THERMAL ENVELOPE c9

CONTENT THIS CHAPTER

***ENERGY COMPLIANCE_**REQUIRED COMPLIANCES ARE BEST UNDERSTOOD UPFRONT ON ANY PROJECT. ENERGY COMPLIANCE HAS SEVERAL OPTIONS WHICH ARE OVERVIEWED THIS CHAPTER. SOME REQUIRE 3RD PARTY INVOLVEMENT.
***LIMITED TO THE CONCEPT OF MANAGING HEAT GAIN AND HEAT LOSS_**INSTRUCTIVE CONCEPTS ARE NOTED THIS CHAPTER ABOUT HEAT GAIN/HEAT LOSS INTENDED TO ESTABLISH AN OVERVIEW LOGIC ABOUT HOW TO CONDITION A HOME INTELLIGENTLY AND EFFICIENTLY. THIS, IN TURN MAY HELP IN BETTER/BEST SYSTEM AND ENERGY SOURCE SELECTION FOR A GIVEN LOCATION, HOME SIZE, AND GEOMETRY.
***DUCTED SYSTEMS_**THE DESIGNS THIS PROJECT DEFAULT TO DUCTED AIR SYSTEMS (d8.15, d8.16). SPACE FOR AIR HANDLERS AND SOMETIMES DUCTING. DUCTING IS ADMITTEDLY DIFFICULT TO DESIGN FOR WITHOUT HAVING OTHER PROJECT SPECIFIC CRITERIA, MOST NOABLY THE BOUNDARIES OF THE THERMAL ENVELOPE. THIS DEFAULT SITUATION EXPLAINS THE EFFORT THIS CHAPTER TO OUTLINE DUCTWORK OPTIONS. DUCTED SYSTEMS ALLOW A RANGE OF SYSTEM SELECTIONS. FUEL FIRED FURNACES, , HEAT PUMP HEATING AND COOLING, AND AC SYSTEMS INDEPENDENT OF HYDRONIC HEATING SYSTEMS, ALL REQUIRE DUCTING. HAVING NOTED THE FORCED AIR SYSTEM DEFAULT THINKING, THERE IS NOTHING PREVENTING THESE PROJECTS DESIGNS FROM BEING HEATED AND OR COOLED SOME OTHER PERFECTLY VALID WAY.
***NOT ATTEMPTED THIS CHAPTER OR PROJECT_**ARE ALTERNATIVE SYSTEM SUMMARIES, OR ENERGY SOURCE OPTIONS, INDOOR AIR QUALITY, OR MAKE UP AIR SYSTEMS. THE SUBJECT IS SIMPLY TOO VAST AND COMPLICATED AND FAR BETTER LEFT TO OTHER APPROPRIATE RESOURCES. THE CHAPTER DOES INTRODUCE AN EXPANSIVE COTTAGE INDUSTRY OF ENERGY, BUILDING SCIENCE, GREEN CONSTRUCTION CONSULTANTS WHOM ARE BECOMING CRITICAL TO THE HOME BUILDING INDUSTRY.

RELATED CONTENT WITHIN THE GUIDE(S)

***d2.3-d2.7_**mother nature's rules
***d4.5-d4.6_**designing with the sun in mind
***d5.1_**thermal envelope and house geometrey
***d5.3-d5.5_**space under roof
***d8.15-d8.16_**mep space allocations
***c3.13-c3.14_**foundation and slab heat gain and loss
***c5.23-c5.24_?**frame floor insulation assemblies
***c6.16-c6.21_**frame wall insulation assemblies
***c7.25-c7.27_**frame roof insulation assemblies
***the addendum drawing set shows conventional 2d section options**

QUALIFY

***CRITERION**_THES ILLUSTRATIONS SHOW THE SAME PHYSICAL SHELL FOR 3 COMMON CONFIGURATIONS, WITH 2 OPTIONS FOR DEFINING THE THERMAL ENVELOPE. THE 2 LEADING CRITERIA FOR SELECTING THE THERMAL ENVELOPE APPROACH IS WHETHER USEFUL SPACE IS GAINED, AND WHAT IS REQUIRED TO INCORPORATE THE HVAC SYSTEM WITHIN THAT THERMAL ENVELOPE. (THIS CHAPTER WILL EMPHASIZE THE IMPORTANCE OF THAT INCLUSION.)

***INVESTMENT**_FINISHING AND OR CONDITIONING MORE SPACE WITHIN THE SAME PHYSICAL ENVELOPE OBVIOUSLY COSTS MORE MONEY UP FRONT. ENERGY COSTS WILL BE LOWER WITH AN INCORPORATED SYSTEM. A COST BENEFIT ANALYSIS IS SMART.

QUANTIIFY

***SURFACE SQUARE FOOTAGE**_MATTERS A LOT. EVERY SQUARE FOOT THAT SEPARATES THE CONDITIONED INSIDE FROM UNCONDITIONED OUTSIDE IS A SQUARE FOOT SUBJECT TO HEAT LOSS AND HEAT GAIN.

***VOLUME**_SYSTEM EFFICIENCY AND DESIGN DOES NOT CARE DIRECTLY ABOUT SPACE VOLUME (CU FT). BUT IT CLEARLY HAS A DIRECT RELATIONSHIP TO SURFACE AREA. MORE VOLUME=MORE SURFACE AREA. NO WAY AROUND IT.

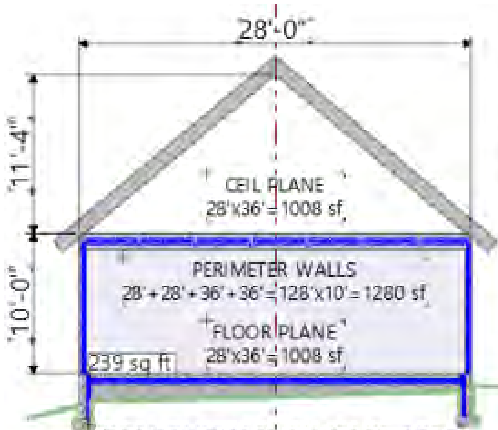
***DELTA T_(c9.2)** EACH SQUARE FOOT OF SURFACE CONSTRUCTION IS SEPARATING 2 TEMPERATURES. THERE IS AN INSIDE (DESIRED) TEMPERATURE AND AN OUTSIDE TEMPERATURE THAT HAS A MIND OF ITS OWN. THE DIFFERENCE BETWEEN THOSE 2 TEMPERATURES IS TYPICALLY REFERRED TO AS DELTA (DIFFERENT) T (TEMPERATURE).

***RESISTANCE**_LOGIC SAYS WE CAN SLOW DOWN THE HEAT GAIN AND LOSS BY CONSTRUCTING ALL THAT SURFACE AREA WITH ADEQUATE INSULATION WHICH IS THE RESISTANCE COMPONENT.

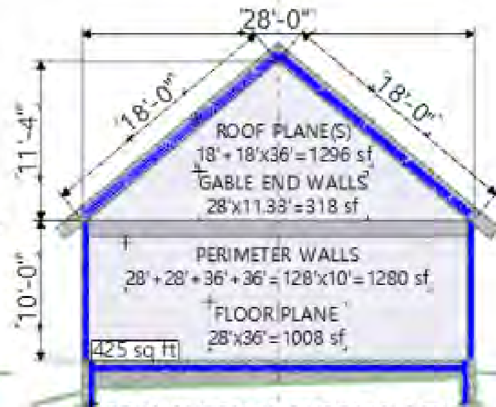
***LOAD**_IS THE DEMAND ASKED OF A HEATING AND COOLING SYSTEM TO MAINTAIN THAT DESIRED INSIDE TEMPERATURE. THE LOAD IS QUANTIFIED AND IS A DIRECT FUNCTION OF SURFACE AREA(S) AND ITS RESISTANCE(S), WHILE DEALING WITH THAT DELTA T CHALLENGE.

THE LOAD FORMULA

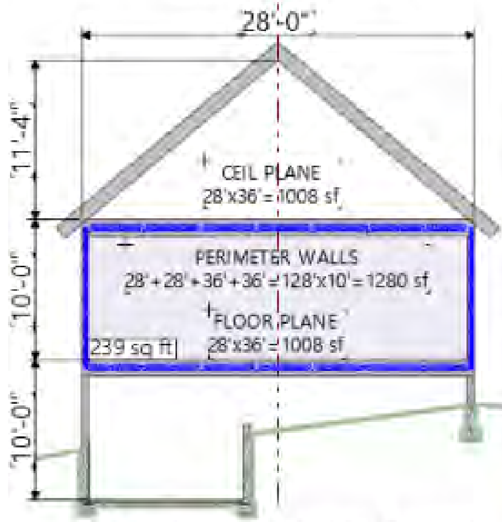
***LOAD FORMULA IS SURFACE AREA TIMES THE DELTA T DIVIDED BY THE UNIT RESISTANCE VALUE OF EACH SQUARE FOOT**_THIS SIMPLE FORMULA IS A GREAT ONE TO REMAIN MINDFUL OF WHILE MAKING THERMAL ENVELOPE DECISIONS. AS WITH SO MUCH OF THIS STUFF THERE ARE LAYERS OF COMPLICATION, BUT THIS CORE FORMULA IS A KIND OF GUIDE POST.



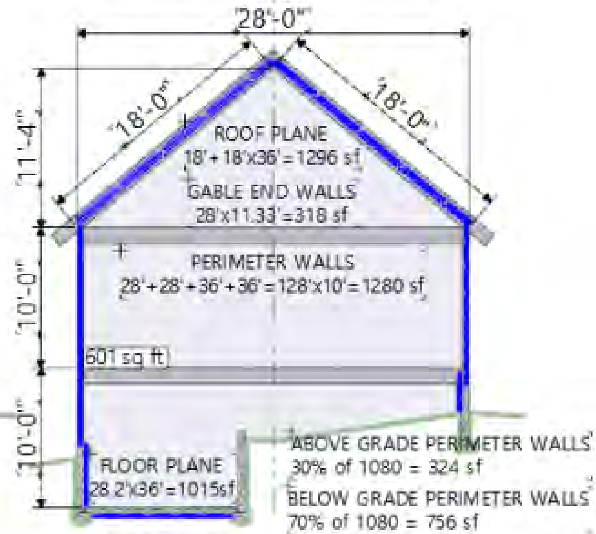
TOTAL THERMAL SURFACE AREA
1008+1280+1008 = 3,296 sf
CONDITIONED VOLUME
239sf x35' = 8,365 cf



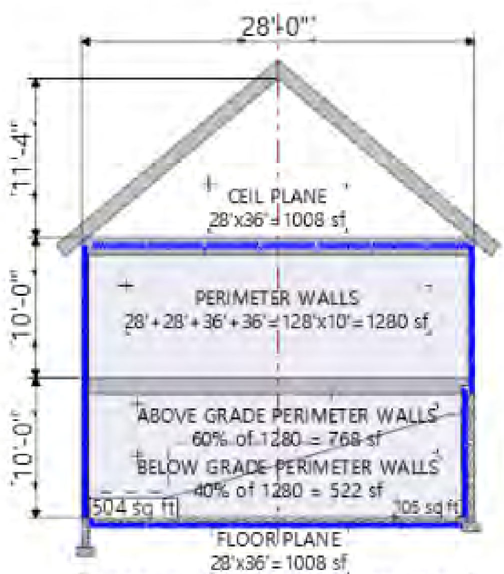
TOTAL THERMAL SURFACE AREA
1296+318+1280+1008 = 3902 sf
CONDITIONED VOLUME
425sf x35' = 14,875 cf



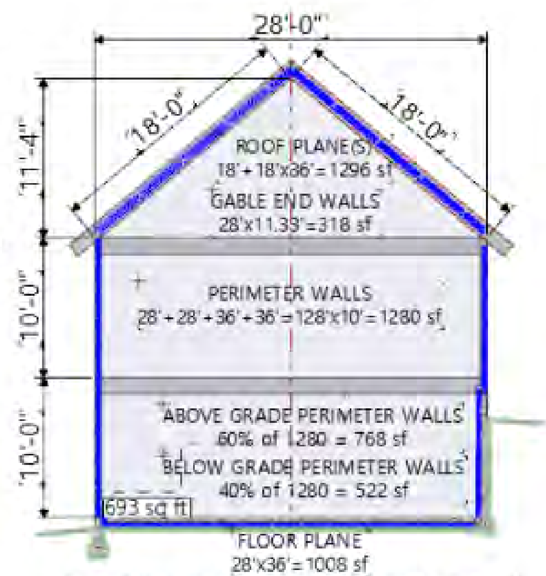
TOTAL THERMAL SURFACE AREA
1008+1280+1008 = 3,296 sf
CONDITIONED VOLUME
239sf x35' = 8,365 cf



TOTAL THERMAL SURFACE AREA
1296+318+1280+1008 = 3902 sf
CONDITIONED VOLUME
601sf x35' = 21,035 cf



TOTAL THERMAL SURFACE AREA
1008+1280+1280+1008 = 4,568 sf
CONDITIONED VOLUME
504 sf x35' = 17,640 cf



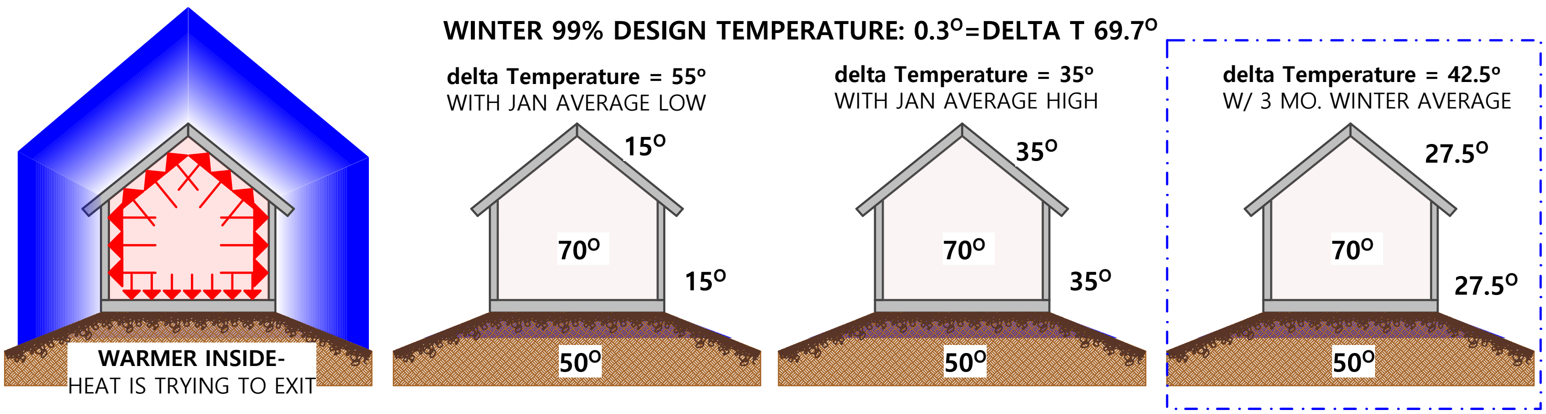
TOTAL THERMAL SURFACE AREA
1296+318+1280+1280+1008 = 5,182 sf
CONDITIONED VOLUME
693 sf x 35' = 24,255 cf

BASIC LOAD EQUATION IS SURFACE AREA X DELTA T / R VALUE

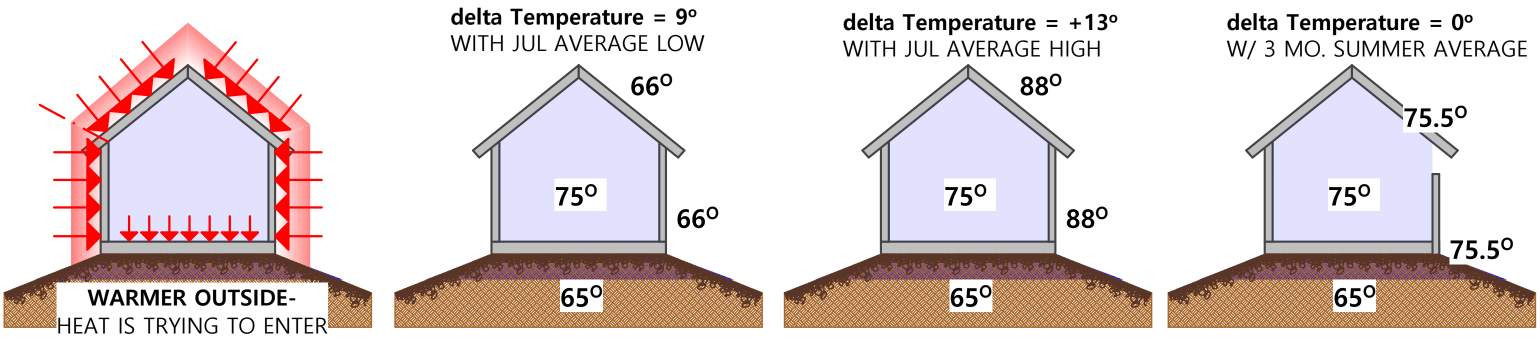
***FIND OUT WHERE THE ENERGY IS GOING_**RECOGNIZING THE 3 VAIABLES, THE SQUARE FOOT, THE INSULATING VALUE OF THAT SQUARE FOOT, AND TEMPERATURE DIFFERENTIAL THAT SQUARE FOOT IS ADDRESSING, ALLOWS ONE TO WALK THRU A HOME AND CONSIDER WHERE THE HEAT IS ESCAPING (HEAT LOSS), AND, DURING HOTTER SUMMER MONTHS, WHERE THE HEAT IS ENTERING (HEAT GAIN).

***DELTA T_**THE DIFFERENCE BETWEEN THE INSIDE DESIRED TEMPERATURE AND THE OUTSIDE REAL TEMPERATURE CREATES THE DEMAND. MORE TEMPERATURE DIFFERENTIAL MORE DEMAND. LIVING IN SAN DIEGO AND HAWAII HAS CLEAR ADVANTAGES IN THIS REGARD. LIVING IN MINNESOTA OR SOUTH TEXAS DOES NOT.

WINTER 99% DESIGN TEMPERATURE: 0.3°=DELTA T 69.7°



SUMMER 1% DESIGN TEMPERATURE: 93.7°=DELTA T 18.7°



TEMPERATURES REFERENCES ABOVE

***LINCOLN NEBRASKA_**A TYPICAL WEATHER CONDITION, MIDDLE OF THE COUNTRY, AND IN CODE DEFINED ZONE 5a. ABOVE NOTES SOME DELTA TEMPERATURES IN LINCOLN. EVERYDAY TEMPERATURES ARE EASILY SEARCHED. (SEARCH 'AVERAGE TEMPERATURES BY MONTH'-THAT SIMPLE)

***DESIGN TEMPERATURES_** TAKE THE RECORDED EVERYDAY TEMPERATURE DATA AND ESTABLISH AN ALMOST EXTREME WINTER AND SUMMER TEMPERATURE NUMBER THAT IS USED TO ESTABLISH HEATING AND COOLING LOADS. WHICH IN TURN DIRECTS HVAC SYSTEM DESIGNS.

