High-Performance Homes
HVAC Mechanical Design

Prepared by:

Rob Pope
Ecolighten Energy Solutions

AGENDA

1. Standards of Practice
2. Importance of Right-Sizing with F280-12
3. Case Study from 319 & 321 Blackman Street
4. Key Takeaways for Builders

CURRENT PRACTICES

- Typical home design is done without anticipation or planning for the home's necessary HVAC system. This approach often leads to limited design choices, additional costs for mechanicals, inadequate performance and frustration for builders and homeowners alike.

- As homes become more energy-efficient, oversized HVAC equipment is emerging as one of the more serious issues in residential construction.

LOAD CALCULATIONS:
Too often 'Rule of Thumb'

HVAC DESIGN:
More coincidental than coordinated

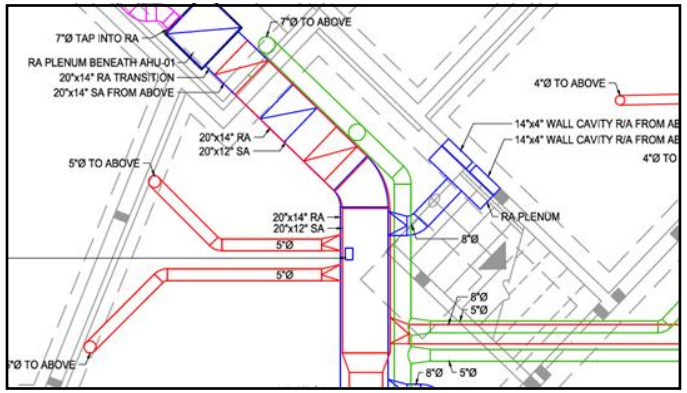
VERIFICATION:
System commissioning is infrequent

BEST PRACTICES

- Best practices in HVAC design start with code compliant F280-12 load calculations as the foundation on which all other HVAC decisions are dependent.

- Integrated and coordinated design between builders, architects/designers, mechanical designers and contractors will optimize the HVAC system performance within changes in housing form, style, design and construction that have impacted the mechanical needs of today's housing.

LOAD CALCULATIONS:
CSA F280-12 Compliant



HVAC DESIGN:
Integrated design practices

VERIFICATION:
Start-up performance documented

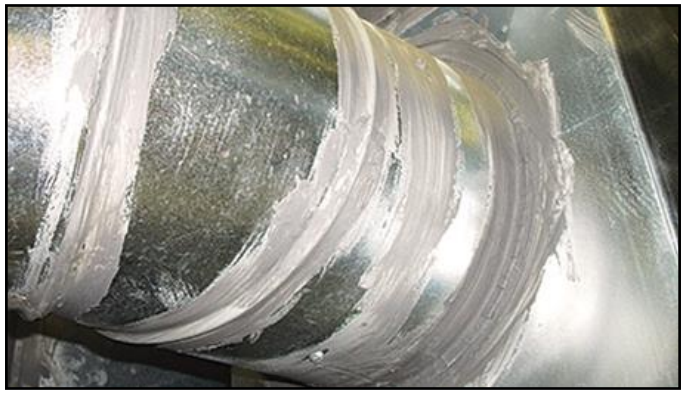
NEXT PRACTICES

- HVAC design landscape is quickly evolving and driven by regulatory changes (e.g. Energy Step Code) and new technologies. Adapting to these changes requires better building/design processes.

- Standardizing HVAC design information for purposes of compliance will encourage better practices by industry, and result in improved energy performance required by BC Building Code and Energy Step Code.

MID-STAGE BLOWER DOOR TESTING:
Confirm air tightness targets

STANDARDIZING HVAC COMPLIANCE:
Harmonizing permitting requirements

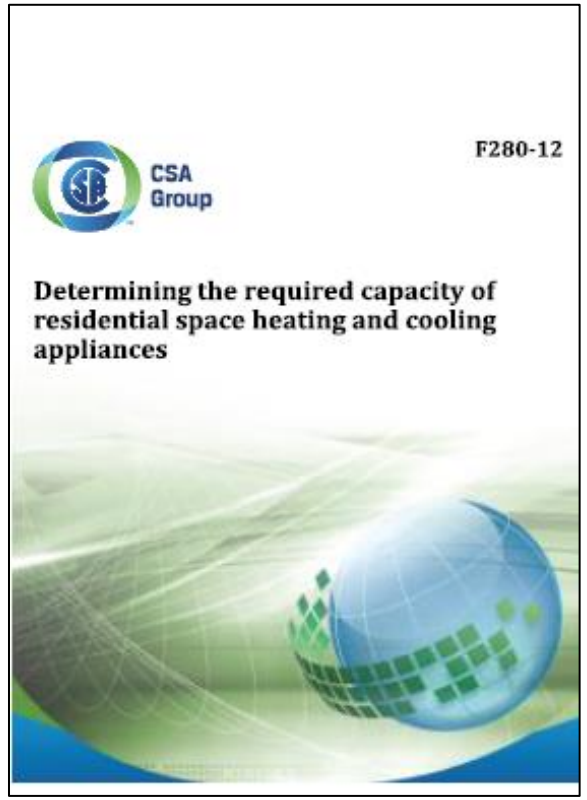


INSPECTIONS:
Verifying installation practices

CAN/CSA F280-12

- F280-12 is the CSA standard for how to properly size HVAC equipment. Making sure this standard is used can:
  - improve your homebuyer's comfort
  - reduce your installed HVAC system costs
  - ensure your comply with code
  - reduce your liability risks

- **The original standard** was published in 1990 and resulted in the oversizing of residential HVAC equipment/ductwork.



KEY CHANGES TO F280-12 STANDARD

- **Key changes from the 1990 version** include:
  - Now recognizes the heat recovery provided by heat and energy recovery ventilators.
  - Now considers advancements in window and wall technologies.
  - Updated air tightness metric, and modelling of infiltration and basement heat loss.

