# IBACOS

HOME TO INNOVATION

# "Local Implementation of High Performance Housing" and "Does Size Matter?"

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# Local Implementation of High Performance Housing

**"Why do Europeans ship sugar cookies to the U.S. when they could just send the recipe?"**

- **1 ton of $CO_2$ per 4000 miles flown[1]**
- **$CO_2$ is more persistent at high altitude[1]**
- **Average Energy Star Home® emissions savings = 1.86 tons per year[2]**

1. http://traveltax.msu.edu/news/Stories/deutsche5.htm
2. http://www.cleanaircounts.org/Resource%20Package/Quant/eshome.pdf

# Background

- **The basic knowledge needed to build a high performance home is old news**
  - Operation Breakthrough
  - Canadian R-2000
  - Building America for 10+ years
  - EEBA Guides
  - Energy Star Homes
  - Utility Programs
  - Green Building Programs
  - Home Energy Ratings

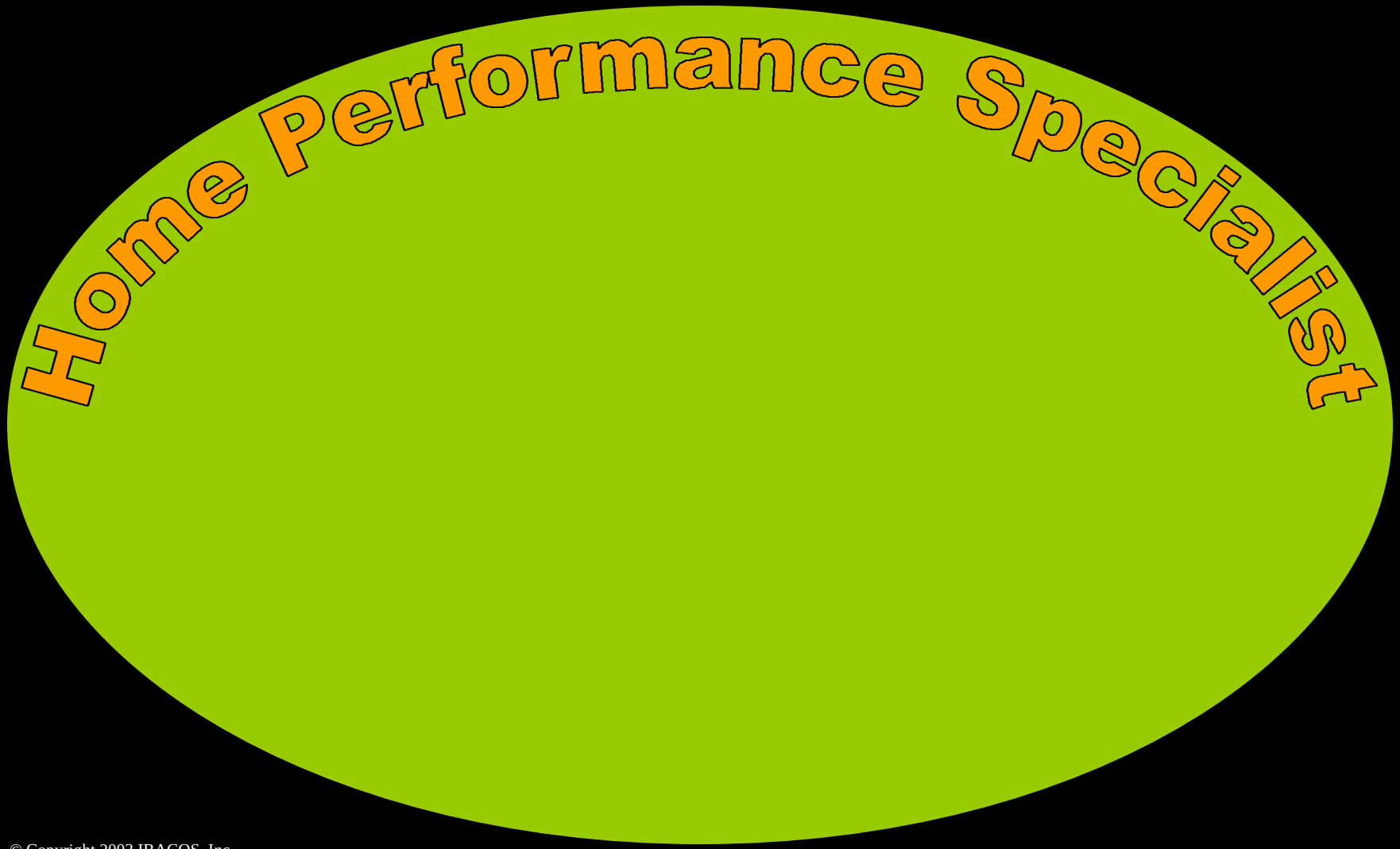
# Technology vs. Process

- **Technology**
  - We have lots of really good “Stuff”
  - Gaps still exist, but they are relatively small
- **The bigger problem is the *Process* of putting the stuff together**
  - Fragmented Industry
  - Continual downstream shifting of responsibility
  - Motives change as process proceeds
    - President of Company vs. Site supervisor

# Hypothesis

- **Local home performance specialist is needed to assist builders throughout the process to champion a predefined standard of quality within a builder's organization.**
- **This specialist could be an advanced home energy rater, who has additional training, professional design review support, and access to a unified design and documentation tool.**
- **Design review, tools, and liability coverage may be "value added" services that a HERS Provider can supply to raters.**

# Big Picture



# Ideal Process

- Map Builders process and local resources
- Performance assessment of current practice
- Set the standard of quality
- Identify the strategies to meet the standards
- Integrate strategies in pre-design phase (programming)
- Review integration during design process
- Design systems and perform design integration during design phase
- Generate documentation for building performance
- Train site supers and subcontractors
- Review construction
