Northwest Power and Conservation Council



Wednesday, May 25, 2011

# MEMORANDUM

**TO:** Power Committee

**FROM:** Tom Eckman and Michael Schilmoeller, Council staff

**SUBJECT:** Status of Direct Use of Natural Gas Analysis

The appropriate role for the Council in promoting the direct use of natural gas for space and water heating has long been an issue in the region. The Council has analyzed the technical and the policy issues associated with the direct use of natural gas in a number of studies dating back to its very first plan. While the specific issues have changed somewhat over time, three central questions have remained:

1. Is the conversion from electricity to natural gas for residential space and water heating a lower cost and lower risk alternative for meeting the region's load growth when compared to other options?

2. If so, how much cost-effective "fuel-switching" potential is there in the region?

3. Are fuel choice markets working adequately? That is, are the space and water heating fuels being selected by consumers consistent with achieving the 6$^{th}$ Power Plan goals.

During the development of the Sixth Plan, a fourth question has also been raised: How the conversion from electricity to natural gas for space and water heating impacts the region's carbon emissions?

Staff presented a webinar to the Power Committee that summarized the analytical approach that it intended to use to address the questions of whether the choice of electric or gas appliances for domestic space and water heating had cost or risk implications for the region and what the impact on regional carbon emissions was. After that presentation, the direct use of gas sub-committee of the Regional Technical Forum had an opportunity to review staff assumptions, methods, and observations and to provide feedback.

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Staff will present an update to the Power Committee on its current analysis and its plans for additional analysis at the meeting in Whitefish. A synopsis of the presentation follows.

Preliminary results suggest that under a "business as usual" scenario (meaning no policy intervention), some existing gas space and water heating customers would convert to electricity. However, the region's electricity system would have lower cost and face lower risk by retaining the current market share of gas space heating customers and to a lesser extent current water heating customers.

These findings are based on "societal" cost for natural gas and electricity, not retail prices. Moreover, they do not reflect that with any conversions to natural gas reduce the amount of conservation available from weatherization, high efficiency heat pumps, duct sealing, and improved electric water.

Therefore, further work is needed prior to reaching any conclusions about whether an explicit policy intervention is needed to ensure that gas market shares are preserved. The scope of this work includes adjusting the Council's conservation assessment to reflect shifts in fuel shares. Staff must still assess whether consumers are likely to select electric space and water heating options over gas options based on retail electricity and natural gas prices instead of the wholesale prices used in the RPM. In addition to this work, we also ask for feedback on the cost and use assumptions we used.

Staff's next step is to develop an analysis of the comparative cost of space and water heating from a consumer perspective rather than from a regional perspective. This analysis will use the same conversion cost and energy use assumptions as were used in the RPM analysis. However, rather than a range of future wholesale market prices for electricity and natural gas, we will use the range of retail rates for both natural gas and electricity found across the region and a range of forecast of energy price escalation from the Sixth Plan.

In addition to this analysis, we will also be adjusting the inputs to the RPM to reflect the reduction in electricity savings available from conservation due to changes in fuel shares. The next iteration will also test the sensitivity of the results to assumptions regarding the "value" of central air conditioning provided by heat pumps which were recommended by the RTF at its March 18 meeting. The current analysis assumes no value for air conditioning.

This work is anticipated to be completed by late-June. When it is ready for review, staff will re-convene the RTF's direct use of gas subcommittee to review the results and then bring a final recommendation to the Council later in the summer.



