Is it time for daily time-of-use electricity pricing? Household response to a pricing experiment

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Motivation

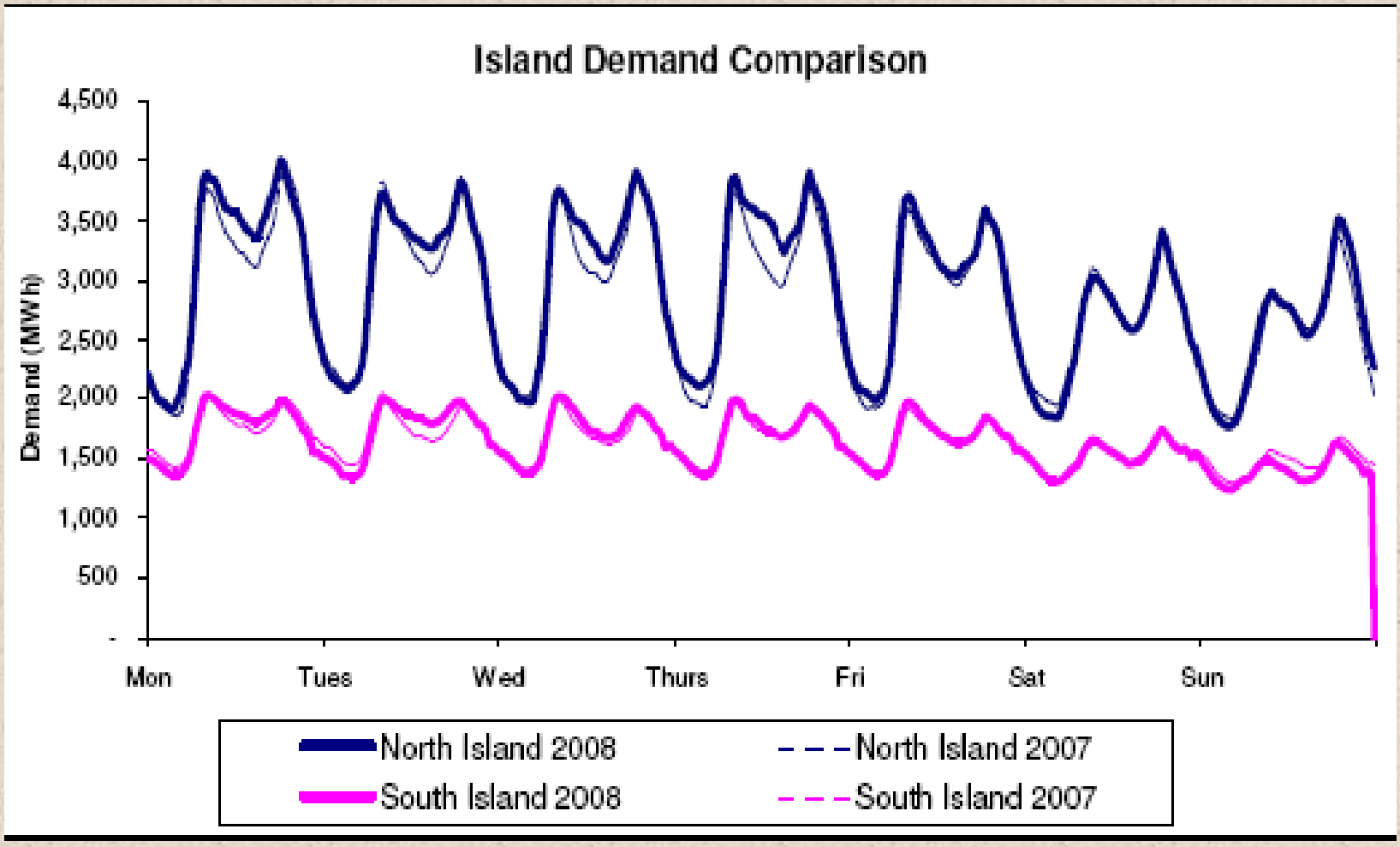
A technical innovation

- Electricity meters that record at half-hourly intervals
  - In this case, readings transmitted wirelessly to the retailer

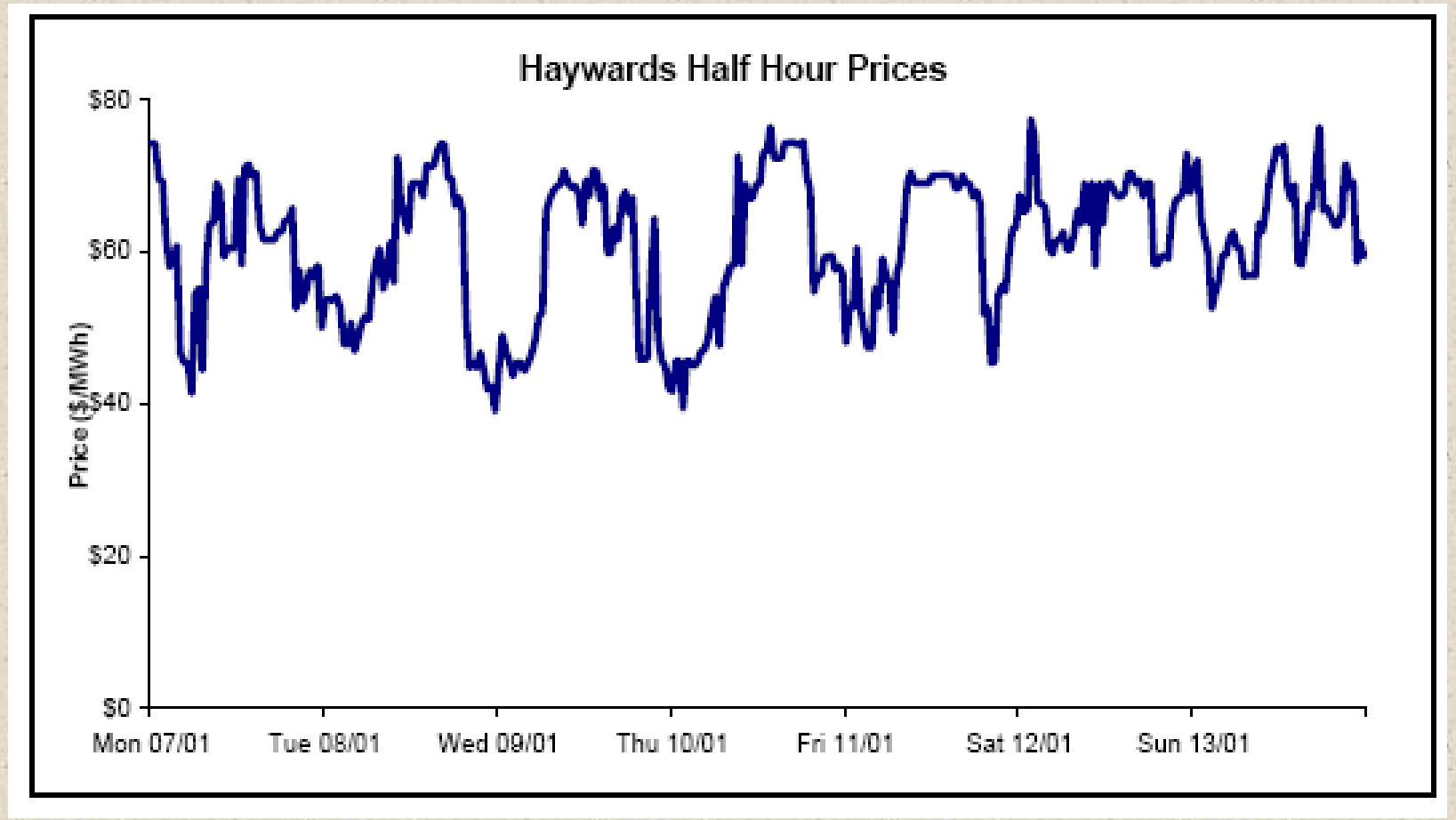
Provides potential market opportunities for the retailer:

- An additional retail ‘product’: prices that vary by time of day
  - As demand and costs vary
- Prepay for electricity
- Provide better information about usage to customers
  - Potentially supply energy-management advice/services

Daily demand cycles



Example of daily cycles in wholesale prices



Demand also can affect local distribution costs

Alternative retail pricing schemes

Average-cost pricing

Same price per kwh all day, the conventional approach

Sometimes higher than cost, sometimes lower

Real-time (marginal-cost) pricing

Retail price varies potentially half-hourly

Time-of-use (TOU)

Retail price varies by set amounts at set times

E.g., peak/off-peak, or peak/shoulder/off-peak

Variants: “critical”/peak/off-peak

Or: “dynamic” TOU pricing

Set up of the experiment

In June of 2008 Mercury staff

- Recruited ~400 households to participate in the experiment
  - Out of 4000 customers with half-hourly meters
  - Customers **'opted-in'**
- Interviewed each household face-to-face

Experiment ran from 1 August 2008 to 31 July 2009

- Peak: 7 am to 7 pm weekdays
- Off-peak: 7 pm to 7 am weekdays
  all day weekends and public holidays

Households interviewed again in September 2009

Set up (continued)