- Performance testing

# Research

- Quality Control Strategies
- Costs
- High Performance Standards and Design Methodology
- Documentation
- Liability and Risk Management

# 2002 - 2003

- **First year in Colorado**
  - Several competent raters
  - E-Star™ Colorado HERS Provider
    - DOE 2 based rating tool
    - Quality assurance support
    - Training and Certification
  - Established relationships with several high performance builders
  - Established Green Building Program
- **Possible mid to late 2003 tie-in with New England (VT, MA, CT)**
  - Exemplary Green Building Program is starting there

# Possible outcomes?

- **Development of integrated building design, simulation, and visualization tool.**
  - Structural
  - Loads & Ducts
  - Plumbing
  - Energy / rating
- **A new model of quality control support for builders using Home Energy Raters**
- **Development of a new way of documenting buildings for high performance**

# And in Five Years....?

- **The Home Energy Rating and Performance Engineered Systems Provider**
  - National or state based non- or for-profit company with a centralized internet-based software system in place to perform integrated design engineering of houses and quality control for builders
  - Local field techs use the software and systems to provide design assistance and quality control, including performance testing
  - A new form of design documentation has been adopted
  - The Provider maintains QC over local techs, does design review, and may provide high level strategic consulting

# O r ..?

- **Architects will realize the level of service they could be providing and reinvent their profession to adopt an integrated approach to design, engineering, and testing and quality control support for builders undertaking residential projects**
  - But I’m not betting the farm on this one

# Does Size Matter?

- **House sizes vary dramatically**
- **Occupancy is less variable**
- **Energy consumption is a function of both**
- **Green Building Programs beginning to say “Yes”**

# Trends in House Size and occupancy

| | 1987 | 2001 |
|---|---|---|
| Average House Size | 1,905 | 2,324 |
| 1,200 square feet or less | 13% | 6% |
| 2,400 square feet or greater | 21% | 38% |
| Household size | 2.66 | 2.62 |

