Perfect Opportunity

RESNET Building performance Conference

February 19-21, 2007

Goals

- Outline the need for energy conservation
- Discuss parameters affecting energy conservation
- Proposal and discussion new more equitable metric
- Comments/input

Energy Today and Into the Future

- Perception short on Energy
- Worse yet, supplies decreasing
- Cost on increasing
- 40% consumed by buildings
- Favorable predisposition to conservation

Drivers

- $$$
- Desire/Demand to conserve energy $$
  - Don’t care how just conserve
- Technical Know-how
  - We have the technology
- We have the materials

What is holding us back

- $$$
- Antiquated 50 yr old metric that addresses single dimension of heat transfer
- O’K initially
- Inadequate today

Additional Barriers

- Lack of plan
  - Insulation air moisture issues
    - Use of code to fix all that ails us
- Direction
  - Rudderless ship
    - Competitors looking after self interest

The Game Is Changing

- Building science
  - Materials changed
  - Performance changed
- The market
  - The way we live
  - The way we build

There is a Reason

- Disclaimer
- There is something lacking
  - References to:
    - Real R value
    - Performing R value
    - Real performance

Air Tightness

- Numerous references of air tightness and energy efficiency relationship
  - IECC hearings
  - Various manufacturers
  - Building scientists
  - DOE
  - Anecdotal evidence
- Lacking hard data to support claims

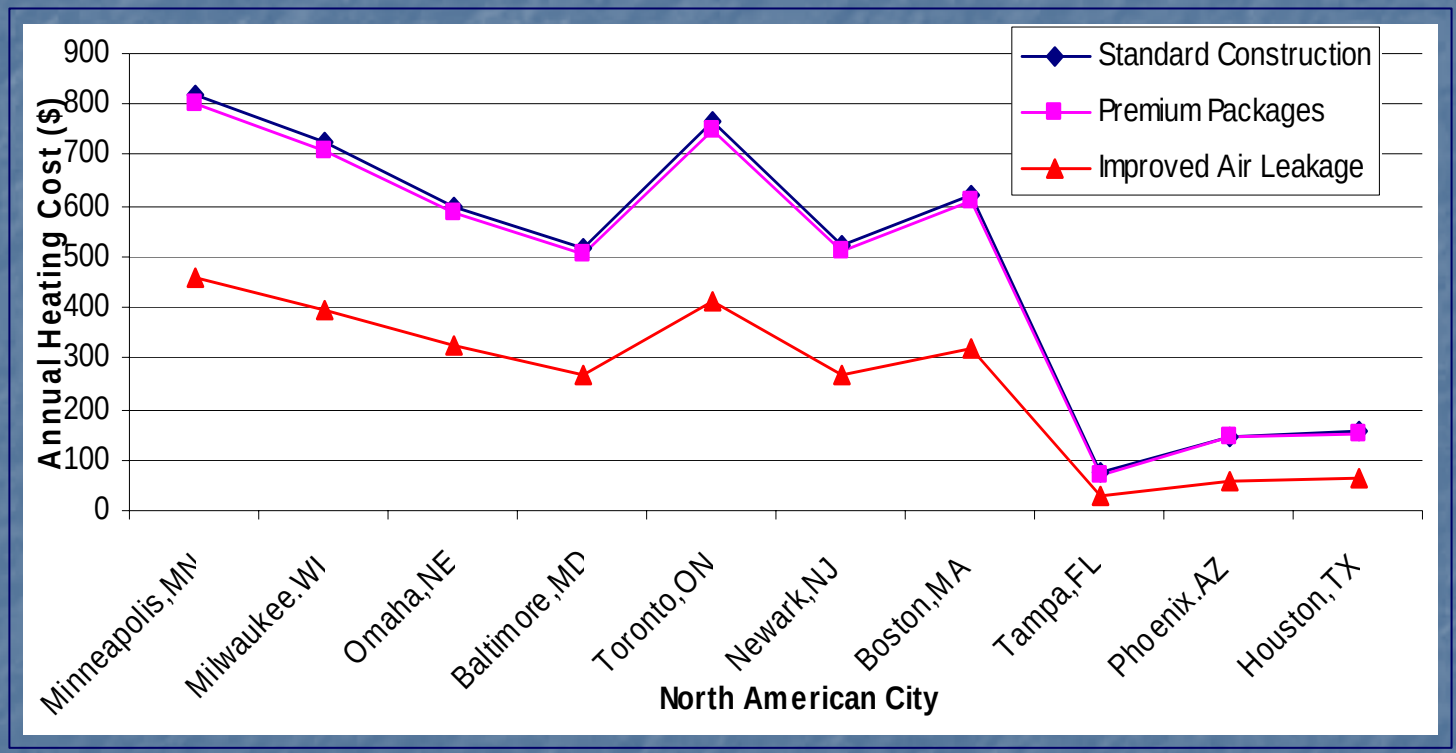
Air Tightness cont'd

- Effective energy conservation vehicle but no credit, even Rescheck not recognizing it while others do.
- Builders practice it but not credited
- Manufacturers have the know-how but lack incentive
- Designers/Consumers desire it but don't know how to get there
- Code is slowly reacting without an over all plan or direction and unenforcable

Modeling Data

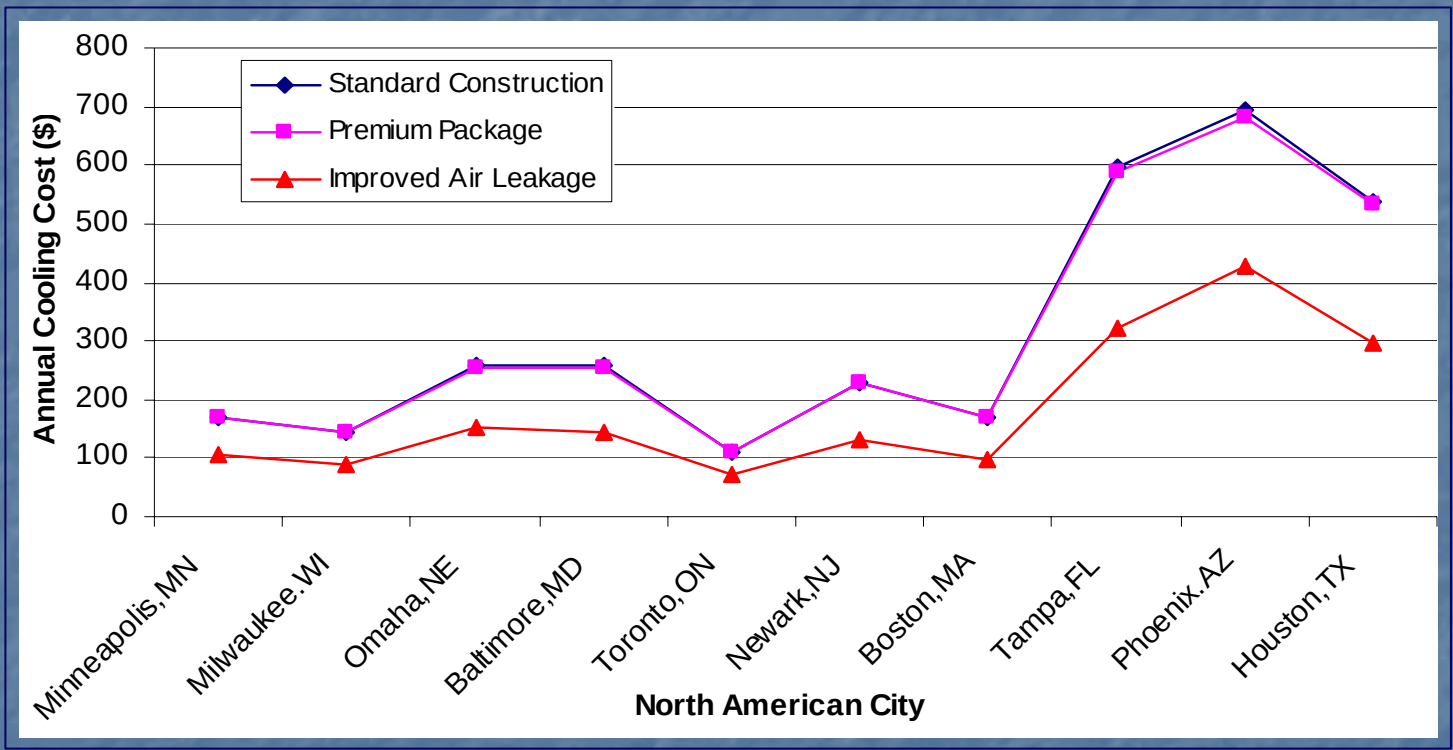
- Modeled on RemDesign
- 3 homes built
  - Dark blue – to IRC
  - Hot pink - to Model Energy code
  - Red - to IRC but airthight

Air Leakage Control: Superior Results - Heating



- In all cities, it was found to be more effective to control air leakage than to increase R-Value.

Air Leakage Control: Superior Results - Cooling



- The results of this study have been verified using results from the field.

Home Specs.

- Two story home
- No garage
- Conditioned floor area: 2,500 sq.ft (equally distributed over 1st & 2nd floor)
- Foundation: unheated slab foundation
- Infiltration rate: 0.1ACH @ natural pressure
- Baseline home design:
  - R-13 wall
  - R-30 ceiling (vented attic)

Home Specs.

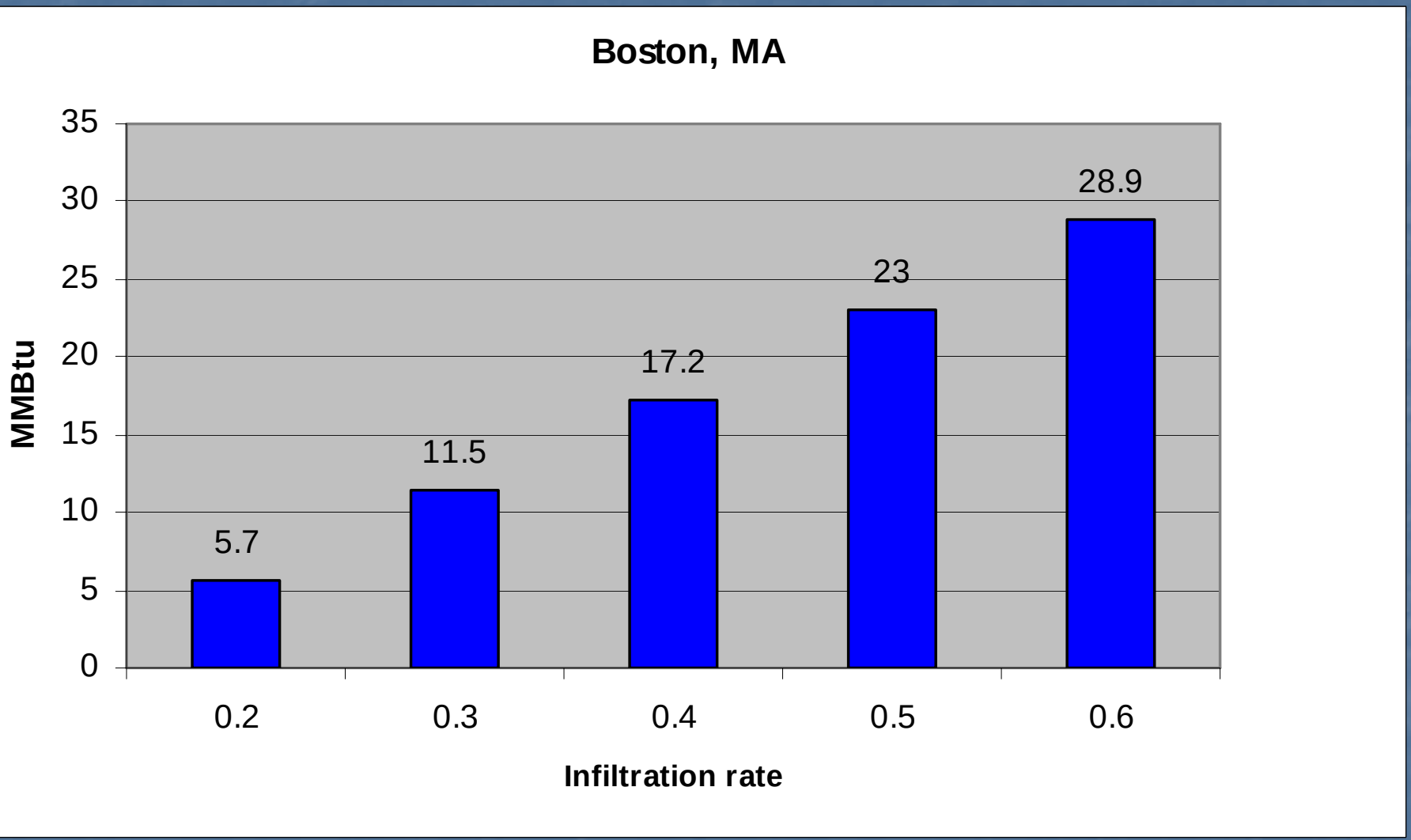
- Orientation: Front facing South
- Window area (U-value: 0.57, SHGC:0.25):
  - Front: 100 sq.ft.
  - Rear: 100 sq.ft.
  - Right: 50 sq.ft.
  - Left: 50 sq.ft.
- Equipment efficiency:
  - Furnace @ 92 AFUE
  - A/C @ 13 SEER

