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AIR BARRIER EDUCATION TRACKS FOR
THE CONSTRUCTION INDUSTRY

The Addition of Moisture Transport to the Air Leakage Energy Calculator

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Som Shrestha, PhD

Oak Ridge National Laboratory



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Presentation summary

- Why do we care air leakage?
- Web-based tool to estimate energy savings associated with air tightness
- Why do we care moisture transfer?
- Addition of moisture transport to the web-based tool
- Some examples

Buildings use a lot of energy

40% of all energy and 75% of all electricity used in the US

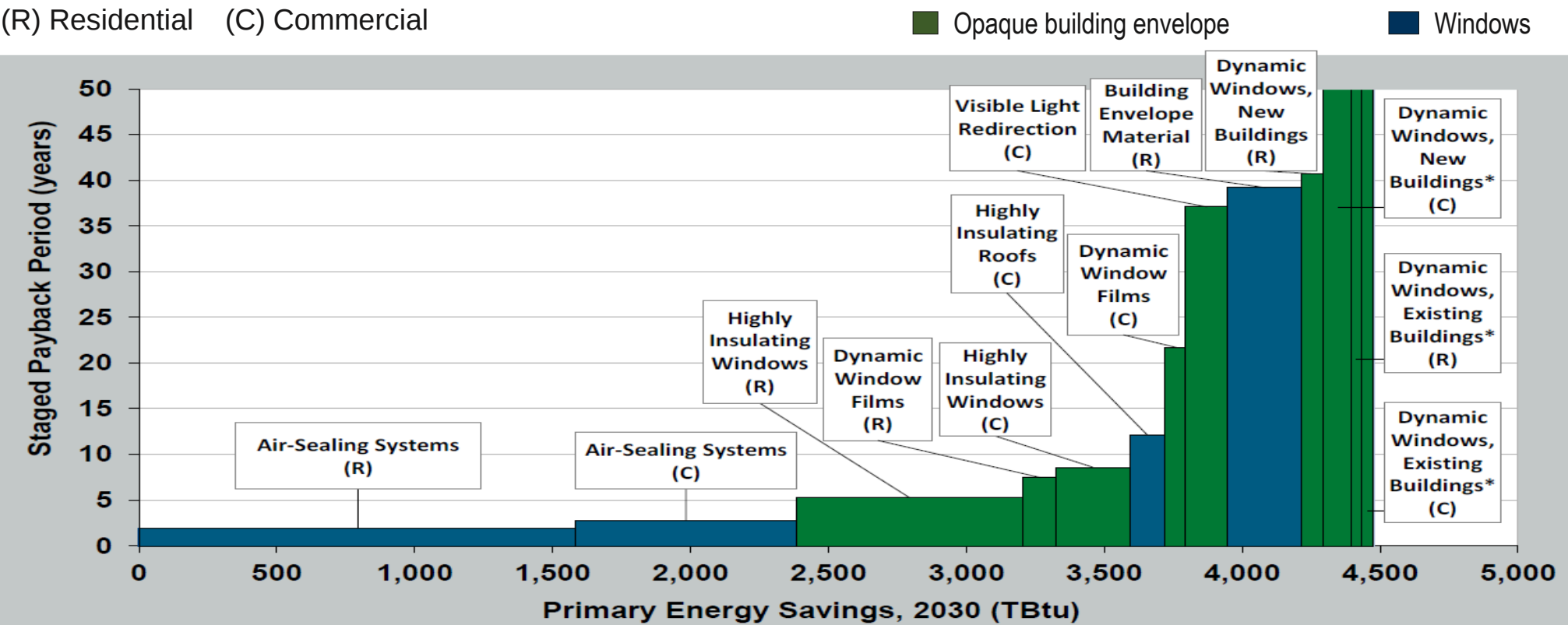
Source: US Department of Energy



Windows and Building Envelope R&D ET roadmap



Windows and building envelope R&D ET roadmap



Vancouver BC circa 1990



PAGE

A12

The Olympian

EDITOR: FRIEDA BUSH (news@theolympian.com): 754-5403

WED

MARKETS IN BRIEF

10,727.19

80.61

DOW

3956.42

-23.87

NASDAQ

1,480.88

5.26

S&P 500

BUSINESS IN BRIEF

WALL STREET

Paper, aluminum

lead stocks higher

Old Economy stocks came out on top Tuesday as two stalwarts of traditional businesses — paper and aluminum — led the market higher, with a little help from an upbeat speech from Federal Reserve Chairman Alan Greenspan.

makes offer

in defective siding lawsuit

THE ASSOCIATED PRESS

FEDERAL WAY — The Weyerhaeuser Co. expects to pay as much as \$82 million to homeowners around the country to settle claims of defective exterior hardboard siding.

The settlement proposed Monday by the forest products giant is intended to resolve a class-action lawsuit filed in 1998 in Superior Court in San Francisco and similar litigation pending in Oregon, Iowa, South Carolina and Texas. The dismissal of a similar case in Washington state is on appeal.

“Weyerhaeuser is stepping up to the plate to solve problems with one of its products,” said Christopher I. Brain of Seattle, one of the principal lawyers representing homeowners.

Deterioration of the half-inch board, a tightly squeezed composite of wood chips, fiber, resin and wax, took many forms, including swelling, warping, splitting, rotting and even sprouting mushrooms, Brain said.

Weyerhaeuser is taking an \$82 million charge after taxes in the second quarter to cover claims by homeowners who installed the siding between Jan. 1, 1981, and Dec. 31, 1999, said Bob Dowdy, vice president and general counsel.

Dowdy would not say Weyerhaeuser was admitting responsibility for the defective siding.

“What we’re saying here is that we would rather have a fair and independent process for people who have our siding to resort to than to continue to have a prolonged and expensive piece of litigation with an uncertain outcome for everyone involved,” he said.

Under a product liability settlement that was negotiated in 1996 involving Inner Seal pressed wood-flake siding, Louisiana-Pacific Corp. of Portland, Ore., had paid about \$470 million to settle claims as of early this year.

Georgia-Pacific, Jefferson Smurfit and Masonite also have settled class-action suits over siding, while siding-related lawsuits are pending against Boise Cascade and Stimson Lumber.

Under the proposed Weyerhaeuser settlement, which is subject to review in the California court later this year, a court-appointed inspector would examine structures to assess claims for compensation.

Brain would not comment on the amount of the settlement or other terms but estimated the siding had been applied to hundreds of thousands of houses and other structures. He said “at least 500,000” people could receive payments over the nine-year term of the proposed settlement.

About 2 billion square feet of the siding was produced at a Weyerhaeuser plant in Klamath Falls, Ore., over 35 years before the line was discontinued in 1996 — the year after the first claims were brought.

The siding carried a 30-year warranty, and company officials said there were warranty claims in about 2 percent of total square footage that was sold.

Most sales were to builders and contractors on the West Coast, but some also was distributed to consumers through retailers such as Eagle Hardware and Garden and Home Depot, Brain said.

