

Load Forecasting Technical Workshop

January 30, 2004



Agenda

- ◆ New Commercial Survey Results (20 Minutes)
- ◆ Changing Commercial Saturation's (20 Minutes)
- ◆ Conditional Demand Analysis (30 Minutes)
- ◆ Changing Commercial Electricity Unit Intensity (EUI)'s (45 minutes)
- ◆ Existing Residential Saturation's (20 minutes)
- ◆ Changing Residential Unit Electric Consumption (UEC)'s (45 minutes)

2003 Commercial Survey Results

(Reed Davis)



Agenda

- ◆ Survey Specifics
- ◆ Major findings
- ◆ Surprises
- ◆ Lessons learned

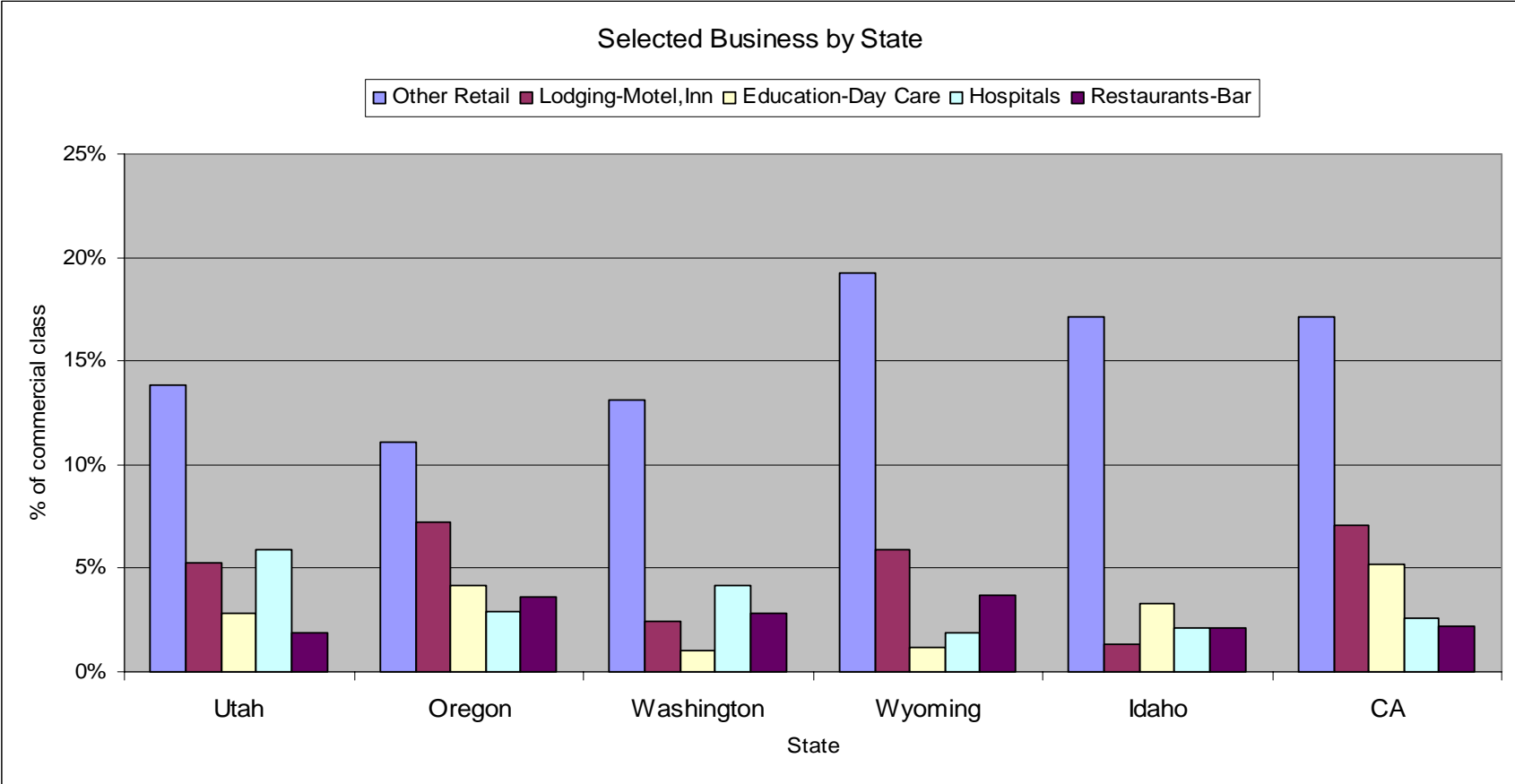
Survey Specifics

- ◆ Last values based on the 1995 Commercial Building Energy Consumption Survey (CBECS) for the Mountain and Pacific Census Region.
 - This is a survey conducted by Energy Information Administration (EIA)
 - Not specific to our service territory

- ◆ New values based on PacifiCorp's Commercial Survey completed Spring 2003
 - Survey done by Market Decisions Corporation of Portland, OR
 - Questions decided by a company committee made up of staff representatives from groups (Load Forecasting, DSM, Customer Service) sponsoring survey and targeted to gather desired information
 - 12,000 accounts sampled
 - 2003 commercial survey sample size selected to satisfy a +/- 10% standard error of the estimate for each market segment within each state with a 90% level of confidence
 - 25% return expected, 20.5% actually returned for 2003 commercial customer survey, ranging from 5% (CA hospitals) to 32% (WA services)

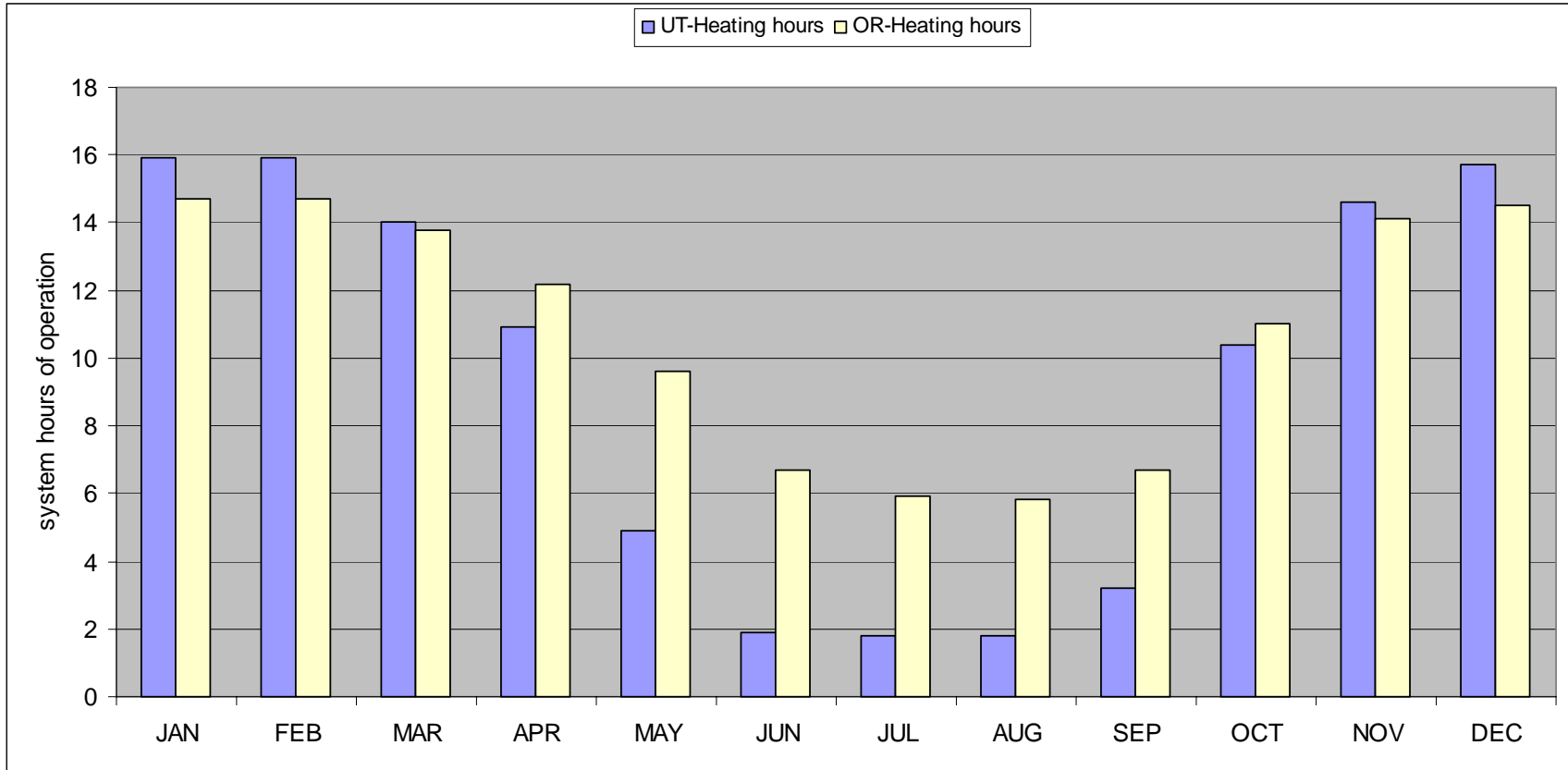
Interesting Observations

Business mix across states is interesting



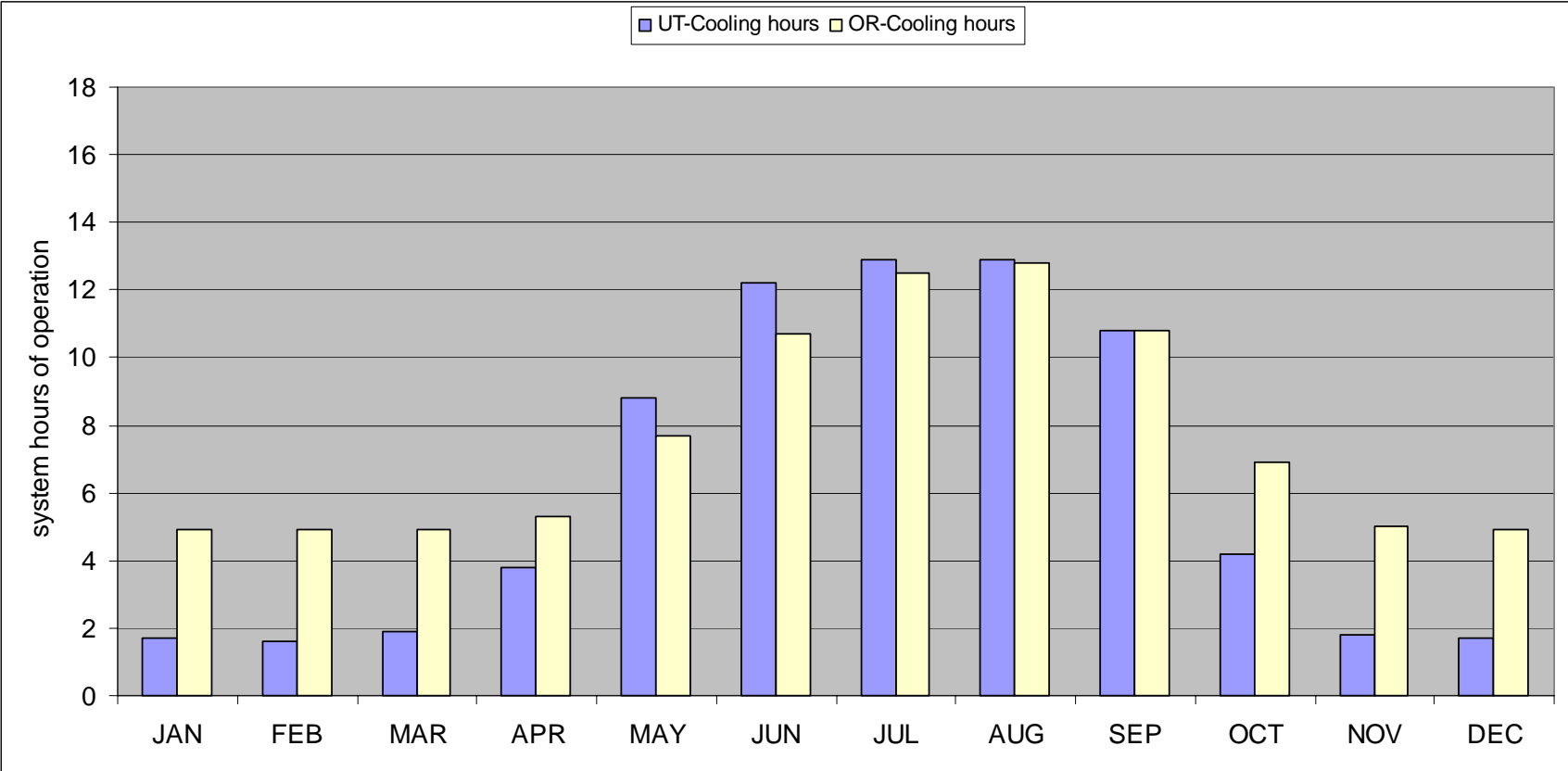
Interesting Observations

East/West Heating and Cooling Patterns are as expected



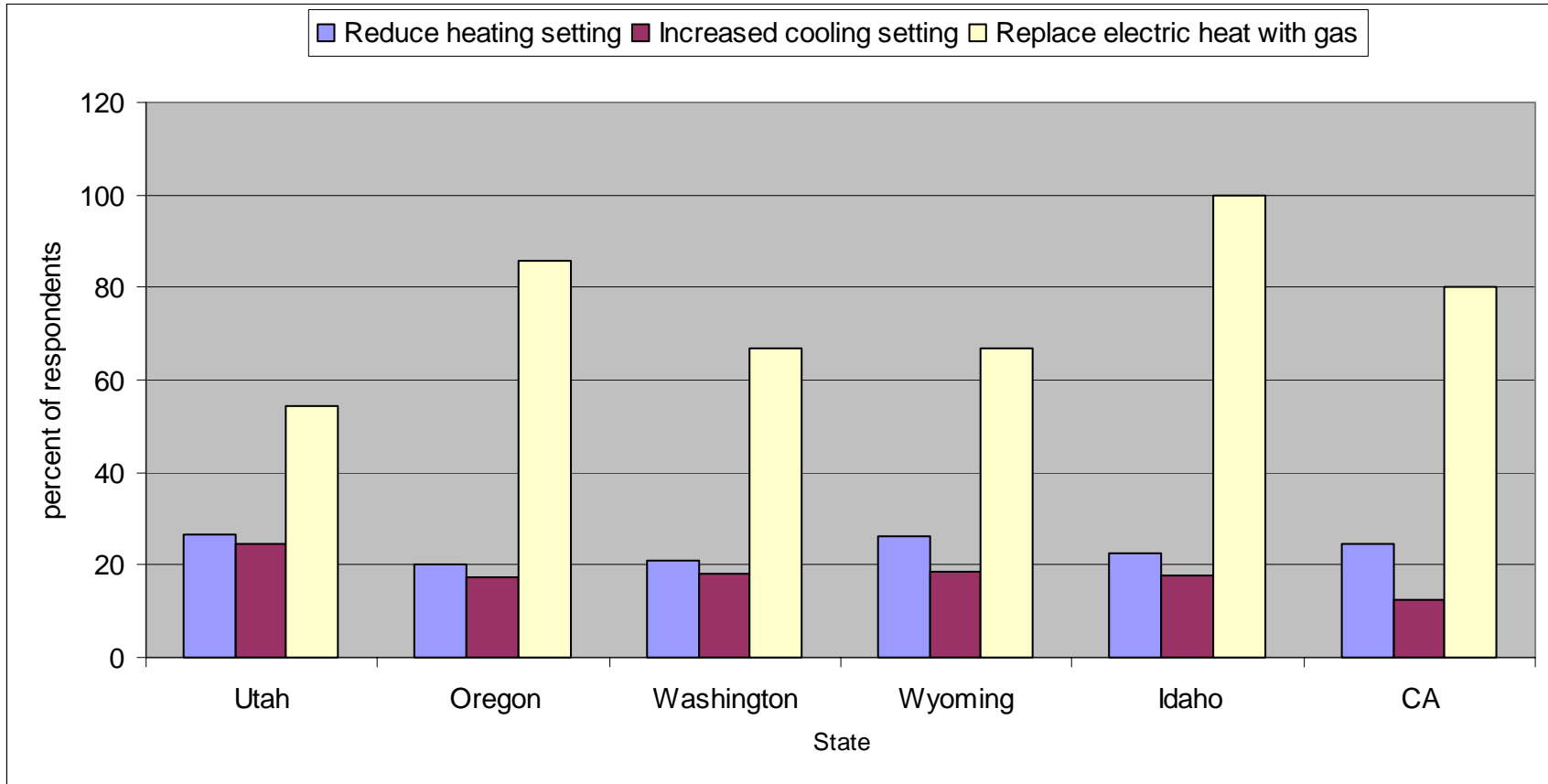
Interesting Observations

Cooling Pattern



Interesting Observations

Conservation/Conversion activity in the last 2 years



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Survey Surprises

- ◆ Low response rates for some states and market segments
- ◆ Survey's sent to corporate headquarters and answered for multiple locations
- ◆ Inconsistent data convention in results dataset
- ◆ Wide distribution of responses for some questions

