9.36 Energy Modeling and Energy Auditing

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BUILDING BLOCKS OF SUSTAINABILITY

Speaker introduction.

Outline:

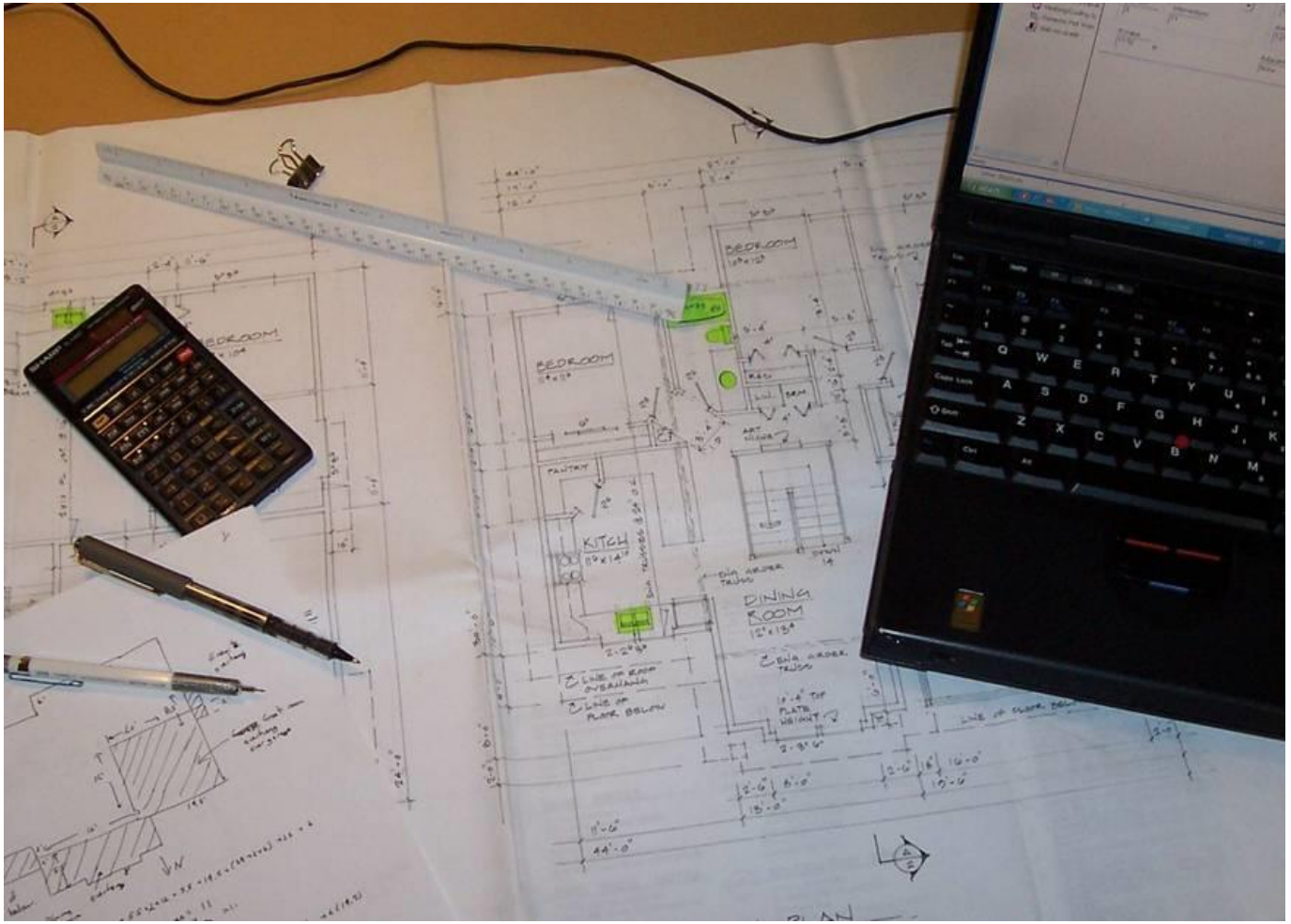
- Define energy modeling and energy auditing
- Applications
- Process
- Who does it
- Example
- How to verify
- Summary and questions.

Definitions:

Energy Modeling:

- Computer simulation of the energy consumption of a house/rowhouse/MURB
- Performed before construction with information from plans and specs
- Can be used for Code compliance and/or optimization.

Definitions:



An Energy Model Includes:

- Geometry of building (thermal envelope)
- Construction and insulation specifications
- Climate data
- Solar orientation
- Ventilation, space heating and DHW…

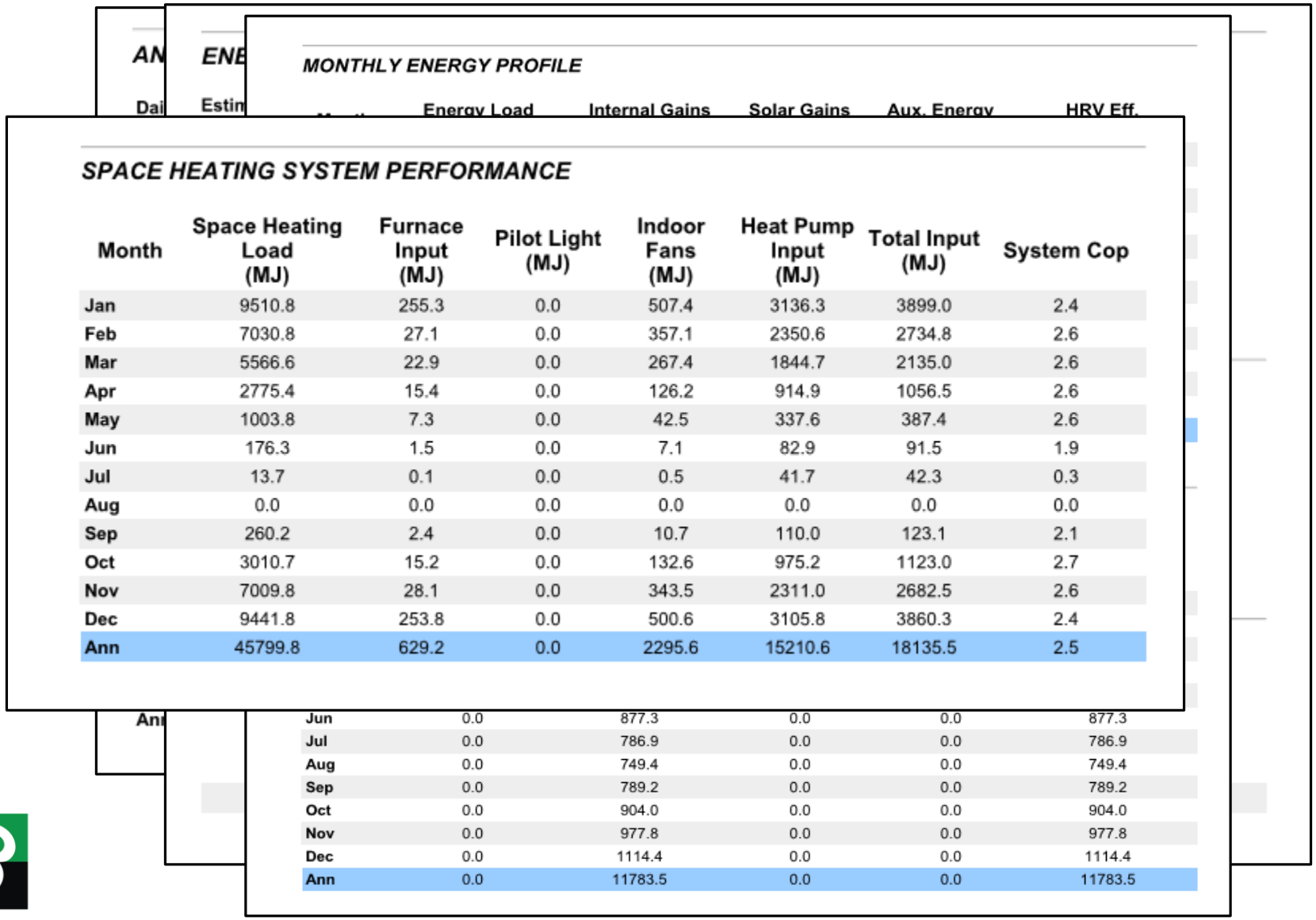
An Energy Model Includes:

- Air tightness of envelope
- Lighting and appliance loads
- Assumptions for occupant habits.