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Moisture and buildings

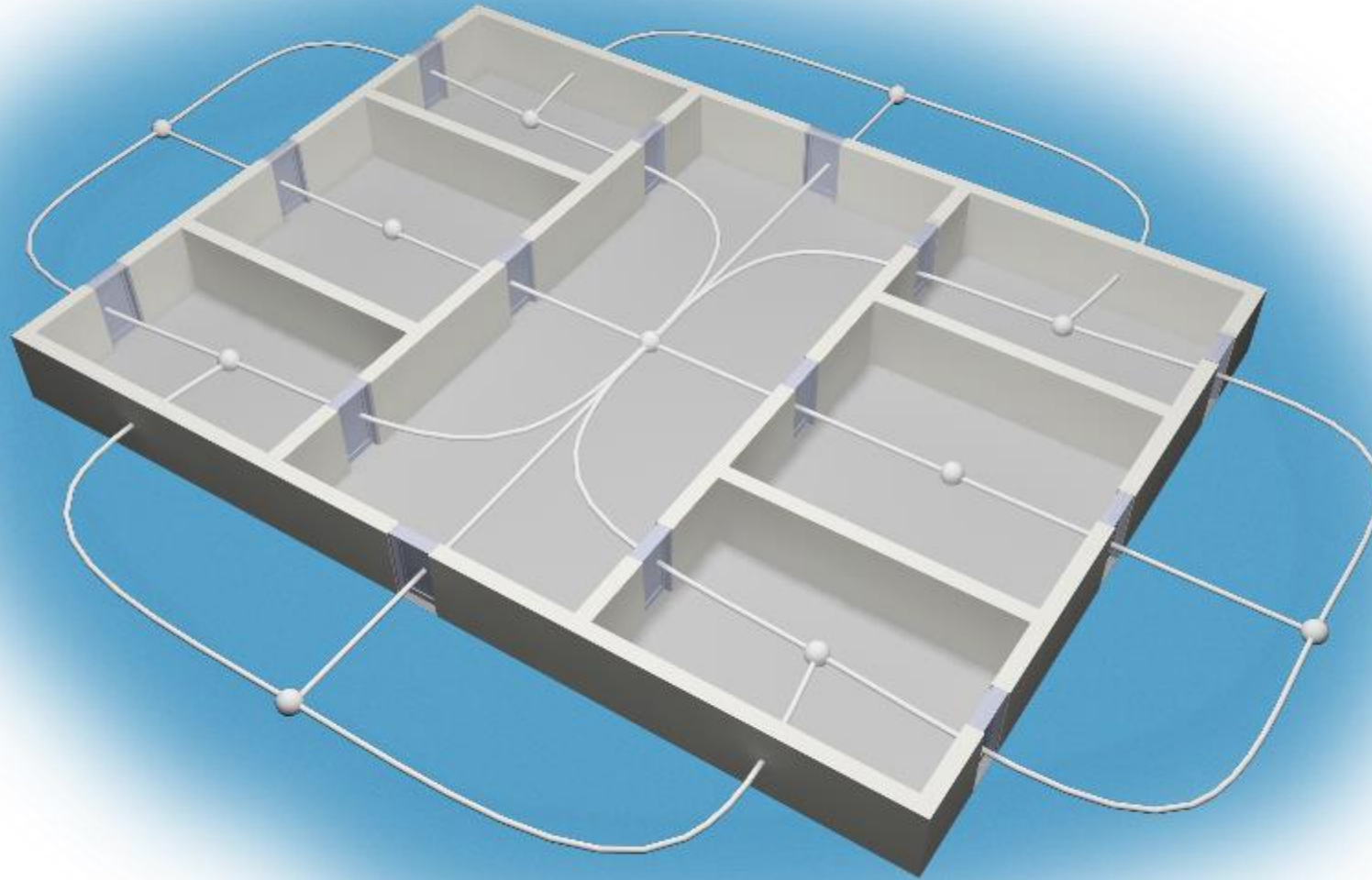
- Moisture involved in almost all building envelope performance problems
 - Energy inefficiency
 - Mold (IAQ)
 - Corrosion
 - Wood rot
 - Termites
 - Staining



(Dregger, 2012)

Develop an air leakage calculator

Air leakage calculation is not a trivial task



Energy and cost savings depend on

- Air leakage rates
- Weather
- Building type
- HVAC efficiency
- Energy and demand price

Challenges

- Air leakage rates depend on multiple variables
 - Envelope airtightness
 - HVAC system operation
 - Occupancy
 - Weather
 - Stack effect
 - Typical assumptions
 - Constant leakage rate
 - Leakage rates from simplified algorithms
- Under- or over-estimated energy use**

Infiltration modeling in EnergyPlus

- ZoneInfiltration:DesignFlowRate
 - DOE commercial prototype building models
- ZoneInfiltration:EffectiveLeakageArea
 - DOE residential prototype building models
- ZoneInfiltration:FlowCoefficient
- AirflowNetwork
 - Future effort

**Typically
do not take into account**

- Temperature difference
- Stack effect
- Wind direction

Zone Infiltration: Design Flow Rate

DOE commercial prototype buildings

Air leakage rate =

$$(I_{design})(F_{schedule})[A + B|T_{zone} - T_{odb}| + C(WindSpeed) + D(WindSpeed^2)]$$

Default values

$A = 0$

$C = 0.224$

$D = 0$

$B = 0 \rightarrow$ Does not take into account effects of temperature difference

Zone Infiltration: Design Flow Rate

DOE commercial prototype buildings

Air leakage rate =

$$(I_{design})(F_{schedule})[A + B|T_{zone} - T_{odb}| + C(WindSpeed) + D(WindSpeed^2)]$$



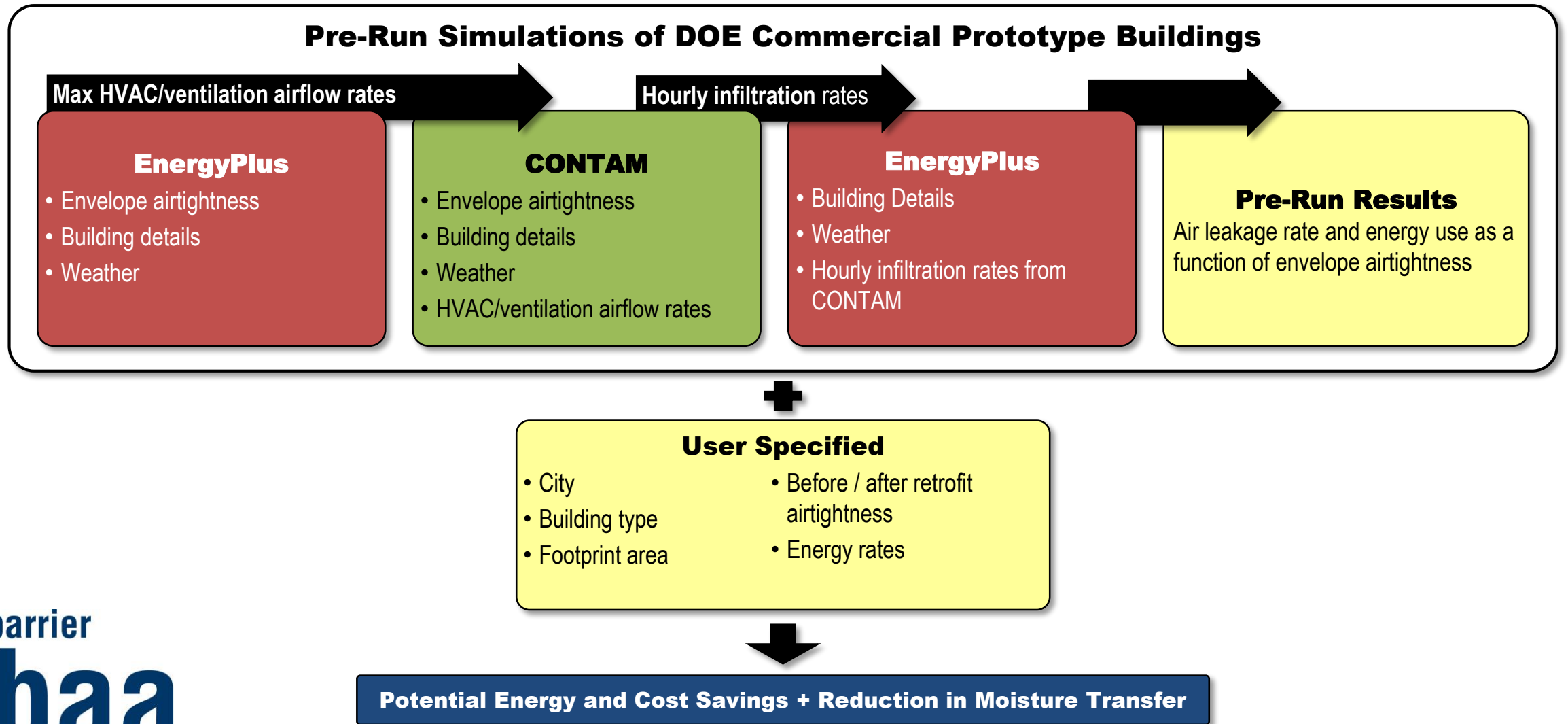
I_{design} in most DOE prototype buildings