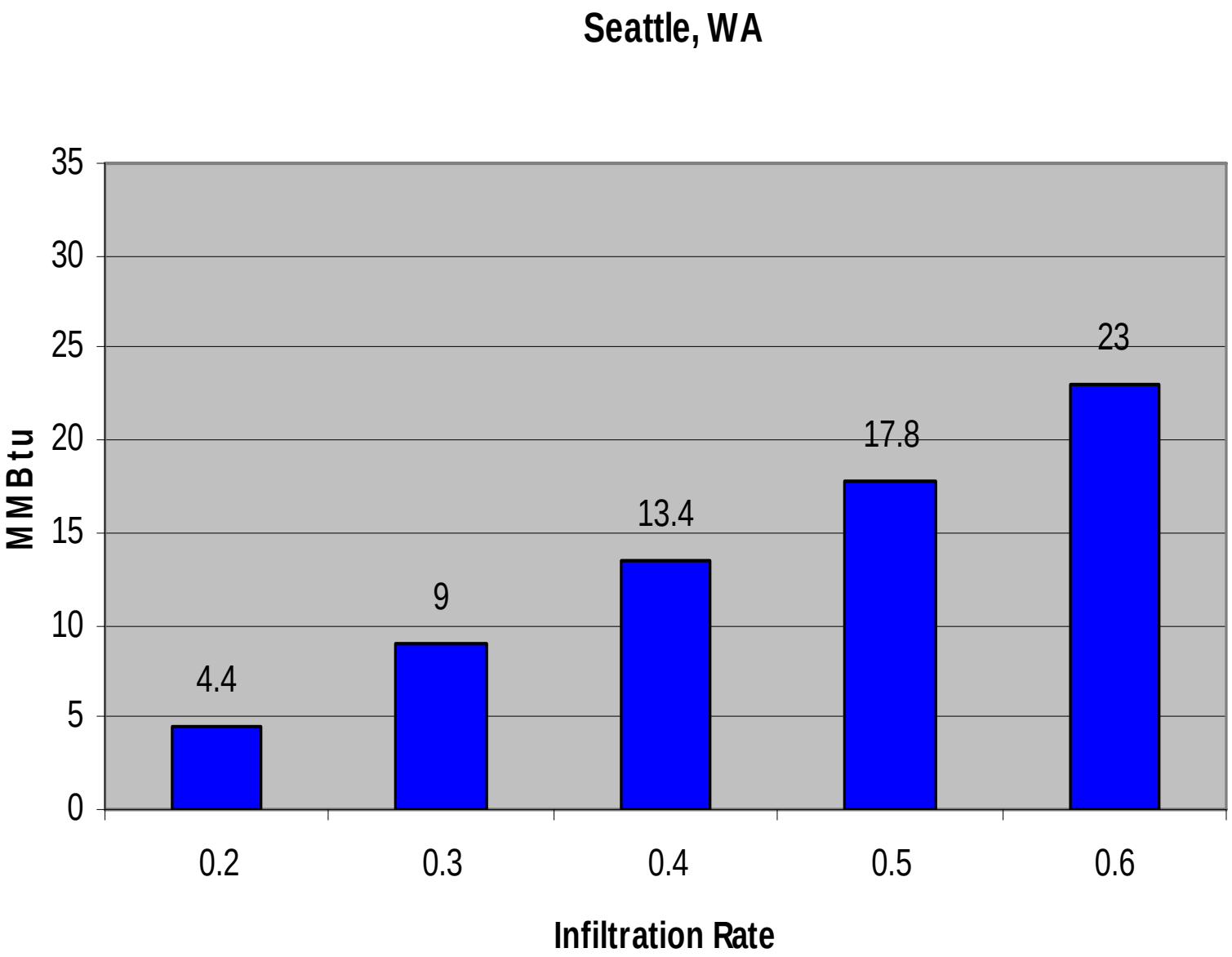
1st Set of Data;

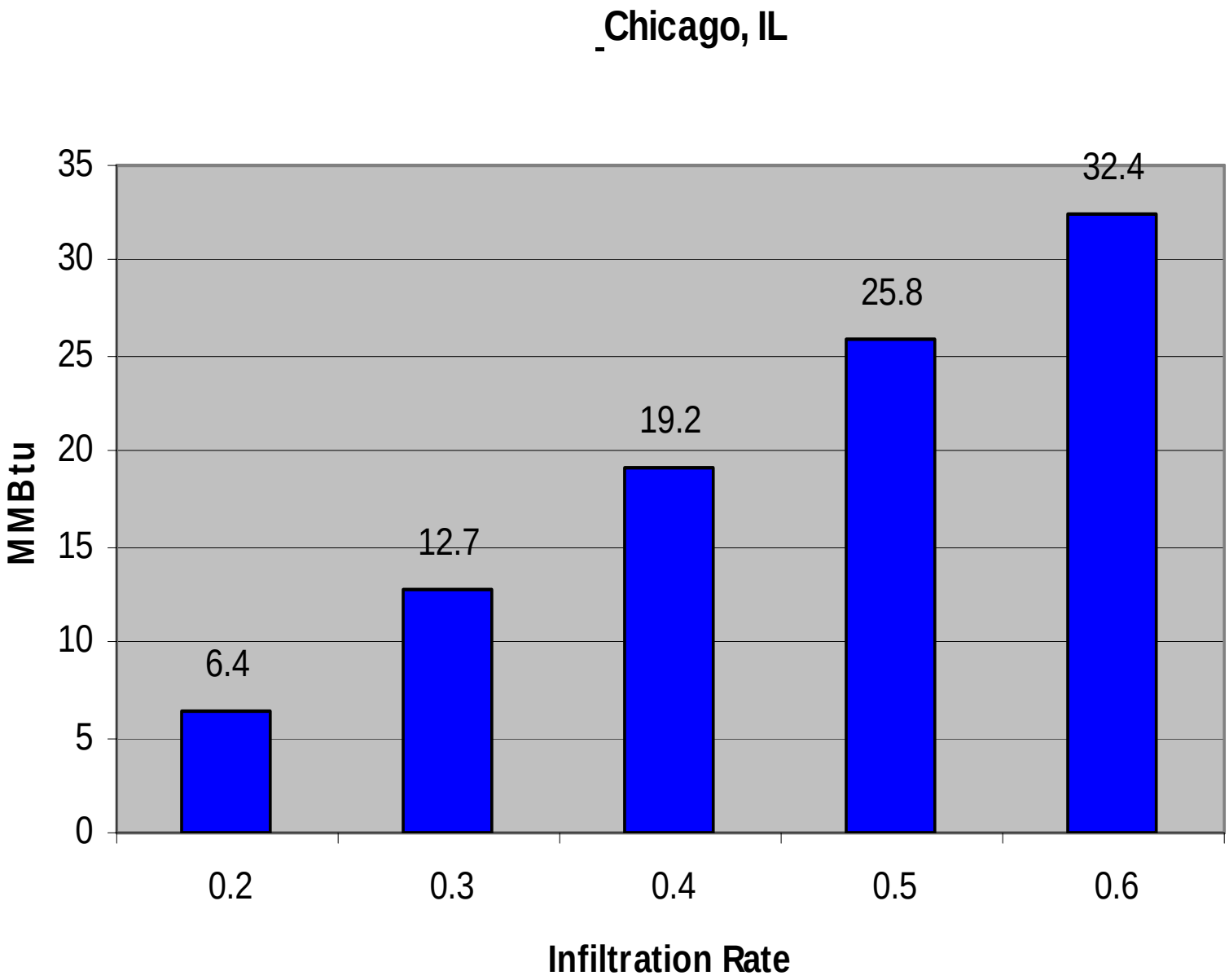
Energy savings @ 0.1ACH nat.vs. Variety of higher infiltration rates Across the country

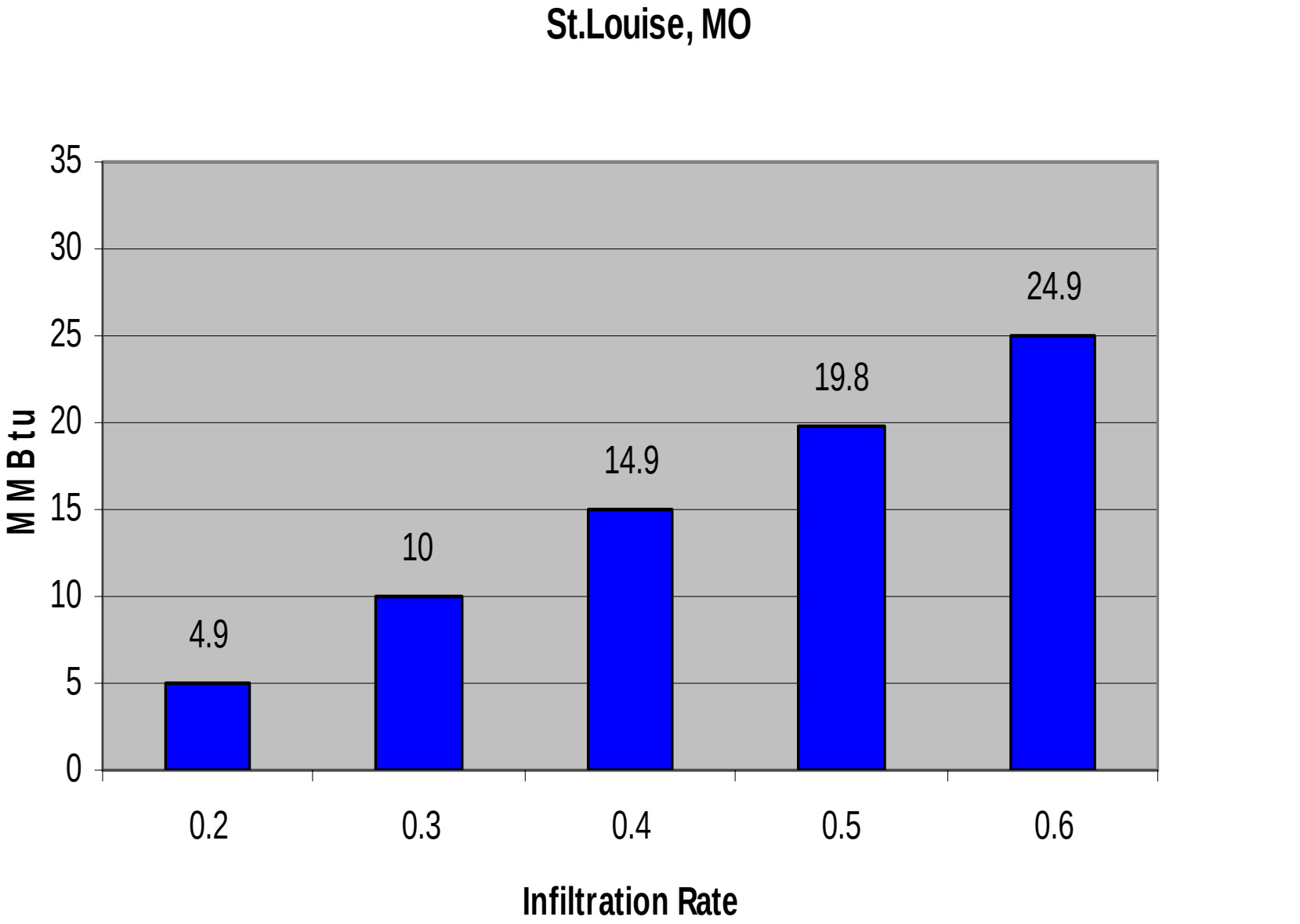
~ MMBtu = Million Btu

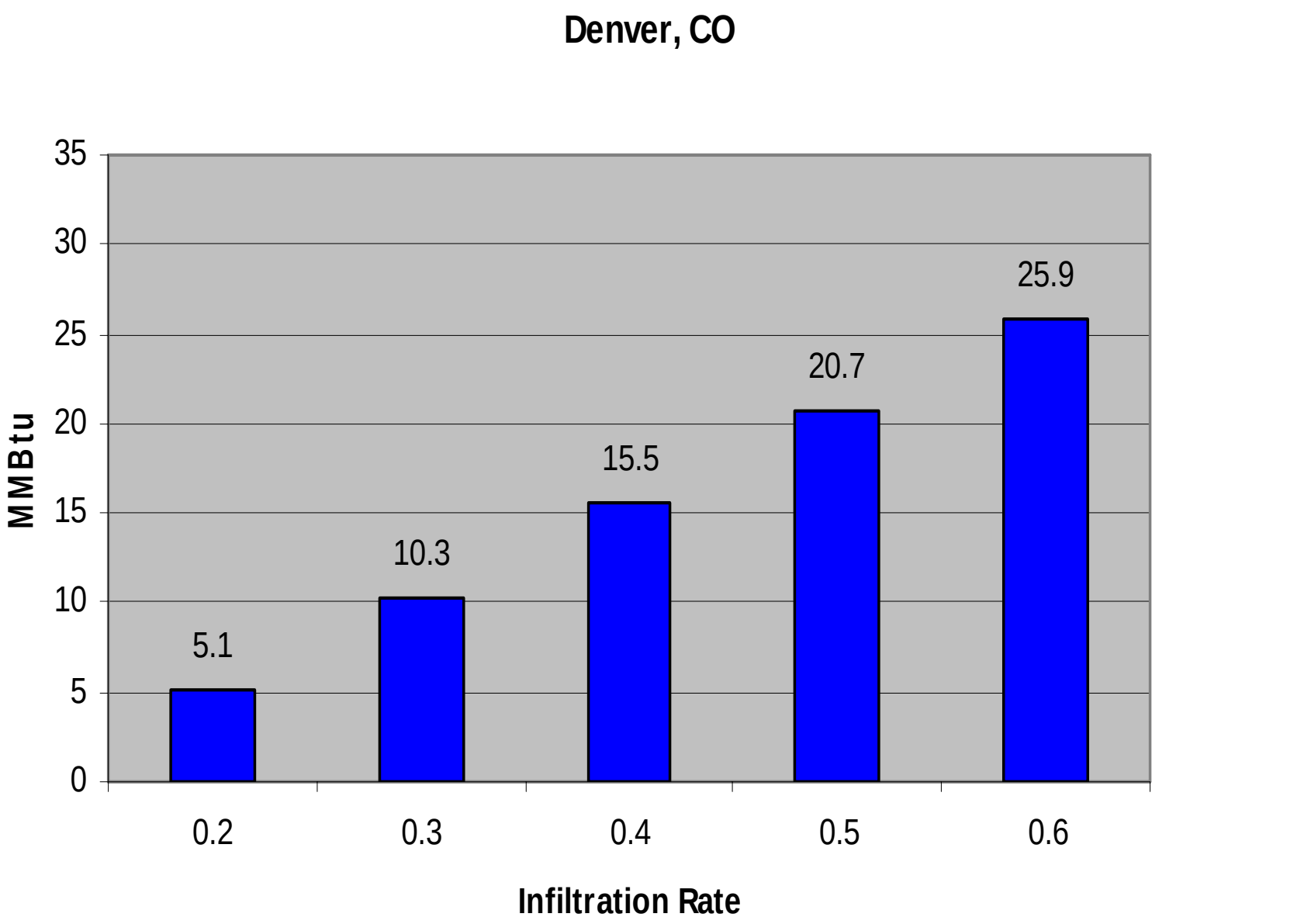
~Air infiltration rate unit is set at natural pressure