An Energy Model Provides:

- Estimation of annual energy consumed for heating, DHW, lighting and appliances
- Heat loss through the envelope components.

An Energy Model Provides:



SPACE HEATING SYSTEM PERFORMANCE

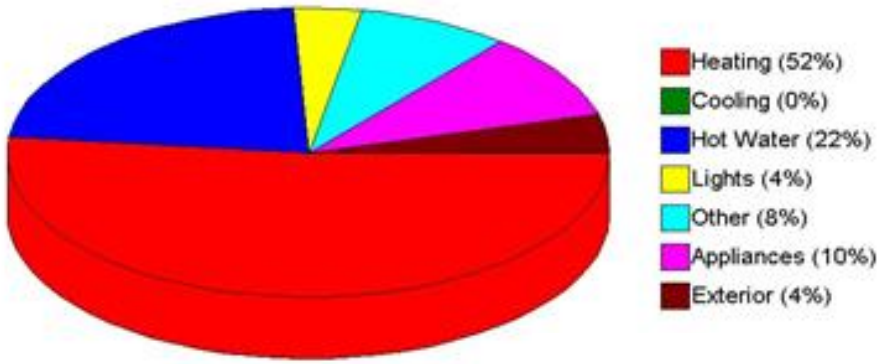
Month	Space Heating Load (MJ)	Furnace Input (MJ)	Pilot Light (MJ)	Indoor Fans (MJ)	Heat Pump Input (MJ)	Total Input (MJ)	System Cop
Jan	9510.8	255.3	0.0	507.4	3136.3	3899.0	2.4
Feb	7030.8	27.1	0.0	357.1	2350.6	2734.8	2.6
Mar	5566.6	22.9	0.0	267.4	1844.7	2135.0	2.6
Apr	2775.4	15.4	0.0	126.2	914.9	1056.5	2.6
May	1003.8	7.3	0.0	42.5	337.6	387.4	2.6
Jun	176.3	1.5	0.0	7.1	82.9	91.5	1.9
Jul	13.7	0.1	0.0	0.5	41.7	42.3	0.3
Aug	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sep	260.2	2.4	0.0	10.7	110.0	123.1	2.1
Oct	3010.7	15.2	0.0	132.6	975.2	1123.0	2.7
Nov	7009.8	28.1	0.0	343.5	2311.0	2682.5	2.6
Dec	9441.8	253.8	0.0	500.6	3105.8	3860.3	2.4
Ann	45799.8	629.2	0.0	2295.6	15210.6	18135.5	2.5

MONTHLY ENERGY PROFILE

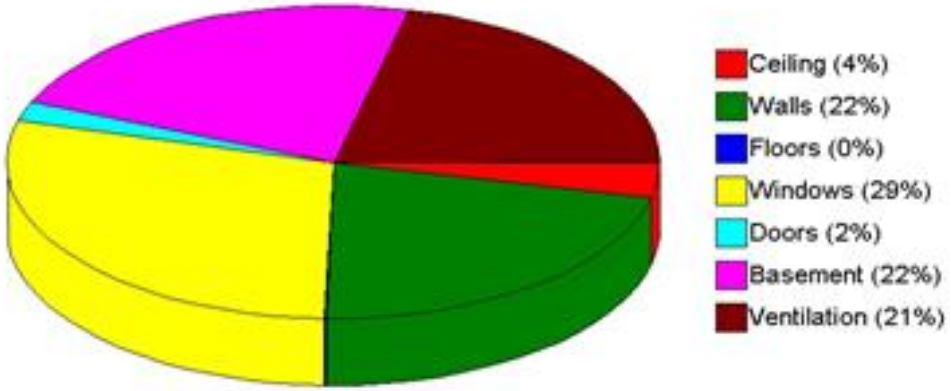
	Energy Load	Internal Gains	Solar Gains	Aux. Energy	HRV Eff.
Jun	0.0	877.3	0.0	0.0	877.3
Jul	0.0	786.9	0.0	0.0	786.9
Aug	0.0	749.4	0.0	0.0	749.4
Sep	0.0	789.2	0.0	0.0	789.2
Oct	0.0	904.0	0.0	0.0	904.0
Nov	0.0	977.8	0.0	0.0	977.8
Dec	0.0	1114.4	0.0	0.0	1114.4
Ann	0.0	11783.5	0.0	0.0	11783.5

An Energy Model Provides:

COMPONENTS OF ANNUAL ENERGY CONSUMPTION



COMPONENTS OF ANNUAL HEAT LOSS



Definitions:

Energy Auditing:

- Deals with an existing house
- Site visit to verify construction specs
- Performed after construction to update the modeling data
- Also performed on older existing house as part of grant programs.

An Energy Audit Includes:

- Blower fan testing
- Verification of construction geometry and specs
- Updating of the energy model
- Submittals to NRCan if an Energuide Rating.

Applications:

Section 9.36 compliance:

1) Prescriptive insulation tables
2) Trade off options
3) Energy modeling option.

Applications:

Will energy modeling ever be used?

Why not just go prescriptive?

Applications:

Part 10 had an energy modeling option:

Section 10.2. Energy Efficiency

10.2.1.Design and Installation

10.2.1.1.Design

1) Except as provided for in Sentences (2) or (4), all *buildings* shall be designed to conform with ANSI/ASHRAE/IESNA 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings".

2) Except as permitted in Sentence (3), those parts of *buildings* of *residential major occupancy* in *buildings* of less than 5 *storeys* in *building height* shall be provided with thermal insulation between heated and unheated space, the exterior air or the exterior *soil*, and heating floor assemblies and heated areas below in conformance to Table 10.2.1.1. A.

3) Alternatives to the requirements of Table 10.2.1.1.A may be determined through

a) the use of energy computer modeling resulting in an equivalent performance to the prescribed requirements in Table 10.2.1.1.A, (See Appendix A), or

b) achieving an EnerGuide Rating System rating of 77, verified by an EnerGuide Rating System energy advisor licensed by Natural Resources Canada to evaluate the energy efficiency of new houses.

Lesson from Part 10:

Part 10- Prescriptive or Energuide 77:

- How did they compare?
- How was it possible to build houses which only reached Energuide 60?

Lesson from Part 10:

What happened here?

- 8.07ACH@50Pa
- mid-efficiency boiler
- gas fireplace with pilot light
- HRV/R22/basement insulated.

Applications- Moving Forward:

Consider:

- 9.36 introduces “performance” metrics rather than just “prescriptive” measures (wall insulation)
- Does this open the door to more performance metrics in the Code?
- Architects, Designers and Builders can start to think beyond 2x6 R20.

Applications- Moving Forward:

Beyond the 2x6 R20 wall:

- City of Vancouver will specify “effective R22” as of January 1, 2015
- Colder climate zones of BC will require similar (effective R21.9) in 9.36
- In Lower Mainland climate, may see 2x4 R14 with exterior insulation or alternatives.

Section 9.36- Moving Forward:

Apply this idea beyond just the walls:

- That is the essence of energy modeling
- "Tell me the end goal, not how to get there"
- Prescriptive measures don't necessarily guarantee performance; what's missing?

Section 9.36:

3 Compliance Options:

1) Prescriptive
   - Table of effective RSI values
   - HRV/ no HRV options
   - Window performance specs
   - Space heating equipment specs
   - Air barrier installation specs.