- Air leakage rate when HVAC is off = 1 L/s·m² at 75 Pa
- Air leakage rate when HVAC is on = 0.25 L/s·m² at 75 Pa (75% reduction)

Objective

- Create an easy-to-use online tool using the simulation results of the best-in-class building energy simulation tool EnergyPlus and the whole building airflow simulation tool CONTAM.
- Online calculator estimates the potential energy and cost savings + reduction in moisture transfer from improvements from improvements in airtightness.
- Further increase market penetration of air barriers.

Calculations flow



Easy to find

infiltration calculator

All Images Videos News Shopping More Settings Tools

About 361,000 results (0.44 seconds)

LW2: Infiltration Calculator : Xcom - Reddit

https://www.reddit.com/r/Xcom/comments/Sp53mm/lw2_infiltration_calculator/

Jan 20, 2017 - 14 posts - 12 authors

based of LW2: **Infiltration Calculator** created by Xwynss I've extended it a little. Choose Expected Infiltration Level and finally you will know final number of enemies on chosen mission. Most of values are easy moddable. Pls Give me your Feedback if you find some errors. Thx and enjoy. VBN XCOM2 ...

[LW2] I've improved my **infiltration calculator**, and ... 11 posts Mar 9, 2017
[LW2] I made a better **Infiltration Calculator**. Check it ... 10 posts Feb 20, 2017
Tired of guessing. I made myself an **Infiltration** ... 2 posts Feb 4, 2017
[LW2][mod-request] Integration of xwynns' **infiltration** ... 2 posts Jan 26, 2017
More results from www.reddit.com

Infiltration calculator by karafso - Pavonis Interactive Forums

pavonisinteractive.com > ... > Long War 2 > Long War 201

Forum rules. Players can post in Long War 201 threads but not start new ones. 1 post • Page 1 of 1.
deaconivory: Long War 2 Crew: Posts: 167: Joined: Tue Dec 29, 2015 1:12 am. **Infiltration calculator** by karafso. Postby deaconivory » Mon Feb 20, 2017 7:41 pm. <https://docs.google.com/spreadsheets/d/...edit#gid=0> ...

Infiltration - calculator - fxSolver

<https://www.fxsolver.com/browse/formulas/Infiltration>

If the precipitation rate exceeds the infiltration rate, runoff will usually occur unless there is some physical barrier. It is related to the saturated hydraulic conductivity of the near-surface soil. The rate of infiltration can be measured using an infiltrometer. **Infiltration calculation** methods Infiltration is a component of the general ...

Phillip Cheng, MD MS - Hepatic Fat MRI Calculator - hsc.usc.edu

www-hsc.usc.edu/~phillimc/calc/hepatic_fat_mri.html

Calculator for determining degree of hepatic steatosis on MRI opposed phase imaging.

[XLS] Infiltration Calculation Spreadsheet - wsdot

www.wsdot.wa.gov/publications/fulltext/Hydraulics/.../InfiltrationCalc.Spreadsheet.xls

2. **Infiltration** Ponds. 3. Length of Pond Bottom (ft), 150. Width of Pond Bottom (ft), 10. 4. Area of Bottom of Pond (acres), 0.03. 5. Pond Side Slopes (3:1 typical), 4. 6. 7. 8. Depth of Pond, Dpond, Depth to Water Table, Dwt, Hydraulic Conductivity, Kequiv, Area of Pond Bottom, Apond, Hydraulic Gradient, i, CFsize, **Infiltration** ...

infiltration

<https://airleakage-calc.ornl.gov/>

Web-Based Energy Savings **Calculator** for Building Envelope Air Tightness. If you want to sign in, you can try the default account: - User (login="user" and password="user"). © 2017 Oak Ridge National Laboratory. Managed by UT-Battelle for the US Department of Energy. Security & Privacy Notice. To report issues with the ...

air leakage calculator

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Air Leakage Calculator - Lubs Technologies

www.lubstech.com/airleakcalculator

(Time on Load [min] x 100) / (Time On Load [min] + Time Off Load [min]). **Air Leakage** rate, 46, [cfm], = (% **Air Leaks** [%]) x (Rated Free Air Delivery [cfm]). Approximate Energy Wasted, 32,308, [kWh/y], = (**Air Leakage** Rate [cfm]) x 700 [kWh/(cfm)]. Average Electricity Price, \$0.140, [\$ / kWh], Insert from Energy Bills Analysis Tool.

[XLS] Air Leakage Calculator (xls) - ThermWise

www.thermwise.com/home/AirLeakSaveCalculator_v2.xls

Jun 1, 2012 - 2, Questar ThermWise Whole House **Air Leakage Calculator**, No, 1.0, OR - Bend. 3, Home Identifier: 4, Purpose: The tool calculates ACH50 from blower door values and provides estimated energy savings for air sealing measure. Instructions: A. Enter data into the white boxes in the "Inputs" section of the ...

Calculators & Tools - Oak Ridge National Laboratory

<https://web.ornl.gov/sci/buildings/tools/>

The air tight savings **calculator** helps homeowners and builders **calculator** energy lost when **air leaks** through a building's envelope. Roof Savings **Calculator**. The Roof Savings **Calculator** was developed as an industry-consensus roof savings **calculator** for commercial and residential buildings using whole-building energy ...

The tool

**OAK RIDGE**
National Laboratory

Infiltration v0.0.1-SNAPSHOT

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Welcome to

Web-Based Energy Savings Calculator for Building Envelope Air Tightness

Uncontrolled heat, air, and moisture transfer through the building envelope has a significant impact on energy usage. A comprehensive strategy for concurrently regulating these factors will have a major impact on reducing energy consumption. The [DOE Windows and Building Envelope Research and Development Roadmap for Emerging Technologies](#) shows that in 2010, infiltration was responsible 4 quads of space conditioning primary energy use in the residential and commercial sectors. In aggregate, infiltration accounted for greater energy losses than any other component of the building envelope, including fenestration and is responsible for over 4 percent of all the energy used in the United States. Furthermore, the Roadmap shows that the payback for the addition of air barrier systems would have a payback that is much less than 5 years.

The Roadmap further states that “computational tools are critically important for the design of commercial buildings with energy efficient envelope materials. As new technologies are developed, models and simulation tools must be updated to account for increased performance.” An impediment for the wider adoption of air barrier systems into buildings is the lack of a simple credible tool that can be employed by building architects, designers, and owners that accurately estimates the energy savings that could be expected if an air barrier system was added to the design. This calculator fills this void, is based on the best science available, and is easy to use.