***OBSERVATION_**USING REAL TEMPERATURES THE 3 MONTH (DEC/JAN/FEB) WINTER AVERAGE IS 27.5° AND THE 3 MONTH (JUN/JUL/AUG) SUMMER MONTH AVERAGE IS 75.5°. SO (DUH) LINCOLN CALLS FOR HEAT A LOT MORE THAN COOLING. KNOWING THAT SIMPLE DISTINCTION BETWEEN A HEAT LOSS DOMINANT CLIMATE LOCATION, OR A HEAT GAIN DOMINANT CLIMATE LOCATION IS USUALLY OBVIOUS BUT STILL IMPORTANT TO KEEP FRONT AND CENTER WHEN MAKING HVAC SYSTEM DECISIONS. IT IS A DIFFERENT CRITERIA SET.

***OBSERVATION_**THE DESIGN TEMPERATURES ARE CLEARLY HIGHER AND LOWER THAN THE AVERAGES. BUT THEY NEED TO ADDRESS WORST CASE SCENARIOS-WHICH OF COURSE REPRESENT THE TEMPERATURES OF GREATEST POTENTIAL DISCOMFORT AND EVEN HEALTH AND SAFETY RISKS. THERE IS A CHALLENGE WITH SETTING DESIGN TEMPERATURES (THEREFORE EQUIPMENT SIZING). OVERSIZED EQUIPMENT RUNS INEFFICIENTLY. NOT BEING ABLE TO ACHIEVE ADEQUATE HEATING OR COOLING IN EXTREME CONDITIONS IS A PROBLEM. THERE ARE 3 SLIGHTLY DIFFERENT DESIGN TEMPERATURES THE HVAC GURUS LIST IN THEIR TABLES, WITH THE 'MIDDLE' 99%/1% SEEMING TO BE THE DEFAULT.

RUNNING THE load FORMULA

***SQUARE FOOTAGE_**

ROOF AREA_1296 SF
WALLS_1800 SF
FLOOR AREA_1008 SF

***RESISTANCE R_**

ROOF AREA_R 49 (TO KEEP THINGS SIMPLE LETS SAY THERE IS ONE ROOF CONSTRUCTION/1 UNIFORM R VALUE AND NO SKYLIGHTS)
WALLS_R-20 (TO KEEP THINGS SIMPLE LETS SAY THERE ARE NO DOORS OR WINDOWS)
FLOOR_R-10 (TO KEEP THINGS SIMPLE LETS SAY THIS TOTAL SLAB AREA IS INSULATED)

***DELTA T_FOR THE 3 MONTH WINTER AVERAGE 27.5°**

roof area (1296) x delta T (42.5) / R value (49) = heat flow (1124 BTU/hr)
wall area (1598) x delta T (42.5) / R value (20) = heat flow (3396 BTU/hr)
floor area (1008) x delta T (20) / R value (10) = heat flow (2016 BTU/hr)
total btu's per hr to maintain temperature equilibrium in the winter months = 6536 BTU/hr

***THE LOAD (BTU/hr)_**

THE 'LOAD' IS ONE OF THE TERMS USED TO DESCIBE THE ENERGY REQUIREMENT NEEDED TO BALANCE THE 2 TEMPERATURES. THE LOAD CALCULATED HERE REPESENTS THE REQUIREMENT FOR A 42.5° DELTA T. THE ACTUAL LOAD ON AN HOUR TO HOUR, DAY TO DAY, BASIS IS ALWAYS CHANGING WITH THE SIMPLE CHANGE OF TEMPERATURE. THE BTU/hr (BRITTISH THERMAL UNIT) IS A FIXED ENERGY MEASURMENT. SEARCH ITS DEFINITION AND HISTORY FOR INTEREST SAKE BUT ALSO NOTE IT IS ULTIMATELY A NUMERICAL TOOL FOR CIPHERING OTHER END DECISIONS.

PLAYING WITH THE load FORMULA

***BELOW FORMULA RUNS** _ARE ONLY EMPHASIZING THAT GETTING A HANDLE ON HEAT GAIN AND LOSS IS NOT ROCKET SCIENCE. REMEMBER RUNNING REAL SEASONAL TEMPERATURE AVERAGES WILL INFORM ABOUT SEASONAL ENERGY CONSUMPTION, RUNNING 'DESIGN TEMPERATURES' WILL INFORM ABOUT SYSTEM CAPACITY REQUIREMENTS. RUNNING SQUARE FOOTAGE AND R VALUE VARIABLES WILL INFORM ABOUT DESIGN DECISIONS VERY MUCH IN ONE'S CONTROL.
***CAVEAT_**THESE EXERCISES ILLUSTRATE THE BASE FORMULA AT WORK ONLY. REAL CONDITONS AND CONSIDERATIONS ARE MORE COMPLEX, BUT STILL SIMPLER THAN ROCKET SCIENCE. THE REScheck TOOL (c9.5,c9.6) ALLOWS MORE ACCURATE "PLAYING" AND IS LAYMAN SIMPLE. THE REScheck TOOL CONSIDERS/INCORPORATES VARYING CONSTRUCTIONS AND R VALUES IN THE ROOF, WALL, AND FLOOR ASSEMBLIES.

***SAME SQUARE FOOTAGES_**
***SAME RESISTANCE R_**
***DIFFERENT DELTA T_FOR THE AVERAGE HIGH IN AUGUST OF 88°=13°**
roof area (1296) x delta T (13) / R value (38) = heat flow (443 BTU/hr)
wall area (1598) x delta T (13) / R value (20) = heat flow (1038 BTU/hr)
floor area (1008) x delta T (10) / R value (10) = heat flow (1008 BTU/hr)
total btu's per hr to maintain temperature equilibrium in high august temperatures = 2489 BTU/hr
*****OBSERVATION_**DELTA T CONTROLS ENERGY CONSUMPTION. WE ALL KNOW JANUARY AND AUGUSTARE CONSUMING MONTHS. MAY AND OCTOBER NOT SO MUCH.

***SAME SQUARE FOOTAGES_**
***SAME RESISTANCE R_**
***DIFFERENT DELTA T_FOR THE SUMMER DESIGN TEMPERATURE 93.7°=18.7°**
roof area (1296) x delta T (18.7) / R value (38) = heat flow (638 BTU/hr)
wall area (1598) x delta T (18.7) / R value (20) = heat flow (1494 BTU/hr)
floor area (1008) x delta T (10) / R value (10) = heat flow (1008 BTU/hr)
total btu's per hr to maintain temperature equilibrium summer design temperature = 3140 BTU/hr
*****OBSERVATION_**THE CODE REQUIRED USE OF THE SUMMER DESIGN TEMPERATURE PROVIDES A 25%+/- BUFFER OVER THE HIGH AVERAGE IN AUGUST.

*SAME DELTA T THIS EXERCISE

***SAME SQUARE FOOTAGES_**
***SAME RESISTANCE R_**
***DELTA T_FOR THE 3 MONTH WINTER AVERAGE 42.5°**
roof area (1296) x delta T (42.5) / R value (49) = heat flow (1124 BTU/hr)
wall area (1598) x delta T (42.5) / R value (20) = heat flow (3396 BTU/hr)
floor area (1008) x delta T (20) / R value (10) = heat flow (2016 BTU/hr)
total btu's per hr to maintain temperature equilibrium in the winter months = 6536 BTU/hr
*****OBSERVATION_**THIS 3 MONTH AVERAGE LOAD HAS A 33% BUFFER COMPARED WITH THE WINTER DESIGN REQUIREMNET

***SAME SQUARE FOOTAGES_**
***INCREASE THE RESISTANCE R_**
***DELTA T_FOR THE 3 MONTH WINTER AVERAGE 42.5°**
roof area (1296) x delta T (42.5) / R value (60) = heat flow (918 BTU/hr)
wall area (1598) x delta T (42.5) / R value (25) = heat flow (2716 BTU/hr)
floor area (1008) x delta T (20) / R value (10) = heat flow (2016 BTU/hr)
total btu's per hr to maintain temperature equilibrium in the winter months = 5650 BTU/hr
*****OBSERVATION_**INCREASING THE ROOF R BY 10 AND THE WALL R BY 5 DECREASES LOAD BY 15%

***ALTER SQUARE FOOTAGES_**
***SAME RESISTANCE R_**
***DELTA T_FOR THE 3 MONTH WINTER AVERAGE 42.5°**
roof area (1008) x delta T (42.5) / R value (49) = heat flow (874 BTU/hr)
wall area (1598) x delta T (42.5) / R value (20) = heat flow (3396 BTU/hr)
floor area (1008) x delta T (20) / R value (10) = heat flow (2106 BTU/hr)
total btu's per hr to maintain temperature equilibrium in the winter months = 6376 BTU/hr
*****OBSERVATION_**INSULATING THE CEILING INSTEAD OF THE THE ROOF PLANE REDUCES THE ROOF SURFACE AREA FROM 1296 TO 1008 OR 22%. BECAUSE THIS BECOMES INCORPORATED INTO THE ENTIRE ROOF/WALL/FLOOR SQUARE FOOTAGE PACKAGE THAT PERCENTAGE OF DECREASE BECOMES LESS.

THE PRINCIPLE -BTU'S, ENERGY SOURCES, AND COSTS

***JUMPING AHEAD_**NOTED THE EXERCISES ABOVE ARE TOO SIMPLE TO CIPHER ACTUAL BTU REQUIREMENTS. BUT THE CONCEPT OF THE BTU BEING THE UNIT OF CONSIDERATION FOR ENERGY SOURCES AND ULTIMATELY ENERGY COSTS IS VALID AND SUMMARIZED BELOW TO EMPHASIZE THAT ACTUAL BTU CONSUMPTION IS THE BOTTOM LINE BOTH REGARDING ENERGY CONSERVATION AND ENERGY COST.
***STARTING WITH THE BTU_**THE HEAT LOSS/HEAT GAIN CALCS CAN RESULT IN AN ANNUAL EDUCATED ESTIMATE SUMMARY DEMAND. ENERGY SOURCES HAVE RECOGNIZED BTU OUTPUT PER UNIT OF CONSUMPTION. UNIT OF CONSUMPTION HAS A MARKET PRICE. ANNUAL ENERGY COSTS CAN BE CONCLUDED.
***FUEL OIL_**134,900 BTU/GAL = 'X' GALLONS ANNUALLY X $UNIT COST = $ANNUAL COST
***PROPANE_**91,600 BTU/GAL = 'X' GALLONS ANNUALLY X $UNIT COST = $ANNUAL COST
***NATURAL GAS_**1,000 BTU/CU FT = 'X' CU FT ANNUALLY X $UNIT COST = $ANNUAL COST
***BIOGAS_**600 BTU/CU FT = 'X' CU FT ANNUALLY X $UNIT COST = $ANNUAL COST
***HARDWOOD_**24,000,000 BTU/CORD= 'X' CORDS ANNUALLY X $UNIT COST = $ANNUAL COST
***WOOD PELLETS_**8,200 BTU/LB='X' LBS ANNUALLY X $UNIT COST = $ANNUAL COST
***COAL_**13,000 BTU/LB = 'X' LBS ANNUALLY X $UNIT COST = $ANNUAL COST
***ELECTRICITY_**3,412 BTU/kWH = 'X' kWH ANNUALLY X $UNIT COST = $ANNUAL COST

R (RESISTANCE) AND U (TRANSMITTANCE) ARE THE SAME THING -SORT OF-

***RESISTANCE AND TRANSMITTANCE_**ARE 2 SIDES OF THE SAME COIN. THEY ARE USED A BIT DIFFERENTLY.
***MATH_**THESE 2 VALUES ARE MATHEMATICAL RECIPROCALS. DIVIDE 1 BY THE R VALUE AND YOU GET THE U VALUE. DIVIDE 1 BY THE R VALUE AND YOU GET THE R VALUE. HIGHER R VALUES MEAN MORE RESISTANCE. HIGHER IS BETTER. HIGHER U VALUES MEAN MORE HEAT IS ESCAPING, SO WITH THE U VALUE LOWER IS BETTER.
***R THINKING_**MOST OF US THINK IN TERMS OF R-THE INSULATING VALUE. EASY. THE BIGGER THE NUMBER THE MORE EFFECTIVE. THE CODE DICTATES A MIN R BY COMPONENT. IT IS REFERRING TO THE INSULATING PRODECT'S R VALUE ONLY. NOT THE WHOLE CONSTRUCTION ASSEMBLY. ALL MATERIALS HAVE A SEARCHABLE R-VALUE USUALLY/FREQUENTLY QUANTIFIED BY A UNIT OF THICKNESS. INSULATION MATERIALS LOUDLY MARKET THEIR R VALUES. R VALUES TYPICALLY REPRESENT A RESISTANCE VALUE OF 1 HOMOGENEOUS MATERIAL.
***U THINKING_**RECIPROCAL VALUE ASIDE , A U VALUE IS MORE FREQUENTLY USED REPRESENTING A COMPOSITE OR ASSEMBLY. AND TAKES INTO ACCOUNT TRANSMITTANCE CONDITIONS THE R VALUE DOES NOT. FOR EXAMPLE, GLAZING PRODUCTS ARE USUALLY SPECIFIED BY U VALUE. THE U VALUE CONSIDERS THE GLASS, THE FRAME, THE GLASS TO FRAME CONNECTION, (AND OTHER TECHNICAL STUFF), AND CONCLUDES A U VALUE FOR THE ENTIRE ASSEMBLY ON A PSF BASIS. ULTIMATELY THE U VALUE FIGURES INTO THE BTU CALCS THE SAME WAY WITH THE ADVANTAGE OF HAVING ITS BASE VALUE MORE ACCURATE, WHICH IS GOOD. THAT U VALUE CAN BE TRANSLATED INTO AN R VALUE TO HELP PUT THE WINDOW IN PERSPECTIVE WITH THE OTHER ASSEMBLIES. USING THE RECIPROCAL RULE-ZONE 5 U VALUE REQUIRED FOR FENETRATION IS .30. THE EQUIVALENT R VALUE IS 1 DIVIDED BY .30 OR 3.33. SO COMPARE R-3.33 FOR GLAZING WITH THE THE REQUIRED R-20 WALL AND THE R-49 CEILING/ROOF. USING R'S DOES HELP KEEP THINGS IN PERSPECTIVE.
ANOTHER ILLUSTRATION OF THIS R AND U DISTINCTION IS THE FRAME WALL REQUIREMENT. COMPONENT IN ZONE 3 THRU 5 IS R-20 CAVITY INSULATION . BUT THE RECIPROCAL (U VALUE EQUIVALENT) OF 20 IS .050. THE U FACTOR CODE REQUREMENT FOR THAT SAME FRAME WALL IS .060. THAT RECIPROCAL (R VALUE EQUIVALENT) OF THAT U=0.60 IS R=16.68. WHY THE DISCREPANCY? BECAUSE THE U FACTOR REQUIREMENT IS CONSIDERING THE ASSEMBLY, WHICH INCLUDES THE MORE EFFICIENT INSULATION ITSELF, AND THE LESS EFFICIENT FRAMING COMPONENT. (c6.17) DEMONSTRATES THE EFFICIENCY FACTORS ASSOCIATED WITH FRAME WALLS WHICH EXPLAINS THE R DE-VALUATION FROM 20 TO 16.68.
THERE ARE MORE VARIABLES HERE IF ONE WANTS TO BE REALLY EXACTING. A 3RD PARTY ATTEMPTING HIGHLY ACCURATE ENERGY PERFORMANCE CODE COMPLIANCES MAY WANT TO DIG DEEPER.
***U(A) THINKING_**REScheck PRESENTS US WITH A 'UA' NUMBER REPRESENTING THE ASSEMBLY U VALUE TIMES THE AREA. IT RUNS A BEHIND THE SCENES CALC TO GENERATE THE U VALUE AND MULTIPLIES IT BY THE SQUARE FOOTAGE INPUT.

***MEETING CODE_**A PROJECT THAT MEETS THE R OR U VALUE REQUIREMENTS SHOULD BE ENERGY ACCEPTABLE.

TABLE N1102.1.2 (R402.1.2)
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b,e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13 + 5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13 + 5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13 + 5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

TABLE N1102.1.4 (R402.1.4)
EQUIVALENT U-FACTORS[a]

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR[b]	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.035	0.084	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.084	0.165	0.064	0.360	0.477
3	0.32	0.55	0.030	0.060	0.098	0.047	0.091[c]	0.136
4 except Marine	0.32	0.55	0.026	0.060	0.098	0.047	0.059	0.065
5 and Marine 4	0.30	0.55	0.026	0.060	0.082	0.033	0.050	0.055
6	0.30	0.55	0.026	0.045	0.060	0.033	0.050	0.055
7 and 8	0.30	0.55	0.026	0.045	0.057	0.028	0.050	0.055

R compliance BASED ON MIN 'R' VALUES BY COMPONENT

***FOOTNOTES_**ONE REALLY HAS TO READ ALL FOOTNOTES THESE TABLES.
ALL THE 'DOUBLE NUMBER' SITUATIONS ARE EXPLAINED THERIN. AND THAT AT MINIMUM NEEDS TO BE UNDERSTOOD.
***FOUNDATIONS/WALLS/ROOFS_**(c3.6-c3.15)(c6.16-c6.19)(c7.25-c7.27) THE COMPOSITE CONDITIONS EFFECTING THESE PRIME ASSEMBLIES ARE ADDRESSED IN THEIR RESPECTIVE CHAPTERS.
***GLAZING_**SWITCHES TO A U-FACTOR REQUIREMENT AS EXPLAINED ABOVE.