F280-12 & BC BUILDING CODE

- **F280-12 standard is referenced in the BC Building Code** and other building industry publications including:

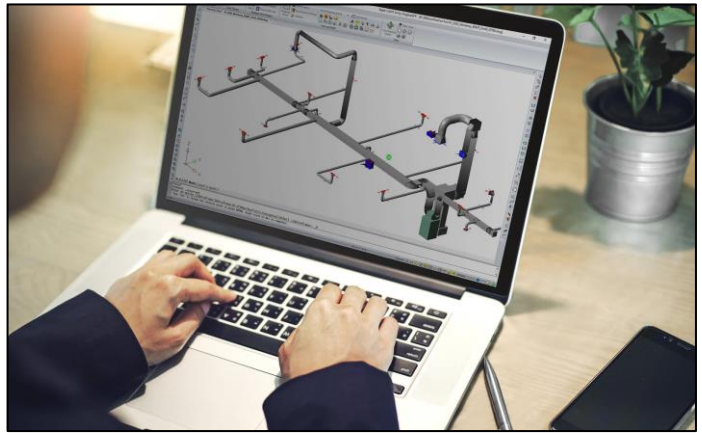
- BCBC Section 9.33.5 Capacity of Heating Appliances:

  - "The required capacity of heating appliances located in a dwelling unit and serving only that dwelling unit, shall be determined in accordance with CSA F280"

- BC Housing states in Energy Efficiency Requirements for Houses in British Columbia:

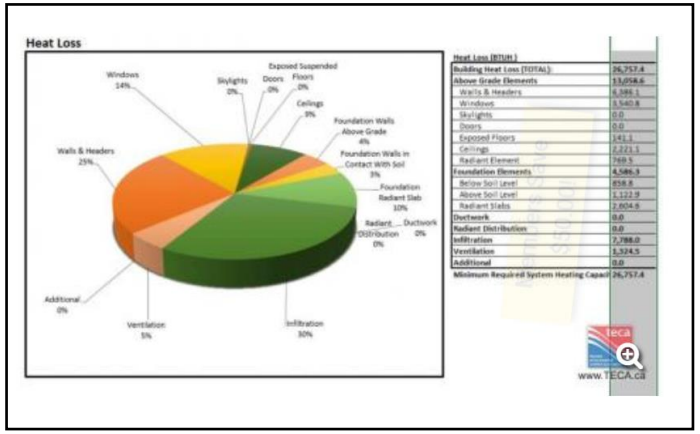
  - *"HVAC systems and ducts are required to be sized in accordance with good practice", such as described in the Thermal Environmental Comfort Association (TECA) reference material, CSA F280, and Section 9.32 and 9.33."*

TREND TOWARDS USE OF F280-12 COMPLIANT SOFTWARE



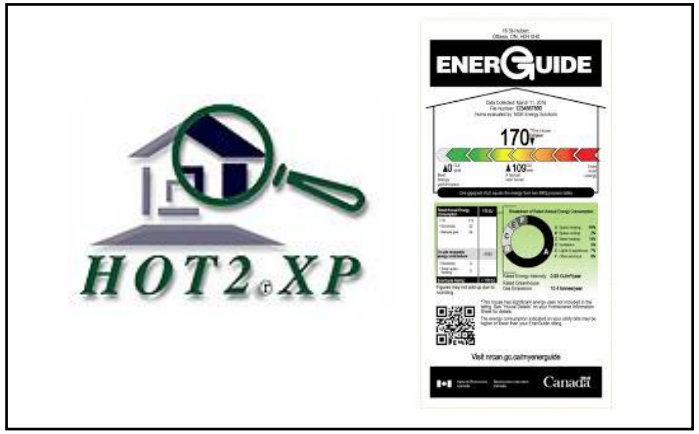
HVAC designers typically use more powerful programs that can also be used for distribution system design.

Wrightsoft is example of company with F280-12 updated software.



HVAC Contractors typically use spreadsheet programs to determine the design heat loss and heat gain.

TECA has released updated F280-12 Quality First™ Companion Software.



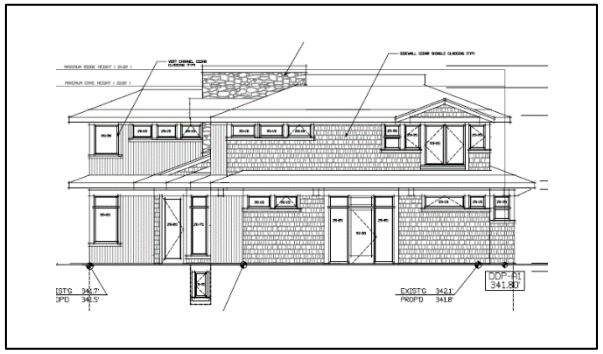
Energy Advisors can use HOT2000 to do F280-12 analysis.

Energy Advisor needs expertise to use so that mechanical contractors can refer to these calculations for sizing heating and cooling systems

F280-12 AT WORK WITH HIGH PERFORMANCE HOMES

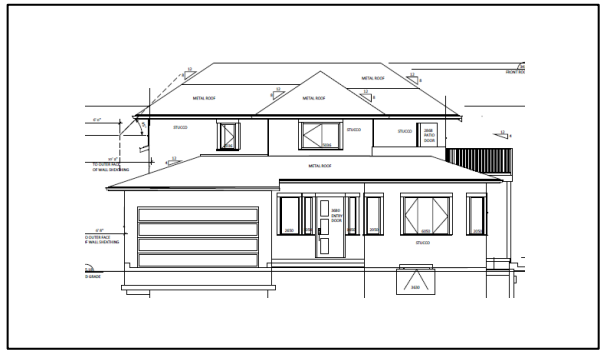
BLACKFISH HOMES

- **Location:** North Vancouver, BC
- **Size:** 4,777 ft^2
- **Construction:** Analysis using combination of as-built and BCBC Minimums



SONBUILT HOMES

- **Location:** Chilliwack, BC
- **Size:** 3,592 ft^2
- **Construction:** Analysis using as-built



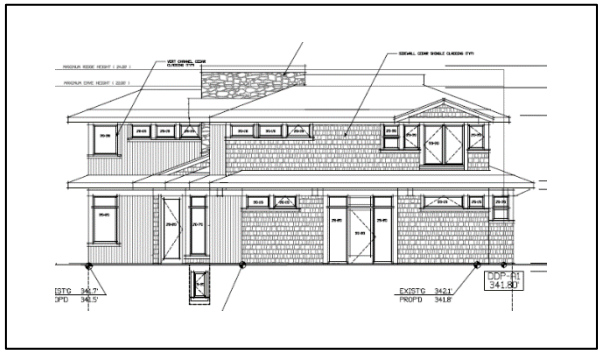
INSIGHTFUL HEALTHY HOMES

- **Location:** North Vancouver, BC
- **Size:** 4,863 ft^2
- **Construction:** Analysis using as-built