Lessons Learned

- ◆ PacifiCorp needs to be more involved in the sample development process to eliminate non-routine items in Company records or alter the process to properly account for the non-routine items
 - Send surveys only to customers with a site address
 - Screen out residential customers with small commercial accounts
 - Stratify sampling by usage size
- ◆ Issue with saturation rates being consistent between surveys, working to resolve
 - Inform/expand our survey practice
 - Review CBECS
 - Partner with gas companies
 - Partner with other internal/external surveys
 - Better question leads and answer anchors (e.g., to improve estimations of square feet lit)

Lessons Learned

- ◆ Need a higher response rate by some categories.
 - Understand reasons for low responses (e.g., CA Hospitals)
 - Explore the use of a short-form and long-form survey strategy
 - Clarify criteria or descriptions for respondents to select their business type

- ◆ Data coding improvement are needed
 - Consistent indicators of missing values
 - More user friendly data file structure

Changing Commercial Saturation Rates

(Reed Davis)

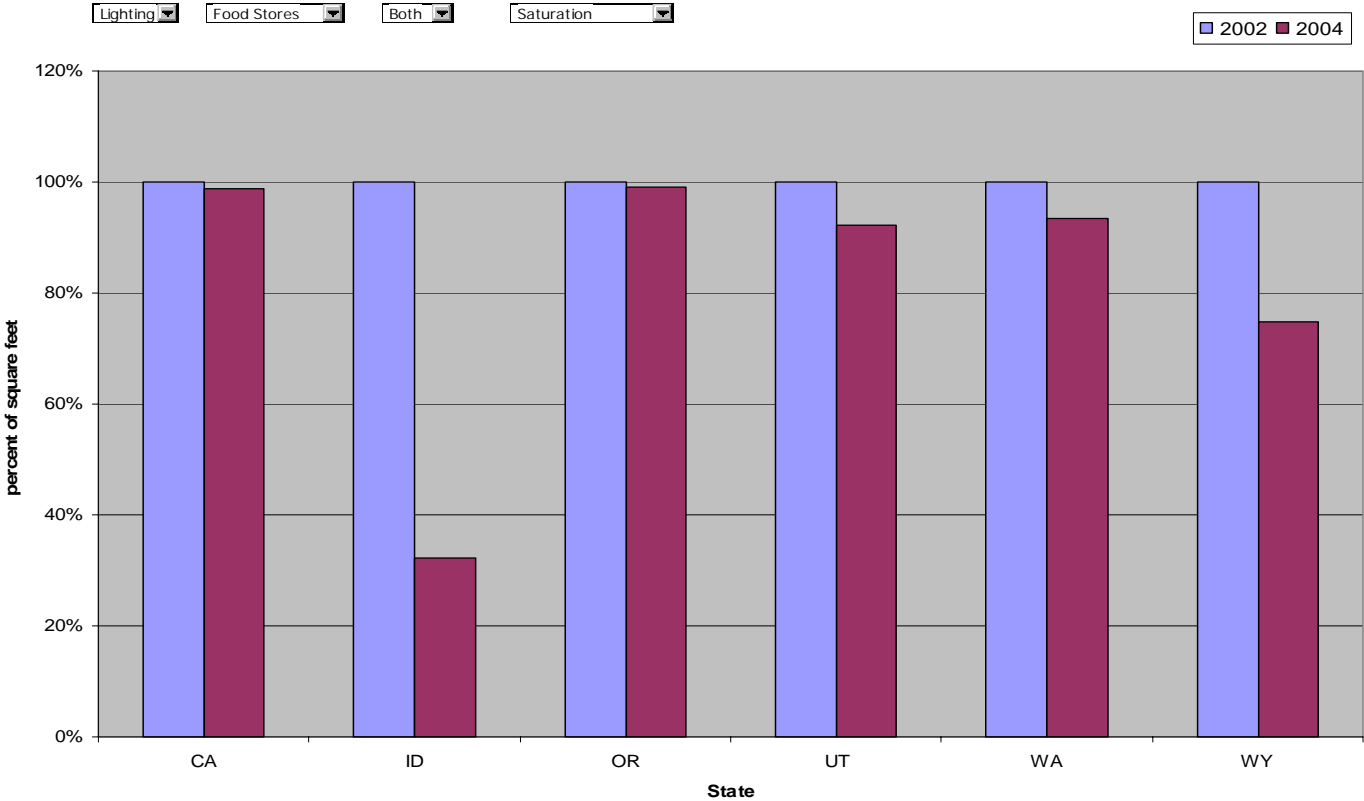


Saturation Specifics

- ◆ Last values based on the 1995 Commercial Building Energy Consumption Survey (CBECS) for the Mountain and Pacific Census Region.
 - This is a survey conducted by EIA
 - Not specific to our service territory
- ◆ New values are based on PacifiCorp's Commercial Survey that was completed in the Spring of 2003
- ◆ Saturation is measured in square feet- not respondents
 - Square feet of positive respondents is divided by entire square feet in category

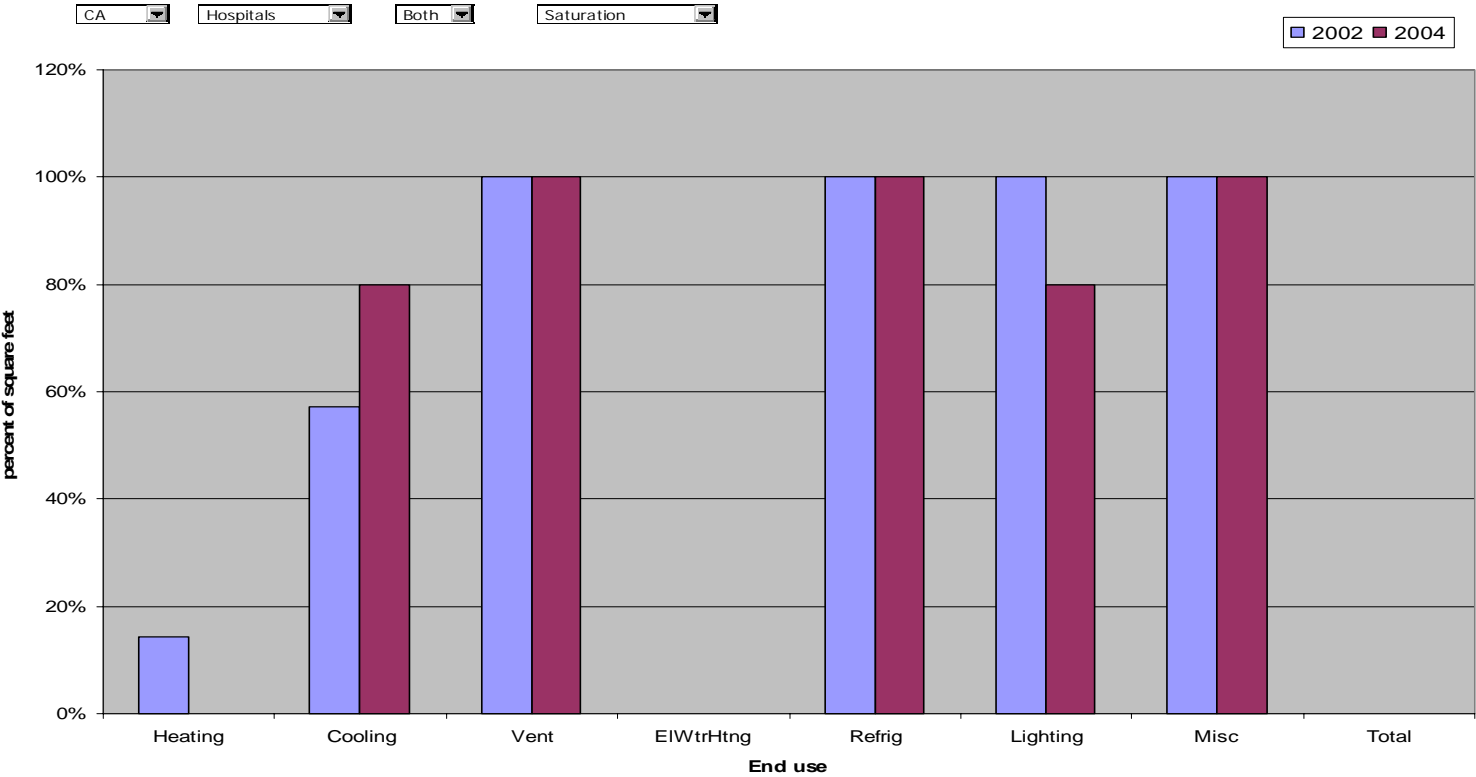
General Observations on survey results

Prior values with 100% Saturation were generally reduced below the 100% level because level of measurement was added into questions



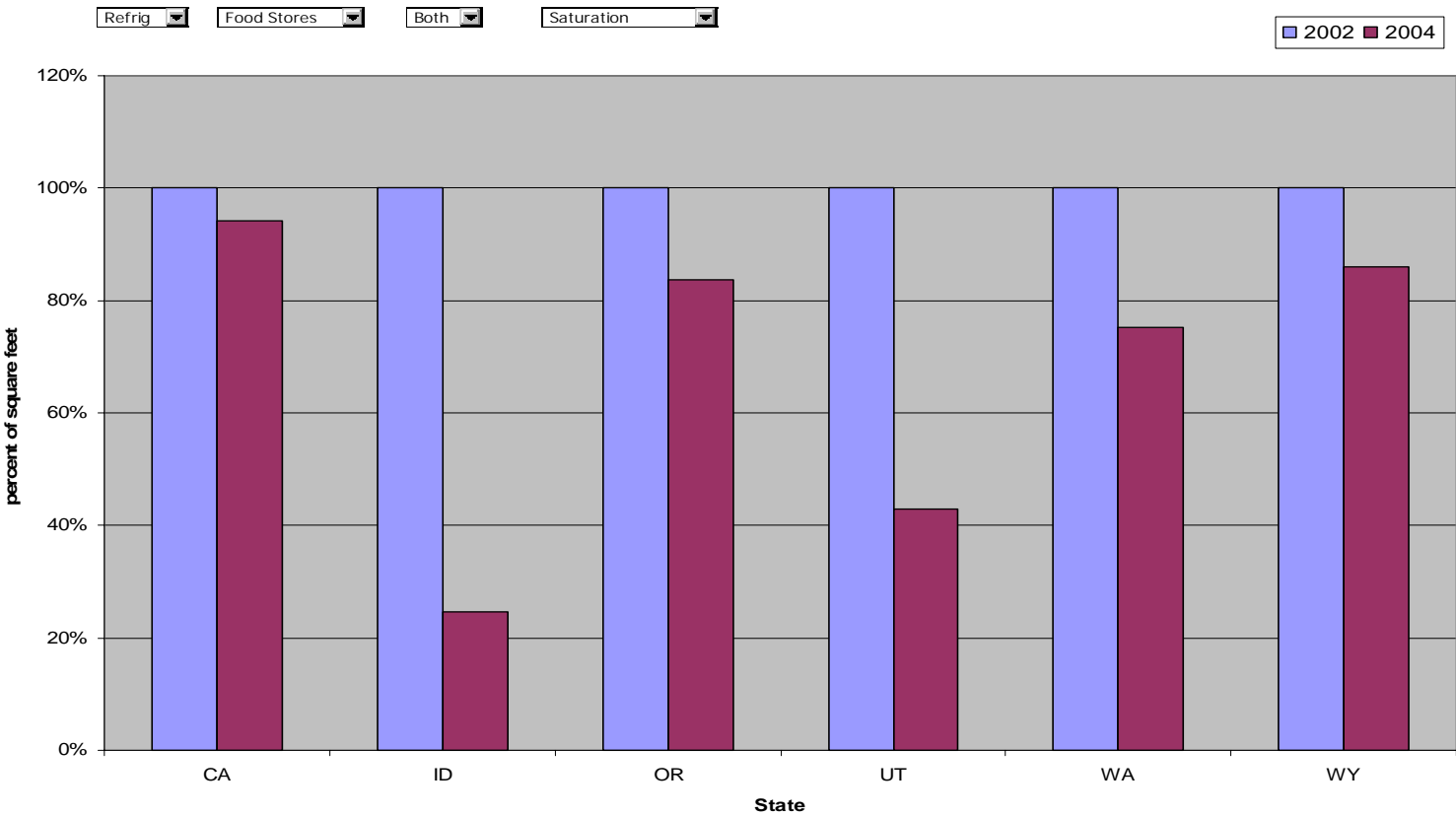
General Observations on survey results

Some saturation measures are suspect due to low response rate in some categories, this requires that we borrow values or rely on old values



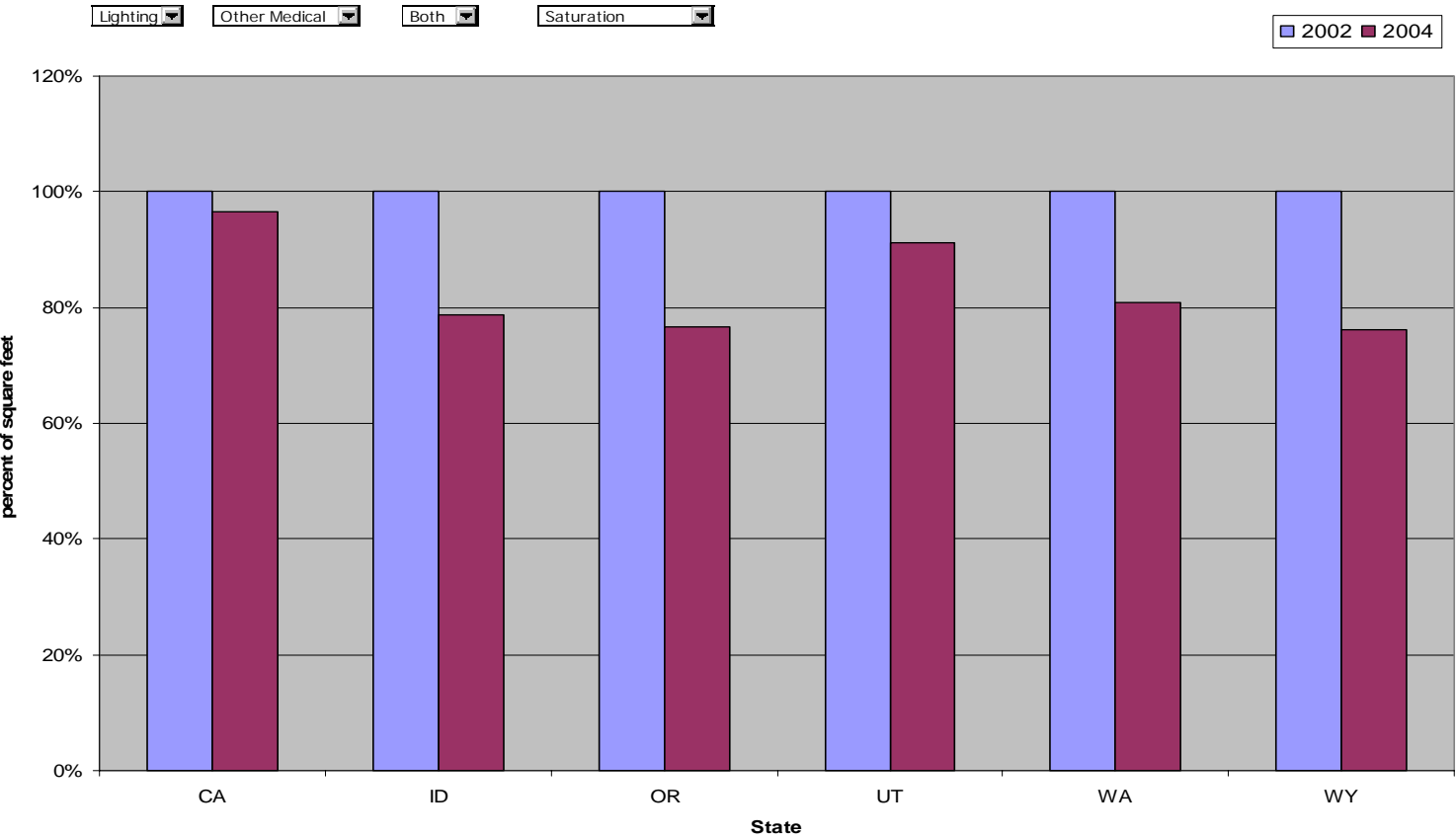
General Observations on survey results

Some had such a wide variety in responses that we wondered how the survey questions were interpreted



