Pre-Weatherization Results from Texas Field Experiment

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Texas Field Experiment is focused on unsolved warm climate evaluation issues

- Why are energy savings and cost effectiveness lower in warm climates than in cold climates?
- How can they be increased? How much can they be increased? Where are the best opportunities for improvements?
- Why do Princeton Scorekeeping Method (PRISM) evaluations fail to measure cooling savings?
- What does occupant cooling behavior look like?

Intensive study of whole house energy use

- Wanted to find out what is really going on in the houses so could understand puzzling evaluation results
- PRISM analysis gives a score in Normalized Annual Savings but little information on what happened or why
- Decided to use more sensitive, intensive monitoring techniques to gain understanding of the process

Created two experimental groups

- Standard procedures group (in 2003, n=15)
  - No changes
- Demonstration group (in 2003, n=17)
  - Best available measure selection techniques with incorporation of monitored data into process
  - New diagnostic procedures
  - New technologies where appropriate

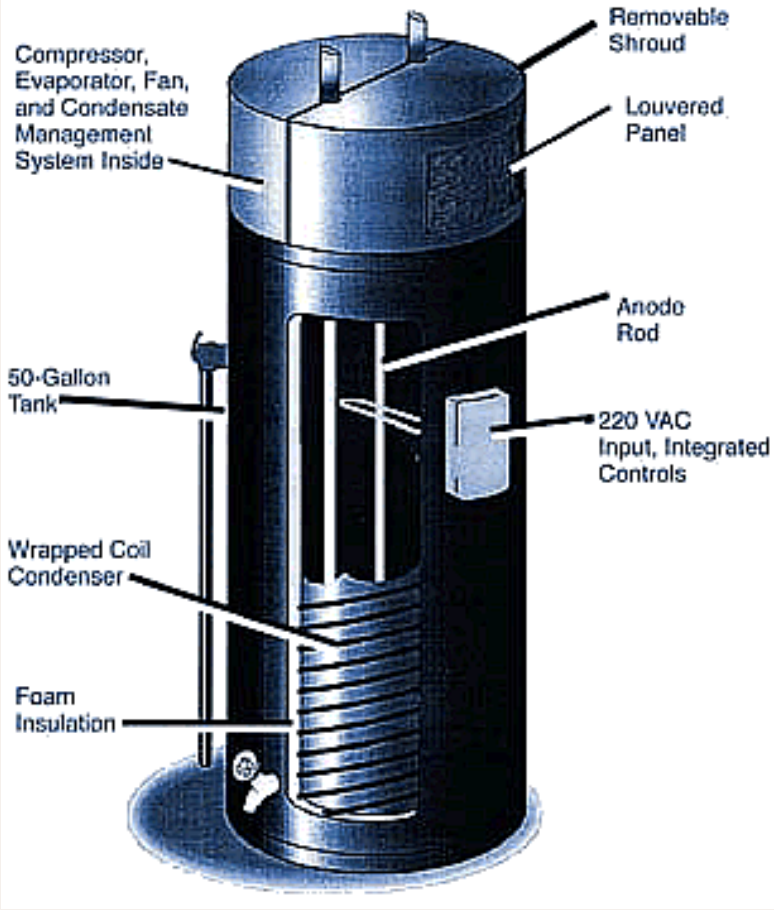
Began with 57 houses, now have 32

- Recorders installed in 57 houses in 2001, now only 32 are still transmitting data
  - 15 moved out
  - Other reasons for sample losses included house that burned down, unsafe wiring, became ineligible, divorce, deaths, illness, nursing home

Testing of new technologies

- Heat pump water heaters
- Central air conditioner tune-ups
- NEAT and MHEA with occupant behavior taken into account
- Advanced duct sealing with a duct blower
- Improved mobile home installation methods for insulation and belly repairs

Heat Pump Water Heater



Did intensive monitoring to look closely at electric usage patterns

- Selected all electric homes for the study to the extent possible
- Described pre-weatherization electricity usage for cooling, electric heating, refrigerators and water heaters
- SPEED/NIALMS monitoring results were compared to audit predictions and to Residential Energy Consumption Survey (RECS) averages

Have assembled a very rich database

- Appliance inventories
- Electric usage by end-use and indoor temperature at 15-minute intervals
- Extensive hourly and daily weather data
- Audit inputs and outputs
- Detailed descriptions of measures installed and costs

Why we described pre-weatherization electricity use in detail

- Identify potentials for electricity savings
- Choose weatherization measures that fit each household's needs and behaviors
- Develop understanding of pre-weatherization usage patterns for cooling, heating, water heating and refrigerators so they can be compared to post-weatherization monitoring results

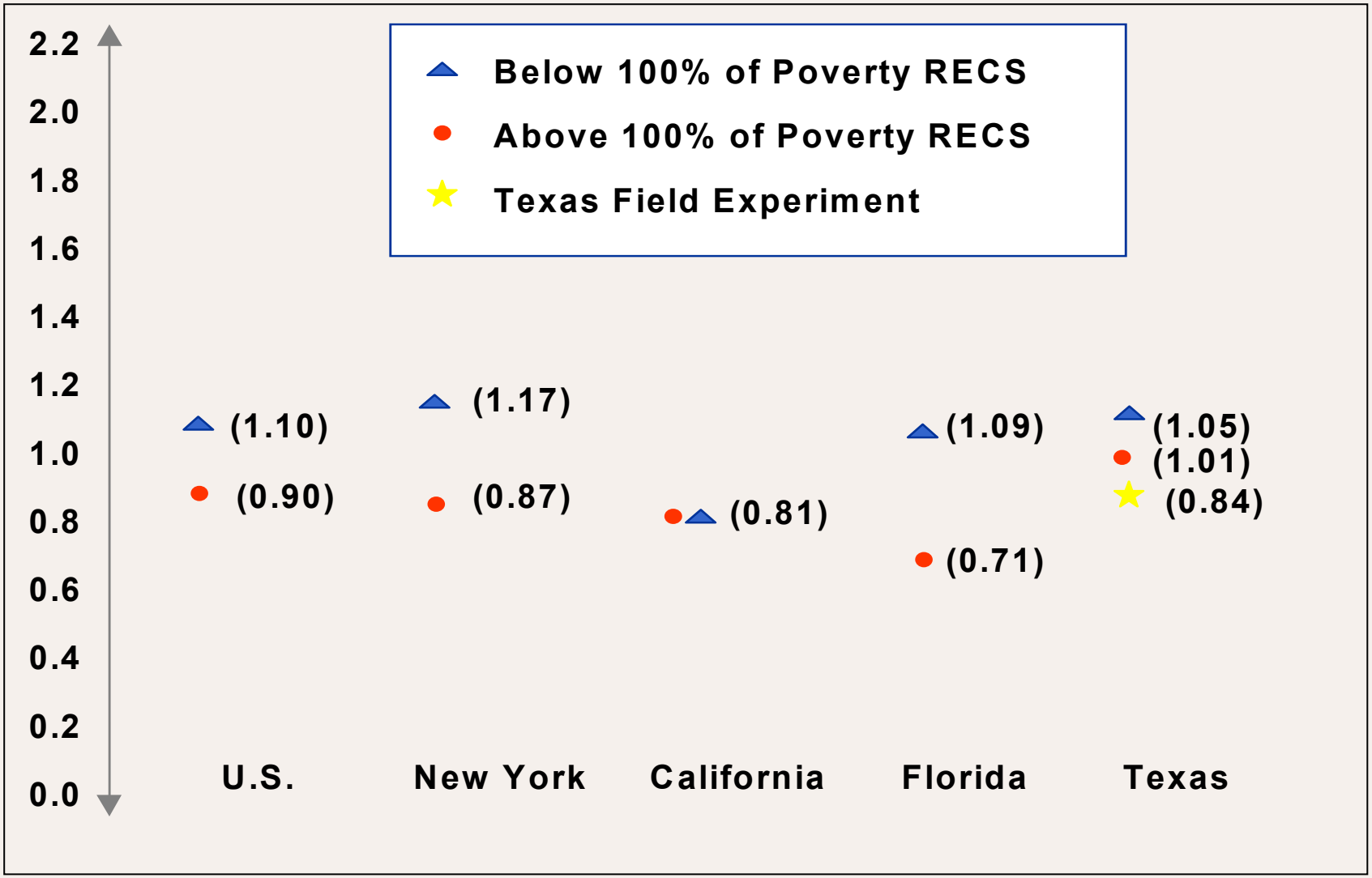
Overview of findings

- Great variability from one house to another
- Cooling usage almost always lower than expected
- Heating usage more variable
- Water heating usage as expected
- Refrigerators lower than expected usage because several already replaced by Entergy
- Time-of-day load profiles had typical shapes

Pre-weatherization cooling usage is low

- Study houses have lower intensity of cooling per square foot per degree day than RECS houses
- All except one house used less for cooling than audits predicted (most in 30-60% range)
- Usage is constrained by capacity, behavior and costs
  - Most have only room air conditioners
  - Equipment often runs at full capacity
  - Zone and time-of-day usage patterns
  - Clients say try to reduce bills by not using A/C

Cooling Intensity Index (kWh/CDD/1,000 Sq. Ft.)



Monitored cooling use much lower than predicted

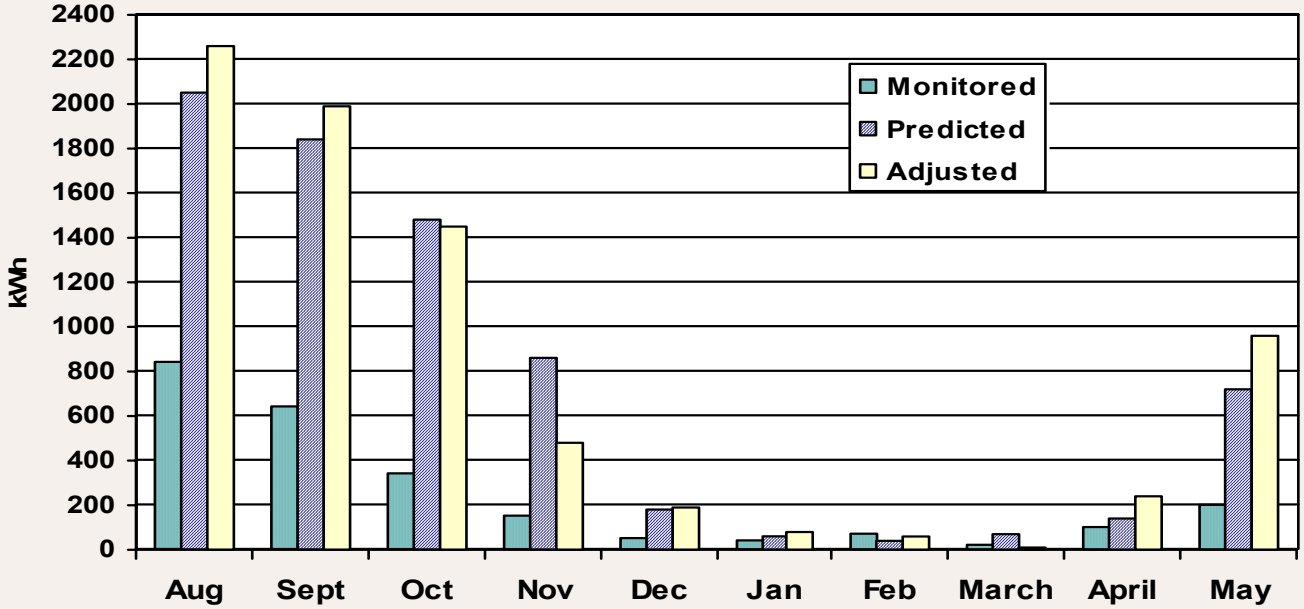
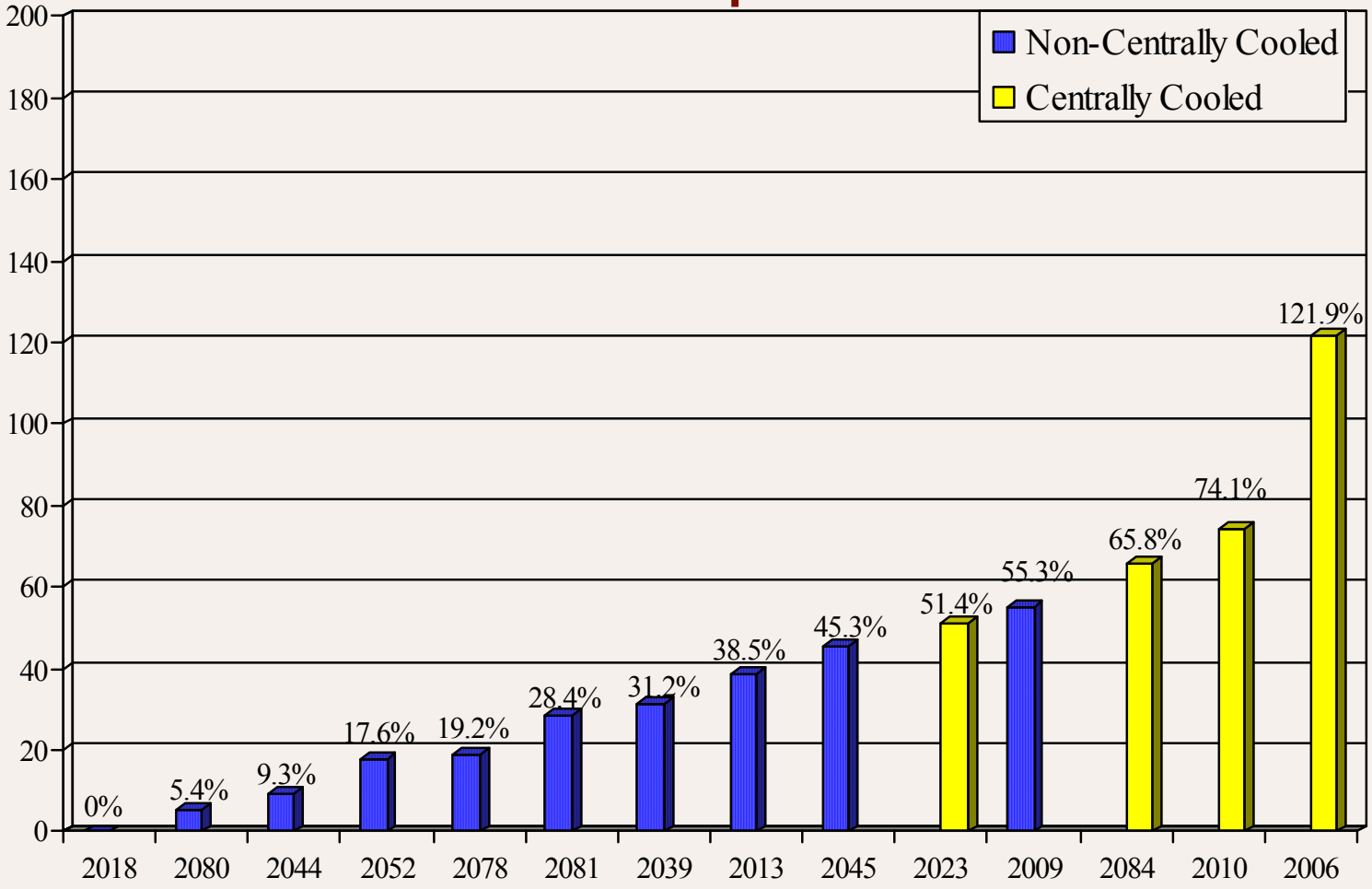


