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Building Energy Codes

The Future of the IECC—High Return Code Changes

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Outline

- Context—why talk about this?
- Definitions—what are “high return” code changes and do they come in various colors and styles?
- A few abstract examples
- One in-the-works example
- One detailed, slightly out-of-the-box example

Context

- State of the IECC: stringency
  - No major efficiency improvements since 1998 (when SHGC was added)
  - No major efficiency improvements since 1992 (where SHGC doesn't apply)
  - Component-specific economic optimizations show the levels have mostly plateaued
- State of the IECC: other factors
  - Complex format simplified
  - Performance path made consistent (with itself and with other programs)

Context

- Other goings on
  - Tax credit
  - Energy Star, Building America, etc.
  - HERS
- Other considerations
  - IRC Energy Chapter—can it be kept in sync with the IECC?
  - Compliance paths
    - Can they all accommodate a high return change?
    - Will existing ones suffice?
    - Will new ones need to be contemplated?
    - Will existing ones need to be eliminated?

So what is a high-return code change?

"Any change that significantly improves residential efficiency"

("significantly" means a lot)

("a lot" means more than just a little)

Types of High Return Code Changes

- Stringency

  Tighten some screws

- Scope

  Add some new screws

- Compliance

  Make existing screws easier to turn; eliminate loopholes that prevent screws from being turned

- Repair

  Fix broken screws, realign misaligned screws

- Philosophy

  Modify where or how the screws…screw; maybe try newfangled screws that haven't been used before

A Few Abstract Examples

Stringency—Tightening Existing Screws

- Glazing SHGC
  - Available products improving
  - Market transforming rapidly
- Glazing U-factor
  - In some parts of the country
- Wall U-factor (?)
  - Insulating sheathing makes improvements possible
  - Complicating factors make it…complicated
- Doors

Scope—Adding New Screws

- Lighting
  - An increasingly large fraction of residential consumption
- Appliances(?)
  - Can the code affect “portable” appliances?
  - Can the code limit types of hookups available?
- Pools
- Glazing Orientation
  - Not prescriptively regulated
  - Performance path is double-edged sword

Compliance—Making Screws Easier to Turn

- Duct tightness and infiltration control
  - Code requires both
  - But with language like,
    - "…shall be sealed"
    - "…durably sealed to limit infiltration."
    - "…substantially airtight"
- HVAC installation
  - Code says things like, "shall conform to the manufacturer's installation instructions"
  - But specifies no metric to test for such
    - Proper airflow
    - Proper refrigerant charging
    - Proper sizing

Repair—Fixing Broken Screws

- Compliance path issues
  - Free-riders via path shopping
  - Excessive trade-off value in performance path
  - Inequities in valuing equipment vs envelope efficiencies
- Perverse incentives
  - Zone-3 basements: Condition them to avoid insulating both the basement and the ducts
- Simple logic errors, typos, etc.
  - Heated slabs: R-5, zero feet deep

(okay, maybe the last two aren't really high return…)

Philosophy—Trying some new screws

- Hot water piping—can it be sized smaller?
  - Current rules predate low-flow fixtures
- HERS compliance path
  - Will it provide incentive for builders to go beyond code?
  - Or will it just add to the path shopping problem?

An In-The-Works Example:

Duct Tightness Testing

Duct Tightness

Code already requires that ducts be sealed:

> "All ducts, air handlers, filter boxes, and building cavities used as ducts shall be sealed. Joints and seams shall comply with Section M1601.3.1 of the *International Residential Code*."

--2006 IECC, Section 403.2.2

Duct Tightness

Code already requires that ducts be sealed:

Subjective and unenforceable

"All ducts, air handlers, filter boxes, and building cavities used as ducts **<u>shall be sealed</u>**. Joints and seams shall comply with Section M1601.3.1 of the *International Residential Code*."

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Duct Tightness

Code already requires that ducts be sealed:

> "Joints of duct systems shall be made substantially airtight by means of tapes, mastics, gasketing or other approved closure systems…"

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Duct Tightness

Studies confirm that the current code leaves many/most ducts unacceptably leaky

Correcting this compliance issue—perhaps by requiring a pressure test— would be a high return code change

Duct Testing and the IECC—Issues

- How should the test be structured?
  - What test to use? (duct blaster, Delta-Q, etc.)
  - What metric to use? (CFM_{xx}, CFM % of rated airflow, CFM_{xx}/sf, etc.)
  - Test conditions?
  - When?
    - After rough-in or post-construction?
    - Before or after air-handler installation?
  - Required score?
    - Just prevent disasters?
    - Or go for the gold?

Duct Testing and the IECC—Issues

- Who should perform the test?
  - HVAC installer?
  - Third-party tester?
  - HVAC installer with random third-party verifications?
  - Can a sampling protocol work in a code?

Duct Testing and the IECC—Issues

- How should the code text be structured?
  - Mandatory requirement (i.e., can't be traded away)?
  - Basic prescriptive requirement?
  - Performance-only requirement?
  - Prescriptive requirement with a "way out"?
    - Performance only?
    - Prescriptive exceptions (e.g., ducts indoors, high HVAC efficiency, etc.)
  - How to coordinate prescriptive and performance?

Duct Testing and the IECC—When should the test occur?

After rough-in?

- Pro
  - Lower cost
  - Less disruption
    - Right time for catching/correcting problems
    - Avoids another visit and/or sub on the schedule
- Con
  - Less accurate (no measurement of leakage to outdoors)
  - Less chance to encourage whole-house testing and ratings
- Discussion
  - Maybe allow post-construction test as a higher-credit alternative?
  - When should third-party verifications occur?

Duct Testing and the IECC—Who should conduct the test?

A third party?

- Pro
  - Know-how
  - Reduces cheating
  - Promotes a healthy testing/rating industry
- Con
  - Requires another sub on the schedule
  - Requires a second visit by HVAC installer to correct problems
  - Higher cost
- Discussion
  - Probably DOA at the code hearings

Duct Testing and the IECC—Who should conduct the test?

The HVAC installer?

- Pro
  - Avoids another visit and/or sub on the schedule
  - Avoids second visit to correct problems
  - Lower cost
- Con
  - Ignorance
  - Cheating
  - Doesn’t promote testing/rating industry
- Discussion
  - Can sufficient instructions be crafted into the code text?
  - Must someone (DOE) develop a training system?
  - Could allow installer to test, official has option to verify
  - Official could design a sampling system
  - Do most testing errors tend toward worse scores?
  - Are some test protocols harder to foul up?

Duct Testing and the IECC—How should the code text be designed?

The duct test is a mandatory requirement?

- Pro
  - Encourages ***duct testing*** rather than the least distasteful trade-off
- Con
  - Less chance of success at code hearings
- Discussion
  - Success at the code hearings may depend on some easy exceptions (ducts indoors, high HVAC efficiency, better insulation package, etc.)
  - Success at the code hearings my depend on limiting exceptions to the performance path

Duct Testing Proposal

2006 IECC, Section 403.2.2 again:

"All ducts, air handlers, filter boxes, and building cavities used as ducts shall be sealed. Joints and seams shall comply with Section M1601.3.1 of the *International Residential Code*."