[Start your evaluation](#)

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Easy to use

Infiltration Calculator

Location:

Building Type: Floor Area:

Leakage Rates:

Energy Costs:

User Inputs

- Location
- Building type
- Floor area
- Envelope airtightness
- Energy rate
- Can switch between IP and SI units
- Descriptions of the input parameters are available

Locations



Building types

- DOE commercial prototype building models
- ASHRAE 90.1-2013 compliant
- 16 building types
- 3 building types (*standalone retail, medium office, and mid-rise apartment*) in the first-phase (28.6% of commercial building footprint)
- 4 building types (*High-Rise Apartment, Hospital, Large Hotel, and Secondary School*) in the second-phase (27.8% of commercial building footprint)

DOE commercial prototype building models (ASHRAE 90.1-2013) used

Building	Total Floor Area, ft ²	Number of Floors	Construction Volume Weights
Standalone Retail	24,695	1	15.3%
Mid-Rise Apartment	33,700	4	7.3%
Medium Office	53,600	3	6.0%
High-Rise Apartment	84,360	10	9.0%
Hospital	241,410	5	3.4%
Large Hotel	122,132	7 (including basement)	5.0%
Small Hotel	43,200	4	1.7%
Large Office	498,600	13 (including basement)	3.3%
Small Office	5,500	1	5.6%
Outpatient Healthcare	40,950	3	4.4%
Restaurant Fast Food	2,500	1	0.6%
Restaurant Sit Down	5,502	1	0.7%
Stripmall	22,500	1	5.7%
Primary School	73,960	1	5.7%
Secondary School	210,900	2	10.4%
Warehouse	49,495	1	16.7%

Standalone retail building specs

Characteristic	Description
Floor area (m ²)	2300 (Length 54.3 m × width 42.4m)
Number of floors	1
Floor to ceiling height (m)	6.1
Window-to-wall ratio (%) Windows on south-facing façade	25.4
Building Envelope	
Walls	20.3 cm concrete masonry block + insulation per ASHRAE 90.1 + 1.3 cm drywall
Roof	Roof membrane + insulation per ASHRAE 90.1 + metal decking
Window U-factor and SHGC	Per ASHRAE 90.1
Foundation	15.2 cm concrete slab-on-grade + insulation per ASHRAE 90.1
Air leakage rates for prototype buildings (not used in the present study)	HVAC off = 1 L/s·m ² at 75 Pa HVAC on = 25% of HVAC off rate = 0.25 L/s·m ² at 75 Pa
HVAC	
Heating type	Gas furnace inside the packaged air conditioning unit
Cooling type	Packaged air conditioning unit
Size	Autosized to design day
Efficiency	Based on climate location and design cooling/heating capacity and ASHRAE 90.1 requirements
Thermostat setpoint (°C)	23.9 cooling / 21.1 heating
Thermostat setback (°C)	29.4 cooling / 15.6 heating
Ventilation	Per ASHRAE 62.1

Air leakage rates: standalone retail building

Case	Air Leakage Rate at 75 Pa (L/s·m²)	Air Leakage Rate at 75 Pa (CFM/ft²)	Source
Baseline	5.4	1.06	Emmerich et al (2005)
1	2.0	0.4	IECC (2015)
2	1.25	0.25	USACE (2012)
3	0.25	0.05	DOE (2014)

Energy costs

- Select the default values
 - [Electricity](#) and [natural gas](#) for US cities: U.S. EIA
 - Energy prices for Canada: rates used to develop the National Energy Code of Canada for Buildings 2011([NECB 2011](#))
- User-defined electricity and natural gas prices

Some examples

Calculator input

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Infiltration Calculator

Map

Satellite



Google

Map data ©2018 Google Terms of Use

Location: 

United States

Illinois

Chicago

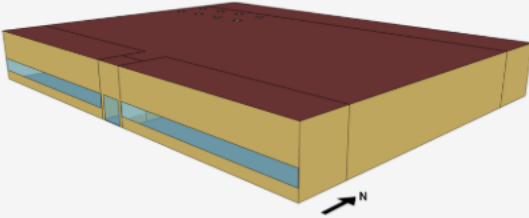
Building Type: 

Standalone Retail

Floor Area:

ft²

24695



Leakage Rates:

L/s.m²



Base case:

5.4

Retrofitted building:

2

Energy Costs: 

Electricity: (\$/kWh)

0.0933

Natural Gas: \$/1000 ft³

8.86

Calculate >>



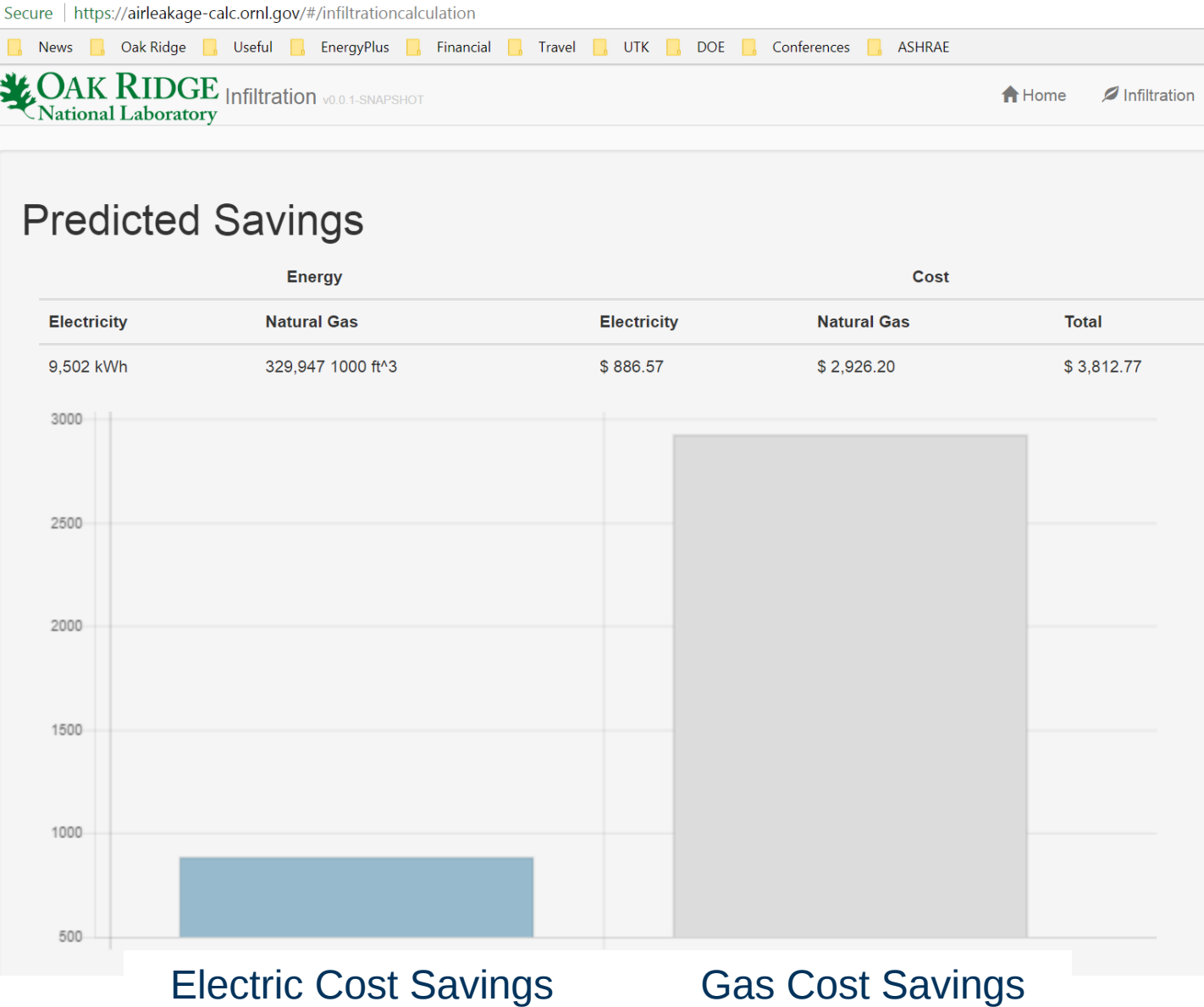
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Calculator output