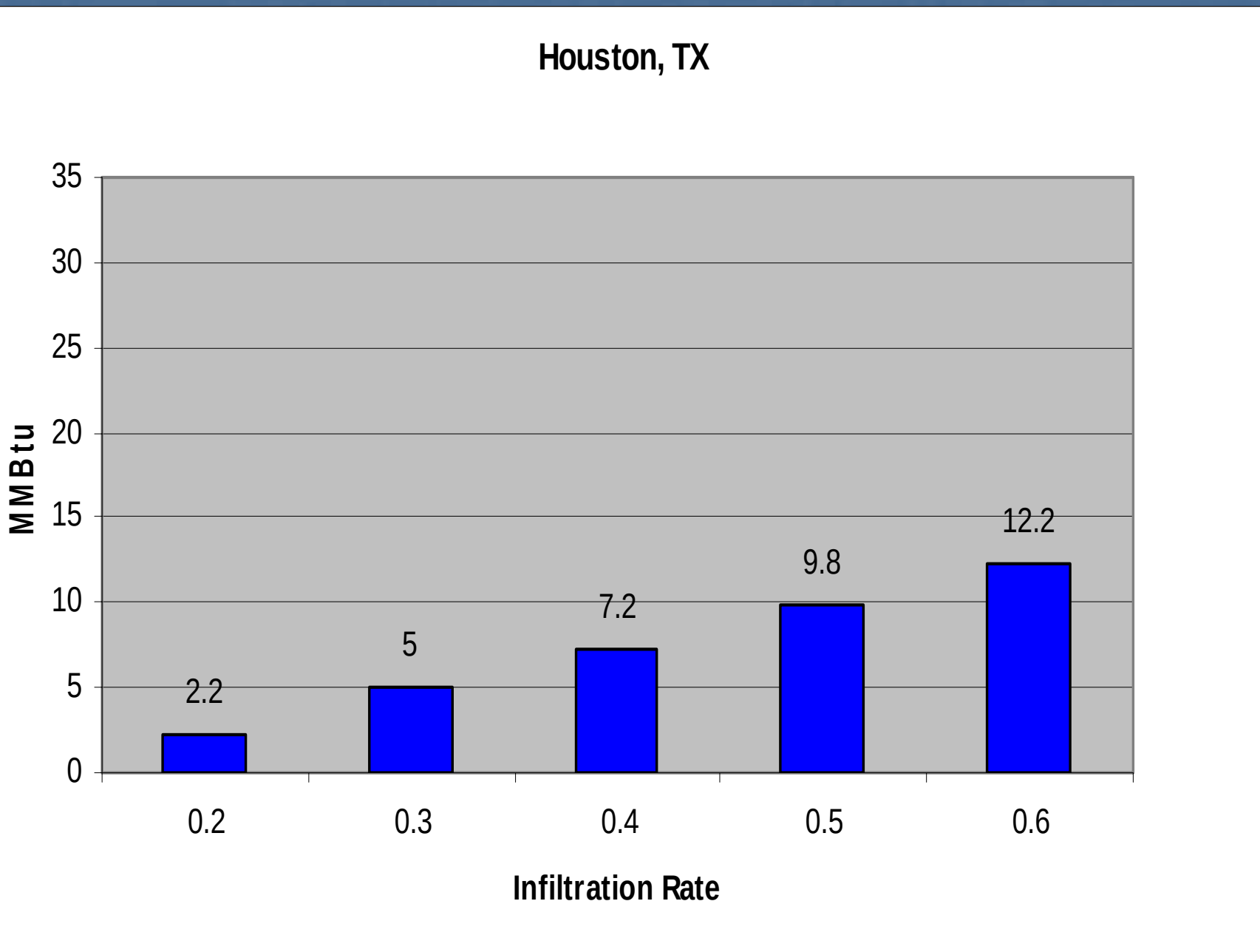

Boston, MA
MMBtu
35
30
25
20
15
10
5
0
5.7
11.5
17.2
23
28.9
0.2
0.3
0.4
0.5
0.6
Infiltration rate

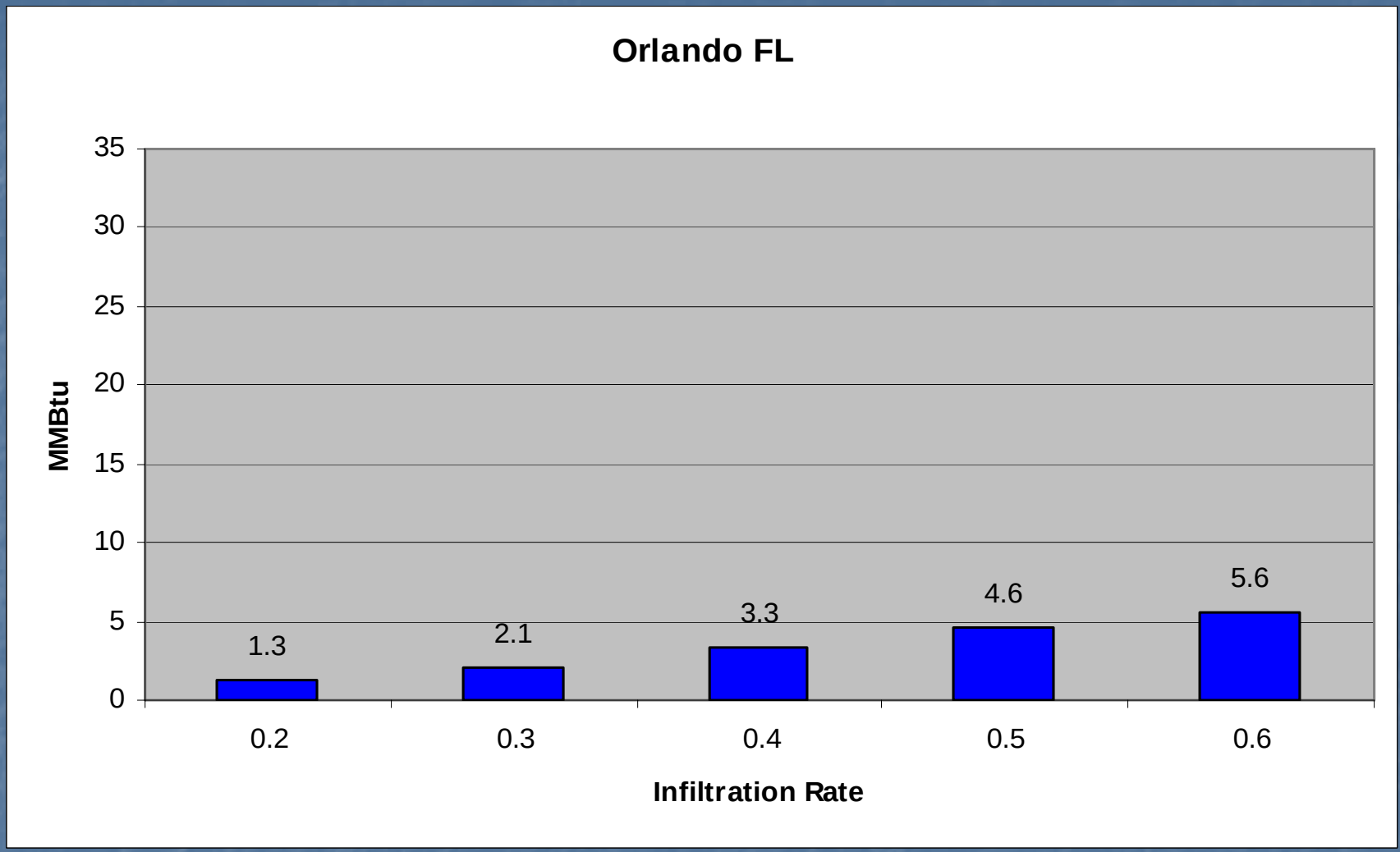

Seattle, WA
MMBtu
35
30
25
20
15
10
5
0
4.4
9
13.4
17.8
23
0.2
0.3
0.4
0.5
0.6
Infiltration Rate

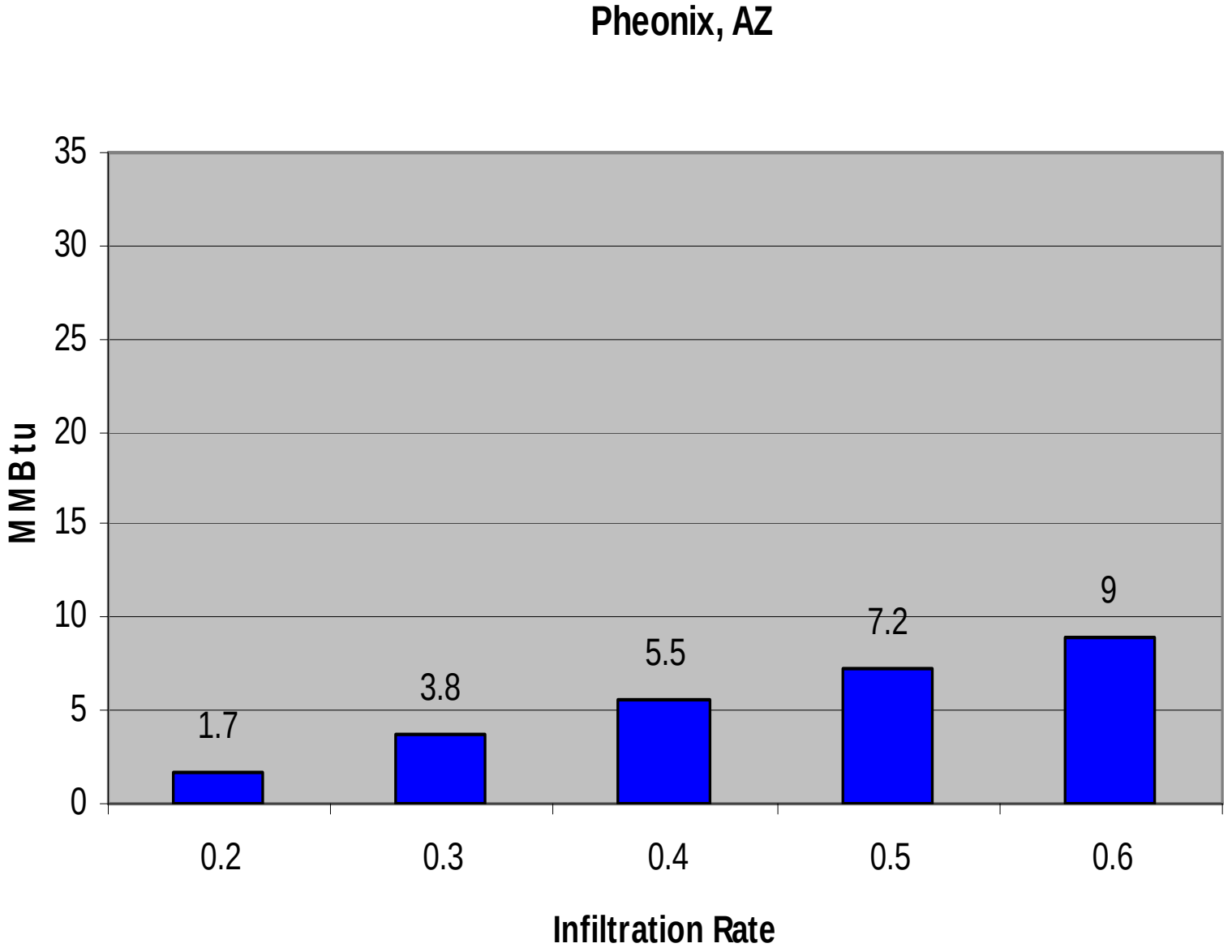

Chicago, IL
35
30
25
20
15
10
5
0
MMBtu
6.4
12.7
19.2
25.8
32.4
0.2
0.3
0.4
0.5
0.6
Infiltration Rate


St.Louise, MO
MMBtu
35
30
25
20
15
10
5
0
4.9
10
14.9
19.8
24.9
0.2
0.3
0.4
0.5
0.6
Infiltration Rate


Denver, CO
MMBtu
35
30
25
20
15
10
5
0
5.1
10.3
15.5
20.7
25.9
0.2
0.3
0.4
0.5
0.6
Infiltration Rate


Houston, TX
MMBtu
35
30
25
20
15
10
5
0
2.2
5
7.2
9.8
12.2
0.2
0.3
0.4
0.5
0.6
Infiltration Rate