Duct Testing Proposal

2006 IECC, Section 403.2.2 again:

"All ducts, air handlers, filter boxes, and building cavities used as ducts shall be sealed. Joints and seams shall comply with Section M1601.3.1 of the *International Residential Code*. Duct tightness shall be verified by either of the following:"

Duct Testing Proposal

"…. Duct tightness shall be verified by either of the following:"

1. Post-construction test (@25 Pa)
   - Leakage to outdoors ≤ 8 CFM/100sf, or
   - Total leakage ≤ 12 CFM/100sf
2. Rough-in test (@25 Pa)
   - Leakage ≤ 6 CFM/100sf, or
   - Leakage ≤ 4 CFM/100sf if AHU not yet installed

(plus associated adjustments to performance path)

An Out-of-the-Box Example:

Glazing Orientation Restrictions

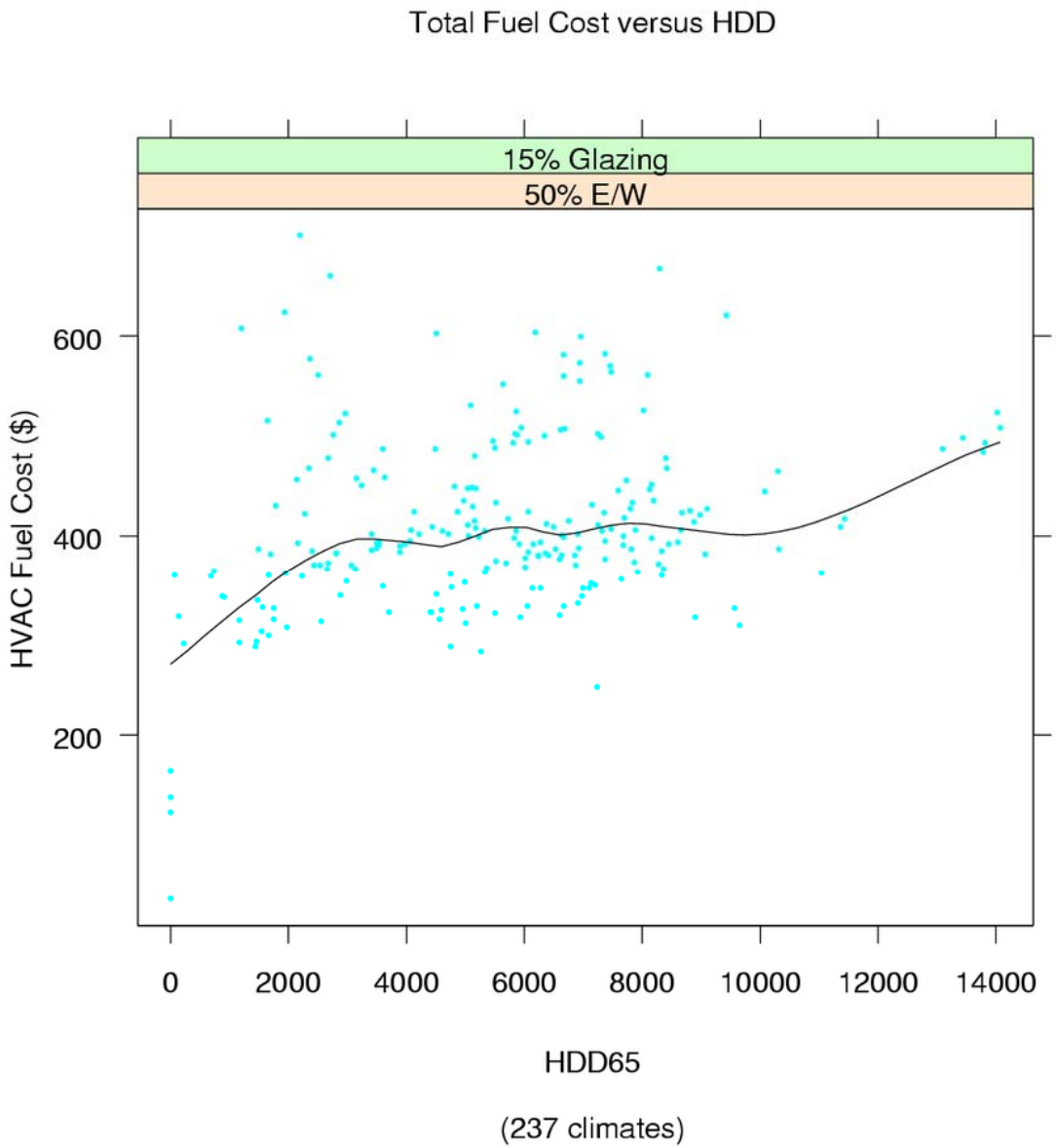
Glazing Orientation—Issues

- Orientation remains a large determinant of residential energy consumption, especially in the south
- The code has never regulated it
- Restricting glazing area (as a percentage of floor or wall area)
  - Can help a little…
  - …But only a little and only incidentally
  - Complicates the code substantially

Glazing Orientation—The Problem(s) with Regulating Glazing Percentage

- Code's requirements aren't "memorizable"
- Code exhibits irrational behaviors
  - Large homes generally comply with less insulation than small homes
  - Homes with inefficient aspect ratios comply with less insulation than compact, efficient homes
  - Changes that increase energy use can allow a house to comply with less insulation
    - Lengthen the house (or even one room)
    - Raise the ceiling height
- Code gives inordinate trade-off credit in performance path
- Still doesn't solve the orientation problem

Glazing Orientation and Glazing Percentage—What Matters?



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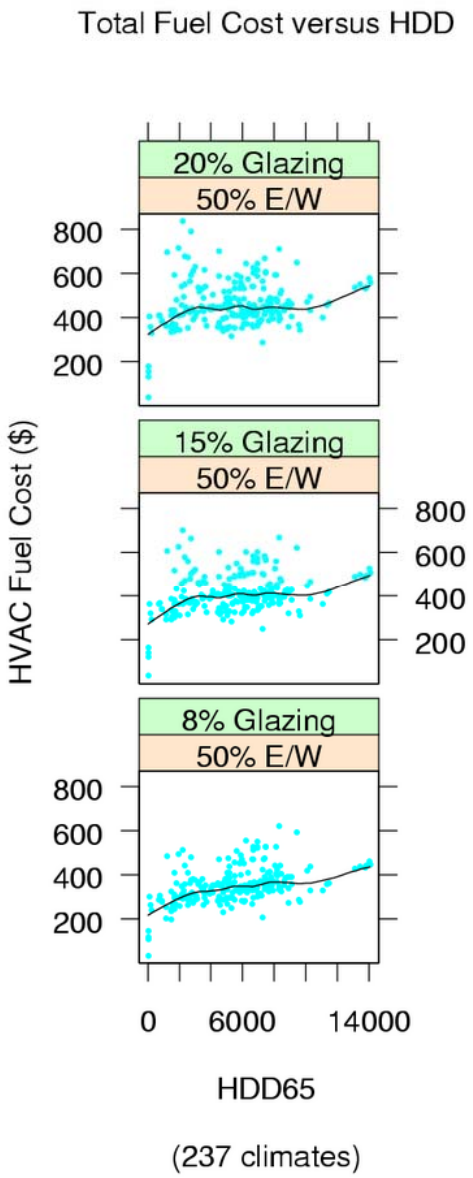

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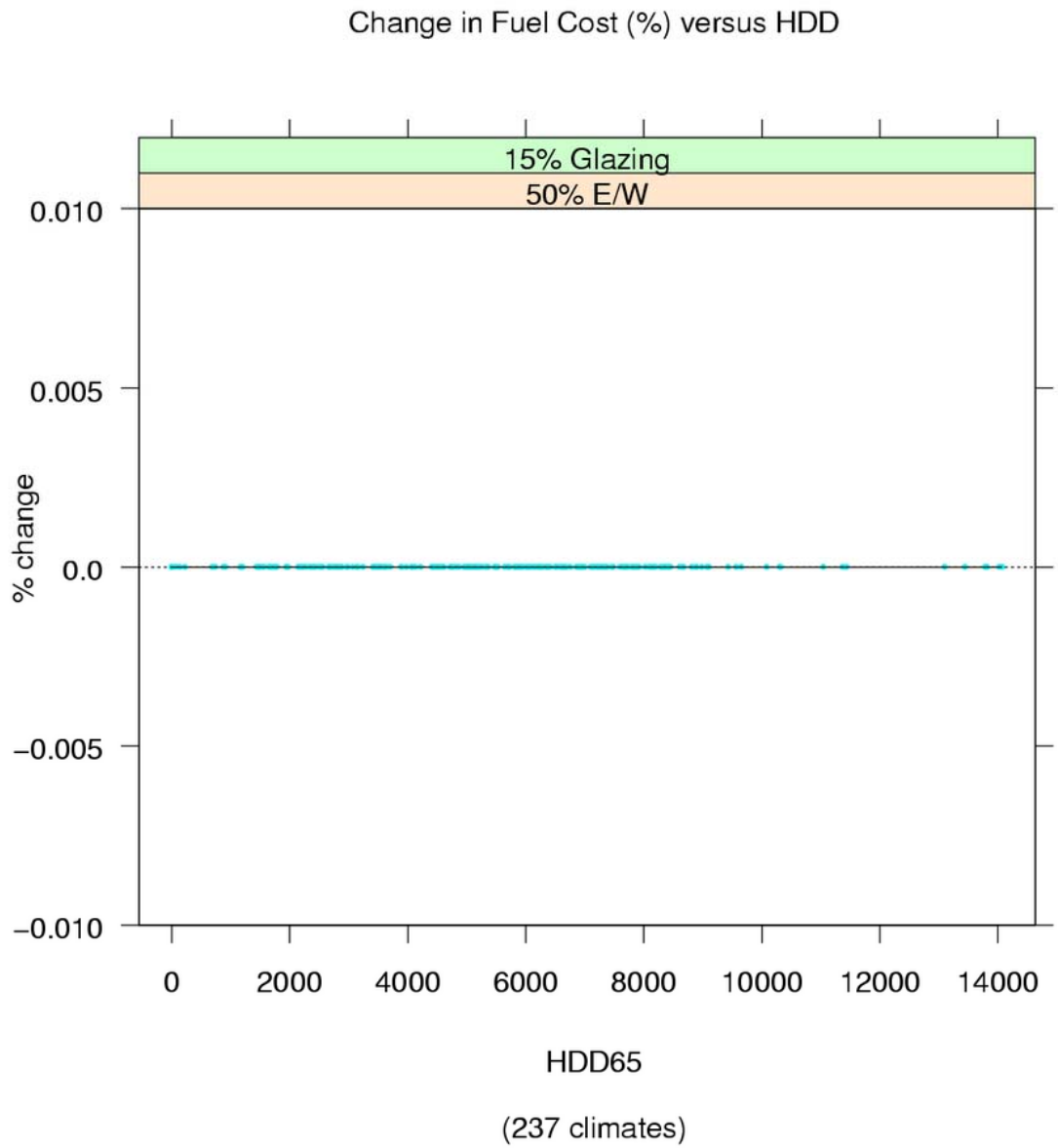