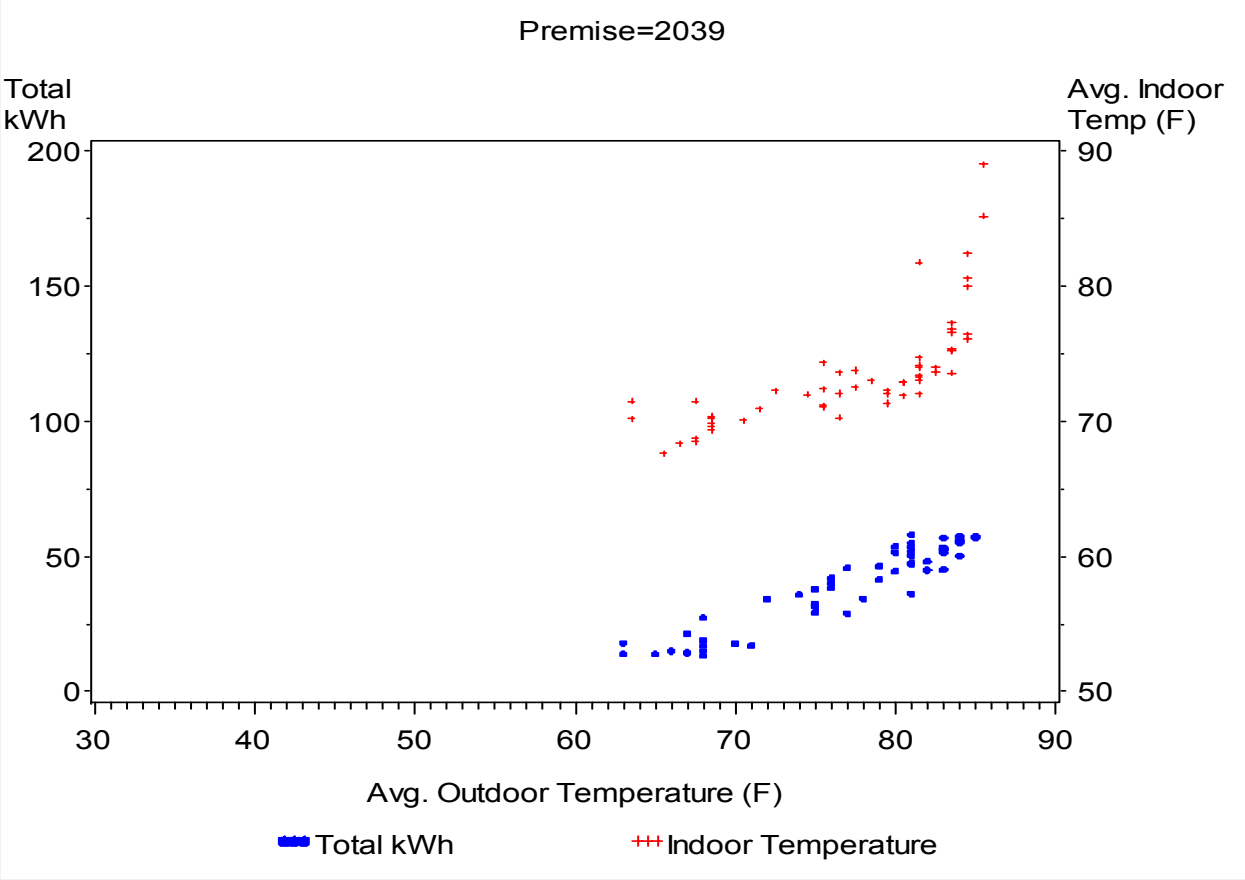
Figure 2039-4. Monitored air conditioning energy use, NEAT predictions for average weather, and NEAT prediction adjustsed for actual weather.

Actual cooling consumption is almost always below audit predictions

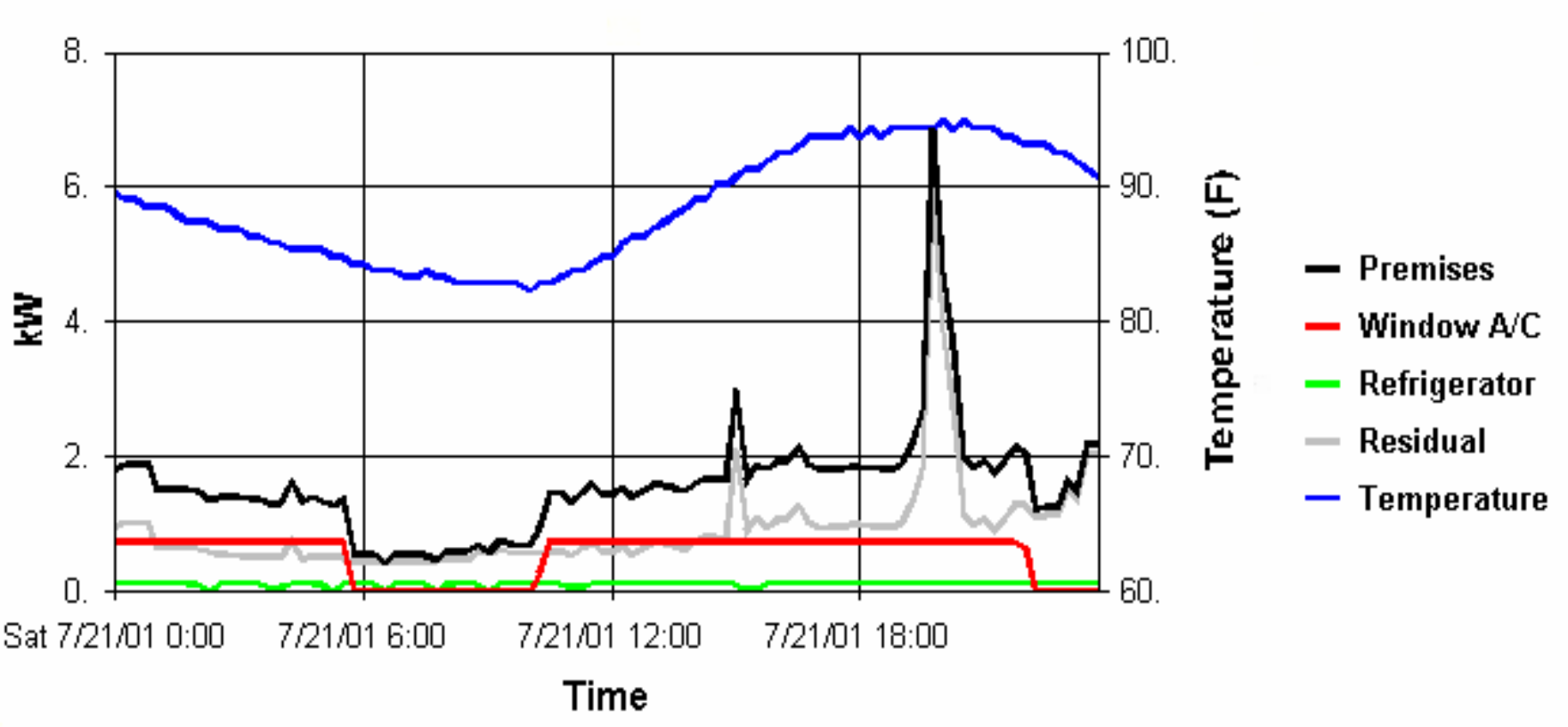


Many houses have low cooling capacity

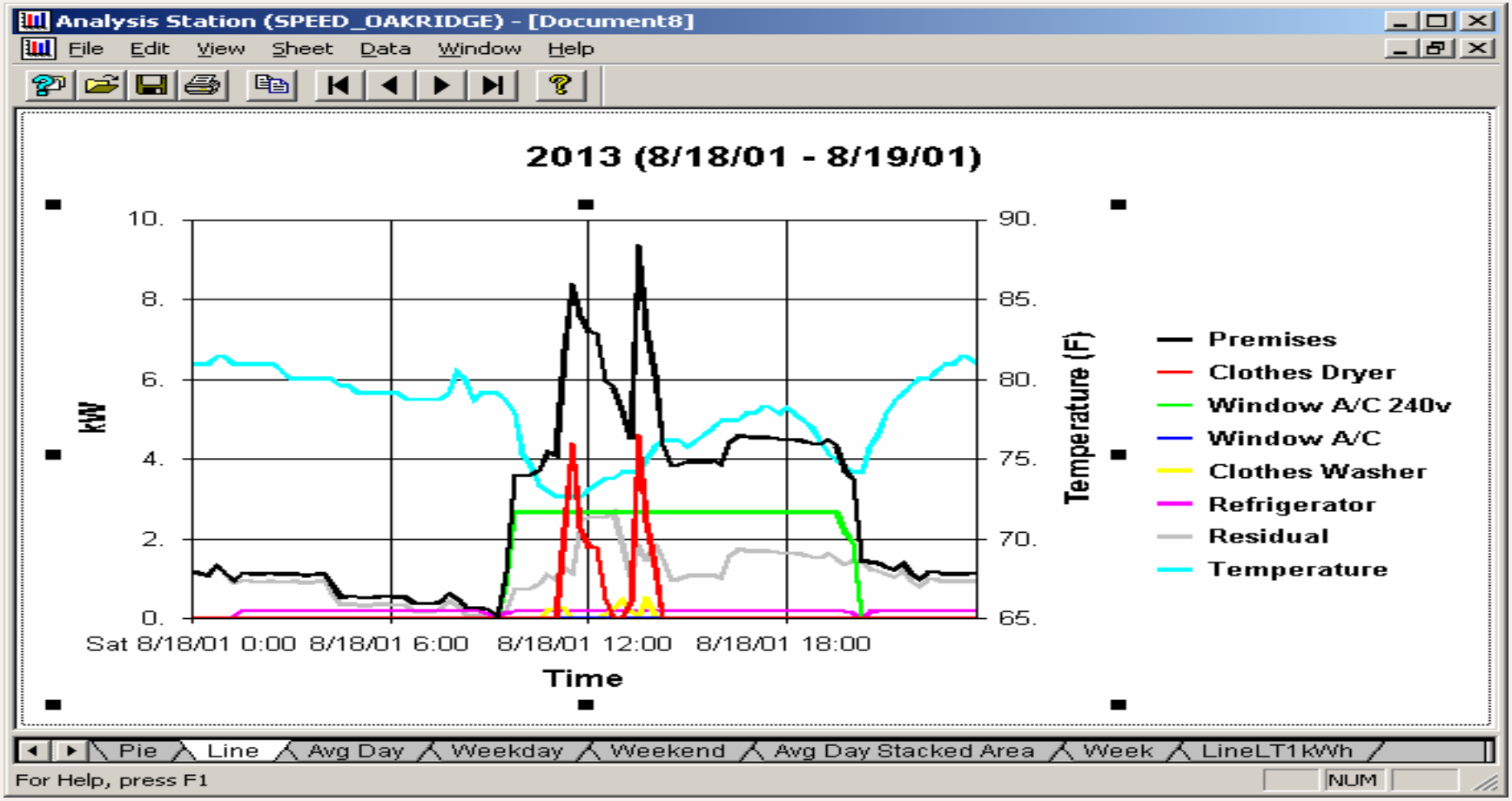
Cooling equipment cannot keep house cool above 80º



