



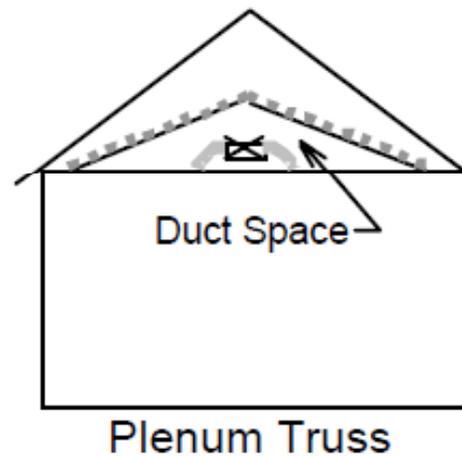
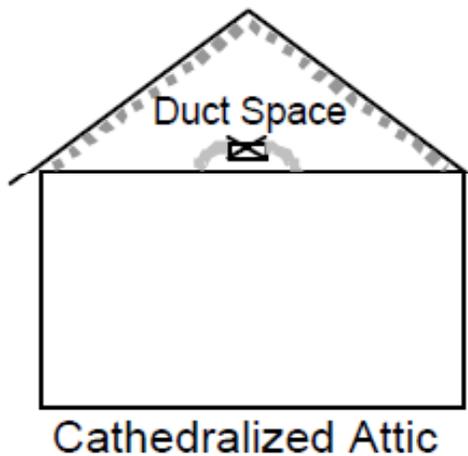
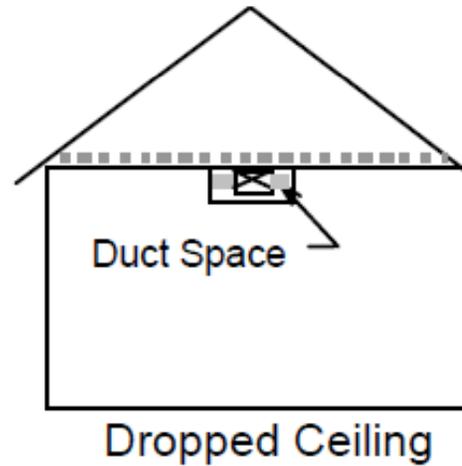
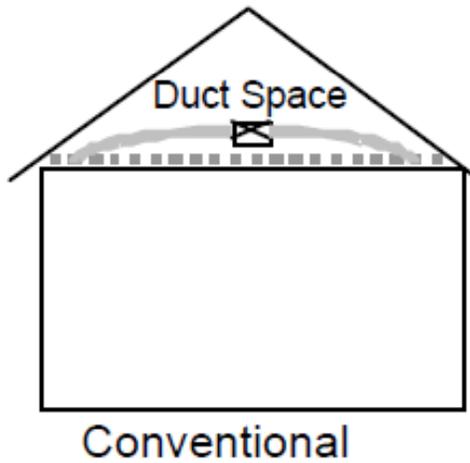
Prescriptive Proposal: Ducts in Conditioned Spaces