U compliance BASED ON MAX 'U' VALUES BY ASSEMBLY

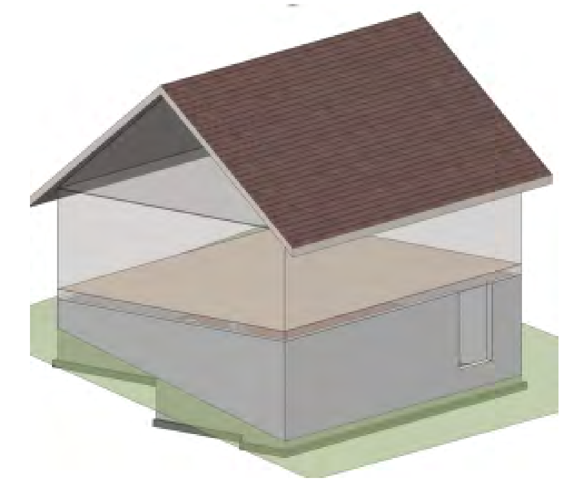
***ASSEMBLY VALUE_**IF/WHEN USING THE U FACTOR COMPLIANCE METHOD THE APPLICANT BECOMES OBLIGED TO TALLY+VERIFY ALL ASSEMBLIES WITH ACCURATE TOTAL ASSEMBLY U VALUES. THIS CAN BE A BIT OF WORK.
***WHY DO THIS?_**ASSEMBLY CALCULATIONS ARE A MORE ACCURATE WAY OF GETTING TO A REAL PROTECTION VALUE, AND SUBSEQUENTLY A MORE ACCURATE HEAT GAIN AND LOSS NUMBER. AND THE EXERCISE FORCES ONE TO UNDERSTAND THE COMPLEXITY OF ANY PROPOSED CONSTRUCTION. OUR HYGRO-THERMAL ASSEMBLIES ARE GETTING MORE COMPLICATED. COMPLEXITY ALWAYS COSTS MORE MONEY AND PRESENTS MORE OPPORTUNITY FOR PROBLEMS, HENCE THIS BECOMES AN OPPORTUNITY TO CHECK ALL CIRCUITS.

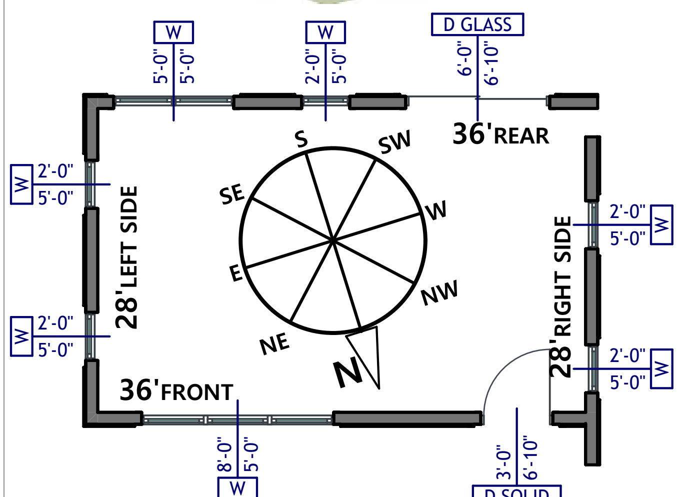
REScheck

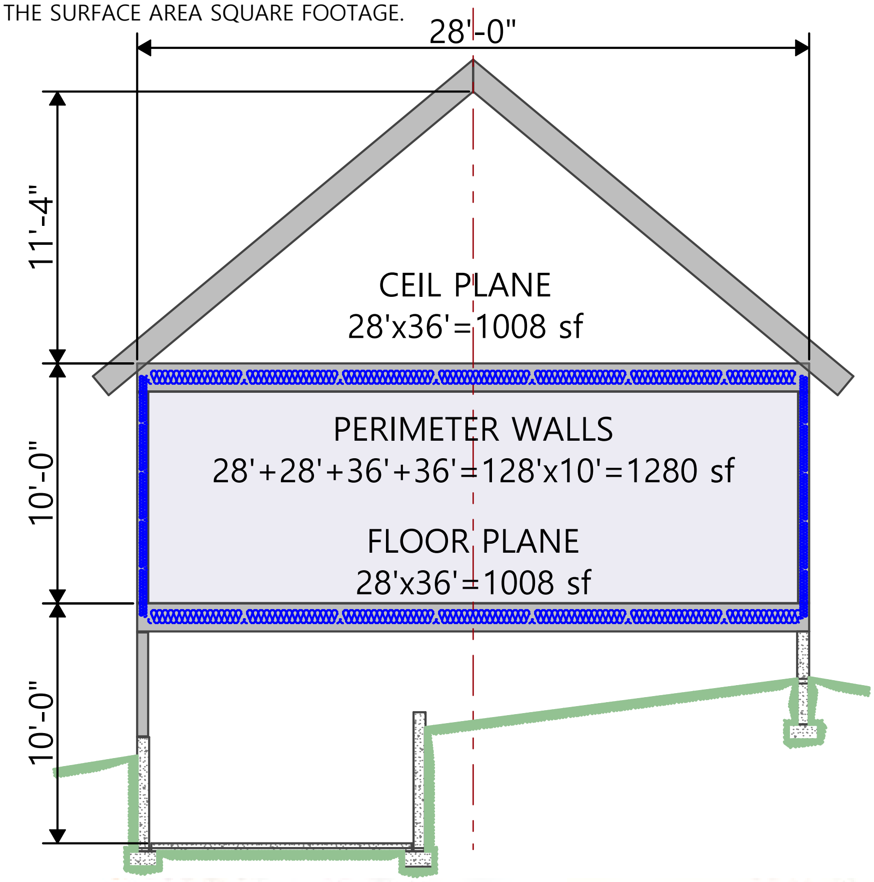
***UA_**UA IS THE RECOGNIZED ACRONYM FOR COMPOSITE TRANSMITTANCE VALUE (U) TIMES THE SURFACE AREA (A). NOTED THESE 2 THINGS WE CAN CONTROL TO GENERATE A MORE EFFECTIVE THERMAL ENVELOPE. REScheck IS A SPREADSHEET THAT TAKES INSULATION R VALUES, WITH JUST A FEW QUALIFIERS THE USER IS ASKED FOR, AND GIVES US U-FACTORS AND UA TOTALS WITHOUT THE USER NEEDING A CALCULATIOR.
***FREE AND SIMPLE_**RESCHECK IS A DEPARTMENT OF ENERGY PRODUCT THAT EXISTS TO HELP US DO THIS STUFF. THERE IS AN ON-LINE AND DOWNLOADABLE VERSION. CHECK APPROPRIATE CODE COMPLIANCE VERSION (MAYBE A LITTLE BEHIND ON THIS). IT IS SIMPLE, NO REASON FOR INTIMIDATION. REMEMBER THIS IS A CODE COMPLIANCE TOOL ONLY. JUST SEARCH resCHECK.
***AS DESIGN TOOL_**ONE CAN PLAY WITH **R** VALUE INPUTS AND AREAS AND COMPARE UA RESULTS SO EASILY..........

SAMPLE PROJECT COMPARISON

***REScheck**_THIS SIMPLE BOX (28' DEEP AND 36' LONG) HOUSE WILL BE CHECKED OUT USING REScheck UA METHOD. LETS SEE HOW IT ENDS UP. ALL THE SAME VALUES WILL BE INPUT FOR THE SMALLER THERMAL ENVELOPE VERSION [THIS PAGE] AND THE LARGER THERMAL ENVELOPE (NEXT PAGE). THE INTENT IS TO FIND THE UA PENALTY FOR INCREASING THE SURFACE AREA SQUARE FOOTAGE.







NOTE ON ORIENTATION (AND HEAT GAIN)

***BOTH CODE AND REScheck**_EXCEPTING THE SHGC FOR GLAZING IN ZONES 1-4, CODE AND REScheck TAKE HEAT GAIN OUT OF THEIR REQUIREMENTS SET. ALTHOUGH THERE IS AN ORIENTATION TAB IN THIS REScheck SAMPLE IT IS ONLY FUNCTIONING AS A REFERENCE.

***HEAT GAIN**_AND ITS QUALIFIER-ORIENTATION TO THE SUN-ARE A VERY ESSENTIAL PART OF ALL HVAC LOAD CALCULATIONS.

BASE UA CALCULATION

***INPUT**_FOLLOWS CODE MINIMUM COMPONENT R VALUES. AND THE RESULT IS 1.6% BETTER THAN CODE. JUST AS IT SHOULD BE.

***UA MAX**_REScheck SETS A MAX UA BASED ON CODE MINIMUM U VALUES COMBINED WITH THE AREAS FOR EACH COMPONENT PER USER INPUT. IT IS REALLY ONLY TESTING

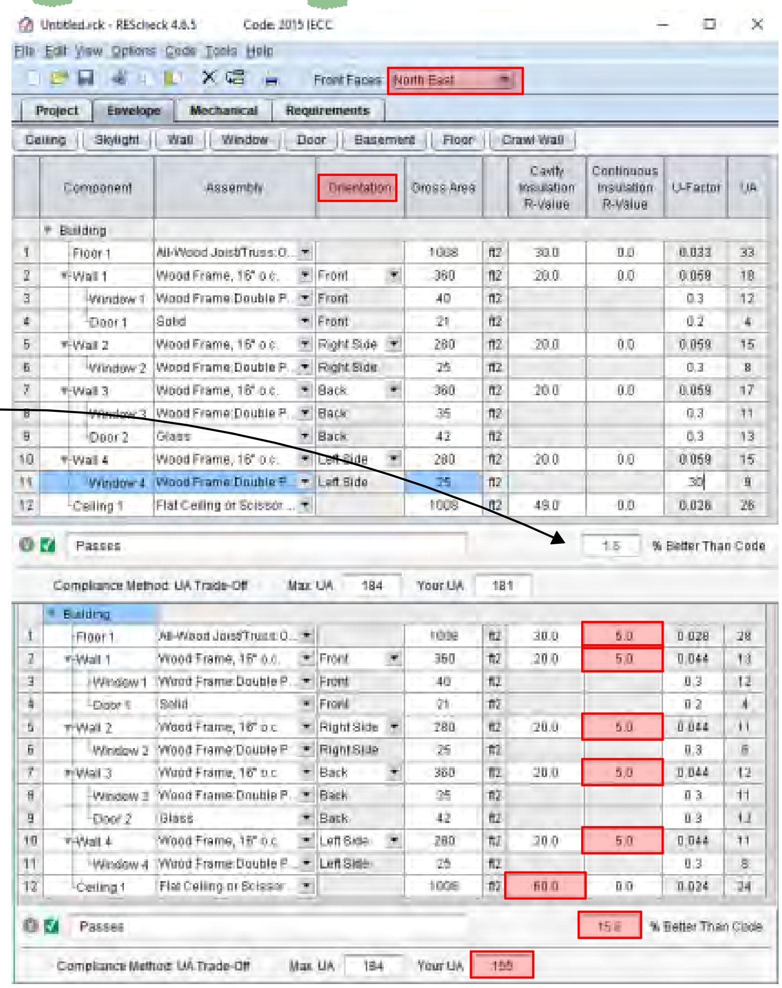
ADJUSTMENT UA CALCULATION

***INCREASED INSULATION**_1" OF XPS (R-5) IS ADDED TO ALL EXTERIOR WALLS AND THE FLOOR PLANE AND AN ADDITIONAL 3" OF LOOSE INSULATION (R-11) ADDED TO THE CEILING PLANE. THE RESULT IS A UA OR 155 OR 26 BELOW THE CODE MINIMUM STANDARD ABOVE OF 181 REPRRESENTING AN EFFICIENCY INCREASE OF 14%. REMEMBER THAT 14% REPRESENTS THE FULL THERMAL ENVELOPE.

***PAY BACK**_A QUESTION THEN IS FIRST WHAT IS THE COST OF THAT ADDITIONAL R AND HOW LONG DOES IT TAKE TO GET THAT INVESTMENT BACK AT AN ENERGY SAVINGS OF 14% PER YEAR.??

REScheck PERFORMANCE ALTERNATIVE

***LIMITED VALUE**_REScheck's OTHER COMPLIANCE OPTION (OTHER THAN THE UA TRADE OFF METHOD) IS THE PERFORMANCE ALTERNATIVE THAT CONSIDERS THE EFFICIENCY OF THE BASIC HVAC EQUIPMENT SELECTED. IT HAS LIMITED VALUE AS A DECISION TOOL, AND NOT EXPERIMENTED WITH THIS PROJECT.



	Component	Assembly	Orientation	Gross Area		Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor	UA
	Building								
1	Floor 1	All-Wood Joist/Truss:O...		1008	ft2	30.0	0.0	0.033	33
2	Wall 1	Wood Frame, 16" o.c.	Front	360	ft2	20.0	0.0	0.059	18
3	Window 1	Wood Frame:Double P...	Front	40	ft2			0.3	12
4	Door 1	Solid	Front	21	ft2			0.2	4
5	Wall 2	Wood Frame, 16" o.c.	Right Side	280	ft2	20.0	0.0	0.059	15
6	Window 2	Wood Frame:Double P...	Right Side	25	ft2			0.3	8
7	Wall 3	Wood Frame, 16" o.c.	Back	360	ft2	20.0	0.0	0.059	17
8	Window 3	Wood Frame:Double P...	Back	35	ft2			0.3	11
9	Door 2	Glass	Back	42	ft2			0.3	13
10	Wall 4	Wood Frame, 16" o.c.	Left Side	280	ft2	20.0	0.0	0.059	15
11	Window 4	Wood Frame:Double P...	Left Side	25	ft2			.30	9
12	Ceiling 1	Flat Ceiling or Scissor ...		1008	ft2	49.0	0.0	0.026	26

Passes 1.5 % Better Than Code

Compliance Method: UA Trade-Off Max UA 184 Your UA 181

	Component	Assembly	Orientation	Gross Area		Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor	UA
	Building								
1	Floor 1	All-Wood Joist/Truss:O...		1008	ft2	30.0	5.0	0.028	28
2	Wall 1	Wood Frame, 16" o.c.	Front	360	ft2	20.0	5.0	0.044	13
3	Window 1	Wood Frame:Double P...	Front	40	ft2			0.3	12
4	Door 1	Solid	Front	21	ft2			0.2	4
5	Wall 2	Wood Frame, 16" o.c.	Right Side	280	ft2	20.0	5.0	0.044	11
6	Window 2	Wood Frame:Double P...	Right Side	25	ft2			0.3	8
7	Wall 3	Wood Frame, 16" o.c.	Back	360	ft2	20.0	5.0	0.044	12
8	Window 3	Wood Frame:Double P...	Back	35	ft2			0.3	11
9	Door 2	Glass	Back	42	ft2			0.3	13
10	Wall 4	Wood Frame, 16" o.c.	Left Side	280	ft2	20.0	5.0	0.044	11
11	Window 4	Wood Frame:Double P...	Left Side	25	ft2			0.3	8
12	Ceiling 1	Flat Ceiling or Scissor ...		1008	ft2	60.0	0.0	0.024	24

Passes 15.6 % Better Than Code

Compliance Method: UA Trade-Off Max UA 184 Your UA 155

SISTER SAMPLE PROJECT

***REScheck**_SAME BOX DESIGN, SAME ORIENTATION, WITH A DIFFERENT ENVELOPE DESIGN. THE VALUE ENGINEERING WANTS TO WEIGH THE ADDITIONAL CONSTRUCTION COST AND ANNUAL ENERGY EXPENSE AGAINST THE VALUE OF AN ENCLOSED HVAC SYSTEM (WHETHER IN ATTIC OR CRAWL SPACE), THE VALUE OF CONDITIONED ATTIC STORAGE, AND A CONDITONED WORK SPACE AS PART OF THE CRAWL. THIS EXERCISE CANNOT PUT HARD NUMBERS TO THIS, WHICH WOULD ULTIMATELY BE SMART. BUT CONSIDERATIONS CAN BE NOTED.

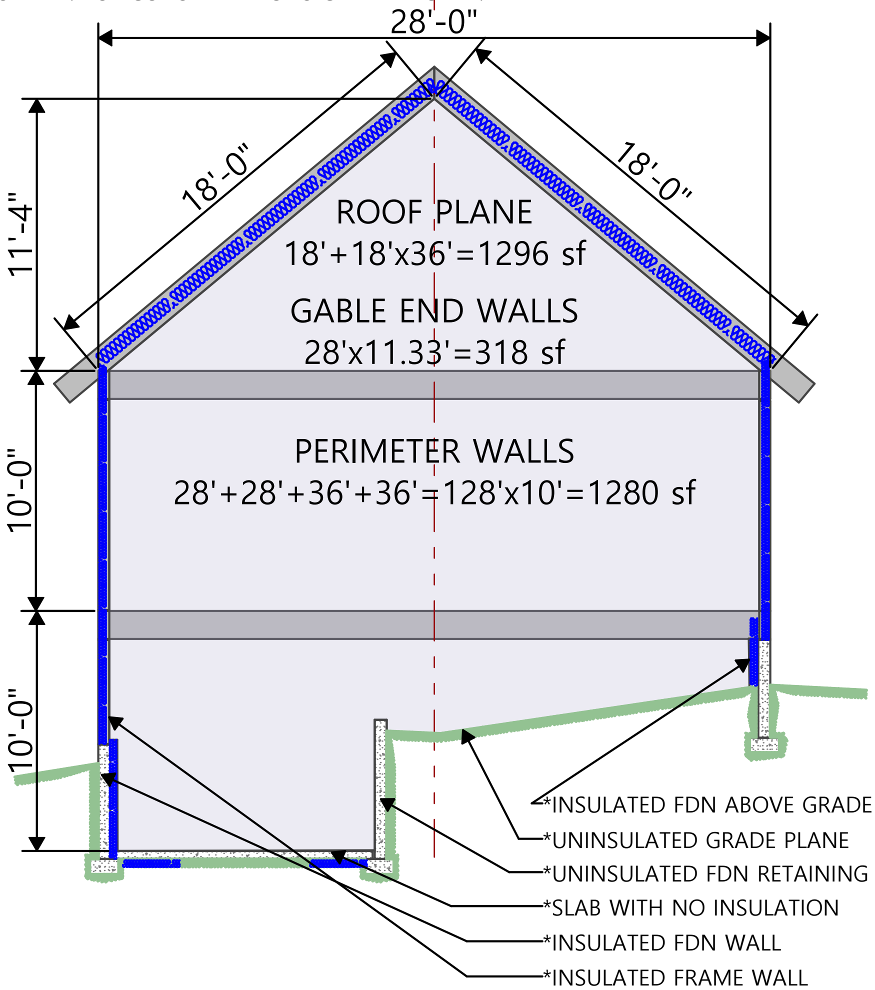
THE ATTIC CLOSURE IS SIMPLER

***SURFACE SQUARE FEET**_THIS ILLUSTRATION NOTES A 1008 SF AREA FOR THE FLAT CEILING PLANE AND A 1296 SF AREA FOR THE ROOF PLANE. A 22% GREATER SURFACE AREA AND 22% GREATER ENERGY PENALTY FOR THE ROOF COMPONENT. THAT PENALTY, ON A PERCENTAGE BASIS, GETS MUCH SMALLER WHEN FACTORED INTO THE ENTIRE ENVELOPE.
***CONSTRUCTIONS**_(c7.24-c7.25) DO A GOOD JOB OF SUMMARIZING INSULATION CONSTRUCTION OPTIONS FOR THE ROOF PLANES