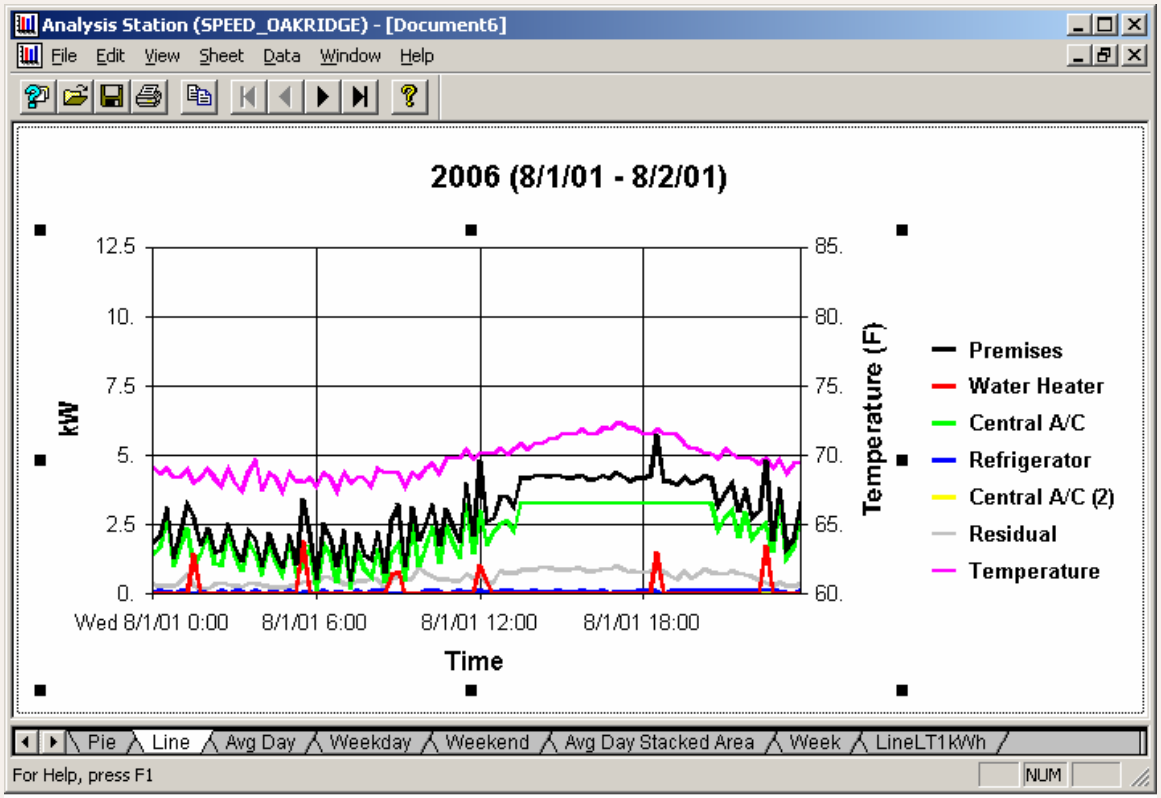
Window A/C runs at full capacity whenever it is on and indoor temperature goes above 90°



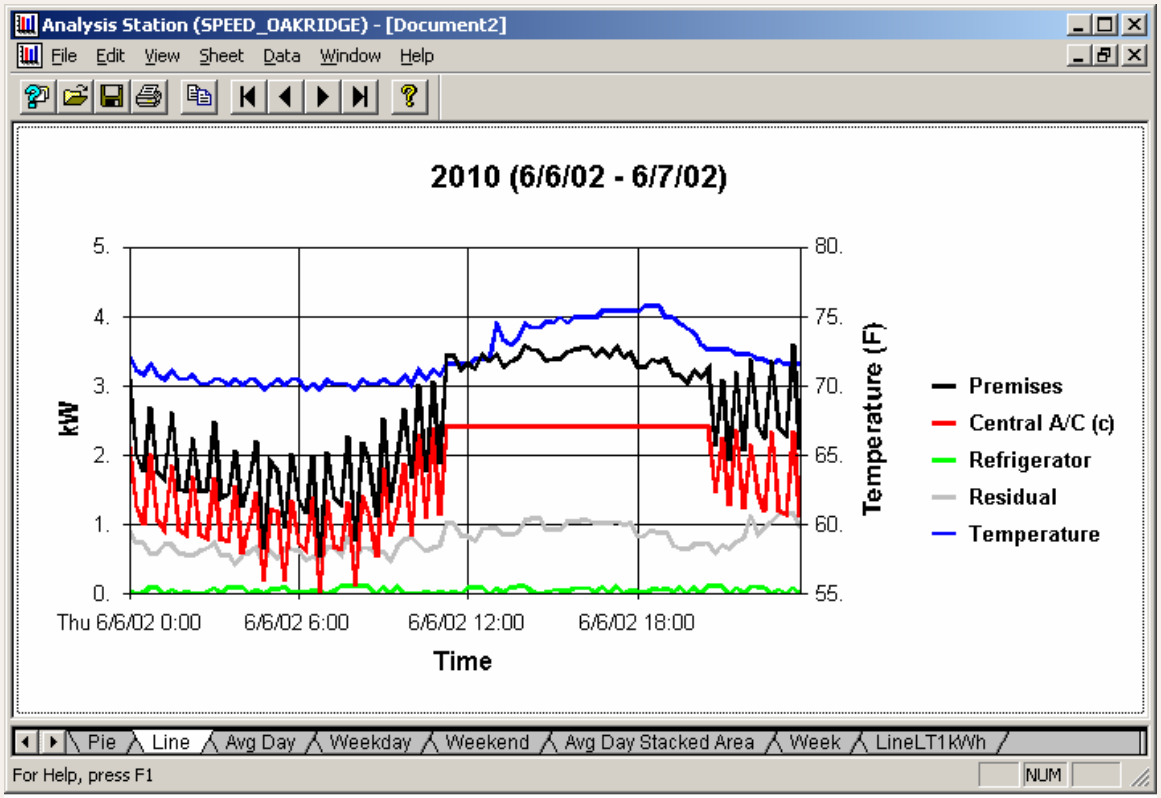
Window air conditioner runs at maximum capacity



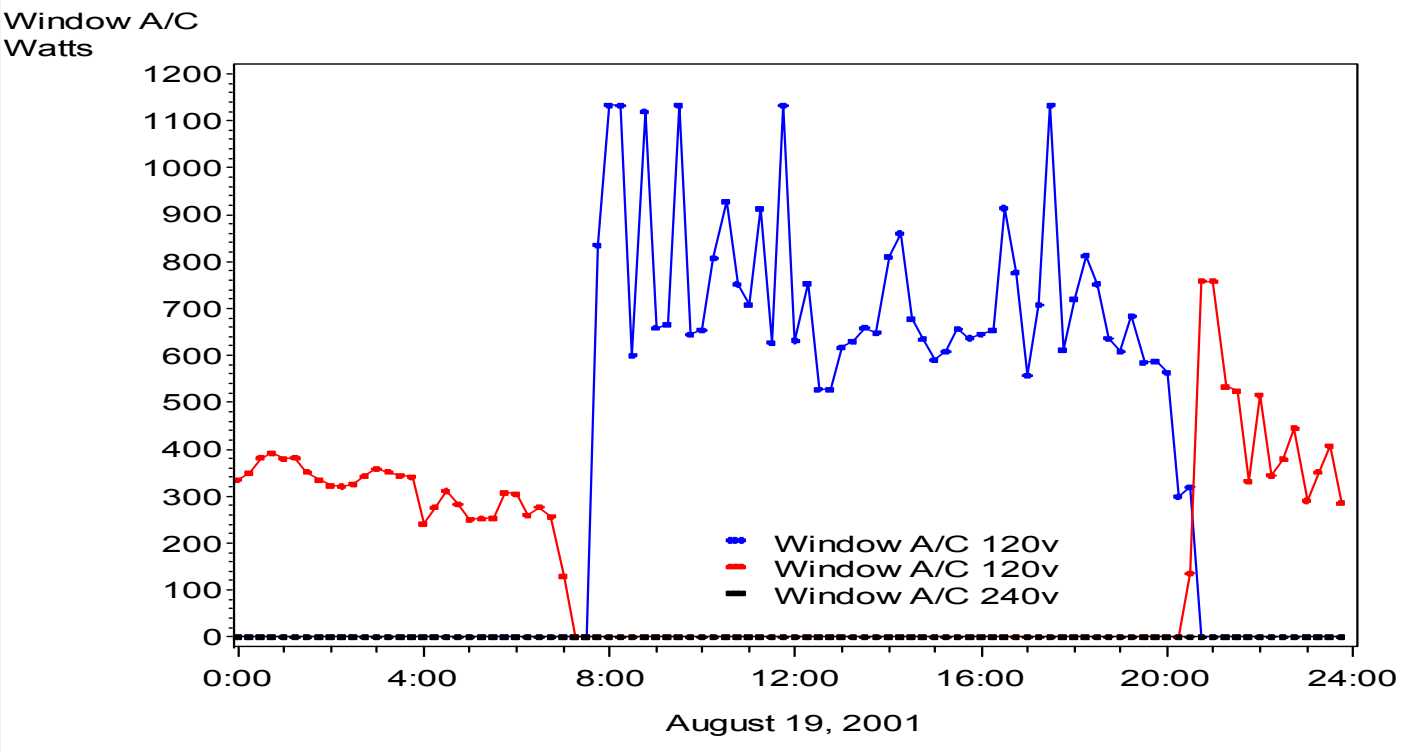
Central air conditioner running at full capacity keeps house at comfortable temperature



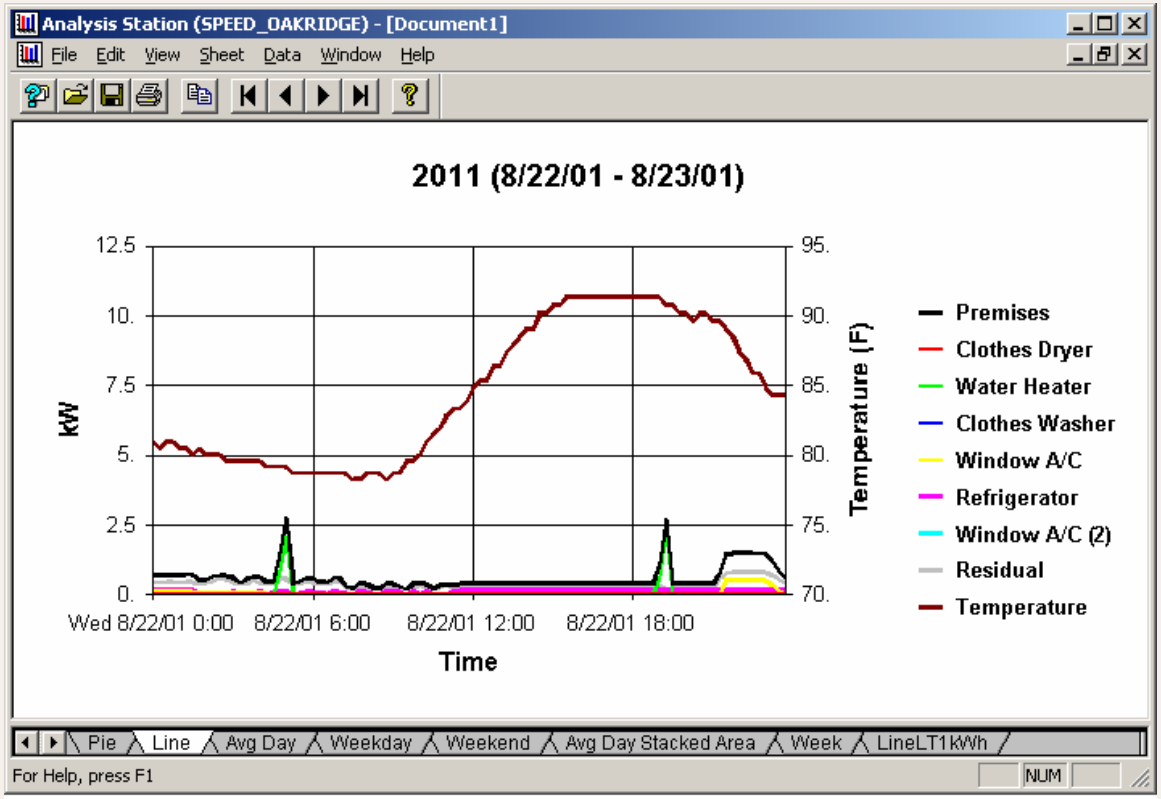
Indoor temperature drifts up even though central air runs at full capacity