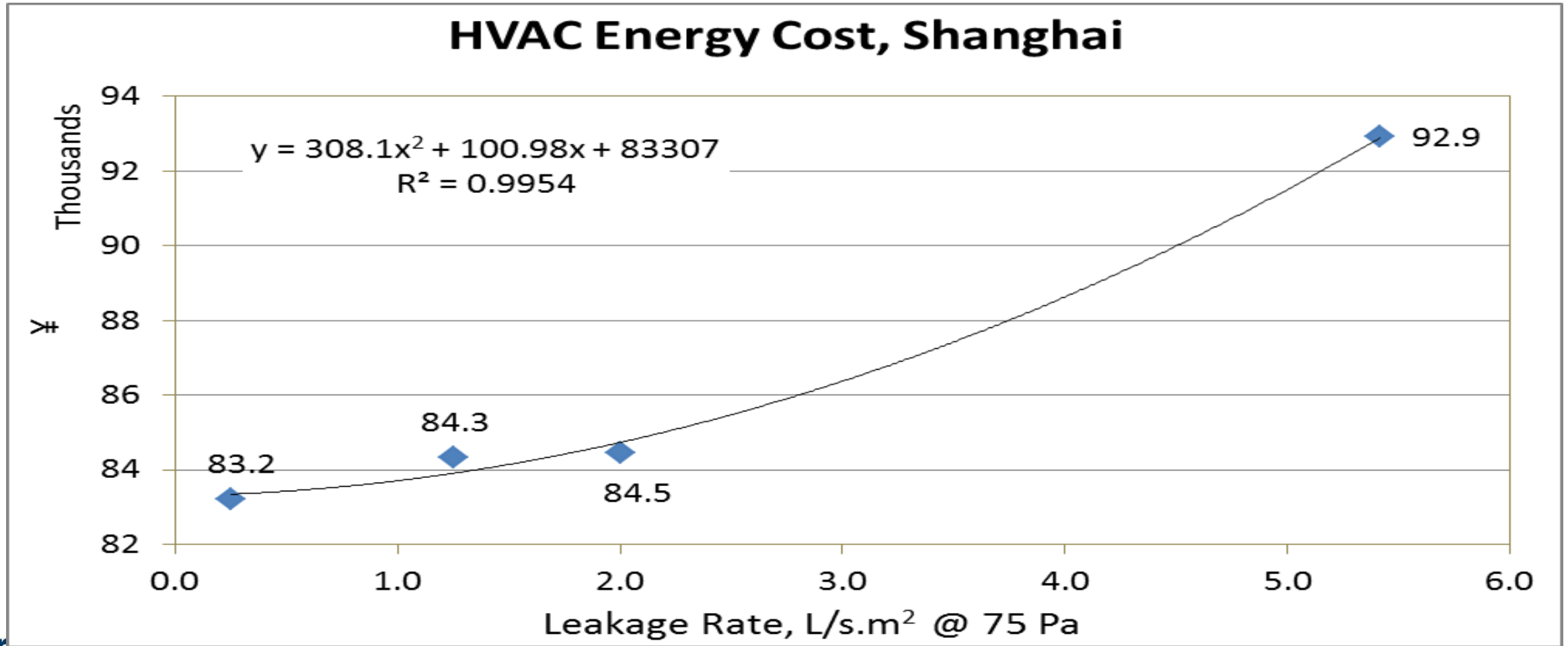


Sample cities

City	DOE Climate Zone	Prototype Building Model Used in Calculator	Electricity Price	Natural Gas Price
Shanghai, China	3A (warm, humid)	Memphis, TN	¥0.781/kWh ^e (≈\$0.12/kWh)	¥3.65/m ³ ^f (≈\$15.9/1000 ft ³)
Chicago, IL	5A (cold, humid)	Chicago, IL	\$0.0933/kWh ^a	\$8.86/1000 ft ³ ^b
Winnipeg, Canada	7 (very cold)	Duluth, MN	C\$0.14/kWh ^c (≈\$0.10/kWh)	C\$0.1605m ³ ^d (≈\$3.4/1000 ft ³)

^a http://www.eia.gov/electricity/sales_revenue_price/
^b http://www.eia.gov/dnav/ng/ng_sum_lsum_a_EPG0_PCS_DMcf_a.htm
^c <https://www.ovoenergy.com/guides/energy-guides/average-electricity-prices-kwh.html>
^d http://www.economicdevelopmentwinnipeg.com/uploads/document_file/natural_gas_rates.pdf?t=1433529826
^e <http://news.asean168.com/a/20150413/5318.html>
^f <http://gas.gold600.com/>