THE CRAWL CLOSURE MAY NOT BE

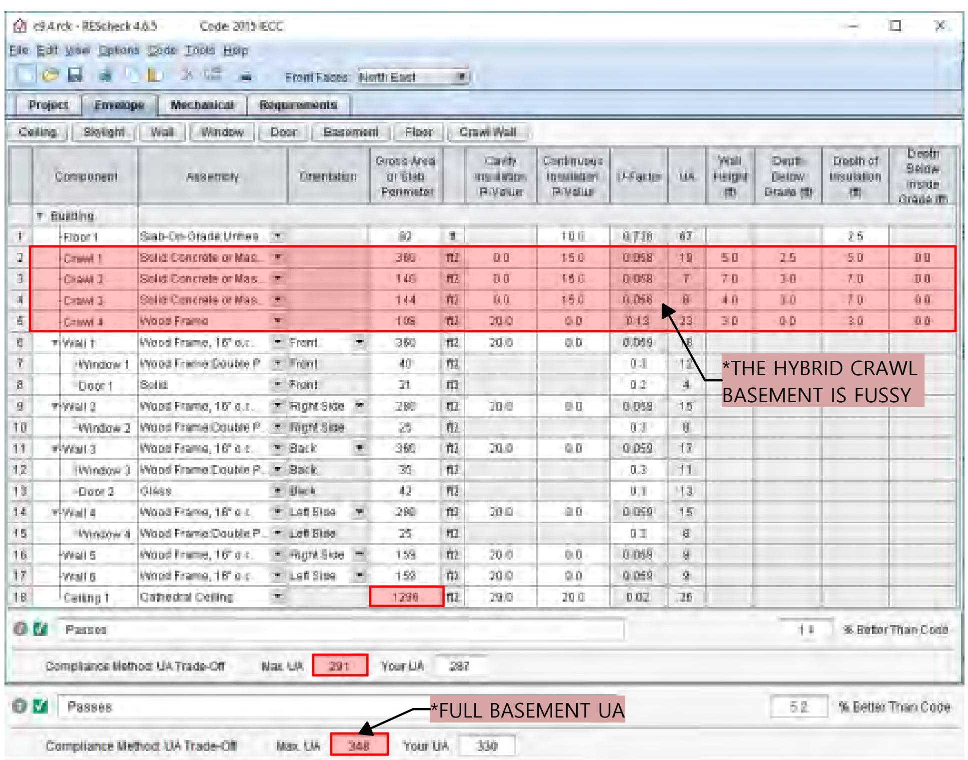
***THIS SAMPLE PROJECT**_SHOWS A PARTIAL CRAWL AND PARTIAL BASEMENT AND A SLOPED SITE. SOME COMPLICATIONS SHOW UP.
***THE CLOSED CRAWL IDEA**_INVOLVES SEALING UP THE WHOLE SPACE AGAINST MOISTURE AND AIR LEAKAGE. IT ALSO INVOLVES THERMALLY PROTECTING IT AS THIS SPACE EFFECTIVELY BECOMES CONDITIONED.

FYI: MAX UA for this 1008 sf sample project: goes down in colder climates? why
Zone 1a_287
Zone 2a_261
Zone 3a_208
Zone 4a_204
Zone 5a_184
Zone 6a_167
Zone 7_162



UA COMPARISONS

***ADDING SURFACES**_WHEN USING THE REScheck TOOL EVERYTIME A NEW SURFACE IS ADDED THE PROGRAM INCREASES THE MAX UA NUMBER. KEEP IN MIND IT IS SEEKING ADEQUATE THERMAL PROTECTION ON A SURFACE AREA UNIT BASIS. IT IS NOT INTERESTED IN MANAGING SQUARE FOOTAGE.
***USING THE UA**_THIS EXPANDED THERMAL ENVELOPE HAS A MAX UA OF 291. THE MORE CONTAINED (c9.5) THERMAL ENVELOPE HAS A MAX UA OF 184. THIS COMPARISON ILLUSTRATES HOW SQUARE FOOTAGE MATTERS. ONE CAN PLUG THESE UA'S INTO THE BASE LOAD FORMULA AND TRANSLATE RESULTS INTO BTU'S. REGARDLESS OF DELTA T THIS SAME PROPORTIONAL RELATIONSHIP WILL EXIST. NOTE INCLUDED BELOW IS THE UA OF 348 FOR A FULL BASEMENT SUBSTITUTION FOR THE HYBRID CRAWL CONSTRUCTION ILLUSTRATED ABOVE.
***MORE R**_IF ONE ADDS MORE R (LESS U) IN CONSISTENT LOCATIONS IN EACH OF THE THREE CONFIGURATIONS BEING COMPARED THE ABOVE CODE COMPLIANCE PERCENTAGE WILL RISE, THE ENERGY REQUIREMENT WILL DIMINISH, BUT THE PROPORTIONAL DIFFERENCE WILL REMAIN THE SAME. SQUARE FOOTAGE MATTERS.



c9.4.rck - REScheck 4.6.5 Code: 2015 IECC

File Edit View Options Code Tools Help

Front Faces: North East

Project | Envelope | Mechanical | Requirements

Ceiling | Skylight | Wall | Window | Door | Basement | Floor | Crawl Wall

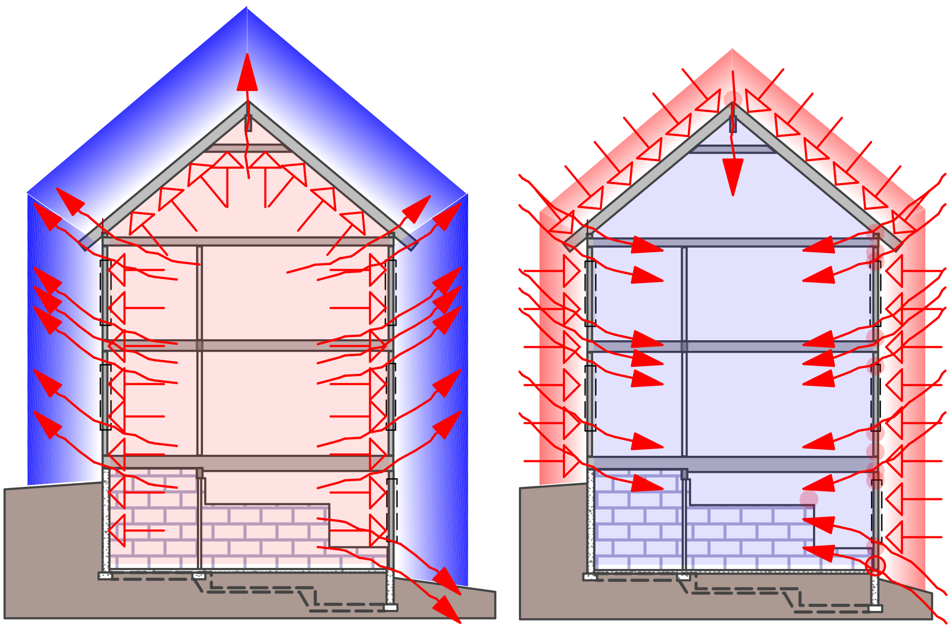
	Component	Assembly	Orientation	Gross Area or Slab Perimeter		Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor	UA	Wall Height (ft)	Depth Below Grade (ft)	Depth of Insulation (ft)	Depth Below Inside Grade (ft)
	Building												
1	Floor 1	Slab-On-Grade:Unhea...		92	ft		10.0	0.738	67			2.5	
2	Crawl 1	Solid Concrete or Mas...		360	ft2	0.0	15.0	0.058	19	5.0	2.5	5.0	0.0
3	Crawl 2	Solid Concrete or Mas...		140	ft2	0.0	15.0	0.058	7	7.0	3.0	7.0	0.0
4	Crawl 3	Solid Concrete or Mas...		144	ft2	0.0	15.0	0.058	8	4.0	3.0	7.0	0.0
5	Crawl 4	Wood Frame		108	ft2	20.0	0.0	0.13	23	3.0	0.0	3.0	0.0
6	Wall 1	Wood Frame, 16" o.c.	Front	360	ft2	20.0	0.0	0.059	18				
7	Window 1	Wood Frame:Double P...	Front	40	ft2			0.3	12				
8	Door 1	Solid	Front	21	ft2			0.2	4				
9	Wall 2	Wood Frame, 16" o.c.	Right Side	280	ft2	20.0	0.0	0.059	15				
10	Window 2	Wood Frame:Double P...	Right Side	25	ft2			0.3	8				
11	Wall 3	Wood Frame, 16" o.c.	Back	360	ft2	20.0	0.0	0.059	17				
12	Window 3	Wood Frame:Double P...	Back	35	ft2			0.3	11				
13	Door 2	Glass	Back	42	ft2			0.3	13				
14	Wall 4	Wood Frame, 16" o.c.	Left Side	280	ft2	20.0	0.0	0.059	15				
15	Window 4	Wood Frame:Double P...	Left Side	25	ft2			0.3	8				
16	Wall 5	Wood Frame, 16" o.c.	Right Side	159	ft2	20.0	0.0	0.059	9				
17	Wall 6	Wood Frame, 16" o.c.	Left Side	159	ft2	20.0	0.0	0.059	9				
18	Ceiling 1	Cathedral Ceiling		1296	ft2	29.0	20.0	0.02	26				

Passes 1.4 % Better Than Code

Compliance Method: UA Trade-Off Max. UA 291 Your UA 287

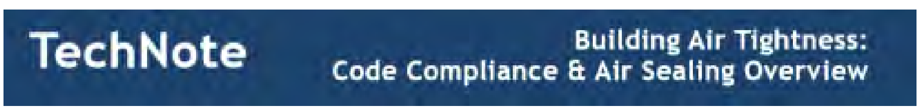
Passes 5.2 % Better Than Code

Compliance Method: UA Trade-Off Max. UA 348 Your UA 330



THE CONSTANT PROBLEM

***HOT TO COLD**_DELTA T IS THE ENGINE THAT IS ALWAYS RUNNING. SO THERE IS SELDOM ANY RELIEF FROM THE HEAT LOSS OR HEAT GAIN CONTINUUM.
***CONDITION 1-THERMAL TRANSFER**_BASED ON SURFACE SQUARE FOOTAGE AND R, U, OR UA) VALUE. ALL SURFACES INTERFACING TEMPERATURE DIFFERENTIALS ARE NEEDING THERMAL RESISTANCE TO LIMIT THERMAL TRANSFER.
***CONDITION 2-THERMAL LEAKS**_ARE A SEPARATE BUT INTEGRATED PROBLEM AND MUST BE ADDRESSED IN ADDITION TO THE TRANSFER NOTED. THE WORKING TERM AS THE RESOLUTION TO LEAKS IS SEALING OR AIR SEALING THE INSULATED THERMAL BARRIER. AN OFT QUOTED AND EFFECTIVE ANALOGY TO THIS DEMAND IS THE WINTER FLEECE TYPE COAT. TO STAY WARM IT WANTS TO BE ZIPPED, AND TIGHT AT THE COLLAR AND SLEEVES (NO LEAKS). TO STAY WARM IT REALLY WANTS A AIR BLOCKING SHELL SO THE FLUFFY FLEECE INSULATION CAN BETTER DO ITS JOB. DITTO THE HOUSE. TAPE, CAULK, THE LEAKS, AND HAVE AN AIR BARRIER CONTINUOUSLY INSTALLED IN CONJUNCTION WITH THE INSULATION TO INCREASE ITS EFFECTIVENESS.



THIS IS A SHORT DOCUMENT SPONSORED BY THE ICC AND NAHB THAT DOES CONTAIN A GREAT 3D ILLUSTRATION OF AIR LEAKAGE LOCATION CANDIDATES.

THIS GUIDE SEEMS COMPREHENSIVE. GOVERNMENT SPONSORED PRESENTATIONS TEND TO BE REASONED. THEY ARE NOT SELLING ANYTHING.

BSI-053: Just Right and Airtight

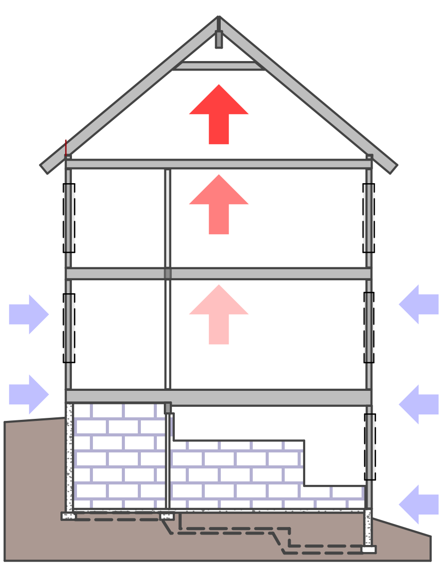
THE BUILDING SCIENCE CORPORATION ALSO KEEPS AN EYE ON WHATS REAL AND WHAT IS NOT. THIS 'INSIGHT' IS A MUST READ AS A MEANS OF MAINTAINING PERSPECTIVE ON WHAT THE SMART THING TO DO IS.

SEALING REFERENCES

***AT LEFT**_JUST A FEW RESOURCES FOR A QUICK COURSE IN AIR TIGHTNESS. THERE IS A MOUNTAIN OF DATA AVAILABLE. THESE RESOURCES WILL DO A MUCH BETTER JOB OF PRESENTATION THAN THIS PROJECT CAN. AS WITH ALL RESEARCH-BEWARE THOSE SELLING SOMETHING.

INSPECTING TIGHTNESS

***KNOWLEDGE**_ KNOWING WHERE A HOME CHARACTERISTICALLY LEAKS IS A GREAT START.
***VISUAL INSPECTIONS**_THAT KNOWLEDGE HELPS DIRECT A VISUAL INSPECTION. THESE CAN'T BE CURSORY. LEAKS CAN BE REAL TINY.
***BLOWER DOOR TESTING**_WHEN PROPERLY EMPLOYED THE BLOWER DOOR TEST IS A GREAT BACKUP TOOL THAT EITHER SALUTES A SUCCESSFUL HOME SEALING, OR TELLS US WE STILL GOT SOME LEAKS TO PLUG.
***ACCEPTABLE PARAMETERS**_THE CODE HAS GENERATED 2 ACCEPTABLE LEAKAGE LIMITS-BASED ON CLIMATE ZONE. SOME ACCEPT THESE LEVELS AS REASONABLE AND OTHERS DO NOT. IF ONE WANTS TO GET DIZZY THERE IS ANOTHER MOUNTAIN OF TECHNICAL OPINION AND DATA READILY AVAILABLE TO RESEARCH.



STACK EFFECT

***MOTHER NATURE**_WARMER AIR RISES BECAUSE IT IS LIGHTER THAN COOLER AIR. THE HOT AIR BALLOON IDEA. WHEN THAT WARMER AIR ESCAPES TO THE OUTSIDE THE PRESSURE CHANGE CREATED WANTS TO SUCK IN COOLER AIR. THE MANY READILY AVAILABLE IMAGES ILLUSTRATING THIS STACK EFFECT ARE SIMILAR TO THE ONE AT LEFT AND SHOW WARMER AIR ESCAPING HIGHER IN THE HOUSE GEOMETRY WITH COOLER AIR ENTERING LOWER IN THE HOUSE GEOMETRY.
***EXFILTRATION**_IS THE TERM USED DENOTING THE EXITING WARMER AIR. THAT EXIT IS CONDITIONAL ON THE OUTSIDE AIR BEING COOLER (HOT TO COLD), AND THERFORE THE STACK EFFECT IS COOL TO COLD WEATHER CONDITIONAL.
***INFILTRATION**_IS THE TERM DENOTING THE ENTRY OF COOLER AIR.
***TRY AS WE MIGHT**_TO GET A HOME TIGHT, IT IS NOT REALISTIC TO EXPECT A HOME CONSTRUCTION TO BE 100% AIR TIGHT. AND IN FACT WE DON'T WANT THEM THAT TIGHT.

FRESH AIR/MAKE UP AIR

***THE CATCH 22**_THE 100% TIGHT HOUSE (WERE IT ACHIEVEABLE) HAS A FATAL FLAW. A HOME NEEDS A CERTAIN AMOUNT OF FRESH (HOPEFULLY) AIR, aka MAKE UP AIR. PRESSURE NEEDS TO BE BALANCED, COMBUSTION APPLIANCES AND FIREPLACES NEED COMBUSTION AIR, AND RECYCLED 'STAGNANT' AIR BECOMES A HEALTH RISK AND NEEDS (HOPEFULLY) HEALTHY STUFF FROM OUTSIDE.
***SO**_VENTILATION, aka MAKE UP AIR, IS NECESSARY AND CODE REQUIRED. THESE REQUIREMENTS ARE IN THE MECHANICAL SECTION OF THE CODE. THERE ARE A FEW DIFFERENT STRATEGIES FOR BRINGING THIS MAKE UP AIR INTO THE HOUSE, AND (ALSO) A LITTLE OUTSIDE THE SCOPE OF THIS GUIDE. HVAC CONTRACTORS AND OR ENERGY CONSULTANTS ARE TYPICALLY GOOD RESOURCES. FOR REQUIREMENTS AND BEST METHODS.

***OBSERVATION_**THE CODE SNIPPETS THESE NEXT 2 PAGES ARE HIGHLIGHT A FEW SELECTED TOPICS THIS CHAPTER 11 TITLED ENERGY EFFICIENCY. THESE SNIPPETS ARE JUST THAT AND DON'T INCLUDE THE FOOTNOTES AND EXCEPTIONS SO BE ADVISED THAT BOTH A COMPLETE READING IS NECESSARY, AND THAT LOCAL REQUIREMENTS VERY WELL MAY VARY AND NEED RESEARCH.

N1102.4 (R402.4) Air leakage (Mandatory).

The *building thermal envelope* shall be constructed to limit air leakage in accordance with the requirements of Sections N1102.4.1 through N1102.4.5.

TABLE N1102.4.1.1 (R402.4.1.1)
AIR BARRIER AND INSULATION INSTALLATION[a]

COMPONENT	AIR BARRIER CRITERIA	INSULATION INSTALLATION CRITERIA

***OBSERVATION_**THIS TABLE LISTS 16 'CATAGORIES' OF COMPONENTS TYPICALLY PART OF THE THERMAL ENVELOPE THAT THEREFORE NEED TO BE AIR SEALED AND INSULATED. CONSIDER IT A GENERIC CHECKLIST. SPECIFIC TECHNIQUES ARE NOT INCLUDED.

N1102.4.1.2 (R402.4.1.2) Testing.

The *building* or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding five air changes per hour in *Climate Zones* 1 and 2, and three air changes per hour in *Climate Zones* 3 through 8. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the *building official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official*. Testing shall be performed at any time after creation of all penetrations of the *building thermal envelope*.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weatherstripping or other infiltration control measures.
2. Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures.
3. Interior doors, where installed at the time of the test, shall be open.
4. Exterior or interior terminations for continuous ventilation systems shall be sealed.
5. Heating and cooling systems, where installed at the time of the test, shall be turned off.
6. Supply and return registers, where installed at the time of the test, shall be fully open.