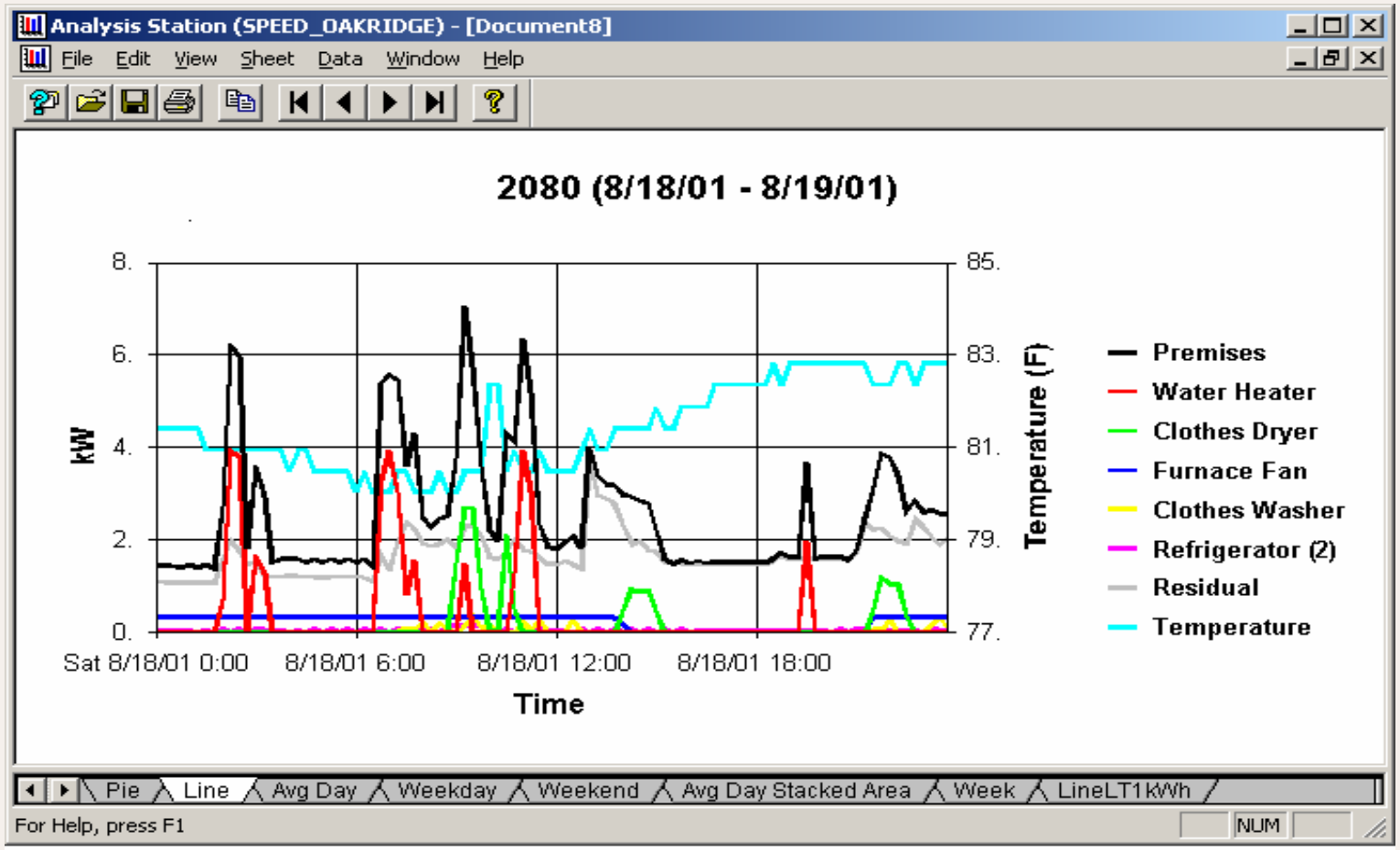
Zone cooling by time-of-day is a common behavior



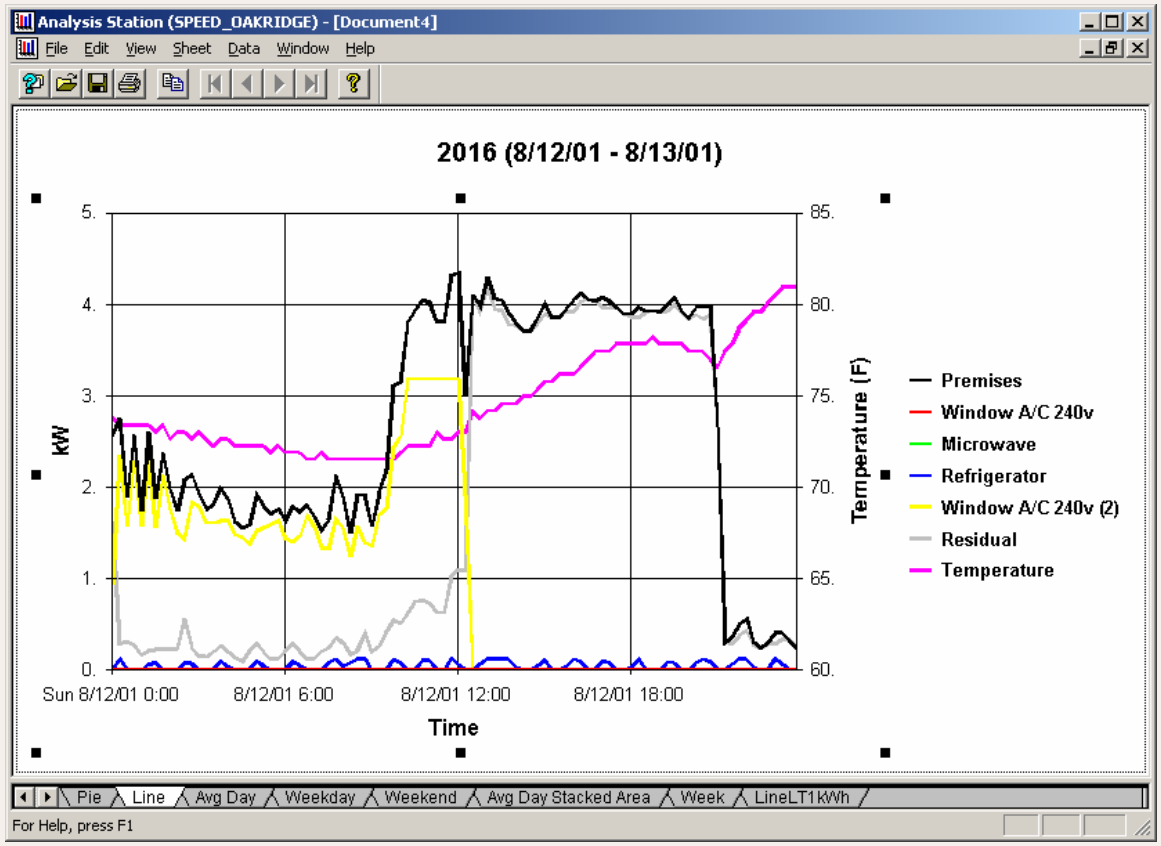
With no air conditioning for most of the day indoor temperature goes over 90 degrees



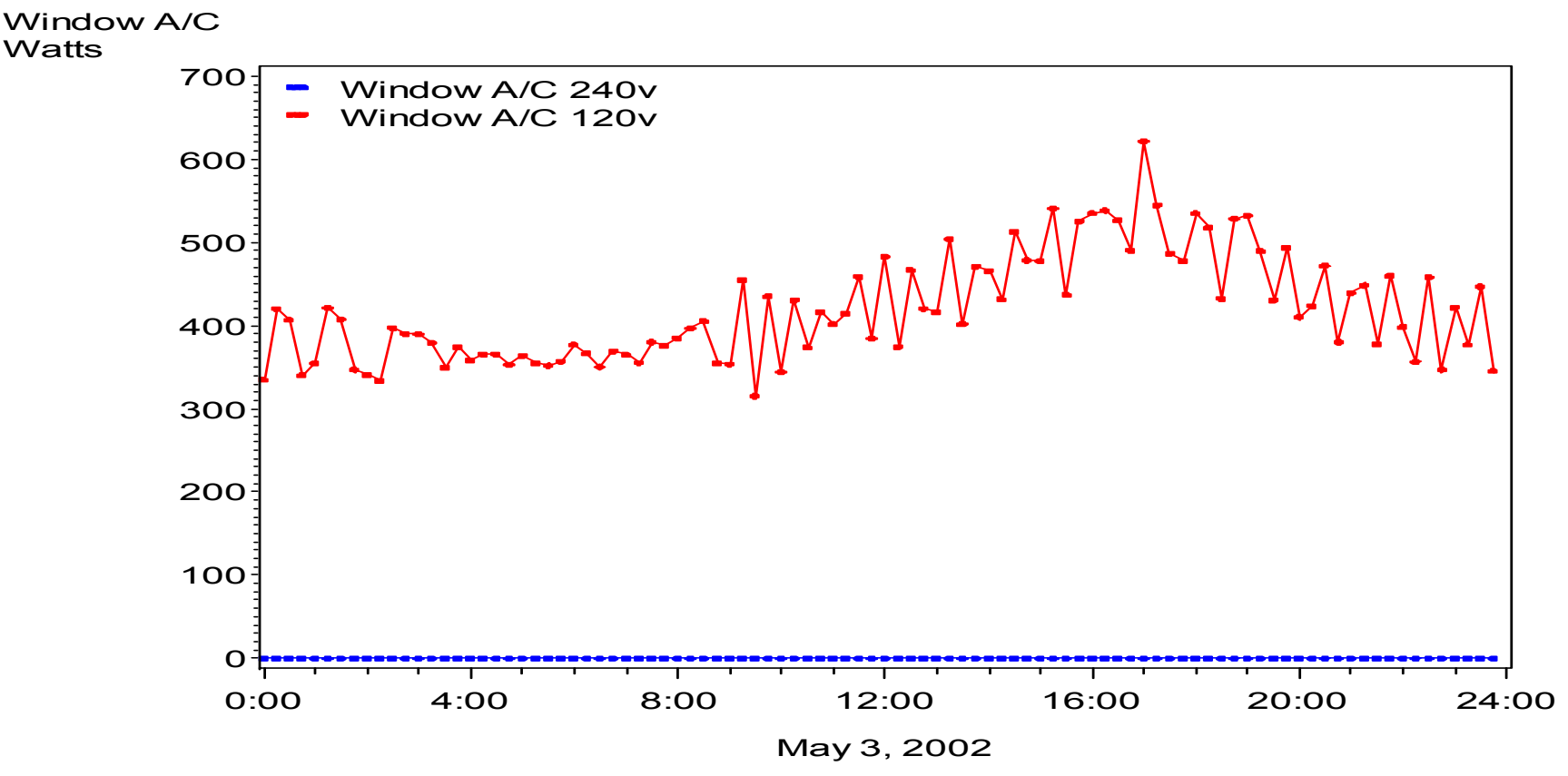
Indoor temperature climbs on August day with no air conditioning