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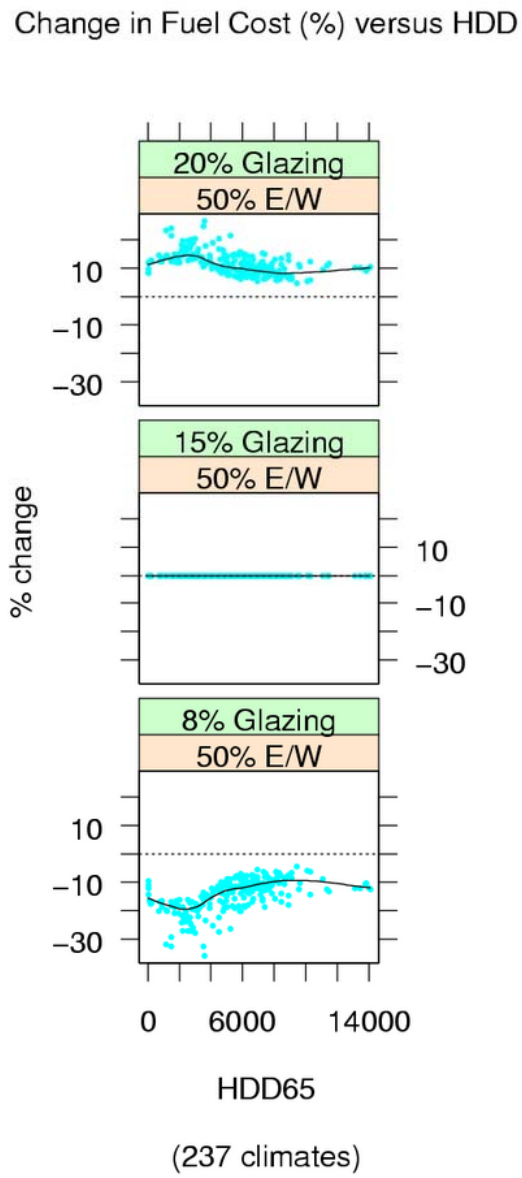

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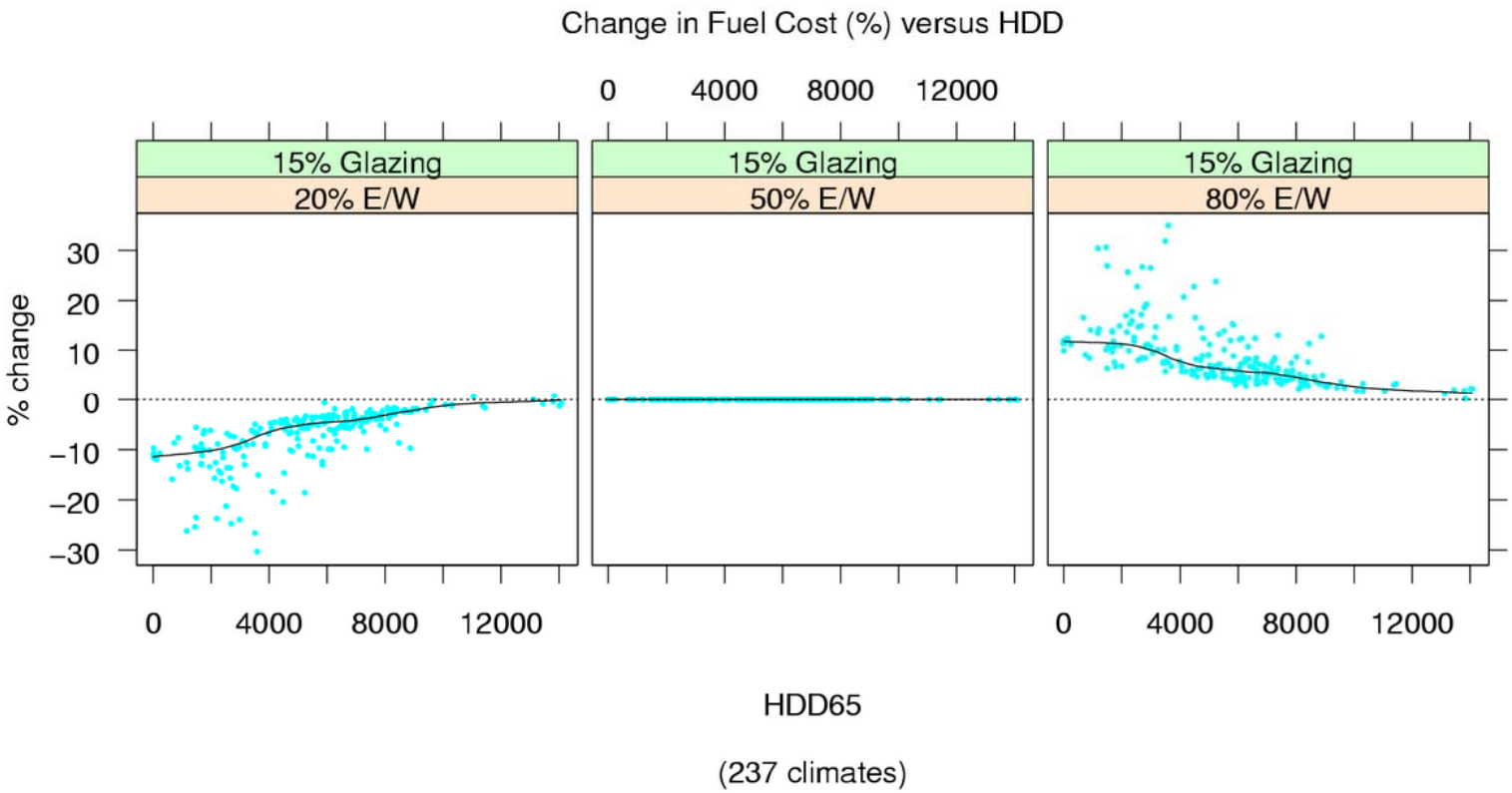