Mercury staff assigned each household at random to one of four experimental groups:

Information only, no TOU pricing: 0¢ differential

Low price differential: 4¢

Medium price differential: 10¢

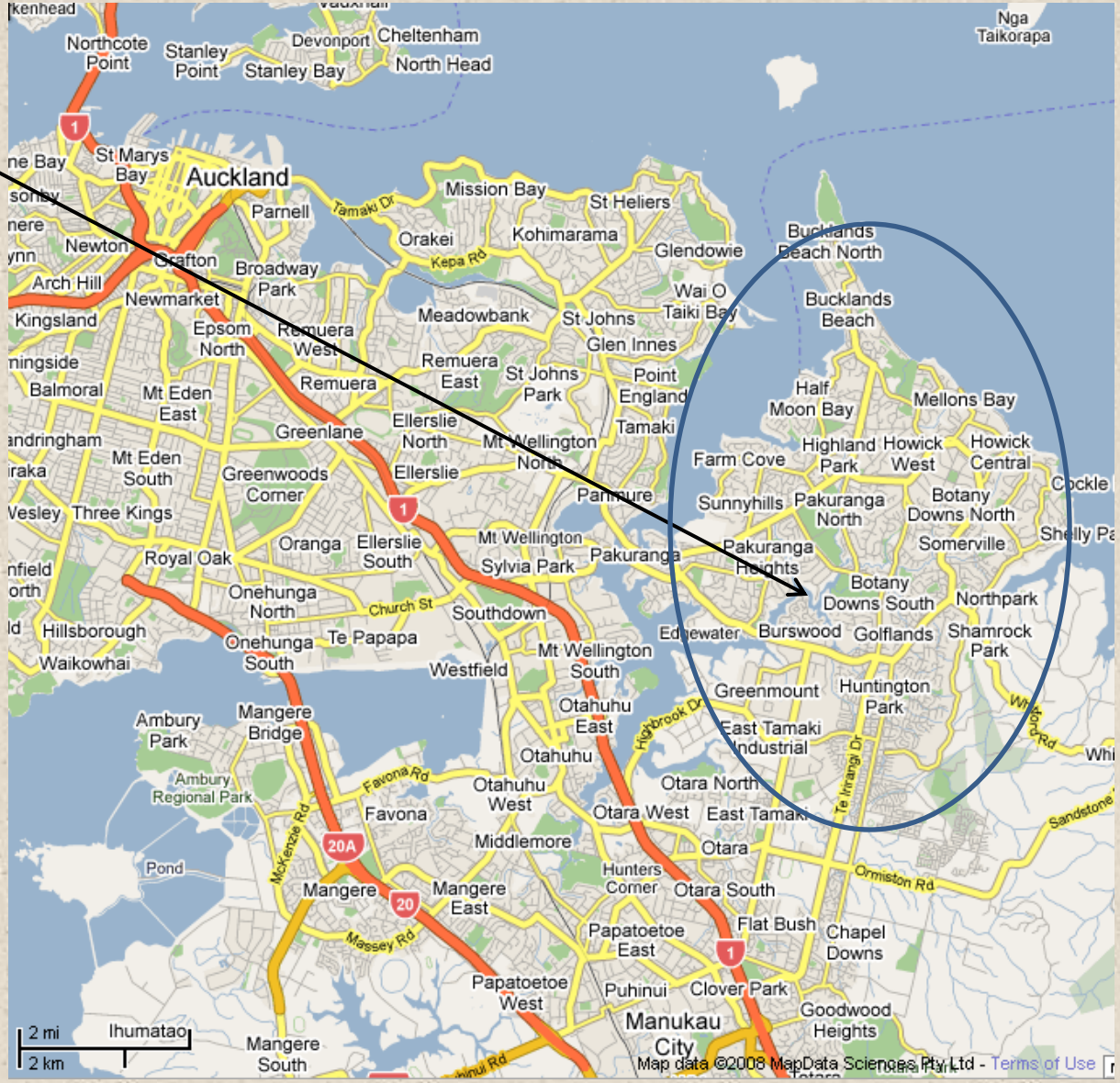
High price differential: 20¢

E.g., 10¢ off-peak and 30¢ peak

~ 80 in each group completed the experiment

+ 50 in a **control** group, who new nothing of the experiment

Study area


Auckland
Northcote Point
Stanley Point
Stanley Bay
Devonport
Cheltenham
North Head
Nga Taikorapa
St Marys Bay
Parnell
Tamaki Dr
Mission Bay
St Heliers
Orakei
Kohimarama
Glendowie
Kepa Rd
Bucklands Beach North
Bucklands Beach
Wai O Taiki Bay
Newton
Grafton
Broadway Park
Arch Hill
Newmarket
Meadowbank
St Johns
Glen Innes
Kingsland
Epsom
Remuera West
Remuera
Remuera East
St Johns Park
Point England
Tamaki
Balmoral
Mt Eden East
Greenlane
Ellerslie North
Mt Wellington North
Half Moon Bay
Mellons Bay
Highland Park
Howick West
Howick Central
Farm Cove
Mt Eden South
Greenwoods Corner
Ellerslie
Panmure
Sunnyhills
Pakuranga North
Botany Downs North
Three Kings
Oranga
Ellerslie South
Mt Wellington
Sylvia Park
Pakuranga
Pakuranga Heights
Somerville
Royal Oak
Onehunga North
Church St
Southdown
Botany Downs South
Northpark
Hillsborough
Onehunga South
Te Papapa
Westfield
Mt Wellington South
Burswood
Golflands
Shamrock Park
Waikowhai
Greenmount
Huntington Park
Ambury Park
Mangere Bridge
Otahuhu East
Highbrook Dr
East Tamaki Industrial
Otahuhu
Ambury Regional Park
Favona Rd
Otahuhu West
Otara North
Favona
Otara West
East Tamaki
Middlemore
Otara
Pond
McKenzie Rd
20A
Hunters Corner
Ormiston Rd
Mangere
20
Mangere East
Otara South
Massey Rd
Papatoetoe East
Flat Bush
Chapel Downs
Papatoetoe West
Puhinui
Clover Park
Goodwood Heights
Manukau City
Ihumatao
Mangere South
2 mi
2 km
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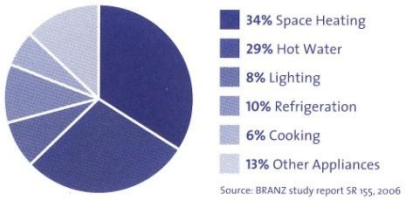
List of energy saving tips

ENERGY SAVING TIPS

The following tips are designed to help you manage your electricity usage, save energy and save money without having to make huge investments.

Mercury Energy

Take a look at the chart for a typical household's spread of electricity usage. As you can see, paying particular attention to space heating and hot water will reap the biggest rewards when it comes to your bill. Plus, using high-usage appliances such as dishwashers, washing machines and heating devices during off-peak hours will effectively reduce your electricity bill.



Source: BRANZ study report SR 155, 2006

GENERAL

- Make sure your house is insulated and free of draughts.
- Ceiling and under floor insulation will make the house warmer with less internal moisture and mould, and fewer draughts. Up to 42% of heat is lost through the ceiling.
- Seal gaps around the windows and doors, fitting weather proofing and door stoppers to reduce draughts.

KITCHEN

- Locate the fridge away from any heat-producing sources, warm airflow, or sunlight. Make sure there is a ventilation gap behind the fridge.
- Ensure the door seals on the fridge and freezer are clean and tight fitting.
- Fridges and freezers work best when they are full and defrosted regularly.
- Fill the jug from the cold tap.
- It is cheaper to boil the jug to wash a few dishes than it is to fill the sink with water from the hot tap.
- It is cheaper to do one load in the dishwasher than three sink-loads of dishes.
- Match pots and pans to the stove element size and keep the lids on.
- Ensure the oven door seals are cleaned regularly, well fitted and in good condition.
- Use smaller appliances for specific tasks whenever possible (e.g. toasters, electric frypans and microwaves rather than ovens).
- When defrosting food do it naturally.
- Use the microwave instead of the oven or stovetop at peak times.
- Don't rinse dirty dishes under the hot tap before washing in the dishwasher or sink.
- Only run the dishwasher when it's full, and use the 'economy' option, trying to avoid peak times.

LIGHTING

- Fluorescent lamps are the most energy efficient form of lighting. They use only 1/5 the energy of standard light bulbs. They are ideal for rooms where lighting is required for long periods of time, such as in the living room, hallway and kitchen.

BATHROOM

- Take a shower instead of a bath and limit the time in showers to 5 minutes.
- Keep the bathroom door closed at all times to reduce the moisture going through the rest of the house.
- Consider installing a timer for your heated towel rail to avoid peak times.
- Consider installing a water saving shower head and save on water bills as well as reduced hot water costs.

LAUNDRY

- Don't over-fill the clothes dryer.
- Wash your clothes in cold water and dry the clothes outside as much as possible. A covered line is useful for wet days.
- Dryers should be ventilated to the outside.
- Carefully set the timer on the dryer to prevent using for longer than necessary, and if possible set to run at off-peak times.
- When buying a dryer look for one which senses when the clothes are dry.
- Do cold washes; hot washes use 90% more electricity.
- Run your washing machine with full loads or adjust your cycle to match the load.