Source: NAHB and U.S. Census Bureau

# Is a Single Energy Standard Appropriate?

- **Energy Star Homes® (HERS 86) is a typical threshold**
- **What is the impact of house size, occupancy, construction features, and energy consumption?**

# HERS Rating Score

Point score = 100 -((TnML / TRL) * 20)

**where:**

**TnML = $nMEUL_{HEAT}$ + $nMEUL_{COOL}$ + $nMEUL_{HW}$**

**(Total of all normalized Modified End Use Loads as calculated using equation 1).**

**TRL = $REUL_{HEAT}$ + $REUL_{COOL}$ + $REUL_{HW}$**

**(Total of all Reference Home End Use Loads).**

As house gets smaller for a given occupancy, hot water becomes a larger percentage of the load

# Analysis Methodology

- **Model a variety of house sizes to meet Energy Star Homes® Performance (HERS 86)**
- **Normalize energy use by Surface Area and Occupancy**
- **Rate all houses with same energy characteristics as mid sized house at HERS 86**
- **Develop a Proposed Rating Score Curve that combines attributes of normalized energy for larger houses and same energy characteristics for smaller houses**

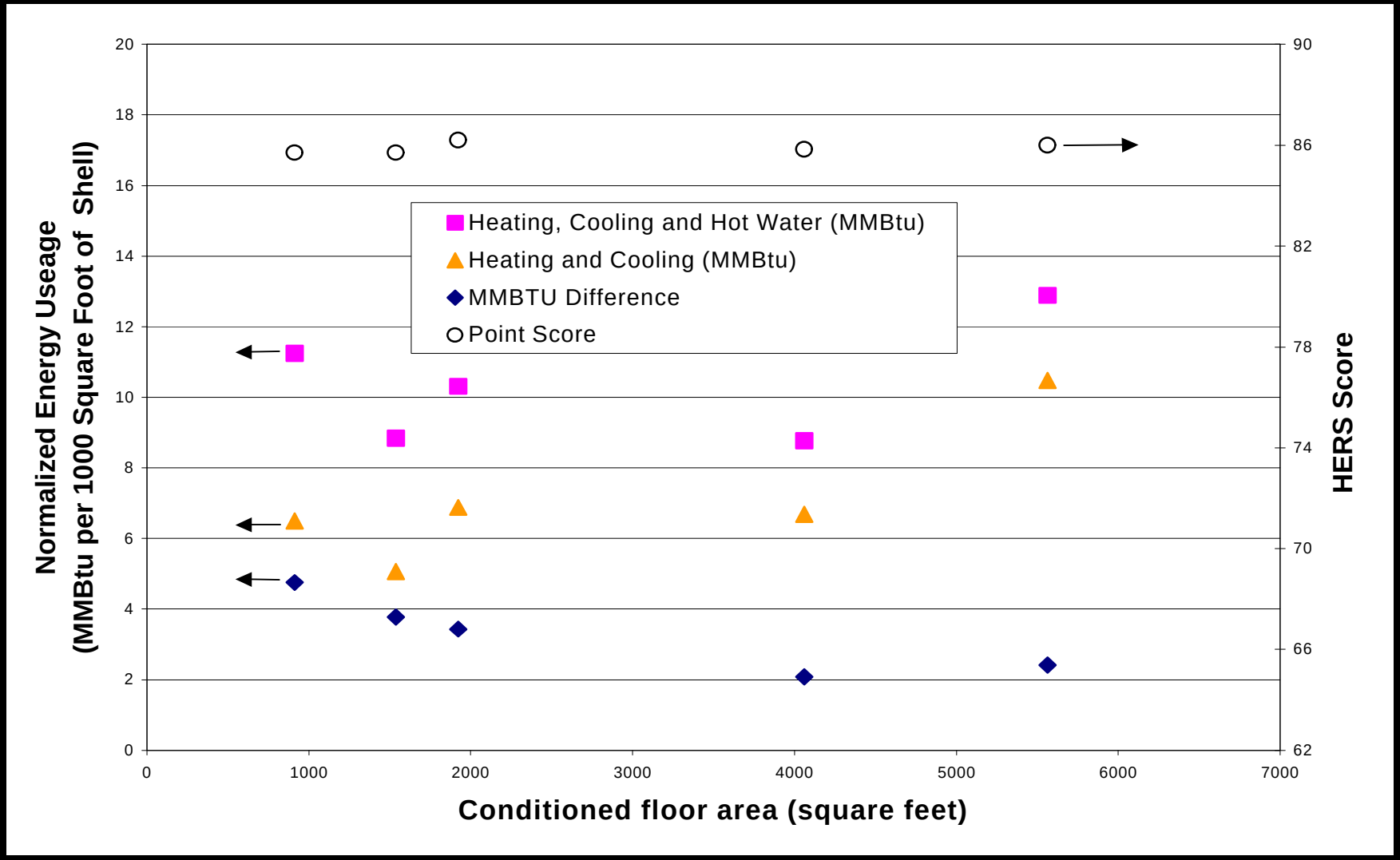
# Comparison of Energy Features to meet HERS 86