F280-12 AT WORK WITH HIGH PERFORMANCE HOMES

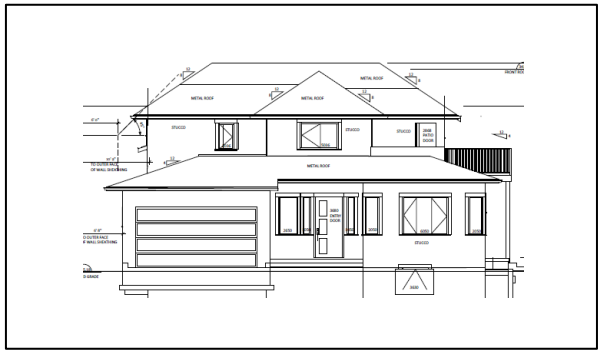
BLACKFISH HOMES

	RULE OF THUMB	F280-12	OVERSIZE
HEATING	64,656 BTU	31,126 BTU	**107%**
COOLING	43,104 BTU	26,440 BTU	**57%**



SONBUILT HOMES

	RULE OF THUMB	F280-12	OVERSIZE
HEATING	71,655 BTU	47,265 BTU	**52%**
COOLING	47,265 BTU	69,884 BTU	**22%** undersized



INSIGHTFUL HEALTHY HOMES

	RULE OF THUMB	F280-12	OVERSIZE
HEATING	72,945 BTU	36,691 BTU	**98%**
COOLING	58,356 BTU	38,045 BTU	**53%**

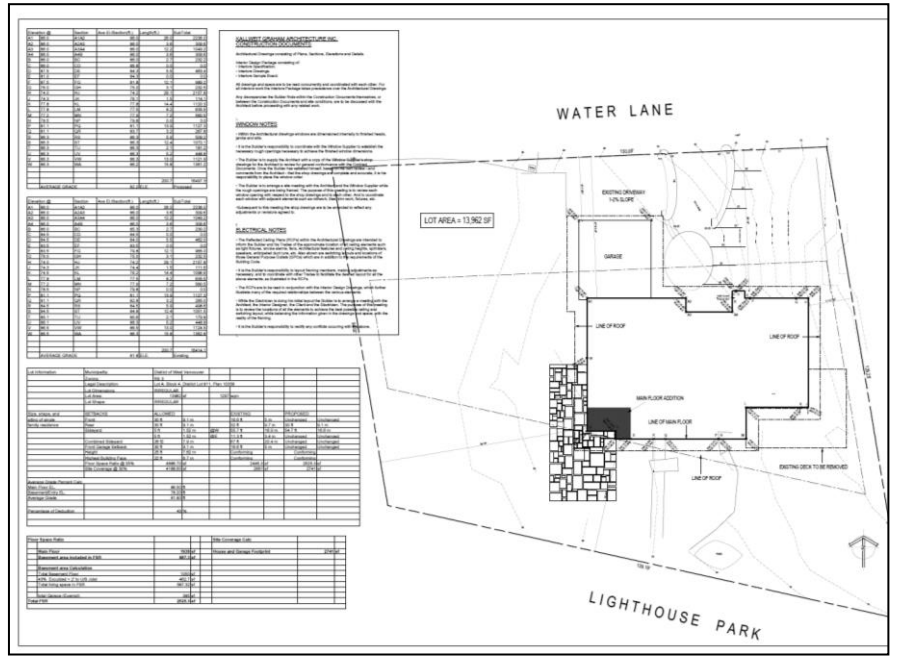
LOAD CALCULATION CHECKLIST FOR BUILDERS

1. Plans that include:
   a. Floor plans
   b. Sections
   c. Elevations
   d. Building Assemblies with effective R-Values
   e. Window sizes with U values & SHGC values

2. Air change target @ 50 pascals (i.e. 2.5 ACH/50, 1.5 ACH/50, etc.)

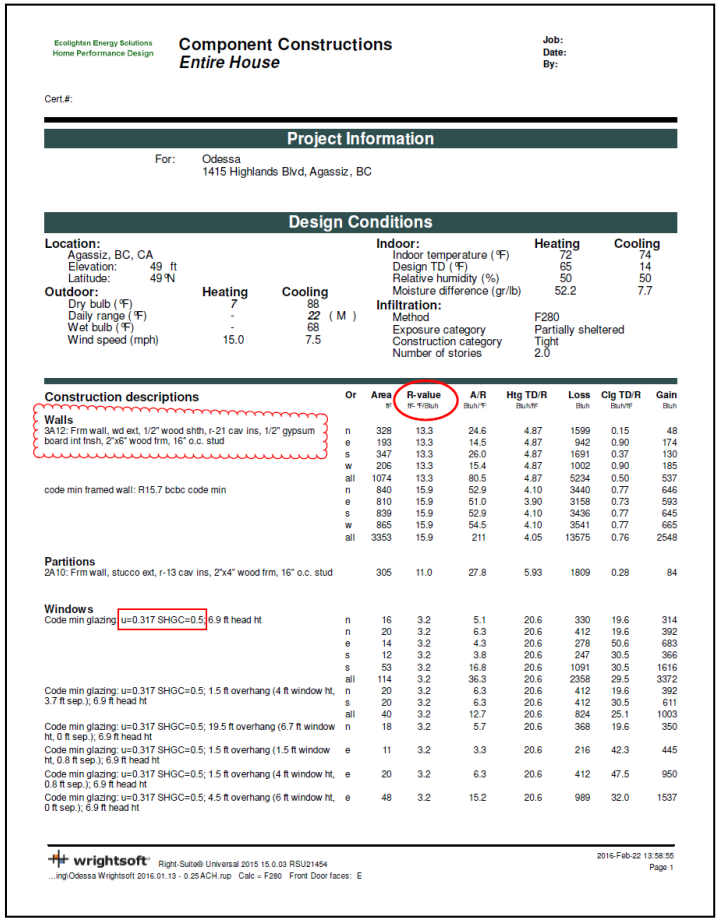
3. Any alternative building assemblies or window packages under consideration.