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# Status Report on Direct Use of Natural Gas

*Power Committee*

*June 7, 2011*

*Tom Eckman and Michael Schilmoeller*

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# Outline

- Review of March 7, 2011 Presentation
- Results presented to the Regional Technical Forum (RTF) Friday, March 18, 2011
- Next steps

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# Review

- Aliases
- Results of the last studies
  - 1994 Regional cost
  - 1996 Retail cost
- Council adopted policy: use the market and monitor
- RTF study initiated 2008, completed and results presented to the RTF in June 2010 and to the Power Committee in July 2010
- Fall 2010, updated analysis, due to
  - New federal efficiency standards
  - New fuel prices, appliance costs

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# Study Limitations

- Ignored some space and water heating fuels and appliances
  - Only natural gas and electricity considered (no propane, oil, solar thermal, etc.)
  - Some small segment groups (e.g., central hot-water heating) excluded as having insignificant effect
  - Some segment groups (gas/heat pump hybrids) excluded for lack of cost information
  - No value for AC (with heat pump)
- Assumed use is insensitive to price, once the choice is made

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# Structure of the Study

1. As a space heater is nearing the end of its life, replace it based on the best guess about future natural gas and electricity prices. Try to minimize total, life-cycle resource cost.
2. Buy and install the appliance(s).
3. Actual cost depends on the simulated future that occurs, not the forecast. As always, the future is a trajectory of carbon penalty, natural gas price, electricity price, and so forth unknown to the forecaster.