HEATING

- Choose the right size of heater for the space to be heated.
- Close the doors separating heated from unheated rooms and block off fireplaces when not in use.
- Install curtains made of thick material that generously cover the windows. They should be well lined or have a thermal backing. Close curtains before sunset and make sure curtains and doors are closed when heaters are on.
- Use a heater with a thermostat. A timer is also useful for setting specific on and off times for heaters.
- If you're going away for more than one week, turn off your hot water cylinder.
- Fix leaking hot water taps and save up to $30 per tap, per year.
- Install an energy saving hot water cylinder wrap and pipe lagging to reduce the constant heat loss from your hot water cylinder.

OTHER APPLIANCES

- Unplug mobile phone chargers when not in use.
- Never have appliances on standby. Standby electricity consumption accounts for around 5% of the total household electricity use in New Zealand.

Source: Energy Smart

EST

Information in monthly bill

SAMPLE

Mercury Energy

Usage Statement this is not a bill

Your account number

ABC / 123 / 123

ELECTRICITY USE FOR PERIOD 1/08/09 - 1/09/09

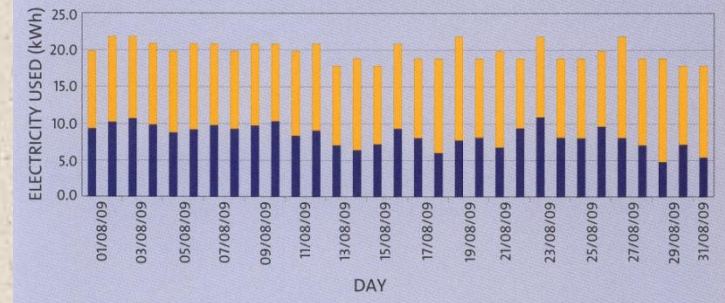
ELECTRICITY	USAGE (KWH)
PEAK (7.00am – 7.00pm weekdays)	200
OFF-PEAK (all other times, weekends & public holidays)	500
TOTAL	700

Power supplied to
123 Sample Road
Sample Suburb
Sample City

ICP identifier
0123456789ABCD

Meter number
123456789

DAILY USAGE



KEY
Peak
Off-peak

MONTHLY USAGE

ENERGY SAVING TIP

Fix leaking hot water taps and save up to $30 per tap, per year.

Source: Energy Smart

SUS4

First-pass analysis

Mercury supplied us:

- Daily peak and off-peak electricity consumption
  - From 1 August 2007 (year before) through 31 July 2009
- For each participant household
  - Plus the control group

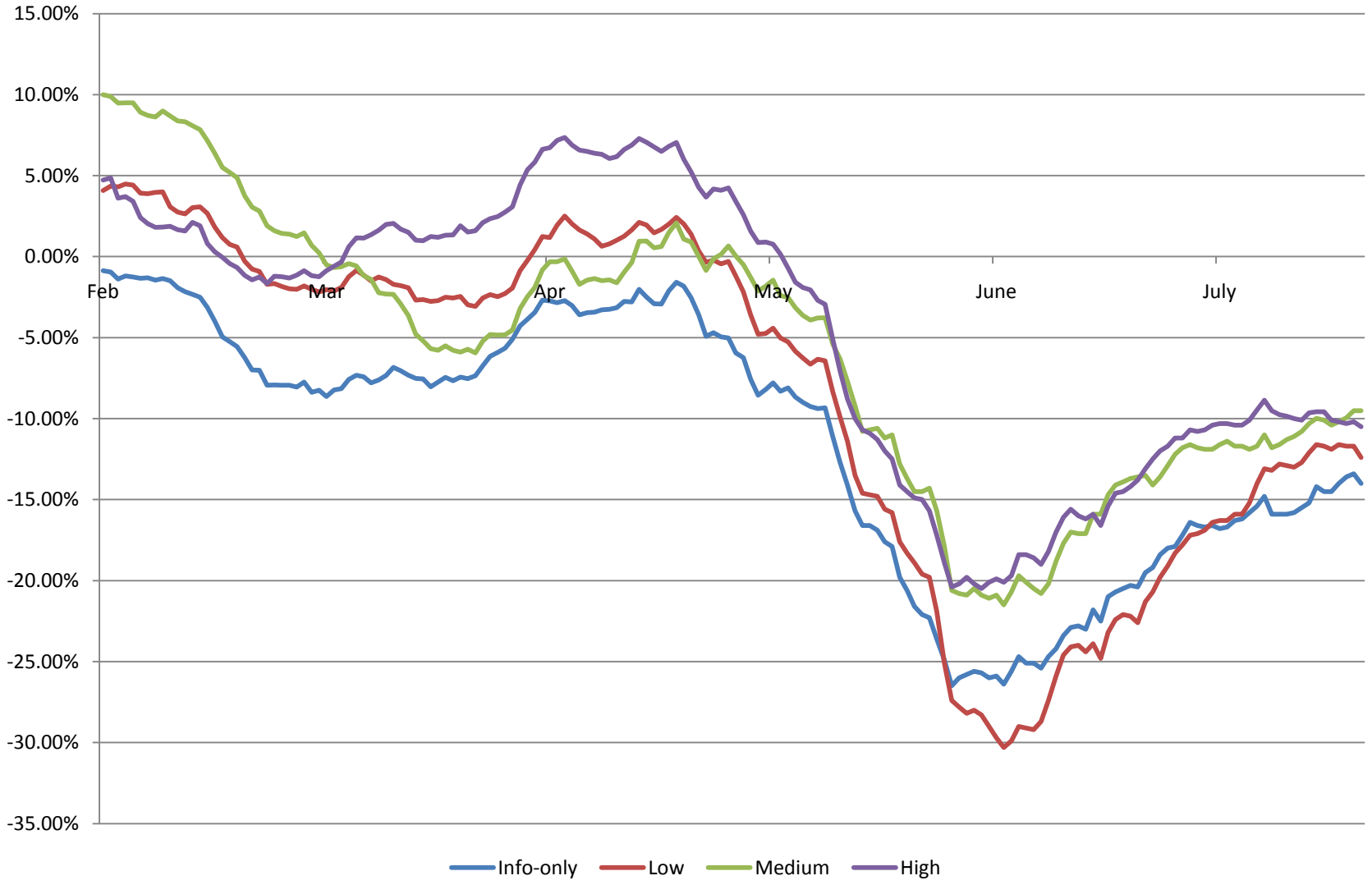
We started with a standard analytical approach:

- "Differences in differences"
  - Average differences across groups (relative to control)
    - in average % differences in year-to-year consumption

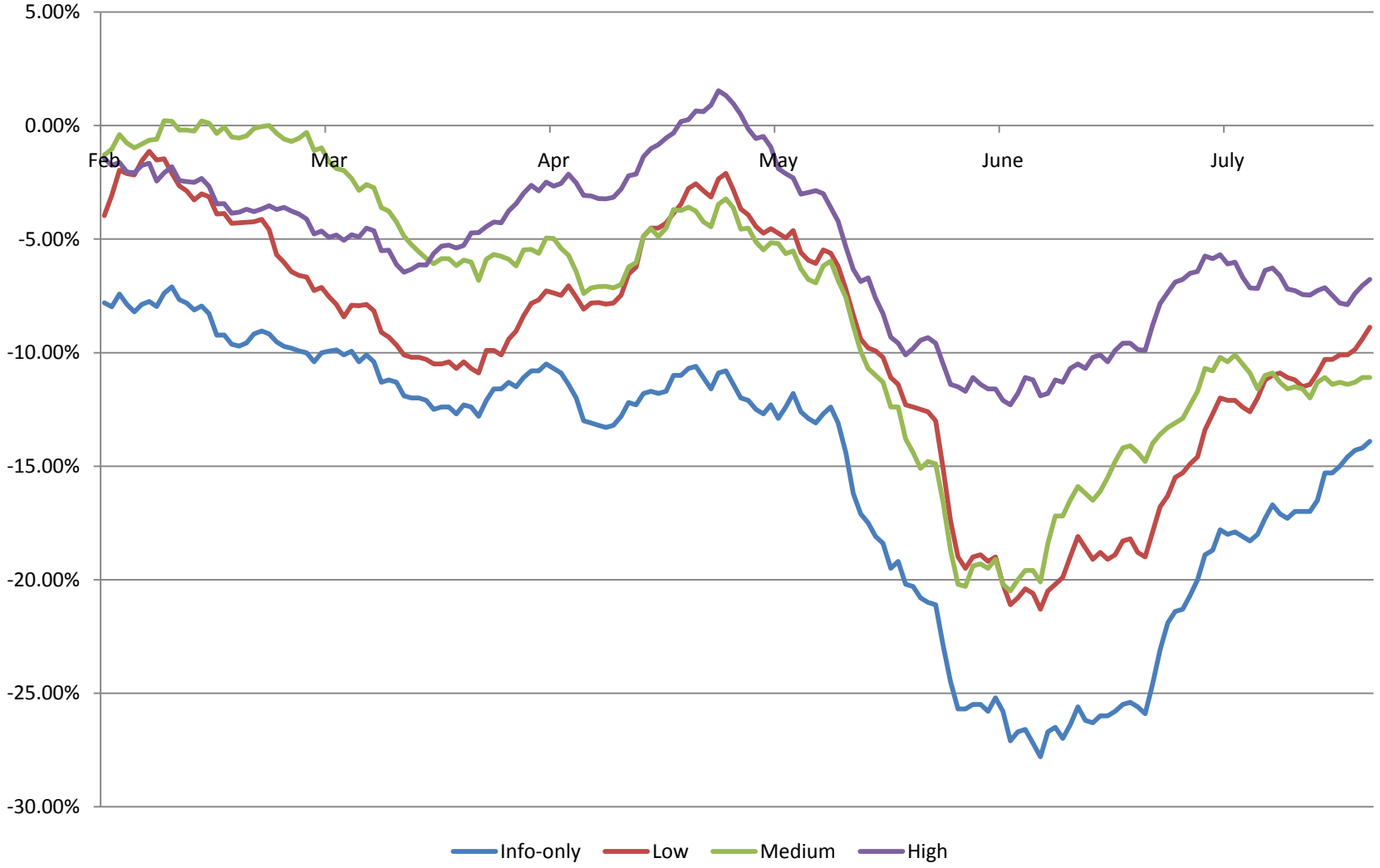
We allowed the response to vary by season