4. Any mechanical systems already under consideration:
   a. Forced-air or radiant
   b. High Efficient Boiler or Furnace
   c. Air Source Heat Pump, Geothermal
   d. HRV or other
   e. Solar thermal



LOAD CALCULATION CHECKLIST FOR BUILDERS

1. **Check** that building assemblies and related R-values & U- values make sense



Ecolighten Energy Solutions
Home Performance Design

Component Constructions
Entire House

Job:
Date:
By:

Cert.#:

Project Information

For: Odessa
1415 Highlands Blvd, Agassiz, BC

Design Conditions

Location:		Indoor:	Heating	Cooling
Agassiz, BC, CA		Indoor temperature (°F)	72	74
Elevation:	49 ft	Design TD (°F)	65	14
Latitude:	49 °N	Relative humidity (%)	50	50
Outdoor:	**Heating** / **Cooling**	Moisture difference (gr/lb)	52.2	7.7
Dry bulb (°F)	7 / 88	**Infiltration:**		
Daily range (°F)	- / 22 (M)	Method	F280	
Wet bulb (°F)	- / 68	Exposure category	Partially sheltered	
Wind speed (mph)	15.0 / 7.5	Construction category	Tight	
		Number of stories	2.0	

Construction descriptions	Or	Area ft²	R-value ft²·°F/Btuh	A/R Btuh/°F	Htg TD/R Btuh/ft²	Loss Btuh	Clg TD/R Btuh/ft²	Gain Btuh
Walls								
3A12: Frm wall, wd ext, 1/2" wood shth, r-21 cav ins, 1/2" gypsum board int finish, 2"x6" wood frm, 16" o.c. stud	n	328	13.3	24.6	4.87	1599	0.15	48
	e	193	13.3	14.5	4.87	942	0.90	174
	s	347	13.3	26.0	4.87	1691	0.37	130
	w	206	13.3	15.4	4.87	1002	0.90	185
	all	1074	13.3	80.5	4.87	5234	0.50	537
code min framed wall: R15.7 bcbc code min	n	840	15.9	52.9	4.10	3440	0.77	646
	e	810	15.9	51.0	3.90	3158	0.73	593
	s	839	15.9	52.9	4.10	3436	0.77	645
	w	865	15.9	54.5	4.10	3541	0.77	665
	all	3353	15.9	211	4.05	13575	0.76	2548
Partitions								
2A10: Frm wall, stucco ext, r-13 cav ins, 2"x4" wood frm, 16" o.c. stud		305	11.0	27.8	5.93	1809	0.28	84
Windows								
Code min glazing: u=0.317 SHGC=0.5; 6.9 ft head ht	n	16	3.2	5.1	20.6	330	19.6	314
	n	20	3.2	6.3	20.6	412	19.6	392
	e	14	3.2	4.3	20.6	278	50.6	683
	s	12	3.2	3.8	20.6	247	30.5	366
	s	53	3.2	16.8	20.6	1091	30.5	1616
	all	114	3.2	36.3	20.6	2358	29.5	3372
Code min glazing: u=0.317 SHGC=0.5; 1.5 ft overhang (4 ft window ht, 3.7 ft sep.); 6.9 ft head ht	n	20	3.2	6.3	20.6	412	19.6	392
	s	20	3.2	6.3	20.6	412	30.5	611
	all	40	3.2	12.7	20.6	824	25.1	1003
Code min glazing: u=0.317 SHGC=0.5; 19.5 ft overhang (6.7 ft window ht, 0 ft sep.); 6.9 ft head ht	n	18	3.2	5.7	20.6	368	19.6	350
Code min glazing: u=0.317 SHGC=0.5; 1.5 ft overhang (1.5 ft window ht, 0.8 ft sep.); 6.9 ft head ht	e	11	3.2	3.3	20.6	216	42.3	445
Code min glazing: u=0.317 SHGC=0.5; 1.5 ft overhang (4 ft window ht, 0.8 ft sep.); 6.9 ft head ht	e	20	3.2	6.3	20.6	412	47.5	950
Code min glazing: u=0.317 SHGC=0.5; 4.5 ft overhang (6 ft window ht, 0 ft sep.); 6.9 ft head ht	e	48	3.2	15.2	20.6	989	32.0	1537

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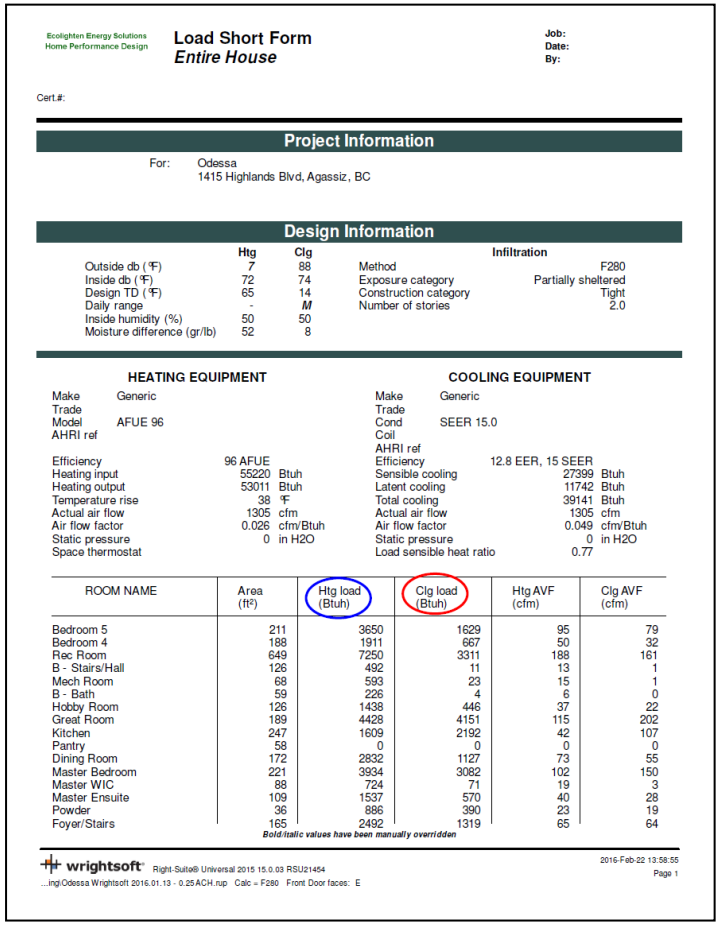
2. **Review** Total Heat Loss & Total Heat Gain



Ecolighten Energy Solutions
Home Performance Design

Load Short Form
Entire House

Job:
Date:
By:

Cert.#:

Project Information

For: Odessa
1415 Highlands Blvd, Agassiz, BC

Design Information

	Htg	Clg		
Outside db (°F)	7	88	**Infiltration**	
Inside db (°F)	72	74	Method	F280
Design TD (°F)	65	14	Exposure category	Partially sheltered
Daily range	-	M	Construction category	Tight
Inside humidity (%)	50	50	Number of stories	2.0
Moisture difference (gr/lb)	52	8		

