-6"
INSTALL SIMPSON H2.5 RAFTER CLIP @ EACH TRUSS TYP.
3/4" PLYWOOD FIREBLOCKING @ TOP OF NEW CAVITY WALL
SEALANT
REMOVE SOFFIT BOARDS AND RETAIN FOR REUSE. REINSTALL W/ NEW CONT. SOFFIT VENT.
CUT ALL EAVES BACK TO INDICATED DIMENSION TYP.
REMOVE EXISTING FIBERGLASS FROM AREA INDICATED AND SPRAY 4-1/2" +/- 2-PART URETHANE SPRAY FOAM INTO TRUSS HEEL AREA TO INCREASE HEEL R-VALUE AND SEAL TOP PLATE CONDITION
INSTALL SIMPSON RSP4 TOP PLATE TIE @ 32" O.C. MAX TYP. TO TIE EXISTING TOP PLATES TO EXISTING STUDS ONCE SHEATHING IS REMOVED
CONT. 2X4 W/ 1/2" DIA. LAG SCREWS @ EA. RAFTER W/ 3" MIN. EMBEDMENT AND SOLID SHIMS @ EA. CONNECTION
NEW 1X CEDAR FASCIA AND DRIP EDGE OVER NEW 2X SUB FASCIA
REMOVE EXISTING FIBERGLASS BATTS AND RETAIN FOR REUSE ELSEWHERE. INSTALL NEW DENSE-PACK CELLULOSE FROM EXTERIOR SIDE TO COMPLETELY FILL NEW WALL CAVITY TYP.
NEW 5/4 X 6 FRIEZE BOARD
REMOVE FIBERBOARD SHEATHING AND CAVITY INSULATION. SEAL SEAMS IN EXISTING VAPOR BARRIER AND SEAL ALL NEW AND EXISTING ELECTRICAL AND OTHER PENETRATIONS.
PRIOR TO INSTALLATION OF CELLULOSE INSULATION, INSTALL 1/2" GWB VERTICALLY FROM BOTTOM TO TOP OF DOUBLE WALL ASSEMBLY FOR FIRESTOPPING @ 10'-0" O.C MAX., TO COVER GAP BETWEEN DOUBLE STUDS
NEW SIDING O/ FURRING O/ HOUSEWRAP O/ 1/2" PLYWD. O/ NETTING FOR CELLULOSE INSULATION O/ 2X3 OR 2X4 WOOD STUDS @ 16" O.C. TYP.
9" +/-
1/2" CDX PLYWOOD GUSSETS @ EA. STUD. @ 48" O.C. MAXIMUM VERTICALLY, MINIMUM TWO GUSSETS PER STUD @ OPENINGS. (10) 1-1/2" DECK SCREWS PER GUSSET

Ely 6. Design



3" OF 2-PART URETHANE SPRAY FOAM INSULATION TO AIR SEAL AND SERVE AS A VAPOR RETARDER
EXISTING FIBERBOARD SHEATHING TO REMAIN HERE
CONT. 2X4 BOTTOM PLATE AND LEDGER ATTACHED TO RIM JOIST W/ 1/2" DIA. LAG SCREWS @ 16" O.C. TYP.
COR-A-VENT SIDING VENT STRIP TYP.
METAL DRIP EDGE LAPPED BEHIND HOUSEWRAP
BACKER ROD AND SEALANT
METAL FLASHING OVER TOP OF QUAD-LOCK FOAM SHEATHING TYP.
EXCAVATE FOUNDATION TO THE TOP OF FOOTINGS MINIMUM TYPICAL ALL SIDES. REMOVE EXISTING FIBERGLASS PANELING AND XPS FOAM. INSTALL NEW "QUAD-LOCK" 4" R-RETRO PANELIZED EPS INSULATION SYSTEM FROM TOP OF CMU WALL TO TOP OF FOOTING TYPICAL. COAT NEW INSULATION WITH STUCCO FROM TOP OF WALL TO 6" MIN. BELOW GRADE TYPICAL.
SLOPE NEW GRADE AWAY FROM HOUSE @ 1/4" PER FOOT MIN. FOR A DISTANCE OF 6' MIN.
APPLY WATERPROOFING MEMBRANE FROM TOP OF FOUNDATION TO BOTTOM OF FOOTING, TYP.
INSTALL SOCKED DRAINTILE AROUND ENTIRE PERIMETER OF BUILDING AND DRAIN TO DAYLIGHT. PLACE 16" MINIMUM OF PEA GRAVEL OVER DRAINTILE, TOP WITH FILTER FABRIC, THEN BACKFILL TRENCH WITH WELL DRAINING NON FROST SUSCEPTABLE SOILS, COMPACTED IN NOT LEST THAN 12" LIFTS. CAP BACKFILL WITH NATIVE SOILS.