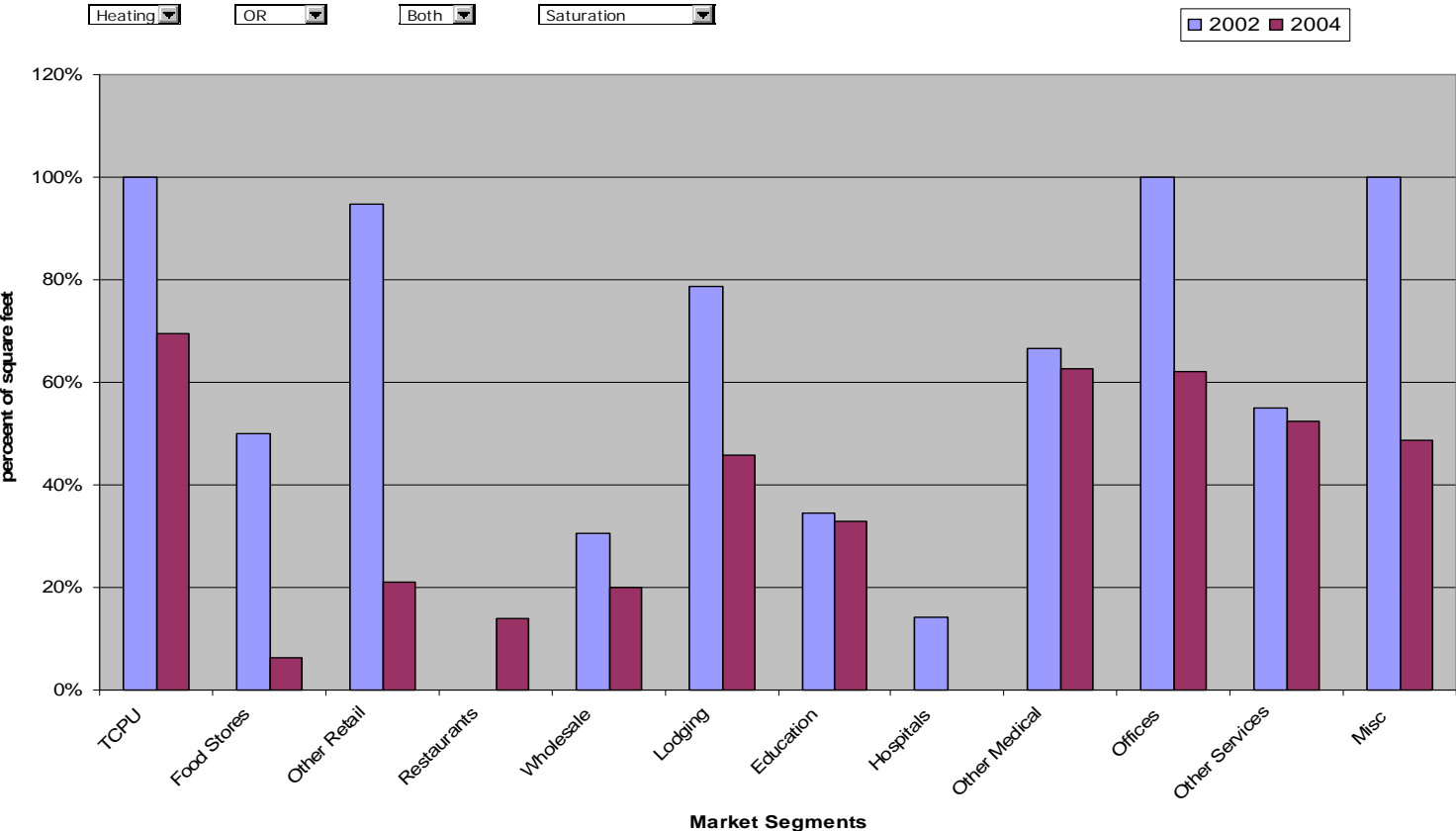
General Observations on survey results

Some seemed very reasonable



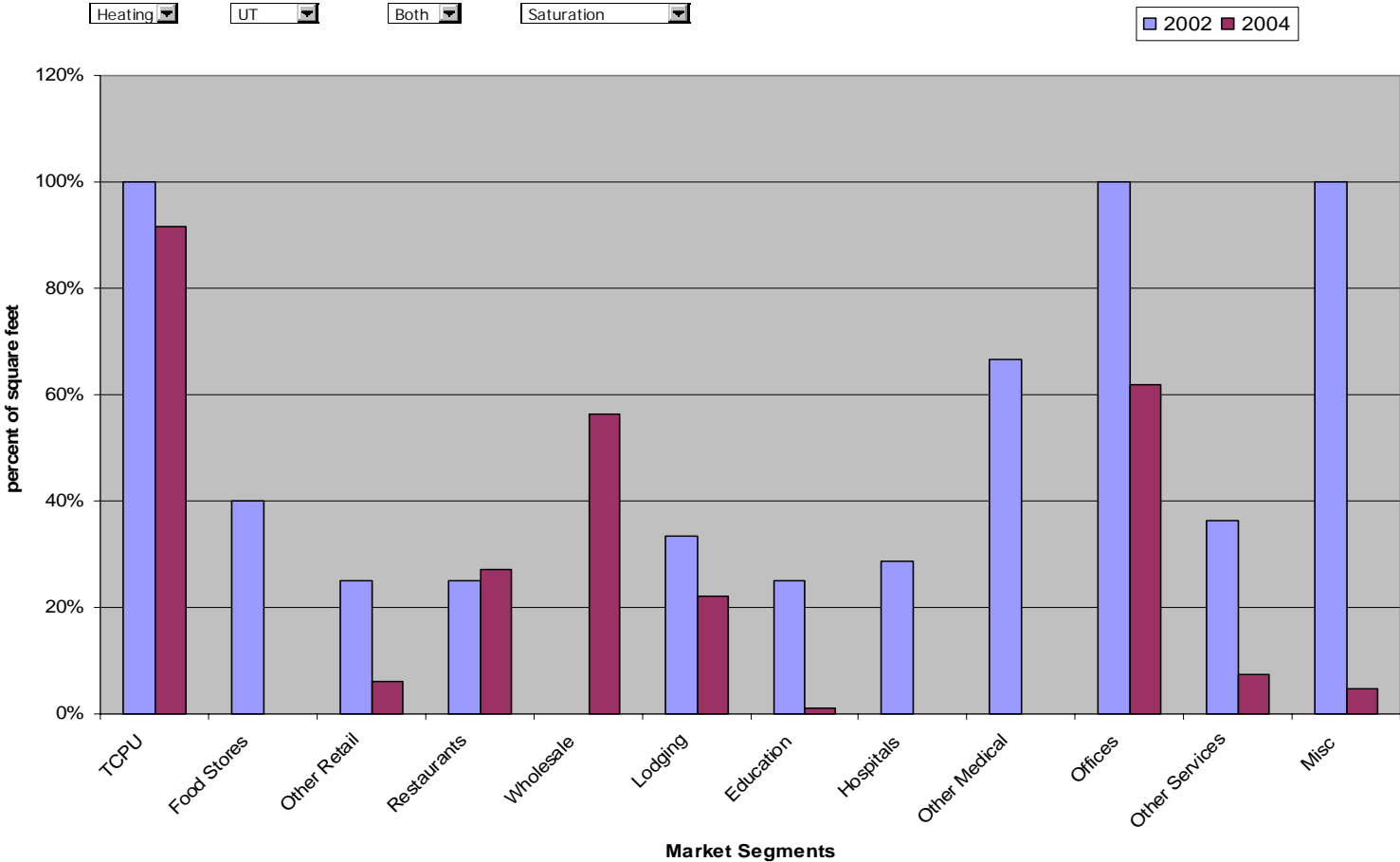
General Observations on Saturation Rates

Heating is generally lower than previously thought
Oregon Electric Heating Saturation Rates



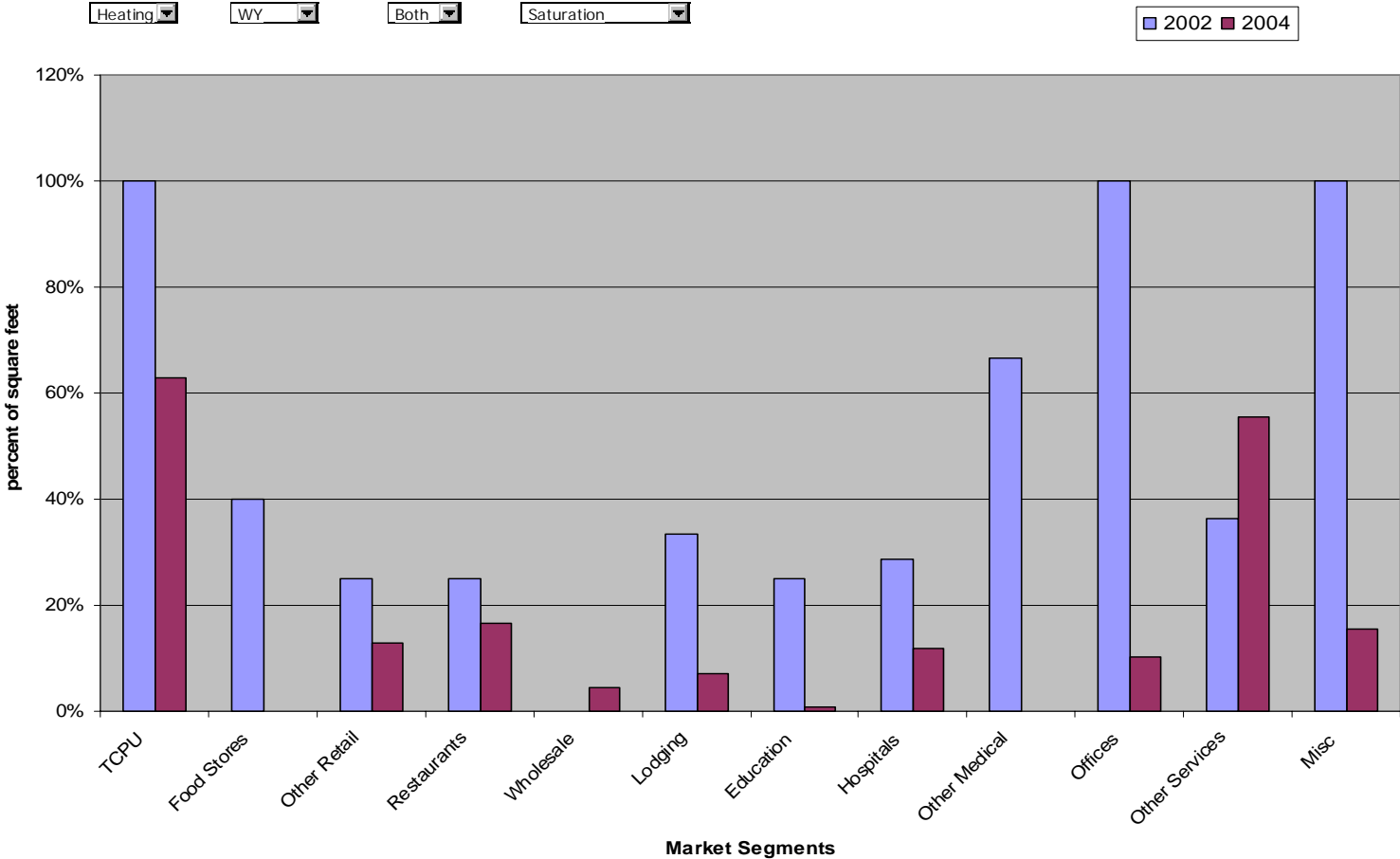
General Observations on Saturation Rates

Utah Electric Heating Saturation Rates



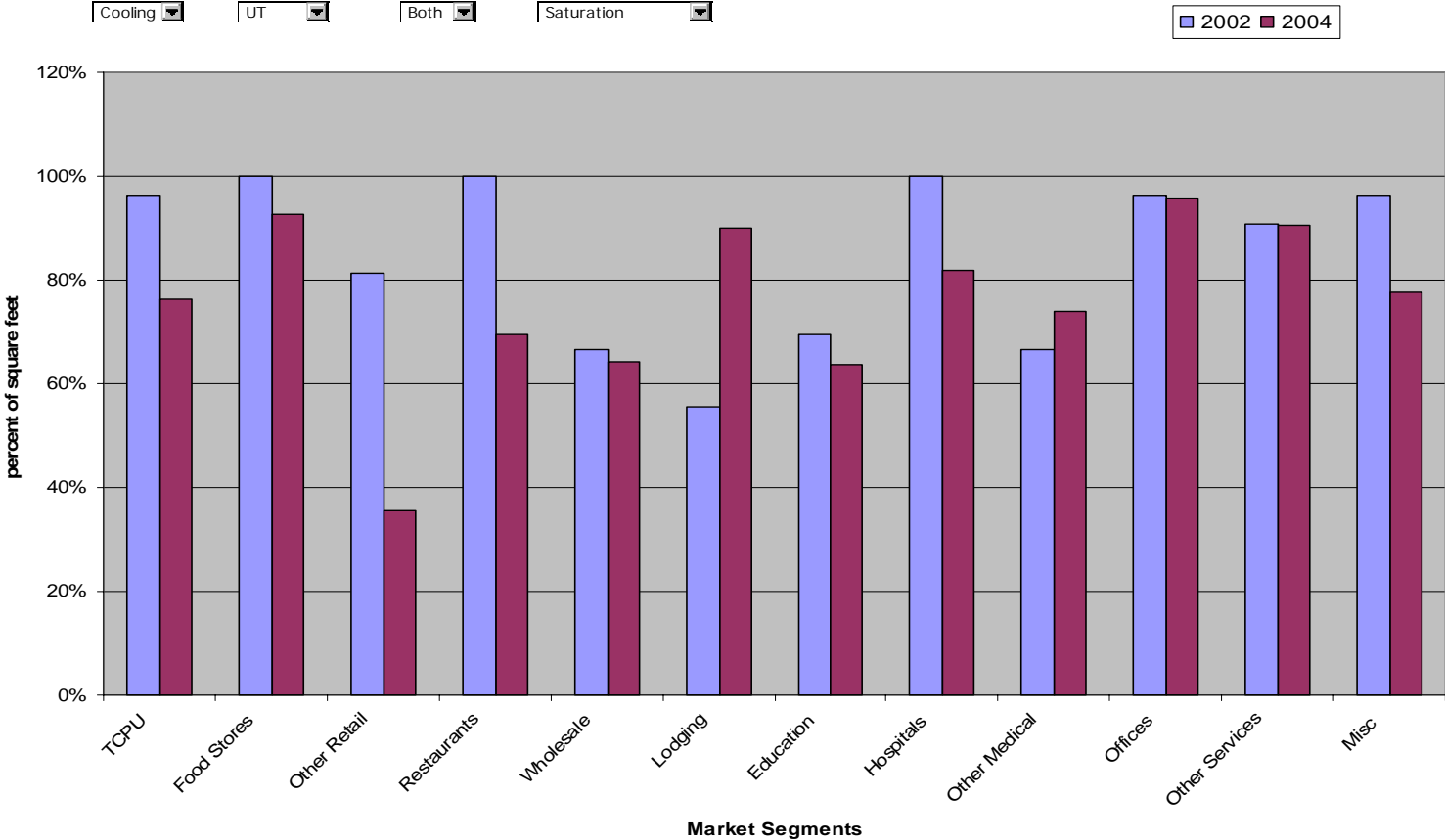
General Observations on Saturation Rates