HEATING EQUIPMENT			COOLING EQUIPMENT	
Make	Generic		Make	Generic
Trade			Trade	
Model	AFUE 96		Cond	SEER 15.0
AHRI ref			Coil	
			AHRI ref	
Efficiency	96 AFUE		Efficiency	12.8 EER, 15 SEER
Heating input	55220 Btuh		Sensible cooling	27399 Btuh
Heating output	53011 Btuh		Latent cooling	11742 Btuh
Temperature rise	38 °F		Total cooling	39141 Btuh
Actual air flow	1305 cfm		Actual air flow	1305 cfm
Air flow factor	0.026 cfm/Btuh		Air flow factor	0.049 cfm/Btuh
Static pressure	0 in H2O		Static pressure	0 in H2O
Space thermostat			Load sensible heat ratio	0.77

ROOM NAME	Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Bedroom 5	211	3650	1629	95	79
Bedroom 4	188	1911	667	50	32
Rec Room	649	7250	3311	188	161
B - Stairs/Hall	126	492	11	13	1
Mech Room	68	593	23	15	1
B - Bath	59	226	4	6	0
Hobby Room	126	1438	446	37	22
Great Room	189	4428	4151	115	202
Kitchen	247	1609	2192	42	107
Pantry	58	0	0	0	0
Dining Room	172	2832	1127	73	55
Master Bedroom	221	3934	3082	102	150
Master WIC	88	724	71	19	3
Master Ensuite	109	1537	570	40	28
Powder	36	886	390	23	19
Foyer/Stairs	165	2492	1319	65	64

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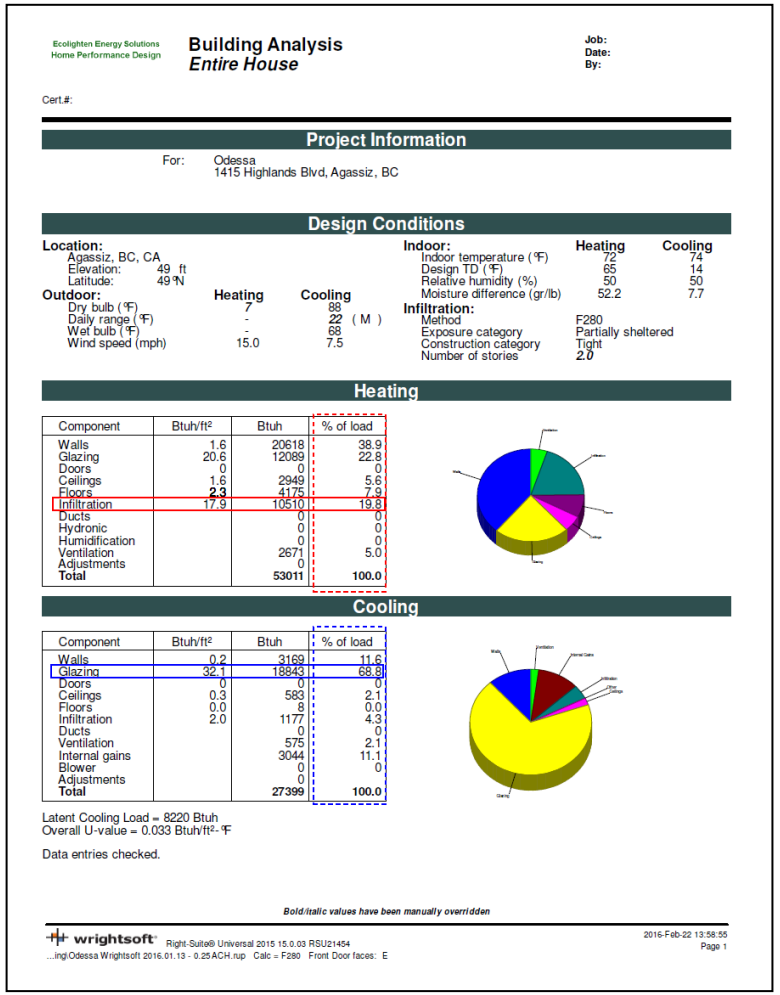
LOAD CALCULATION CHECKLIST FOR BUILDERS



Ecolighten Energy Solutions
Home Performance Design

Building Analysis
Entire House

Job:
Date:
By:

Cert.#:

Project Information

For: Odessa
1415 Highlands Blvd, Agassiz, BC

Design Conditions

Location:
Agassiz, BC, CA
Elevation: 49 ft
Latitude: 49 °N

Outdoor:	Heating	Cooling
Dry bulb (°F)	7	88
Daily range (°F)	-	22 (M)
Wet bulb (°F)	-	68
Wind speed (mph)	15.0	7.5

Indoor:	Heating	Cooling
Indoor temperature (°F)	72	74
Design TD (°F)	65	14
Relative humidity (%)	50	50
Moisture difference (gr/lb)	52.2	7.7

Infiltration:

Method	F280
Exposure category	Partially sheltered
Construction category	Tight
Number of stories	2.0

Heating

Component	Btuh/ft²	Btuh	% of load
Walls	1.6	20618	38.9
Glazing	20.6	12089	22.8
Doors	0	0	0
Ceilings	1.6	2949	5.6
Floors	2.3	4175	7.9
Infiltration	17.9	10510	19.8
Ducts		0	0
Hydronic		0	0
Humidification		0	0
Ventilation		2671	5.0
Adjustments		0	
Total		**53011**	**100.0**

Cooling

Component	Btuh/ft²	Btuh	% of load
Walls	0.2	3169	11.6
Glazing	32.1	18843	68.8
Doors	0	0	0
Ceilings	0.3	583	2.1
Floors	0.0	8	0.0
Infiltration	2.0	1177	4.3
Ducts		0	0
Ventilation		575	2.1
Internal gains		3044	11.1
Blower		0	0
Adjustments		0	
Total		**27399**	**100.0**

Latent Cooling Load = 8220 Btuh
Overall U-value = 0.033 Btuh/ft²·°F

Data entries checked.

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3. <u>Look</u> at what has most impact on your Design Heat Loss / Gain.

4. <u>Review</u> your upgrade options

5. <u>Select</u> your final specifications

A brief heat load/gain summary report will be provided with your chosen specifications.