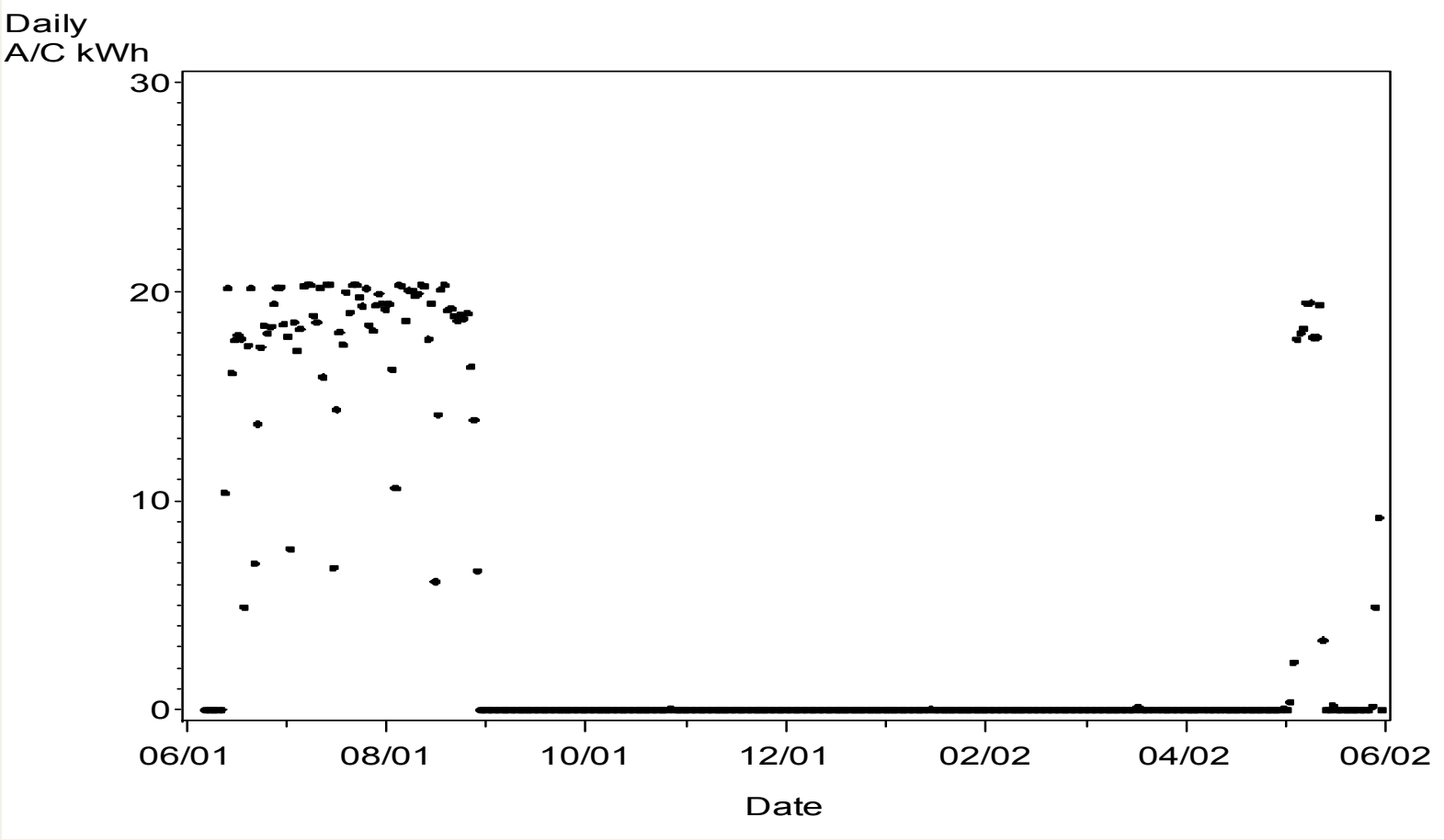
Air conditioner used only part of the day



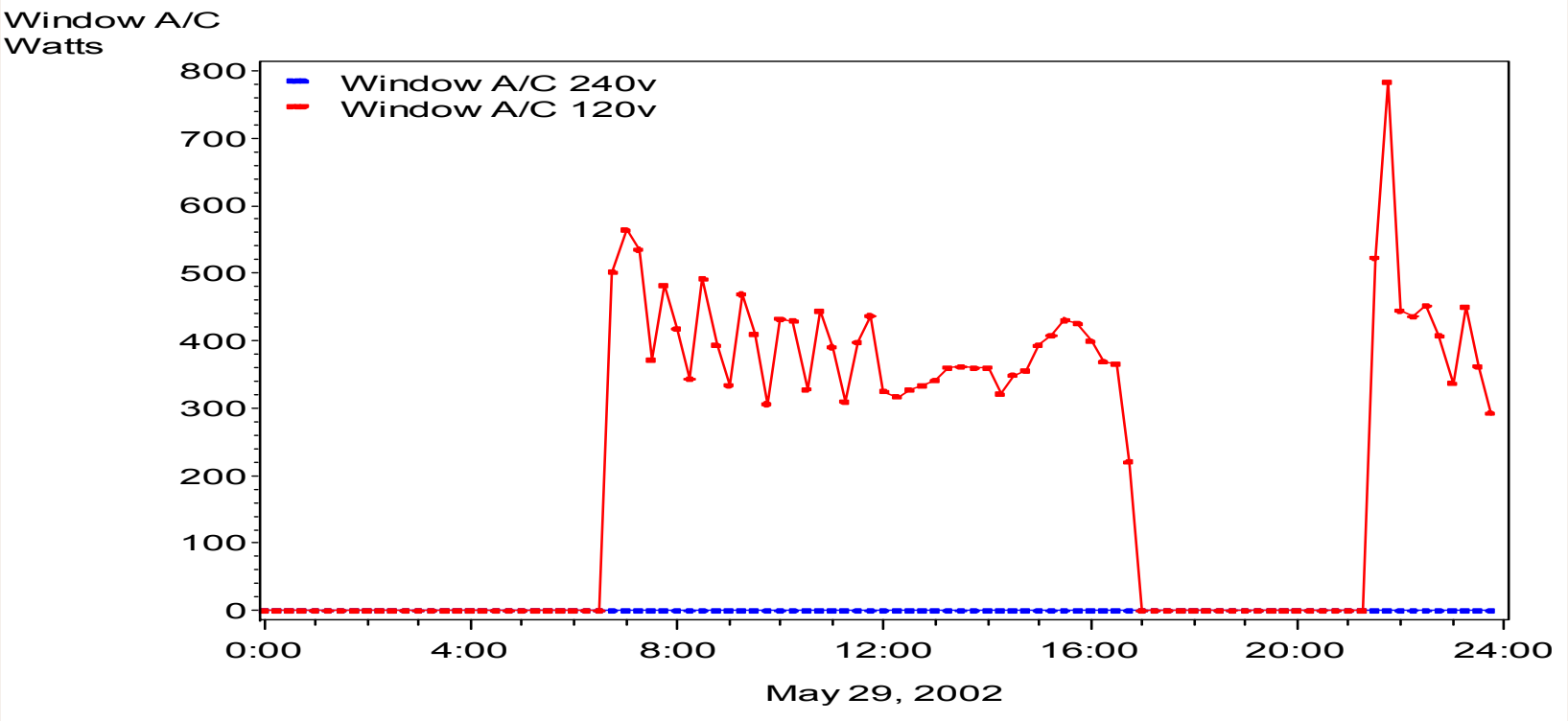
Only one air conditioner is used



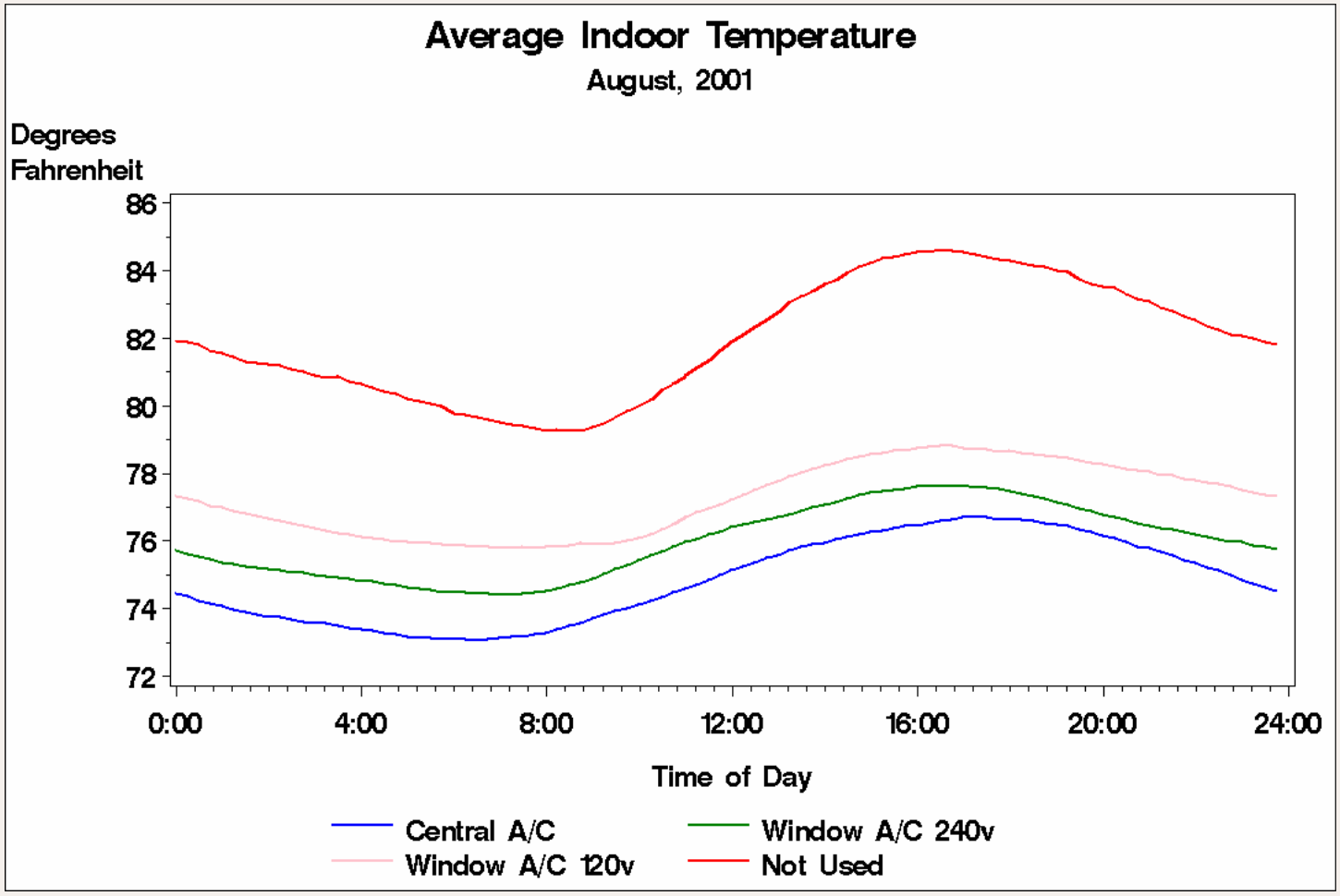
No cooling load from September to May



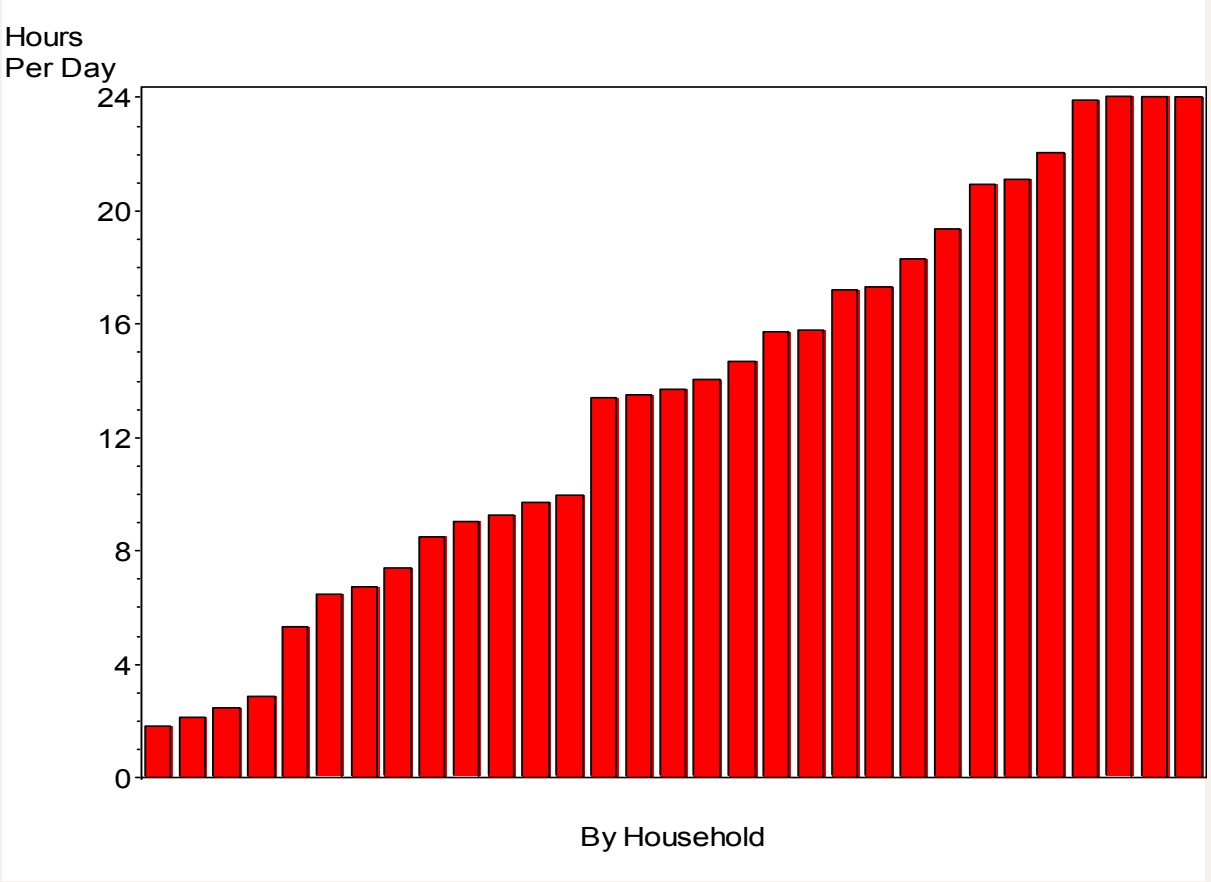
Only one air conditioner is used and for only part of the day