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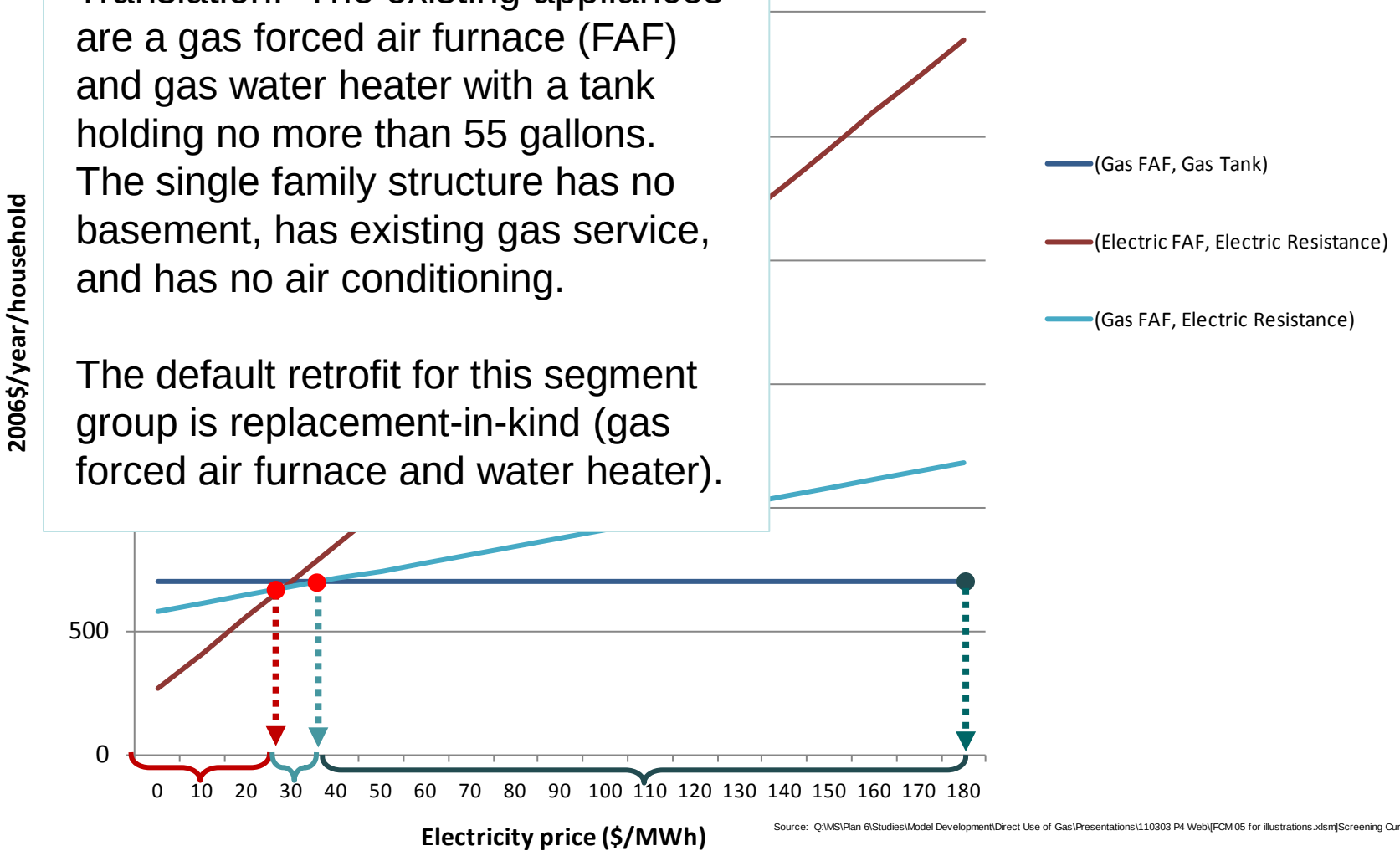
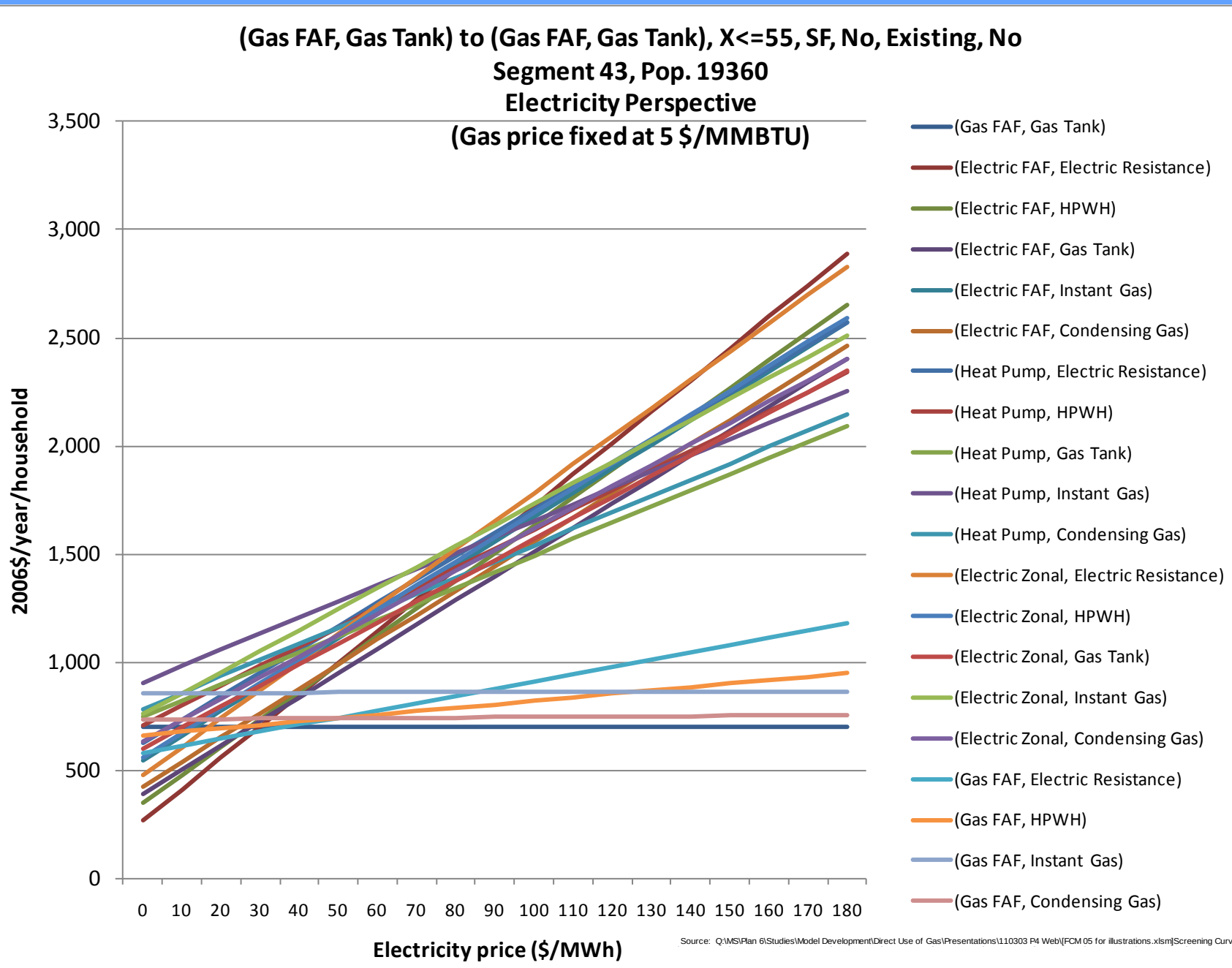
## (Gas FAF, Gas Tank) to (Gas FAF, Gas Tank), X<=55, SF, No, Existing, No
## Segment 43, Pop. 19360
## Electricity Perspective
## (Gas price fixed at 5 $/MMBTU)