California Statewide Utility Codes and Standards Program

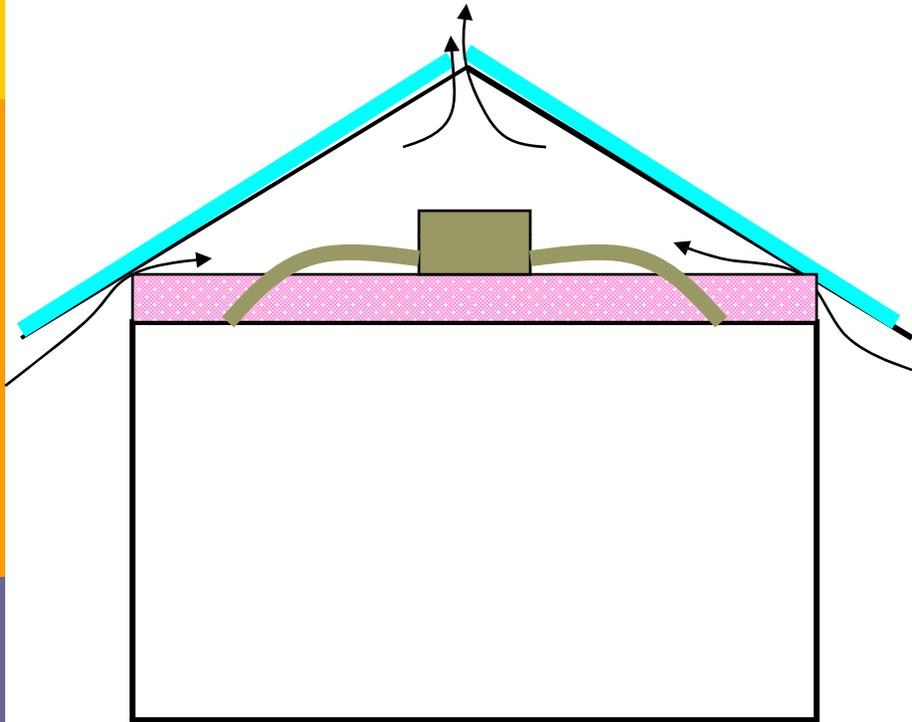


Different Attic Approaches



..... Roof Insulation

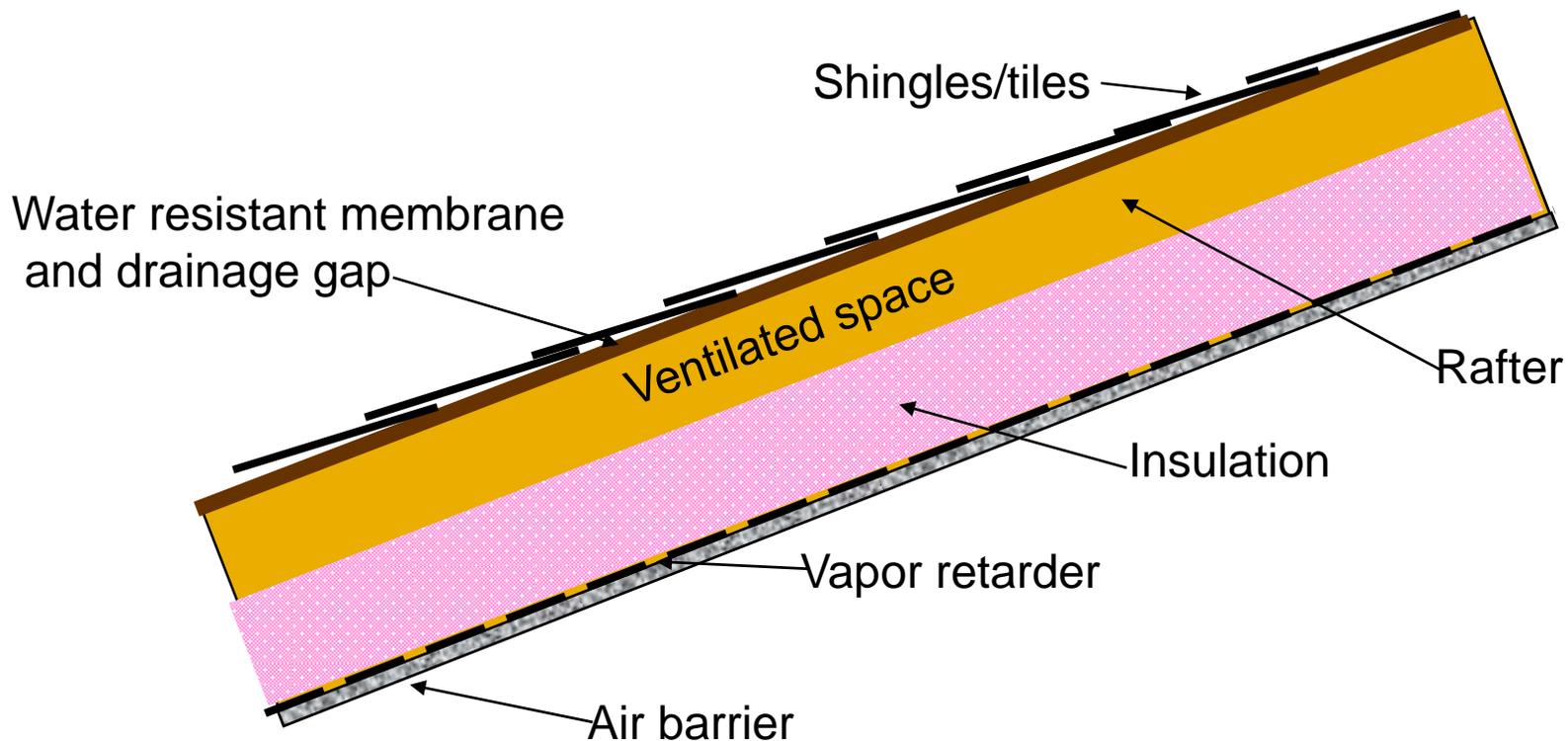
2013 Insulated Roof Deck Code Proposal



- Insulation at ceiling and roof deck
- Venting is thermal by-pass of roof insulation but reduces heat in attic
- Infiltration through ceiling plan is significant