***OBSERVATION_**THE AIR SEAL TEST IS PRETTY SIMPLE IN PRINCPLE. A BLOWER FAN IS POSITIONED IN AN EXTERIOR DOOR OPENING AND MADE TIGHT TO THAT OPENING WITH PLASTIC SHEETING AND TAPE. ALL EXTERIOR DOORS AND WINDOWS ARE CLOSED. THE FAN IS BLOWING OUT AND THEREFORE SUCKING AIR THRU THE HOUSE. ONCE A SPECIED PRESSURE IS REACHED THE AMOUNT OF AIR THEN BEING PERMITTED IN THRU THE AIR SEALED ENVELOPE IS MEASURED. IF TOO MUCH AIR IS PASSING THEN SOMETHING HAS NOT BEEN ADEQUATELY SEALED. THOSE LEAKS NEED TO BE FOUND AND REMEDIED.

A FEW OF THE 'KEY' COMPONENTS SINGLED OUT IN THE CODE ARE INCLUDED BELOW.

N1102.4.2 (R402.4.2) Fireplaces.

New wood-burning fireplaces shall have tight-fitting flue dampers or doors, and outdoor combustion air. Where using tight-fitting doors on factory-built fireplaces *listed* and *labeled* in accordance with UL 127, the doors shall be tested and *listed* for the fireplace.

N1102.4.3 (R402.4.3) Fenestration air leakage.

Windows, *skylights* and sliding glass doors shall have an air infiltration rate of not greater than 0.3 cfm per square foot (1.5 L/s/m^2), and for swinging doors not greater than 0.5 cfm per square foot (2.6 L/s/m^2), when tested in accordance with NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory and *listed* and labeled by the manufacturer.

N1102.4.5 (R402.4.5) Recessed lighting.

Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and *unconditioned spaces*. Recessed luminaires shall be IC-rated and *labeled* as having an air leakage rate of not greater than 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E283 at a pressure differential of 1.57 psf (75 Pa). Recessed luminaires shall be sealed with a gasket or caulked between the housing and the interior wall or ceiling covering.

***OBSERVATIONS_**THESE SINGLED OUT CONDITIONS ARE CONCERNS. BUT REALIZE THAT EVERY GEOMETRIC CONNECTION AND MATERIAL CONNECTION AT THE ENVELOPE REPRESENTS A POTENTIAL LEAK. WOW. ULTIMAELY THE BLOWER DOOR TEST IS A SMART DEAL, EVEN IF NOT LOCALLY REQUIRED.

***THIS PROJECT**_DUCTING OVERVIEW NOTES ARE INCLUDED THIS CHAPTER BECAUSE THE DUCTED HVAC SYSTEM HAS BEEN SELECTED AS THE DEFAULT THIS PROJECT. THE BUILDING SHELL AND STRUCTURE MUST ALLOW SPACE FOR THE DUCTWORK. DUCTWORK SIZING/SPACE ALLOWANCE IS GENERATED FROM SOME RULES OF THUMB AND CFM CONSIDERATIONS WHICH RESULTS IN DUCT SIZING. SEE (c9.12). THIS IS INCLUDED AS AN AWARENESS EXERCISE. IT IS NOT POSSIBLE TO DESIGN ANY HVAC PACKAGE WITHOUT SPECIFIC SITE AND ORIENTATION DATA.

N1103.3 (R403.3) Ducts.

Ducts and air handlers shall be installed in accordance with Sections N1103.3.1 through N1103.3.8.

N1103.3.1 (R403.3.1) Insulation (Prescriptive).

Supply and return ducts in attics shall be insulated to an *R*-value of not less than R-8 for ducts 3 inches (76 mm) in diameter and larger and not less than R-6 for ducts smaller than 3 inches (76 mm) in diameter. Supply and return ducts in other portions of the *building* shall be insulated to not less than R-6 for ducts 3 inches (76 mm) in diameter and to not less than R-4.2 for ducts smaller than 3 inches (76.2 mm) in diameter.

Exception: Ducts or portions thereof located completely inside the *building thermal envelope*.

N1103.3.3 (R403.3.3) Duct testing (Mandatory).

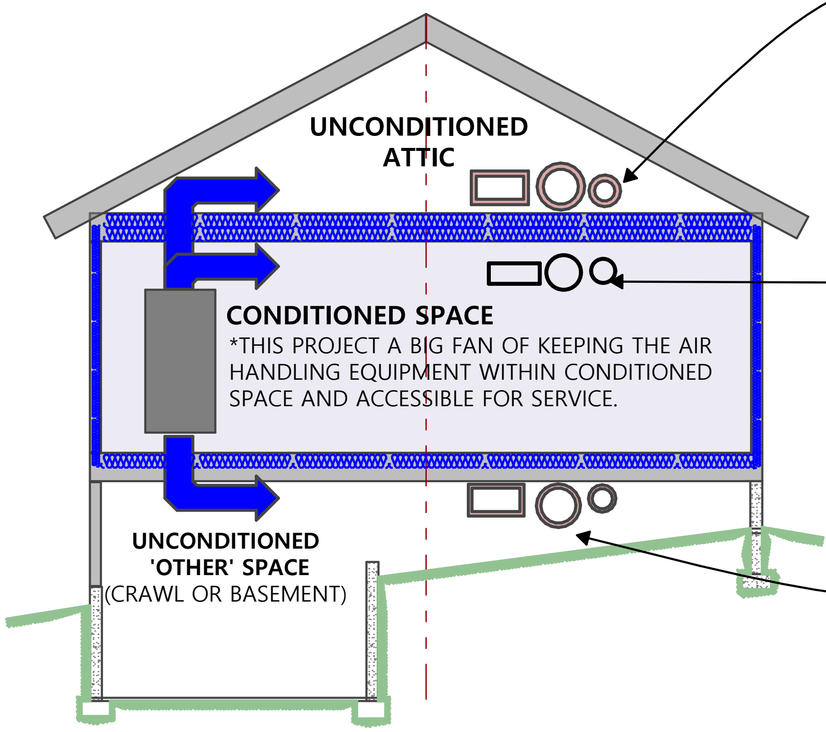
Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test.
2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exceptions:

1. A duct air-leakage test shall not be required where the ducts and air handlers are located entirely within the *building thermal envelope*.
2. A duct air-leakage test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

A written report of the results of the test shall be signed by the party conducting the test and provided to the *building official*.



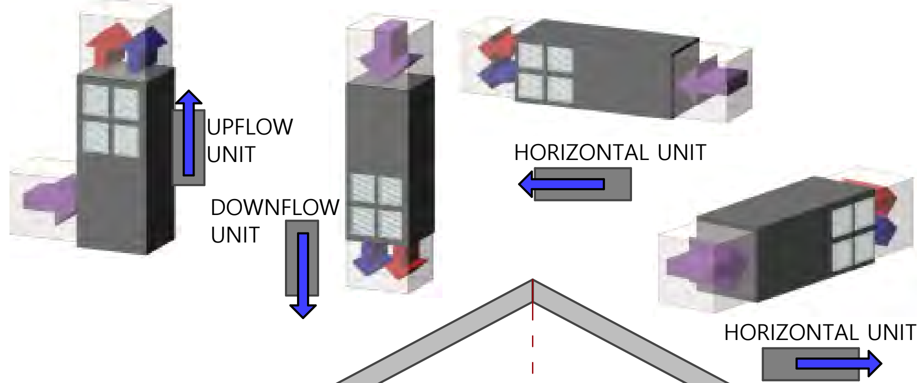
FOR DUCTS IN NON CONDITIONED ATTIC SPACES
*R-8 DUCTS 3"ID AND GREATER
*R-6 DUCTS SMALLER THAN 3"ID
*DUCT LEAKAGE TEST REQUIRED
*IT IS EASY TO RUN DUCTS UP HERE AS THERE ARE NO PHYSICAL BARRIERS EXCEPTING TRUSS WEBS. ROUND FLEX DUCTS ARE AN INSTALLATION SNAP. BURTING DUCTS UP HERE IS DOABLE AND OFFERS MUCH BETTER PERFORMANCE.SEE (c9.11). THINK ABOUT DUCTS TRYING TO DELIVER 65^0 COOLING IN A 120^0 ATTIC SPACE. IT DOESN'T COMPUTE.

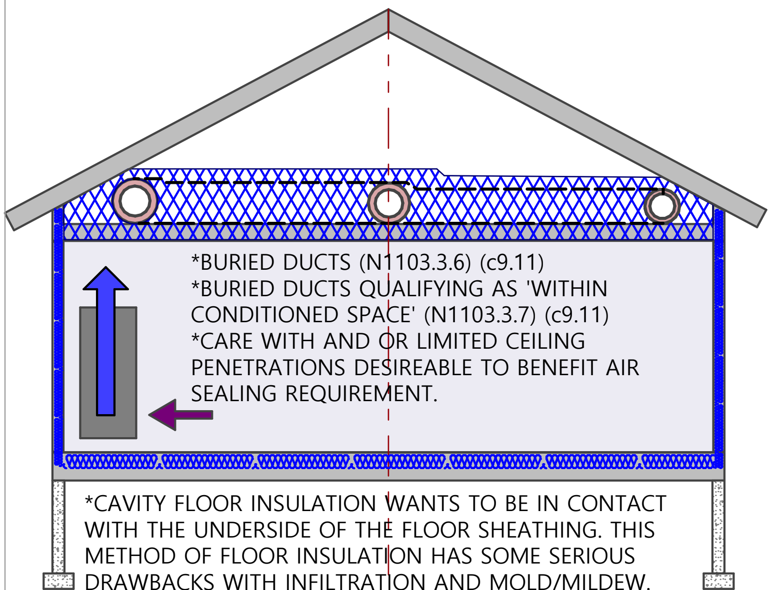
FOR DUCTS IN CONDITIONED SPACE
*NOT DOING THIS IS DUMB.
*NO INSULATION REQUIRED
*DUCT LEAKAGE TEST NOT REQUIRED
**LEAKY DUCTS- REALLY ANY DUCT INEFFFICENCY- ARE PERMITTED BUT NOT ADVISED. NEW CONDITIONED AIR WILL STAY WITHIN THE THERMAL ENVELOPE WHICH IS GOOD, BUT IT NOT GETTING DELIVERED TO THE INTENDED DISCHARGE POINT EFFICIENTLY STILL MAKES THE SYSTEM HAVE TO WORK HARDER.

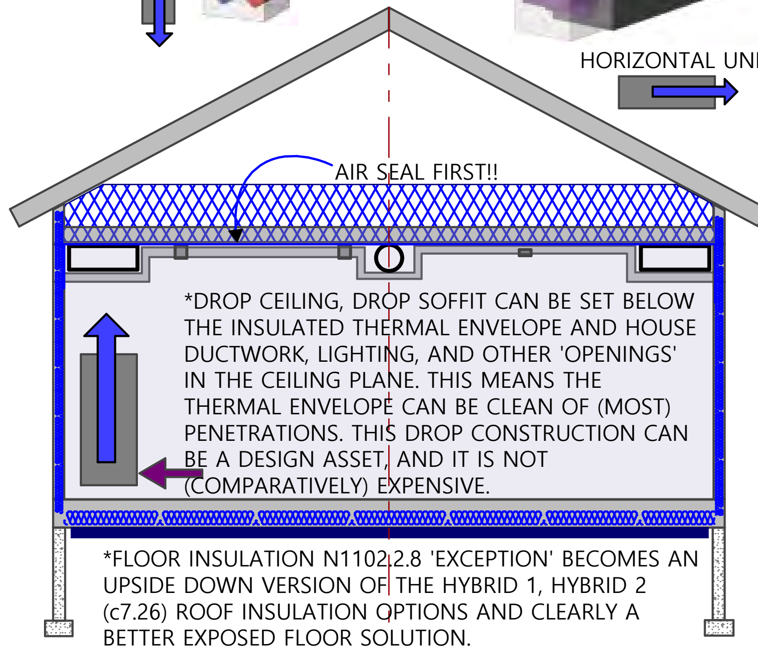
FOR DUCTS IN NON CONDITIONED OTHER SPACES
*R-6 DUCTS 3"ID AND GREATER
*R-4.2 DUCTS SMALLER THAN 3"ID
*DUCT LEAKAGE TEST REQUIRED
**THE UNCONDITIONED CRAWL SPACE (OR BASEMENT) MAINTAINS A SLIGHTLY ADJUSTED OUTSIDE TEMPERATURE. THE DUCTWORK'S DELIVERY TEMPERATURE IS FIGHTING THAT CRAWL SPACE TEMPERATURE. IN WINTER MONTHS THIS IS A DRAG ON HEAT DELIVERY. COOLING MONTHS ACTUALLY HAVE A DEW POINT PROBLEM WITH PRETTY SIGNIFICANT AMOUNTS OF MOISTURE COLLECTING ON THE DUCTWORK.

***DUCT SIZE, GEOMETRY AND LAYOUT**_(c9.12) A FEW COMMENTS ON DUCTING ARE MENTIONED. THIS SCHEMATIC IS APPROPRIATE TO POINTING OUT ONE CONDITION WITH DUCT GEOMETRY. FOR EXAMPLE A 20" ROUND MAIN SUPPLY OR RETURN DUCT ARE POSSIBLE TO RUN IN THE OPEN AREAS DEPICTED IN THIS CRAWL AND ATTIC SPACES. RUNNING THAT SAME 20" ROUND DUCT WITHIN THE MAIN LEVEL CONDITIONED SPACE HOWEVER CAN BE A REAL PHYSICAL PROBLEM. A RECTANGULAR DUCT DELIVERING THE SAME AIR IS BETTER SUITED TO FIT- FOR EXAMPLE A SOFFIT SITUATION WHERE A WIDER AND NOT SO HIGH GEOMETRY IS BEST.

INTRO TO AIR HANDLER SPACE ALLOCATION (d8.15,d8.16)
*HELPFUL TO REVIEW THOSE SCHEMATICS WHEN CONSIDERING THE BELOW
*AIR HANDLERS AND DUCTS HAVE TO BE IN SYNC. THERE IS A SUPPLY SIDE AND A RETURN SIDE TO THE UNIT AND TO THE DUCT SYSTEM SERVING THE UNIT. SO THERE ARE CONDITIONS. DUCT SYSTEMS ARE -OF NECESSITY- CUSTOMIZED TO SUIT.



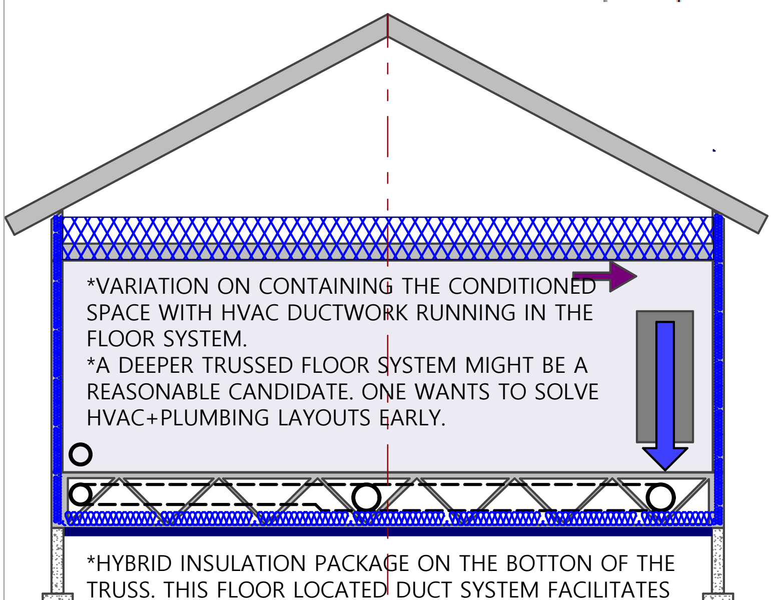




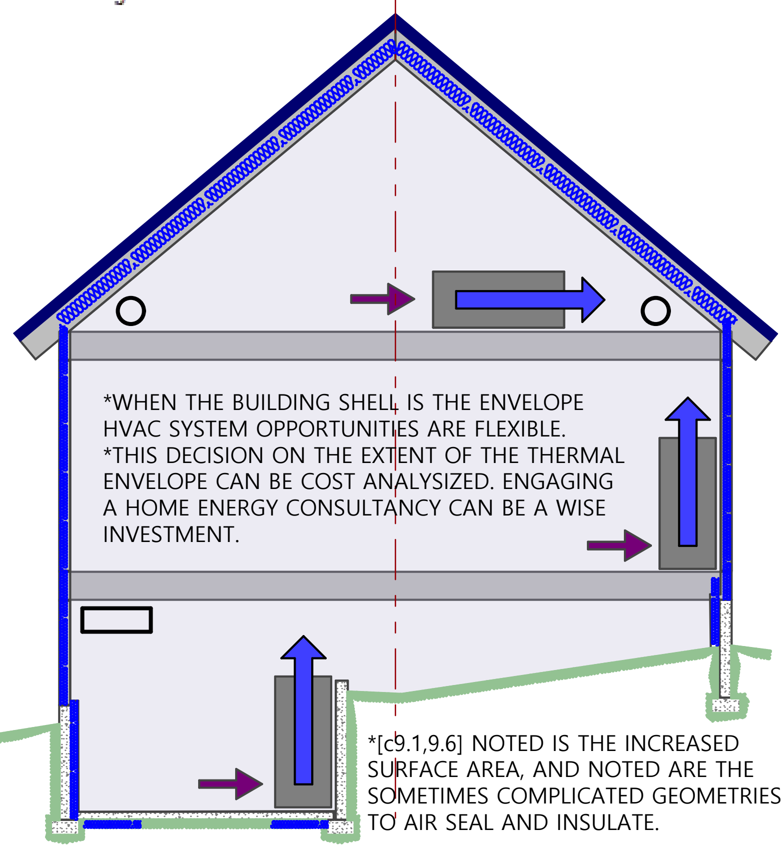
N1102.2.8 (R402.2.8) Floors.

Floor framing-cavity insulation shall be installed to maintain permanent contact with the underside of the subfloor decking.

Exception: As an alternative, the floor framing-cavity insulation shall be in contact with the topside of sheathing or continuous insulation installed on the bottom side of floor framing where combined with insulation that meets or exceeds the minimum wood frame wall *R*-value in Table N1102.1.2 and that extends from the bottom to the top of all perimeter floor framing members.