| | House Size | | | | |
|---|---|---|---|---|---|
| Component | 912 SF | 1527SF | 1922 SF | 4060SF | 5564SF |
| **Walls** | **R-19 +R-5** | **R-19 +R-5** | **R-19+R-5** | **R-13+R-4** | **R-13** |
| **Ceilings** | **R-38** | **R-38** | **R-38** | **R-38** | **R-30** |
| **Windows & Glass Doors** | **R-3.1 SHGC 0.34** | **R-3.1 SHGC 0.34** | **R-3.1 SHGC 0.34** | **R-2.6 SHGC 0.34** | **R-2.4 SHGC 0.55** |
| **Heating efficiency (AFUE)** | **93%** | **96%** | **93%** | **80%** | **80%** |
| **Air conditioning SEER** | **10** | **12** | **10** | **10** | **10** |
| **HERS Score** | **85.7** | **85.7** | **85.9** | **85.9** | **86.0** |

Doors: R- 2.2, Basement walls: R- 11 Air tightness: 0.2 ACH Nat

DHW: 40 gal, 0.56 EF Duct location: Inside envelope

# Comparison Of Heating, Cooling and DHW



# Normalizing Loads

- $TML_N$ = TnML / SOF
- $TML_{H\&CN}$ = ($nMEUL_{HEAT}$ + $nMEUL_{COOL}$)/ SOF
- $TML_{OccN}$ = TnML / Occ
- $TML_{OCcH\&C}$ = ($nMEUL_{HEAT}$ + $nMEUL_{COOL}$)/Occ

**Where SOF = Shell area / occupancy**

# TML (in Occupant• MMBtu/1000 sf Total Shell Area)

| House Size (sf) | $TML_N$ | $TML_{H\&CN}$ | Percent reduction in $TML_{H\&CN}$ compared to $TML_N$ |
|---|---|---|---|
| 912 | 32.6 | 19.7 | 39.5% |
| 1537 | 36.0 | 21.1 | 41.6% |
| 1922 | 41.7 | 27.9 | 32.9% |
| 4060 | 45.7 | 32.7 | 28.4% |
| 5564 | 64.2 | 51.7 | 19.5% |