Wyoming Electric Heating Saturation Rates



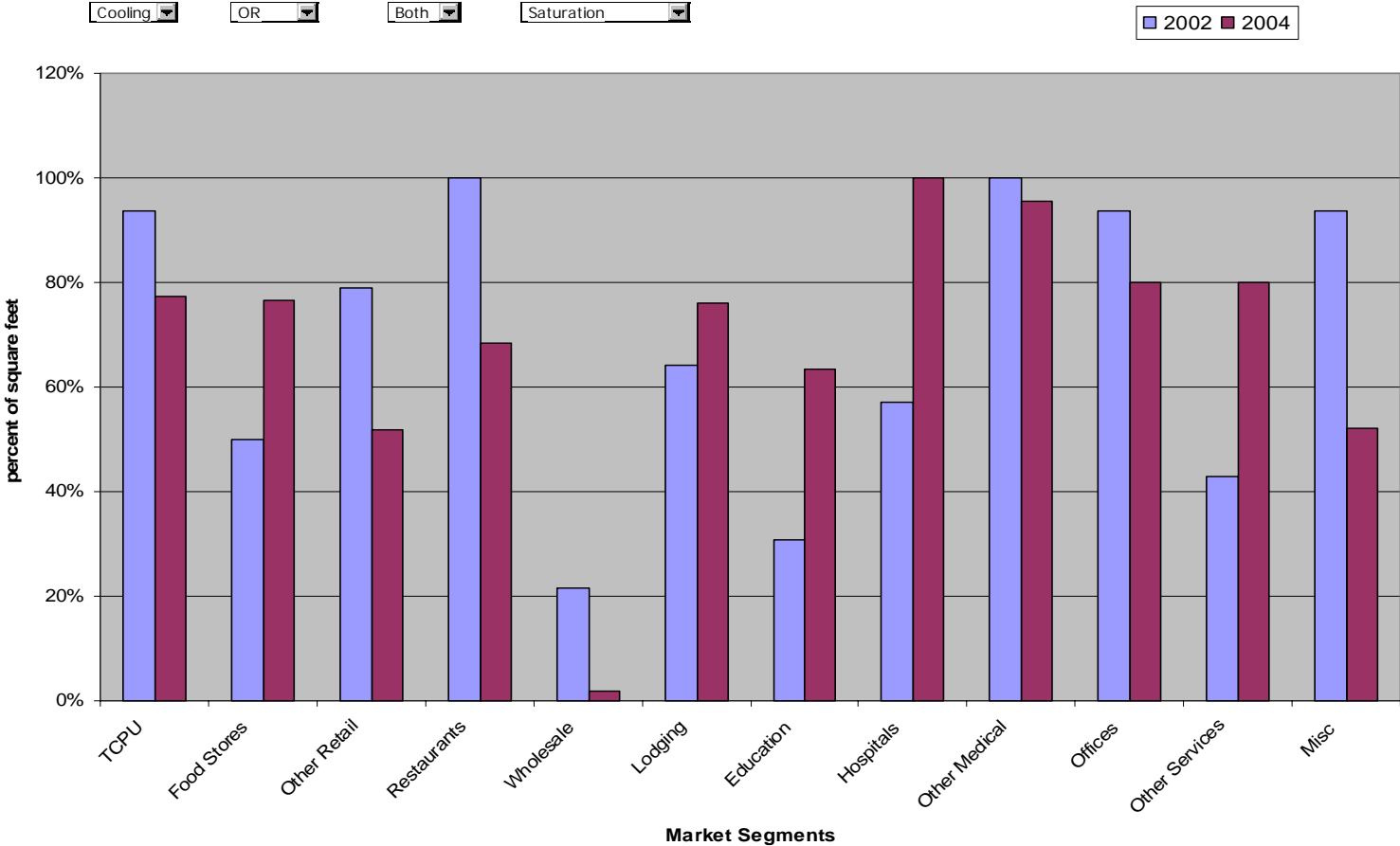
General Observations on Saturation Rates

Cooling is mixed from what was previously thought, but seems reasonable
Utah Electric Cooling Saturation Rates



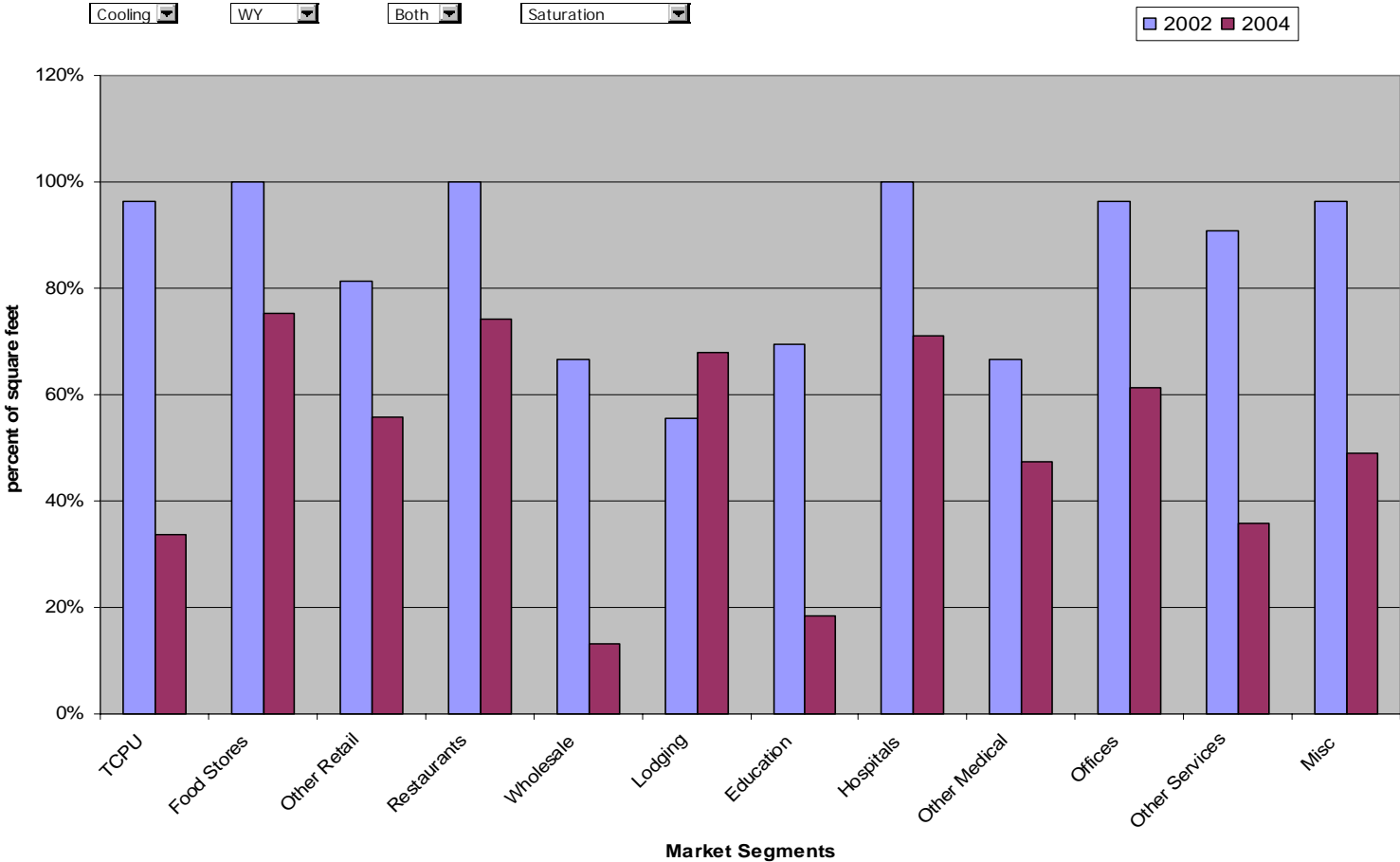
General Observations on Saturation Rates

Oregon Electric Cooling Saturation Rates



General Observations on Saturation Rates

Wyoming Electric Cooling Saturation Rates



Conditional Demand Analysis

(Michael Rife)



Conditional Demand Analysis (CDA)

- ◆ A CDA is a regression technique that expresses usage (or usage per square foot) as a function of end-uses and weather.
 - Cross section regression technique
 - Used to calculate Energy Use Intensity (EUIs) for the commercial sector and Unit Energy Consumption (UECs) for the residential sector.
- ◆ Prior Data
 - For 2002, the EUIs from the CBECS CDA results were used.
 - Mountain region = Utah, Idaho, and Wyoming
 - Pacific region = Oregon, California, and Washington
 - One for each of 13 Market Segments (VMS) and 7 end-uses.
 - For 2002, RECS usage data and survey responses from 1997 for the Mountain and Pacific regions were used to develop CDAs
 - Mountain region represented the Eastern states
 - Pacific region represented the Western states
 - Separated by housing type (Single family, multi-family, mobile homes)
 - Dependent variable was total usage for the end-use

Estimation of Commercial CDAs for 2004

◆ Commercial CDA 2004

- CDAs based on the 2003 commercial survey will be used.
 - Separate CDA equation for each state and VMS
 - Within a VMS equation matches each respondents' 12 months of usage against survey responses.
 - » Allows for better weather responsive/seasonal fit.
 - » EUI is calculated on an annual basis
 - Utah Restaurant Example

Variable	Coefficient
Intercept	-2.115919
Freezers	0.479590
Dishwasher	2.991224
T12 Lighting	0.057349
T8 Lighting	0.066028
Electric Ventilation	0.646834
T12 Lighting/SQRFT	109.6469
Grills/SQRFT	1158.101
CDH*A/C	0.003605
Electric Water Heating*HDH	0.001959
Refrigeration	0.224238
% Interior Lighting	0.016066
Electric Heating	0.379522
# of Refrigerators/SQRFT	279.5901
Ovens/SQRFT	1027.442
R-squared	0.577730

Estimation of Residential CDAs for 2004

◆ Residential CDA 2004

- RECS data was used but there was a suspicion of heteroskedasticity
 - Dependent variable is usage per square foot for the end-use.
 - » A/C, Water Heating, Electric Heat (mobile homes and multi-family) changed
 - Mountain Region Mobile Home Water Heating example

Variable	Coefficient
Intercept	-0.385238
Age of Structure	0.019923
# of Showers per Week	1.146935
# of Household Members per Square Foot	216.7591
R-squared	0.868626

Cautions about CDA estimation

- ◆ Heteroskedasticity (unequal residual variance)
 - Usually discovered by plotting residuals against square feet.
 - Ways to reduce this problem
 - Specify with use per square feet as dependent variable
 - Cross terms and power terms on the right hand side
 - R^2 range
 - Typically lower than time series regression
 - Can range from 0.40 to 0.90+
 - Sometimes it is better to get more end-uses in an equation than to have a high R^2
 - Validation of data
 - Attending User Group Meetings
 - Cross reference values with other sources

A Note about Forecast Influence

- ◆ These CDA processes are used to calculate the EUI's and UEC's
- ◆ The EUIs/UECs presented are the starting values for the last historical/first forecast year.
- ◆ EUIs/UECs often change over the forecast horizon.
 - Decrease for equipment that are expected to have gains in efficiency
 - Increases for equipment that are expected to increase in concentration within the average VMS
- ◆ A higher EUI/UEC than last time does not necessarily mean that the forecast will increase.
 - A commercial end-use forecast is driven by changes over time in
 - Square feet (non-manufacturing employment),
 - Equipment saturations
 - EUI
- ◆ The EUIs/UECs can represent the share of the total energy pie.
 - A higher EUI means that equipment's share has increased.
 - If all EUIs increase by the same percent, then the pie's distribution does not change.

Changing Commercial EUI's

(Michael Rife)



Specifics

- ◆ Conditional Demand Analysis (CDA) performed on 2003 survey participants using survey results.
- ◆ Through the CDA energy use intensity (EUI) values can be calculated which measures the kWh per square foot usage of a commercial end-use (equipment).
- ◆ EUIs are calculated for
 - 7 end-uses (Heating, Cooling, Ventilation, Electric Water Heating, Lighting, Refrigeration and Miscellaneous)
 - 13 VMSs, e.g., Offices, Restaurants.
 - Each of the six states
- ◆ Important variables for the CDA include weather, cooling and heating equipment, office equipment, interior and exterior lighting, square feet.

Reasons for Changing EUIs

◆ Census Region vs. Service Area Specific Information

- Mountain Census Region includes everything from Montana through Arizona and New Mexico. Pacific Census Region includes Alaska and Hawaii along with Oregon and Washington.
 - Influences Saturation Rates.
 - CDA changed from EIA for the census region to state specific CDAs.

◆ Weather Input Change

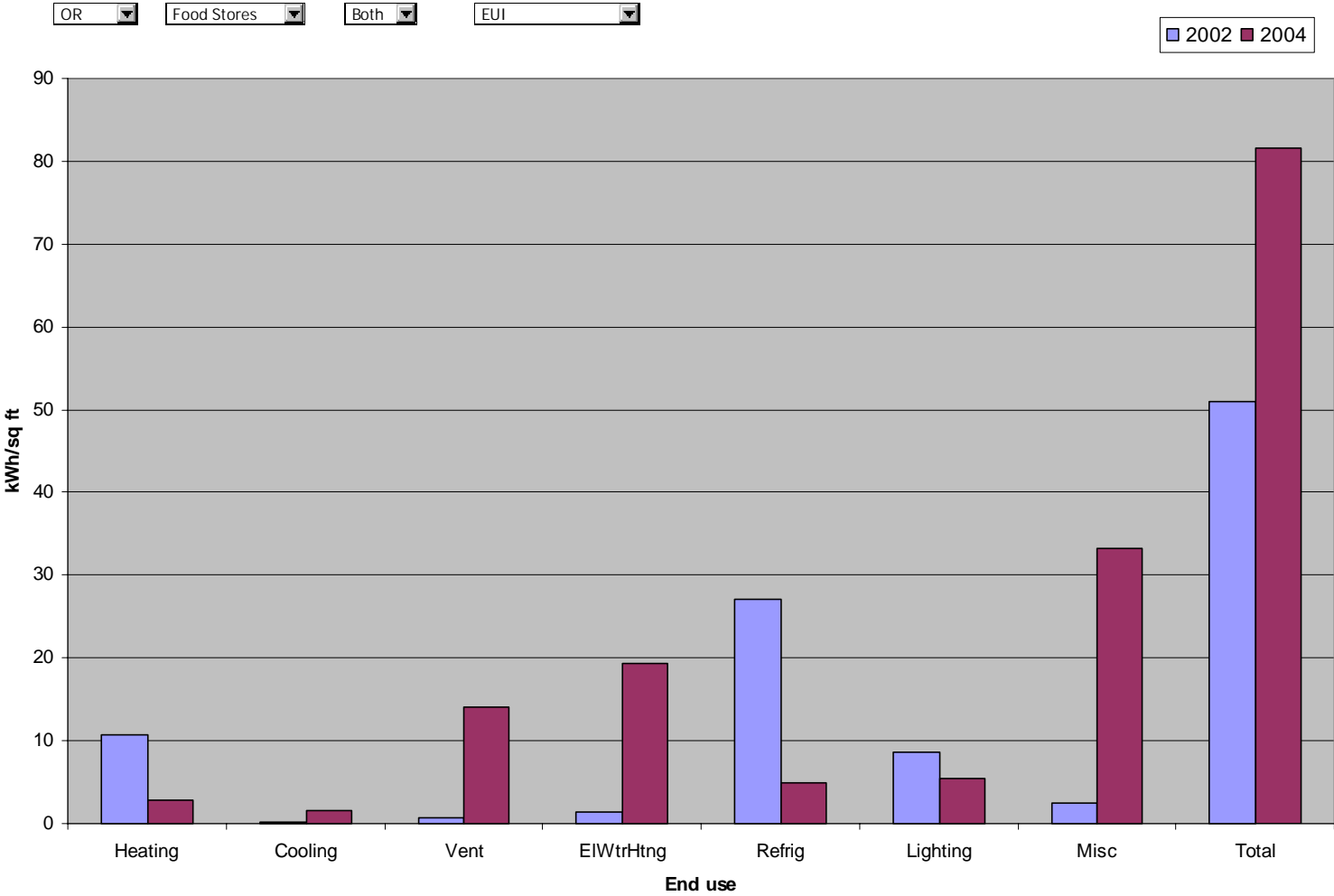
- For 2002 all Western states used Portland weather information
- For 2004 Medford was used for Oregon and California; Yakima for Washington
- For 2002 all Eastern states used Salt Lake City weather information
- For 2004 Salt Lake City was used for Utah, Pocatello for Idaho, and Casper for Wyoming.
- Influences Electric Heating and Water Heating EUIs.