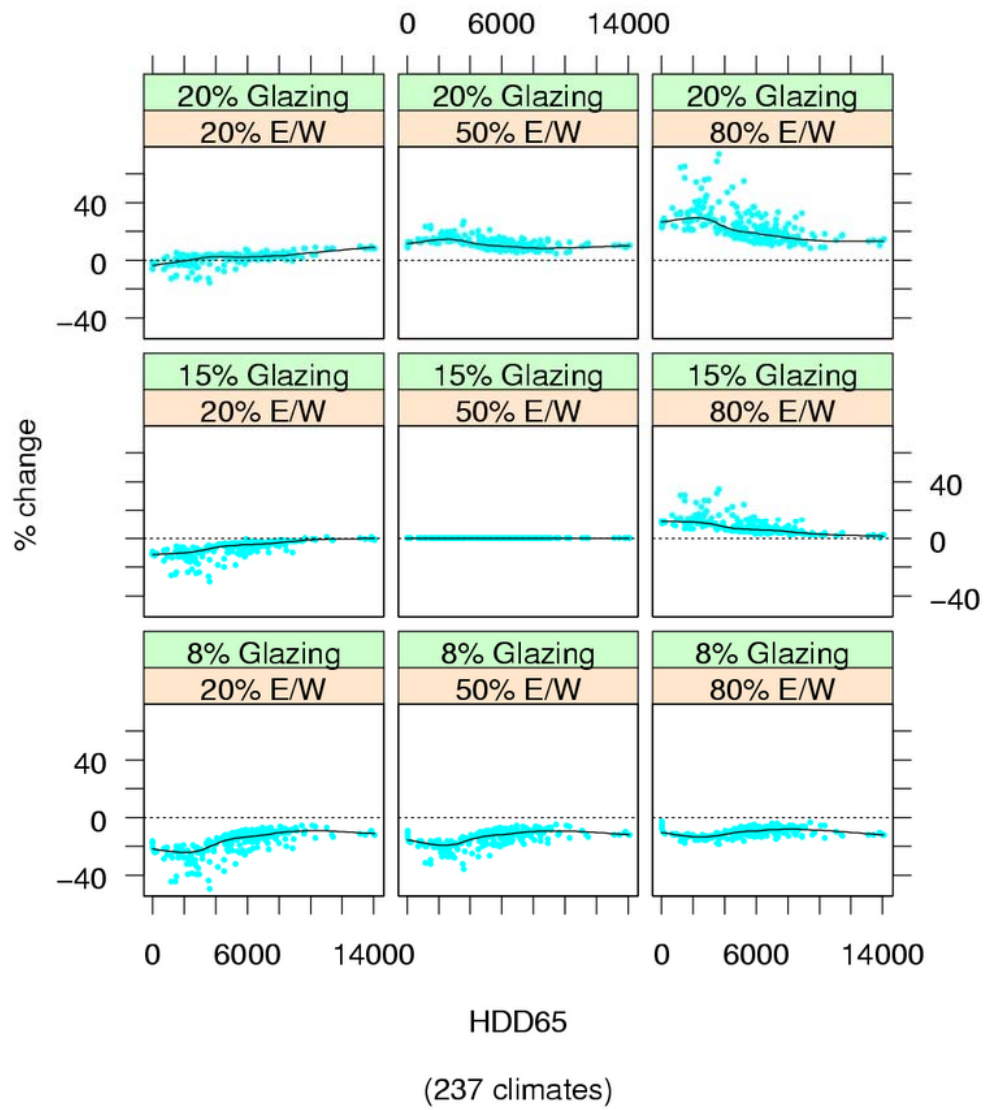
Glazing Orientation and Glazing Percentage—What Matters?

Good Orientation

Change in Fuel Cost (%) versus HDD

Bad Orientation

High Glazing Percentage



Low Glazing Percentage

Implications

- Both glazing percentage and glazing orientation, if regulated at a “middle” value, are too volatile in terms of trade-off value
- If either glazing percentage or glazing orientation is in its most advantageous arrangement, a poor arrangement of the other is tolerable

Other Considerations

- High glazing percentage is naturally constrained by economics (except for big-budget homes)

  (Purchase price, framing cost, installation labor, trim cost, siding labor, etc.)
- Bad orientation has no natural enemies
  - No additional cost associated with west-facing glass
  - Few land-use regulations encourage solar sensitive street layout
- Achieving good orientation can be *very* costly on poorly oriented lots

Goal

Design an orientation code requirement that:

- Avoids excessive trade-off volatility
- Maintains the code's current prescriptive simplicity
- Has minimal impact on low-budget, small-lot, track homes
- Yet moves the industry toward sensible solar orientation

Key Observation

Conclusion:

Don’t have to regulate all four sides

Regulating Orientation—A New Approach

- Assume most homes have two-sided glazing distribution (say, 80% to front/back yard, 20% to side yards)
  - Only need to regulate two of four sides
- Assume front/back distribution is even (i.e., 40% front, 40% back, 10% left side, 10% right side)
  - Not right, but probably pretty close
  - Now we only need to regulate one of four sides

Regulating Orientation—A New Approach

- Assume achieving good orientation is most difficult for smaller (i.e., starter) homes
  - Larger homes have more land, more options, more budget, more designers involved

Regulating Orientation—A Possible Approach

- Put a prescriptive limit on absolute glazing area (not percentage) that is “west facing”
- E.g.,

  “Not more than 110 ft^2 of glazing facing west (± 45 degrees)”

  - Note the implicit definition of “west facing”
  - Note that only one side is regulated
    - Any inspections can be done from a single face of the building
  - Note that there is no need to verify floor area or wall area—there are no percentages involved

Regulating Absolute Glazing Area--Implications

- Impact on a small house:

  1500 ft^2 x 18% glazing = 270 ft^2

  270 ft^2 x 40% = 108 ft^2

  No impact

- Impact on a large house:

  5000 ft^2 x 18% glazing = 900 ft^2

  900 ft^2 x 40% = 360 ft^2

  Bigger impact: 250 ft^2 over

- Impact on an average house:

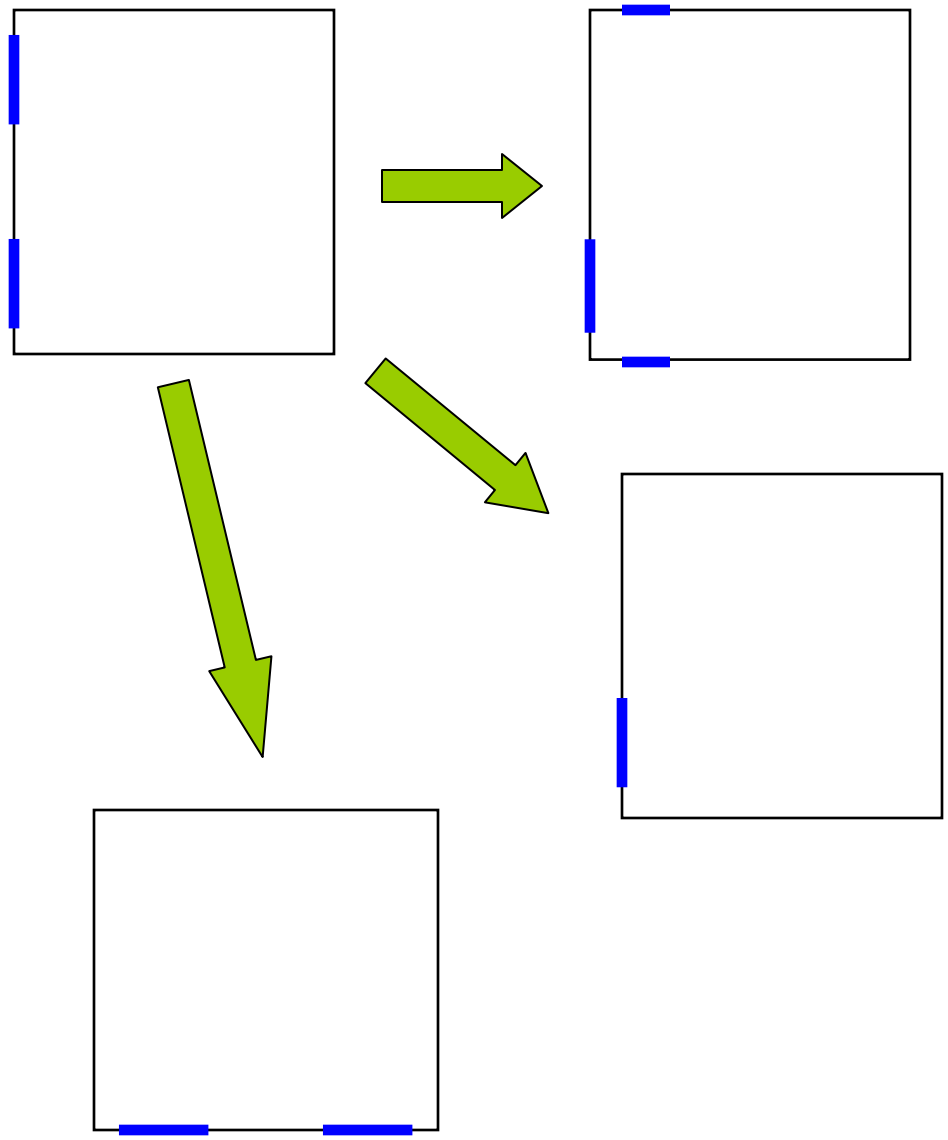
  2200 ft^2 x 15% glazing = 330 ft^2

  330 ft^2 x 40% = 132 ft^2

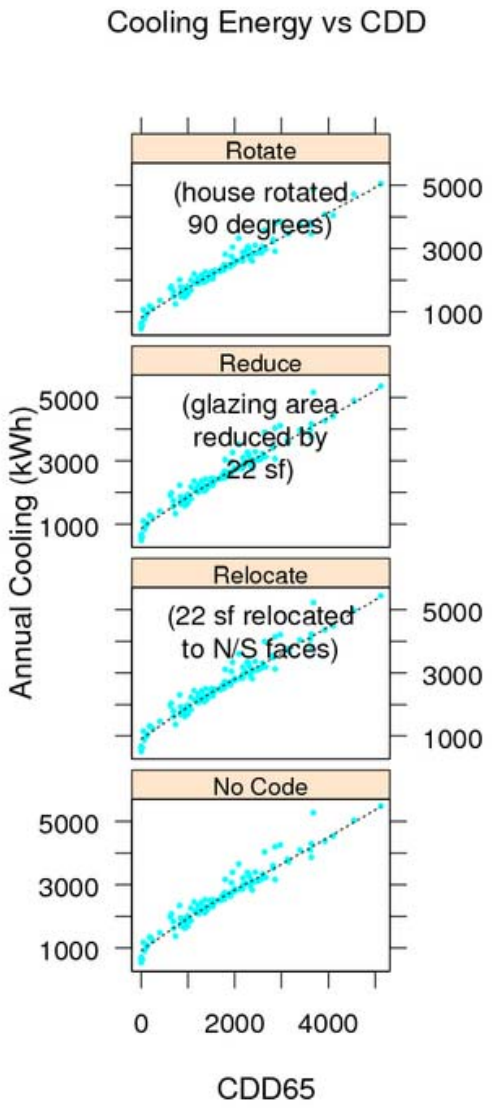
  Modest impact: 22 ft^2 over

How might a builder respond to a 22-ft^2 overage?

1. Relocate it
2. Reduce it
3. Rotate it

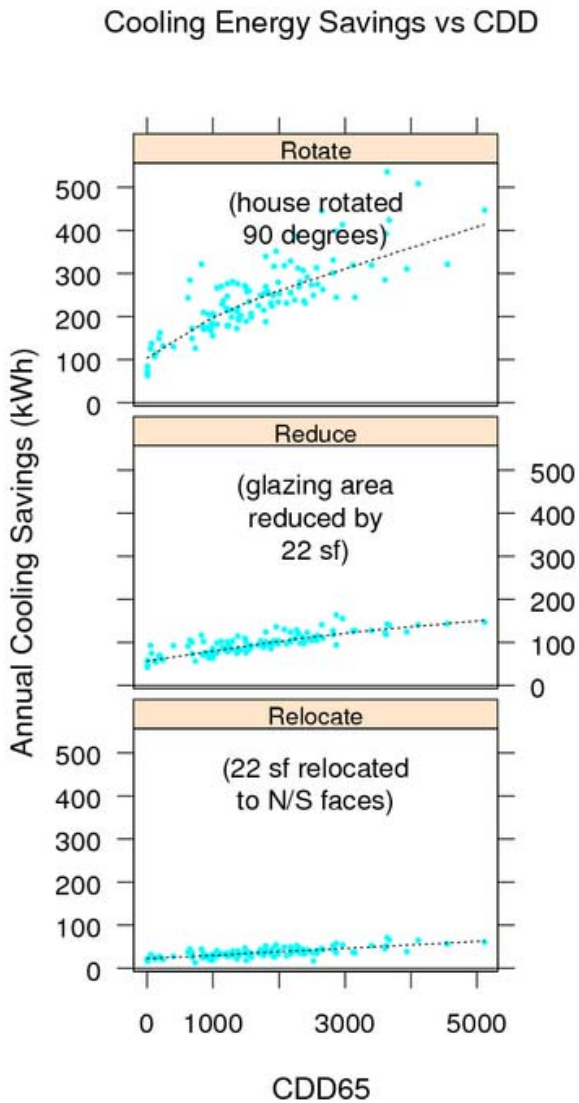


Cooling Energy Impacts of a Maximum West-facing Glazing Area (MaxWGA) Limit



MaxWGA = 110, CFA = 2200, WFR = 0.15, AZIMUTH = 270, SHGC = 0.4

Cooling Energy Impacts of a MaxWGA Limit



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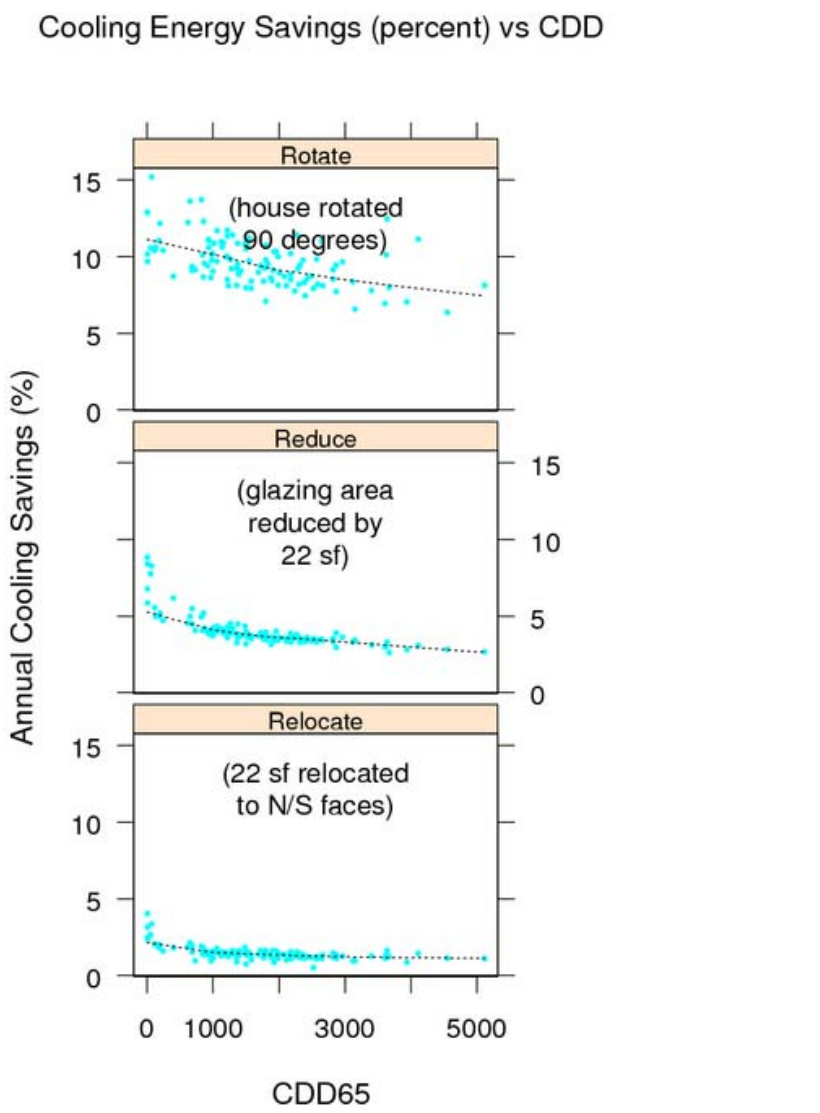
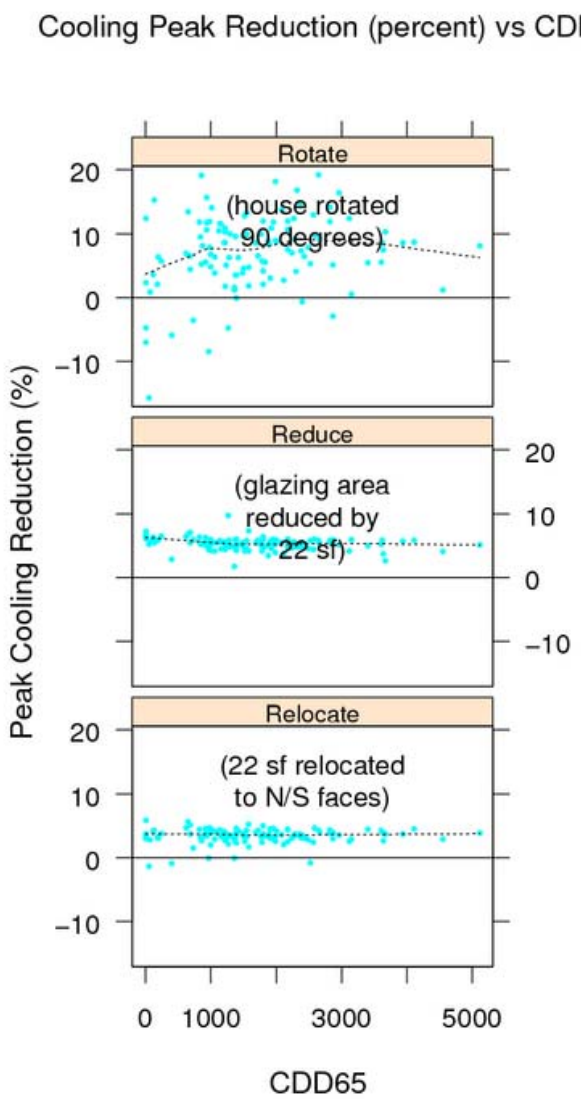