 - approx ½ of infiltration area
- Requires sealed duct
- Requires insulated ducts
- Duct still running through moderately hot attic
- Requires two layers of insulation

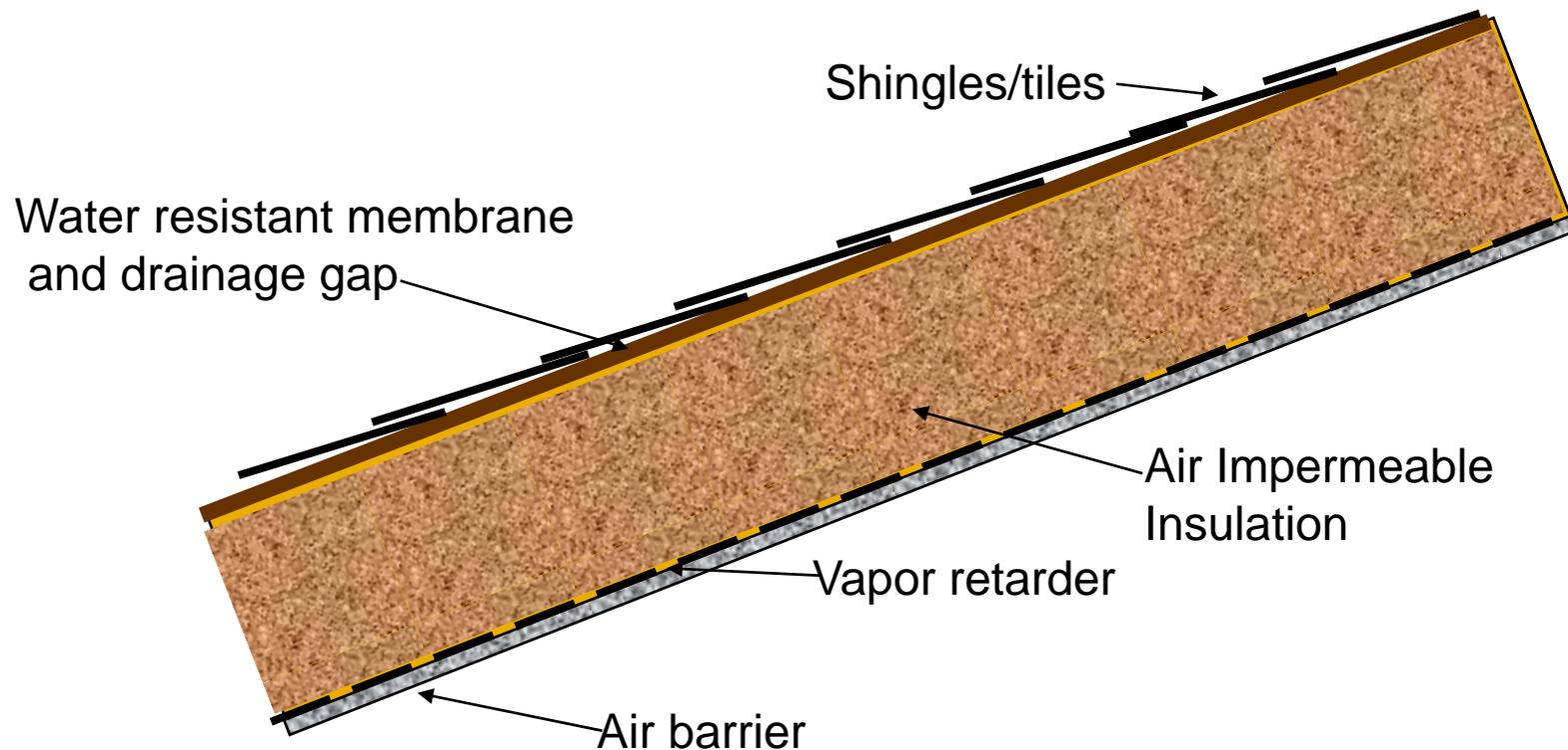
Vented cathedral ceiling

- ❑ Can use radiant barrier on underside of roof deck.
- ❑ Limitations associated with gables and other roof projections
- ❑ Keeps lower temperature for asphalt tiles