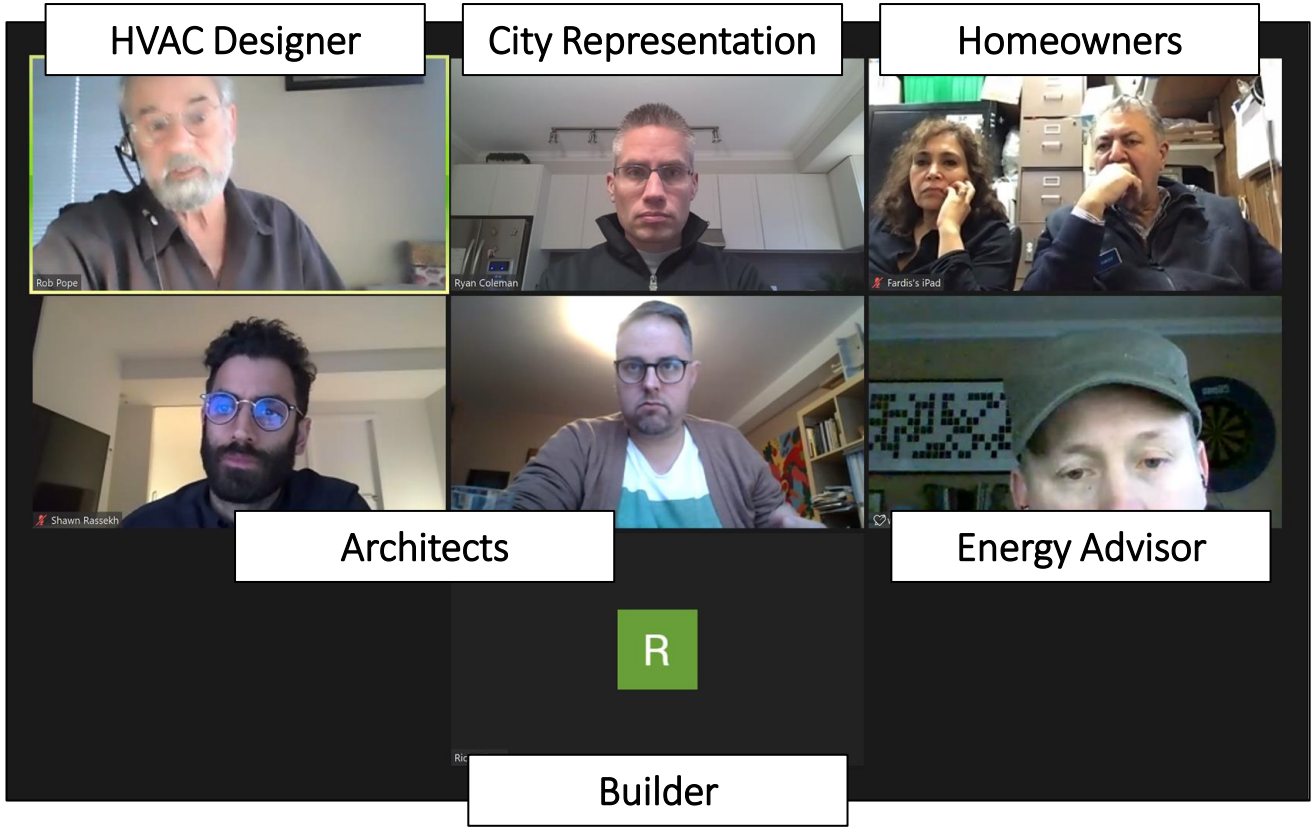
CASE STUDY FROM 319 & 321 BLACKMAN STREET

- Two single-detached custom homes, conditioned floor space 2,720 ft^2
- **Architect:** Burtwhistle Design + RAAF Projects
- **Builder:** Ample Construction
- Homeowner and project team motivated to build better than code minimum and attracted to suite of incentives and technical support offered to support a better constructed home with enhanced benefits.
- Project targeting Energy Step Code Level 4.

CASE STUDY FROM 319 & 321 BLACKMAN STREET

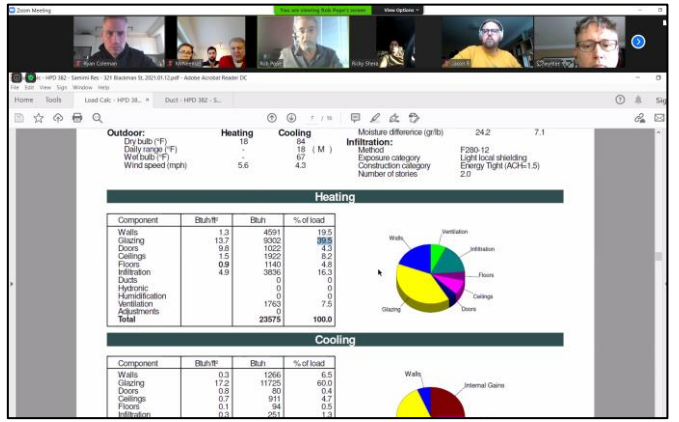
CASE STUDY FROM 319 & 321 BLACKMAN STREET

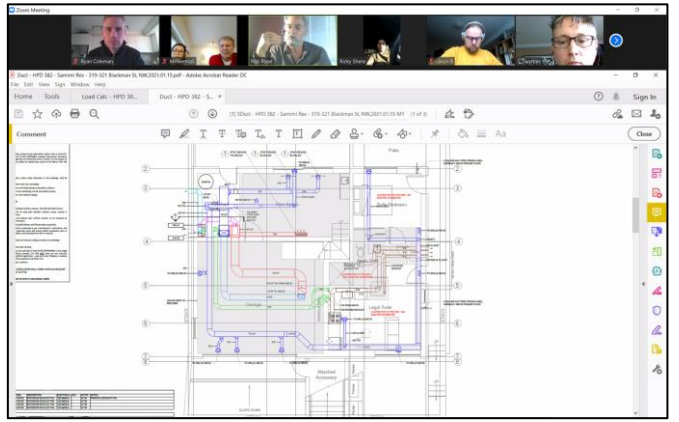
- Collaboration between the City, Utility, Builder, Energy Advisor and Mechanical HVAC Designer through coordinated design sessions including Discovery, Load Calculations & recommendations and HVAC Design review to achieve Step Code 4 house.



CASE STUDY FROM 319 & 321 BLACKMAN STREET

- Key outcomes from coordinated design session:
  - ✓ Project team decision to build a Step Code 4 home.
  - ✓ Confirmation of building assembly and mechanical HVAC requirements to achieve Step Code 4.
  - ✓ Need for load calculations and alignment with HOT2000 modeling.
  - ✓ Appreciation for homeowner performance priorities.
  - ✓ Strategies for field coordination between builder and subtrades.
  - ✓ Insights to inform mechanical design routing to achieve performance requirements and building aesthetics.