Ely 6. Design



Removing the chimney helped water management, air sealing, insulation.

Ely 7. Working with the Builder

- Conditions can be messier than imagined
- Builder called when existing conditions varied ☺
- Lots of detail in drawings is great
  - If the builder follows the drawings ☹

Ely   8. Construction

4” EPS foam added to uninsulated foundation walls

Ely 8. Construction

Ely 8. Construction

Second wall framed outside of existing wall.

Ely 8. Construction

Ely 8. Construction

New wall sheathing, and walls insulated (or so we thought).

Ely 9. Evaluation and Verification

If you don’t get it right the first time

It is much harder the second time.

A retrofit of a retrofit.

Ely 9. Evaluation and Verification

Actual Energy Use - Ely

Annual Consumption	Before	After
Household Electricity	15,601 kWh	14,278 kWh
Heating - Electricity	69.1 MMBtu	47.1 MMBtu
Heating - Oil	65.4 MMBtu	1.4 MMBtu
Heating - Total	134.5 MMBtu	48.5 MMBtu
	40 KBtu/ft2	14.6 kBtu/ft2
Total Site Energy	187.7 MMBtu	97.2 MMBtu
	56.64 kBtu/ft2	29.33 kBtu/ft2

Accuracy of Energy Modeling - Ely

	Before	After
Annual Heating Energy		
Modeled Consumption	149.2 MMBtu	43.2 MMBtu
	45 kBtu/ft2 yr	13 kBtu/ft2 yr

	Before	After
Actual Consumption	134.5 MMBtu	48.5 MMBtu
	40 KBtu/ft2	14.6 kBtu/ft2

Ely 9. Lessons Learned

Make things easy to verify.

1. Open up more things before drawing details, even though it can be disruptive.
2. Set “STOP” points if you haven’t worked with Contractor before … and even if you have.
2. Keep things uncovered where possible (e.g. don’t allow cellulose to be blown into plywood).

Ely 9. Lessons Learned

What I'd do different.

1. Keep existing sheathing on exterior walls. Create the air barrier on the outside of the sheathing, then add Larsen trusses.
2. Net each bay of the Larsen trusses and blow cellulose through fabric.
3. Offer more solutions to reduce household electricity usage.

Superior, WI

- 9800 HDD
- 180 CDD
- 1950 1-story
- 2500 ft2
- Peninsula
- City sewer
- Well water
- Natural gas
- Grid electricity

Superior 1. Goals

- Reduce energy consumption and costs
- Improve comfort
- Improve occupant safety
- Repair/maintain for long-term durability
- Improve delivery of domestic hot water
- Maintain views and ample windows

Superior 2. Existing Conditions

- Prior attic insulation and air sealing work
- Recent kitchen remodel
- Uninsulated slab
- Uninsulated masonry foundation and walls
- Wrecked wood and aluminum windows
- Little opportunity for passive solar gain (missed opportunity!)
- Beautiful views of pines and water

Superior 2. Existing Conditions

- Atmospherically vented boiler and water heater (#1: combustion safety)
- Water piping under slab

Superior 3. Analysis

- Blower door test previously done
- REM Design baseline energy model
- Energy consulting
- Existing energy bills
- Exterior approach chosen:
  - Owner wanted to keep interior finishes
  - Masonry walls and slab = thermal bridges

Superior 4. Schematic Approach

- New boiler and indirect-fired water heater
- New domestic water distribution piping
- HRV and balanced ventilation system
- Replace master bath exhaust fan
- Exterior foundation insulation
- Exterior wall insulation
- Attic insulation where possible
- New windows
- Small entry addition