- Summer through to winter (Feb through July)

Moving average peak % difference from control



Moving average off-peak % difference from control



Conclusions from the first-pass analysis

Less response in summer (on average)

- Some conservation off-peak
- Seems likely due to relatively small summer bills (on average)

Conservation in winter (on average)

- ~ 15% (?)

Little response to higher prices during peak (on average)

- All experimental groups conserved similar amounts

Response to lower prices off-peak (on average)

- Lower prices encouraged less conservation relative to control

Questions raised from the first-pass analysis

How do individual responses vary around the averages?

- e.g., with house and household characteristics
  - income, household size, water and space heaters…

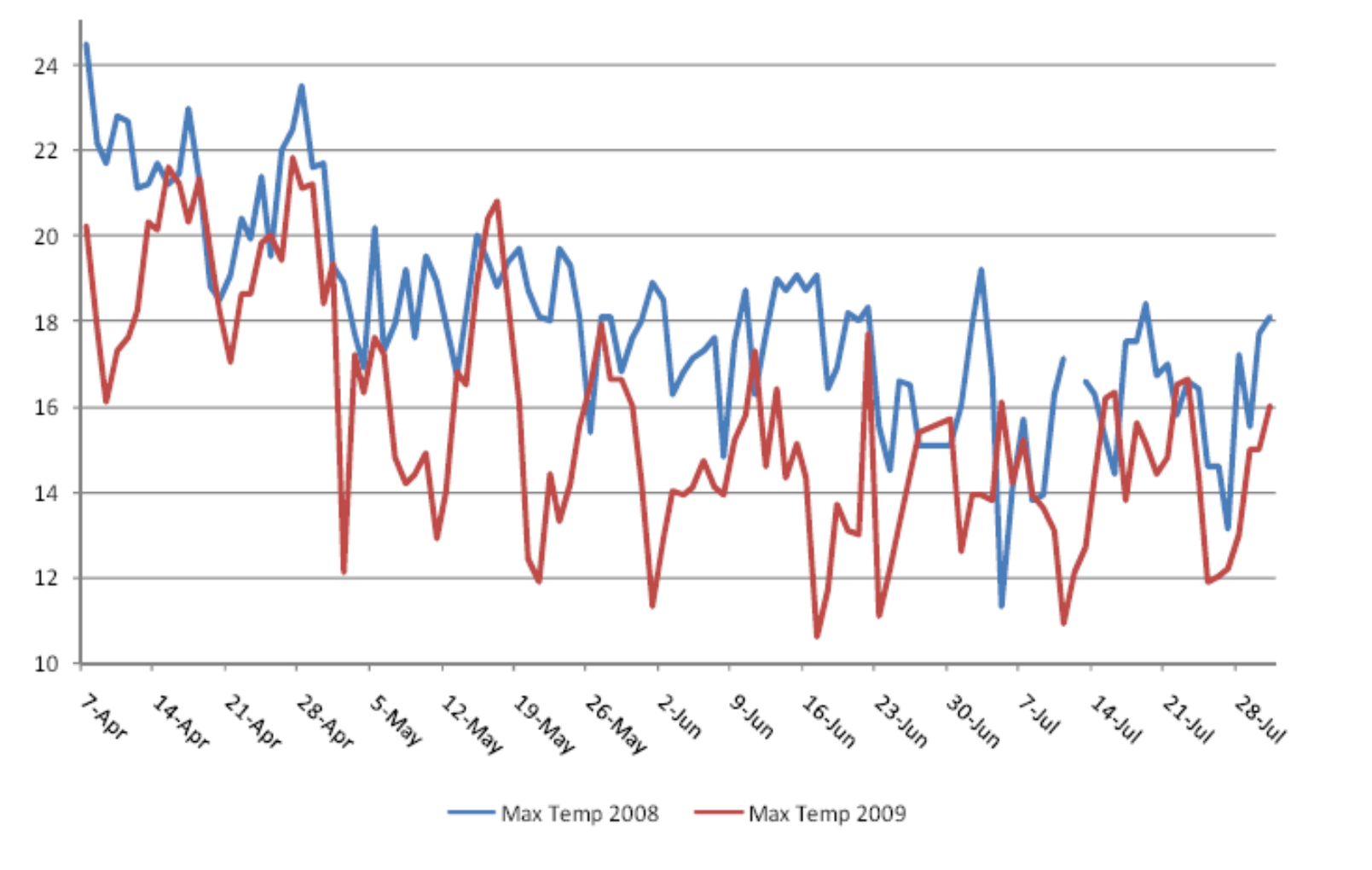
Are there effects of changes year-to-year?

- Conditions (e.g., weather…)
- Household circumstances

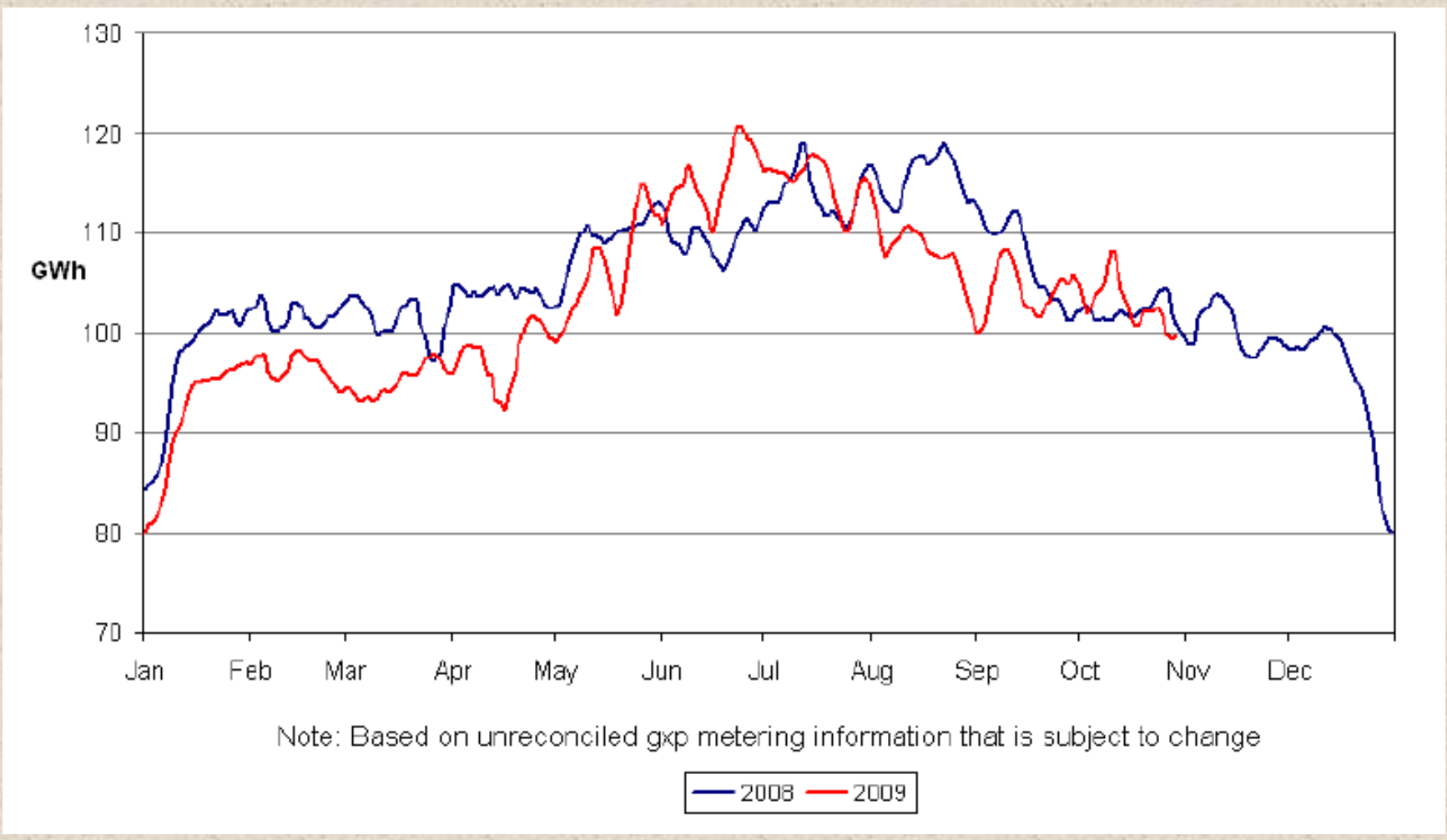
Other statistical issues?