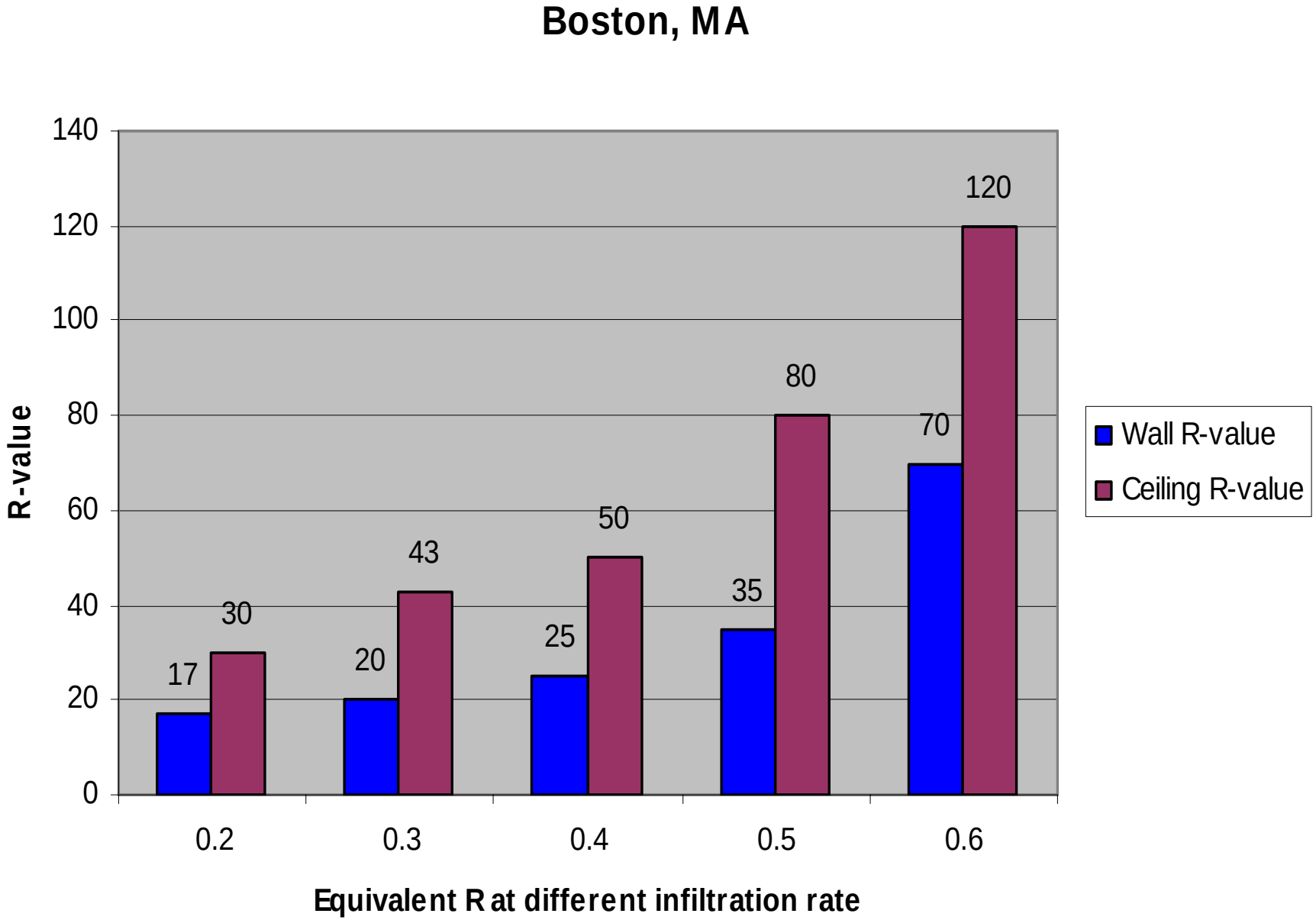

Orlando FL
35
30
25
20
15
10
5
0
MMBtu
1.3
2.1
3.3
4.6
5.6
0.2
0.3
0.4
0.5
0.6
Infiltration Rate

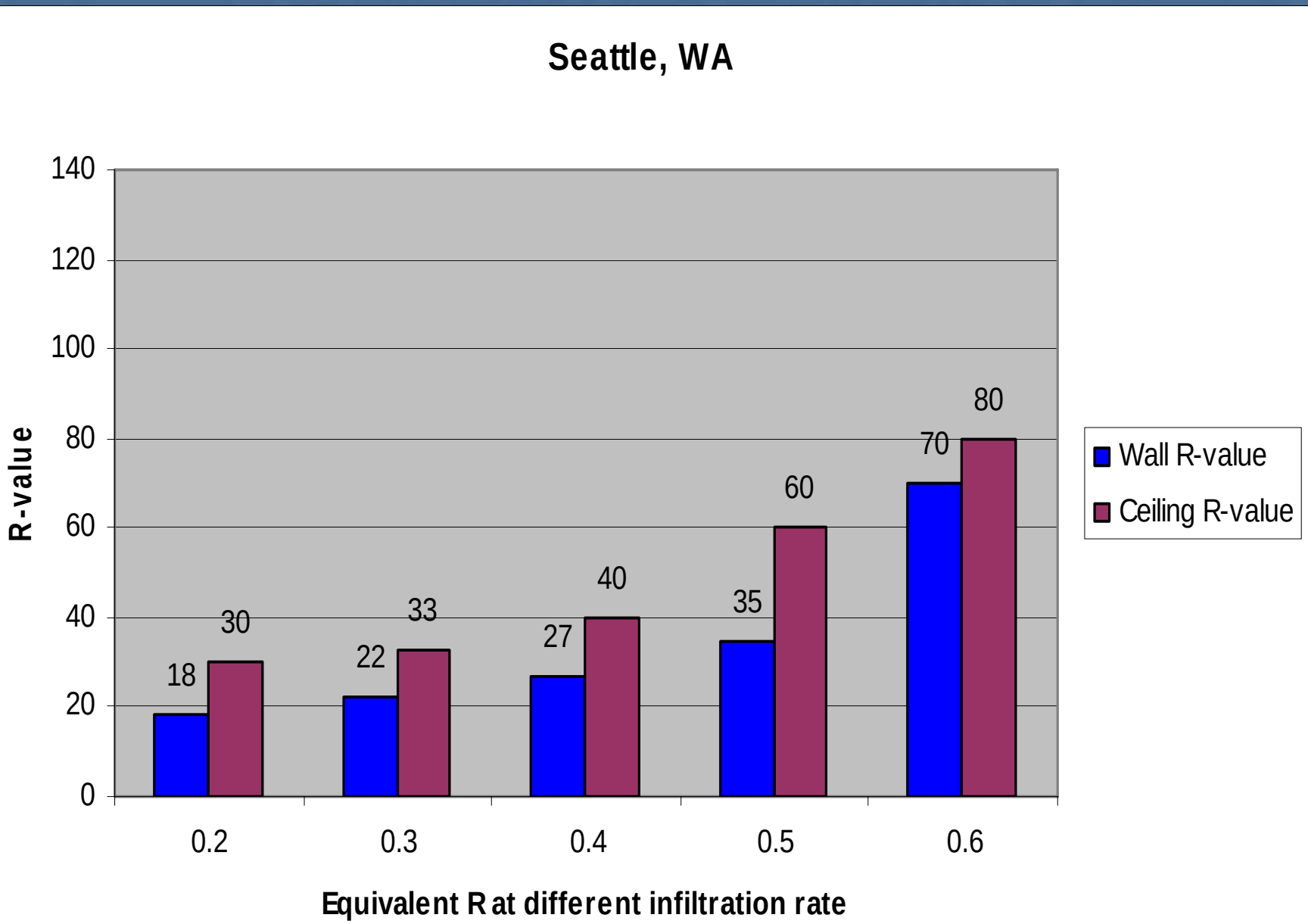

Pheonix, AZ
MMBtu
35
30
25
20
15
10
5
0
1.7
3.8
5.5
7.2
9
0.2
0.3
0.4
0.5
0.6
Infiltration Rate

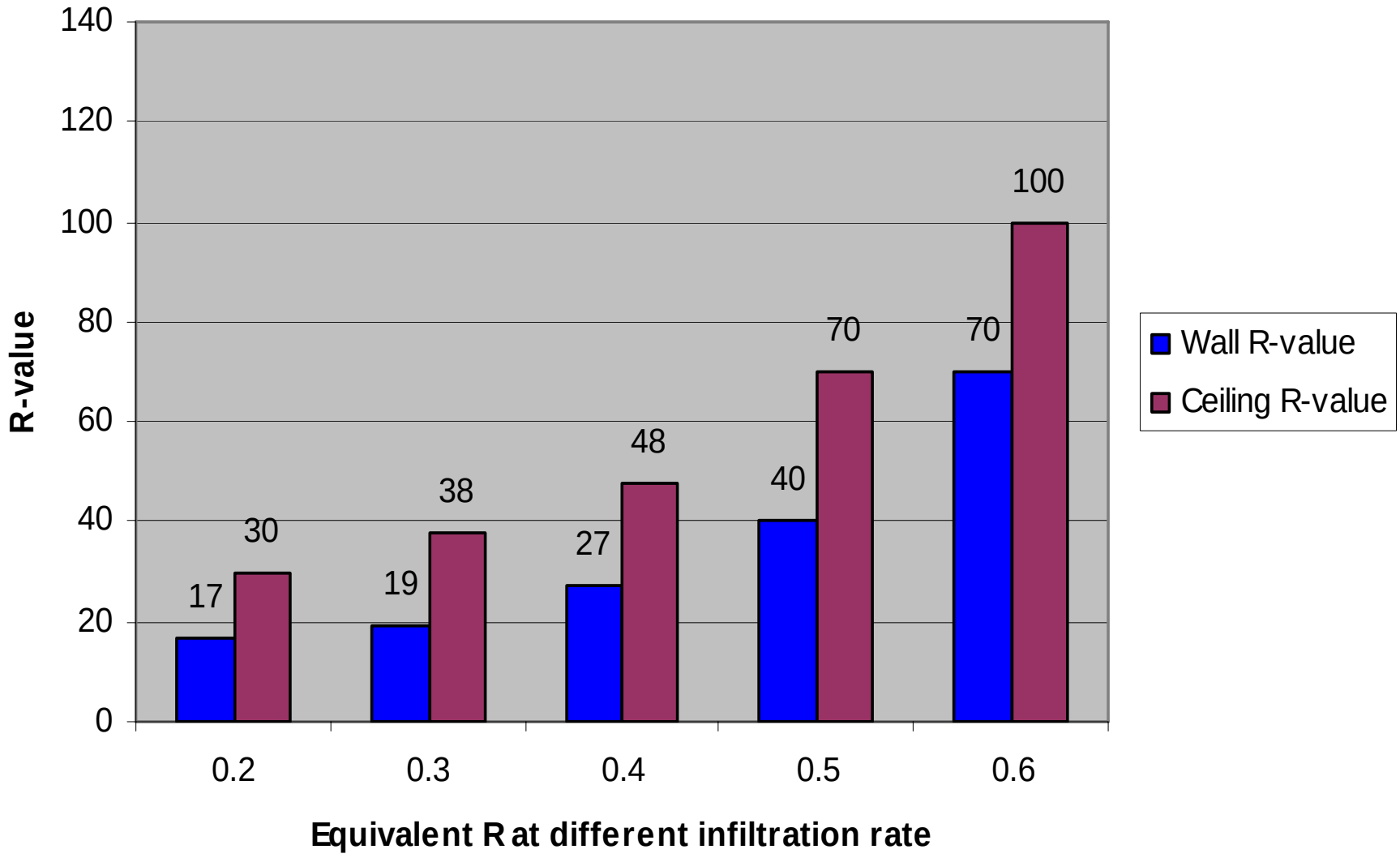
2nd Set of Data;

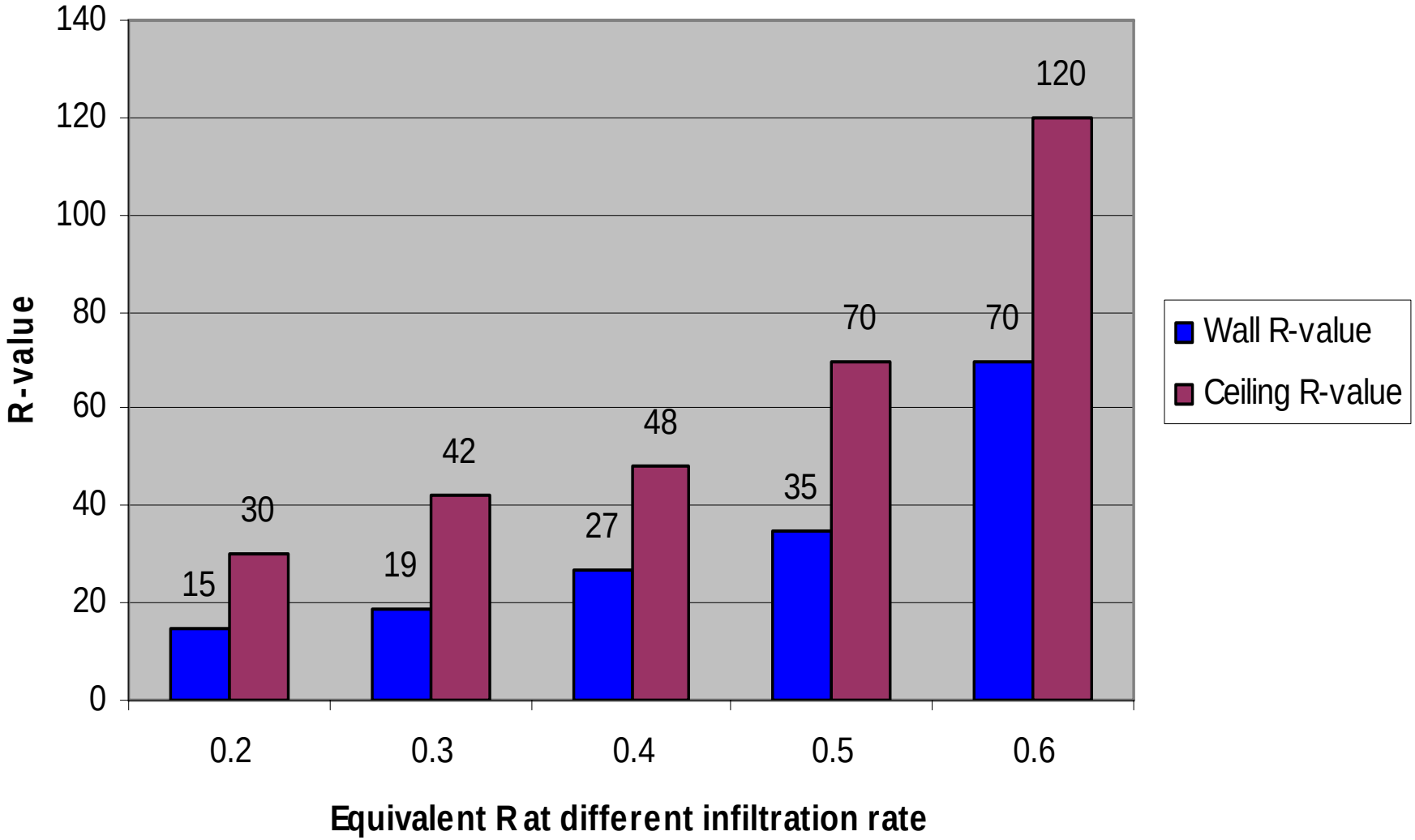
R values required to equal energy performance of tighter homes in previous examples