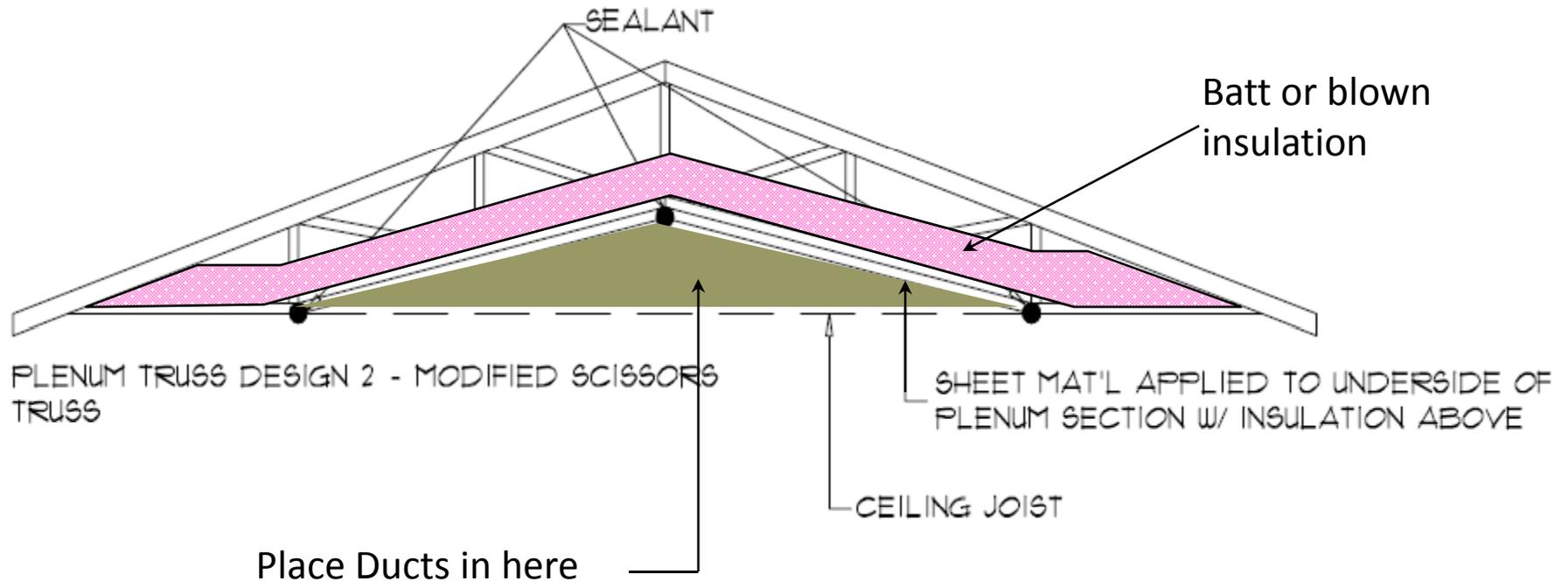


Unvented Cathedral Ceiling

- ❑ Can have complex roof features
- ❑ More attic or more conditioned space volume
- ❑ Very low infiltration
- ❑ Air barrier, moisture barrier and thermal barrier in same location



Modified Scissor Truss



- ❑ Costs about \$0.18/sf for scissor truss over regular truss
- ❑ Similar space design if full ceiling installed below or could make use of cathedral ceiling to bring interest to space.
- ❑ Ventilated like standard attic
- ❑ Duct insulation and sealing not so important

Costs associated with measure (2,700 ft² Prototype)

- Roof structure – scissor truss \$0.18/sf (\$261/house)
- Extra drywall and taping \$1.65/sf for ½” drywall and finish (from \$330 to \$2400/house)
- Net added insulation cost: approx. \$161 (\$1.61/sf)
 - Base case insulation cost: \$2,335
 - Proposed insulation cost: \$2,496
 - Assumes no special securing required for 2:12 scissor truss; additional netting adds up to \$500 to \$600 to cost, if required
- Reduced initial costs not included in B/C table
 - Duct insulation - \$200+ reduction per prototype house
 - *Drop insulation to R-4.2*
 - HVAC downsizing @\$300/ton range from \$75 to \$300
 - Impact on envelope sealing – could be easier
 - Cathedral ceilings cheaper than scissor truss.