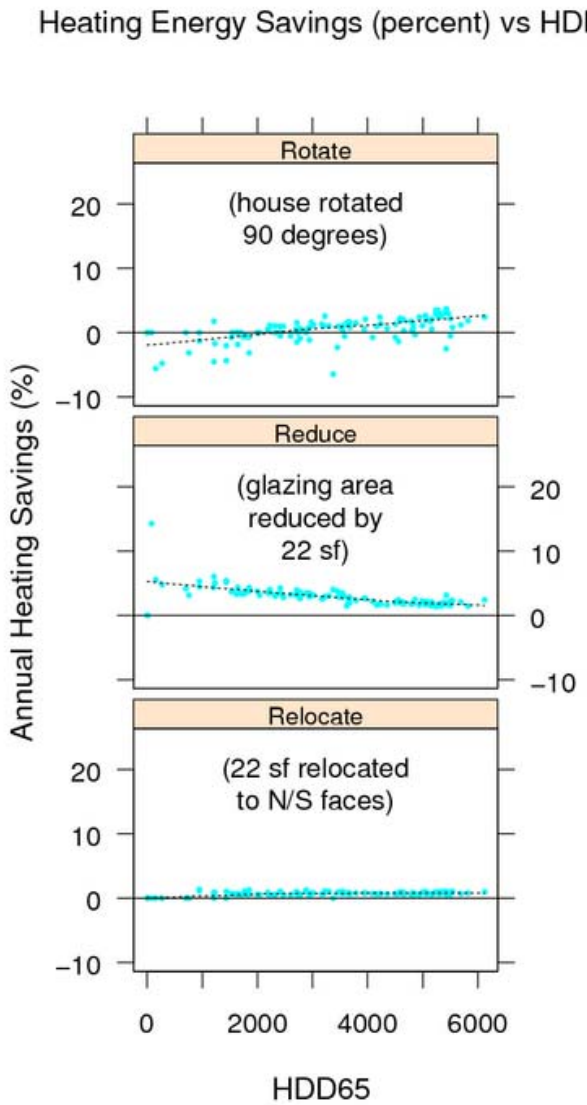
MaxWGA = 110, CFA = 2200, WFR = 0.15, AZIMUTH = 270, SHGC = 0.4