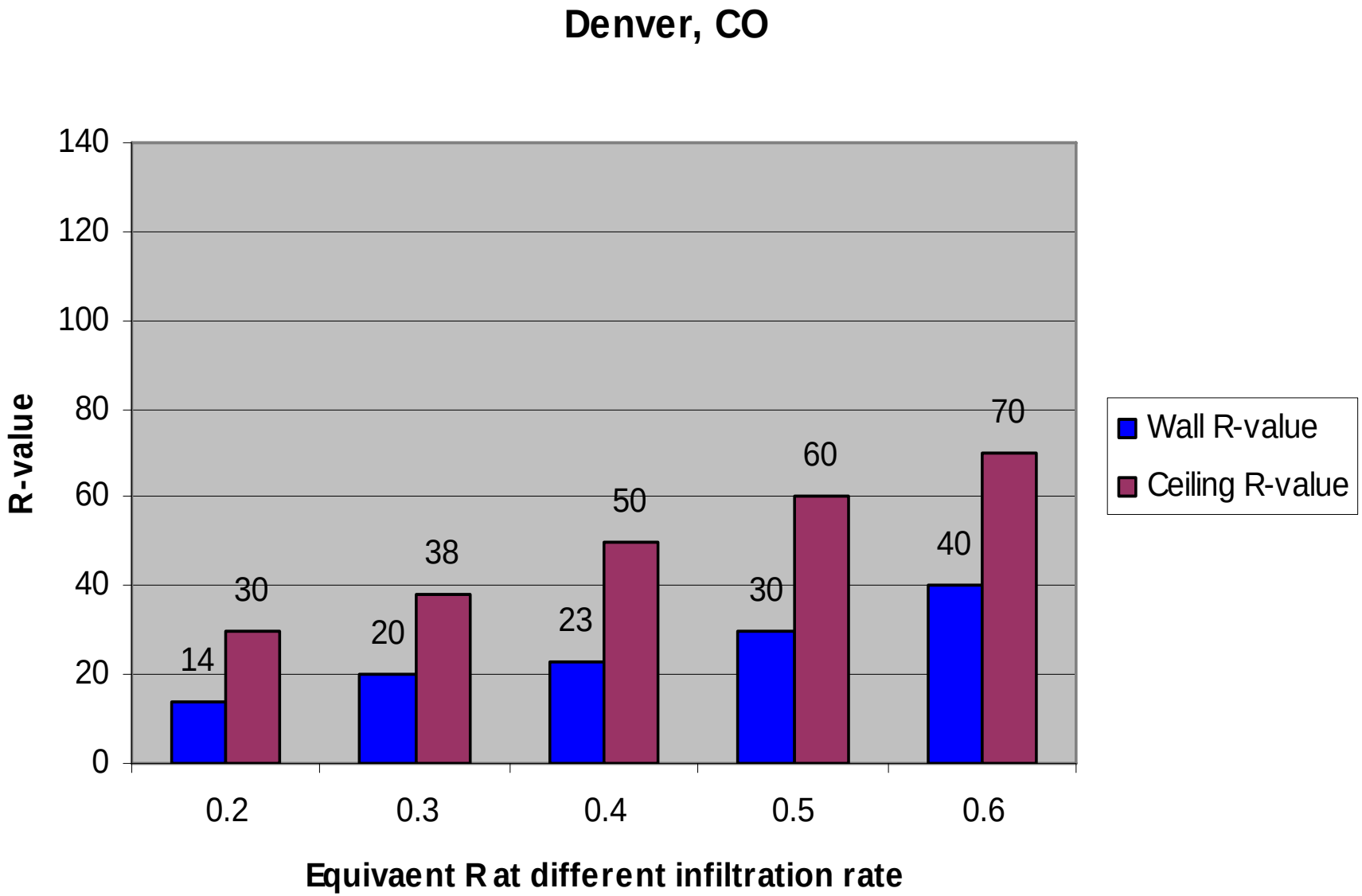
infiltration rate vs. the baseline design (0.1ACH nat. & R-13 wall & R-30 ceiling).

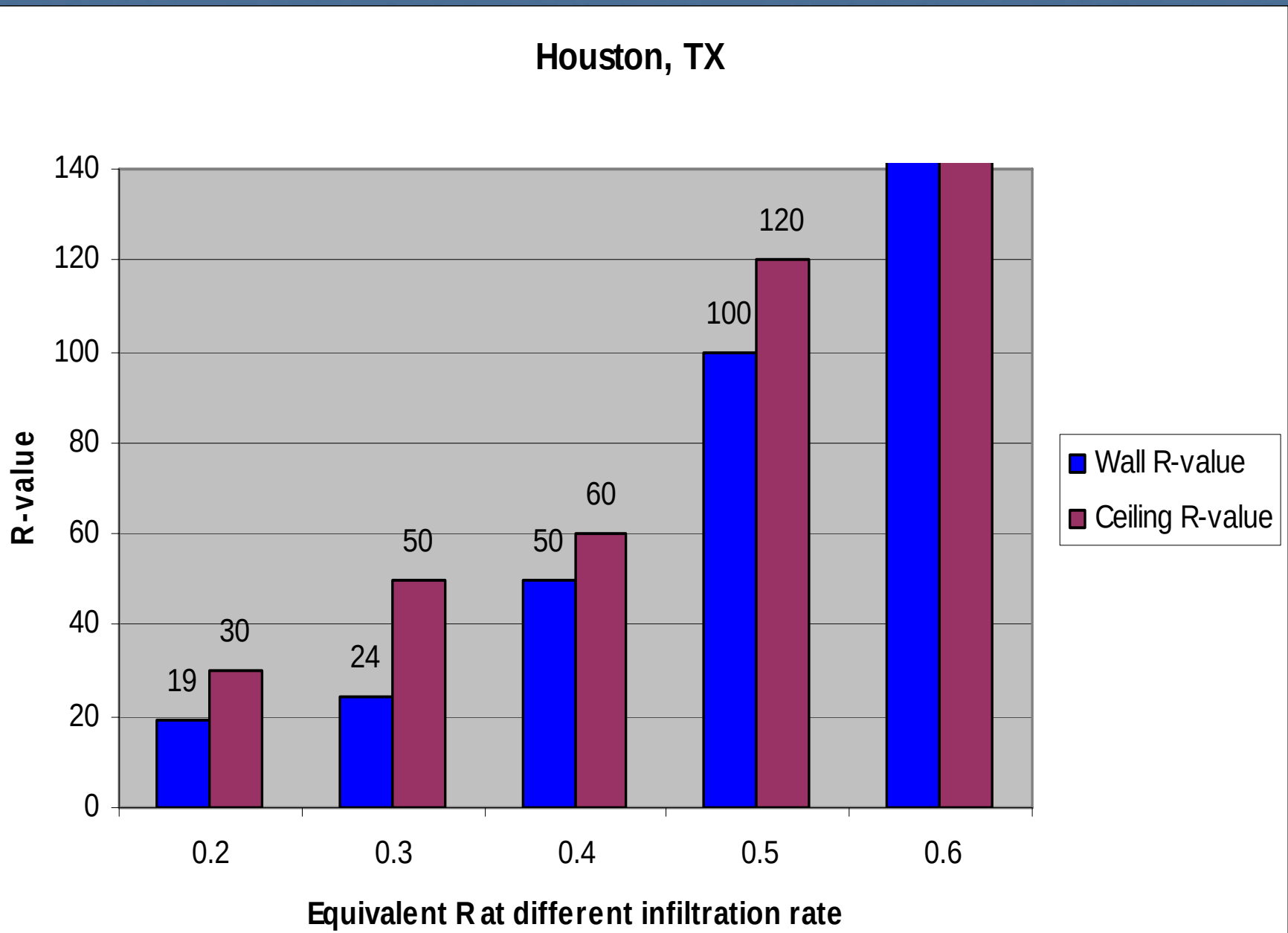

Boston, MA
R-value
140
120
100
80
60
40
20
0
17
30
20
43
25
50
35
80
70
120
0.2
0.3
0.4
0.5
0.6
Equivalent R at different infiltration rate
Wall R-value
Ceiling R-value

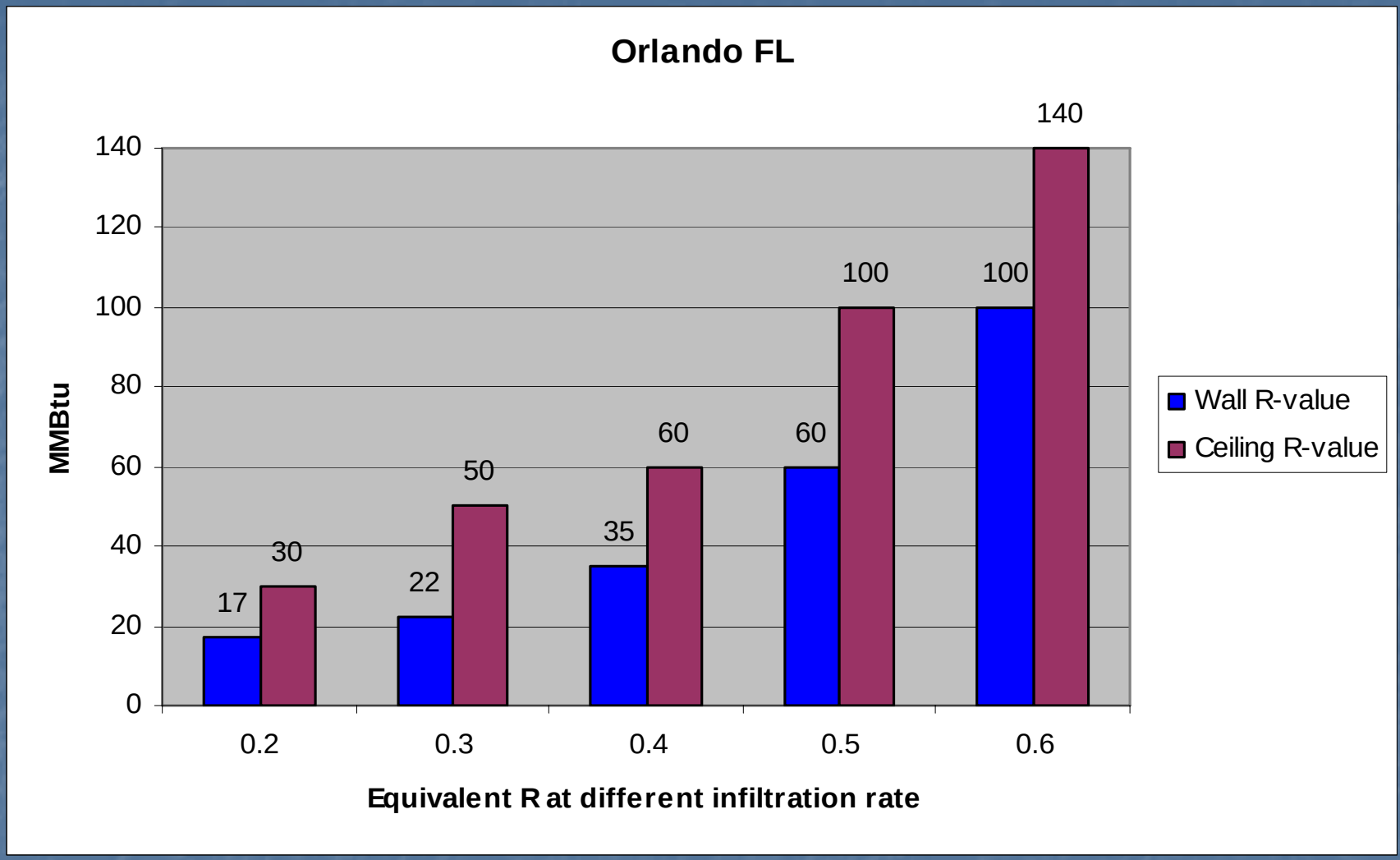

Seattle, WA
R-value
140
120
100
80
60
40
20
0
18
30
22
33
27
40
35
60
70
80
0.2
0.3
0.4
0.5
0.6
Equivalent R at different infiltration rate
Wall R-value
Ceiling R-value