Section 9.36:

2) Prescriptive with trade offs (9.36.2.11)

- Start with effective RSI value table
- Offset low RSI areas with higher RSI areas
- Maintain the same A/RSI value- but keep A constant.

Section 9.36:

3) Performance (Energy Modeling)

- 9.36.5 Energy Performance Compliance
- 25 pages of Code.

Why Use Energy Performance?

Potential benefits to energy modeling path:

- More options than trade offs
- Proposed insulation values can be dropped more than with trade offs
- A more “wholistic” approach.

Energy Performance Protocol:

1) Model the “reference house”
2) Model the “proposed house”
3) Annual energy consumption (space conditioning energy and service water heating energy) of proposed house shall not exceed the energy consumption of the reference house.

Energy Modeling Software:

- 9.36.5.4.8b: “tested in accordance with ANSI/ASHRAE 140, “Evaluation of Building Energy Analysis Computer Programs”
- Energy modeling calculations shall account for energy used for space heating, ventilation, service water heating and space cooling.

Energy Modeling Software:

9.36.5.6. Building Envelope Calculations

1) For each hour of the year, the energy model calculations shall account for heat transfer through wall assemblies, roof-ceiling assemblies, including attics where applicable, and exposed floor assemblies due to the thermal characteristics of the particular assembly and thermal bridging.

2) The following *building* envelope assemblies and components shall be addressed in the energy model calculations:

a) above-ground walls and roof-ceiling assemblies,

b) floors and walls in contact with the ground, and

Energy Modeling Software:

c) doors, windows and skylights.

(See Subsection 9.36.2.)

3) For each wall assembly, fenestration component, roof-ceiling assembly and exposed floor assembly, the energy model calculations shall account for

a) the area of the interior side of the insulated surface,

b) emissivity, and

c) the effective thermal resistance or overall thermal transmittance, as applicable.

4) The energy model calculations shall account for the effect that each assembly in contact with the ground has on below-*grade* heat transfer due to

a) the geometry of the *foundation*,

b) *soil* conditions (see A-1.1.3.1.(1) in Appendix A), and

c) the configuration of the insulation.

Energy Modeling Software:

5) The energy model calculations shall account for heat transfer through fenestration separating *conditioned spaces* from the outdoors, including skylights, while accounting for both temperature difference and transmission of solar radiation based on

a) orientation as a function of azimuth and tilt of the surface,

b) area of frame opening and glazed area,

c) overall thermal transmittance, and

d) solar heat gain coefficient.

6) Where the energy model calculations account for the effect of thermal mass, the contents of the house shall be excluded. (See Appendix A.)

7) The energy model calculations shall account for the presence of thermally active walls, floors and ceilings with embedded conditioning systems that form part of the *building* envelope.

8) Where skylights are installed in the roof, the gross roof area shall be determined in accordance with Sentence 9.36.2.3.(3).

9) Skylights shall be considered to have no shading.

10) The energy model calculations shall account for the effects of exterior permanent and fixed shading only on solar heat gain from fenestration.

11) The ratio of fenestration area to opaque area of doors shall be the same for the proposed and reference houses. (See Appendix A.)

Energy Modeling Software:

9.36.5.7. HVAC System Calculations

1) The energy model calculations shall account for the energy consumption of each heating, ventilating and, where installed, cooling system for each hour of the year. (See Appendix A.)

2) Each heating system and, where installed, cooling system shall be accounted for separately in the energy model calculations.

3) *Conditioned spaces* in both the reference and proposed houses shall be modeled as being

Energy Modeling Software:

a) heated, where only heating systems are provided in the proposed house,

b) cooled, where only cooling systems are provided in the proposed house, or

c) heated and cooled, where complete heating and cooling systems are provided in the proposed house.

4) The performance requirements stated in Table 9.36.3.10. shall be used in the energy model calculations.

5) Where duct and piping losses are accounted for in the energy model calculations, they shall be included for both the proposed and reference houses and calculated the same way for both houses. (See Appendix A.)

6) The same time periods shall be used in the simulation of the operation of the ventilation system for both the proposed and reference houses.

7) During the heating season, any solar and internal heat gains that cause an increase in space temperature beyond 5.5°C above the setpoint shall be

a) excluded from the energy model calculations, or

b) calculated as being vented from the house.

8) The energy model calculations shall account for the part-load performance of equipment, including electrical consumption.

9) The energy model calculations shall account for the heat-recovery efficiency of heat-recovery ventilators using a minimum of 2 data test points derived from testing in accordance with Clause 9.36.3.9.(3)(a) or (b), as applicable.

Energy Modeling Software:

- HOT2000.

HOT2000 software:

- Developed and maintained/updated by NRCan
- Used for all Energuide Ratings (new and existing homes) and R2000

HOT2000 software:

- The most prevalent energy modeling software for Part 9 buildings
- Users are trained and licensed by NRCan: Certified Energy Advisors.

Create the Reference House:

- Use appropriate modeling software
- Model the house geometry
- Specify all components to comply with prescriptive measures (thermal envelope and space heating/service water heating equipment)...

Create the Reference House:

- Adjust window area if necessary (min. 17% FDWR, max 22% FDWR)
- Distribute fenestration equally on all sides of reference house
- Specify the airtightness as 2.5ACH@50Pa.

Create the Proposed House:

Change allowable components of the "reference" house to create the "proposed" house:

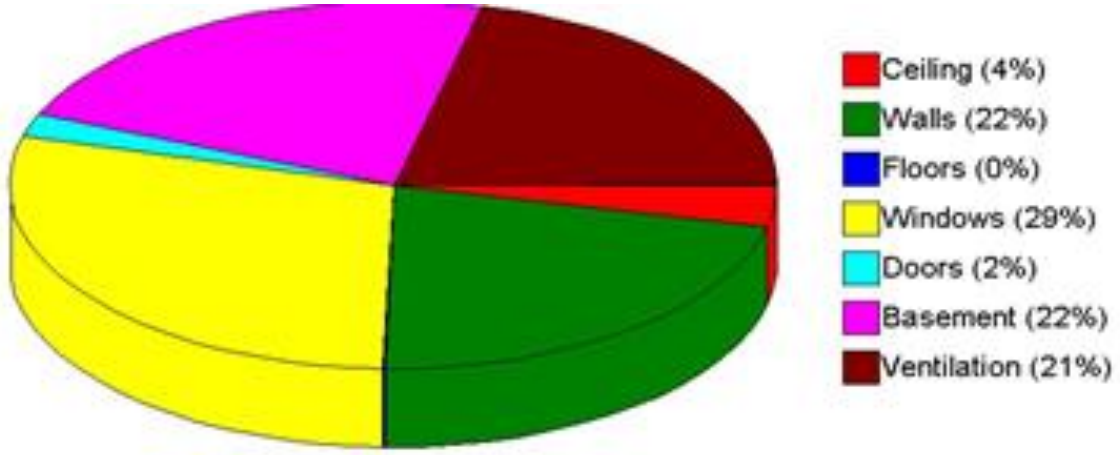
- Envelope thermal values to whatever desired
- Include the actual amount of fenestration to be used in the proposed house
- Mechanical systems can improve in efficiency but must remain same type and fuel…

Create the Proposed House:

- Can add drain water heat recovery
- Airtightness value to be 3.2ACH@50Pa or 2.5ACH@50Pa or as per airtightness test
- No changes to geometry of house, location, orientation, fuel, occupancy.

Energy Performance Compliance WON'T:

- WON'T allow for a heat pump to be used to jack up the performance
- WON'T easily allow for low-performance windows to comply.



Who does the Modeling:

- Suggest that Certified Energy Advisor is most appropriate
- Engineers or Architects are not known to conduct modeling for Part 9 buildings
- Engineers and Architects are more involved in Part 3 buildings; different software and different protocols.

Who does the Modeling:

- Certified Energy Advisor specializes in Part 9 buildings
- CEAs have modeled hundreds of houses/rowhouses/MURBs
- Already a reasonable supply of CEAs for the demand.