CASE STUDY FROM 319 & 321 BLACKMAN STREET

ecolighten

ecolighten energy solutions **Load Short Form**
Entire House
Ecolighten Energy Solutions Ltd.

Job: HPD 382
Date: 2021.01.12
By: Rob Pope

Cert.#: 15-584
SUITE 201-1515 Barrow street, North Vancouver, BC V7J 1B7 Phone: (604) 971-2088 Email: rob@ecolighten.com

Project Information

For: Samimi Residence
321 Blackman Street, New Westminster, BC

Design Information

	Htg	Clg		Infiltration
Outside db (°F)	18	84	Method	F280-12
Inside db (°F)	72	74	Exposure category	Light local shielding
Design TD (°F)	54	10	Construction category	Energy Tight (ACH=1.5)
Daily range	-	M	Number of stories	2.0
Inside humidity (%)	30	50		
Moisture difference (gr/lb)	24	7		

HEATING EQUIPMENT

Make		
Trade		
Model		
AHRI ref	n/a	
Efficiency	100 EFF	
Heating input	0	Btuh
Heating output	23575	Btuh
Temperature rise	16	°F
Actual air flow	1392	cfm
Air flow factor	0.064	cfm/Btuh
Static pressure	0	in H2O
Space thermostat		

COOLING EQUIPMENT

Make	Generic	
Trade		
Cond	SEER 14.0	
Coil		
AHRI ref		
Efficiency	12.2 EER, 14 SEER	
Sensible cooling	29227	Btuh
Latent cooling	12526	Btuh
Total cooling	41753	Btuh
Actual air flow	1392	cfm
Air flow factor	0.072	cfm/Btuh
Static pressure	0	in H2O
Load sensible heat ratio	0.77	

ROOM NAME		Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Basement	p	633	5547	3688	354	267
Main	p	1110	9342	8068	596	585
Upper	p	978	6923	7454	442	540
Entire House	p	2720	21812	19210	1392	1392
Other equip loads			1763	330		
Equip. @ 1.00 RSM				19541		
Latent cooling						
TOTALS		2720	23575	25403	1392	1392

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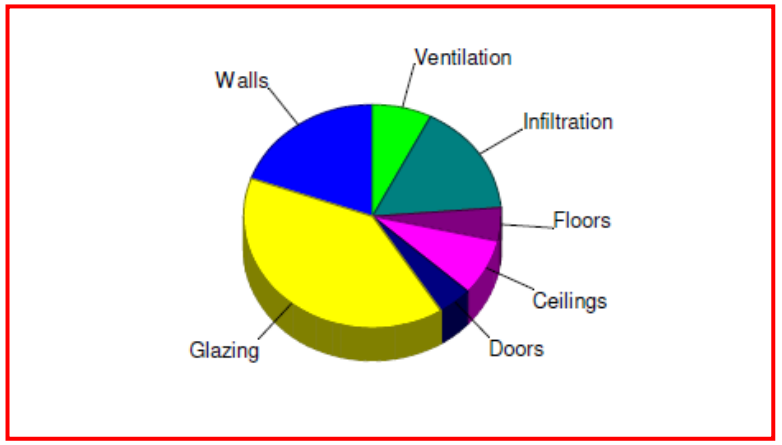
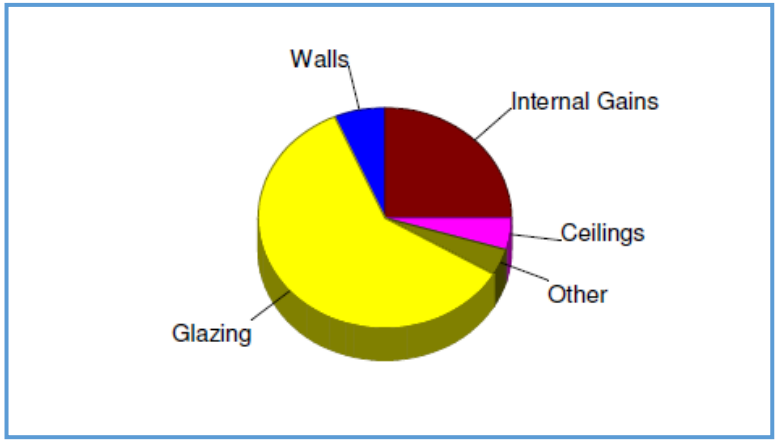


A. HEATING LOAD
23,575 BTUs



B. COOLING LOAD
25,403 BTUs

CASE STUDY FROM 319 & 321 BLACKMAN STREET

HOT2000 ENERGY MODELING
Design Heat Loss from Energy Advisor

CaptureEnergy

Energy Performance Design – Step 4

Project: 321 Blackman Street, New Westminster

Energy Performance of current design (Base Case)
With Options required to meet Step 4 of the Step Code

Criteria	Base Case From plans	Option A for Step 4
Rating (Energy Use)	31 GJ/year	30 GJ/year
Reference House (House built to national building code)	73 GJ/year	73 GJ/year
Project must be 40% lower than Reference House	57 % Lower	59 % Lower
	Or	Or
MEUI (Mechanical Energy Use Intensity) must be less than 45kWH/m2/year	33 kWh/m2 year	32 kWh/m2 year
TEDI (Thermal Energy Demand Intensity) must be less than 20kWH/m2/year	35 kWh/m2 year	31 kWh/m2 year
	Or	Or
Adjusted TEDI (Thermal Energy Demand Intensity) must be less than 26 kWH/m2/year	35 kWh/m2 year	31 kWh/m2 year
Building Envelope 20% better with Reference House Mechanical	32 % Better	39% Better
Please share the calculations below with your HVAC Contractor (Block Load for sizing reference)		
Design Heat Loss at 19.4 F (.93 BTU/h / Ft3)	22220 BTU/hr	20772 BTU/hr

22,220 BTU/hr

F280-12 LOAD CALCULATION
Design Heat Loss from HVAC Designer

ecolighten energy solutions

Load Short Form
Entire House
Ecolighten Energy Solutions Ltd.