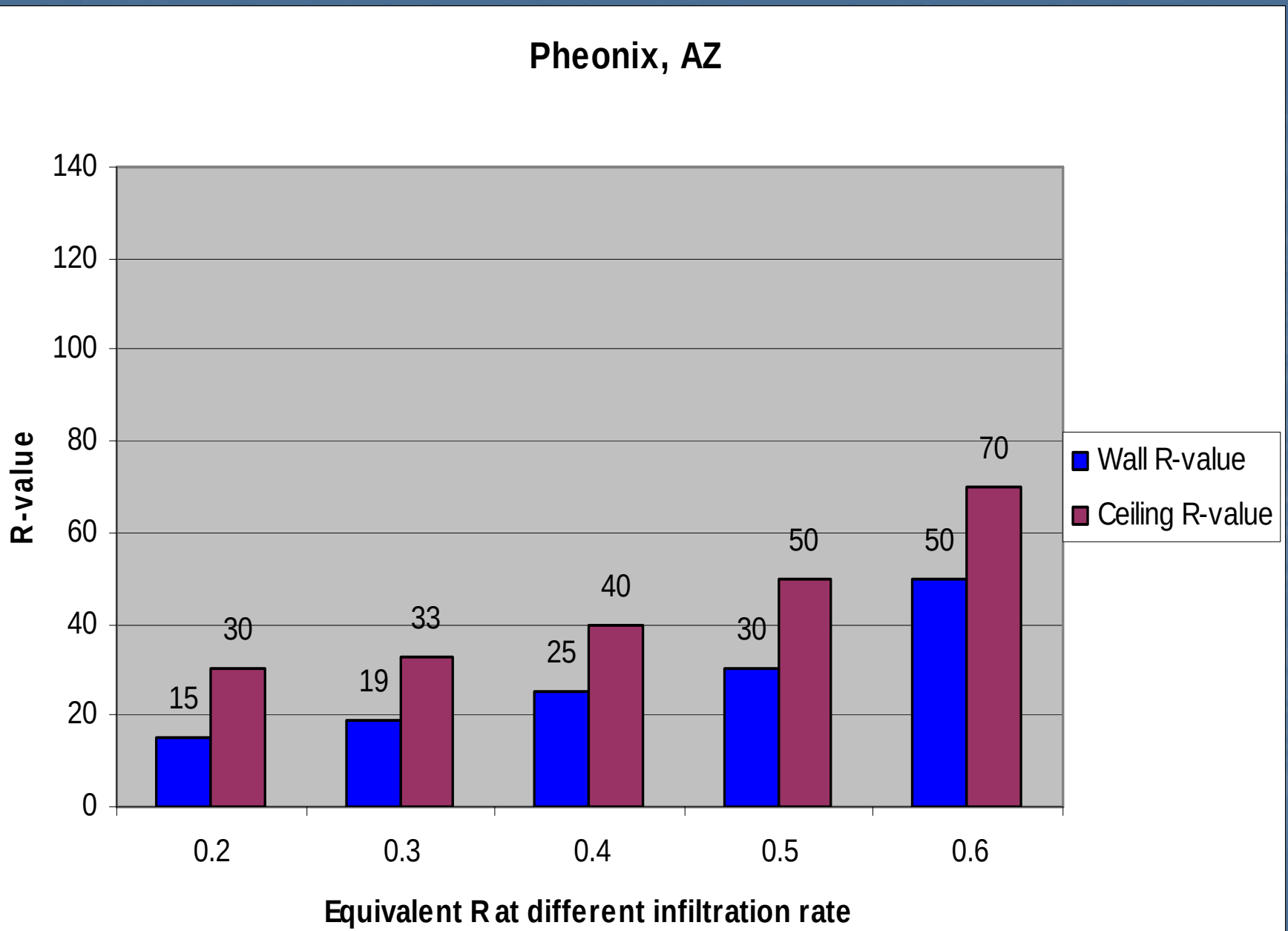

Chicago, IL
R-value
140
120
100
80
60
40
20
0
17
30
19
38
27
48
40
70
70
100
0.2
0.3
0.4
0.5
0.6
Equivalent R at different infiltration rate
Wall R-value
Ceiling R-value


St.Louise, MO
140
120
100
80
60
40
20
0
R-value
15
30
19
42
27
48
35
70
70
120
0.2
0.3
0.4
0.5
0.6
Equivalent R at different infiltration rate
Wall R-value
Ceiling R-value


Denver, CO
140
120
100
80
60
40
20
0
R-value
14
30
20
38
23
50
30
60
40
70
0.2
0.3
0.4
0.5
0.6
Equivaent R at different infiltration rate
Wall R-value
Ceiling R-value


Houston, TX
140
120
100
80
60
40
20
0
R-value
19
30
24
50
50
60
100
120
0.2
0.3
0.4
0.5
0.6
Equivalent R at different infiltration rate
Wall R-value
Ceiling R-value


Orlando FL
MMBtu
140
120
100
80
60
40
20
0
17
30
22
50
35
60
60
100
100
140
0.2
0.3
0.4
0.5
0.6
Equivalent R at different infiltration rate
Wall R-value
Ceiling R-value


Pheonix, AZ
140
120
100
80
60
40
20
0
R-value
15
30
19
33
25
40
30
50
50
70
0.2
0.3
0.4
0.5
0.6
Equivalent R at different infiltration rate
Wall R-value
Ceiling R-value

Observations

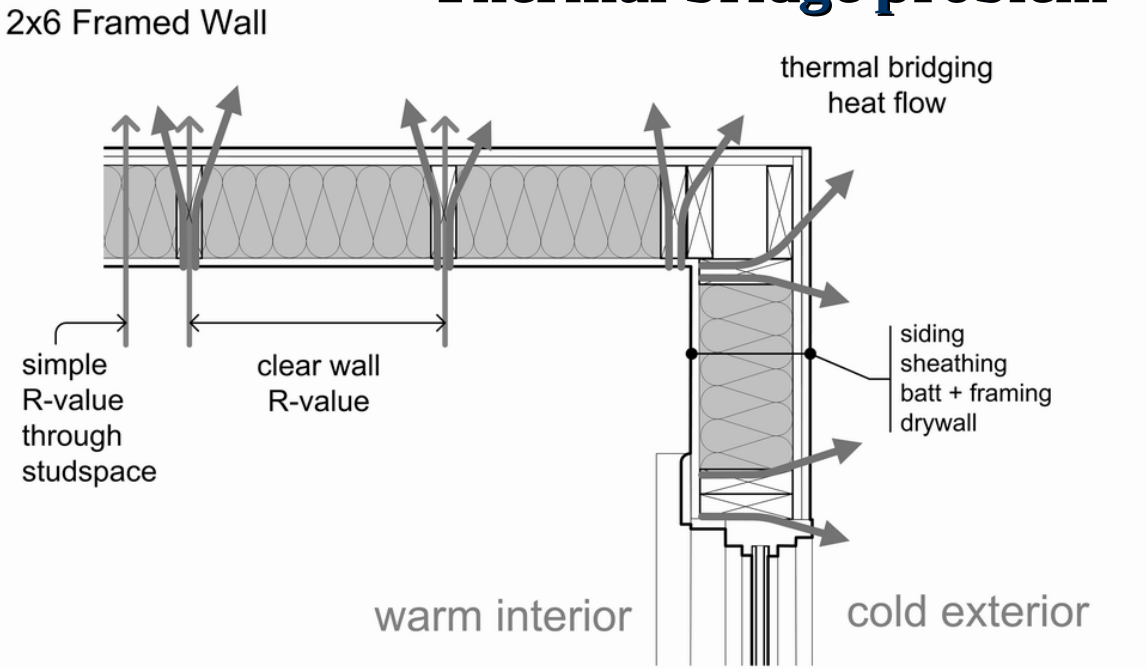
- Heating dominant regions show more savings than cooling dominant regions.
- R values have much smaller effect on energy consumption than infiltration
- Required R-values in dry climates reduced
- Required R-values in humid climates increased.
- Latent Heat/Humidity/Moisture hold commanding role in energy conservation