- e.g., especially odd and influential observations
- Influential differences across groups

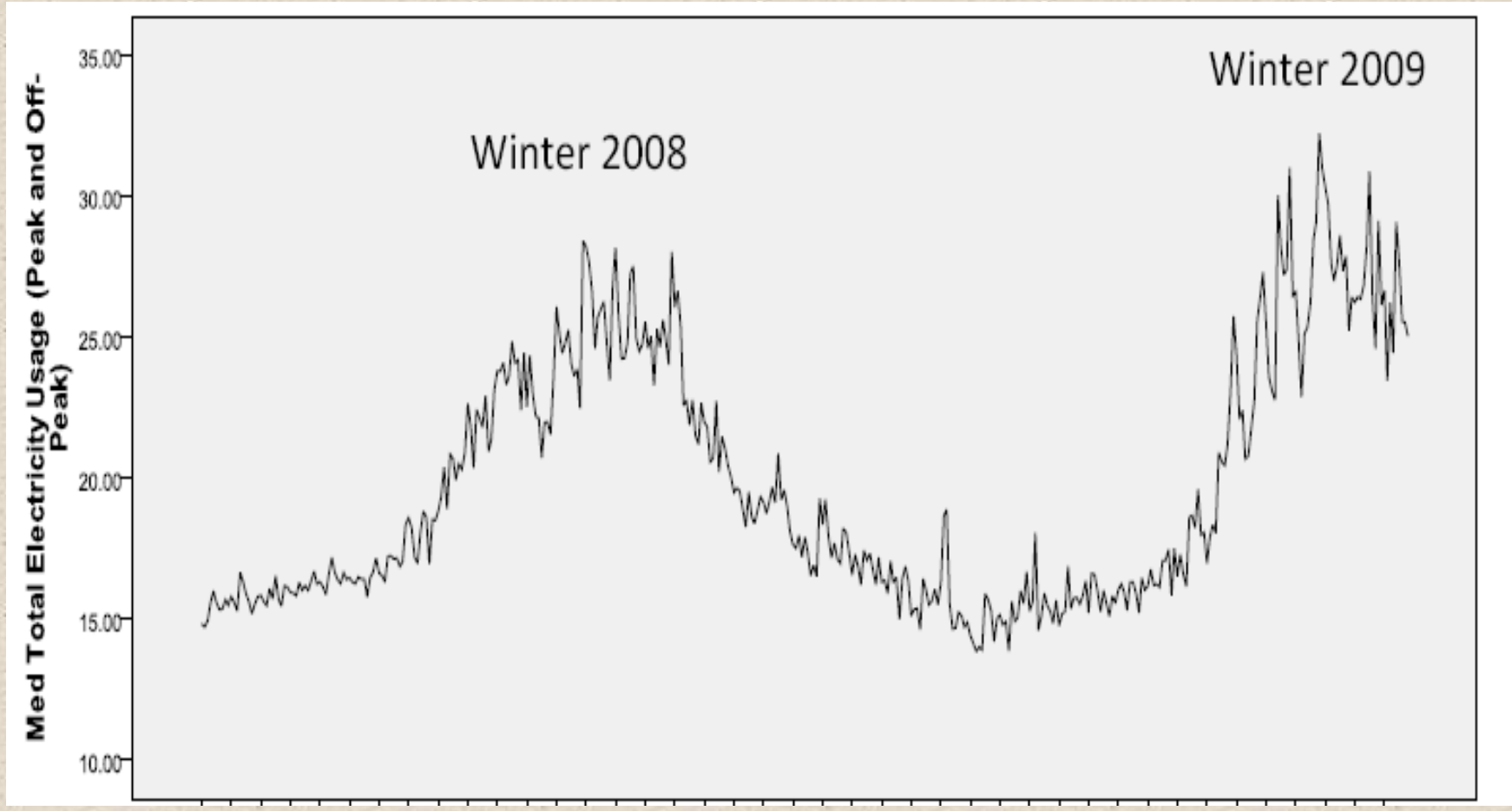
Daily max temps, April – July, 2008 and 2009



Demand 2008 vs. 2009, seven day rolling average



Median daily usage in the sample



So, what do we do next?

Concentrate on a range of winter temperatures

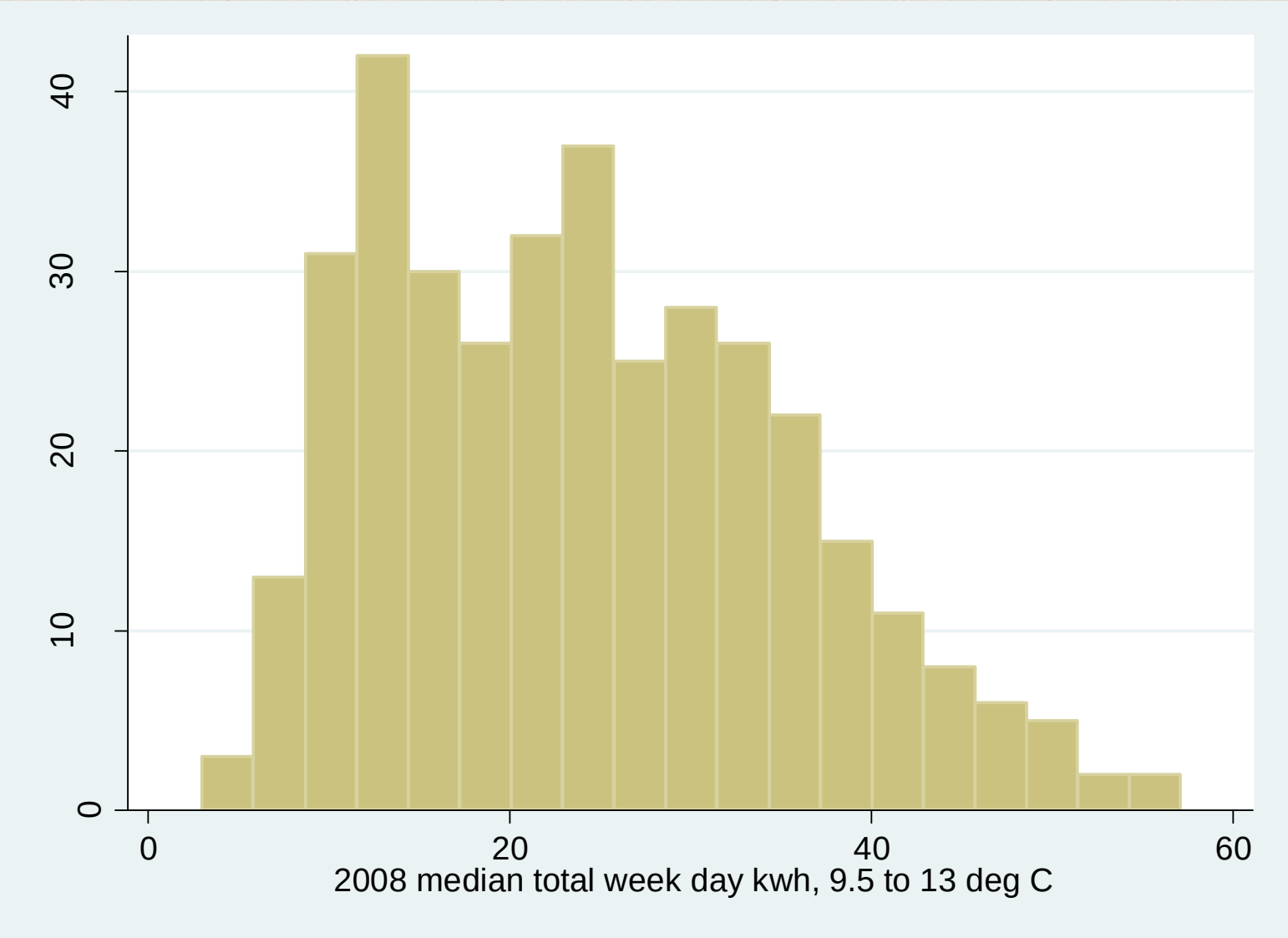
- Mean daily temperature range of 9.5 to 13 deg C

Look at how house and household characteristics affect total week day consumption

Estimate the response **of each household** to the experiment

- Median % difference in peak and off-peak week day consumption in 2009 relative to 2008
- How does the response vary with price and house and household characteristics?