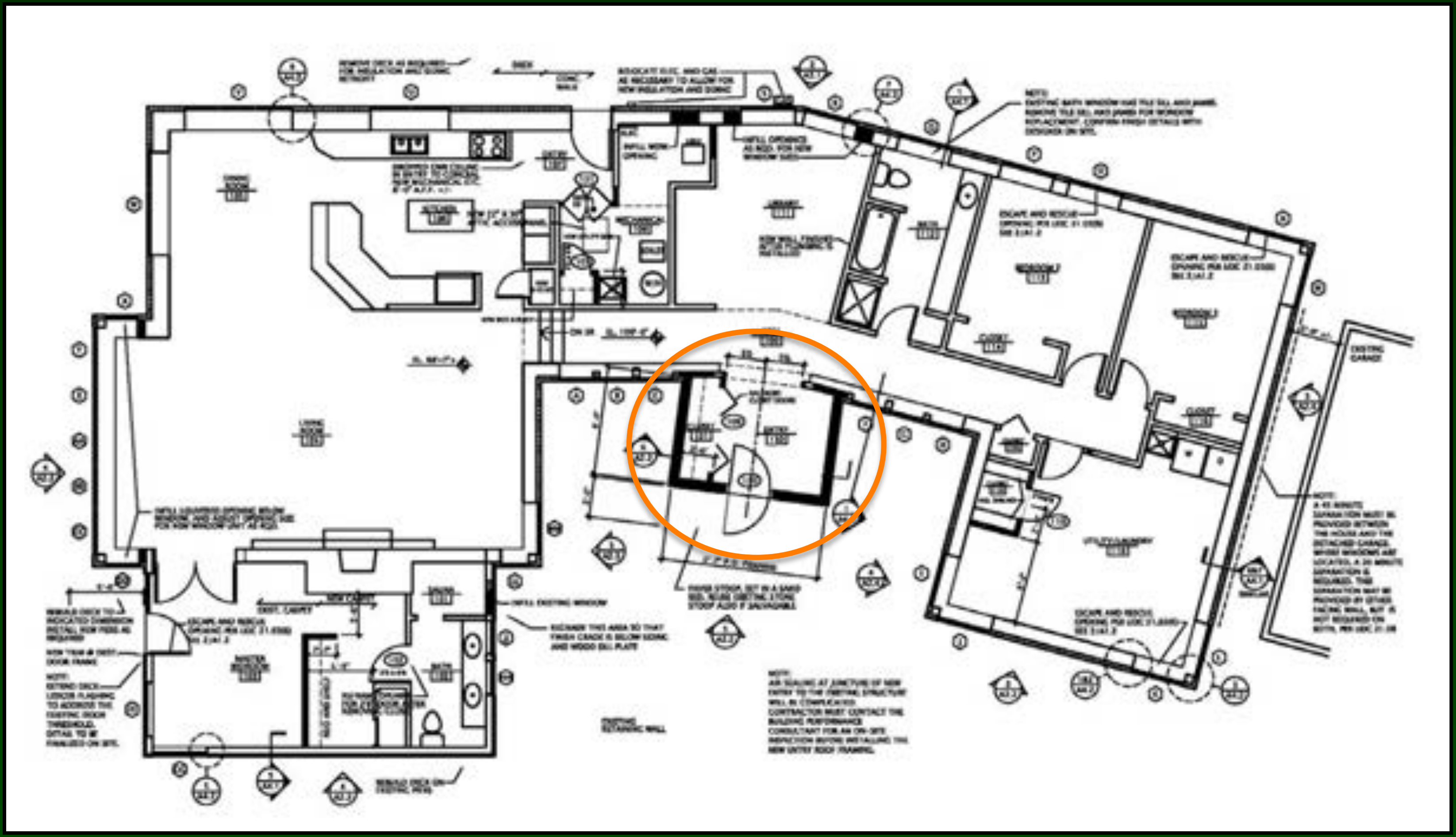
Superior 5. Modeled Approach

- Foundation: R-20 (4” XPS, fdn wall exterior and horiz skirt)
- Walls: R-24 (4” polyisocyanurate)
- Windows: U-0.23 (Loewen tri-pane)
- Attic: R-50 (blown cellulose over existing fiberglass)