Other opportunities to conserve

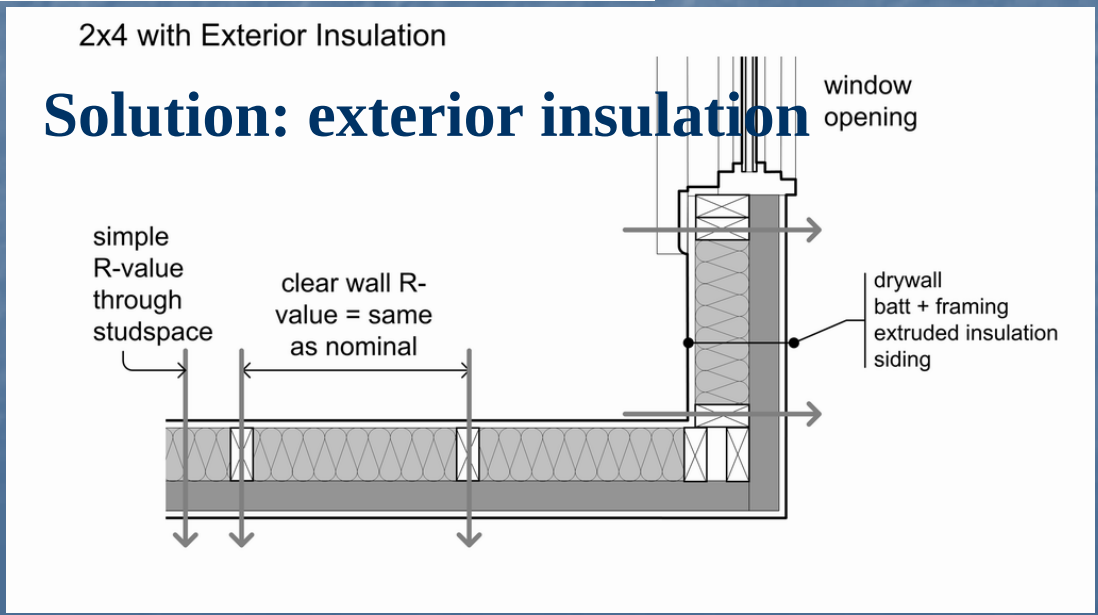

Find the thermal bridge

Find the thermal bridge

Thermal bridge problem



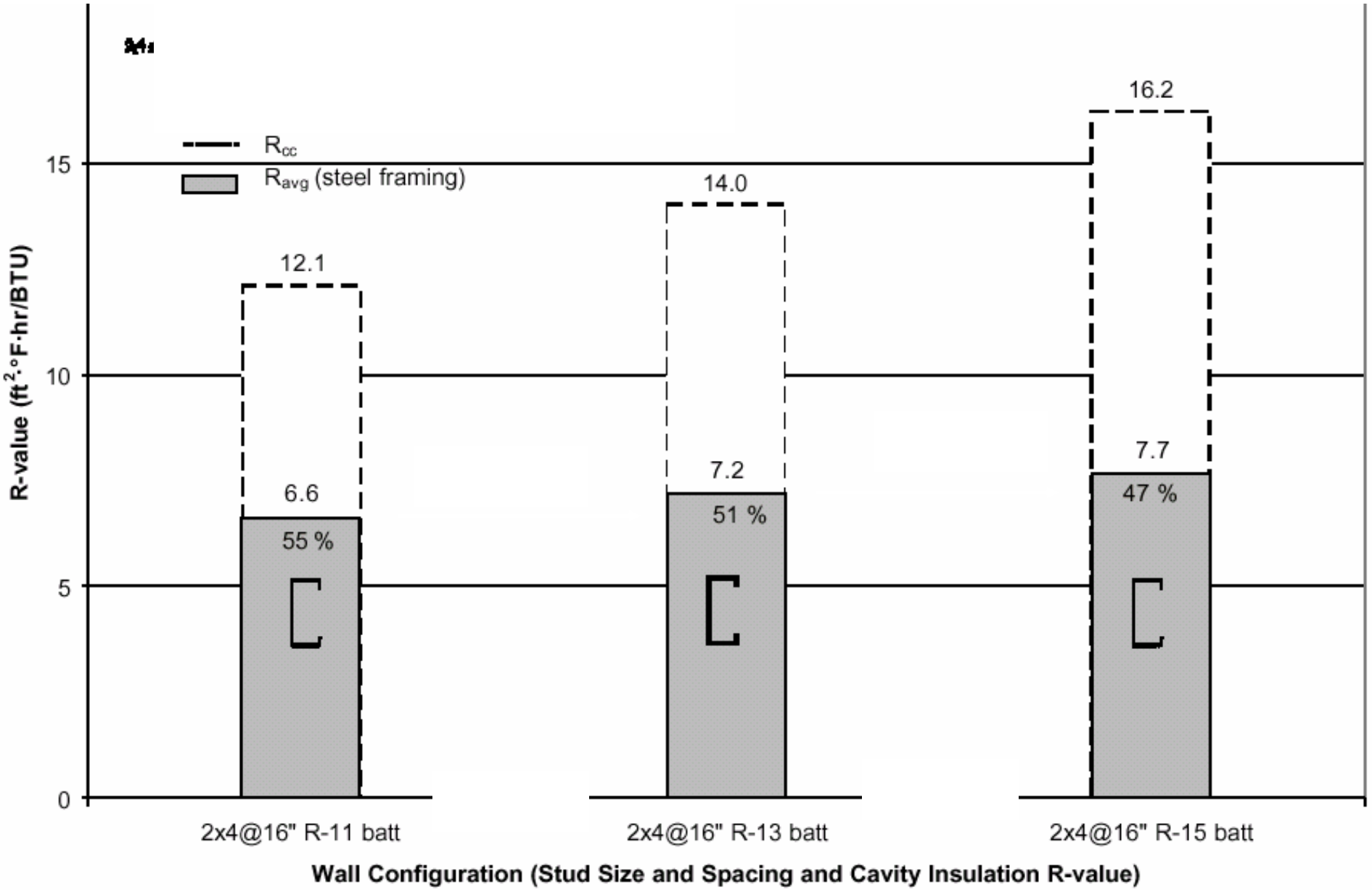
Solution: exterior insulation



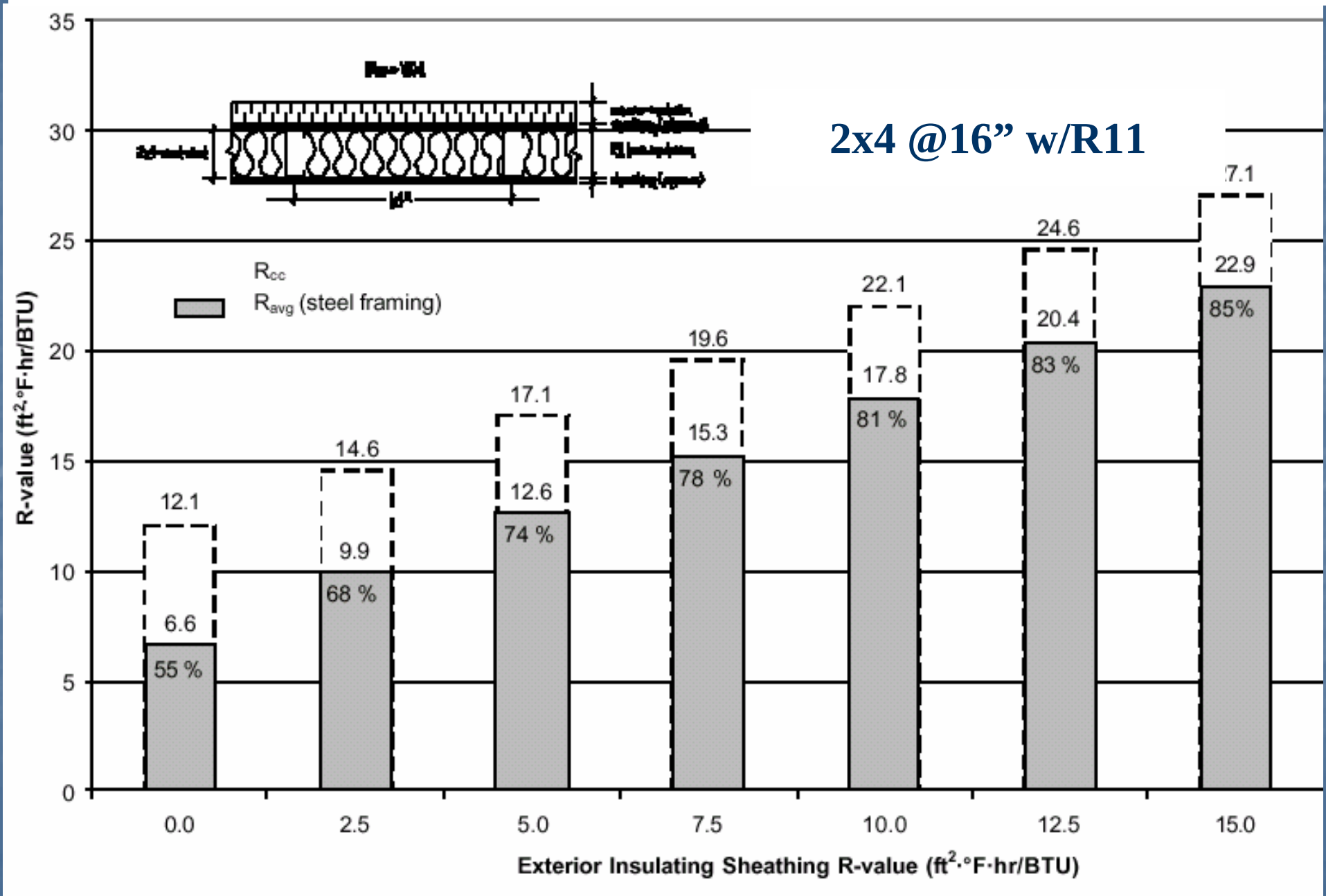
R-value Comparison

2x4 @16” w/R11

Adding studspace insulation is not helpful!



Impact of Insulating Sheathing



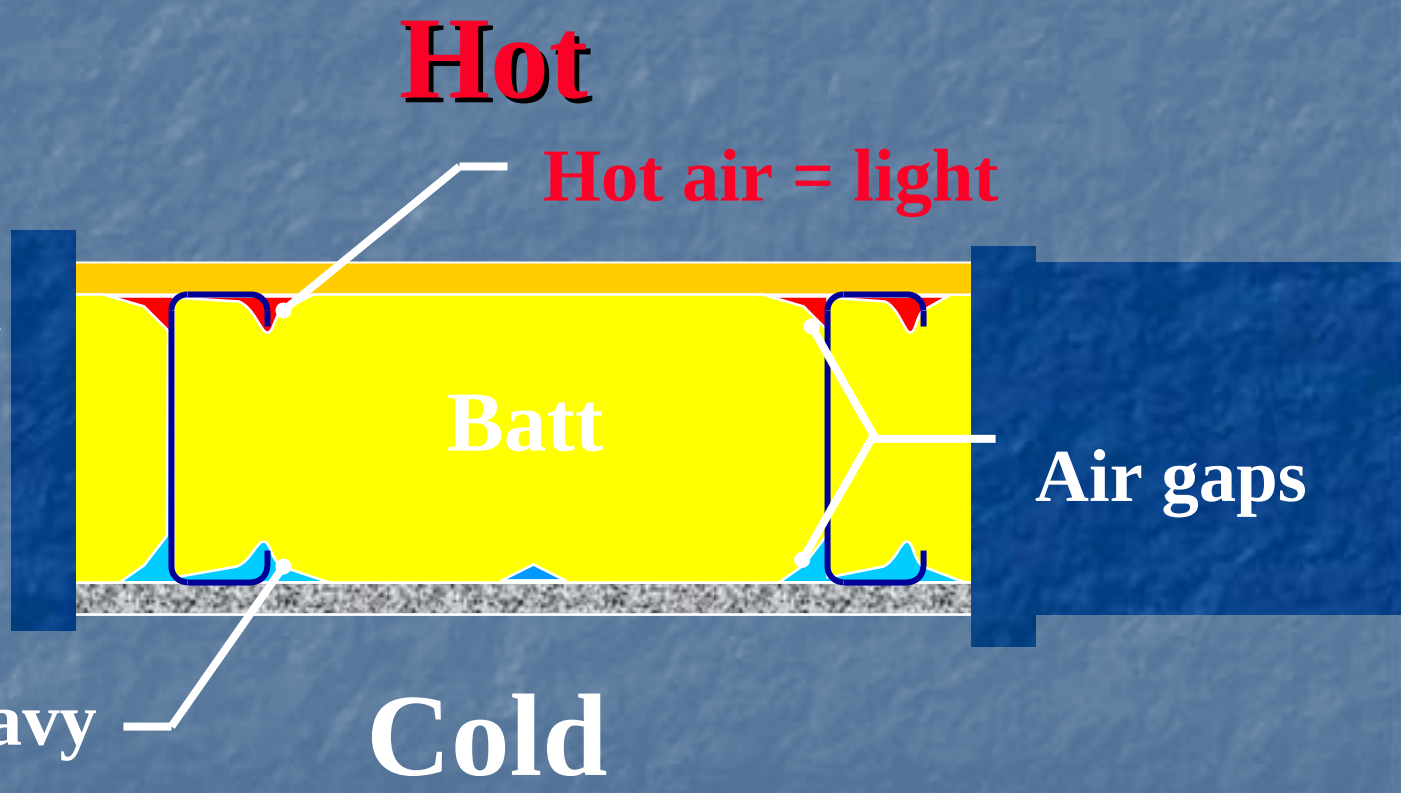
Internal Stack Effect & Insulation

- Gaps in batt insulation on both sides
- Wrinkles inevitable

Common problem

Steel studs are even “better”

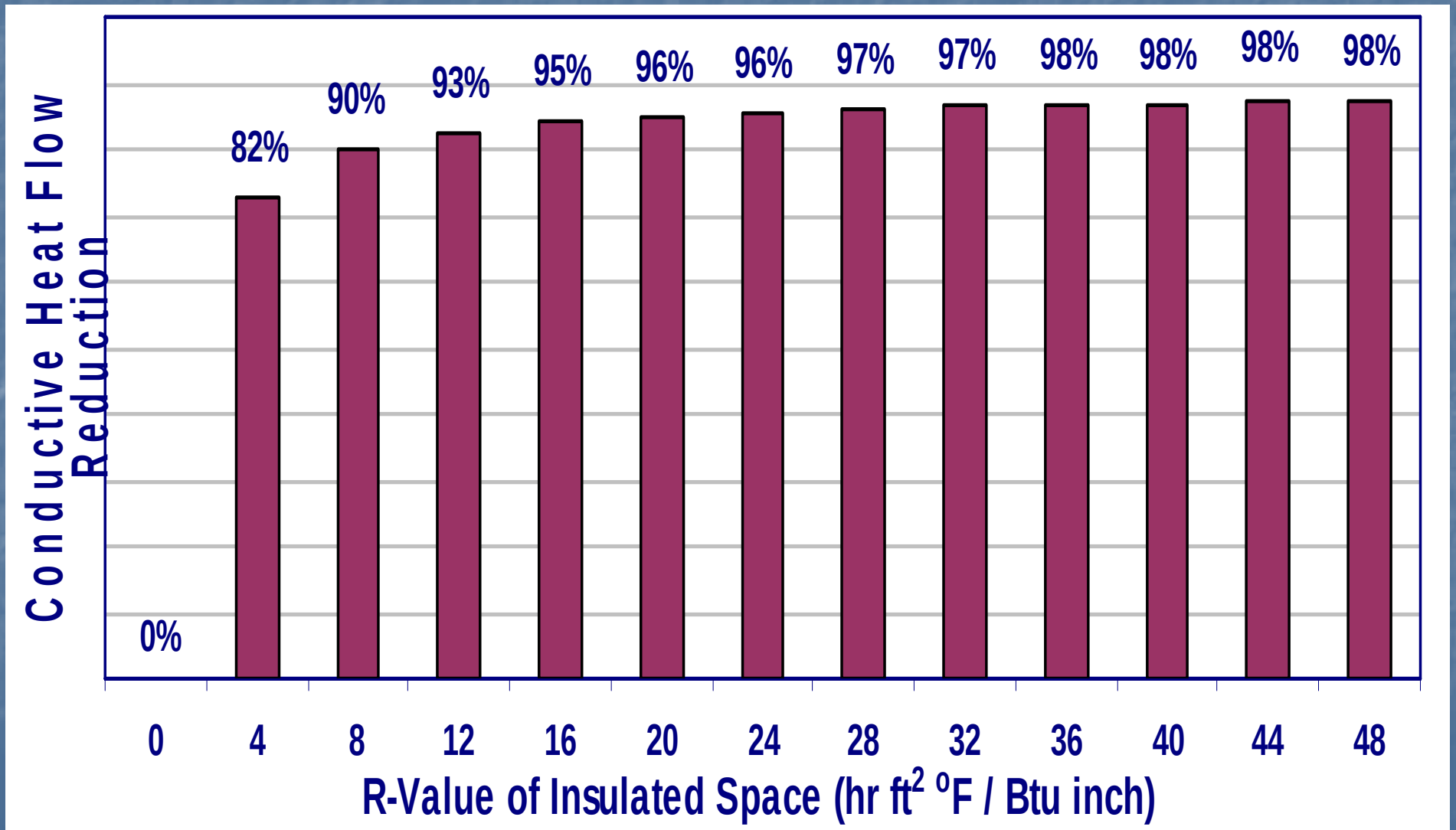
- Gaps in batt insulation on both sides
- hard to fill steel studs




Styrofoam
Styrofoam
Styrofoam
Styrofoam
Styrofoam
Styrofoam


R-19
R19

R-Value in the Real World



Summary

- Heat transfer
  - Conductance
    - R-value
  - Radiation
    - emissivity
  - Convection
    - Air/wind movement
  - Mass transfer
    - moisture

REMA

insulation	Material R, emissivity	Material Moisture diffusion	Material Air Permeance	Material REMA factor
Glass fiber	Xg	Yg	Zg	REMAg
Cellulose	Xc	Yc	Zc	REMAc
LDI	Xl	Yl	Zl	REMAl
PU	Xp	Yp	Zp	REMAp
EXP	Xe	Ye	Ze	REMAe

Consideration

- Heat transfer parameters measurable
  - R-value, conductance
  - Radiation, emissivity
  - Effect of convection
- Moisture/humidity
  - Complicated, many variables
  - Lack of adequate modeling tools

Proposal

- Launch a study to quantify and define the relationship between R-value, air tightness and energy conservation
  - Different materials
  - Different assemblies
  - Different climates
- Already behind, further delay makes it just that much harder

Plan

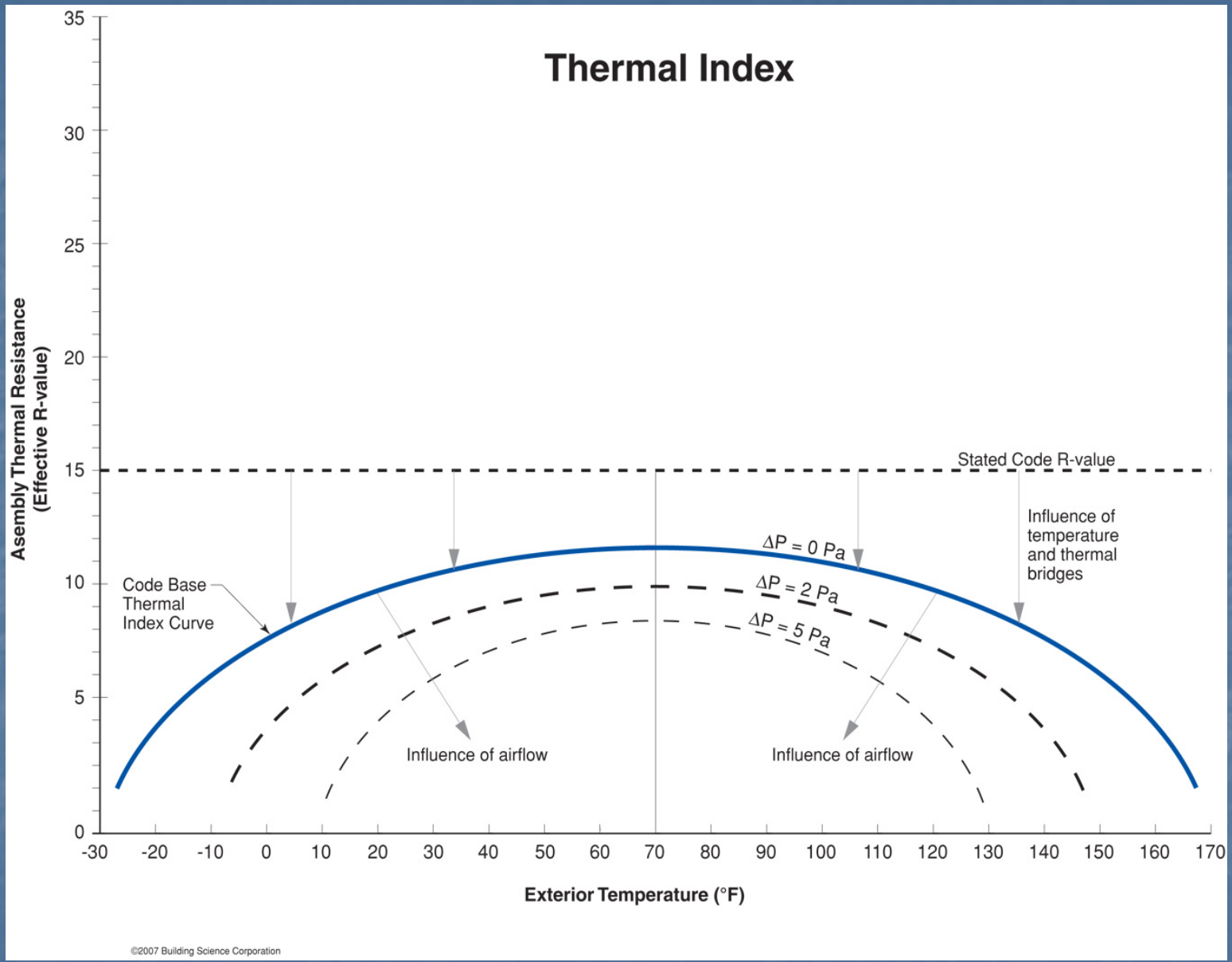
- Use the newly acquired data bank to create a more accurate thermal performance determination tool.