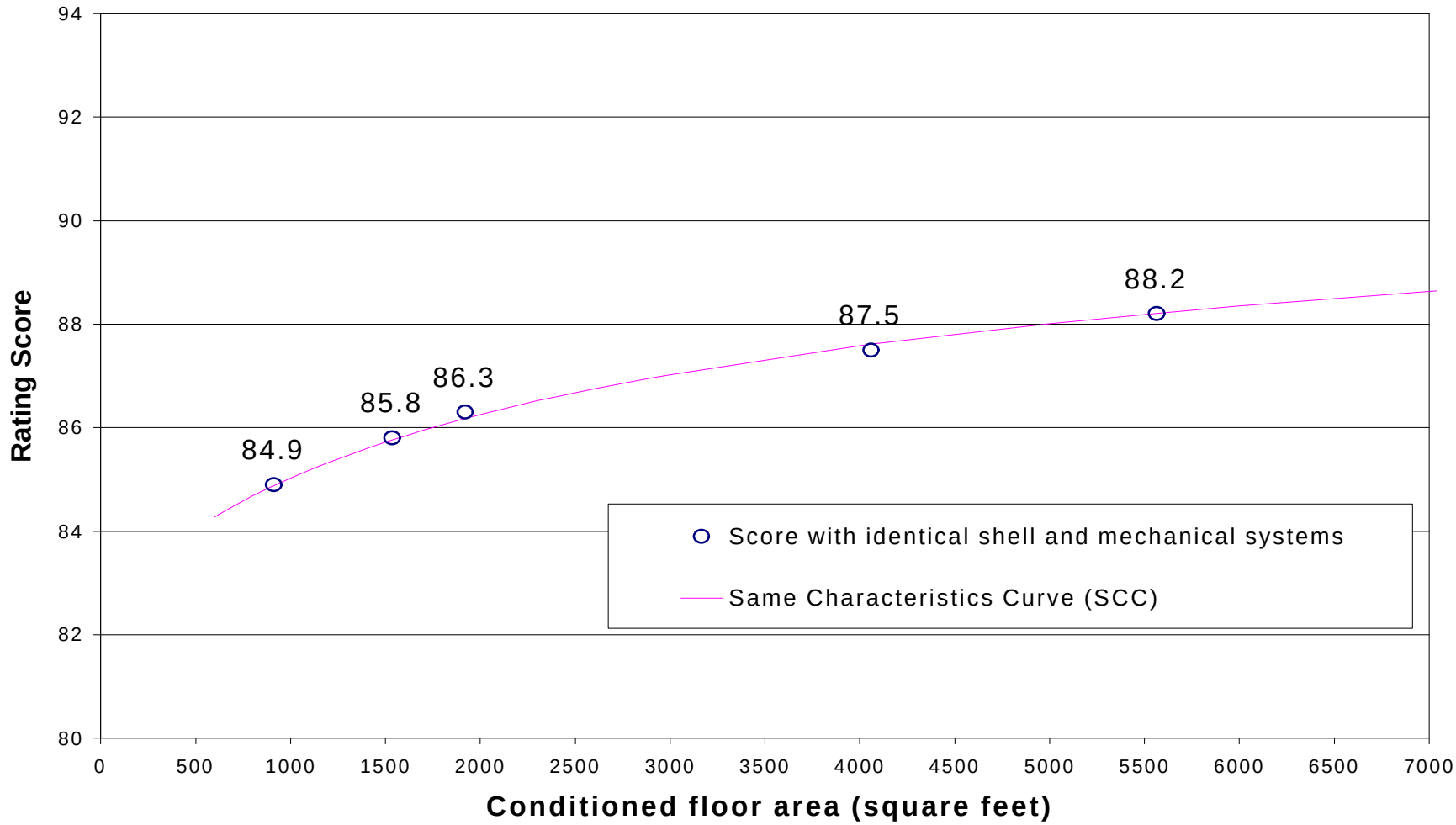
# Projected Total Loads and Scores Normalized using Total Shell area (1922 sf house base)

| House Size (sf) | $PTL_{house}$ | $PTL_{house}$ Rating Score | $PTL_{houseH\&C}$ | $PTL_{houseH\&C}$ Rating Score |
|---|---|---|---|---|
| 912 | 47.25 | 82.5 | 47.85 | 82.3 |
| 1537 | 53.76 | 83.3 | 55.56 | 82.8 |
| 1922 | 61.32 | 86.2 | 61.32 | 86.2 |
| 4060 | 80.87 | 86.7 | 74.36 | 87.7 |
| 5564 | 83.67 | 91.1 | 80.32 | 91.4 |