GOALS:

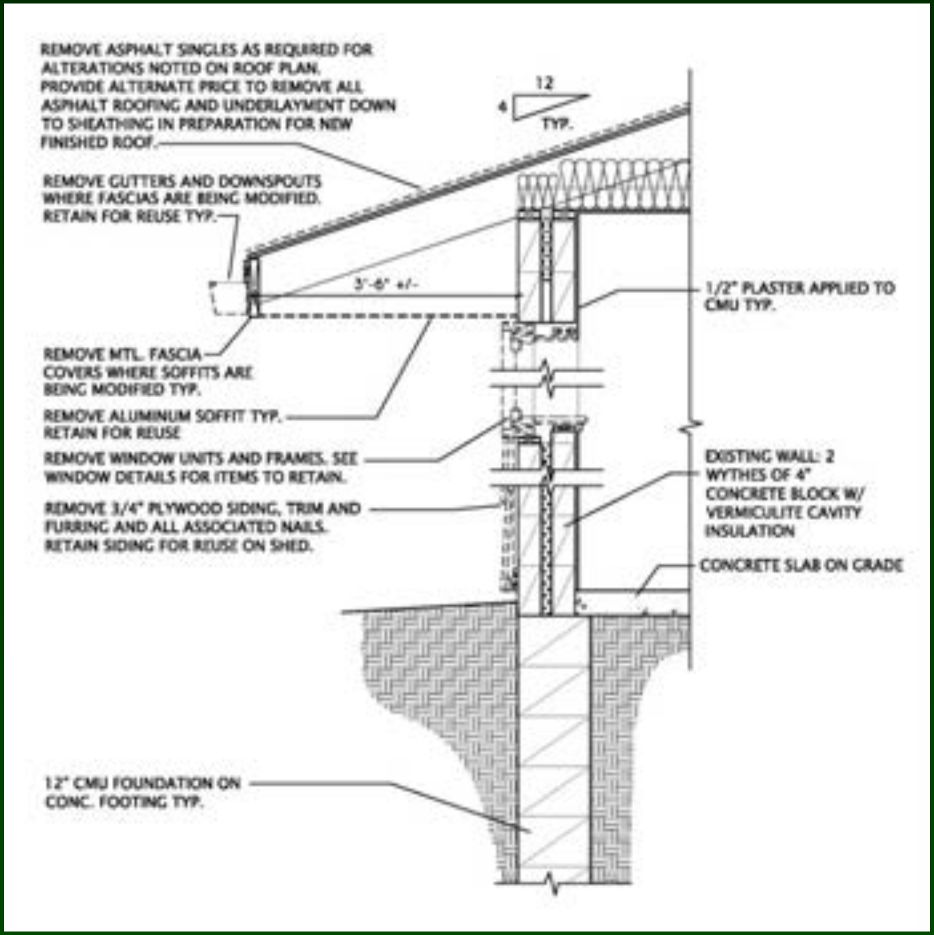
- Air tightness 3 ACH50 (50% reduction)
- 65% reduction in heating energy
- 50% reduction in total energy use

Superior 6. Design



A Simple Plan?