Oregon EUI summary for all VMS

◆ Increases (change generally > +20%)

- Electric Heating
- Air Conditioning
- Ventilation
- Water Heating
- Refrigeration
- Lighting
- Miscellaneous

EUIs for Oregon Food Stores



Utah EUI summary for all VMS

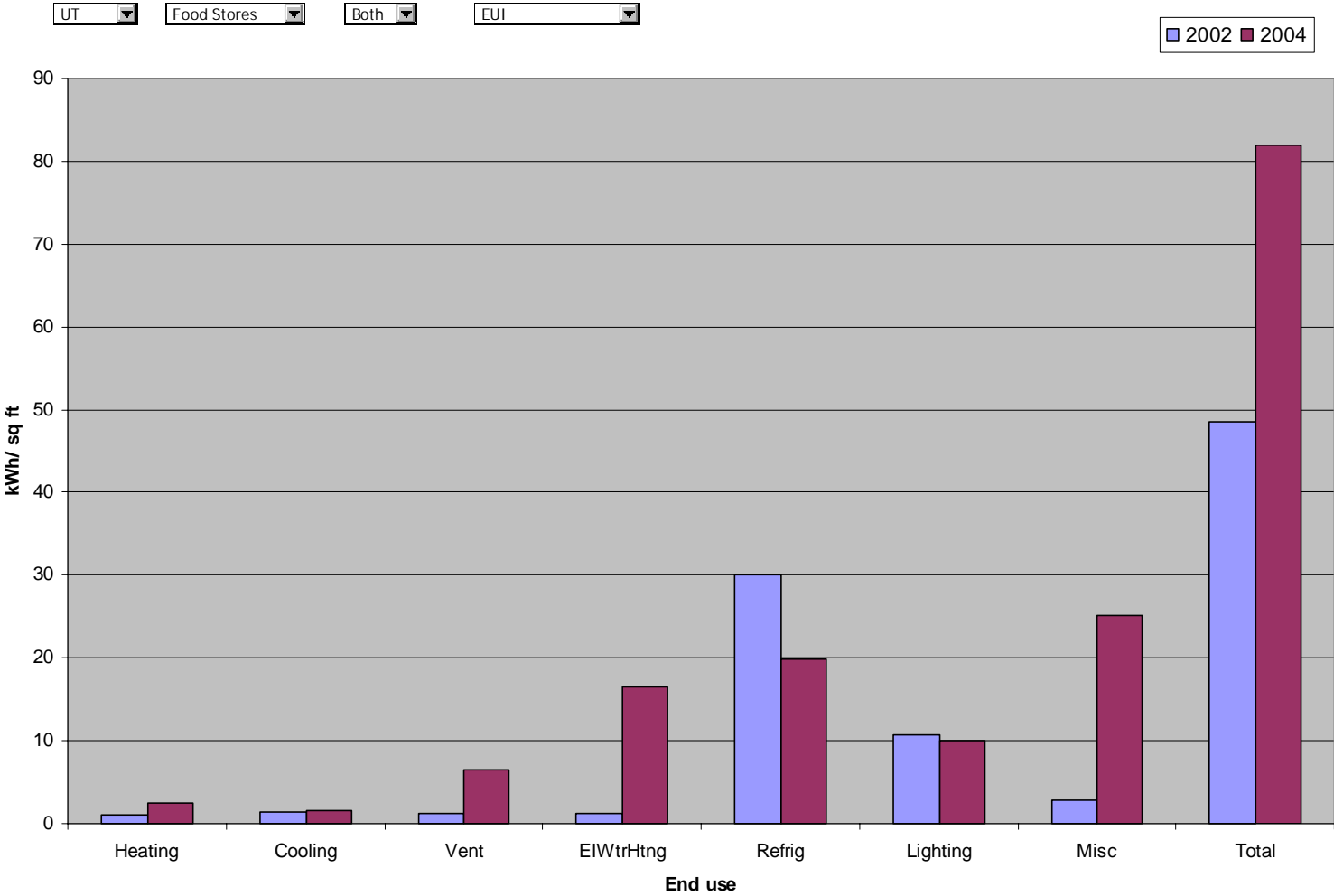
◆ Increases (change generally > +20%)

- Air Conditioning
- Ventilation
- Water Heating
- Refrigeration
- Miscellaneous

◆ Little Change (< +/- 20%)

- Electric Heating
- Lighting

EUIs for Utah Food Stores



Washington EUI summary for all VMS

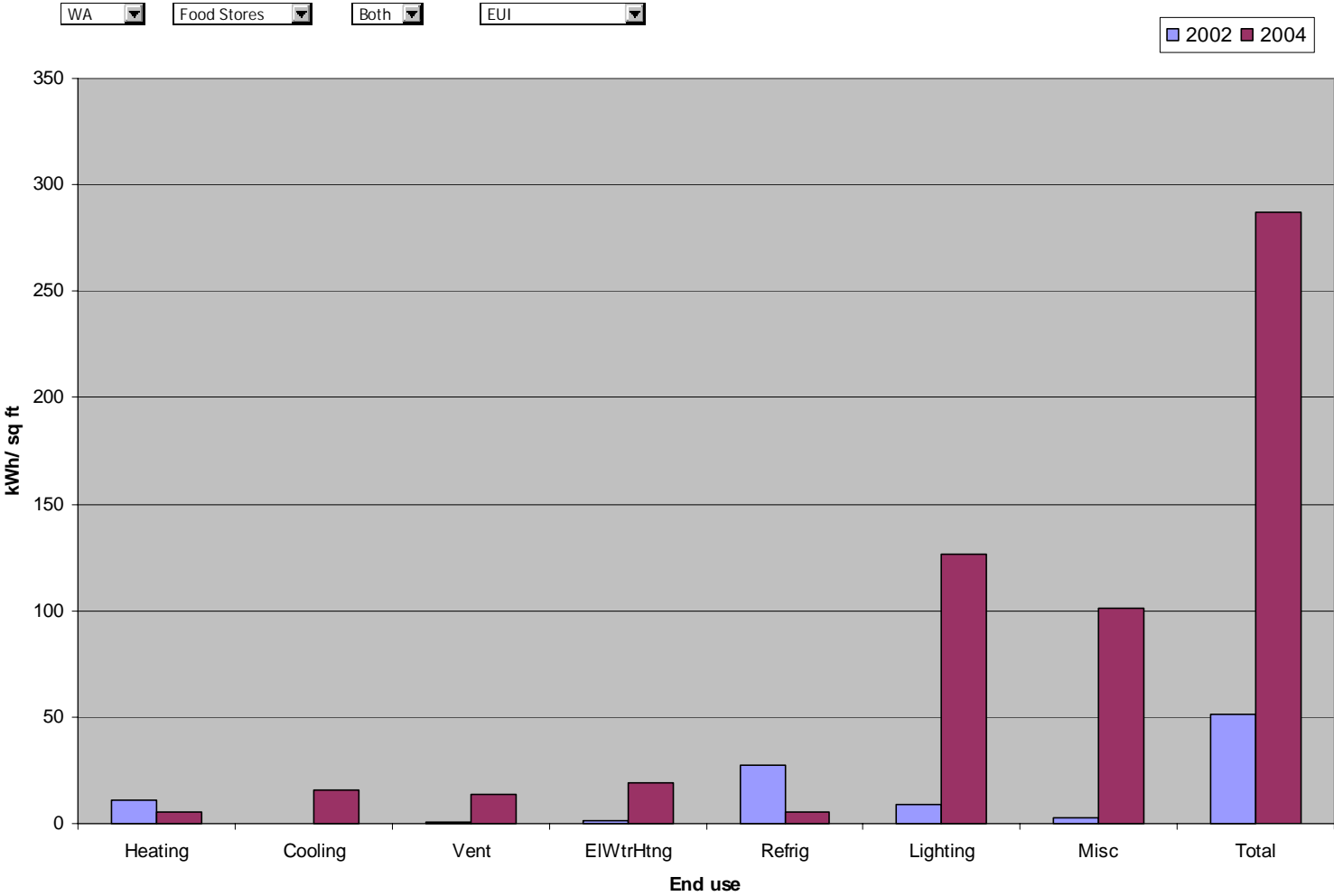
◆ Increases (change generally > +20%)

- Electric Heating
- Air Conditioning
- Ventilation
- Water Heating
- Lighting
- Miscellaneous

◆ Little Change (< +/- 20%)

- Refrigeration

EUIs for Washington Food Stores



Wyoming EUI summary for all VMS

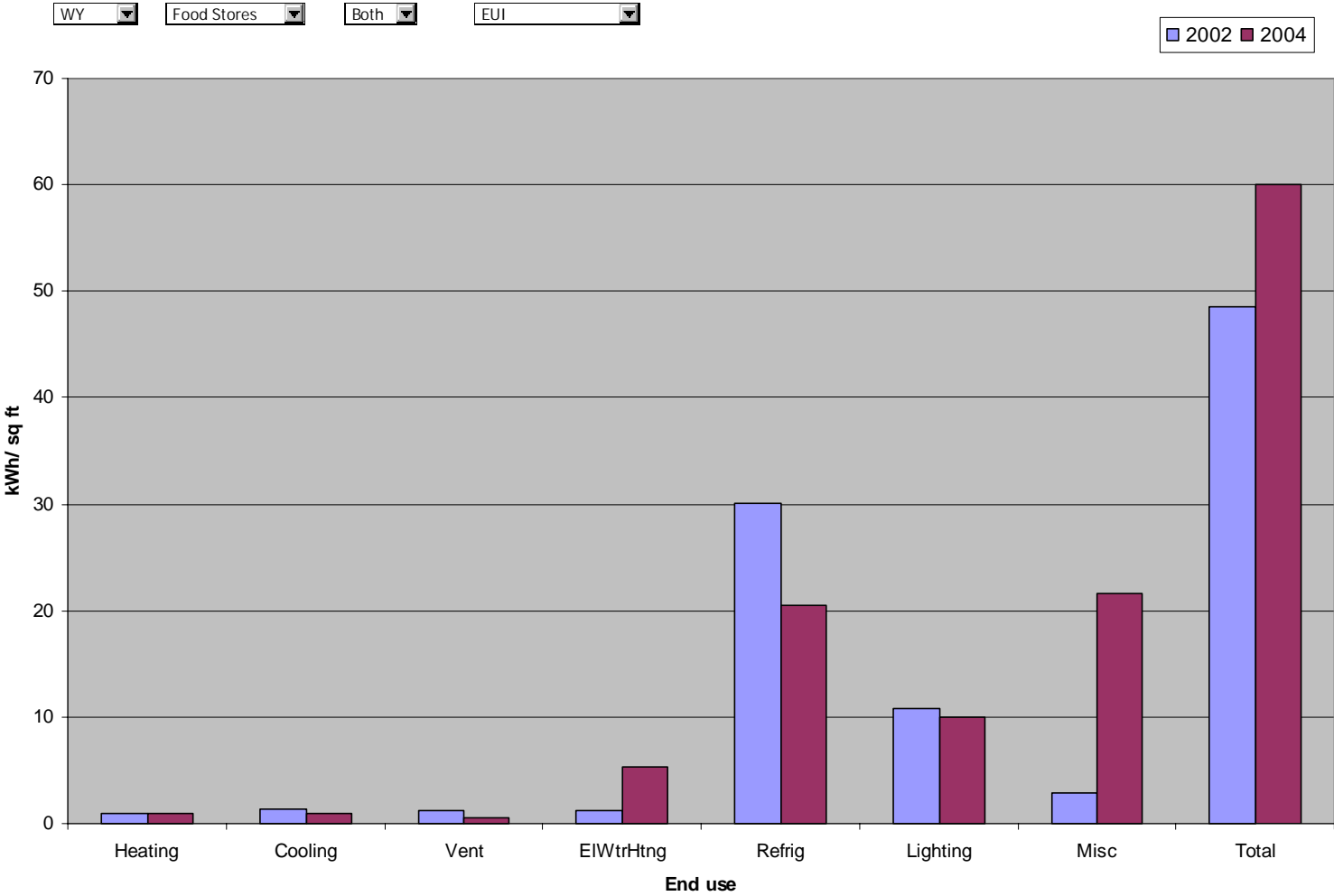
◆ Increases (change generally > +20%)

- Electric Heating
- Ventilation
- Water Heating
- Refrigeration
- Miscellaneous

◆ Little Change (< +/- 20%)

- Air Conditioning
- Lighting

EUIs for Wyoming Food Stores



California EUI summary for all VMS

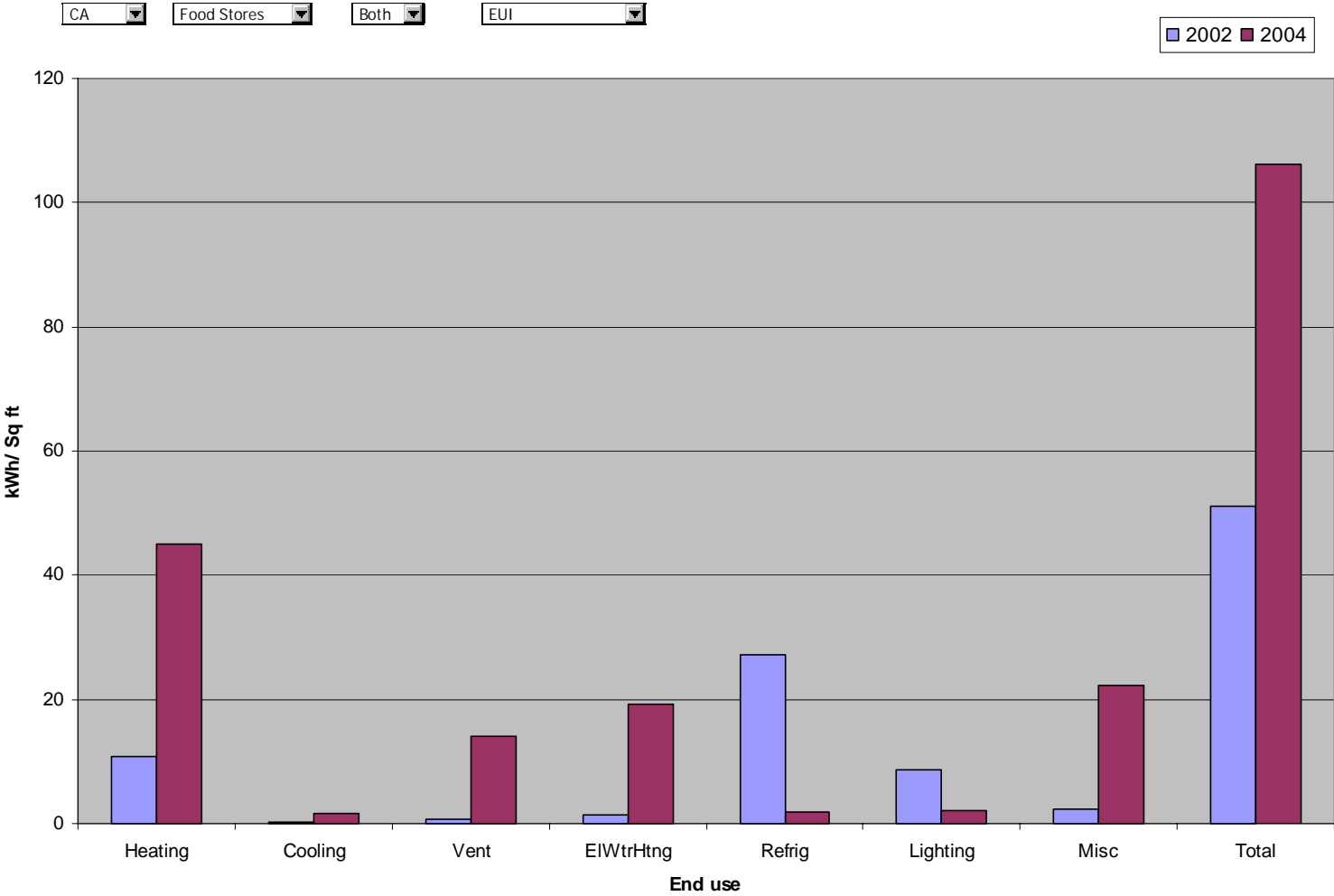
◆ Increases (change generally > +20%)