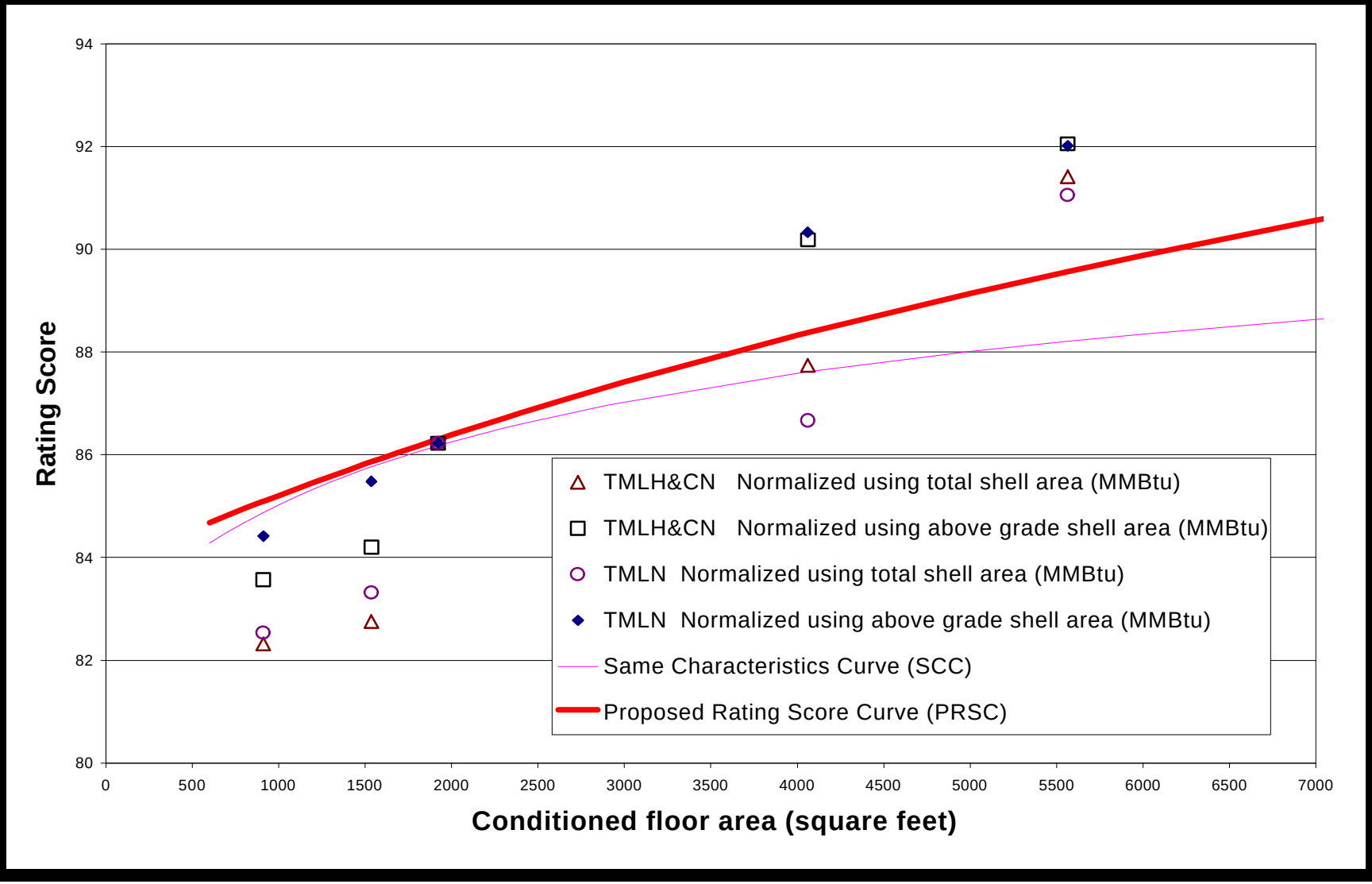
# Rate houses with the same energy characteristics