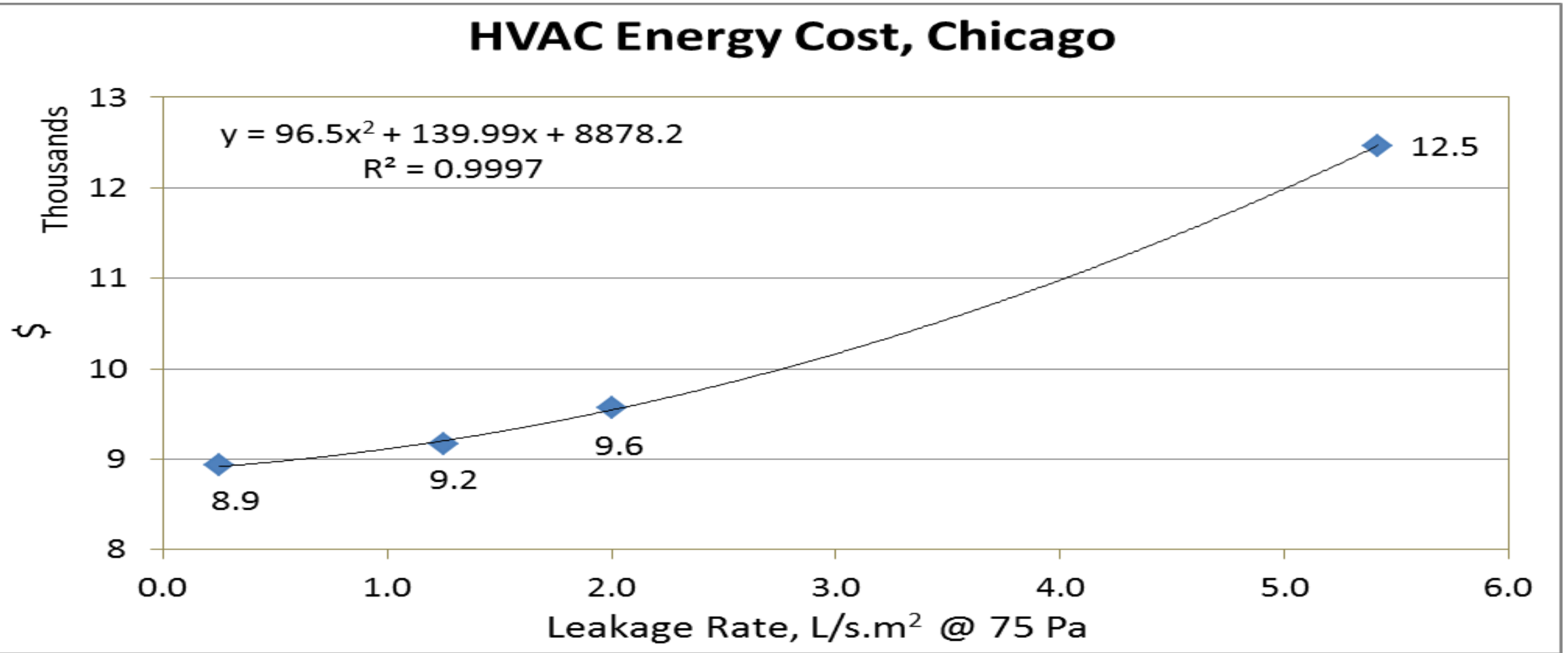
Energy savings - Shanghai



HVAC energy cost for a prototype standalone retail building in Shanghai

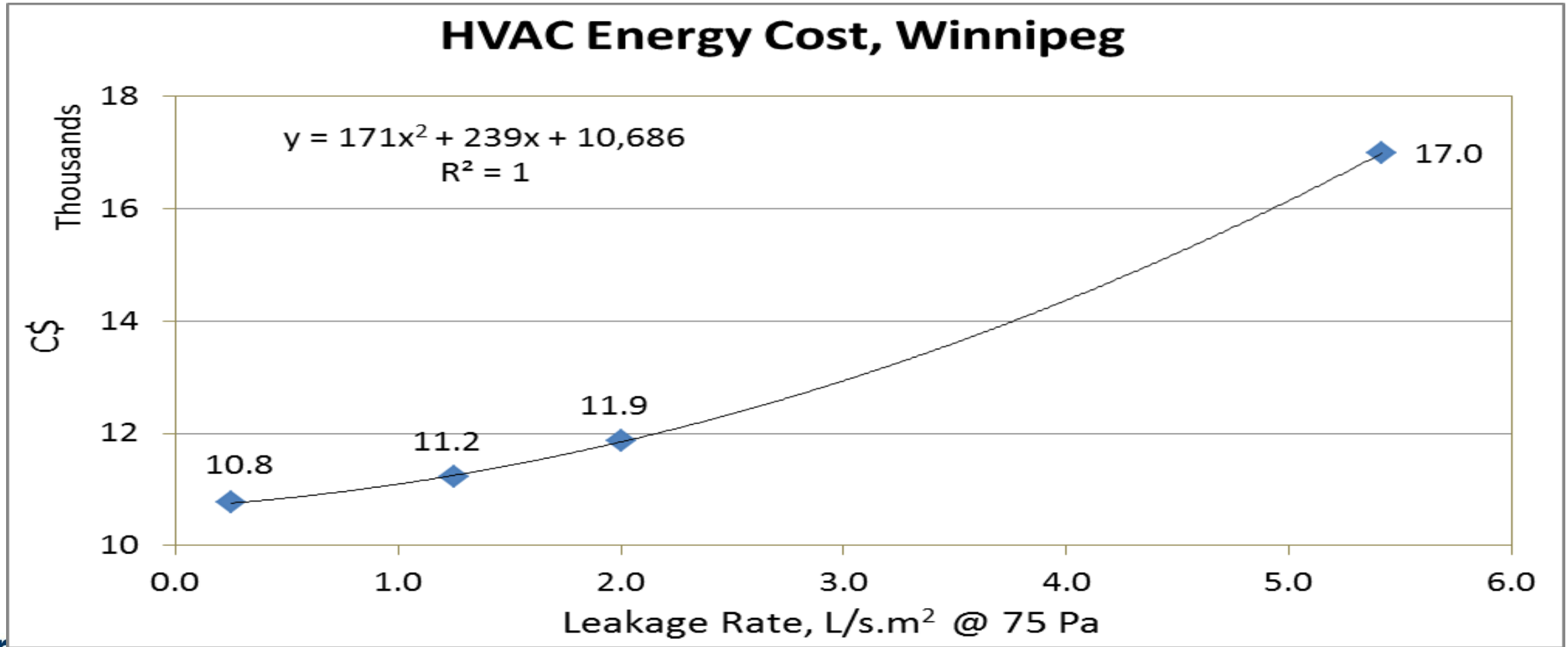
Energy savings - Chicago

HVAC Energy Cost, Chicago



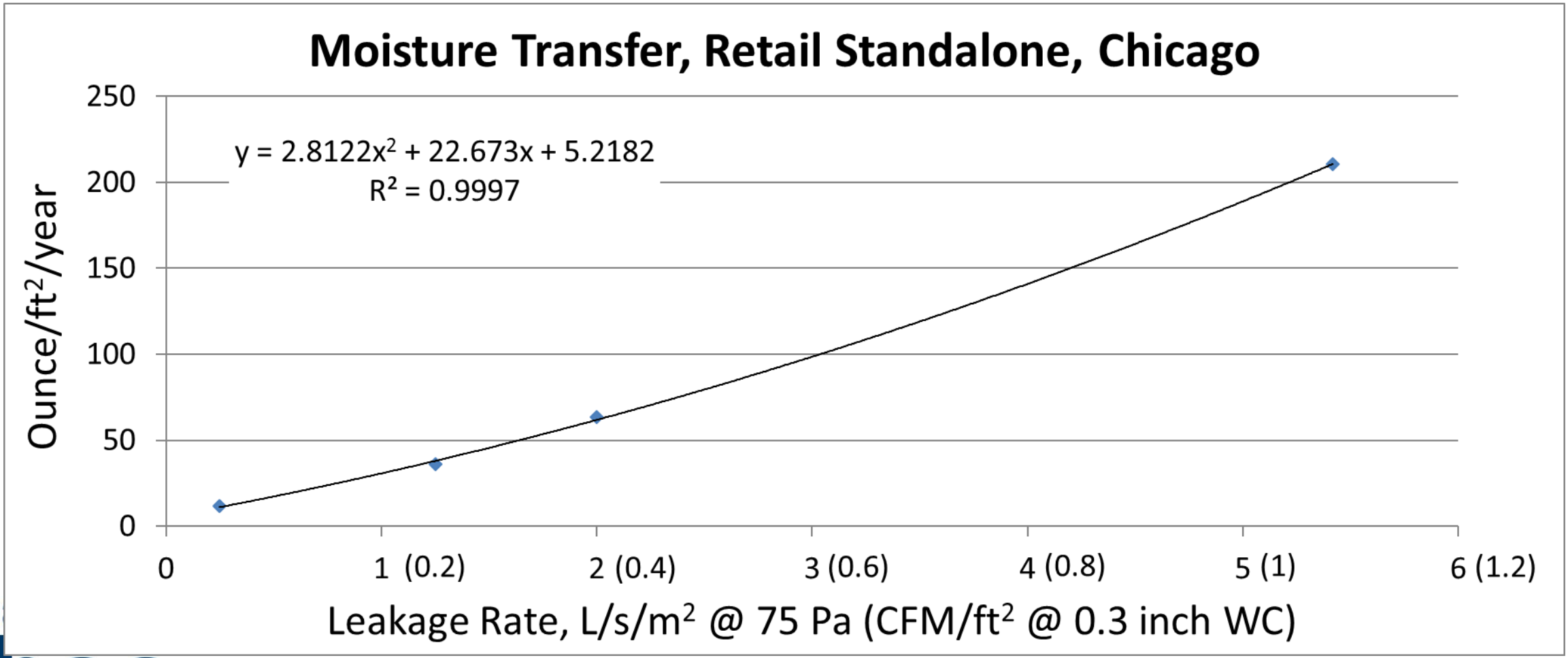
HVAC energy cost for a prototype standalone retail building in Chicago