Builder's Estimated Costs from PIER study

Table 13 - Cost Impacts for House 1

Item	Dropped Ceiling	Plenum Truss	Cathedralized Attic
Build Garage soffit	\$100	\$100	\$100
Insulate both soffits in garage (existing and new)	\$100	\$100	\$100
Drywall upstairs lid in new soffit area	\$300	\$300	\$300
Cost for special trusses	\$0	\$400	\$0
Framing	incl	\$300	incl
Blocking / Sheet Material	incl	\$150	\$150
Build upstairs soffit – Labor	\$900	incl	incl
Build upstairs soffit – Material	\$400	incl	incl
Banjoist / Rim Sealing / Insulation	\$136	\$136	\$136
Total	\$1,936	\$1,486	\$786

Table 14 - Cost Impacts for House 2

Item	Dropped Ceiling	Plenum Truss	Cathedralized Attic
Build Garage soffit	\$100	\$100	\$100
Insulate both soffits in garage (existing and new)	\$100	\$100	100
Drywall upstairs lid in new soffit area	\$300	\$300	\$300
Cost for special trusses	\$0	\$400	\$0
Framing	incl	\$300	Incl
Blocking / Sheet Material	incl	\$150	\$150
Build upstairs soffit – Labor	\$900	incl	Incl
Build upstairs soffit – Material	\$400	incl	Incl
Banjoist / Rim Sealing / Insulation	\$123	\$123	\$123
Total	\$1,923	\$1,473	\$773

- From Costs & Savings For Houses Built With Ducts In Conditioned Space: Technical Information Report, October 2003 Publication number 500-03-082-A-31
- House 1 Two Story, Single Family Detached 2,493 sf CZ 12
- House 2 Two Story, Single Family Detached 2,057 sf CZ 12
- Slightly higher cost (5% to 26% higher) – would only impact CZ 3, 5, 7 results
- Consol article– added cost of \$500 to bring ducts inside conditioned space (between floor truss space) and build mechanical room*

* May/June 2008 Home Energy, “Green Production Building: Moving Ducts Inside”

Energy Savings and Cost-Effectiveness

- Range of PV Energy Cost Savings from \$0.58 (CTZ5) to \$3.76/sf (CTZ15)
 - Approximately 9.1% to 15.4% of TDV consumption by home
 - Approximately 2X to 5X more energy savings than R-13 under deck + current prescriptive insulation on attic floor
- Benefit cost ratio varies from 0.9 to 6.0 when insulation thickness equals current attic floor insulation levels
 - Conservative costs – currently assumes no savings from reducing duct insulation, HVAC sizing
 - Uses base TDV numbers
 - Cost effective in all climate zones except CTZ 5.
- Potentially synergy with envelope sealing
- Reduced material expenditure as compared to current proposal (i.e. less insulation required for greater savings)
- Part of what ZNE buildings will likely include – start migration to different design strategy
 - If mechanical ventilation is here to stay, some form of tempering air (i.e. air conditioning and forced hot air) common method for heating and cooling