Distribution of 2008 median weekday consumption



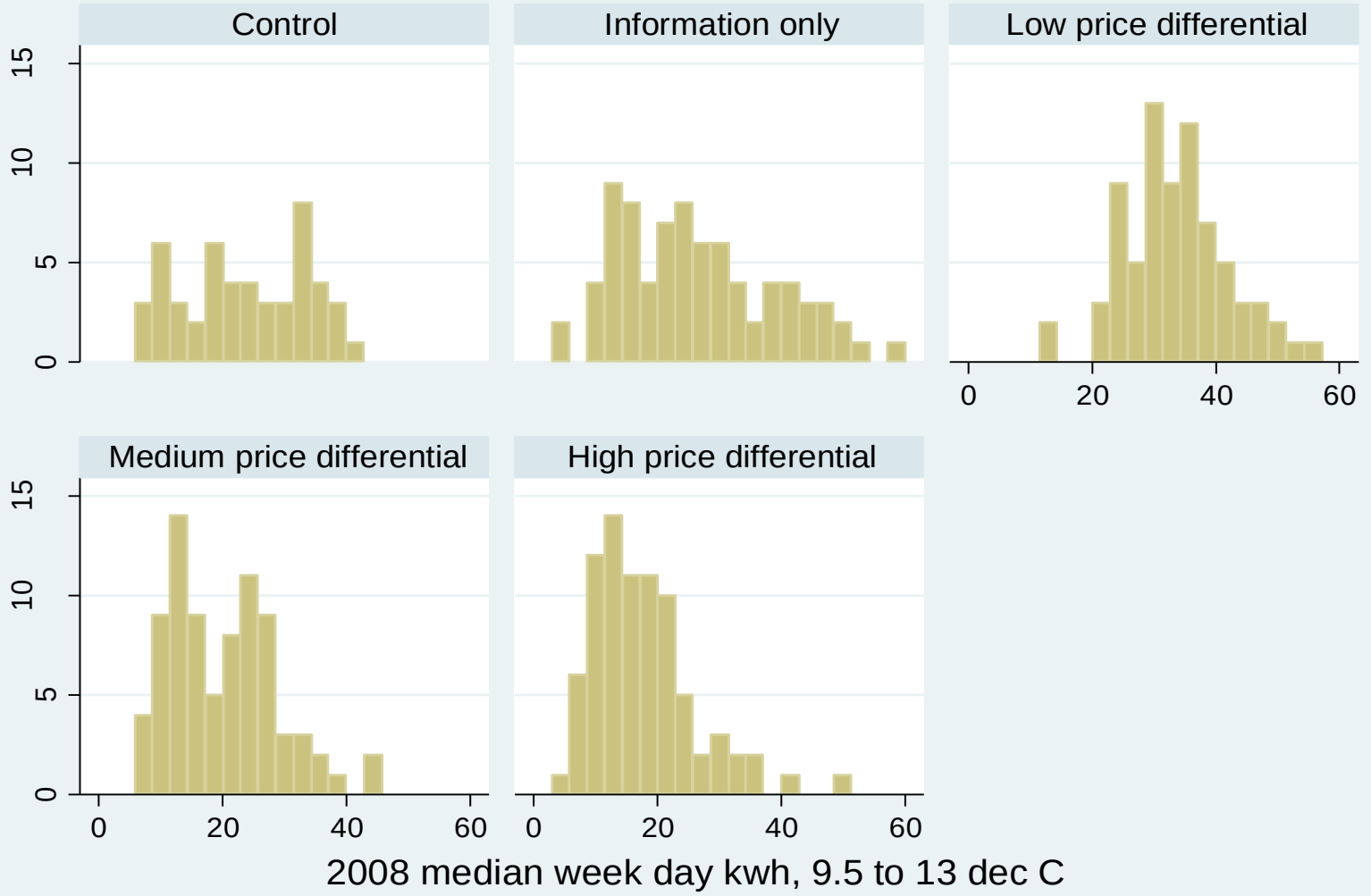
Influences on weekday electricity consumption

	% change in kwh	Std error
10 m of floor area	2.2%	0.6%
Electric hot water	76.7%	6.0%
Built pre-1980	-7.1%	9.0%
Heatpump	9.5%	7.9%
Woodburner	-4.3%	8.1%
Gas central heat	-29.7%	38.4%
Electric central heat	25.1%	19.1%
$10k more HH income	4.1%	0.8%
1 more person	11.1%	2.0%
1 more hour away	-1.6%	0.7%
Someone home ill	31.6%	13.9%

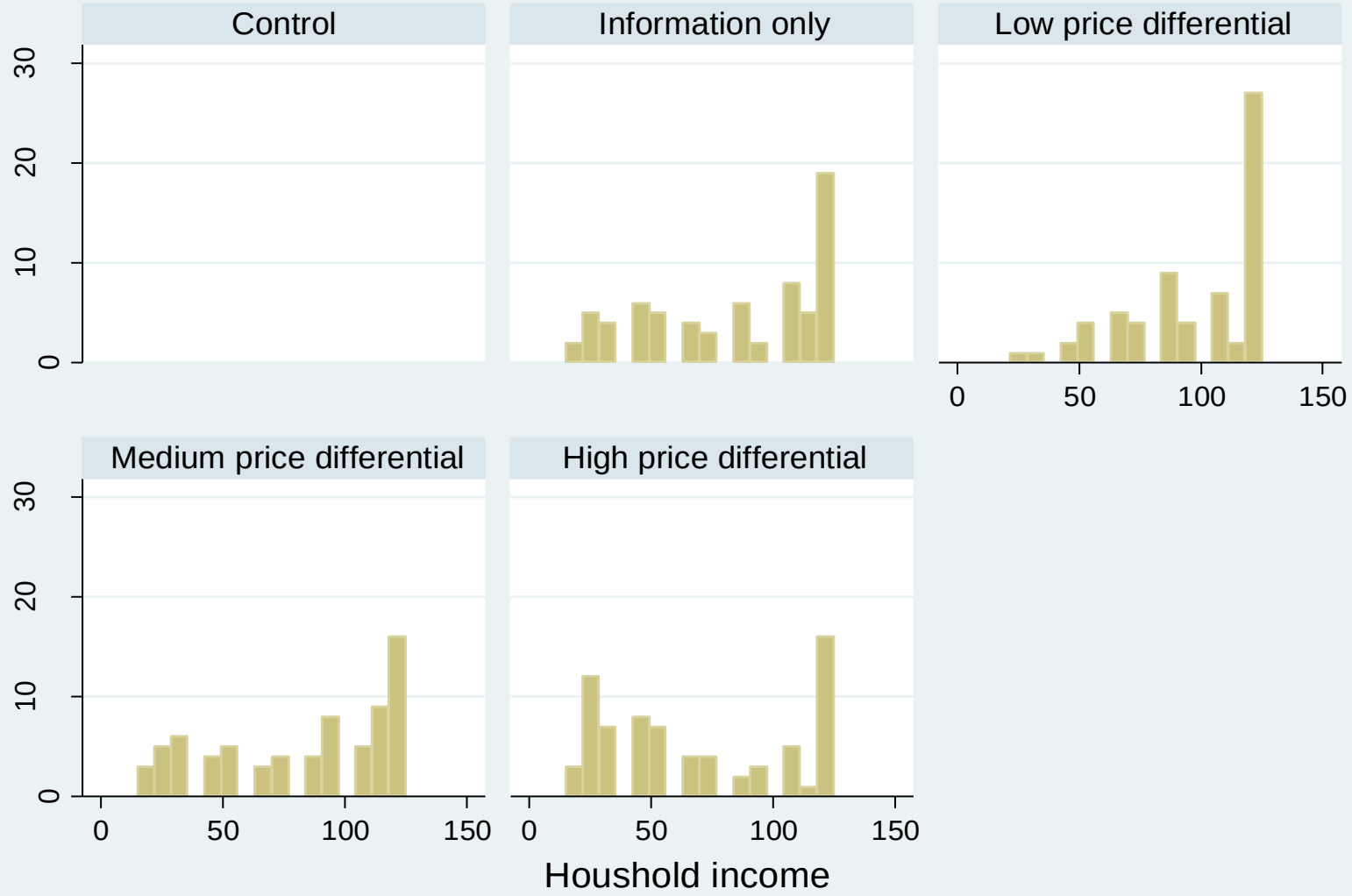
Characteristics of sample houses/households

	Mean	Std dev	Min	Max
Winter weekday kwh	24.2	12	4	67.1
Floor area (m)	186	51	60	340
Electric hot water	71.9%			
Built pre-1980	9.5%			
Heatpump	11.0%			
Woodburner	10.1%			
Gas central heat	0.6%			
Electric central heat	2.5%			
Household income	$83,400	$36,800	$15,000	$125,000
Household size	2.96	1.44	1	9
Hours away from home	5.78	3.65	0	16
Someone home ill	3.8%			