Energy savings - Winnipeg

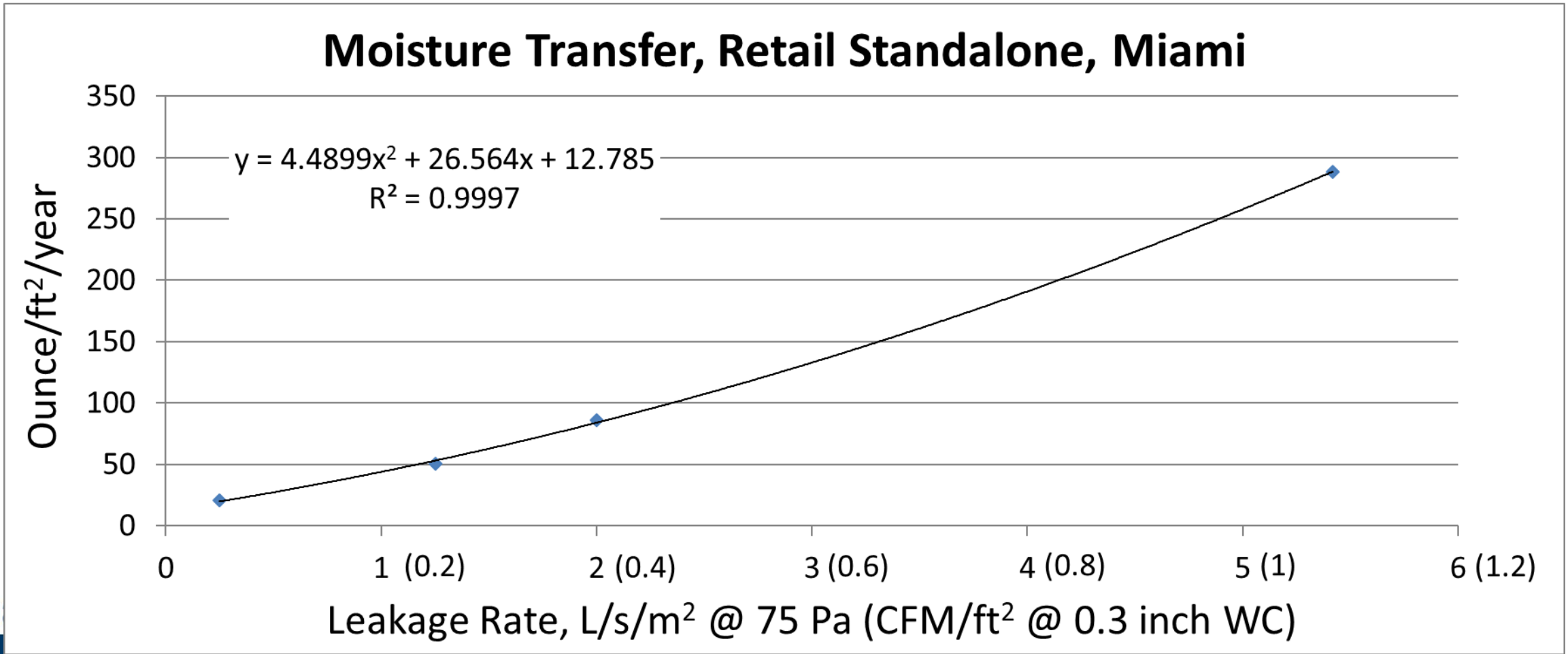


HVAC energy cost for a prototype standalone retail building in Winnipeg

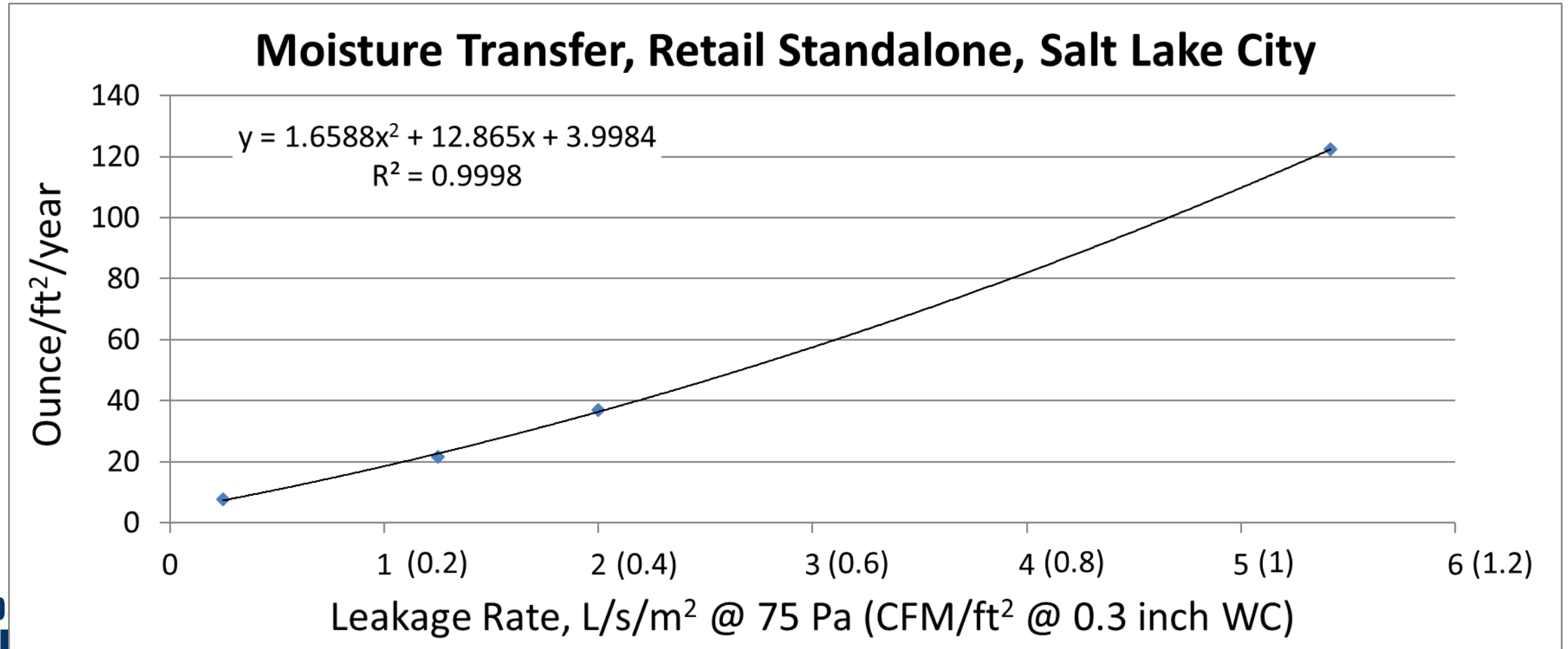
Moisture transfer – standalone retail, Chicago