Superior 6. Design



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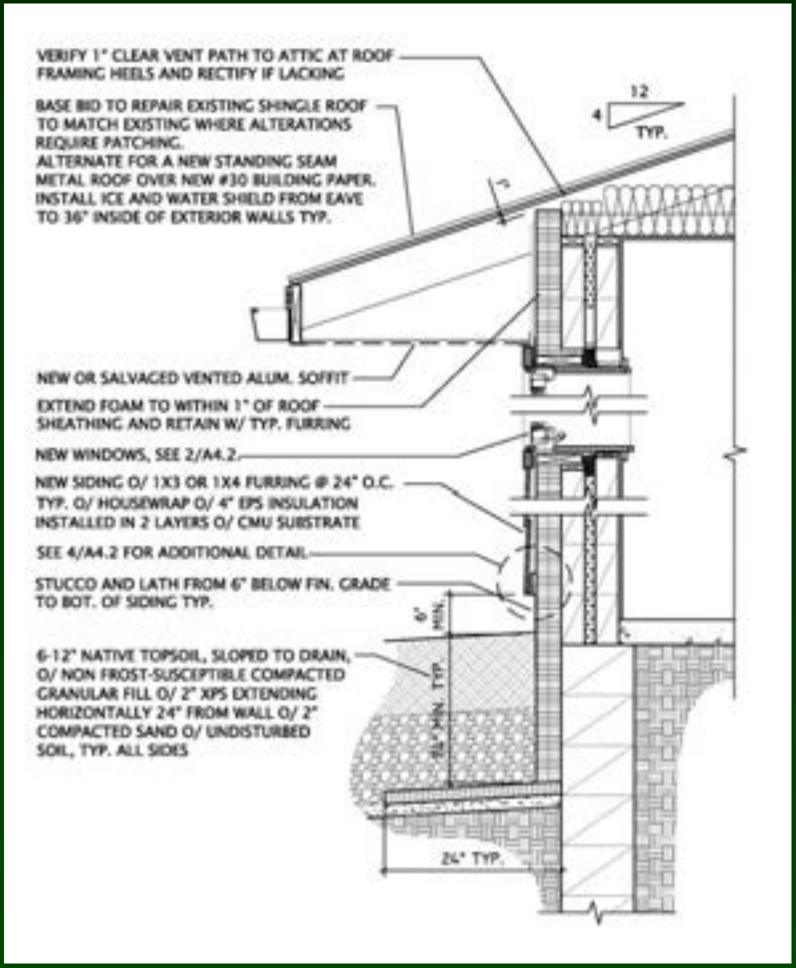
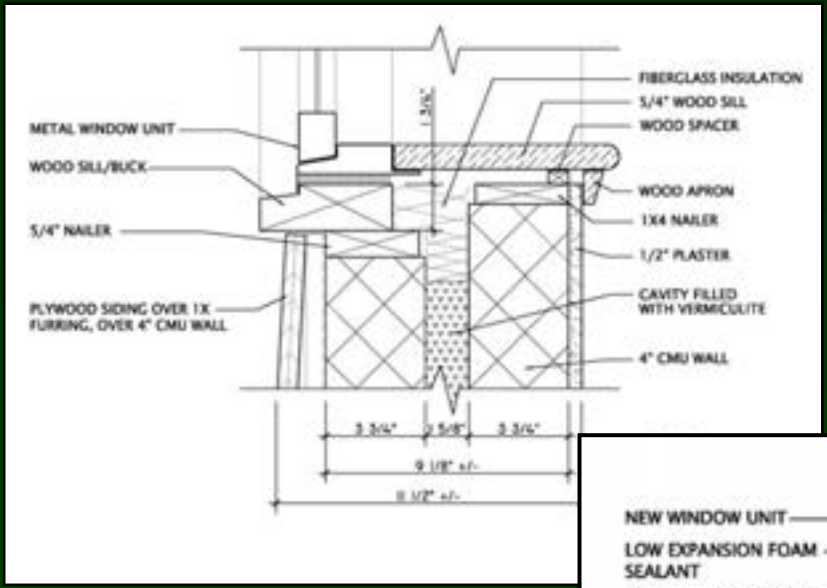


AFTER

Superior 7. Working with the Builder

Investigative demolition: Discovering what we will be getting into.