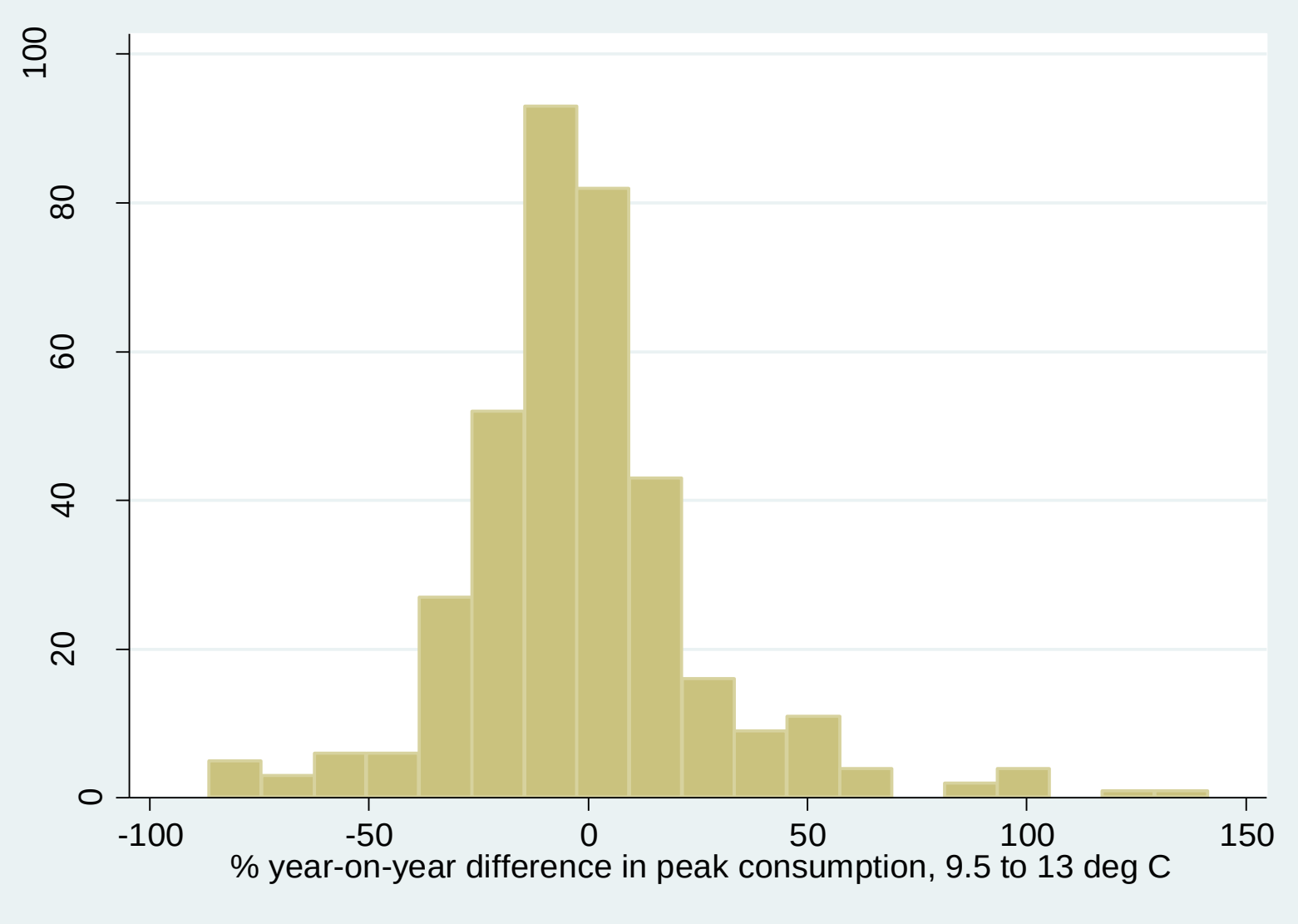
Distribution of total week day kwh across groups



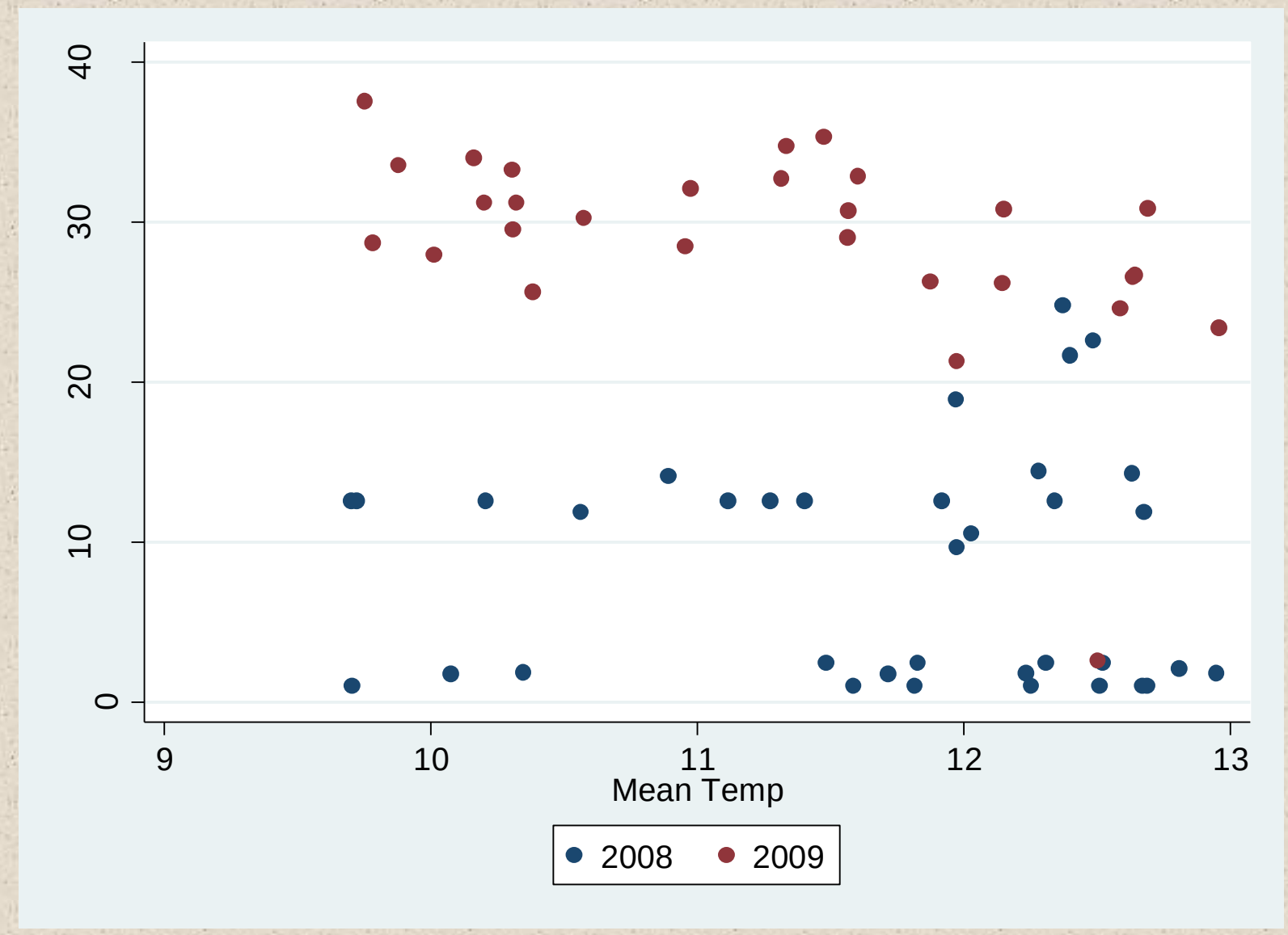
Distribution of household incomes across groups