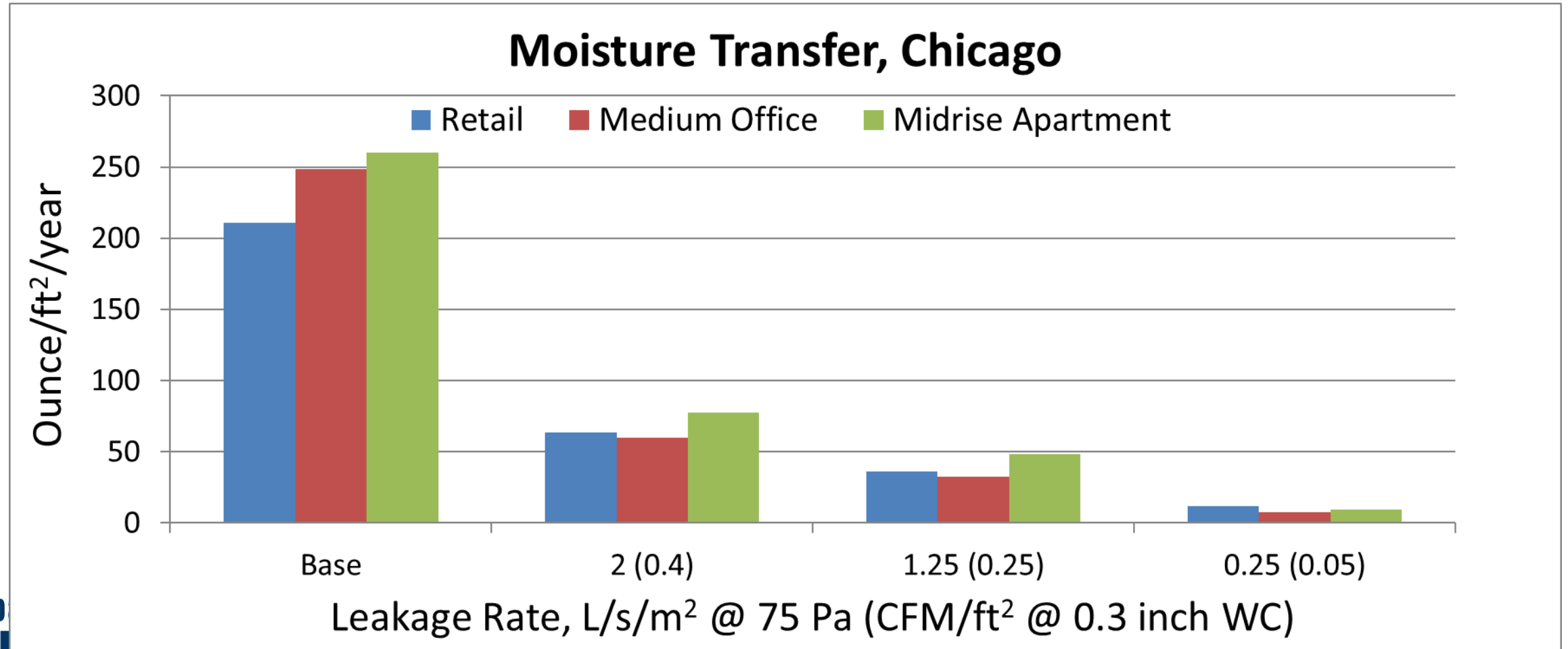
Moisture transfer – standalone retail, Miami



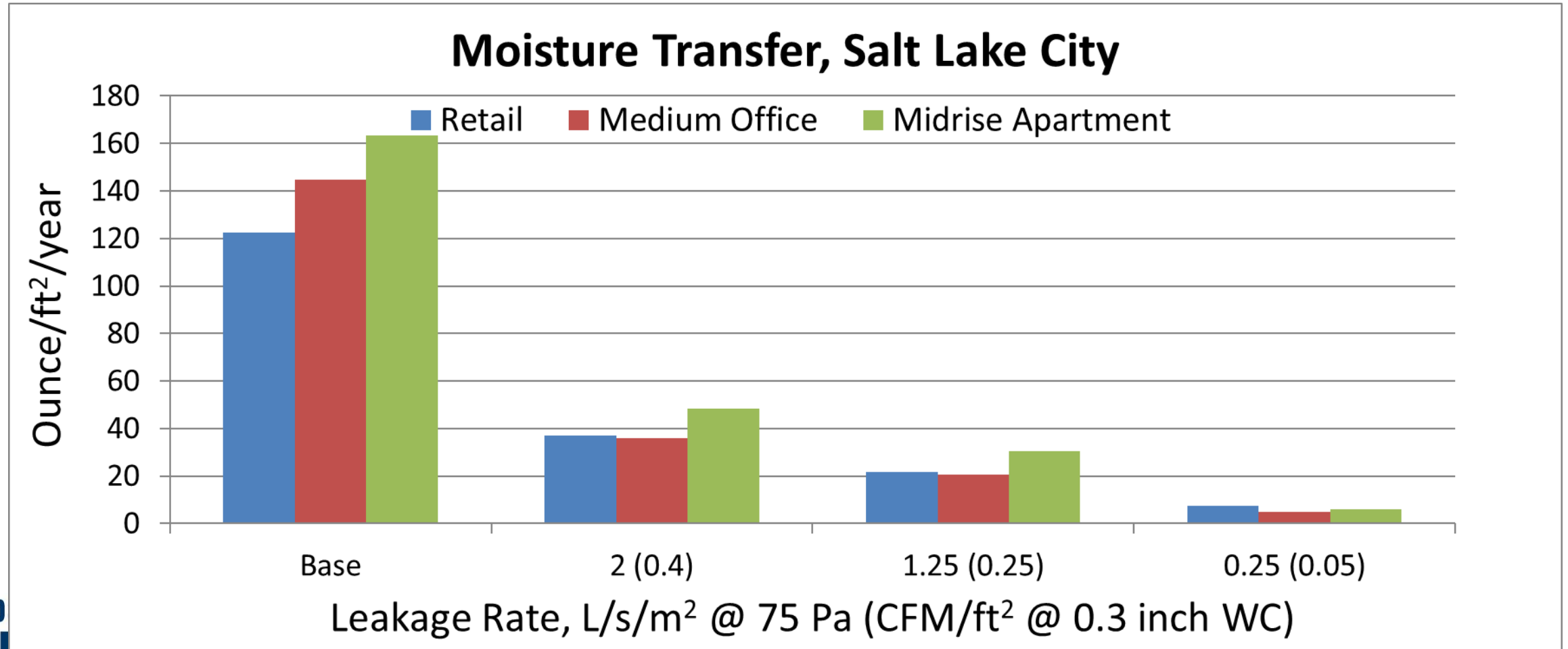
Moisture transfer – standalone retail, Salt Lake City



Moisture transfer by building type – Chicago



Moisture transfer by building type – Salt Lake City



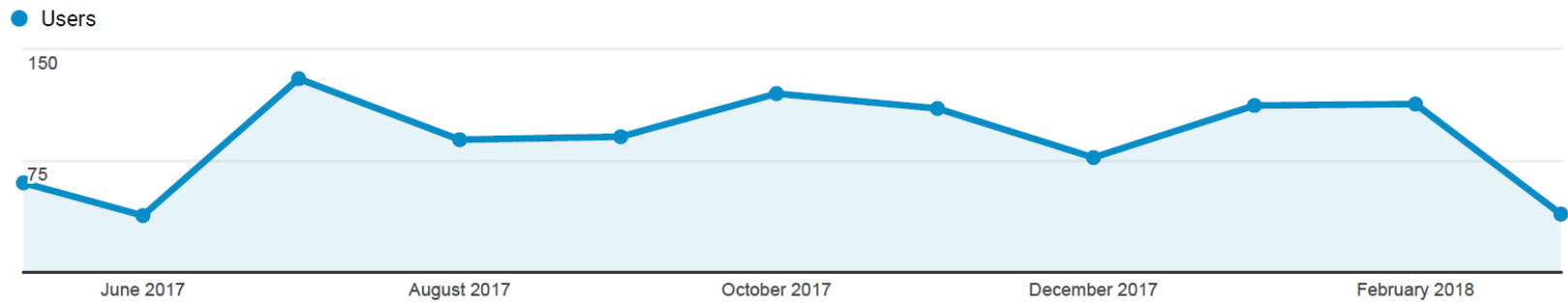
Acknowledgments

- Laverne Dalglish, ABAA
- Steven Emmerich, NIST
- Lisa Ng, PhD, NIST
- Diana Hun, PhD, ORNL
- Gina Accawi, ORNL

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1,232



Avg. Session Duration

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Discussion