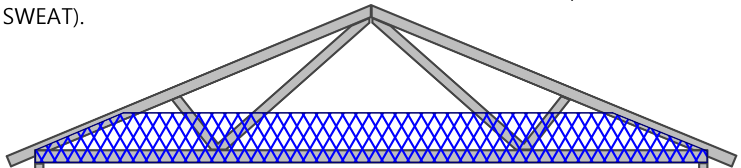


*HYBRID INSULATION PACKAGE ON THE BOTTON OF THE TRUSS. THIS FLOOR LOCATED DUCT SYSTEM FACILITATES HEAT REGISTERS AT THE FLOOR PLANE DESIRED IN HEATING DOMINATED COLDER CLIMATES.
*A BIG CONDITION THIS SYSTEM IS THE DUCTWORK AND PLUMBING NEEDING TO BE POSITIONED BEFORE THE SUBFLOOR CAN BE FIXED IN PLACE!!!!!!!!!!
*A FEW DESIGNS THIS PROJECT MAY SHOW A PERIMETER BENCH SEAT/PLANT SHELF WITH HVAC DUCT. UNFORTUNATELY DOORS BECOME A VERY DIFFICULT WORKAROUND.

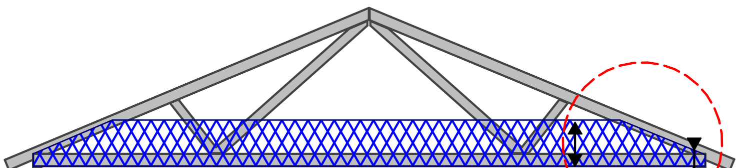


OVERVIEW ON CEILING INSULATION

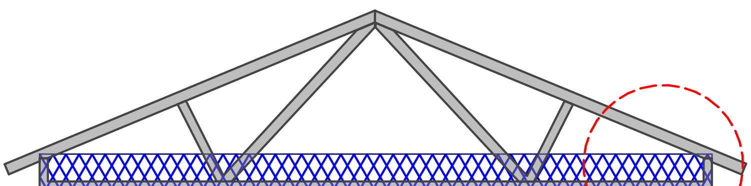
***BUILDING SCIENCE CORP**_OFFERS A RELAVENT ARTICLE ON BURIED DUCTWORK IN CEILINGS TITLED 'INSIGHT-NO SWEAT' (OR BSI-094: NO SWEAT).



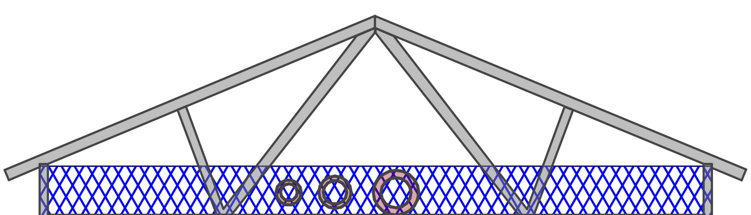
*THIS SIMPLE SLAB AND TRUSS CONSTRUCTION IS VERY COMMON (AND ECONOMICAL). THE ONE MAJOR DEVIL HAS ALWAYS BEEN THE DUCTWORK WHICH BEGS TO JUST LAY IN THE ATTIC ATOP THE BOTTOM TRUSS CORD OR RAFTER. BAD IN ALL CLIMATES.
*CODE HAS ADDRESSED THIS. SEE NOTES AT RIGHT.



*THE REDUCED HT AND OFTEN COMPRESSION OF INSULATION AT THE EAVES IS A TRADITIONAL PROBLEM AREA.
*VENTILATION MAY BE STIFLED.
*HEAT LOSS/GAIN INCREASED AT THE LONG RUNNING EAVES.
*COLD CLIMATE ICE PROBLEMS AT THE EAVES COMMON.

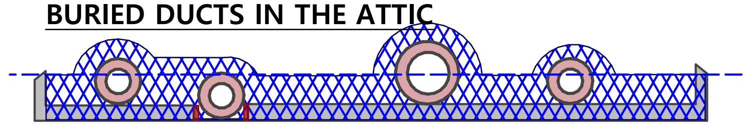


*WHERE R-38 IS REQUIRED, R-30 IS PERMITTED IF FULL HT (9"+/-) THROUGHOUT
*WHERE R-49 IS REQUIRED, R-38 IS PERMITTED IF FULL HT (9"+/-) THROUGHOUT
*THIS EXCEPTION REQUIRES A RAISED HEEL CONSTRUCTION.
*REDUCING THIS R IS PERMITTED BUT NOT RECOMMENDED.
*RAISE THE HEEL ENOUGH TO GET THE IDEAL MAXIMUM R.

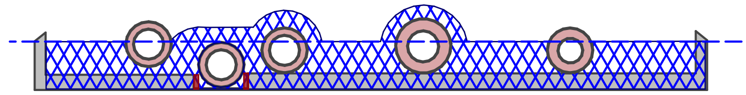


*IF THE DUCTWORK GETS BURIED IT CAN PERFORM MORE EFFECTIVELY IN BOTH COLD WEATHER COLD, AND DEALING WITH WARM WEATHER DUCT CONDENSATION. CODE PERMISSIONS NOTED AT RIGHT GET SLIGHTLY AWKWARD, BUT ARE WORTH RECOGNIZING BECAUSE OF VALUE OF THIS DEFINITE ENERGY IMPROVEMENT.

BURIED DUCTS IN THE ATTIC

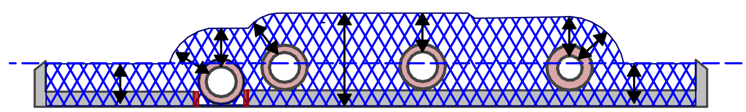


N1103.3.6 DUCTS BURIED WITHIN CEILING INSULATION
*FOR ZONES 1-3 R-30 OR R-38 IS THE BASELINE REQUIREMENT. THE R-13 INSULATED DUCTS MUST BE FULLY BURIED. THE 'COVER' INSULATION IS NOT SPECIFIED.



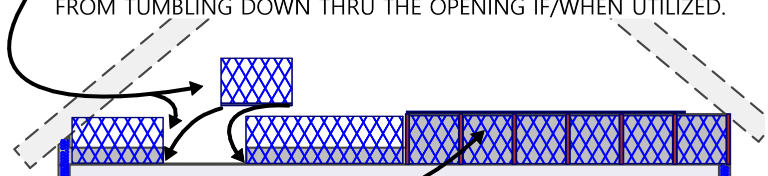
N1103.3.6 DUCTS BURIED WITHIN CEILING INSULATION
*FOR ZONES 4-8 R-38 OR R-49 IS THE BASELINE REQUIREMENT. THE R-8 INSULATED DUCTS MUST HAVE AN R-19 BELOW, OR ABOVE, OR PRORTIONED AS SELECTED ABOVE AND BELOW.

N1103.3.6.1 EFFECTIVE R VALUE OF DEEPLY BURIED DUCTS
*STATES THAT IF DUCTS ARE FULLY BURIED WITH 3.5" MIN OF INSULATION ABOVE, THEY WILL HAVE ACHIEVED AN EFFECTIVE R-25 FOR PURPOSES OF SIMULATED ENERGY PERFORMANCE ANALYSIS (AND HEAT GAIN/LOSS CALCS).
*THIS WOULD NOT INCLUDE THE PERMITTED ZONE 4-8 INSULATED DUCT SITTING ABOVE THE BASELINE PLANE-WHICH IS A QUESTIONABLE TACTIC TO BEGIN WITH.



N1103.3.7 (BURIED) DUCTS LOCATED IN CONDITIONED SPACE
*CONDITIONED SPACE IS REQUIRED TO HAVE A SEALED THERMAL BARRIER 'ENVELOPE'. BURIED DUCTS HAVE THE THERMAL BARRIER BUT ARE OUTSIDE THE SEALED AIR BARRIER. SO CONDITONS EXIST FOR THESE BURIED DUCTS TO BE CLASSIFIED AS BEING INSIDE THE THERMAL ENVELOPE-IN CONDITIONED SPACE. THIS IS IMPORTANT BECAUSE HVAC SYSTEMS LOCATED WITHIN CONDITIONED SPACE BENEFIT GREATLY IN HEAT GAIN/LOSS CALCULATIONS WHICH RESULT IN SMALLER MORE EFFCIENT EQUUIPMET
*THE AIR HANDLER MUST BE WITHIN CONDITIONED SPACE- SO IT EITHER MUST BE LOCATED BELOW THE ATTIC PLANE OR CONSTRUCTED IN AN ATTIC "TENT" (HVAC ROOM) WHICH IS VIABLE IN LARGE PROJECTS WITH BIGGER ATTIC VOLUMES, BUT HARDLY PRACTICAL/POSSIBLE IN SMALL TRUSS ROOF CONSTRUCTIONS.
*THE CODE PRESCRIBED R VALUE MUST BE MAINTAINED ABOVE ALL DUCTS.
*DUCT LEAKAGE TESTING REQUIRED AND IS SIGNIFICANTLY MORE STRINGENT.

N1102.2.4 ATTIC ACCESS HATCH
*THIS DESIGN SCENARIO-WITH DEEP INSULATION AND POSSIBLE BURIED DUCTS-SAYS THE ATTIC SPACE WILL NOT BE USED FOR STORAGE. THE AIR HANDLER IS LOCATED ON THE FLOOR BELOW, AND ACCESS IS ESSENTIALLY NOT USE REQUIRED, ONLY CODE REQUIRED.
*THE INSULATION ABOVE THE HATCH OPNG HAS TO MAINTAIN THE SAME INSULATION VALUE AS THE CEILING PLANE, AND IT NEEDS A WEATHERSTRIPING DETAIL THAT KEEPS IT AIR SEALED. A 'FENCE' MECHANISM IS REQUIRED TO KEEP THE LOOSE INSULATION FROM TUMBLING DOWN THRU THE OPENING IF/WHEN UTILIZED.



OTHER SITUATIONS
*(d6.10, a7) OTHER CONDITIONS (USUALLY WITHOUT DUCTS) CAN INSTALL FULL R DEPTH LOOSE INSULATION WITHIN A CEILING STRUCTURAL DEPTH, PUT A SUBFLOOR ON TOP, AND USE AN ATTIC FLOOR WITH PULL DOWN STAIR AS REASONABLE STORAGE. THE PULL DN STAIR OPENING IS SUBJECT TO THE SAME REQUIREMENT.

HVAC DESIGN

***RULES OF THUMB THAT ARE DANGEROUS BUT USEFUL**_ALL HVAC DESIGN IS REQUIRED TO BE CALCULATED USING THE MANUAL 'J'___. THE THEORY IS THAT HEAT GAIN AND LOSS CALCULATIONS WOULD BE RESPONSIBLE AND ACCURATE, WHICH WOULD DIRECTLY RESULT IN EFFICIENT EQUIPMENT SELECTIONS. THE GENERIC BAD RAP ON RULES OF THUMB IS THAT EQUIPMENT GETS OVERSIZED TO BE ABSOLUTELY SURE THERE IS ENOUGH HEATING AND COOLING TO ADDRESS THE MOST EXTREME SITUATIONS. THE COOLING SIDE IS THE PRIMARY TARGET HERE AS OVERSIZED EQUIPMENT (TONS) WILL RUN INEFFICIENTLY AND LESS EFFECTIVELY THAN PROPERLY SIZED EQUIPMENT. THIS IS A PROVEN REALITY. THE MANUAL 'J' DOES NOT RELY ON RULES OF THUMB. WITH CORRECT AND CAREFUL INPUT IT WILL GENERATE HOUSE AND LOCATION SPECIFIC HEAT GAIN/LOSS AND SOLAR GAIN NUMBERS.
***RULES OF THUMB THIS SHEET**_THIS SHEET HAS A RULE OF THUMB CHART THAT HAS ONE PURPOSE AND ONE BENEFIT. THE PURPOSE IS TO PROVIDE THIS PROJECT WITH SOME PARAMETERS FOR THE SUPPY AND RETURN DUCT SIZES SO THAT WHEN A STRATEGY FOR A DUCTWORK LAYOUT IS POSSSIBLE, PROPER SPACE WILL HAVE BEEN ALLOWED FOR THAT DUCTWORK. THE OPPORTUNITY OF THIS RULE OF THUMB CHARTING IS TO INFORM A LITTLE ABOUT THE RANGE OF VALUES IN THESE RULES OF THUMB AND THE REASONS FOR THEM.

THIS PROJECTS' IN HOUSE DUCT CHART

***DOMINATION OF COOLING IN THIS DISCUSSION**_WHEN FORCED AIR SYSTEMS ARE MANAGING COOLING AND HEATING IT IS MORE COMMON FOR THE DUCTWORK REQUIRED TO NEED TO BE LARGER FOR THE COOLING CYCLE. THIS IS OFTEN TRUE EVEN IN COLDER CLIMATES. BUT NOTE IT IS NOT ALWAYS THE CASE AND CERTAINLY NOT THE CASE WHEN HEATING ONLY IS BEING PROVIDED BY THE FORCED AIR SYSTEM. THIS IN HOUSE CHART BELOW USES COOLING IN TONS AS THE DUCT SIZE DETERMINANT.
***#1 RULE OF THUMB**_HOW MANY SQUARE FEET OF LIVING SPACE CAN 1 TON OF AIR CONDITIONING HANDLE?
***MOST QUOTED RULE OF THUMB**_400 SF, OR 600 SF. QUALIFIED HVAC FOLKS MIGHT SAY THE RANGE IS FROM 350 SF TO 2000 SF, BASED ON THE CLIMATE ZONE BUT MORE IMPORTANTLY ON THE GEOMTRY AND QUALITY OF THE THERMAL ENVELOPE.
***#2 RULE OF THUMB**_HOW MANY CFM IS BEST TO DELIVER THAT TONAGE THROUGHOUT THE DUCT SYSTEM?
***MOST QUOTED RULE OF THUMB**_400 CFM PER TON. AND THIS SEEMS A VIABLE RULE OF THUMB TO USE. OTHER ACCEPTED NORMS ARE HUMID AIR IS BETTER DELIVERED AT SLOWER RATES. 350 CFM OFTEN QUOTED. AND HEAT PUMP SYSTEMS PERFORM MORE EFFICIENTLY AT 450 OR 500 CFM. THIS PREFERRED CFM DELIVERY IS A BEST DESIGN TO EQUIPMENT SELECTION SEQUENCE.
***CFM IS THE ANSWER BEING SOUGHT**_THE CFM (CUBIC FEET PER MINUTE) DICTATES THE DUCT SIZE. THAT SIMPLE. THE CFM PER TON THINKING ASSUMES THE COOLING SIDE IS DICTATING THE LARGER CFM AND THERFORE DUCT SIZE. SEE NOTE ABOVE.

***SF PER TON 'YIELD' IS ESSENTIALLY AN EFFICIENCY RECOGNITION-HIGHER IS BETTER. SEE GLIB COMMENTS BELOW CHART.**

HOUSE SF	400 sf	600 sf	675 sf	750 sf	1000 sf	400 sf/TON	round flex	rectangular		
1000 SF	2.5 tons	2 tons	1.5 tons	1.5 tons	1 ton	600 cfm	14"dia	8" x 18"	10" x 14"	12" x 12"
1250 SF	3.5 tons	2.5 tons	2 tons	2 tons	1.5 tons	800 cfm	16"dia	8" x 22"	10" x 16"	12" x 14"
1500 SF	4 tons	2.5 tons	2.5 tons	2 tons	1.5 tons	1000 cfm	16"dia	8" x 26"	10" x 16"	12" x 18"
1750 SF	5 tons	3 tons	3 tons	2.5 tons	2 tons	1200 cfm	17"dia	8" x 30"	10" x 22"	12" x 20"
2000 SF	5 tons	3.5 tons	3 tons	3 tons	2 tons	1200 cfm	17"dia	8" x 30"	10" x 22"	12" x 20"
2250 SF	2 UNITS	4 tons	3.5 tons	3 tons	2.5 tons	1400 cfm	18"dia	8" x 34"	10" x 22"	12" x 20"
2500 SF	2 UNITS	5 tons	4 tons	3.5 tons	2.5 tons	1600 cfm	20"dia	8" x 40"	10" x 30"	12" x 24"

*400 SF_EITHER SLOPPY HVAC DEISGN OR SLOOPPY HOME DESIGN.
*600 SF_THE ACCEPTIBLE INEFFICIENT CATEGORY.
*675 SF_ USED THIS PROJECT AS A COMPROMISE BETWEEN OK AND GOOD
*750 SF_ENERGY STAR PERFORMANCE SHOULD GET HERE.
*1000 SF_REPRESENTS A THOUGHTFUL HOME AND HVAC DESIGN.

*HOUSE SF DIVIDED BY THE 675 SF PER TON EQUALS THE AC UNIT IN TONS, AND THEN DIVIDED BY THE 400 cfm PER TON TO GET THE UNIT'S CFM REQUIREMENT. THE MAIN SUPPLY AND RETURN SIZE IS BASED ON THAT CFM NUMBER.
*LOTS OF ROOM FOR ERROR USING THESE RULES OF THUMB. EXACT SITE CONDITIONS, ORIENTATION AND THE MANUAL J,D,S CALCULATIONS NEEDED FOR REAL DESIGN.

***SYSYTEM SCHEMATIC IN A PLAN VIEW**_SCHEMATICS IN d8.16, c9.9, c9.10 SHOW PROFILE SECTIONS THAT ARE ILLUSTRATING THE FLOOR TO FLOOR CONDITIONS A SYSTEM IS HAVING TO DEAL WITH. THOSE PROFILE CANNOT REALLY SHOW DUCT DELIVERY LAYOUTS. THIS SCHEMATIC IS USING A PLAN FORMAT TO MAKE A FEW GENERAL POINTS ABOUT DUCTWORK IN PLAN. CONVERSELY THIS SCHEMATIC CANNOT SHOW THE VERTICAL CONDITIONS DUCTWORK MAY ENCOUNTER.