- Electric Heating
- Ventilation
- Water Heating
- Refrigeration
- Miscellaneous

◆ Decreases (change generally < -20%)

- Air Conditioning
- Lighting

EUIs for California Food Stores



Idaho EUI summary for all VMS

◆ Increases (change generally > +20%)

- Electric Heating
- Air Conditioning
- Ventilation
- Water Heating

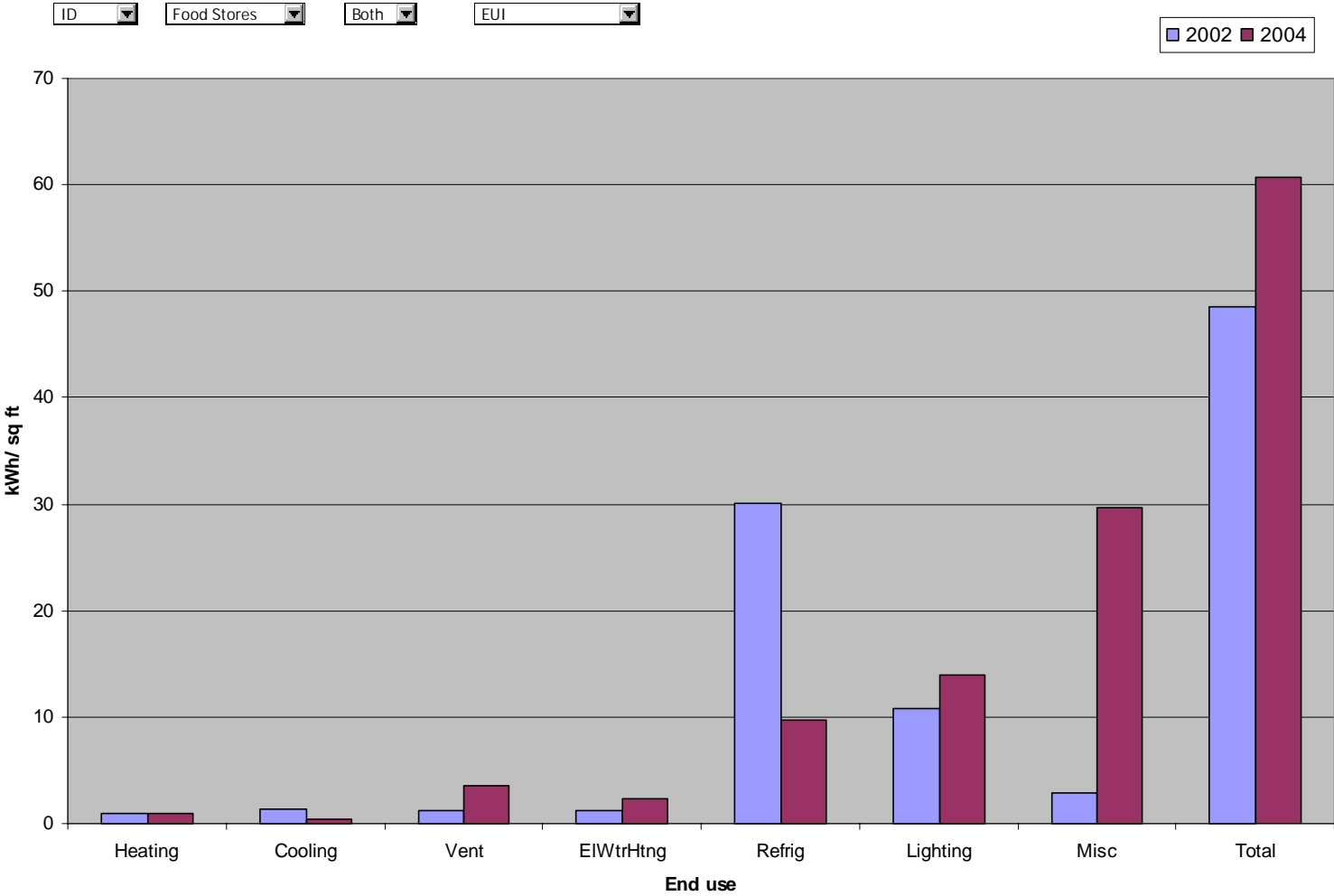
◆ Decreases (change generally < -20%)

- Lighting

◆ Little Change (< +/- 20%)

- Refrigeration
- Miscellaneous

EUIs for Idaho Food Stores



Residential Saturation's

(Heather Talbot)

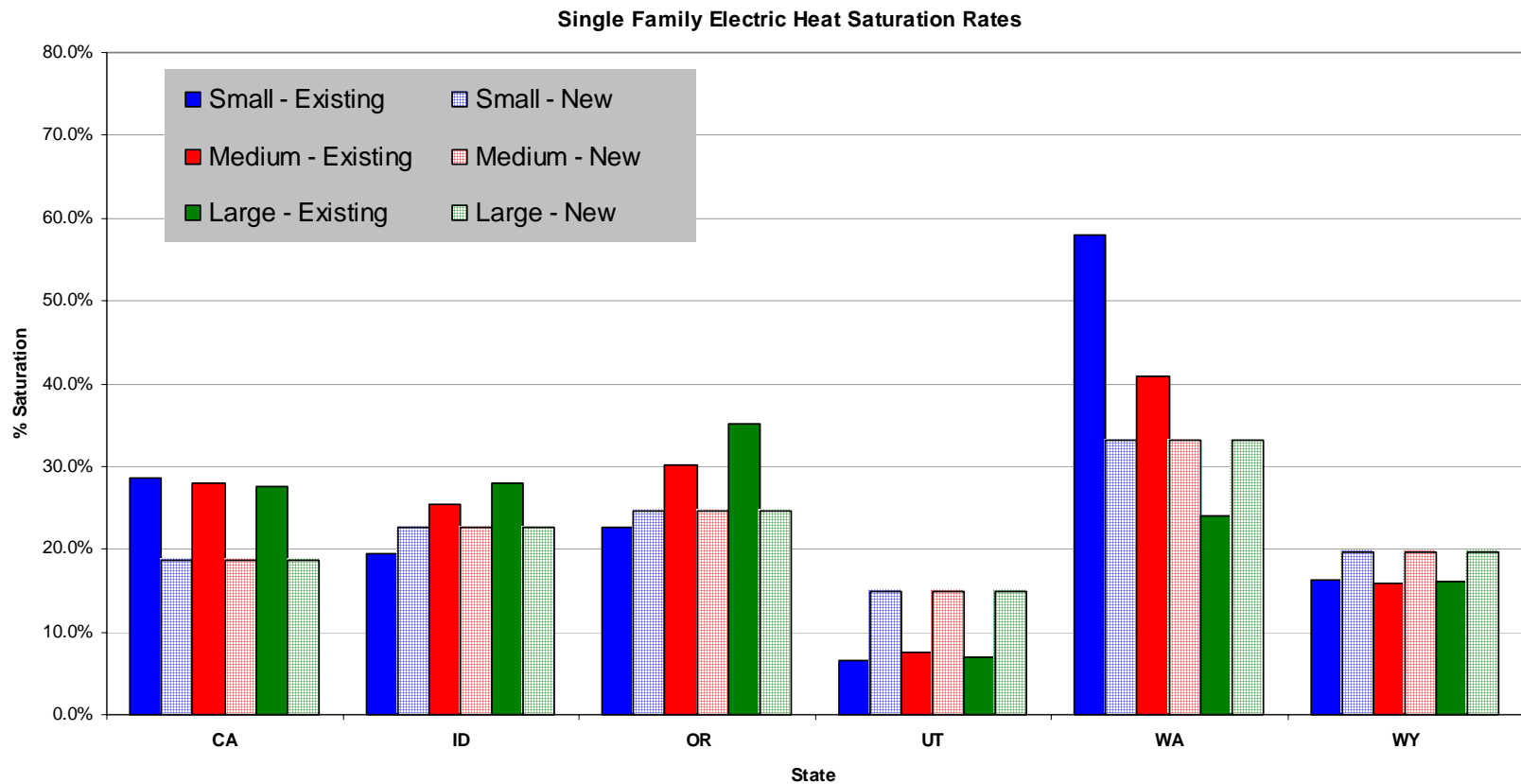


Specifics

- ◆ Based on PacifiCorp's Residential Appliance Saturation survey of 2001
- ◆ Existing structure saturation rates based on survey results for all structures
- ◆ New housing structure saturation rates based on survey results for houses built since 1990 or appliances purchased since 1990.
- ◆ Residential Appliance Saturation survey occurs every other year, next one is scheduled for Spring of 2004

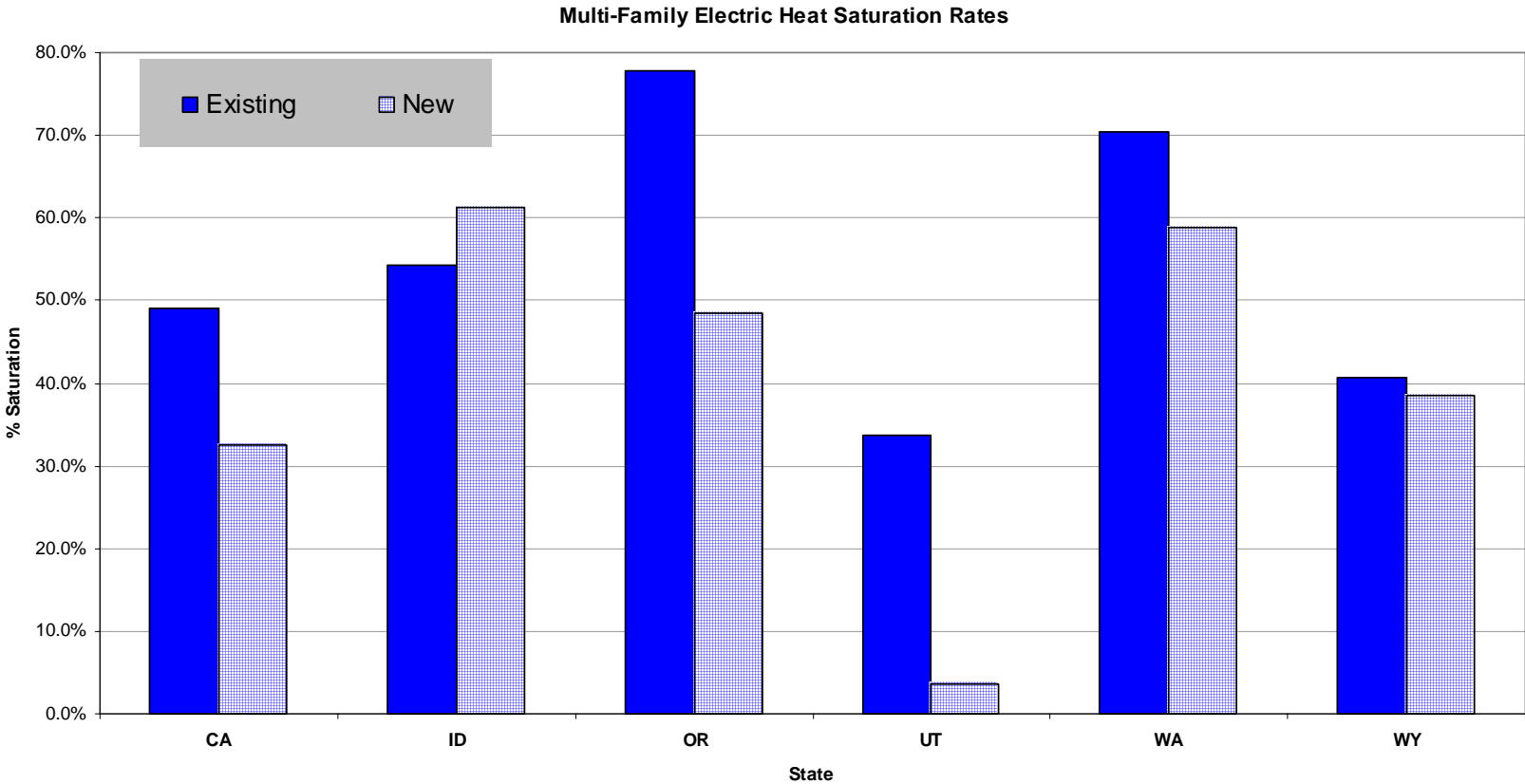
Single Family Electric Heat

- Electric heating saturation has generally gone down in all states (with the largest decreases occurring in Washington's);
- Utah and Wyoming however have realized an increase in electric heat saturation.



