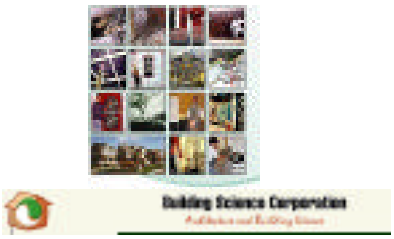
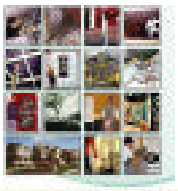


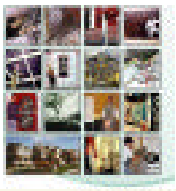
BSC Building America High Performance Homes: Today & Tomorrow

Peter Yost
Senior Building Scientist



Building America homes…

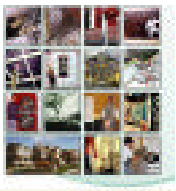
- create **energy efficient** environments that:
  - are affordable to operate
  - use materials to their maximum potential
  - minimize or eliminate waste
- create **healthy** environments
- create **comfortable** environments that are:
  - aesthetically pleasing
  - plenty of day-lighting
  - draft-free
- create **durable** environments that are:
  - built to last
  - provide moisture control and forgiving building envelopes



1st Cycle BA Performance Targets

- Energy Star home +
- Whole house ventilation: ASHRAE 62.2 P (base – 2X pot.)
- Spot ventilation: 100 cfm – kitchen, 50 cfm intermittent or 20 cfm continuous – baths
- combustion in conditioned space – sealed (furnace)/power-vented (water heater)
- All ducts & air handler equipment in conditioned space

http://www.buildingscience.com/buildingamerica/targets.htm



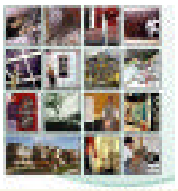
1st Cycle BA Performance Targets

- **Testing protocol – Snapshot**

http://www.buildingscience.com/buildingamerica/snapshot_form.pdf

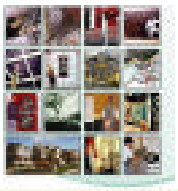
- **Testing schedule: custom vs. production**
- **Air leakage (by blower door): < 2.5 sq. in./100 sq. ft. SA leakage ratio**
- **duct leakage: < 5%**
- **balanced air flow: room-room delta of no greater than 3 Pa**

http://www.buildingscience.com/resources/mechanical/transfer_grille_detail.pdf



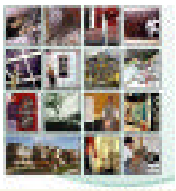
What happened – climate by climate

Climate	Location	1-story	2-story
V. Cold	Minneapolis, MN	88.4	87.4 - 88.7
Cold	Chicago, IL	88.5	87.3 - 88.8
Hot Humid	Houston, TX	87.6	89.2
Mixed Humid	Atlanta, GA	88.0	88.1 - 88.9
	Dallas, TX	87.4	88.9 - 89.6
Hot Dry	Phoenix, AZ	88.1	90.4
	Tucson, AZ	87.9	90.1
Mixed Dry	Albuquerque, NM	87.5 - 89.1	88.7 - 91.7



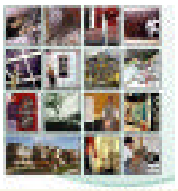
How It Happened – Cold

- Ceiling: R-38 loose-fill
- Walls : R-19 2X6 24" OC + 1" R-5 XPS
- Basement: 2" R-10 XPS (int)
- Windows: low-e vinyl (U=0.36, SHGC=0.46)
- Heat: sealed combustion in conditioned basement, 90%+ AFUE
- Cool: 12 SEER split
- DHW: power-direct vent, 0.54 EF, 50-gal. in basement
- Ventilation: Central fan integrated supply AirCycler FRV + motorized damper, 40 – 60 cfm cont. ave. on 33% duty cycle
- Pressure relief: transfer grilles/jump ducts at bedrooms
- Air sealing