Translation: The existing appliances are a gas forced air furnace (FAF) and gas water heater with a tank holding no more than 55 gallons. The single family structure has no basement, has existing gas service, and has no air conditioning.

The default retrofit for this segment group is replacement-in-kind (gas forced air furnace and water heater).




Source: Q:\MS\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110303 P4 Web\[FCM 05 for illustrations.xlsm]Screening Curves


(Gas FAF, Gas Tank) to (Gas FAF, Gas Tank), X<=55, SF, No, Existing, No
Segment 43, Pop. 19360
Electricity Perspective
(Gas price fixed at 5 $/MMBTU)
2006$/year/household
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
Electricity price ($/MWh)
(Gas FAF, Gas Tank)
(Electric FAF, Electric Resistance)
(Electric FAF, HPWH)
(Electric FAF, Gas Tank)
(Electric FAF, Instant Gas)
(Electric FAF, Condensing Gas)
(Heat Pump, Electric Resistance)
(Heat Pump, HPWH)
(Heat Pump, Gas Tank)
(Heat Pump, Instant Gas)
(Heat Pump, Condensing Gas)
(Electric Zonal, Electric Resistance)
(Electric Zonal, HPWH)
(Electric Zonal, Gas Tank)
(Electric Zonal, Instant Gas)
(Electric Zonal, Condensing Gas)
(Gas FAF, Electric Resistance)
(Gas FAF, HPWH)
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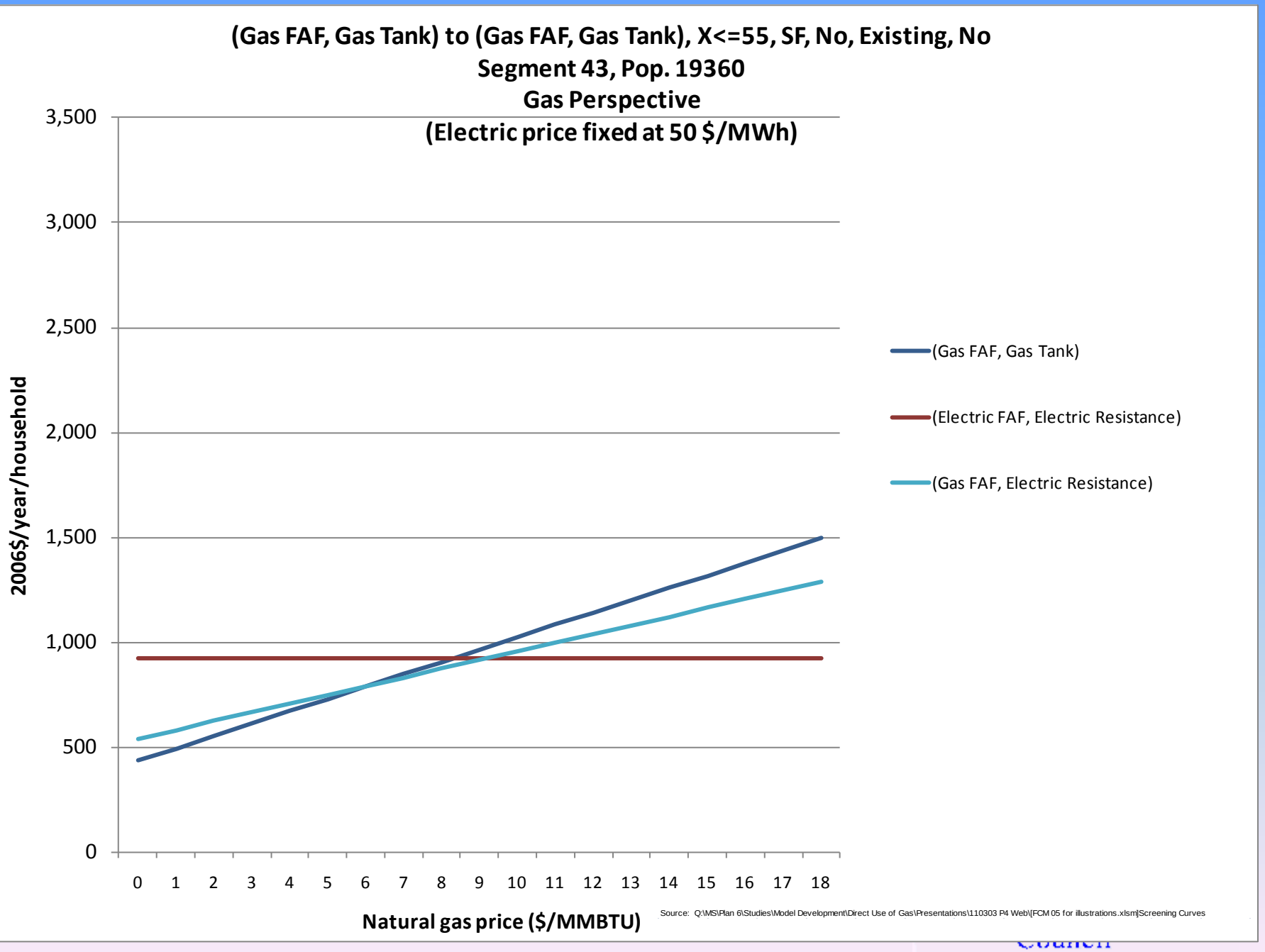
(Gas FAF, Gas Tank) to (Gas FAF, Gas Tank), X<=55, SF, No, Existing, No
Segment 43, Pop. 19360
Gas Perspective
(Electric price fixed at 50 $/MWh)
2006$/year/household
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Natural gas price ($/MMBTU)
(Gas FAF, Gas Tank)
(Electric FAF, Electric Resistance)
(Gas FAF, Electric Resistance)
Source: Q:\MS\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110303 P4 Web\[FCM 05 for illustrations.xlsm]Screening Curves

## Least-cost Segments for SegmentGroup * 43 *, annual households: 19360,

**segment group (Gas FAF, Gas Tank) to (Gas FAF, Gas Tank), DWH tank size <=55 gal., SF, no basement, existing gas, no A/C**