| House Size 1922 sf | | | | |
|---|---|---|---|---|
| **Component** | | | **Component** | |
| Walls | R-13 +R-4 | | Duct location | Inside envelope |
| Ceilings | R-38 | | Heating efficiency (AFUE | 93% |
| Windows & Glass Doors | R-3.1, SHGC 0.34 | | Domestic water heating efficiency | 30 gal, 0.58 EF |
| Doors | 2.2 | | Air tightness | 0.2 ACH Nat |
| Basement walls above grade | R-11 | | Air Conditioning SEER | 12 |
| Basement walls below grade | R-14 | | Floors over unconditioned space | N/A |
| | | | | |
| HERS Score | 86.3 | | | |

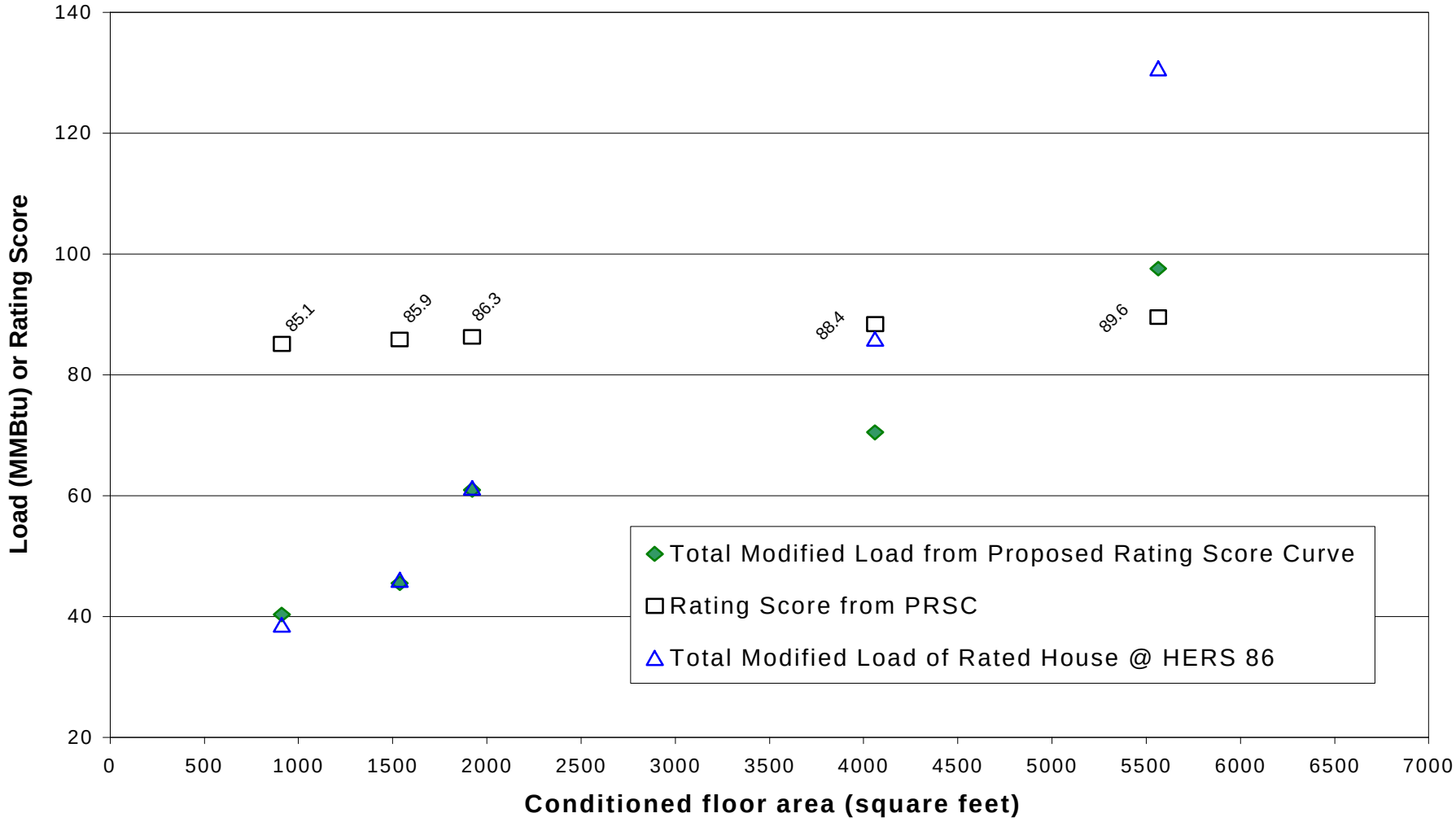
# Rating Score for houses with the same energy characteristics