Certified Energy Advisor:

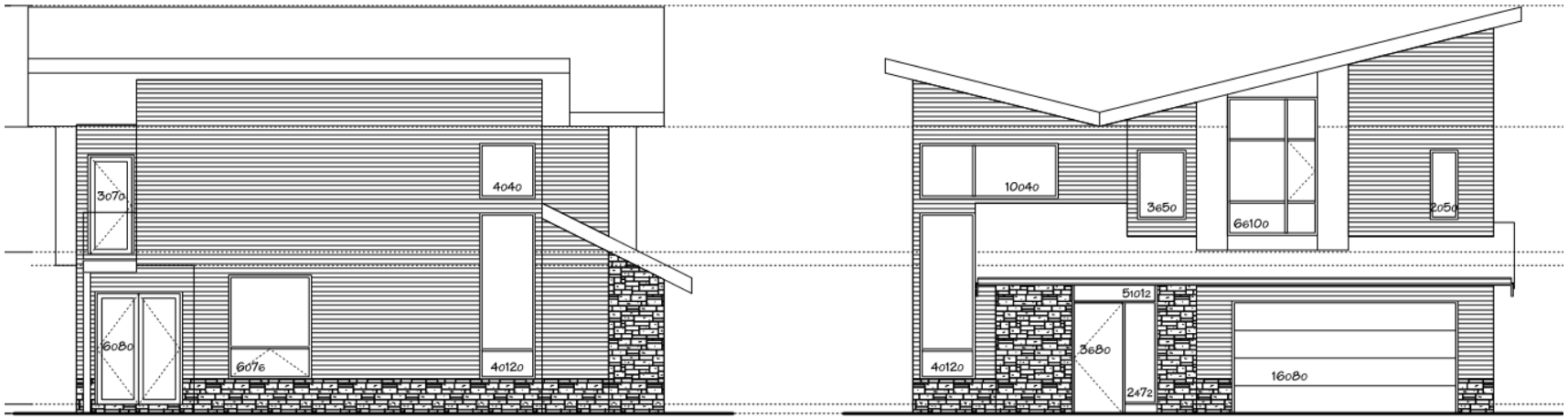
- Trained in BC by Service Organizations
- Certified by NRCan
- QA'd by NRCan and SO
- Experience in construction, building science, new technologies, keeps updated.

Certified Energy Advisor:

- Energy modeling
- Consulting to Builder
- Site inspection and blower fan test
- Update to initial version of “proposed house” if required.

Certified Energy Advisor:

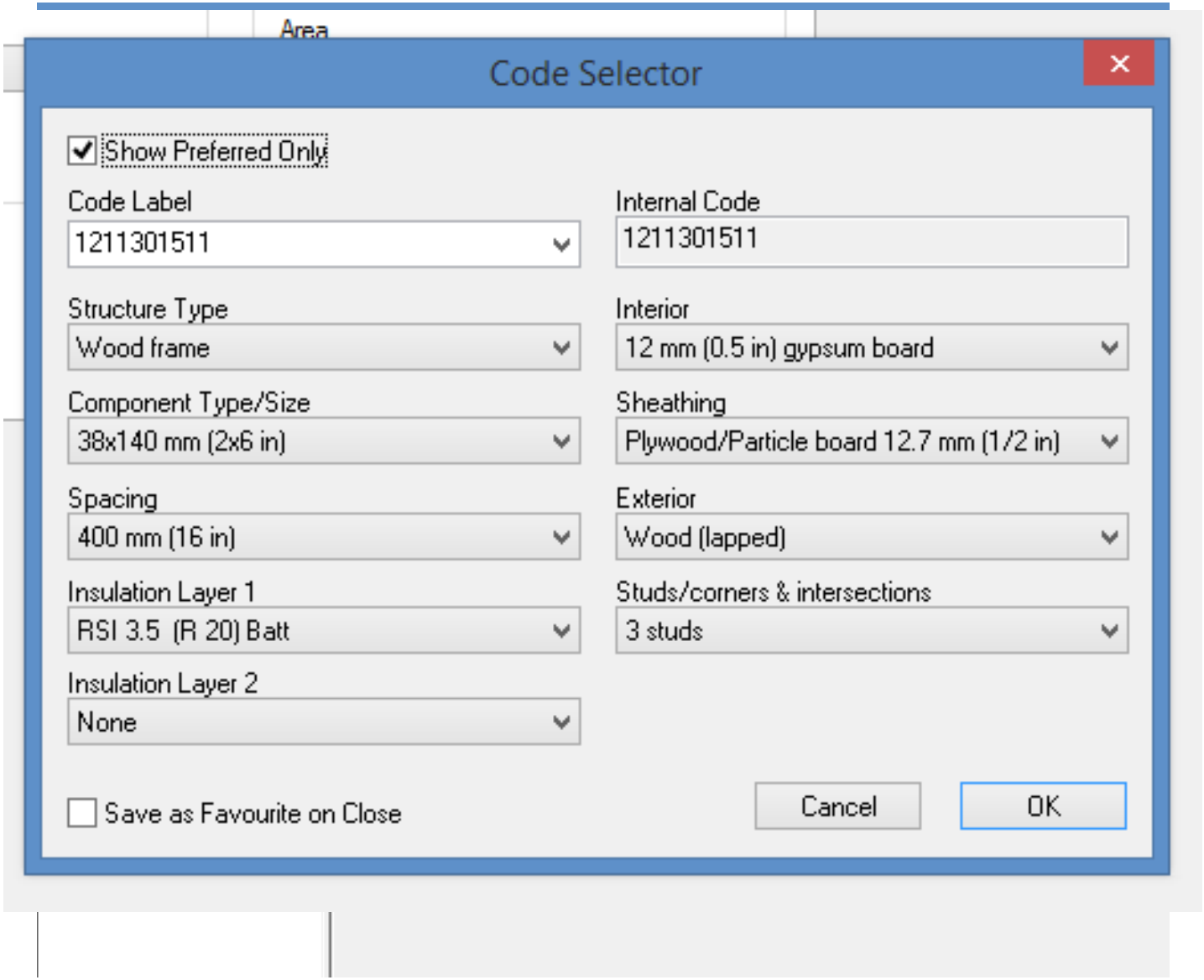
Example of Energy Modeling:



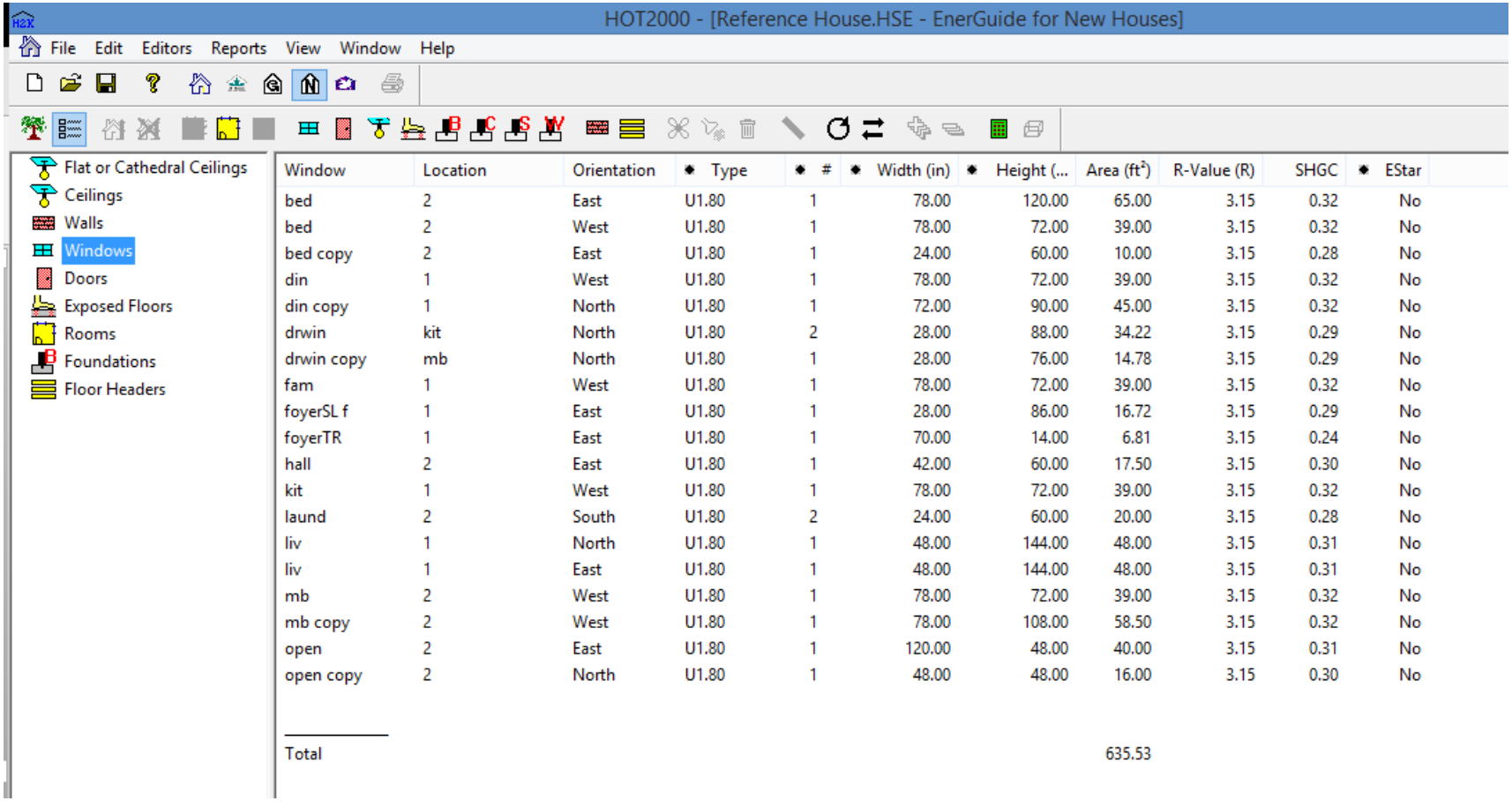
Example of Energy Modeling:

- Single Family House
- Richmond
- Typical construction

Reference House:



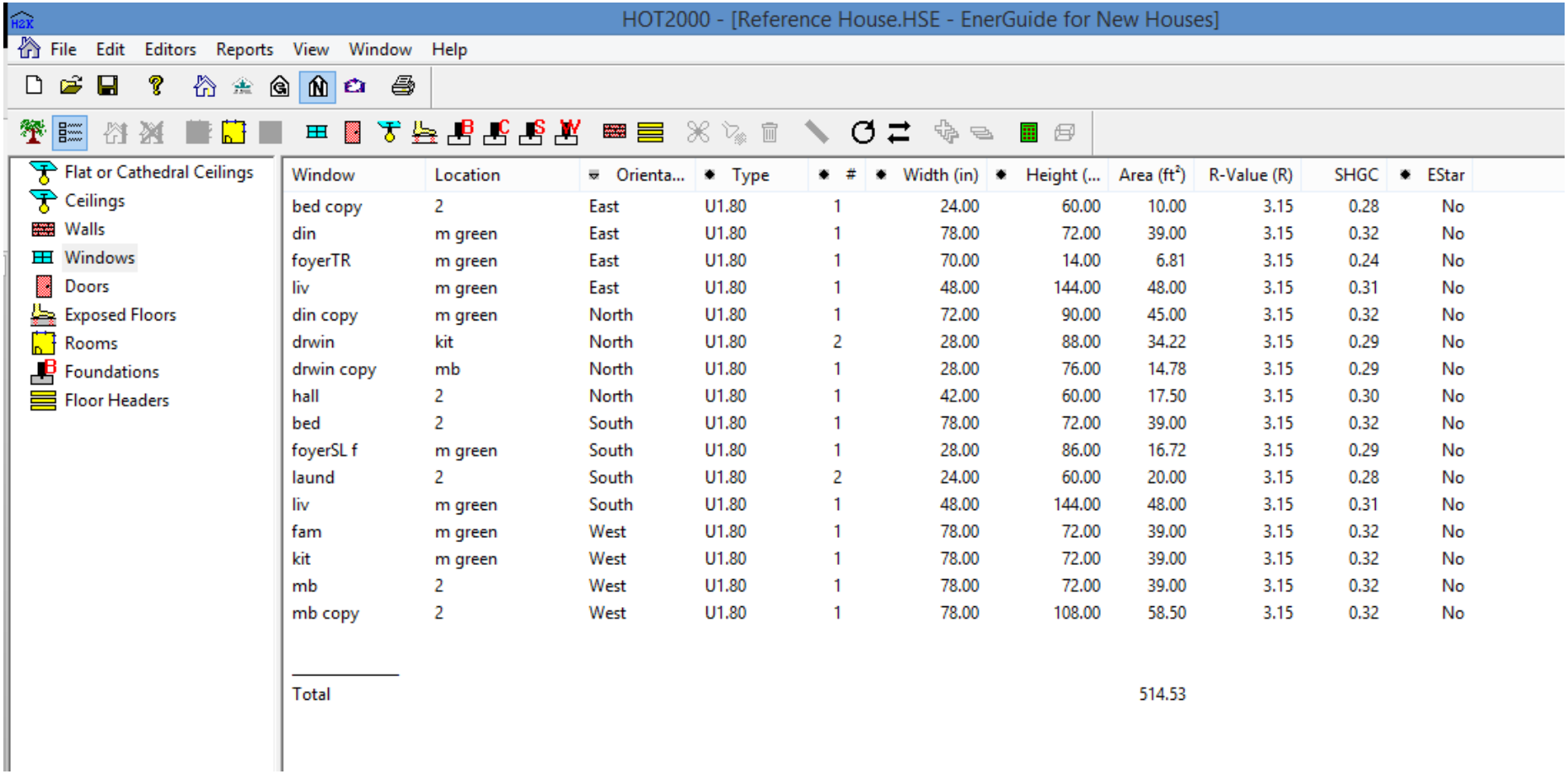
Reference House:



Window	Location	Orientation	Type	#	Width (in)	Height (...	Area (ft²)	R-Value (R)	SHGC	EStar
bed	2	East	U1.80	1	78.00	120.00	65.00	3.15	0.32	No
bed	2	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
bed copy	2	East	U1.80	1	24.00	60.00	10.00	3.15	0.28	No
din	1	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
din copy	1	North	U1.80	1	72.00	90.00	45.00	3.15	0.32	No
drwin	kit	North	U1.80	2	28.00	88.00	34.22	3.15	0.29	No
drwin copy	mb	North	U1.80	1	28.00	76.00	14.78	3.15	0.29	No
fam	1	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
foyerSL f	1	East	U1.80	1	28.00	86.00	16.72	3.15	0.29	No
foyerTR	1	East	U1.80	1	70.00	14.00	6.81	3.15	0.24	No
hall	2	East	U1.80	1	42.00	60.00	17.50	3.15	0.30	No
kit	1	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
laund	2	South	U1.80	2	24.00	60.00	20.00	3.15	0.28	No
liv	1	North	U1.80	1	48.00	144.00	48.00	3.15	0.31	No
liv	1	East	U1.80	1	48.00	144.00	48.00	3.15	0.31	No
mb	2	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
mb copy	2	West	U1.80	1	78.00	108.00	58.50	3.15	0.32	No
open	2	East	U1.80	1	120.00	48.00	40.00	3.15	0.31	No
open copy	2	North	U1.80	1	48.00	48.00	16.00	3.15	0.30	No
Total							635.53			

FDWR = (635.53+ 159.94)/3046.00 = 26%

Reference House:



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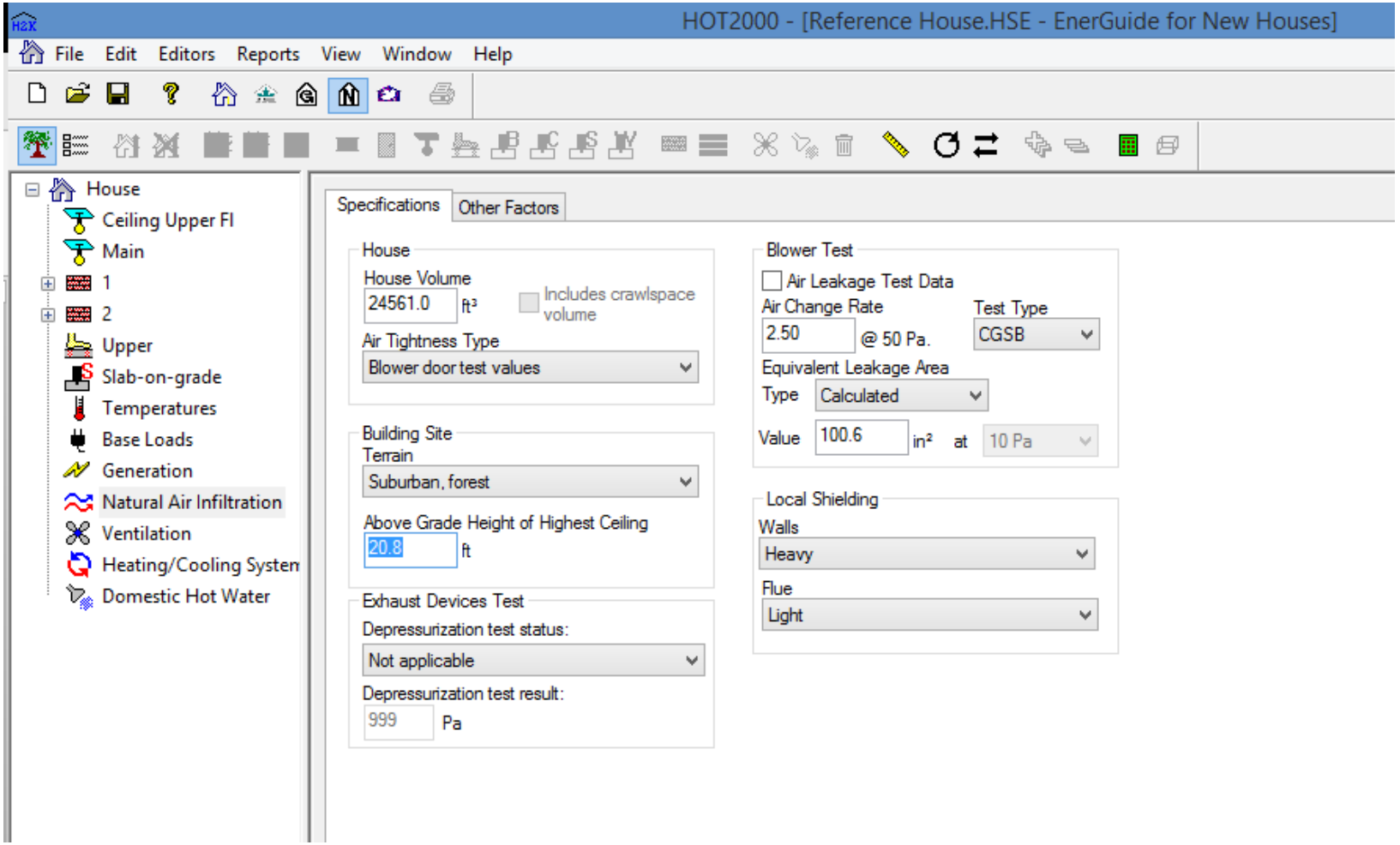
bed copy	2	East	U1.80	1	24.00	60.00	10.00	3.15	0.28	No
din	m green	East	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
foyerTR	m green	East	U1.80	1	70.00	14.00	6.81	3.15	0.24	No
liv	m green	East	U1.80	1	48.00	144.00	48.00	3.15	0.31	No
din copy	m green	North	U1.80	1	72.00	90.00	45.00	3.15	0.32	No
drwin	kit	North	U1.80	2	28.00	88.00	34.22	3.15	0.29	No
drwin copy	mb	North	U1.80	1	28.00	76.00	14.78	3.15	0.29	No
hall	2	North	U1.80	1	42.00	60.00	17.50	3.15	0.30	No
bed	2	South	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
foyerSL f	m green	South	U1.80	1	28.00	86.00	16.72	3.15	0.29	No
laund	2	South	U1.80	2	24.00	60.00	20.00	3.15	0.28	No
liv	m green	South	U1.80	1	48.00	144.00	48.00	3.15	0.31	No
fam	m green	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
kit	m green	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
mb	2	West	U1.80	1	78.00	72.00	39.00	3.15	0.32	No
mb copy	2	West	U1.80	1	78.00	108.00	58.50	3.15	0.32	No
Total							514.53			

FDWR = (514.53+ 159.94)/3046.00 = 22%

Reference House:



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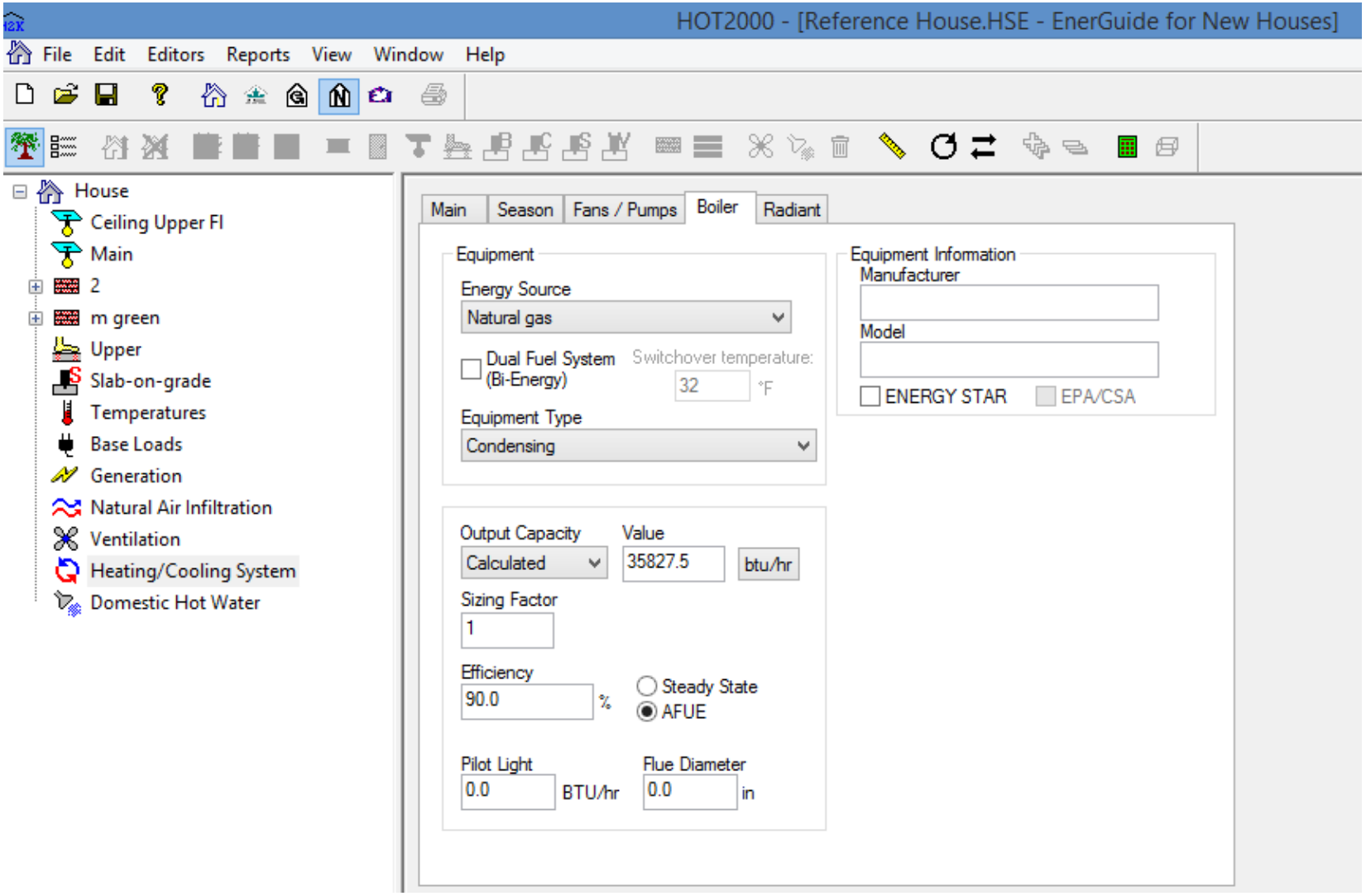