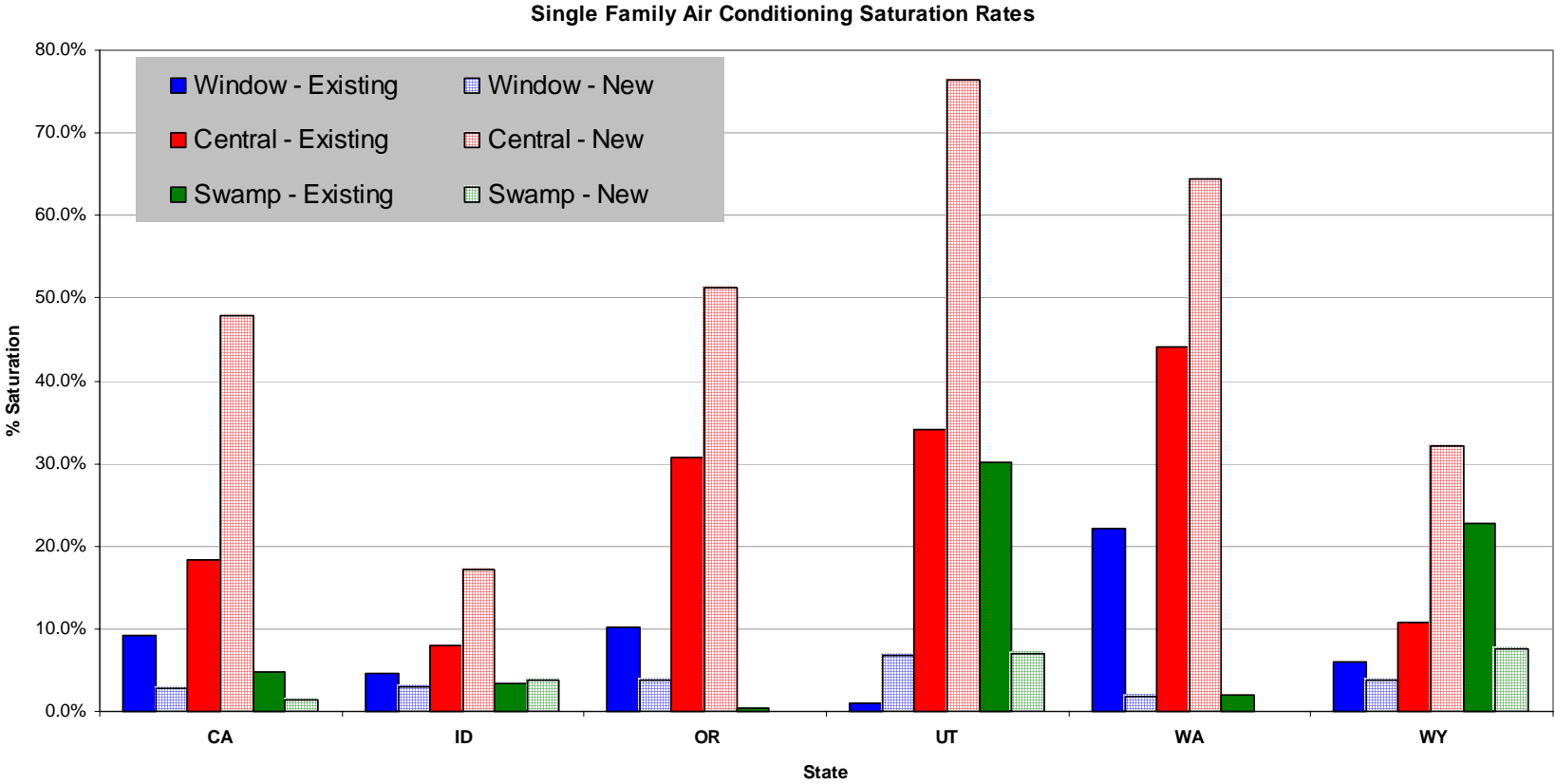
Multi-Family Electric Space Heat

- Multi-Family home electric heat saturation rates are higher for existing homes than for new homes; except in Idaho where there is a slight increase



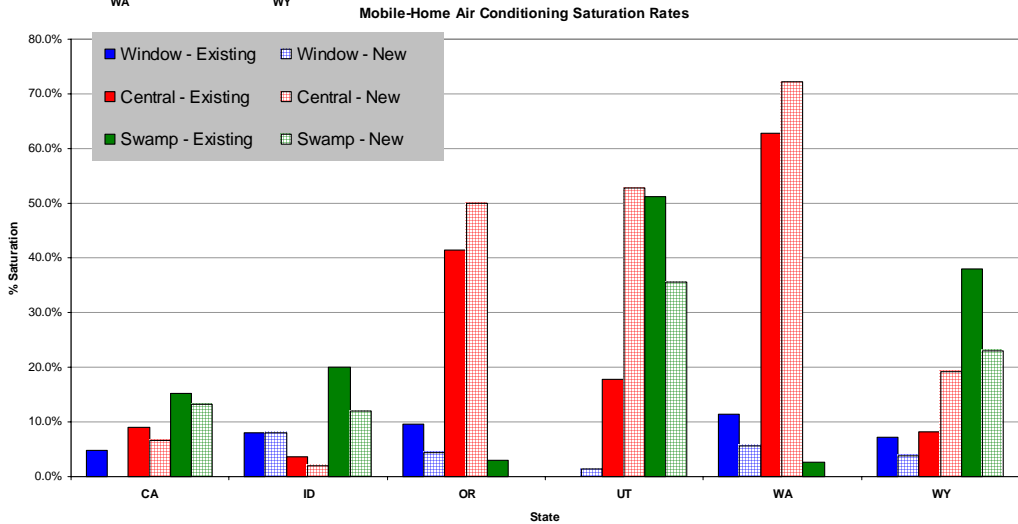
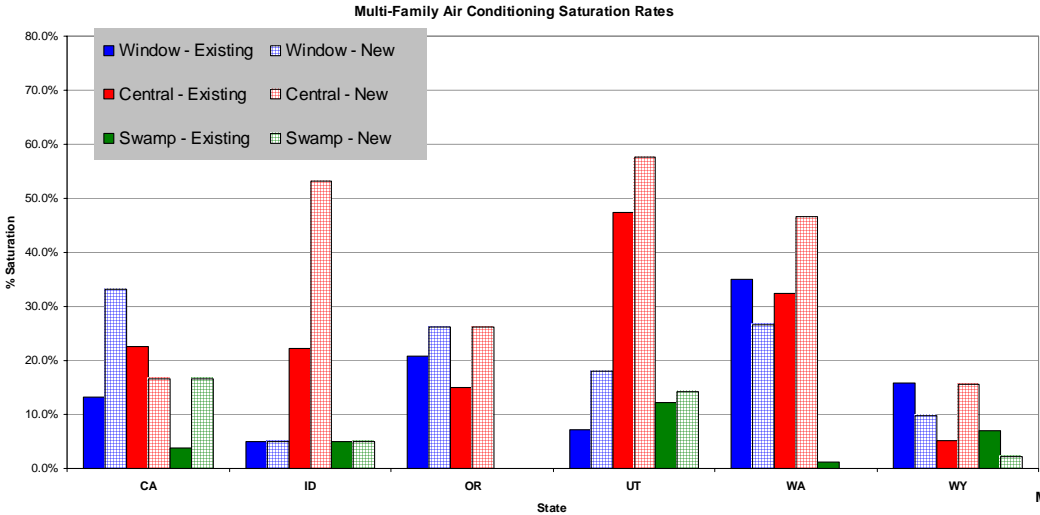
Single Family Air Conditioning

- Central Air Conditioning has the highest saturation rates for both existing and new homes in all states; largest saturation rates occur in California, Oregon, Washington & Utah



Multi-Family/Mobile Home Air Conditioning

•Multi-Family home and Mobile homes have high saturation rates for AC in Oregon, Utah, and Washington



Residential UEC's

(Kevin Cline)



Unit Energy Consumption (UEC)

- ◆ Unit energy consumption (UEC) for an end-use is defined as the amount of energy (kWh) that end-use consumes in one year
- ◆ Example: assume a central A/C unit for a single family home consumes 1,500 kWh per year, the UEC for this central A/C unit is 1,500
- ◆ UECs are calculated using the conditional demand technique presented earlier
- ◆ Variables that help determine UECs: housing unit size, weather, number of members in household, age of housing unit, age of equipment, and others
- ◆ UECs for a given end-use will be calculated for each of the states PacifiCorp serves (CA, ID, OR, UT, WA, WY) and for three housing types (Single Family, Multi-family, Mobile Homes)

Reasons for Change

- ◆ Attempted to resolve heteroskedasticity problem mentioned earlier by specifying models with use per square foot as the dependent variable
- ◆ Used results from 2001 Energy Decisions residential customer survey to calculate UECs, replacing 1997 RECS (Residential Energy Consumption Survey) data
- ◆ Used weather data from Medford for OR and CA, Yakima for WA, SLC for UT, Casper for WY, Pocatello for ID; replacing Portland for the West system and SLC for the East system

Residential UECs with Little or No Change

- ◆ UECs for Single Family space heating (all states) remain unchanged
- ◆ UECs for electric cooking, dryers, dishwashers, refrigerators, and freezers remain unchanged for all states and housing types
- ◆ UECs for well pumps, waterbeds, and hot tubs were calculated using the aforementioned survey data, but did not change much

Oregon - Notable UEC Changes

◆ Single Family

- Central A/C increases

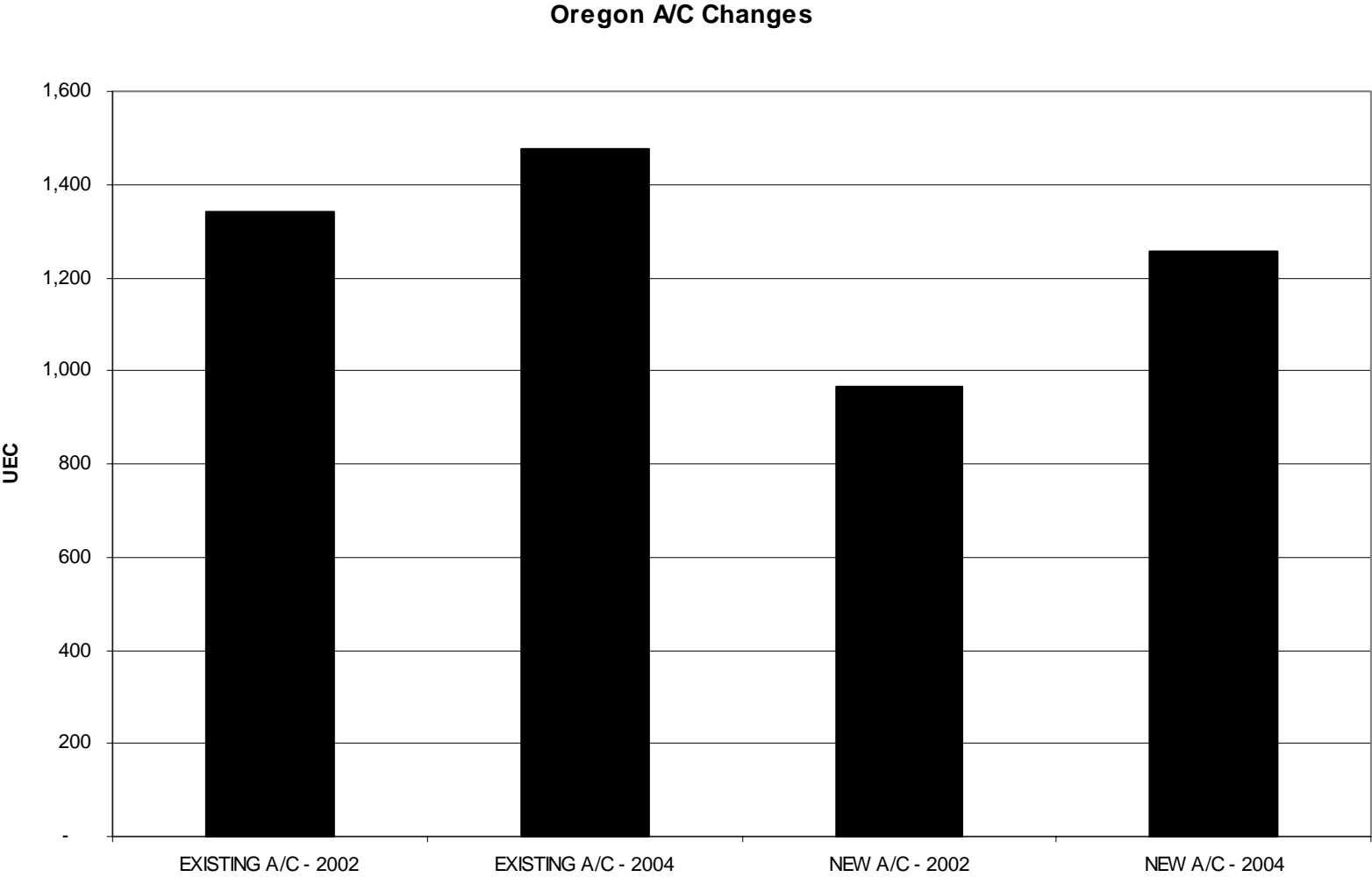
◆ Multi Family

- Water heating decreases for new and existing homes
- Miscellaneous residual UEC decreases
- Lighting increases

◆ Mobile Homes

- Miscellaneous residual UEC decreases
- Water heating decreases for new and existing homes
- Central A/C increases

Oregon – Single Family A/C UEC Changes



Utah - Notable UEC Changes

◆ Single Family

- Central A/C increases due to increasing housing size
- Miscellaneous residual UEC increases

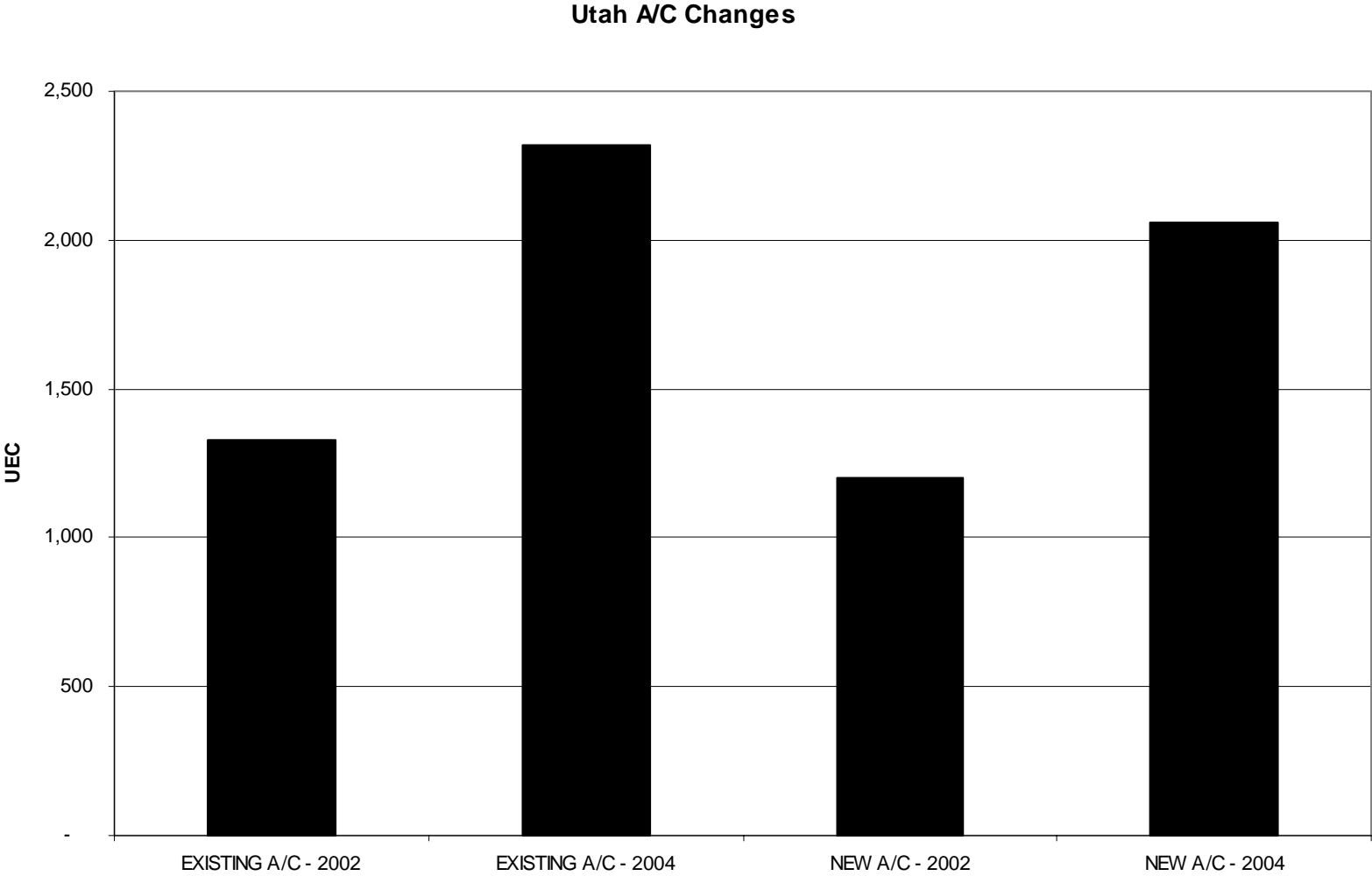
◆ Multi Family

- Water heating decreases
- Miscellaneous residual UEC increases
- Lighting increases

◆ Mobile Homes

- Miscellaneous residual UEC decreases
- Water heating increases
- Central A/C increases