Job: HPD 382
Date: 2021.01.12
By: Rob Pope

#: 15-584
201-1515 Barrow street, North Vancouver, BC V7J 1B7 Phone: (604) 971-2088 Email: rob@ecolighten.com

Project Information

For: Samimi Residence
321 Blackman Street, New Westminster, BC

Design Information

	Htg	Clg		Infiltration
Outside db (°F)	18	84	Method	F280-12
Inside db (°F)	72	74	Exposure category	Light local shielding
Design TD (°F)	54	10	Construction category	Energy Tight (ACH=1.5)
Daily range	-	M	Number of stories	2.0
Inside humidity (%)	30	50		
Moisture difference (gr/lb)	24	7		

ROOM NAME		Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Htg AVF (cfm)	Clg AVF (cfm)
Basement	p	633	5547	3688	354	267
Main	p	1110	9342	8068	596	585
Upper	p	978	6923	7454	442	540
Entire House	p	2720	21812	19210	1392	1392
Other equip loads			1763	330		
Equip. @ 1.00 RSM				19541		
Latent cooling				5862		
TOTALS		2720	23575	25403	1392	1392

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Page 1
...- Samimi Res - 321 Blackman St, 2021.01.12.rup Calc = F280-12 Front Door faces: S

23,575 BTU/hr

CASE STUDY FROM 319 & 321 BLACKMAN STREET

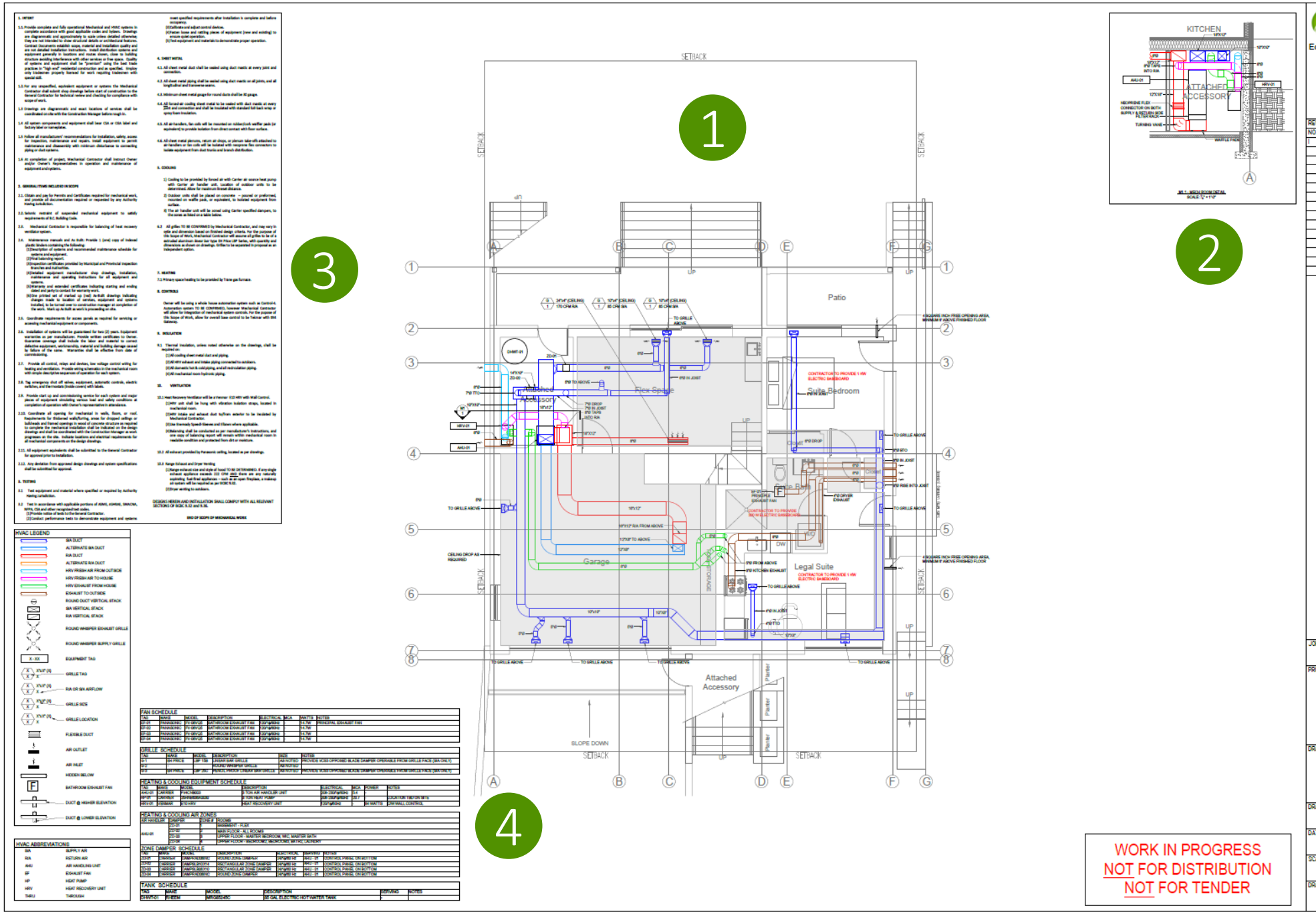
HEATING & COOLING

HEAT RECOVERY VENTILATION

DOMESTIC HOT WATER

Mechanical HVAC Design

1. Duct Design
2. Mechanical Room
3. Standards of Practice
4. Equipment Schedule



ecolighten
Ecolighten Energy Solutions Ltd.
Home Performance Design
201 - 1515 Barrow Street
North Vancouver, BC V7J 1B7
Phone: 604.971.2088
Website: www.ecolighten.com
Email: info@ecolighten.com

REVISIONS:

NO.	DATE	DESCRIPTION
1	2021.01.15	ISSUED FOR COORDINATION

JOB NUMBER: HPD 382

PROJECT NAME: Samimi Residence
319 Blackman Ave. &
321 Blackman Ave.
New Westminster

DRAWING TITLE: Duct Layout
Basement

DRAWN BY: FL | CHECKED BY: RP

DATE: January 15, 2021

SCALE: 1/4" = 1'-0"

DRAWING NO.: M1

KEY TAKEAWAYS

1. **Improve confidence.** Carrying out CSA F280-12 heat loss/gain analysis will right size heating and cooling systems, improve comfort, and can reduce cost.

2. **Ensure F280-12 compliance.** Make sure your heat loss/gain is completed using a solution that conforms with CSA F280-12.

3. **Don't guess.** Reinforce the importance of taking ownership of the load calculations being completed on the home.

4. **Good process leads to good results.** Taking a more sophisticated approach to load calculations and HVAC design to avoid the issues with poor equipment performance (e.g. oversizing, comfort, etc.).

5. **Adopt new Technologies.** Heat pumps are a growing HVAC option in the Lower Mainland that supports electrification strategies being implemented by Provincial and local government policy makers.

THANK YOU.

Rob Pope
Senior Consultant / Partner

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