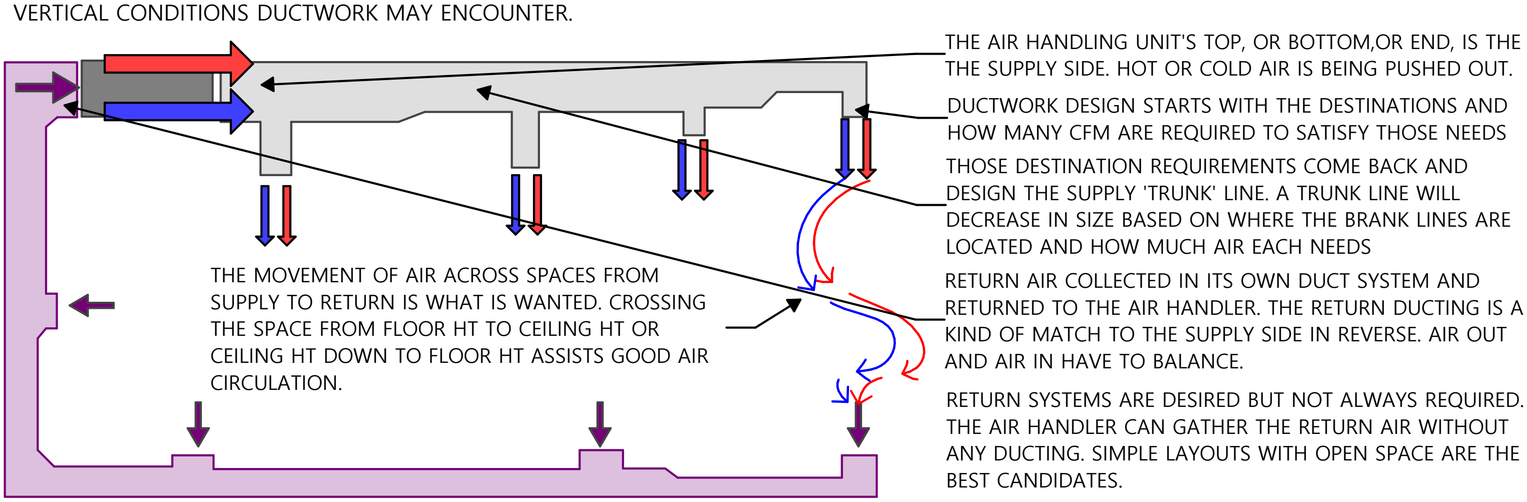


TABLE N1102.1.2 (R402.1.2) INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13 + 5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13 + 5[h]	8/13	19	10 /13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13 + 5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20 + 5 or 13 + 10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20 + 5 or 13 + 10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

HEAT LOSS CALCULATIONS

***R,U-FACTOR_**CODE COMPLIANCE CALCULATIONS WILL WANT TO KNOW R VALUE FOR THE WALLS AND U FACTOR FOR THE FENESTRATION. THE U VALUE FOR WINDOWS AND GLASS DOORS (FENESTRATION) IS REQUIRED BY MANUFACTURERS TO BE VERIFIED AND LISTED. THE ZONE 2 CODE REQUIRED .40 IS EQUIVALENT OF AN R-2.5, ZONES 3-4 REQUIRED .35 AN EQUIVALENT OF R-2.9, ZONES 5-8 REQUIRED .32 AN EQUIVALENT OF R-3.1. COMPARED TO THE WALLS VALUE OF SAY R-20. NOTE THE BETTER CARDINAL GLASS IS RATED AT .25 EQUIVALENT TO R-4. FENESTRATION IS A WEAK LINK FROM THE BASIC STANDPOINT OF HEAT GAIN/LOSS THRU THE WALLS. THESE COMPARATIVE VALUES FOR THE FENETRATION'S U VALUES CAN BE MANIPULATED IN THE REScheck SOFTWARE TO YIELD A PERCENTAGE OF DIFFERENCE IN PERFORMANCE FOR THE TOTAL ENCLOSURE.

***HEAT GAIN/LOSS_**ENERGY CALCULATIONS WILL USE THE R WALL VALUES AND FENESTRATION U FACTOR TO DETERMINE BASIC HEAT LOSS AND GAIN. HEAT LOSS IS CALCULATING INTERIOR HEAT BEING RELEASED THRU THE ENVELOPE TO THE COLDER OUTSIDE. HEAT GAIN IS CALCULATING EXTERIOR HEAT'S PENETRATION THRU THE ENVELOPE TO THE COOLER INSIDE.

***SOLAR HEAT GAIN_**IS A SPECIFIC CALCULATION EXAMINING DIRECT SUNLIGHT HITTING GLASS. THE GLASS ITSELF HAS A RATING CALLED THE SOLAR HEAT GAIN COEFFICIENT (SHGC). A LOWER NUMBER MEANS THE GLASS IS KEEPING MORE HEAT FROM PENETRATING AND THE HIGHER NUMBER MEANS MORE HEAT IS PENETRATING. THE CODE IS REQUIRING MINIMUMS FOR GLASS RATINGS AND ALL WINDOW AND DOOR MANUFACTURERES ARE SIMPLY REQUIRED TO MEET THOSE STANDARDS. THIS IS GOOD. BOTH LOWER U AND SHGC RATINGS HAVE SAVED A LOT OF ENERGY IN THE SINGLE FAMILY HOME.

***GLASS TECHNOLOGY_**GLASS SKYSCRAPERS HAVE BEEN AROUND A GOOD WHILE IN SOME SERIOUS HOT CLIMATES. GLASS TECHNOLOGY HAS HAD TO BE ADDRESSED BIG TIME. THE RESIDENTIAL GLASS MARKET HAS BENEFITED FROM THAT TECHNOLOGY.

***ENERGY CALCULATIONS_**BECAUSE SOLAR HEAT GAIN CAN EFFECT AIR CONDITIONING LOADS IT NEEDS TO BE ACCURATELY CALCULATED. LOGIC SAYS SMALL RANCH STYLE HOMES WITH CONVENTIONALLY SIZED WINDOWS AND ROOF OVERHANGS DON'T NEED TO DEAL WITH A LOT OF SOLAR GAIN, BUT COMTEMPORARY DESIGNS WITH LARGE/TALL WINDOW ASSEMBLIES HAVE TO BE VERY CONSCIOUS. NEXT PAGE WILL GIVE SOME OUTLINE TO THE SIMPLE FACTORS INVOLVED.

GLASS OPTIONS

***BETTER DATA_**BOTH WINDOW MANUFACTURER'S AND GLASS MANUFACTURERS HAVE PRETTY EFFECTIVE PRESENTATIONS OF THESE 4 MOST PRESENTED PERFORMANCE CATEGORIES.
***U-FACTOR_**THE U-FACTOR IS THE 'INSULATING' RATING.
***SHGC_**HOW WELL THE GLASS BLOCKS THE SUN'S HEAT
***TRANSMITTANCE_**HOW MUCH NATURAL LIGHT PASSES THRU THE GLASS.
***UV PROTECTION_**ULTRAVIOLET RAYS CAN ALTER THE COLOR OF MATERIALS- AND ARE A CAUSAL SKIN CANCER INGREDIENT.
***BEWARE GLASS VALUES AND WINDOW UNIT VALUES_**
VALUES ARE RECORDED AT CENTER OF GLASS FOR GLASS ONLY PERFORMANCE. WINDOWS REQUIRE UNIT TESTING IN THEIR FRAMES AND IS A BETTER REAL TIME PERFORMANCE NUMBER.

(FROM THE ANDERSEN WINDOW CATALOGUE)

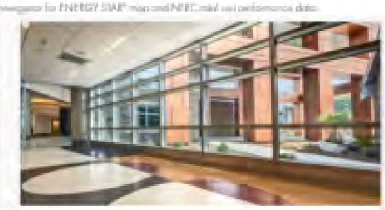
GLASS	ENERGY: U-Factor	ENERGY: Solar Heat Gain Coefficient	LIGHT: Visible Light Transmittance	LIGHT: UV Protection
SmartSun	● ● ● ○	● ● ● ●	● ● ◐ ○	● ● ● ●
SmartSun with HeatLock Coating	● ● ● ◐	● ● ● ●	● ● ○ ○	● ● ● ●
Low-E4	● ● ● ○	● ● ● ○	● ● ● ○	● ● ● ○
Low-E4 with HeatLock Coating	● ● ● ◐	● ● ● ○	● ● ◐ ○	● ● ● ○
Sun	● ● ● ○	● ● ● ●	● ○ ○ ○	● ● ● ○
PassiveSun	● ● ◐ ○	● ○ ○ ○	● ● ● ○	● ● ● ○
Triple-Pane with Low-E coatings on two surfaces	● ● ● ○	● ○ ○ ○	● ● ◐ ○	● ● ● ○
Clear Dual-Pane	● ○ ○ ○	○ ○ ○ ○	● ● ● ●	○ ○ ○ ○

(FROM THE GUARDIAN GLASS WEB SITE)

ClimaGuard 80/70
ENERGY STAR® Northern Zone
Selectively lets visible light in to brighten and warm northern homes naturally, and provides insulation to stop heat from escaping

ClimaGuard 72/57
ENERGY STAR® Northern and North-Central Zones
Provides ample light, solar heat gain and retains heat indoors in climates with cold winters

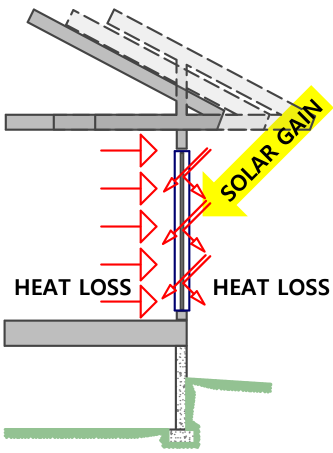
ClimaGuard 53/23
South-Central and Southern ENERGY STAR® Zones
Cools homes in warm, southern climates with triple silver protection to lower solar heat gain and U-value



ClimaGuard IS-20
All ENERGY STAR® Zones
Enhances performance by lowering U-value of standard low-E windows to help meet energy codes

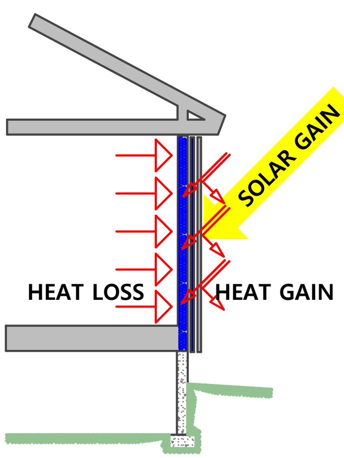
SETTING THE SOLAR HEAT GAIN CRITERIA

***POWER OF THE SUN_**A SIMPLE WAY TO EXPERIENCE SOLAR RADIATION IS TO PICK A COOL CLEAR (MID)DAY AND STEP IN AND OUT OF THE SUN WEARING SHIRTSLEEVES. THE WARMTH THE SUN MAKES AVAILABLE CAN BE FELT INSTANTANEOUSLY. ONE CAN EXPERIENCE SOMETHING SIMILAR INSIDE BY STEPPING INTO AND OUT OF DIRECT SUNLIGHT AT A WINDOW. NOT AS INTENSE MAYBE BUT STILL A VERY REAL PRESENCE. SO THE QUESTION IS WHETHER THAT (HEAT GAIN) IS WELCOME OR NOT.
***PASSIVE SOLAR THINKING_**THE WHOLE IDEA OF PASSIVE SOLAR DESIGN IS TO WELCOME THAT SOLAR GAIN, AND STORE IT IN A HEAT SINK FOR DISTRUBUTION BACK INTO THE SPACE AS INTERIOR TEMPERATURES COOL DOWN AFTER SUNSET......USING SOLAR GAIN REQUIRING FAIRLY SPECIFIC MANAGEMENT TECHNIQUES.
***REDUCE SOLAR GAIN THINKING_**SAYS THAT MANAGING THAT PASSIVE SOLAR ENERGY IS JUST TOO DIFFICULT- AND ULTIMATELY RESULTS IN INCONSISTENCIES AND INEFFICIENT ENERGY MANAGEMENT. SO THE SMART THING TO DO IS MINIMIZE SOLAR GAIN WITH PROPER GLASS SIZING, POSITION, APPROPIATE ROOF OVERHANGS AND BLANKET THE HOUSE WITH AIR TIGHT HIGH PERFORMING INSULATION. GET IN ABSOLUTE CONTROL OF ENERGY CONSUMPTION.
***TRADITIONAL DESIGN_**THE SUNROOM WAS ONCE A SPACE AND FUNCTION IN THE AMERICAN HOME. A CENTERHALL DESIGN WOULD HAVE THE SUNROOM ON ONE SIDE OF THE HOME USUALLY ACCESSIBLE FROM THE LIVING SPACE THROUGH GLASS DOORS. THIS ALLOWED THE SUN ROOM (OR CONSERVATORY) TO HAVE GENEROUS PERIMETER GLASS ON 3 WALLS, AND PROVIDE THAT WELL LIT AND OUTSIDE FEELING SPACE SO VALUABLE ON CERTAIN WEATHER DAYS. SUBJECT TO BEING SIMPLY TOO COLD IN WINTER AND OR POSSIBLY TOO HOT IN SUMMER. RETREAT FROM TOO COLD AND TOO HOT WAS AVAIALBLE IN THE ADJACENT 'INTERIOR' LIVING SPACE.
***MANY INBETWEEEN OPTIONS_**TODAYS GLASS OPTIONS MAKE ALL THREE OPTIONS NOTED ABOVE MORE VIABLE. AND THEY MAKE OTHER INBETWEEN OPTIONS VIABLE AS WELL.



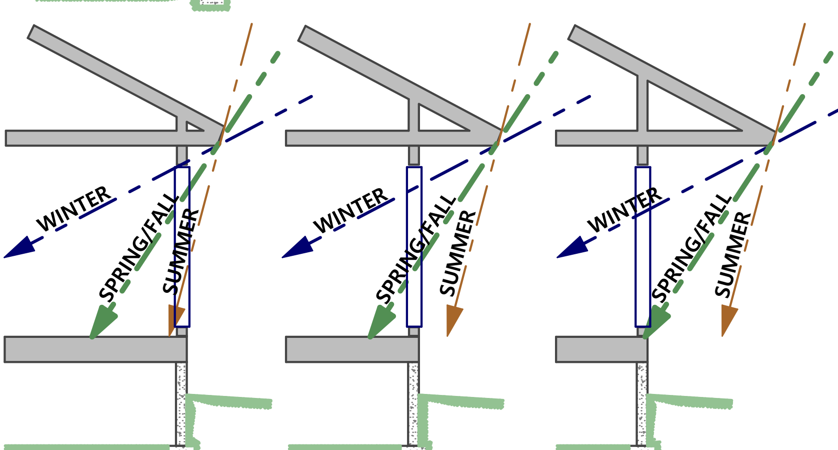
MANAGING SOLAR HEAT GAIN

***LATTITUDE_**IS A FIXED CONDITION OF A SITE SELECTION, SO THE SUN'S EXACT ANGLE IS A PREDICABLE YEAR ROUND, AND THERFORE A DESIGN CONDITION.
***ORIENTATION_**BASED ON SITE CONDITIONS AND LIMITS ON THE BUILDING FOOTPRINT POSITIONING, THE ORIENTATION MAY BE UNDER THE DESIGNERS MANAGEMENT. CHAPTER d4 ATTEMPTS TO PRESENT AND SUMMARIZE THESE SITE BASED CONSIDERATIONS. THIS IS SUGGESTING THE CONTROL OF GLASS FACING EAST, SOUTH AND WEST.
***OVERHANG_**THIS IS ALWAYS UNDER THE CONTROL OF THE DESIGN. AND CLEARLY WANTS TO BE CONSIDERED EARLY IN A DESIGN. FOR EXAMPLE LIVING SPACES ON THE LOWER OF 2 FLOORS DON'T HAVE ROOF TYPE PROTECTION UNLESS IT IS CONSCIOUSLY DESIGNED IN.
***SHGC_**SEE GLASS OPTIONS. SELECTING A SHGC RATING FOR SPECIFIC THE POSITIONING OF GLASS IN A DESIGN IS BEING DONE MORE AND MORE. THE TYPICAL APLLICATION IN PASSIVE SOLAR THINKING IS USING A HIGHER SHGC RATED GLASS ON SOUTH WALLS, A LOWER RATED SHGC GLASS ON EAST AND WEST WALLS, AND A LOW U-FACTOR GLASS ON NORTH WALLS. SOME WINDOW MANUFACTURERS WILL ALLOW GLASS SPECIFICATION WITHIN A HOUSE ORDER USING THE SAME WINDOW TYPE.



SOLID WALL OPTIONS

***GENERAL_**ALTHOUGH WE MEASURE THE SOLAR GAIN THRU GLASS, IT IS OBVIOUS THE OPAQUE WALLS ARE SUBJECT TO THE SAME ENERGY FROM THE SUN. HOW DOES THAT PLAY INTO ENERGY CONSUMPTION AND HOUSE HEALTH? THIS PROJECT HONESTLY DOES NOT KNOW. OPAQUE WALLS ARE NOT A DESIGN FACTORS IN THE SOFTWARE THIS PROJECT IS FAMILIAR WITH.
***WHAT WE KNOW_**MATERIALS AND COLORS HAVE HEAT AND LIGHT REFLECTIVE COEFFICIENTS, AND HAVE HEAT RETENTION COEFFICIENTS. THE EASY EXAMPLE IS A DARK COLORED METAL SIDING HEATING UP QUICKLY, AND DISSAPATING HEAT QUICKLY. A LIGHT COLOR METAL WILL REFLECT/DEFLECT SOME PERCENTAGE OF THAT HEAT. A FULL 5" STONE VENEER WILL HEAT UP SLOWLY AND DISSIPATE THAT GAINED HEAT SLOWLY. THAT STONE IS PLAYING THE ROLE OF THERMAL MASS- AS WOULD MOST MASONRY MATERIALS.
***THE REST OF THE WALL ASSEMBLY_**CONTAINS THE HYGROTHERMAL DEFENCE PACKAGE AND IS THERE TO MANAGE THAT SUN'S INTERPLAY WITH THE OUTSIDE PROTECTIVE SIDING MATERIAL. SO THE QUESTION OF THE ENERGY BASED IMPORTANCE OF THAT OUTER SKIN REMAINS UNCLEAR TO THIS PROJECT. IT IS NOT A CODE CONSIDERATION



THIS GRAPHIC IS SHOWING THE ROOF OVERHANG LENGTH ONLY AS ONE FIXED VARIABLE. THE SUN'S POSITION RELATIVE TO THE HOUSE IS ALWAYS IN FLUX.

SOLAR GAIN CALCULATIONS

***HVAC CALCULATIONS** _WILL NEED TO KNOW THE BELOW TO ASSESS SOLAR HEAT GAIN.
***LATTITUDE_**OF THE SITE WILL ESTABLISH THE SUNS ALTITUTE.
***ORIENTATION_**EAST, SOUTH, WEST ORIENTATION OF WALLS/WINDOWS.
***OVERHANG DATA_**ROOF OVERHANG DATA WILL DETERMINE EXTENT OF SUNS DIRECT CONTACT WITH THE GLASS.
***SHGC_**WILL DETERMINE THE PERCENTAGE OF THAT SUN RADIATION THAT WILL PENETRATE TO THE INTERIOR.
***ORIENTATION CALCULATIONS_**THIS PROJECT IS NOT EXPERIENCED ENOUGH WITH AVAVILABLE HVAC/ENERGY SOFTWARES TO KNOW HOW THESE GEOMETRICALLY COMPLICATED PERMUTATIONS ARE INCORPORATED. REMEMBER THE SUN POSITION IN RELATION TO THE HOME CHANGES MINUTE BY MINUTE ALL YEAR LONG SO NECESSARILY DOES THE SOLAR GAIN. AND SUN'S INTENSITY IS OF COURSE NOT CONSISTENT.