Reference House Energy Target:

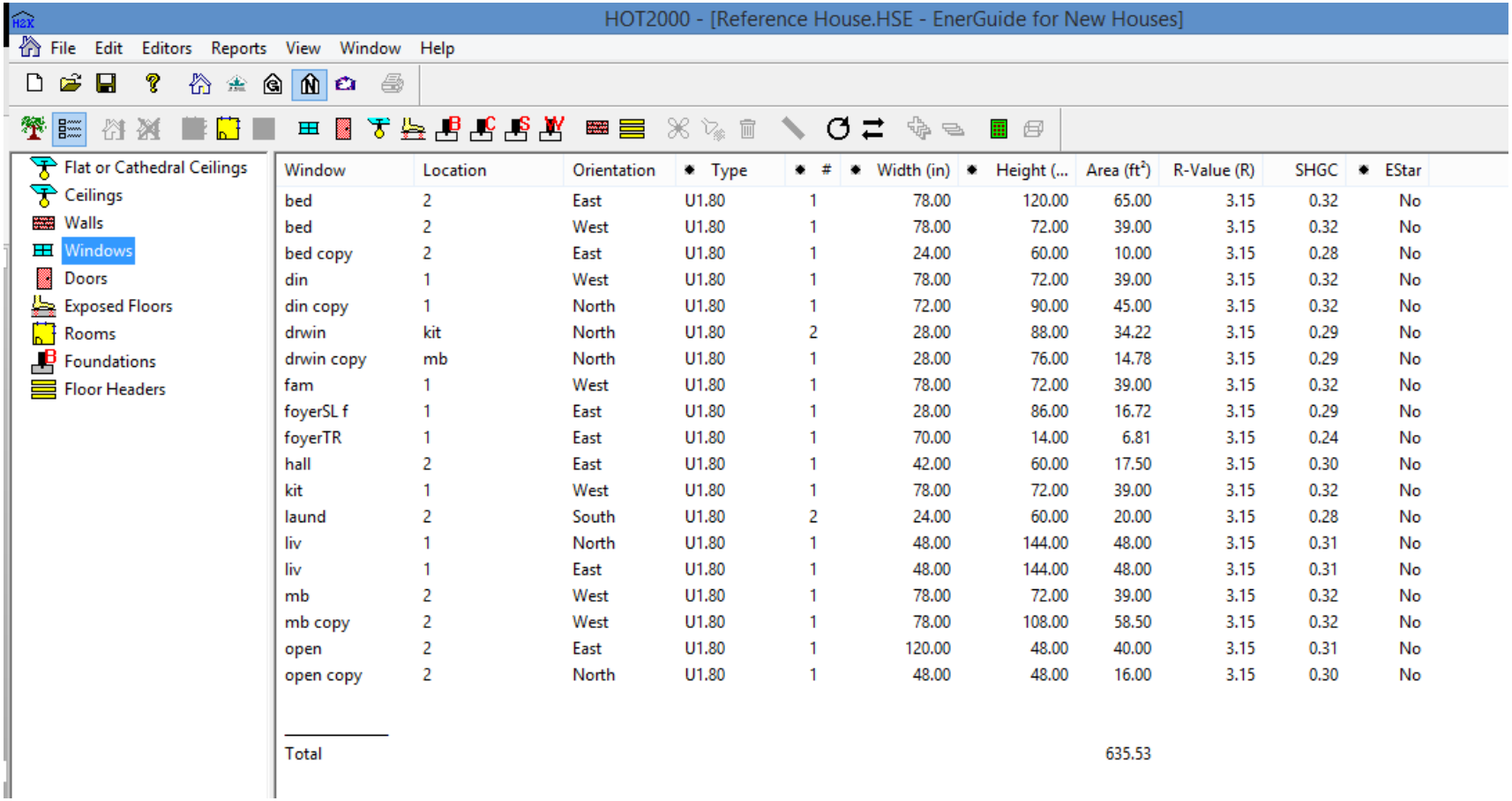
Energy required for:

- Space heating
- Service hot water

ENERGUIDE FOR HOUSES ENERGY CONSUMPTION SUMM

Estimated Annual Space Heating Energy Consumption	= 58433.55 MJ
Ventilator Electrical Consumption: Heating Hours	= 381.36 MJ
Estimated Annual DHW Heating Energy Consumption	= 22607.54 MJ
ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION	= 81422.46 MJ

Proposed House:



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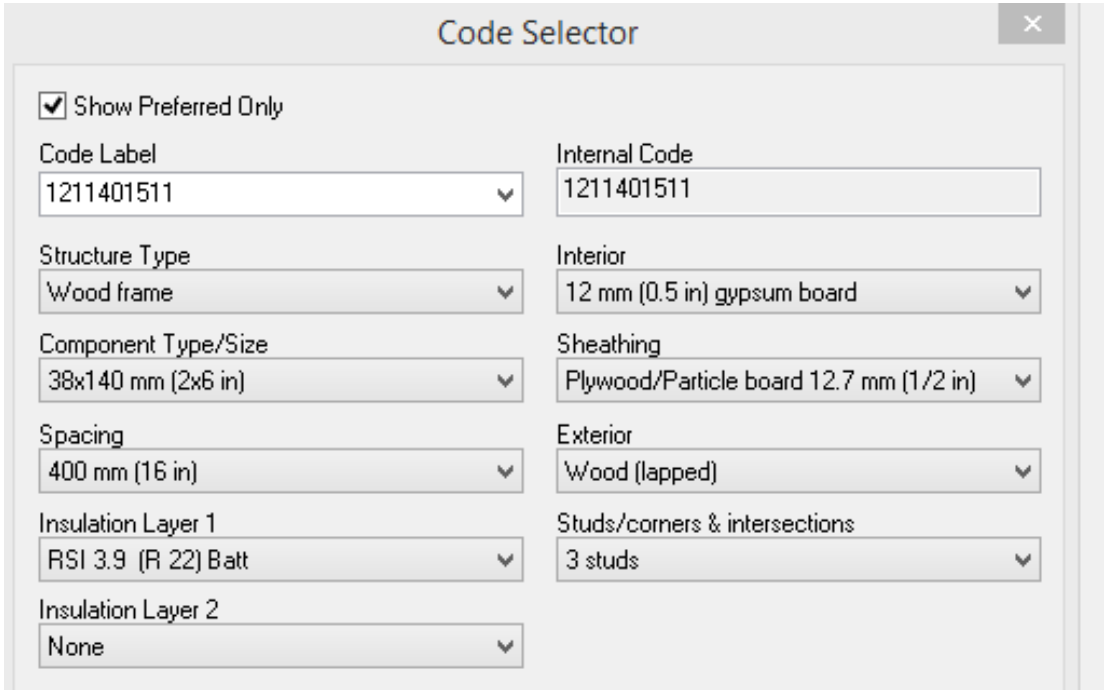
Total							635.53			

Annual Space + DHW Energy Consumption 85050 MJ

Proposed House:



Annual Space + DHW Energy Consumption 83404 MJ

Proposed House:

More upgrades:

- Space heat Boiler to 95% AFUE
- Service water heater to 0.90EF condensing tank

Annual Space + DHW Energy Consumption 75915 MJ

Proposed House:

Blower fan test:

- 4.7 ACH@50Pa
- Problem?