Superior 6. Design



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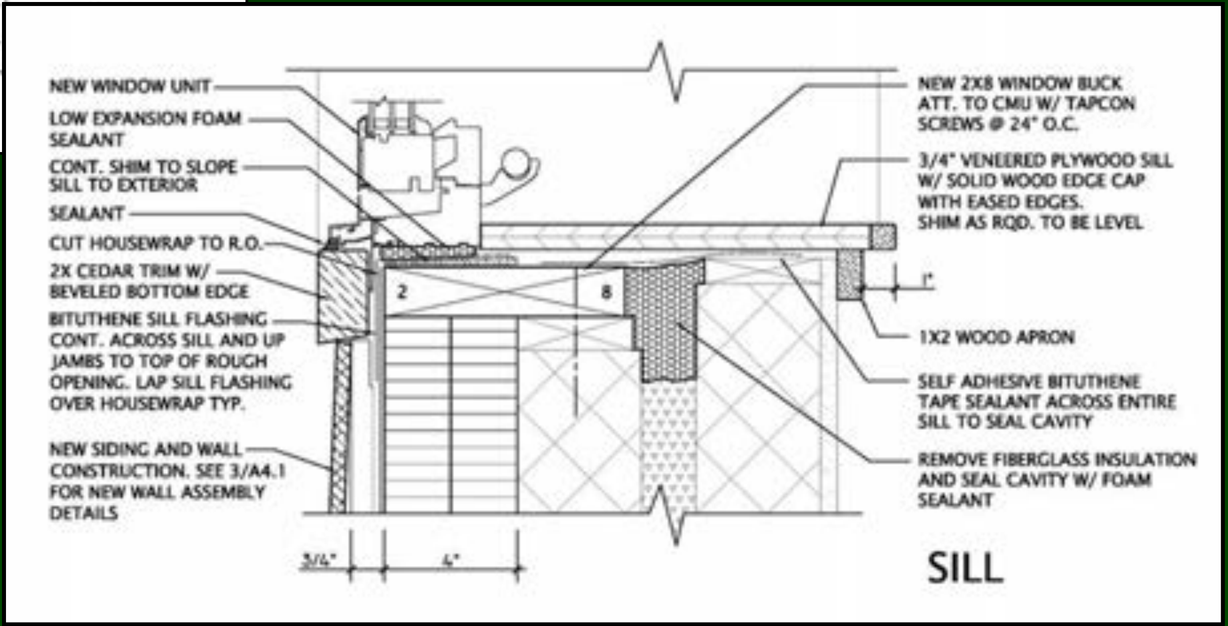

AFTER

Superior 8. Construction

Starting from the "bottom up" with insulating foam sheathing.

Superior 8. Construction

Siding over furring over WRB over foam sheathing over existing walls.

Superior 9. Evaluation and Verification

BEFORE

AFTER

Actual Energy Use - Superior

	Before: 2009	After: 2011	After: 2012
Electricity	5222 kWh	5647 kWh	5820 kWh
	2.02 kWh/ft2	2.12 kWh/ft2	2.18 kWh/ft2
Natural Gas	212.6 MMBtu	89 MMBtu	77.1 MMBtu
	82 kBtu/ft2	30 kBtu/ft2	28.9 kBtu/ft2
Total Site energy	230.4 MMBtu	108.9 MMBtu	96.3 MMBtu
	89.3 kBtu/ft2	40.8 kBtu/ft2	36.1 kBtu/ft2
Heating Degree Days	8920	9200	7609

Accuracy of Energy Modeling - Superior

	Before	After
Modeled Consumption (heat/DHW)	82.8 kBtu/ft2 yr	35.6 kBtu/ft2 yr

	Before	After
Actual Annual Energy Consumption		
Natural gas (heat/DHW)	82.3 kBtu/ft2 yr	30 +/- kBtu/ft2 yr

Superior 9. Lessons Learned

“Trust but verify”

We should have planned for our own blower door and infrared before and after retrofit.

The “Energy Star provider” was lax.

With Contractor, lines of communication and accountability weren’t always clear.

Superior 9. Lessons Learned

What I'd do different

1. Conduct a blower door test at the start. It would have resulted in a slightly different scope of work.
2. Explored options for more natural light into that hallway.
3. Laid out a plan for the eventual roof replacement (and suggest chimney removal).

Opportunities

1. Use "House as a system" thinking.
2. Educate your clients.
3. Offer new ideas and "enhancements."
4. Present the idea of phased projects.

Opportunities

Rule #1: Learn from your own work.

Rule #2: Learn from others' work.

Opportunities for More Learning

- Fine Homebuilding Energy Smart Homes Winter 2013 special issue

- Journal of Light Construction
- www.greenbuildingadvisor.com
- www.buildingscience.com
- www.affordablecomfort.org
- http://www1.extension.umn.edu/environment/housing-technology/

Thank you.

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