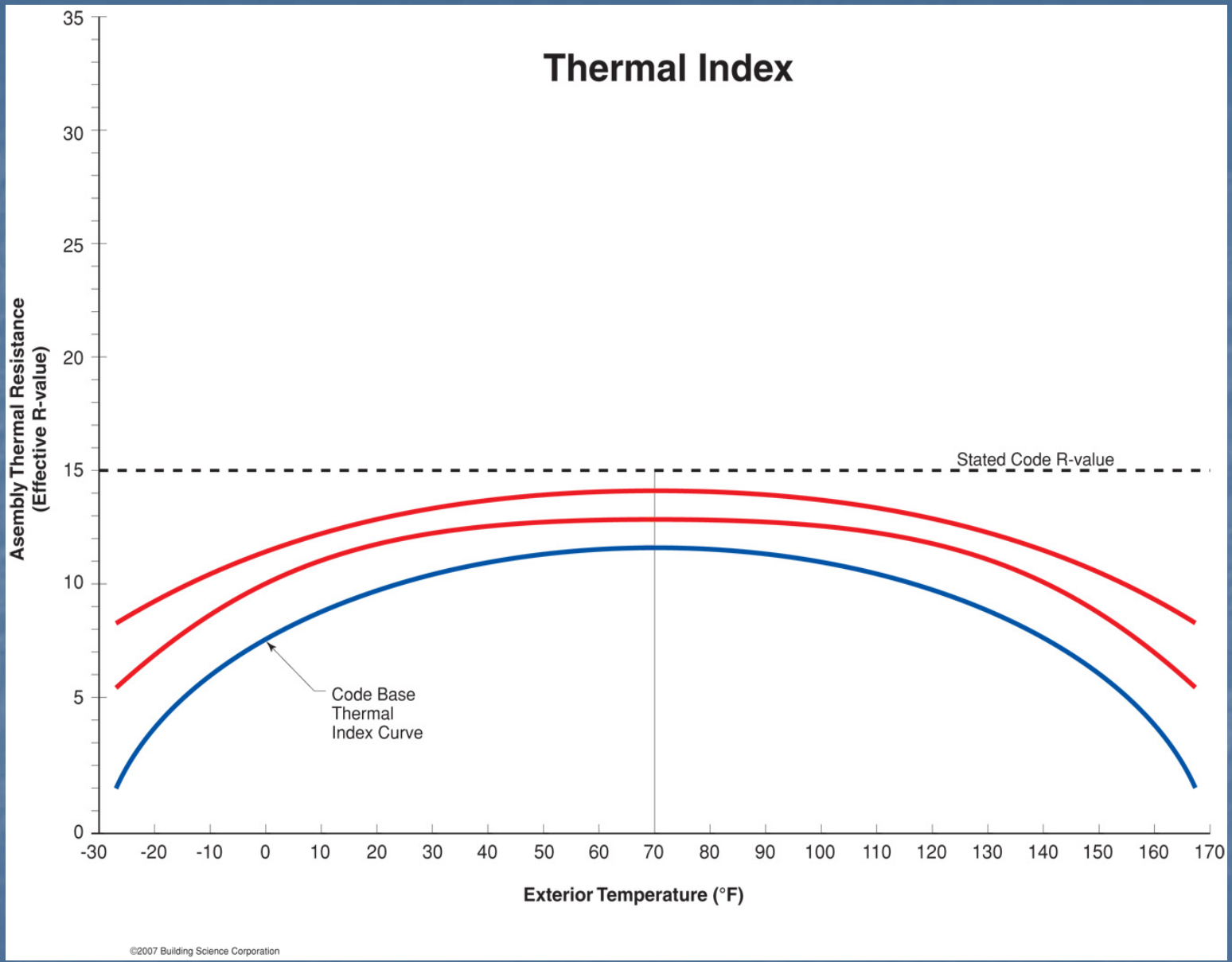
Concept

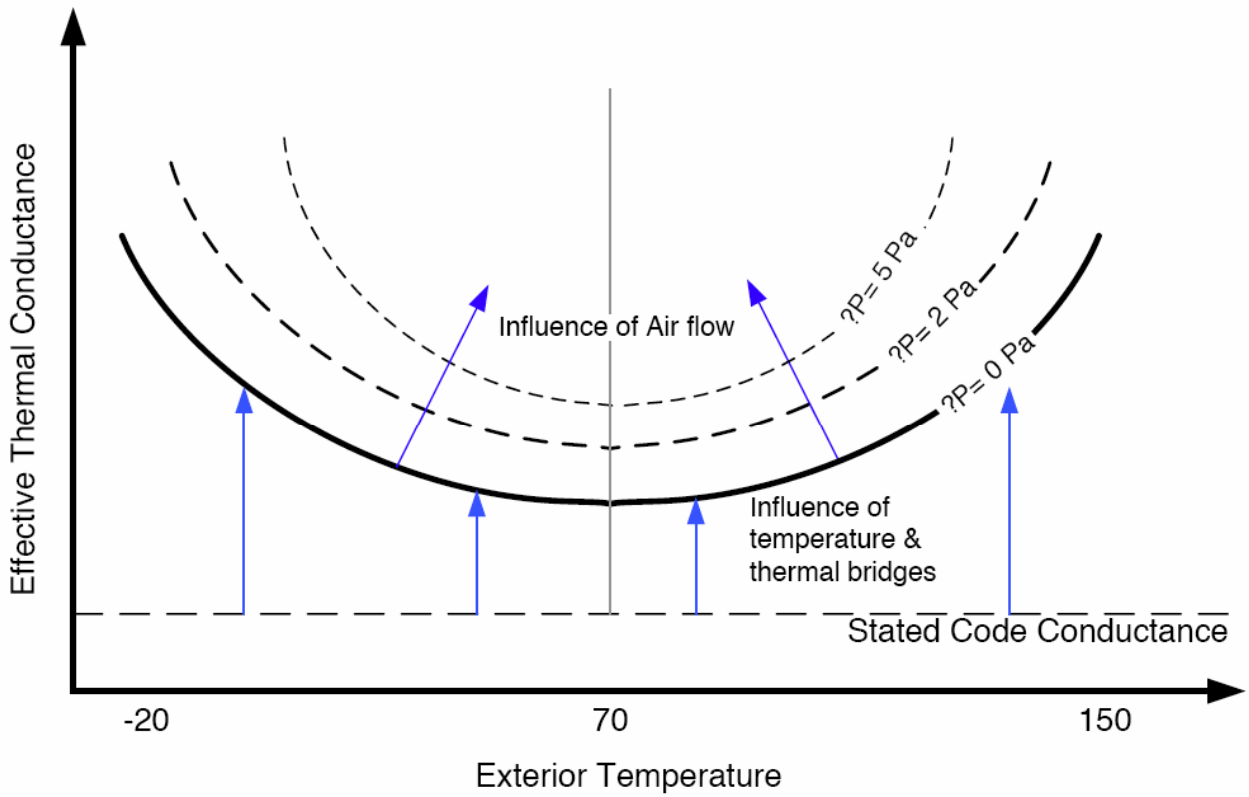
- Create a “blended metric”/index for insulation to augument current antiquated R-value
  - Incorporate air tightness, conductive and convective property into single number
- Concept not novel (Canadian window rating tool – CSA A440)

Challenge

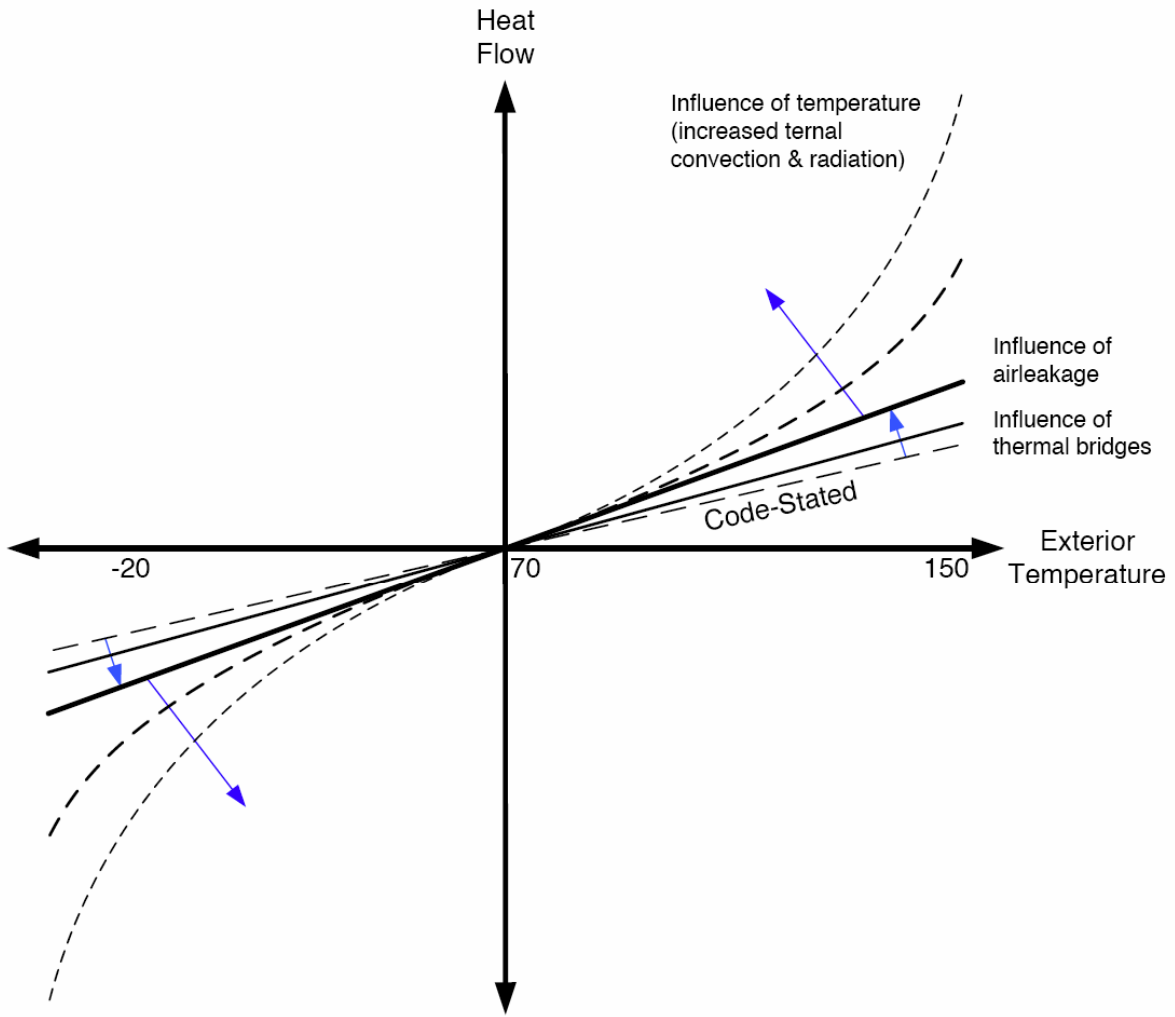
- Needs to be simple and accurate
  - Easy to use by building officials, industry, raters and consumers
  - Prescriptive
    - Table format
  - Must require minimum change


Thermal Index
Asembly Thermal Resistance (Effective R-value)
35
30
25
20
15
10
5
0
Stated Code R-value
Influence of temperature and thermal bridges
ΔP = 0 Pa
ΔP = 2 Pa
ΔP = 5 Pa
Code Base Thermal Index Curve
Influence of airflow
Influence of airflow
-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Exterior Temperature (°F)
©2007 Building Science Corporation


Thermal Index
Asembly Thermal Resistance
(Effective R-value)
35
30
25
20
15
10
5
0
Stated Code R-value
Code Base
Thermal
Index Curve
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Exterior Temperature (°F)
©2007 Building Science Corporation



Thermal Conductance


Heat
Flow
Influence of temperature
(increased ternal
convection & radiation)
Influence of
airleakage
Influence of
thermal bridges
Code-Stated
-20
70
150
Exterior
Temperature

Heat Flow

The Ultimate Challenge

- Promote and gain acceptance by the industry (designers, builders, raters, manufacturers) and public
- Standardize
- Introduce into the code

Next Steps?

- Identify projects for potential research and similar approaches in state codes (eg Michigan, California)
- Bring teams together as stakeholder groups, build consensus
- Identify opposition and obtain buy-in
- Publish and promote research
- Create timeline project, implementation into the code

Summary

- Supported and justified the need for a new improved thermal metric
- Proposed a concept
- Proposed a road map

- Comments?
- Suggestions?
- Questions?