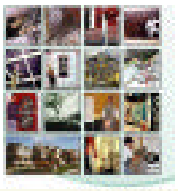
How It Happened – Mixed Humid

- Ceiling: R-30 loose-fill
- Walls : R-19 2X6 24" OC + 1" R-5 XPS
- Slab: 1" R-4 EPS edge & under
- Windows: vinyl low-e^2 spec. select (U=0.35, SHGC=0.37)
- Heat: sealed combustion in conditioned space, 90%+ AFUE
- Cool: 12 SEER split
- DHW: power-direct vent, 0.54 EF, 40-gal. in garage
- Ventilation: Central fan integrated supply AirCycler FRV + motorized damper, 40 – 60 cfm cont. ave. on 33% duty cycle
- Pressure relief: transfer grilles/jump ducts at bedrooms
- Air sealing



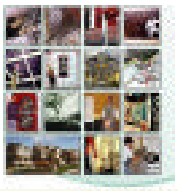
How It Happened – Mixed Dry

- Ceiling: R-38 loose-fill
- Walls : R-19 2X6 24" OC + 1" R-5 XPS
- Slab: 1" R-5 XPS perimeter
- Windows: vinyl low-e (U=0.36, SHGC=0.46)
- Heat: 90%+ sealed combustion
- Cool: 12 SEER split
- DHW: nat. aspirated, 0.54 EF, 40-gal. in garage
- Ventilation: Central fan integrated supply AirCycler FRV + motorized damper, 40 – 60 cfm cont. ave. on 33% duty cycle
- Pressure relief: transfer grilles/jump ducts at bedrooms
- Air sealing



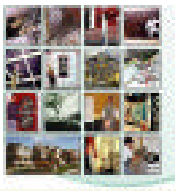
How It Happened – Hot Humid

- Ceiling: R-22 unvented/sealed
- Walls : R-13 2X4 16" OC + 3/8" R-1.5 XPS
- Slab: uninsulated
- Windows: vinyl low-e^2 spec. select (U=0.35, SHGC=0.37)
- Heat: sealed combustion in conditioned attic, 90%+ AFUE
- Cool: 12 SEER split
- DHW: 0.54 EF, 40-gal. in garage
- Ventilation: Central fan integrated supply AirCycler FRV + motorized damper, 40 – 60 cfm cont. ave. on 33% duty cycle
- Pressure relief: transfer grilles/jump ducts at bedrooms
- Supplemental dehumidification
- Air sealing



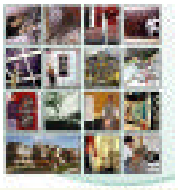
How It Happened – Hot Dry

- Ceiling: R-22 unvented/sealed
- Walls : R-19 2X6 24" OC + 1" R-4 EPS
- Slab: uninsulated
- Windows: vinyl low-e^2 spec. select (U=0.35, SHGC=0.37)
- Heat: sealed combustion in conditioned attic, 90%+ AFUE
- Cool: 12 SEER split
- DHW: nat. aspirated, 0.54 EF, 50-gal. in garage
- Ventilation: Central fan integrated supply AirCycler FRV + motorized damper, 40 – 60 cfm cont. ave. on 33% duty cycle
- Pressure relief: transfer grilles/jump ducts at bedrooms
- Air sealing



Ongoing challenges

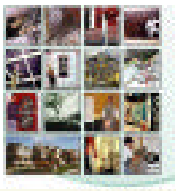
- Advanced framing
- Climate-tuned exterior foam sheathing
- Air sealing details
- Unvented roof assemblies (code officials)
- Basement/slab insulation (climate-specific concerns: termites, drying potential)
- Right-sizing of equipment and ducts



Low Energy Advanced House

- Pulte Southwest (hot-dry)
- Energy Star score: 91.6
- Upgraded combo heat: Polaris 94% sealed combustion
- Upgraded cooling: 15 SEER variable speed ECM
- Not reflected in the score
  - Fluorescent lighting package: 60% wattage reduction
  - Appliances: Energy Star refrigerator, dishwasher, clothes washer

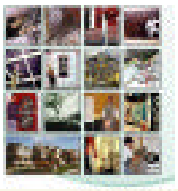
NOTE: completely equipment-based improvements