Cooling Peak Impacts of a MaxWGA Limit

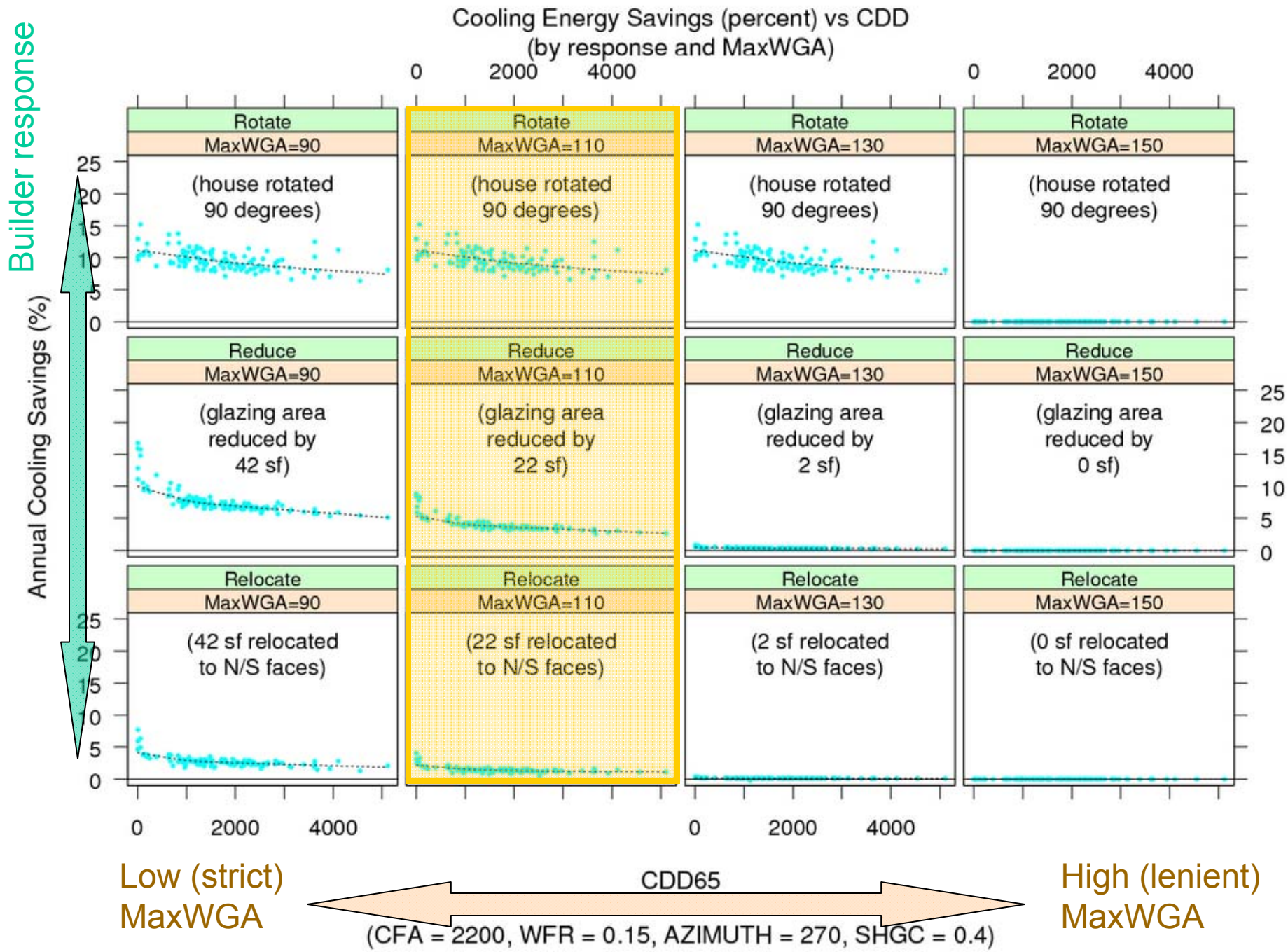


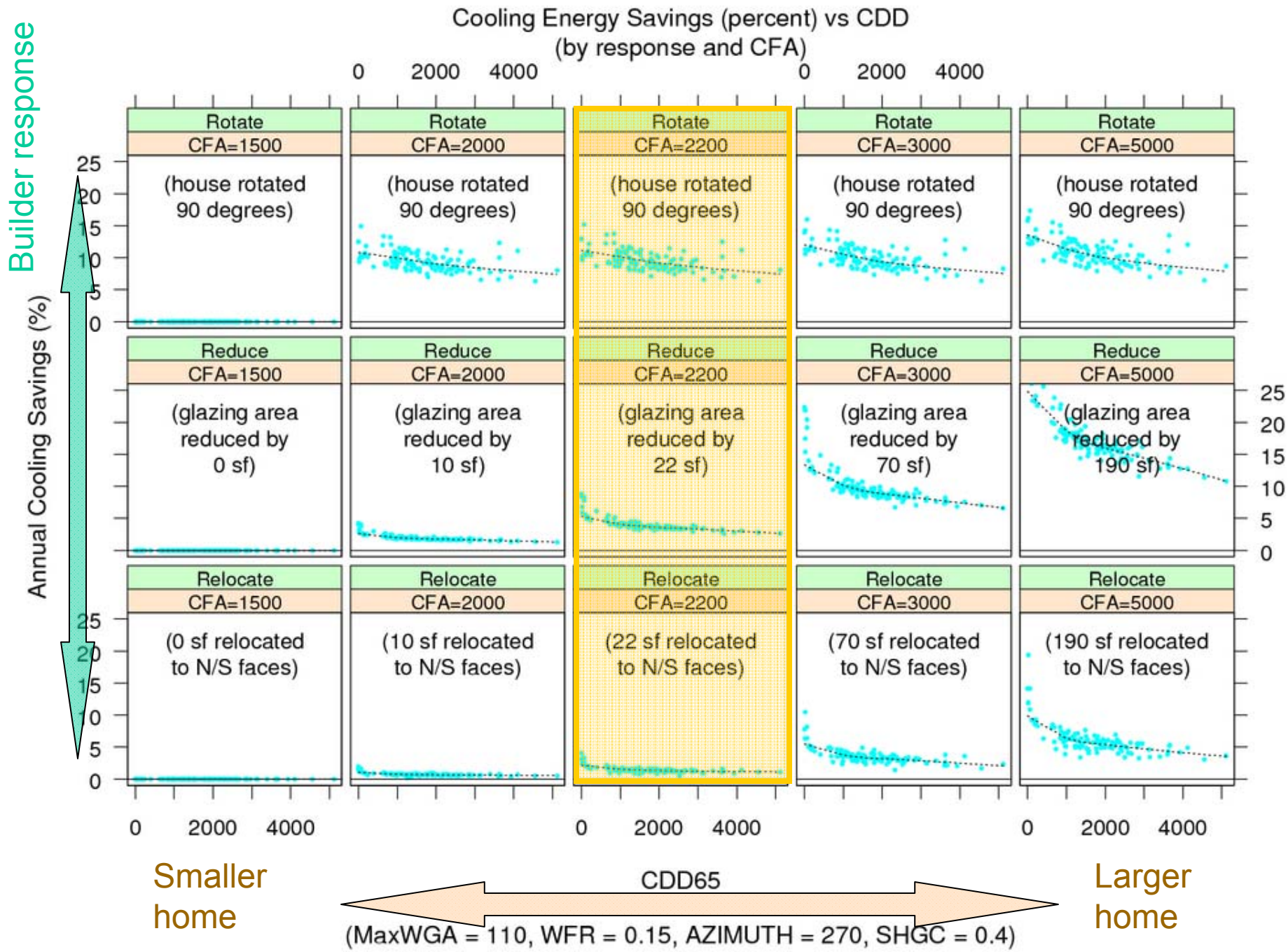
MaxWGA = 110, CFA = 2200, WFR = 0.15, AZIMUTH = 270, SHGC = 0.4

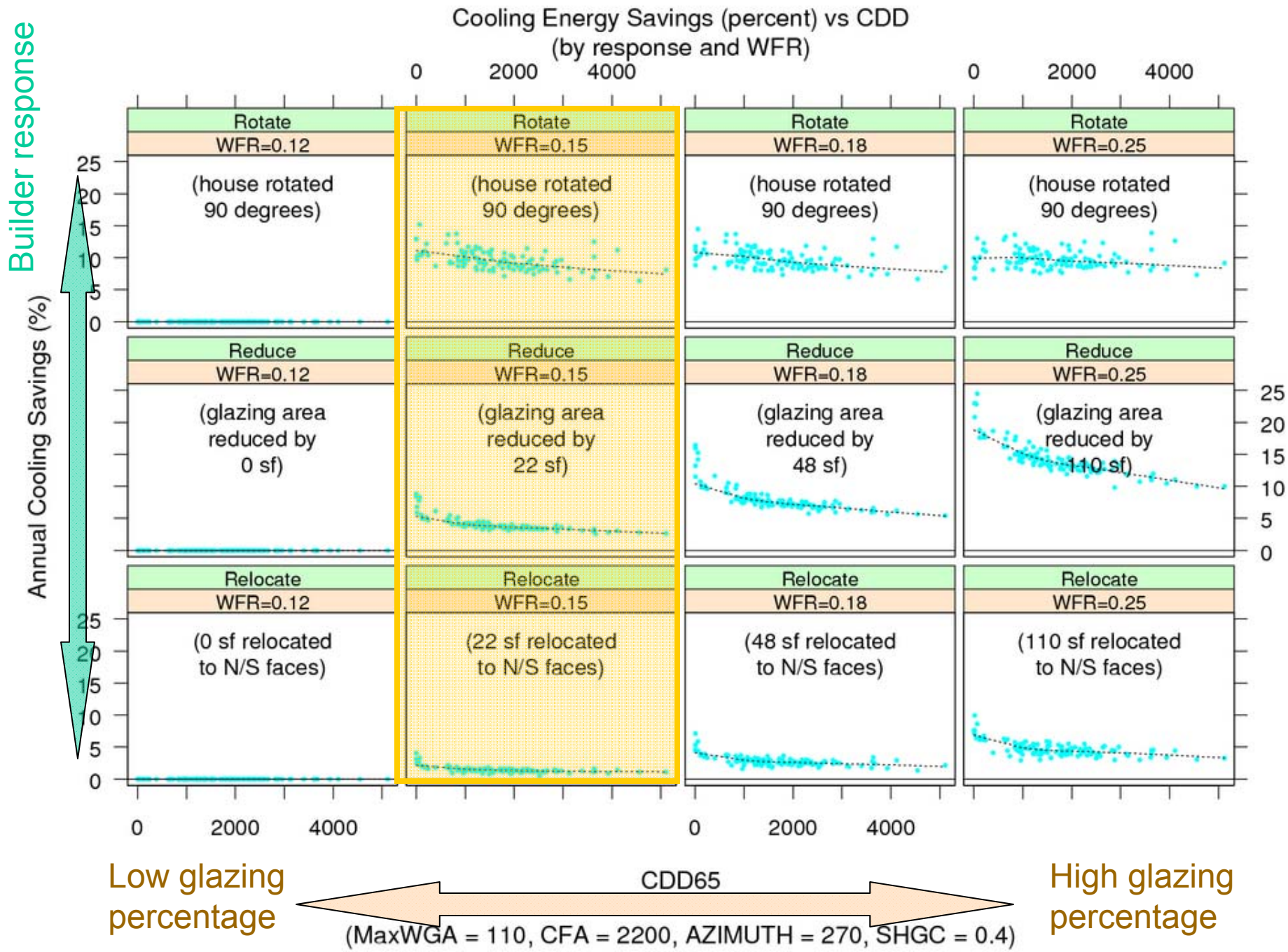
Heating Energy Impacts of a MaxWGA Limit