COMPLIANCE (IRC 2018)

***CHAPTER 11**_IS TITLED ENERGY EFFICIENCY AND IS PART OF THE 2018 IRC. (THIS CHAPTER REFERENCES IN EVERY SECTION THE SAME CONTENT AS FOUND IN THE 2018 IECC (INTERNATIONAL ENERGY CODE COUNCIL). THE IECC CODE USES A PREFIX 'R' WHICH IS UNFORTUNATELY CONFUSING BECAUSE ALL BUT THIS ENERGY CHAPTER IN THE BASE IRC ALSO USES THAT PREFIX 'R'. THE IECC ENERGY CODE IS IT OWN (BIG FAT) BOOK.
***CHAPTER 11 COMPLIANCE INQUIRY**_IT IS NECESSARY, PARTICULARLY WITH THE ENERGY COMPLIANCE THIS CHAPTER TALKS ABOUT, TO REQUEST LOCAL CODE COMPLIANCE REQUIREMENTS. THIS IS SUGGESTED BOTH TO KNOW WHAT WILL BE REQUIRED, AND TO AVOID BEING OVERWHELMED WITH REQUIREMENTS NOTED BELOW. REMEMBER EACH STATE AND LOCAL CODE JURISDICTION MAY OR MAY NOT HAVE ADOPTED THIS 2018 IRC CODE, AND MAY OR MAY NOT HAVE PRODUCED THEIR OWN CUSTOMIZED VERSION. SO REQUIREMENTS WILL VARY. AS A 'FOR INSTANCE' NORTH CAROLINA DELETED N1101.5 AND N1101.5.1 IN ITS VERSION OF THE 2018 IRC.
***ARCHITECTURAL/DESIGN DOCUMENTS**_TRADITIONALLY AND TYPICALLY DO NOT INCLUDE ALL THE ENERGY SPECIFIC CONTENTS NOTED BELOW (N1101.5). THERE ARE EXCEPTIONS TO THIS. SOME MORE COMPLETE ARCHITECTURAL SERVICES MAY ELECT TO INCORPORATE ALL ENERGY/MECHANICAL REQUIREMENTS AND APPROPRIATE DRAWINGS INTO ONE COMPREHENSIVE PACKAGE. THESE 2 CODE SECTIONS ARE INCLUDED FOR REFERENCE.

N1101.5 (R103.2) Information on construction documents.

Construction documents shall be drawn to scale on suitable material. Electronic media documents are permitted to be submitted when *approved* by the *building official*. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include the following as applicable:

1. Insulation materials and their *R*-values.
2. Fenestration *U*-factors and *solar heat gain coefficients* (SHGC).
3. Area-weighted *U*-factor and *solar heat gain coefficient* (SHGC) calculations.
4. Mechanical system design criteria.
5. Mechanical and service water heating systems and equipment types, sizes and efficiencies.
6. Equipment and system controls.
7. Duct sealing, duct and pipe insulation and location.
8. Air sealing details.

N1101.5.1 (R103.2.1) Building thermal envelope depiction.

The *building thermal envelope* shall be represented on the construction documents.

STANDARD COMPLIANCE METHODS

R VALUE (N1102.1.3) _COMPONENT COMPLIANCE (c9.4).
U VALUE (N1102.1.4) _ ASSEMBLY COMPLIANCE (c9.4)
UA ALTERNATIVE (N1102.1.5) _TOTAL THERMAL ENVELOPE COMPLIANCE (c9.5, c9.6)

PERFORMANCE OPTIONS TO ACHIEVEING CODE COMPLIANCE

ONE REASON SIMULATED PERFORMANCE AND ERI COMPLIANCES EXIST IS TO OPEN THE DOOR TO NON TRADITIONAL CONSTRUCTIONS WHILE MEETING ENERGY STANDARDS.
SECTION N1105 SIMULATED PERFORMANCE ALTERNATIVE
*PERFORMANCE BASED COMPLIANCE-STARTS WITH AN ENERGY ANALYSIS OF THE PROJECT BASED ON ALL CODE PRESCRIBED MINIMUMS. THE (ANNUAL) ENERGY REQUIRED BY THAT DESIGN IS THE BASELINE. THE PROJECT CAN THEN DEVIATE FROM PRESCRIBED REQUIREMENTS BUT MUST MEET OR REDUCE THOSE (ANNUAL) ENERGY REQUIREMENTS.
*ANY CODE MINIMUMS DESIGNATED 'MANDATORY' MUST BE MET.
*PRE-APPROVED ENERGY ANALYSIS SOFTWARE/DOCUMENTATION IS REQUIRED. 3RD PARTY INVOLVEMENT REQUIRED.
SECTION N1106 ENERGY RATING INDEX (ERI) COMPLIANCE ALTERNATIVE aka HERS rating
*SIMILAR TO THE ABOVE IN BEING AN ENERGY BASED ANALYSIS, BUT RESTRICTED TO A SPECIFIC VERIFICATION (A GRADE CARD) TECHNIQUE QUALIFED BY A 'STANDARD' TITLED 'RESNET/ICC 301'. A PROPOSED PROJECT IS EVALUATED ON PAPER BASED ON A ZERO TO 100 NUMERICAL SYSTEM. THE ENTIRE HOUSE IS ENERGY ANALYSIZED AND AWARDED POINTS WHERIN LOWER IS BETTER. ZERO IS ZERO ENERGY.
*PRE-APPROVED ENERGY ANALYSIS SOFTWARE/DOCUMENTATION IS REQUIRED. 3RD PARTY INVOLVEMENT REQUIRED.
*THE MORE WELL KNOWN 3RD PARTY SERVICE IS AVAILABLE FROM A CERTIFIED **HERS** RATER (HOME ENERGY RATING SYSTEM).

THE SPEED OF CHANGE IN HYGRO-THERMAL AND SUSTAINABLE DESIGN CONSIDERATIONS

***THIS CHAPTER**_AND OTHER PAGES AND CONTENT THIS PROJECT DEALING WITH ABOVE NOTED TOPICS RUN THE RISK OF GETTING OUT DATED. BOTH KNOWLEDGE ABOUT, AND CODE COMPLIANCES FOR THESE TOPICS ARE CHANGING MORE QUICKLY THAN MOST OF THE GENERAL CONSTRUCTION TOPICS. AS/WITH CLIMATE CHANGE SCIENCE AND CONSEQUENT NECESSARY REGULATION, WE ARE LIKELY HEADED TOWARD AN EVEN MORE ACCELERATED PACE OF CHANGE.
***ENERGY CONSULTANCIES**_PART OF THIS CHANGE HAS BEEN THE EVOLUTION OF A VERY LARGE COTTAGE INDUSTRY PROVIDING A WHOLE RANGE OF INFORMATIONAL, TESTING, AND COMPLIANCE SERVICES TARGETING ENERGY CONSERVATION AND SUSTAINABLE DESIGN. IMPORTANT, USEFUL, AND GENERALLY WELL INTENTIONED.

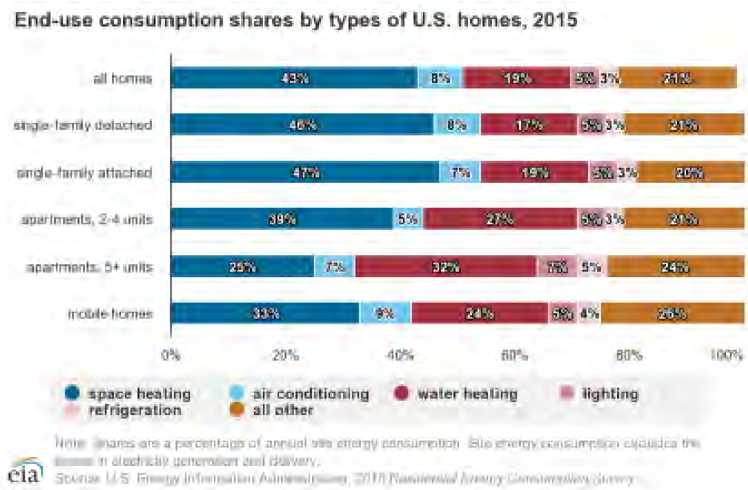
APPROACHES TO 3RD PARTY INVOLVEMENT

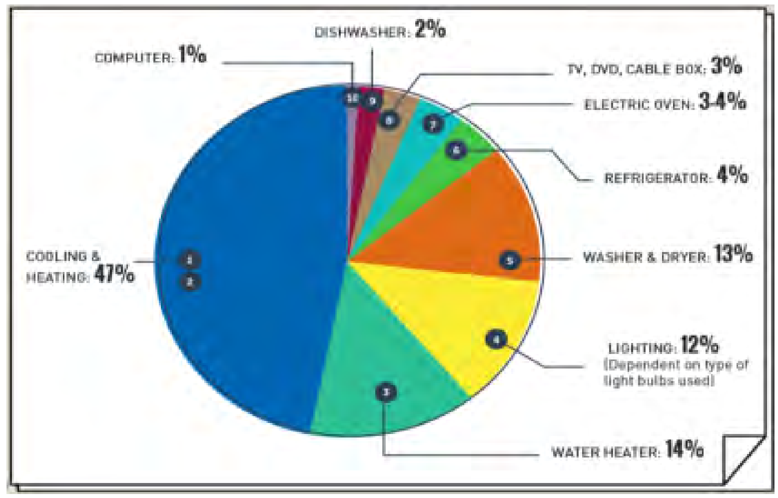
***CHOICES**_GREEN BUILDING ADVOCACY ORGANIZATIONS, INDEPENDENT ENERGY AND SUSTAINABLE CONSULTANCIES, ARE MANY AND ALL OVER. THEY NEED TO BE LOCALLY RESEARCHED. ARCHITECTS, HVAC VENDORS, AND PV SOLAR PROVIDERS ARE ADDITIONAL VIABLE RESOURCES.
***CERTIFICATIONS AND RATERS**_GREEN BUILDING 'CERTIFICATION' PROGRAMS**,** AND ENERGY RATING COMPANIES ARE HERE TO STAY. THE GOVERNMENTS SPONSORED 'ENERGY STAR' PROGRAM, AND THE RESNET (NON-PROFIT) SPONSORED 'HERS' RATING SERVICE IS NATIONALLY AVAILABLE, AND CONSIDERED (AT LEAST BY NON-COMPETITORS) TO BE REASONED AND WELL DESIGNED. RESNET IS BEHIND THE REScheck SOFTWARE COMPLIANCE PACKAGE NOTED THIS CHAPTER.

MAKING THE COMPLEX SIMPLE(R)

***THE COMPLEX_**ONE BIG CHALLENGE PUTTING THIS DESIGN AND CONSTRUCTION GUIDE PACKAGE TOGETHER HAS BEEN DECIDING WHAT TO INCLUDE, AND HOW DEEP TO DIG. SCIENCE WOULD LET US DIG FOREVER. IT IS NOT THAT HARD TO GET LOST IN THE WEEDS, AND LOSE SITE OF THE ULTIMATE GOALS.

***THE SIMPLE_**THESE INSTRUCTIVE CHARTS BELOW (GOVERNMENT STATISTICS) GIVE US A HAND REVISITING THE IMMEDIATE GOAL. THE PIE CHART IS PARTICULARLY CLEAR INDICATOR OF THE PECKING ORDER OF ATTENTION AND CONCENTRATION. THE THERMAL ENVELOPE/HVAC SYSTEM IS CLEARLY THE BIG PLAYER AND BY FAR THE MORE COMPLICATED ONE. THE BALANCE OF THESE CATEGORIES OF ENERGY EXPENDITURE CAN BE RESEARCHED WITH OPTIONS AND BETTER SOLUTIONS BEING PRETTY EASY TO TRACK DOWN.





FIND A GUIDING APPROACH

***LIST BELOW_**APPROACHES BELOW ARE ESSENTIALLY MAINSTREAM, AND COMPATIBLE WITH 'CONVENTIONAL' RESIDENTIAL CONSTRUCTION. THEY ALL ARE DIRECTLY RELATED TO ENERGY EFFICIENCY.

***ABSOLUTE OR SYNTHESIZED APPROACH_**ONE COULD PICK ANY OF THE BELOW AND GO FOR IT- MEANING LETTING THAT APPROACH BE THE DECISION MAKER. OR ONE CAN MIX AND MATCH A BIT TO SUIT THOSE NEEDS THAT ABSOLUTE SYSTEMS NOTORIOUSLY HAMSTRING. ITS ALL VALID, IT JUST HAS TO DO THE JOB.

***BOTTOM LINE_**WHATEVER APPROACH ONE MIGHT BE INCLINED TO PURSUE, AND TO WHATEVER LEVEL OF DEDICATION, THE VALUE OF HOOKING UP WITH A MEANS OF COMPUTERIZED ENERGY ANALYSIS IS HIGHLY RECOMMENDED. AS QUICKLY DEMONSTRATED, EVEN WITH THE NOT SO SOPHISTICATED (AND FREE) REScheck, ONE CAN MONITOR THE RAMIFICATIONS OF DESIGN CHANGES ALL ALONG THE DESIGN PATH TO ASSIST IN THOSE GOOD/BETTER/BEST DECISIONS. MORE SPOHISTICATED SOFTWARE OFFERING MORE FEEDBACK ON DECISIONS IS BETTER YET. VENDORS AND 3RD PARTY ENERGY FOLKS MAY NEED TO ASSIST.

1.CONTAIN THE THERMAL ENVELOPE

***GUIDES_**THE WHOLE IDEA OF DEFINING AND CONTAINING THE THERMAL ENVELOPE HAS BEEN FRONT AND CENTER THESE GUIDES. MAYBE THE BEST QUANTITATIVE INDICATOR IS THAT SQUARE FOOTAGE OF THERMAL ENVELOPE.

***SIMPLE AND SMALL_**COMMON SENSE TELLS US SIMPLE AND SMALL IS ONE SUSTAINABLE APPROACH. IT IS ALSO NOT SUITABLE TO EVERYONE.

***NOT SO SIMPLE, NOT SO SMALL_**DESIGNS MANAGE SIZE AND SHAPE (d5) AND THERE ARE MORE AND LESS EFFICINT WAYS TO INCREASE FOOTAGE. COMPLEXITY IN GEOMETRY WILL INCREASE THERMAL ENVEOPE FOOTAGE SO MAKE IT COUNT.

2.MAXIMIZE THE EFFICIENCY OF THE HVAC SYSTEM

***ANY SYSTEM_**ANY TYPE OF HEATING AND OR COOLING 'SYSTEM' WOULD CLEARLY WANT TO BE PERFORMING AT ITS HIGHEST EFFICIENCY.

***DUCTED SYSTEMS_**NUMBER ONE IS THE CORRECT SYSTEM SIZING. NUMBER TWO IS HAVING THE ENTIRE SYSTEM LOCATED INSIDE CONDITIONED SPACE. NUMBER THREE IS HIGHER EFFICIENCY EQUIPMENT. AND THEN DESIGNING GEOMETRICALLY STAIGHTFORWARD DUCT RUNS AS IS POSSIBLE, WITH A RETURN SYSTEM LETTING THAT SUPPLY SIDE DO ITS BEST JOB.

3.PASSIVE SOLAR

***THE STRICT PASSIVE SOLAR FORMULA_**THERE ARE RULES AND REGULATIONS ONE CAN SUBSCRIBE TO FOR A HOME TO ACHIEVE PASSIVE SOLAR STATUS. THIS CAN BE AN ISSUE IF ONE IS PURSUING TAX CREDITS. WHETHER ONE IS AFTER TAX CREDITS OR NOT THOUGH, THOSE RULES OF DESIGN ARE IMPORTANT TO KNOW. THEY SET THE STAGE FOR MAXIMUM EFFICIENCY/EFFECTIVENESS, SO AS DESIGN GUIDELINES ARE VALUABLE.ONE CAN CHOOSE TO FOLLOW THOSE 'RULES' TO THE LETTER, OR TO INTERPRET/UTILIZE CREATIVELY.

***THE UNIVERSAL PASSIVE SOLAR WARNING_**THE PRIME IDEA IS TO CAPTURE (FREE) HEAT. OVERHEATING IN FACT IS A COMMON REAL PROBLEM. WHICH IS UNCOMFORTABLE AND COUNTER PRODUCTIVE.

4.THE PASSIVE HOUSE APPROCAH

***HISTORY_**EASY TO SEARCH THE HISTORY AND PURPOSE OF THE PASSIVE HOUSE- WHICH IS INTERESTING AND ENLIGHTENING. AND IT WILL PUT THE WHOLE CERTIFICATION SIDE OF THE PASSIVE HOUSE INITIATIVE IN PERSPECTIVE. ALTHOUGH A CERTIFICATION BASED INITIATIVE THERE IS PLENTY OF EFFICENCY CONTENT TO LEARN ABOUT.

***IN THE US_www.PHIUS.org (Passive House Institute,US) www.PHAUS.org (Passive House Alliance,US)**

***GENERAL_**ENERGY PERFORMANCE **IS** THE GOAL. INSULATING AND SEALING EXTREMELY WELL IS PART OF THE DEAL.

***ENERGY RECOVERY VENTILATION(ERV/HEAT RECOVERY VENTILATION(HRV)_**THESE ARE VENTILATION AIR 'EXCHANGERS' THAT CAN BECOME PART OF ANY SYSTEM, BUT ARE A CENTRAL AND SIGNIFICANT PLAYER IN THE PASSIVE HOUSE APPROACH. A LITTLE COMPLICATED AND NEEDS PROPER RESEARCH. THEIR ROLE REDUCES THE ENERGY REQUIREMENTS FOR MAINTAINING COMFORT.

5.ACTIVE SOLAR

***THE GREAT BANDAID_**PHOTOVOLTAIC SOLAR PANELS OR ROOFING IS OFTEN A GREAT OPTION IN DECREASING USE OF DIRTY ENERGY. IT CAN BE EMPLOYED AT ANY SCALE. AND IT PERFORMS INDEPENDENTLY FROM THE HOUSE, AND IN FACT FROM EVERY APPROACH NOTED ABOVE. FOR THOSE WHO CARRY SOME SENSE OF RESPONSIBILITY ABOUT ENERGY USE AND CONSEQUENT CLIMATE CHANGE, AND DON'T WANT TO BE HAMSTRUNG BY BUILDING SHELL ENERGY EFFICIENCY RESTRICTIONS, IT OFFERS A PRETTY GOOD OUT. NEEDS A LOT OF SOUTH FACING AREA-.