Indoor Temperatures High in Homes Not Using AC



On hottest days indoor temperatures above comfortable levels (76°) in nearly all houses



More than half of houses received replacement A/C units

- Those with lowest pre-weatherization cooling consumption most likely to receive new units
- Audit justified replacement because it assumes normal usage levels for cooling
- Assumption usually not correct
- If consider the low pre-weatherization usage, then must justify A/C replacement because of the value of nonenergy benefits

High expenditures for repairs and equipment replacement

- About one-third of total expenditures for
  - Attic insulation
  - Wall insulation
  - Air infiltration reduction
- Majority of funds spent for repairs, window and door replacements, and HVAC equipment replacements

Pre-weatherization heating usage is closer to audit predictions than cooling usage was

- Some houses use more for heating than audits predict, some use less. Most in 60-90% range
- Heating usage is less constrained by capacity
  - Supplemental portable electric heaters are commonly used to heat zones by time-of-day
  - Portable electric heaters less expensive to purchase, easier to add, than A/C units

Monitored electric heating use sometimes more, sometimes less, than predicted

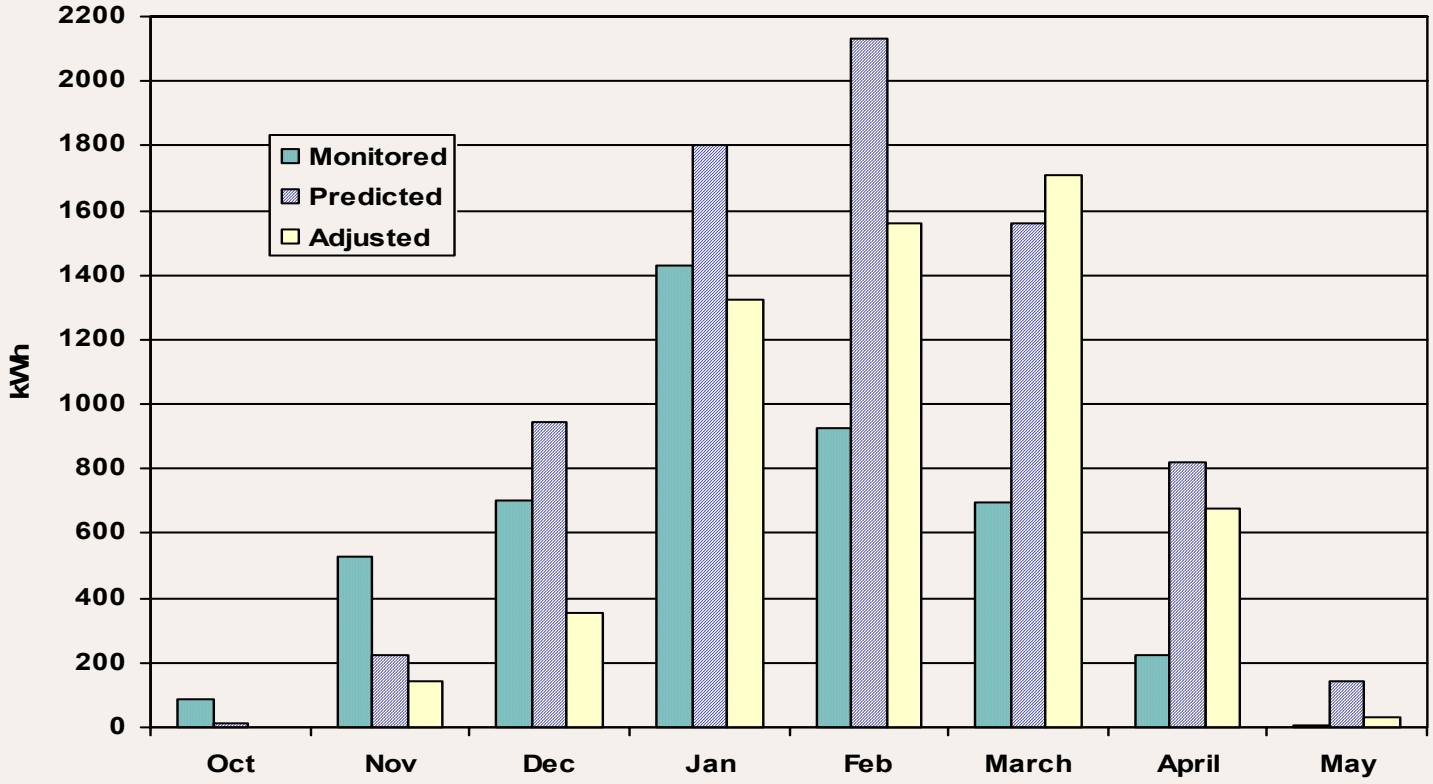
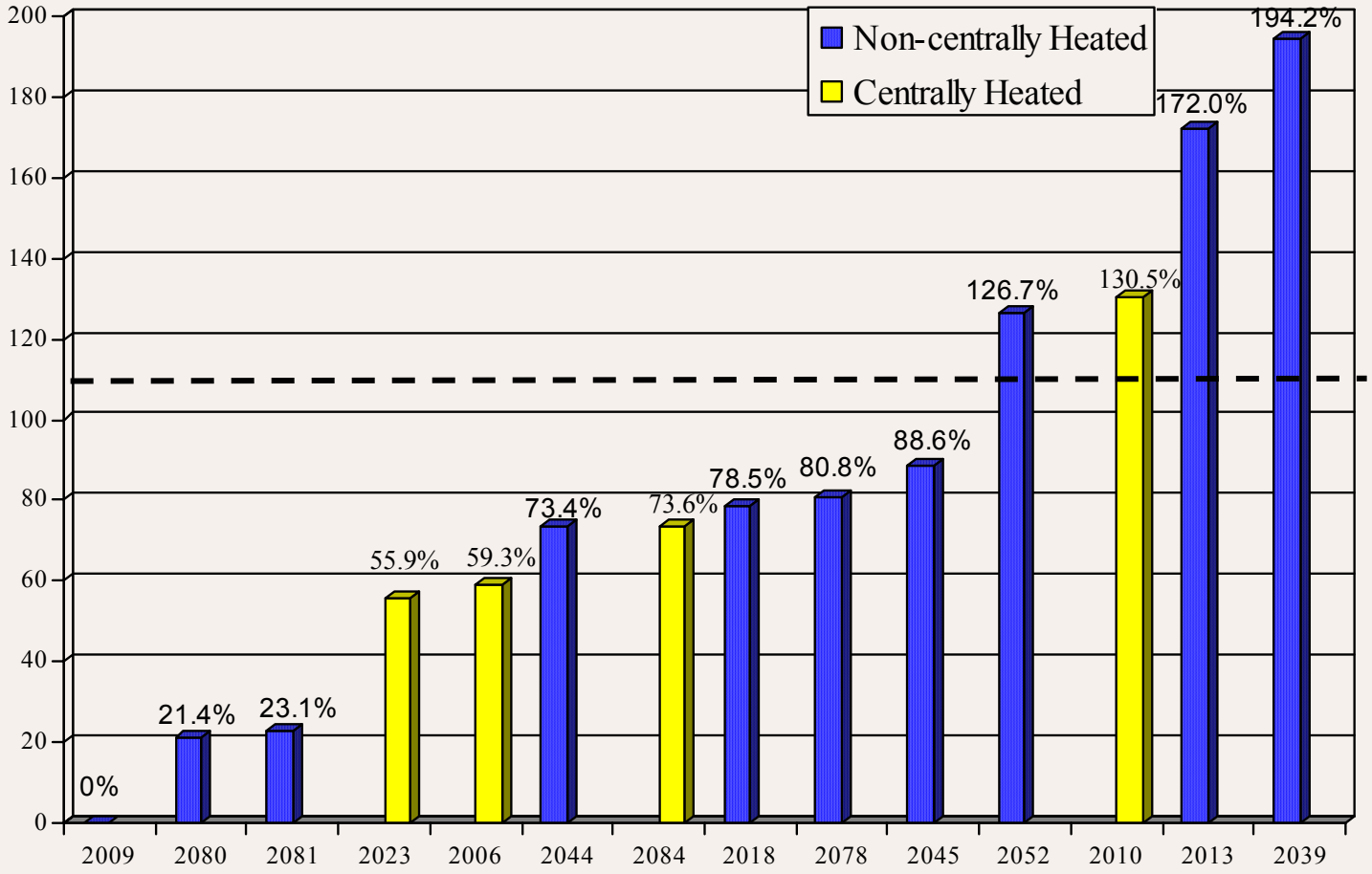
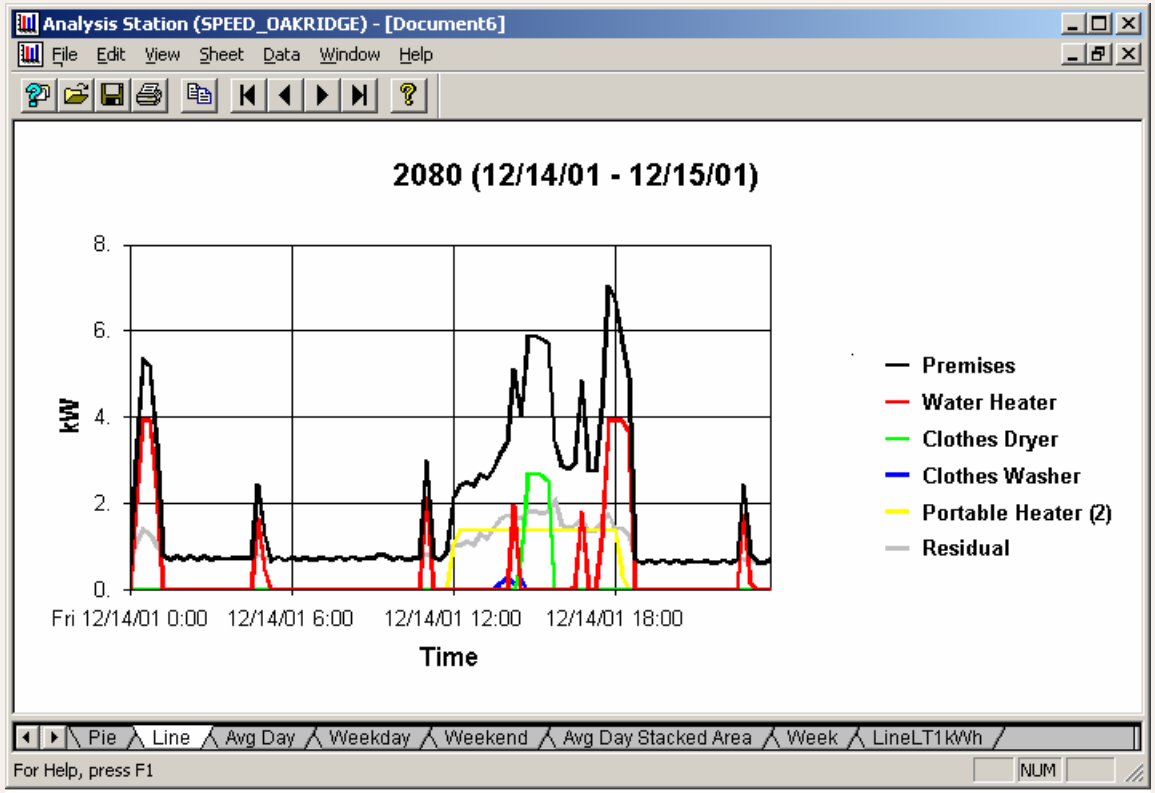


Figure 2078-6. Monitored electric space heating energy use, NEAT prediction for average weather, and NEAT predictions adjusted for actual weather.