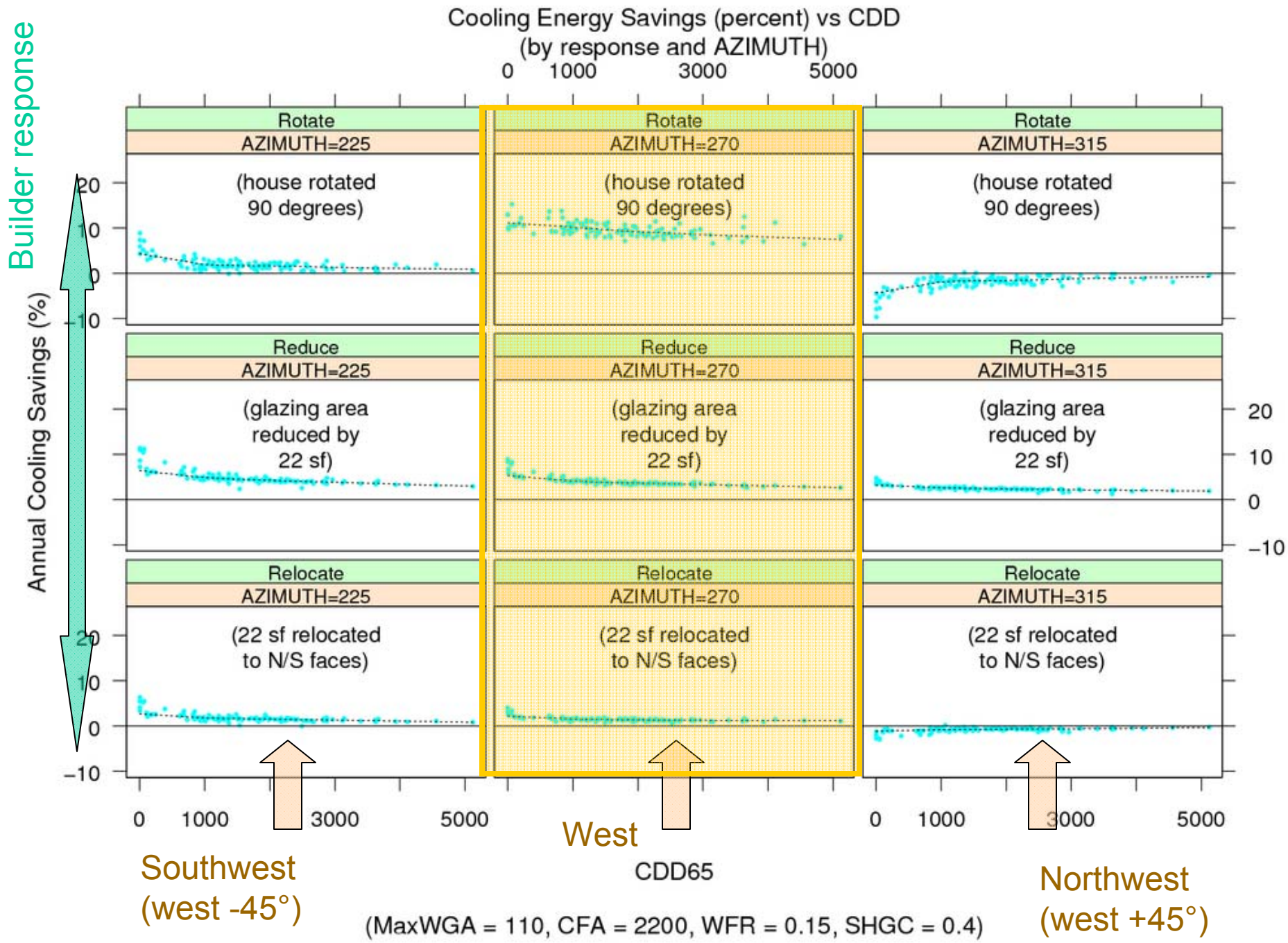


MaxWGA = 110, CFA = 2200, WFR = 0.15, AZIMUTH = 270, SHGC = 0.4


Builder response
Cooling Energy Savings (percent) vs CDD
(by response and MaxWGA)
Annual Cooling Savings (%)
Rotate
MaxWGA=90
(house rotated 90 degrees)
Rotate
MaxWGA=110
(house rotated 90 degrees)
Rotate
MaxWGA=130
(house rotated 90 degrees)
Rotate
MaxWGA=150
(house rotated 90 degrees)
Reduce
MaxWGA=90
(glazing area reduced by 42 sf)
Reduce
MaxWGA=110
(glazing area reduced by 22 sf)
Reduce
MaxWGA=130
(glazing area reduced by 2 sf)
Reduce
MaxWGA=150
(glazing area reduced by 0 sf)
Relocate
MaxWGA=90
(42 sf relocated to N/S faces)
Relocate
MaxWGA=110
(22 sf relocated to N/S faces)
Relocate
MaxWGA=130
(2 sf relocated to N/S faces)
Relocate
MaxWGA=150
(0 sf relocated to N/S faces)
0
2000
4000
0
5
10
15
20
25
Low (strict) MaxWGA
CDD65
High (lenient) MaxWGA
(CFA = 2200, WFR = 0.15, AZIMUTH = 270, SHGC = 0.4)


Cooling Energy Savings (percent) vs CDD
(by response and CFA)
Builder response
Annual Cooling Savings (%)
Rotate
CFA=1500
(house rotated 90 degrees)
Rotate
CFA=2000
(house rotated 90 degrees)
Rotate
CFA=2200
(house rotated 90 degrees)
Rotate
CFA=3000
(house rotated 90 degrees)
Rotate
CFA=5000
(house rotated 90 degrees)
Reduce
CFA=1500
(glazing area reduced by 0 sf)
Reduce
CFA=2000
(glazing area reduced by 10 sf)
Reduce
CFA=2200
(glazing area reduced by 22 sf)
Reduce
CFA=3000
(glazing area reduced by 70 sf)
Reduce
CFA=5000
(glazing area reduced by 190 sf)
Relocate
CFA=1500
(0 sf relocated to N/S faces)
Relocate
CFA=2000
(10 sf relocated to N/S faces)
Relocate
CFA=2200
(22 sf relocated to N/S faces)
Relocate
CFA=3000
(70 sf relocated to N/S faces)
Relocate
CFA=5000
(190 sf relocated to N/S faces)
0
2000
4000
0
5
10
15
20
25
Smaller home
CDD65
Larger home
(MaxWGA = 110, WFR = 0.15, AZIMUTH = 270, SHGC = 0.4)


Cooling Energy Savings (percent) vs CDD
(by response and WFR)
Builder response
Annual Cooling Savings (%)
Rotate
WFR=0.12
(house rotated 90 degrees)
Rotate
WFR=0.15
(house rotated 90 degrees)
Rotate
WFR=0.18
(house rotated 90 degrees)
Rotate
WFR=0.25
(house rotated 90 degrees)
Reduce
WFR=0.12
(glazing area reduced by 0 sf)
Reduce
WFR=0.15
(glazing area reduced by 22 sf)
Reduce
WFR=0.18
(glazing area reduced by 48 sf)
Reduce
WFR=0.25
(glazing area reduced by 110 sf)
Relocate
WFR=0.12
(0 sf relocated to N/S faces)
Relocate
WFR=0.15
(22 sf relocated to N/S faces)
Relocate
WFR=0.18
(48 sf relocated to N/S faces)
Relocate
WFR=0.25
(110 sf relocated to N/S faces)
0
2000
4000
0
5
10
15
20
25
Low glazing percentage
CDD65
High glazing percentage
(MaxWGA = 110, CFA = 2200, AZIMUTH = 270, SHGC = 0.4)


Cooling Energy Savings (percent) vs CDD
(by response and AZIMUTH)
Builder response
Annual Cooling Savings (%)
Rotate
AZIMUTH=225
(house rotated 90 degrees)
Rotate
AZIMUTH=270
(house rotated 90 degrees)
Rotate
AZIMUTH=315
(house rotated 90 degrees)
Reduce
AZIMUTH=225
(glazing area reduced by 22 sf)
Reduce
AZIMUTH=270
(glazing area reduced by 22 sf)
Reduce
AZIMUTH=315
(glazing area reduced by 22 sf)
Relocate
AZIMUTH=225
(22 sf relocated to N/S faces)
Relocate
AZIMUTH=270
(22 sf relocated to N/S faces)
Relocate
AZIMUTH=315
(22 sf relocated to N/S faces)
0
1000
3000
5000
20
10
0
−10
Southwest (west -45°)
West
Northwest (west +45°)
CDD65
(MaxWGA = 110, CFA = 2200, WFR = 0.15, SHGC = 0.4)