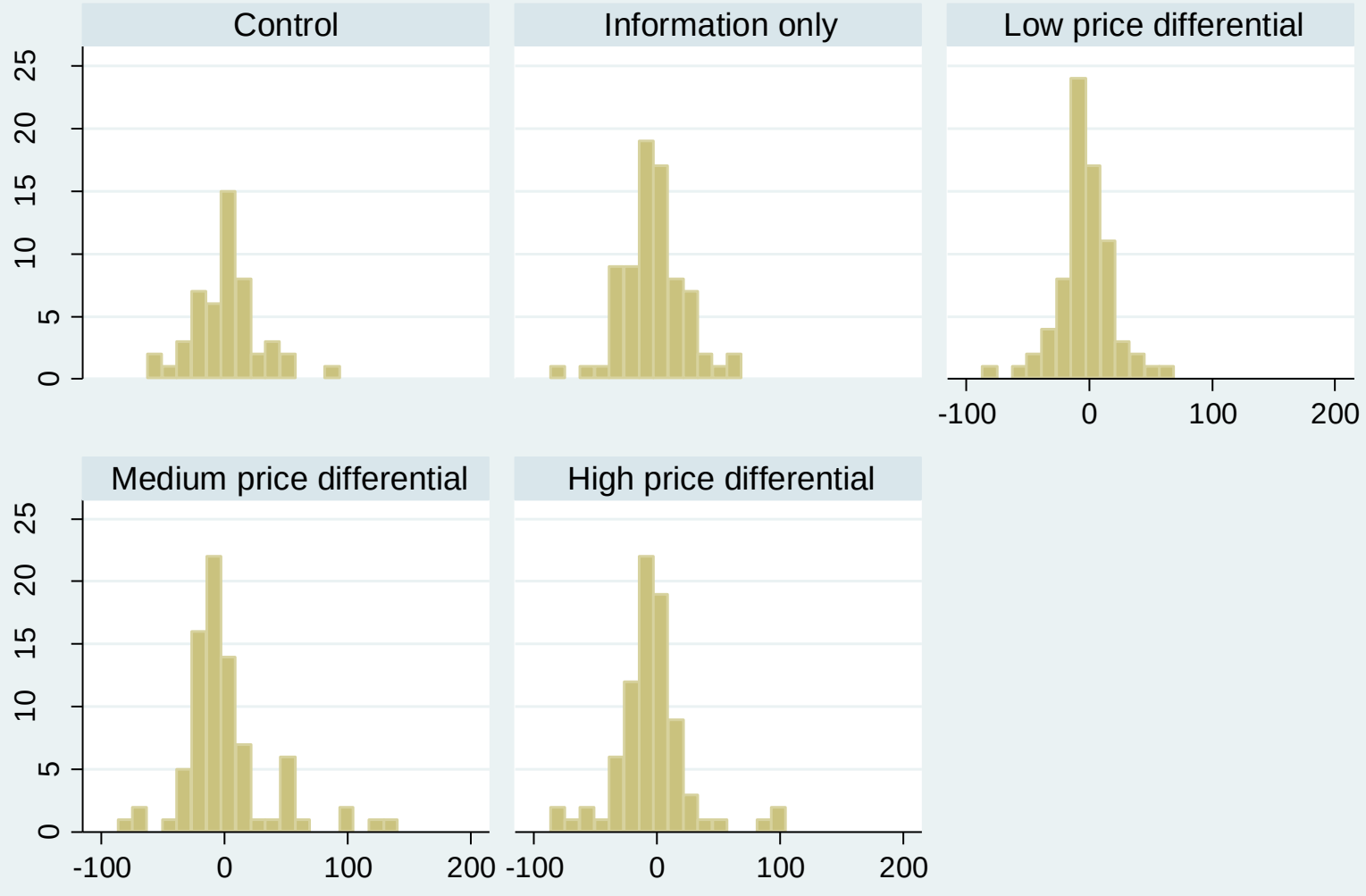
% year-on-year difference in peak consumption



Outlier in the control group



Distribution of percent peak response by group



Average % year-on-year difference in peak kwh by group, 9.5 to 13 deg C

	Mean % diff	Standard error
Control	+ 1.8%	4.7%
Info only	– 5.1%	3.7%
Low (+2¢) diff	– 6.3%	3.3%
Med (+5¢) diff	– 5.2%	4.5%
High (+10¢) diff	– 11.1%	4.4%

Influences on % year-on-year difference in peak kwh

	Mean	Std error
Built before 1980	7.14%	3.23%
Woodburner	1.49%	2.76%
Heatpump	-4.74%	2.74%
Electric hot water	6.27%	2.02%
Household income	0.11%	0.24%
Household size	-3.26%	0.63%
Added insulation	-3.44%	3.89%
New heater	4.02%	3.06%
New HRV	30.86%	5.37%
Increase in HH size	11.46%	1.52%
New illness	8.52%	5.74%
R-squared	0.16	

Average % year-on-year difference in peak kwh by group, 9.5 to 13 deg C

	W/o control vars	With controls
Control	+ 1.8%	+ 1.8%
Info only	– 5.1%	– 5.1%
Low (+2¢) diff	– 6.3%	– 8.5%
Med (+5¢) diff	– 5.2%	– 2.3%
High (+10¢) diff	– 11.1%	– 11.3%

Note. Response in the 'high' group falls with income:

–2% per $10k, on average

Lower income households respond more to price

Influences on % year-on-year difference in off-peak kwh

	Mean	Std error
Built before 1980	9.62%	5.58%
Woodburner	-8.59%	4.83%
Heatpump	-5.76%	4.66%
Electric hot water	7.57%	3.48%
Household income	-0.76%	0.42%
Household size	-0.16%	1.10%
Added insulation	-0.79%	6.82%
New heater	8.55%	5.35%
New HRV	17.53%	10.03%
Increase in HH size	9.07%	2.66%
New illness	-4.89%	11.25%
R-squared	0.16	

Effects of lower off-peak prices with control variables

	w/o control vars	With controls
Control group	+ 3.2%	+ 3.2%
Info only	– 4.9%	– 4.9%
Low (– 2¢) diff	– 1.3%	– 4.0%
Med (– 5¢) diff	– 1.3%	– 3.6%
High (– 10¢) diff	– 0.8%	– 0.5%

Less response to lower off-peak prices with controls by the low and medium price differential groups

Conclusions revised from the first-pass analysis

Conservation in winter (on average)

- ~ 7.5% (rather than ~ 15%)

Peak response higher in the high-price-differential group

- Additional 6% conservation on average
  - Lower income led to a stronger response, on average (in contrast to existing estimates)

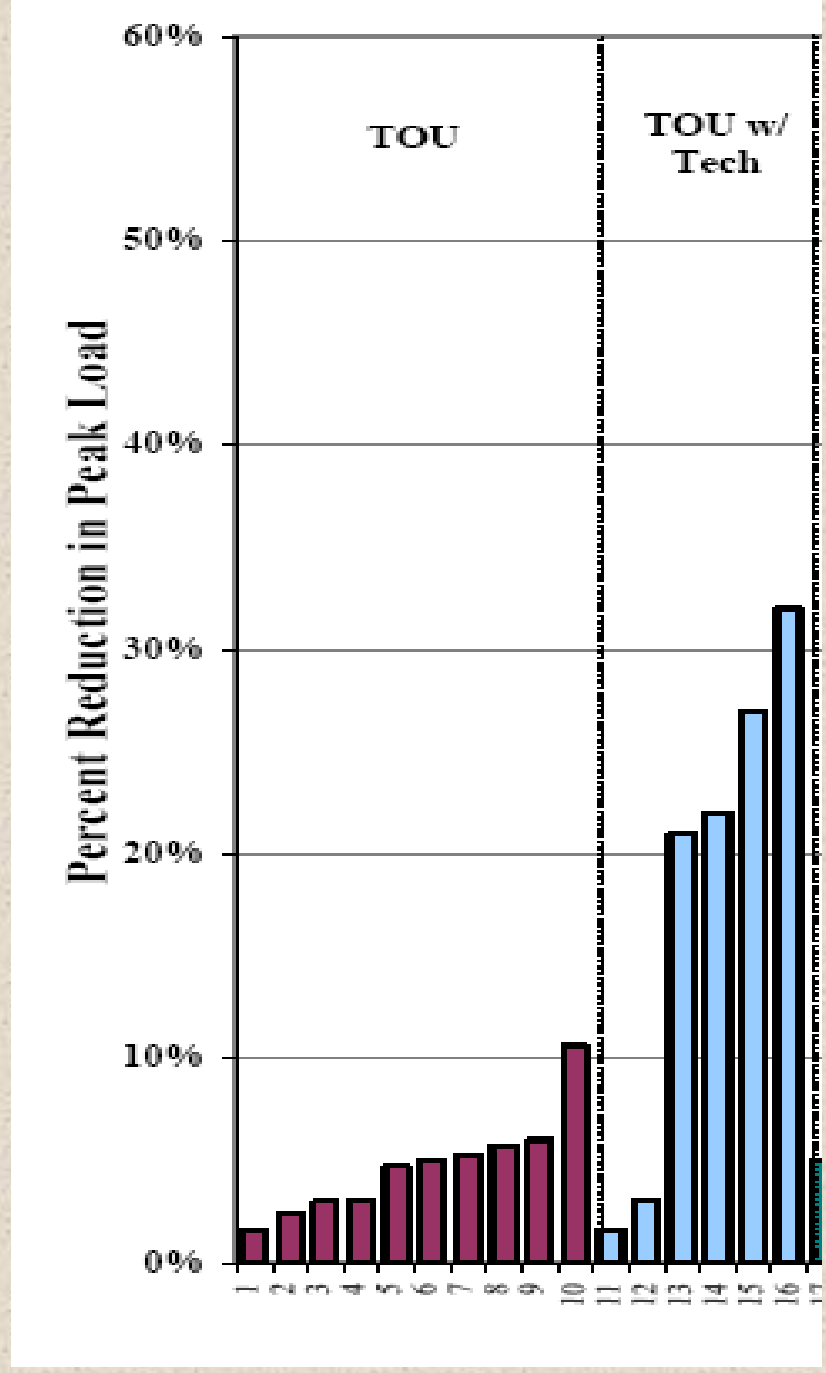
Similar result off-peak (on average)

- High-price-differential group conserved ~ 5% less

These results roughly in line with international experience

- Key questions: do they generalise? Is it good?

Results from some recent international experience



Opinions expressed after the experiment

	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)
The differences in prices was an incentive to change the time of use	25.1	48.5	11.9	11.9	2.2
The difference in prices was too small to make the effort	6.6	30.0	12.3	41.4	5.7
Easy to change to take advantage of prices	13.7	50.2	15.0	16.7	2.6
Too much trouble to change	1.3	17.2	11.0	59.5	9.3
Information graphs were easy to understand	28.5	66.4	1.7	3.3	0.3
Monthly reports did not supply enough information	2.6	16.9	7.7	61.9	10.9

Average % changes around peak/off-peak boundary