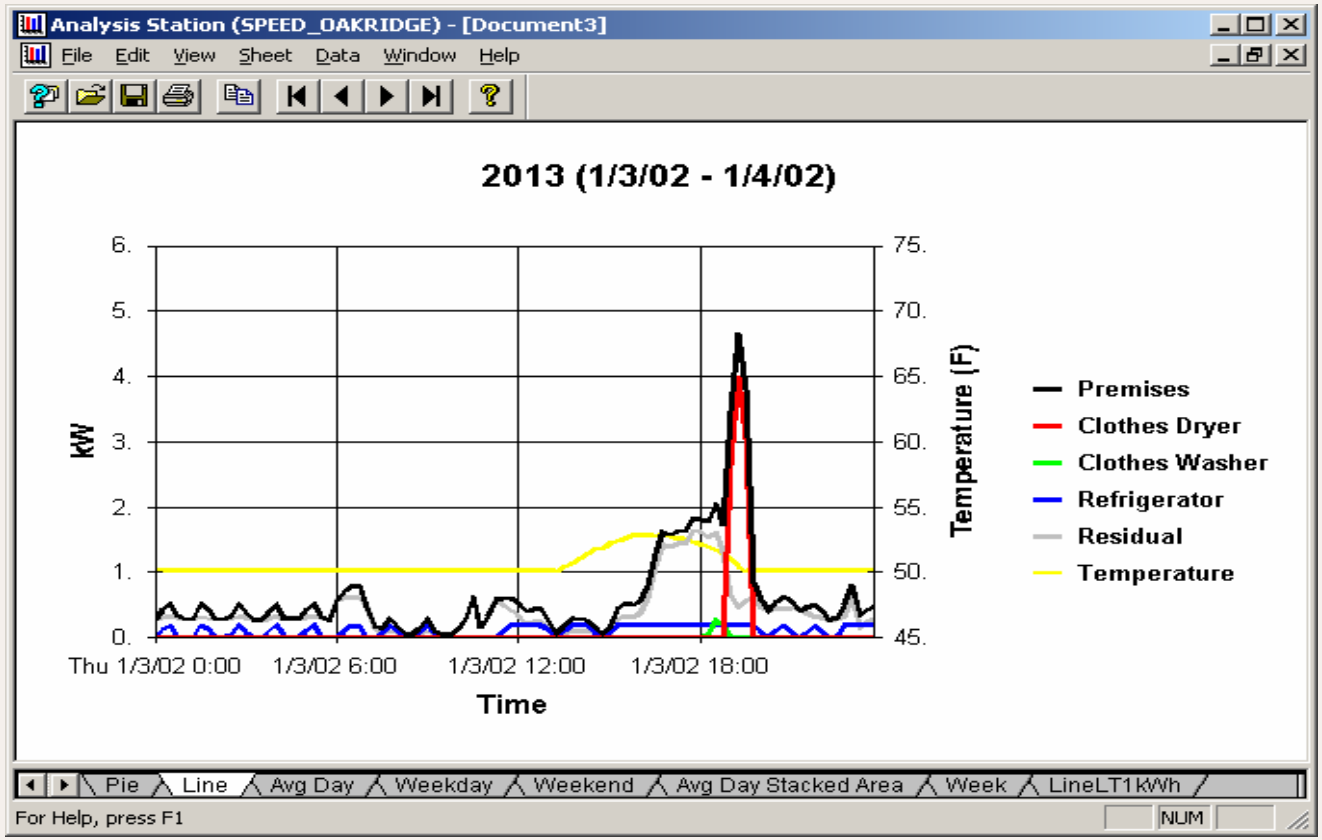
Actual heating consumption is sometimes higher, sometimes lower than audit predictions



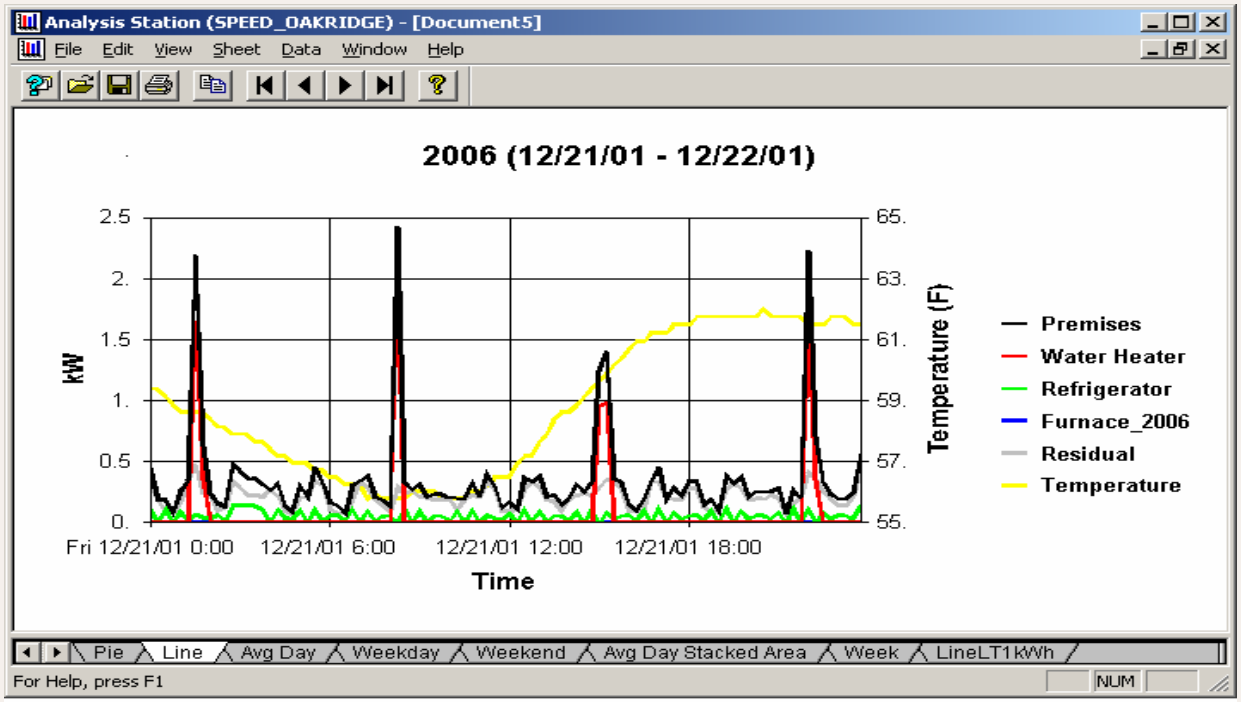
Small portable electric heater is only source of heat



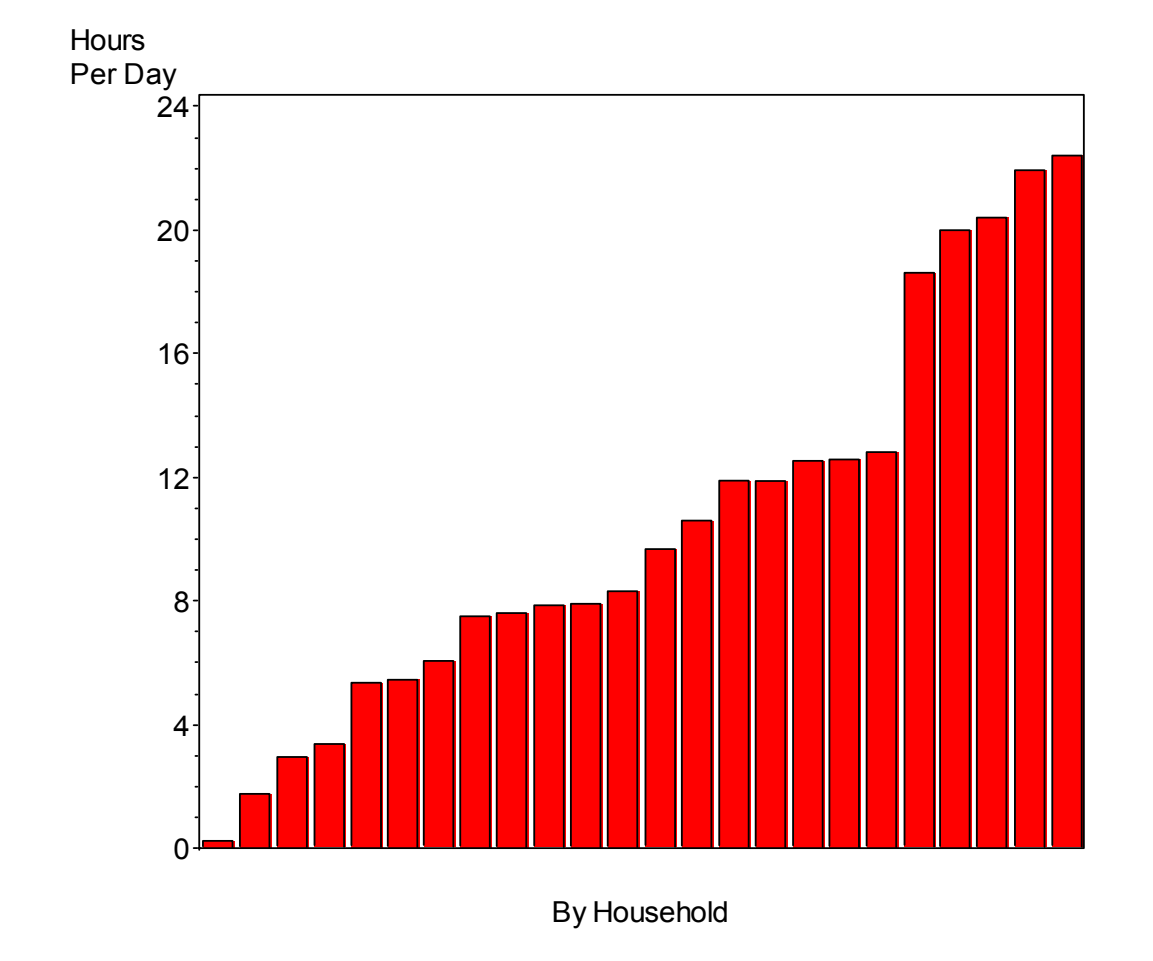
No heating on a cold January day



No heating on a cold December day



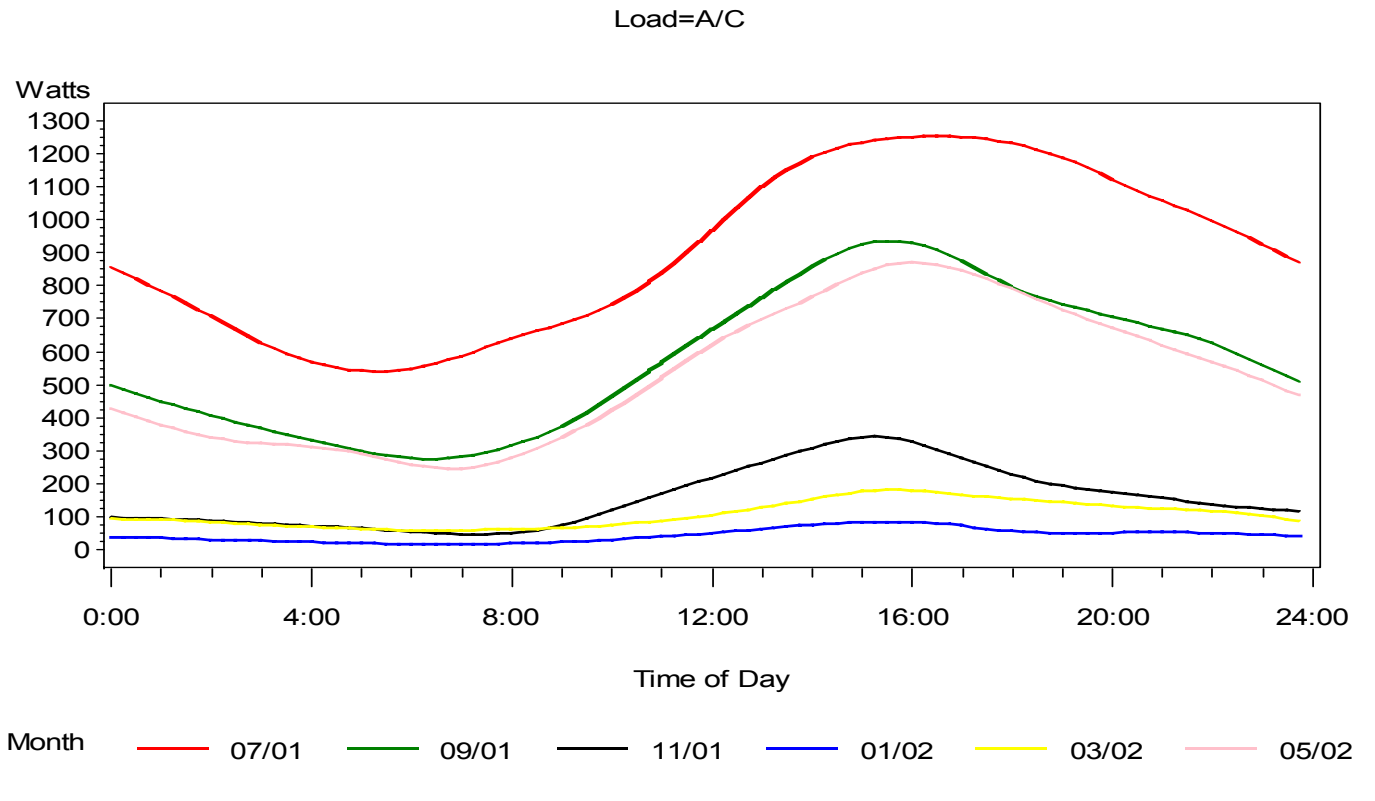
On coldest days indoor temperatures below comfortable levels (60°) in most houses