**Electricity Price (2006$/MWh)**

| Gas Price (2006$/MMBTU) | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 1 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 2 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 3 | 714 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 4 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 5 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 6 | 714 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| 7 | 714 | 714 | 714 | 714 | 729 | 730 | -1 | -1 | -1 | -1 | -1 | -1 |
| 8 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | -1 | -1 | -1 | -1 | -1 |
| 9 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | 730 | -1 | -1 | -1 | -1 |
| 10 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | 730 | 730 | -1 | -1 | -1 |
| 11 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | 732 | 732 | 732 |
| 12 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | 730 | 732 | 732 |
| 13 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | 730 | 730 | 732 |
| 14 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 730 | 730 | 730 | 730 | 732 |
| 15 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 730 | 730 | 730 | 730 | 730 |
| 16 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | 730 | 730 | 730 |
| 17 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | 730 | 730 | 730 |
| 18 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | 730 | 730 | 730 |
| 19 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | 730 | 730 | 730 |
| 20 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | 715 | 720 | 730 |
| 30 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | 715 | 720 | 720 |
| 40 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | 715 | 720 | 720 |
| 50 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | 715 | 720 | 720 |
| 60 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | 715 | 720 | 720 |

Source: Q:\MS\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110303 P4 Web\[FCM 05 for illustrations.xlsm]RPM Input

| | | | |
|---|---|---|---|
| -1 | gas FAF space heater, gas tank water heater (replacement in kind) | 729 | gas FAF space heater, electric resistance water heater |
| 714 | electric FAF space heater, electric resistance water heater | 730 | gas FAF space heater, heat pump water heater |
| 715 | electric FAF space heater, heat pump water heater | 732 | gas FAF space heater, condensing gas water heater |
| 720 | heat pump space heater, heat pump water heater | | |

# Key Points

- Commodity prices get used in two different ways in this evaluation
  - To ***forecast***
  - To value the outcome

  and these two will typically be very different
- The selection has consequences beyond heating costs: to the need for power resources and to the emission of greenhouse gases
- We ask, can we improve the outcome by influencing the selection?

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# The Selector

- There are many ways to do this, for example,
  - Changing relative fixed cost of appliances in the selection process
  - Letting the optimizer test every option for each segment group and tracking
- If the decision is influenced by perceptions of likely future economics, let's use that
- We already model electricity and gas price uncertainty
- Use the "diagonal" nature of the typical boundary between gas and electric appliances