# Ratings using TML shell and Proposed Rating Score Curve (PRSC)



# Comparison of total modified loads



# Comparison of energy features for homes meeting the PRSC

| | House Size | | | | |
|---|---|---|---|---|---|
| Component | 912 sf | 1537 sf | 1922 sf | 4060 sf | 5564 sf |
| Walls | R-13 +R-5 | R-13 +R-3 | R-13 +R-4 | R-19 +R-5 | R-20 +R-5 |
| Ceilings | R-38 | R-38 | R-38 | R-38 | R-38 |
| Windows & Glass Doors | R-3.1 SHGC 0.34 | R-3.1 SHGC 0.34 | R-3.1, SHGC 0.34 | R-3.1 SHGC 0.34 | R-3.1 SHGC 0.34 |
| Doors | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Basement walls above grade | R-11 | R-11 | R-11 | R-11 | R-11 |
| Basement walls below grade | R-11 | R-11 | R-14 | R-11 | R-11 |
| Duct location | Inside envelope | Inside envelope | Inside envelope | Inside envelope | Inside envelope |
| Heating efficiency (AFUE | 80% | 96% | 93% | 96% | 96% |
| Domestic water heating efficiency | 30 gal, 0.58 EF | 40 gal, 0.56 EF | 30 gal, 0.58 EF | 40 gal, 0.58 EF | 40 gal, 0.84 EF |
| Air tightness | 0.2 ACH Nat | 0.2 ACH Nat | 0.2 ACH Nat | 0.2 ACH Nat | 0.2 ACH Nat |
| Air Conditioning SEER | 10 | 12 | 12 | 12 | 12 |
| Floors over unconditioned space | N/A | N/A | N/A | 19 | N/A |
| | | | | | |
| HERS Score | 85.1 | 85.9 | 86.3 | 88.4 | 89.6 |

# Loads and scores associated with the PRSC

| House Size (sf) | TML of HERS 86 House (MMBtu) | TML from PRSC (MMBtu) | Relative Difference (%) | Absolute Difference (MMBtu) | Original Rating Score | Rating Score from PRSC |
|---|---|---|---|---|---|---|
| 912 | 38.64 | 40.33 | -4% | -1.69 | 85.7 | 85.1 |
| 1537 | 46.08 | 45.55 | 1% | 0.53 | 85.7 | 85.9 |
| 1922 | 61.32 | 60.98 | 1% | 0.34 | 86.2 | 86.3 |
| 4060 | 85.92 | 70.49 | 22% | 15.43 | 85.8 | 88.4 |
| 5564 | 130.68 | 97.54 | 34% | 33.14 | 86 | 89.6 |

# Factors Impacting the Method

**Technical**

- **Climate zone and proportion of heating, cooling and DHW loads**
- **Characteristics of the HERS 86 home for the SCC**
- **Other performance issues**

**Policy**

- **What house size is used to set the HERS 86 level**
- **Production vs. custom**
- **Individual house score vs. fleet average**

# Policy vs. Technical

- **What house size is used to set the HERS 86 level**
- **Production vs. custom**
- **Individual house score vs. fleet average**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