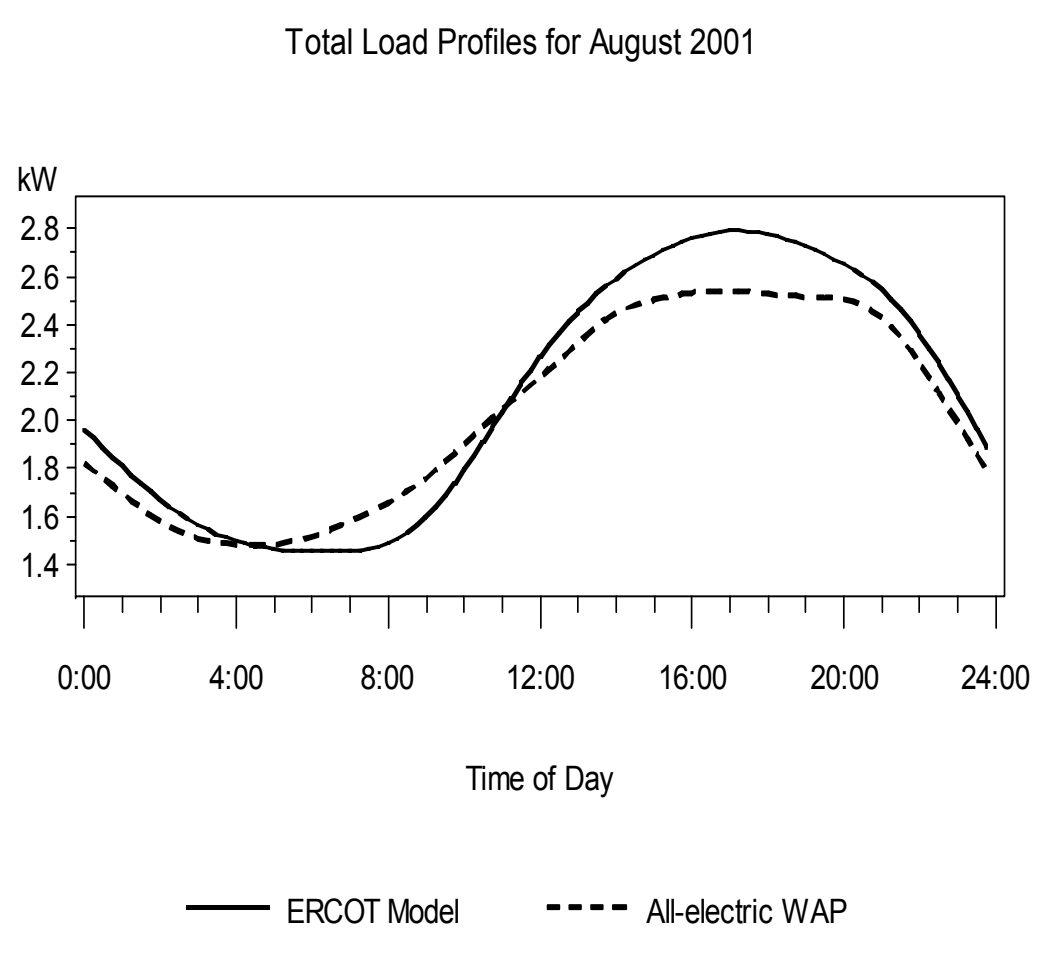
Address time-of-use issues

- Electric utilities are interested in load management
- Weatherization may be able to help manage loads
- Comparison of loads for low-income versus average-income homes was needed to determine how weatherization can contribute to load management goals

Cooling in all months peaks in late afternoon in monitored homes



Total load in monitored Program homes lower than average Entergy household in hottest part of day



Space heating has morning and evening peaks

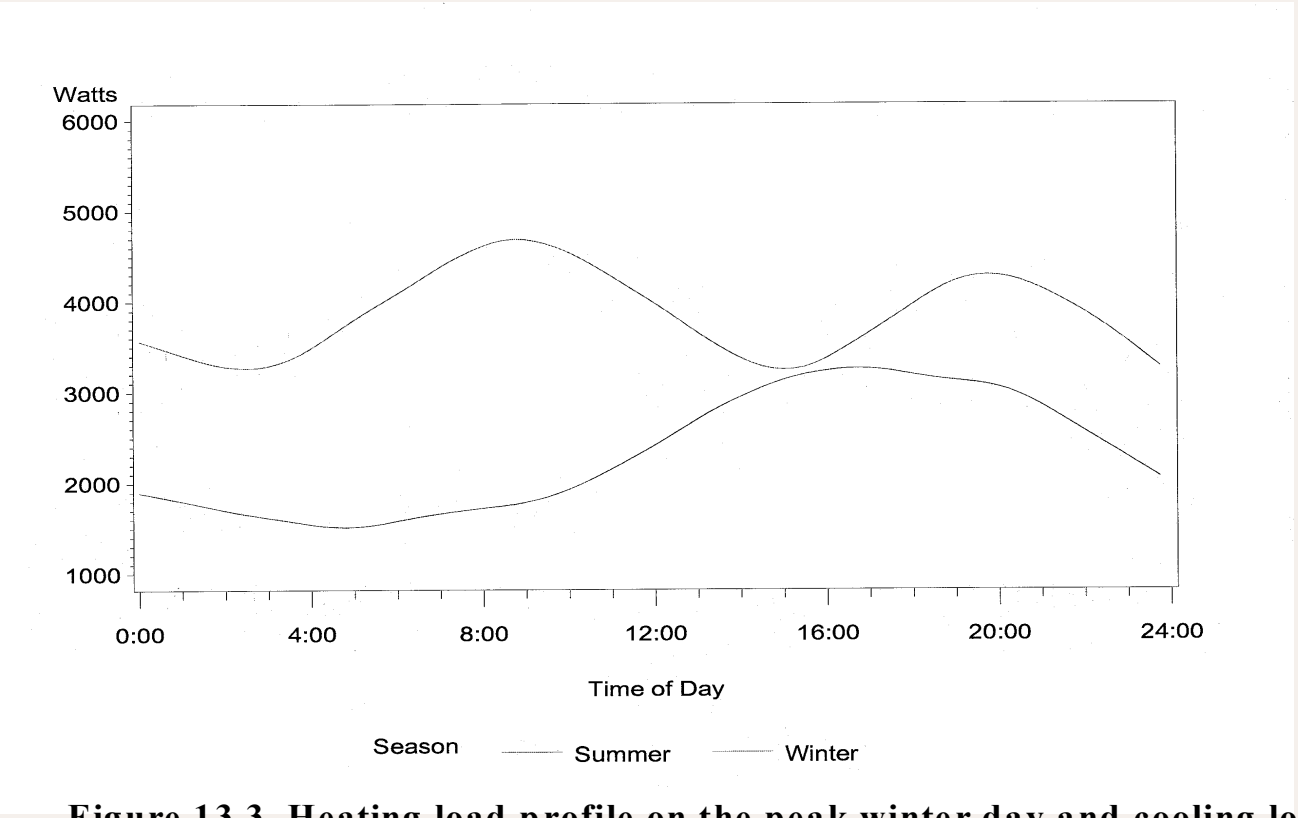
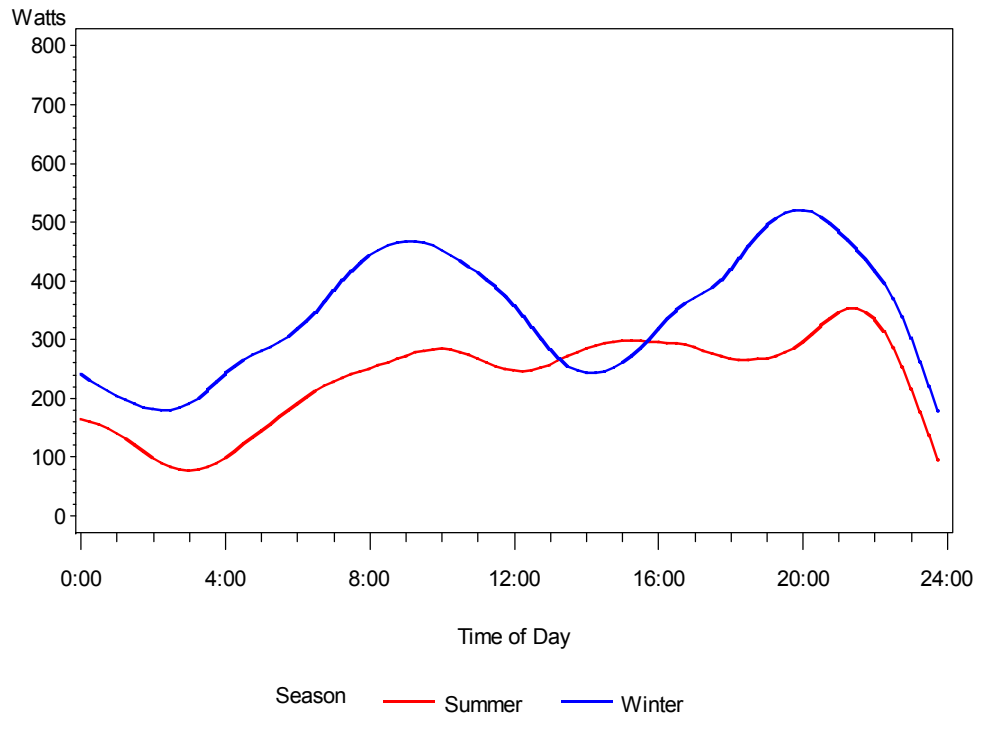
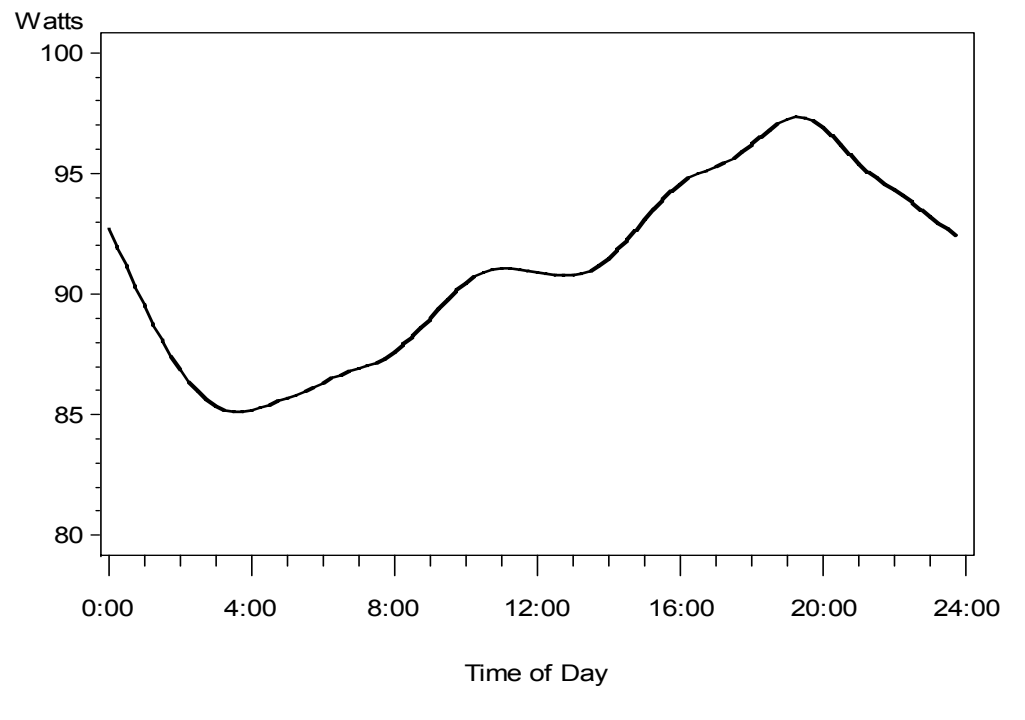


Figure 13.3. Heating load profile on the peak winter day and cooling load profile on the peak summer day of the pre-weatherization time period.

Water heating peaks higher in winter



Refrigerators show small increase at dinner hour



Time-of-day usage patterns

- Cooling peaks in late afternoon in all income groups, but total usage at hottest times of day is less for low-income monitored homes than for average home
- High rates of replacing A/C may increase peaks
- Typical morning and evening peaks for space heating
- Water heating has typical higher peaks in winter lower in summer
- Slight increase in refrigerator consumption at dinner hour, which is typical

Conclusions

- Now we understand why PRISM evaluations based on the analysis of billing records did not show cooling savings
- Pre-weatherization cooling usage is low
  - Occupant behavior (cooling by zone and time-of-day)
  - Limited capacity of A/C equipment
  - High indoor temperatures
  - A/C turned off to reduce bills

Next steps in the analysis

- Compare pre- and post-retrofit loads
- Compare change in pre- and post-retrofit cooling patterns for houses receiving new A/C units versus those that did not
- Examine issue of how to account for the value of nonenergy benefits of improved health, safety, comfort and quality of life from installation of new cooling equipment