Annual Space + DHW Energy Consumption 77658 MJ

Proposed House:

How low could the windows go?
Single pane?

Annual Space + DHW Energy Consumption 140761 MJ

How low could the walls go?
2x4 R14?

Annual Space + DHW Energy Consumption 87512 MJ

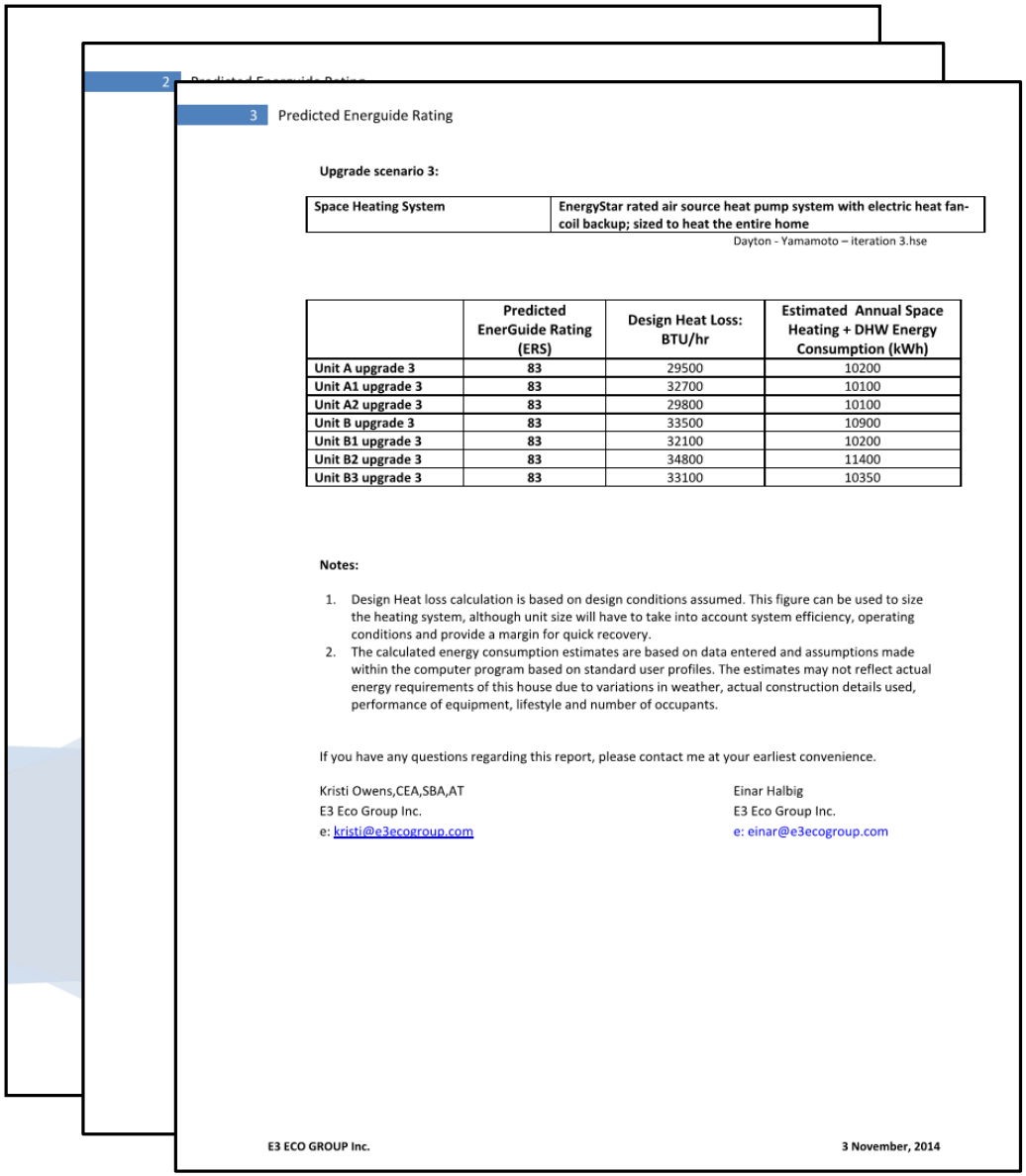
How to Verify:

- Request a summary report from a Certified Energy Advisor (CEA)
- This is standard practice by municipalities using the Energuide Rating as a tool for rezoning/density bonus
- CEAs are the primary resource for Part 9 energy modeling and auditing.

How to Verify:

- 9.36.5.10.1) requires “the energy model calculations for the proposed house shall be consistent with the proposed construction specifications for that house”
- How can municipalities verify this?

How to Verify:



3 Predicted Energuide Rating

Upgrade scenario 3:

Space Heating System	**EnergyStar rated air source heat pump system with electric heat fan-coil backup; sized to heat the entire home**

Dayton - Yamamoto – iteration 3.hse

	Predicted EnerGuide Rating (ERS)	Design Heat Loss: BTU/hr	Estimated Annual Space Heating + DHW Energy Consumption (kWh)
Unit A upgrade 3	**83**	29500	10200
Unit A1 upgrade 3	**83**	32700	10100
Unit A2 upgrade 3	**83**	29800	10100
Unit B upgrade 3	**83**	33500	10900
Unit B1 upgrade 3	**83**	32100	10200
Unit B2 upgrade 3	**83**	34800	11400
Unit B3 upgrade 3	**83**	33100	10350

Notes:

1. Design Heat loss calculation is based on design conditions assumed. This figure can be used to size the heating system, although unit size will have to take into account system efficiency, operating conditions and provide a margin for quick recovery.
2. The calculated energy consumption estimates are based on data entered and assumptions made within the computer program based on standard user profiles. The estimates may not reflect actual energy requirements of this house due to variations in weather, actual construction details used, performance of equipment, lifestyle and number of occupants.

If you have any questions regarding this report, please contact me at your earliest convenience.

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How to Verify:

Weather Location: Vancouver

Base Case Review: Single Family Dwelling

Slab on Grade	R12 full under slab insulation and R12 skirt insulation
Above Grade Wall Construction	2x6 @ 16"o.c. R20 interior batt insulation & R20 headers
Roof Construction	Hip roof: Trusses @ 24"o.c with R40 batt insulation; cathedral ceilings: 2x10 @ 24" o.c. with R28 batt insulation
Window Specification	Double glazed, soft coat low-E, metal spacer, fixed windows with vinyl frames
Door Specification	Steel with polyurethane insulation core. Glazing in doors: Double
Supplemental Heating	Natural Gas fireplace with spark ignition (sealed) (not all units have fireplaces)
Domestic Hot Water	Natural Gas, Indirect Fired Water Heater, 50 US gal tank, e.f. 0.79 (Triangle tube Smart Series)
Energy Credits:	
Drainwater Heat Recovery	0 kWh/yr
Low energy lighting	0 kWh/yr
Energy Star appliances	0 kWh/yr

	Predicted EnerGuide Rating (ERS)	Design Heat Loss: BTU/hr	Estimated Annual Space Heating + DHW Energy Consumption (kWh)
Unit A base case	**76**	29500	18800

Dayton - Yamamoto – basecase.hse

How to Verify:

- Request the “Full House Report” as generated by HOT2000
- Full House Report lists all input and calculations
- If you want it “official”, require an Energuide Rating
- City of Vancouver requires this for all new houses.

Summary:

- Section 9.36 allows compliance by energy modeling
- Energy modeling will likely not be employed often
- Municipalities should look for CEAs to perform the energy modeling and report on it.

QUESTIONS