Utah – Single Family A/C UEC Changes



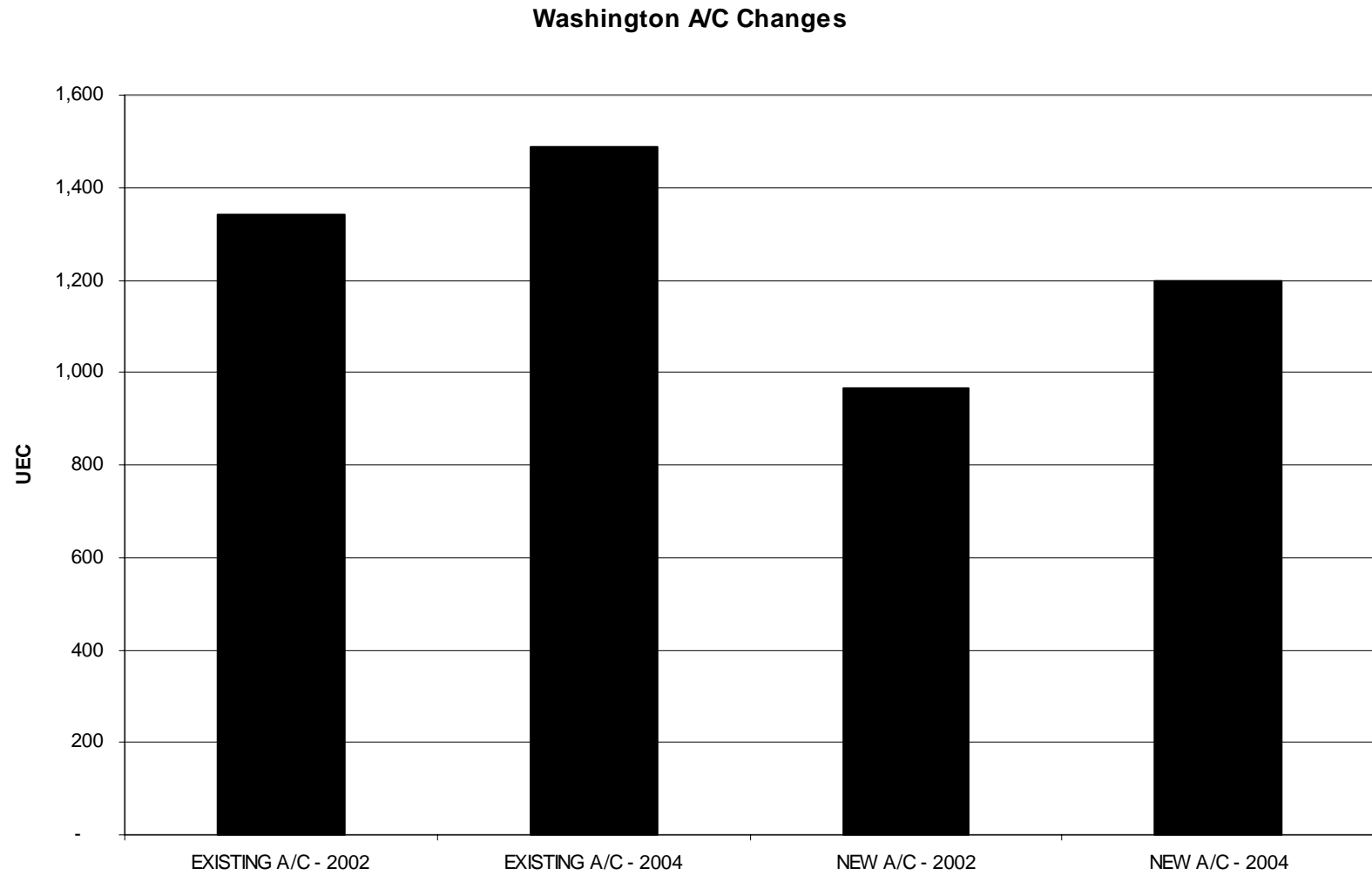
Washington - Notable UEC Changes

- ◆ Single Family
 - Central A/C increases

- ◆ Multi Family
 - Water heating decreases
 - Miscellaneous residual UEC decreases
 - Lighting increases

- ◆ Mobile Homes
 - Central A/C increases

Washington – Single Family A/C UEC Changes



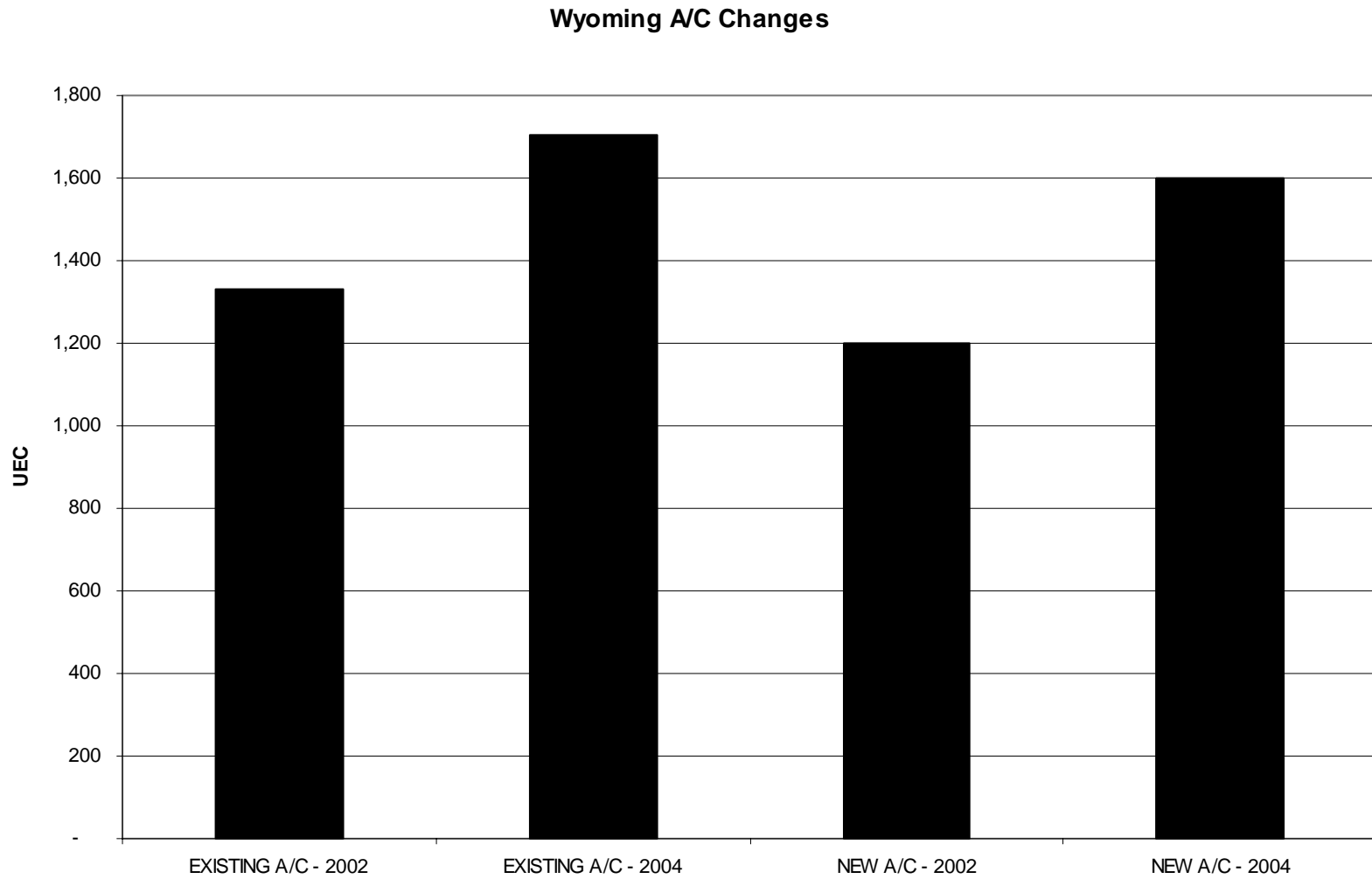
Wyoming - Notable UEC Changes

- ◆ Single Family
 - Central A/C increases

- ◆ Multi Family
 - Existing space heating increases
 - Miscellaneous residual UEC decreases

- ◆ Mobile Homes
 - Central A/C increases
 - Water heating increases

Wyoming – Single Family A/C UEC Changes



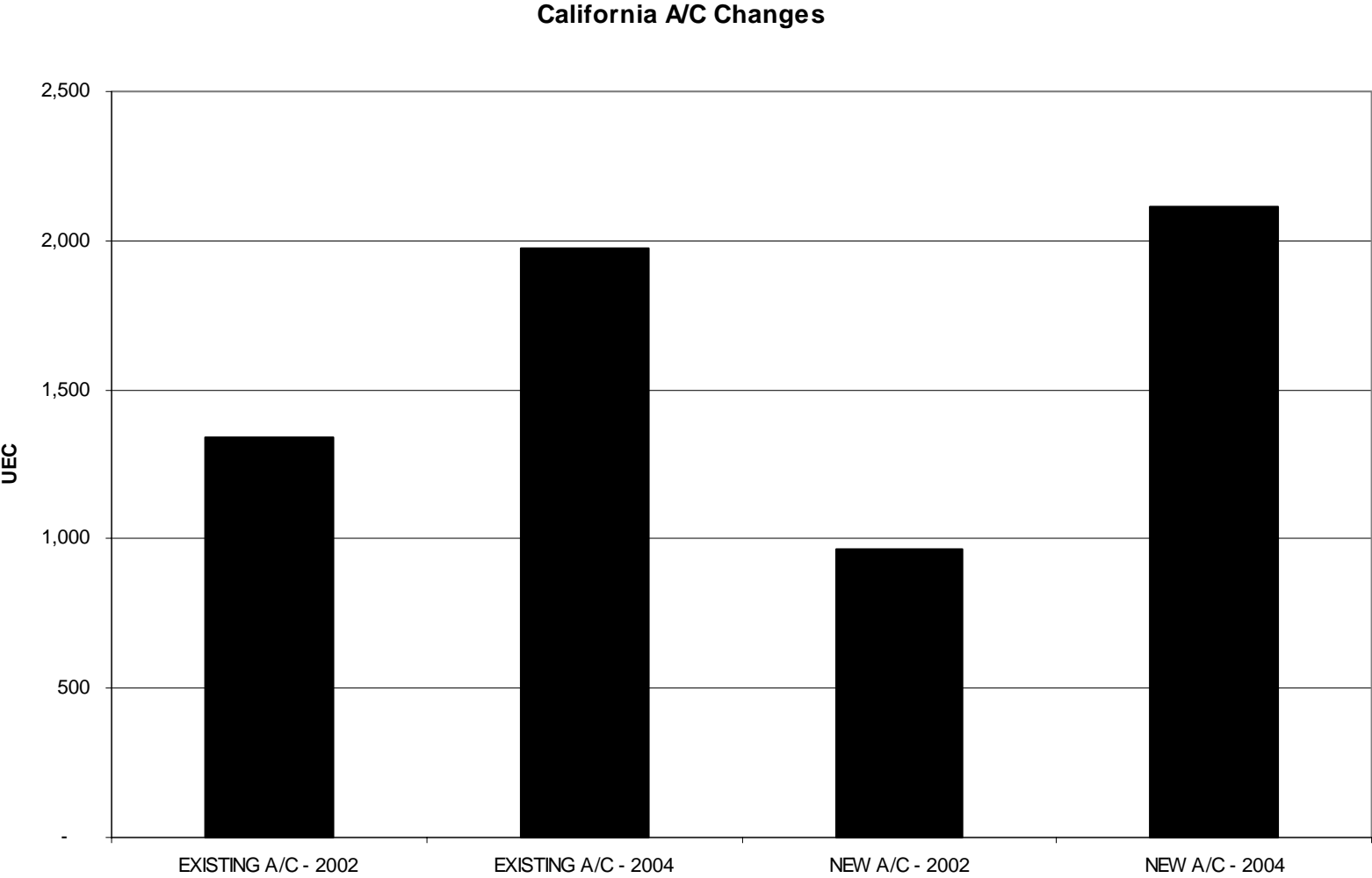
California – Notable UEC Changes

- ◆ Single Family
 - Central A/C increases due to increasing house size

- ◆ Multi Family
 - Water heating decreases

- ◆ Mobile Homes
 - Water heating decreases
 - New resistance heating increases

California – Single Family A/C UEC Changes



Idaho - Notable UEC Changes

◆ Single Family

- Miscellaneous residual UEC increases
- Central A/C decreasing for existing homes, increasing for new homes

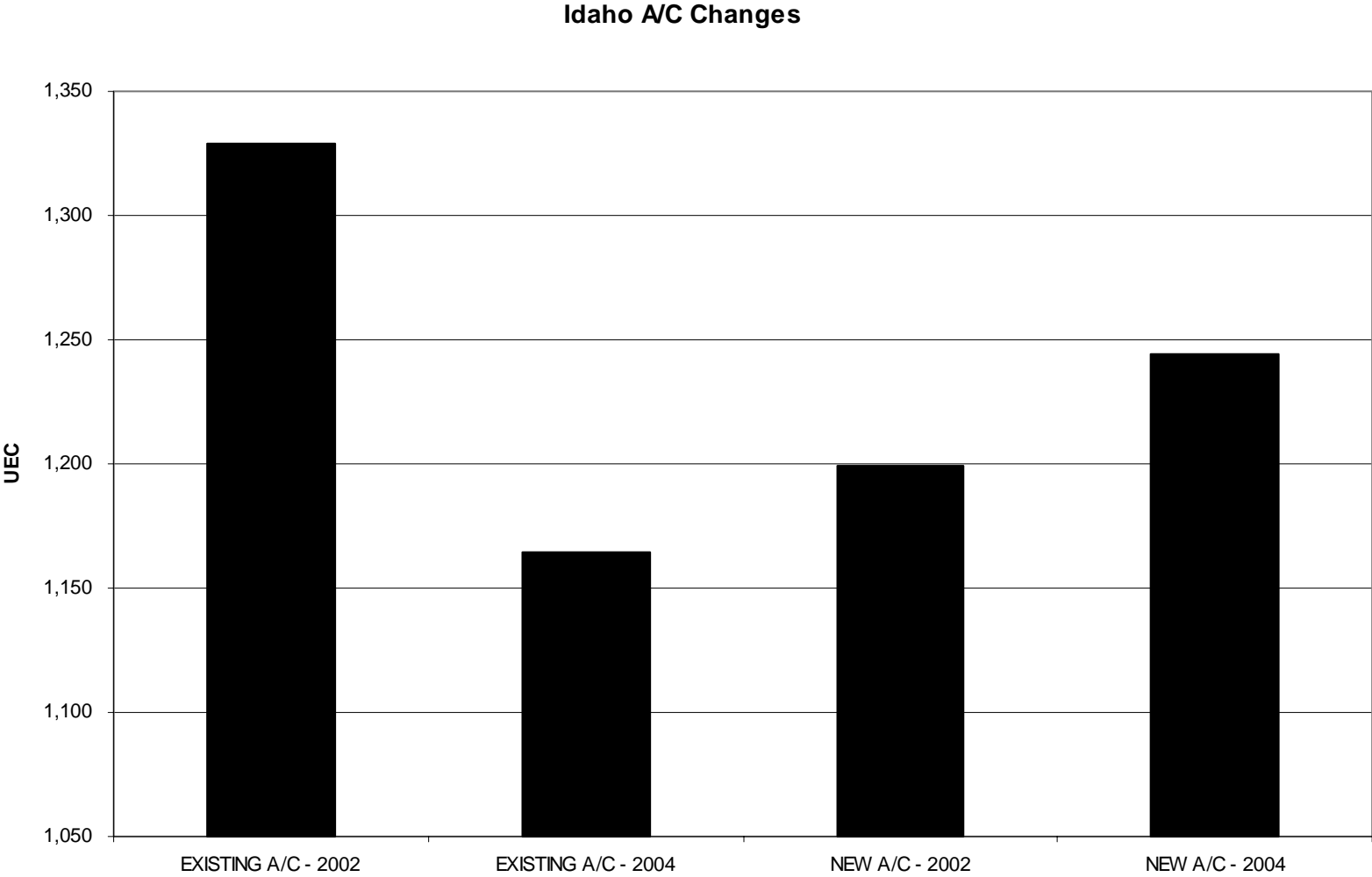
◆ Multi Family

- Miscellaneous residual UEC increases
- Existing space heating increases
- Central A/C increases

◆ Mobile Homes

- Miscellaneous residual UEC decreases
- Existing space heating increases
- Central A/C increases

Idaho – Single Family A/C UEC Changes



Conclusions

- ◆ Newly calculated UECs reflect state-specific data – weather, housing unit size, members in household, household activities, age of housing unit, and age of equipment, type and number of appliances, etc. – regional data was used previously
- ◆ UECs for Single Family A/C increased for most states
- ◆ The use of “local”, more recent data yielded improved results