EcoVillage Cleveland

- Cold climate
- Energy Star scores: 89.4 – 91.0
- 90+% AFUE gas furnace
- 12 SEER
- Advanced framing with rigid insulation sheathing (above grade/below grade walls, slab)
- Multi-family (sheltering aspects inherent to design) positive or penalty?
- PV: 2 – 3.2 kW arrays on detached garages

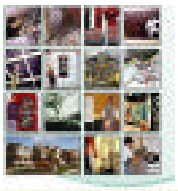
EcoVillage Cleveland



Getting to the next level

- DHW – what are the options:
  - Solar rooftop: lots of different units but we modeled a .7 to a 1.3 point boost
  - Moving from .54 to .62 EF conventional: .2 or so score bump
  - Combo instantaneous gas heaters (.82 EF) maybe full a point
- HVAC efficiency
  - From 12 to 13 or 14: a little less than a point bump

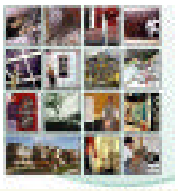
NOTE: impacts are often climate-specific



Getting to the next level

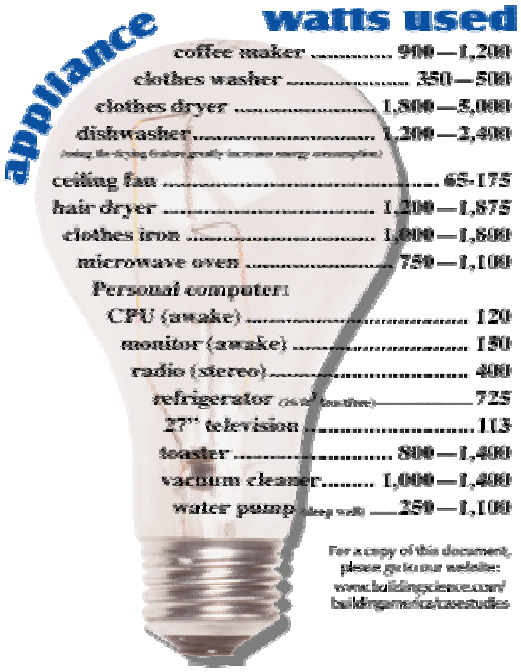
- Windows: going from BA specs to super windows (triple-glazed, gas-filled) – about .5 to almost a point
- Lighting no Energy Star score bump (yet) but still significant relative energy savings
  - systems engineering (task lighting, background)?
  - 1:1 cfl substitution?
- Foundation insulation: systems engineered foundation systems (system and boost climate dependent)
- Production design issues – house orientation, climate-tuned window locations and properties, exterior shading – .3 – .5 point

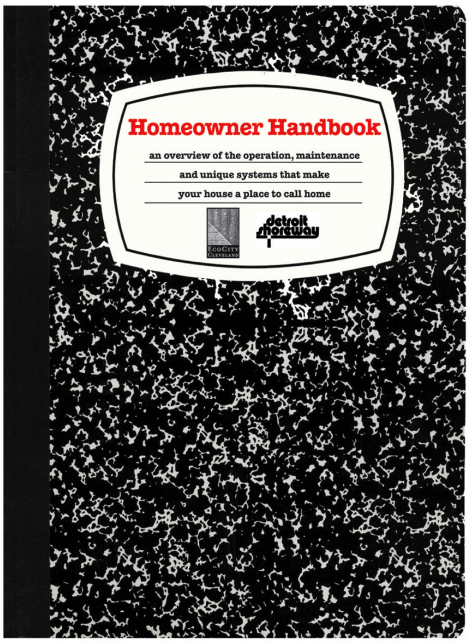
NOTE: not much in the way of envelope

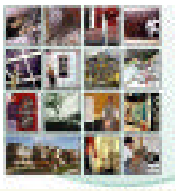


Building Science Corporation

Energy Management







Conclusions

- Moving production builders from about 88 to 92 will take creativity (or soaring energy prices!)
- We know what the next lowest hanging fruit are, but the lowest are already harvested
- Reverse synergies – diminishing returns on further improvements
- A lot depends on market conditions, and on the ability and willingness of builders to push and consumers to pull the market
- In many cases, the technologies are there for the next steps, but not always--e.g. water heating