Energy Savings Estimate and Approx. Costs

	Std	Prop	Margin	TDV Saving	Energy Cost Saving	PV Energy Cost Savings	Truss Cost	Drywal l Cost	Insulation Cost	Total	
CTZ	kTDV/ft ²	kTDV/ft ²	kTDV/ft ²	%	\$/ft ²	PV \$	\$/ft ² r	\$/ft ² r	\$	\$	BCR
1	44.73	40.06	4.67	10.4%	0.81	\$2,181	0.178	0.88	\$161	\$1,694	1.29
2	56.62	50.07	6.55	11.6%	1.13	\$3,060	0.178	0.88	\$161	\$1,694	1.81
3	39.76	35.75	4.01	10.1%	0.69	\$1,873	0.178	0.88	\$161	\$1,694	1.11
4	57.87	50.67	7.20	12.4%	1.25	\$3,363	0.178	0.88	\$161	\$1,694	1.98
5	36.95	33.60	3.35	9.1%	0.58	\$1,565	0.178	0.88	\$161	\$1,694	0.92
6	42.57	36.73	5.84	13.7%	1.01	\$2,728	0.178	0.88	\$161	\$1,694	1.61
7	33.29	29.24	4.05	12.2%	0.70	\$1,892	0.178	0.88	\$161	\$1,694	1.12
8	53.81	46.46	7.35	13.7%	1.27	\$3,433	0.178	0.88	\$161	\$1,694	2.03
9	76.75	67.23	9.52	12.4%	1.65	\$4,447	0.178	0.88	\$161	\$1,694	2.62
10	82.16	70.73	11.43	13.9%	1.98	\$5,339	0.178	0.88	\$161	\$1,694	3.15
11	123.94	105.06	18.88	15.2%	3.27	\$8,819	0.178	0.88	\$161	\$1,694	5.20
12	87.27	75.15	12.12	13.9%	2.10	\$5,661	0.178	0.88	\$161	\$1,694	3.34
13	122.42	103.52	18.90	15.4%	3.27	\$8,828	0.178	0.88	\$161	\$1,694	5.21
14	111.45	96.52	14.93	13.4%	2.58	\$6,974	0.178	0.88	\$161	\$1,694	4.12
15	162.55	140.82	21.73	13.4%	3.76	\$10,150	0.178	0.88	\$161	\$1,694	5.99
16	97.55	84.17	13.38	13.7%	2.31	\$6,250	0.178	0.88	\$161	\$1,694	3.69

HVAC Sizing Reduction and Cost Impact

CTZ	Base Load (Btu/hr)	Proposed Load (Btu/hr)	Equip Size Base (Btu/hr)	Equip Size Proposed (Btu/hr)	Load Reduction (Tons)	Equipment Reduction (Tons)	Equipment Savings (\$)
1	48,808	45,809	60,808	51,809	0.25	0.75	\$225
2	45,952	40,578	51,952	46,578	0.45	0.45	\$134
3	49,959	44,904	61,959	50,904	0.42	0.92	\$276
4	35,389	32,035	41,389	38,035	0.28	0.28	\$84
5	34,040	31,092	40,040	37,092	0.25	0.25	\$74
6	37,395	33,038	43,395	39,038	0.36	0.36	\$109
7	36,000	32,596	42,000	38,596	0.28	0.28	\$85
8	39,451	35,754	45,451	41,754	0.31	0.31	\$92
9	42,662	38,254	48,662	44,254	0.37	0.37	\$110
10	52,424	46,505	64,424	52,505	0.49	0.99	\$298
11	52,253	45,864	64,253	51,864	0.53	1.03	\$310
12	47,178	41,852	53,178	47,852	0.44	0.44	\$133
13	49,279	43,603	61,279	49,603	0.47	0.97	\$292
14	56,451	49,535	68,451	61,535	0.58	0.58	\$173
15	57,326	49,952	69,326	61,952	0.61	0.61	\$184
16	52,310	47,389	64,310	53,389	0.41	0.91	\$273

Feasibility issues

- Redesign of current building prototypes
 - Only 2.5 years out
- Limit on types of heating placed in conditioned space
 - Sealed combustion furnace
 - Heat pump
 - Hot water coil in air handler
- What is appropriate energy impact of sealed mechanical room (alternate approach)
 - Two ducts each no less than 3" diameter and with 1 sq inch area per 4,000 Btu/hr.
- Code clarification on allowed/recommended type of cathedral ceiling
 - Vented
 - Unvented (and type of insulation allowed)
 - Does this change by climate zone?

Prescriptive Package Proposal

Ducts in Conditioned Space

- Ducts in conditioned space
 - Attic/cathedral roof insulation w/ same R-value as current attic insulation
- Envelope tested and sealed to 3 ACH 50
 - Savings due to integrity of envelope
 - Matches IECC minimum federal standard
- Walls R-21 24" OC w/ R-4 continuous insulation
- Glazing as described in CEC Package A
 - $U = 0.32$, SHGC = 0.5 in CTZ's 1, 3, 5, SHGC = 0.25 in all other CTZ's
- Federal min eff furnace/AC in sealed and insulated mechanical room with combustion air ducts.
 - Credit for systems without uncontrolled combustion air (sealed combustion, heat pump, combined water + space heating)
- Simple to implement
- Intuitively understandable
- Statewide implementation