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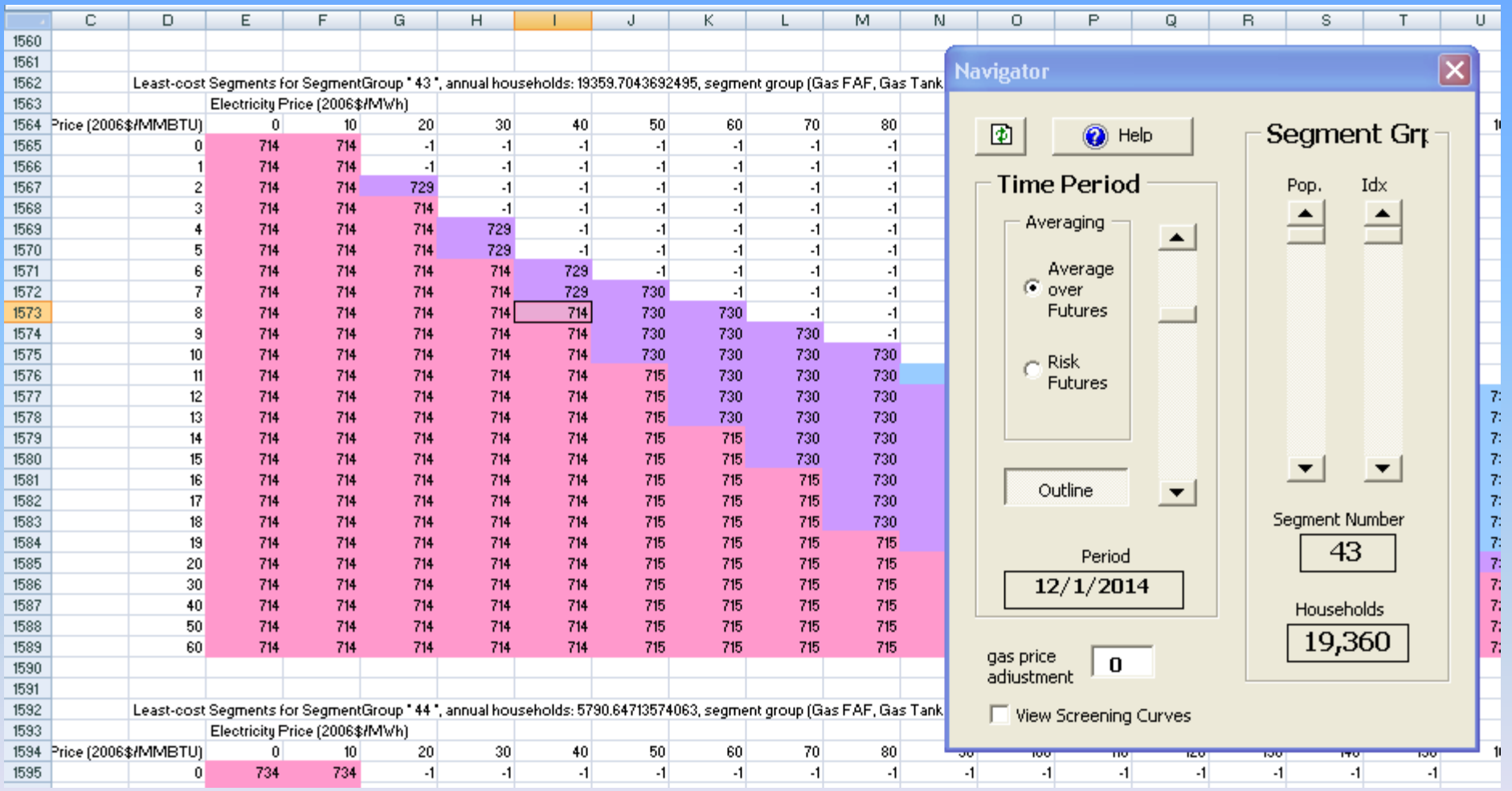

| | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1560 | | | | | | | | | | | | | | | | | | | |
| 1561 | | | | | | | | | | | | | | | | | | | |
| 1562 | | Least-cost Segments for SegmentGroup " 43 ", annual households: 19359.7043692495, segment group (Gas FAF, Gas Tank | | | | | | | | | | | | | | | | | |
| 1563 | | | Electricity Price (2006$/MWh) | | | | | | | | | | | | | | | | |
| 1564 | Price (2006$/MMBTU) | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | | | | | | | | |
| 1565 | | 0 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | |
| 1566 | | 1 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | |
| 1567 | | 2 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | |
| 1568 | | 3 | 714 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | |
| 1569 | | 4 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | | | | | | | | |
| 1570 | | 5 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | | | | | | | | |
| 1571 | | 6 | 714 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | | | | | | | | |
| 1572 | | 7 | 714 | 714 | 714 | 714 | 729 | 730 | -1 | -1 | -1 | | | | | | | | |
| 1573 | | 8 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | -1 | -1 | | | | | | | | |
| 1574 | | 9 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | 730 | -1 | | | | | | | | |
| 1575 | | 10 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | 730 | 730 | | | | | | | | |
| 1576 | | 11 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | | | | | | | | |
| 1577 | | 12 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | | | | | | | | |
| 1578 | | 13 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | | | | | | | | |
| 1579 | | 14 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 730 | 730 | | | | | | | | |
| 1580 | | 15 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 730 | 730 | | | | | | | | |
| 1581 | | 16 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | | | | | | | | |
| 1582 | | 17 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | | | | | | | | |
| 1583 | | 18 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | | | | | | | | |
| 1584 | | 19 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | |
| 1585 | | 20 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | |
| 1586 | | 30 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | |
| 1587 | | 40 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | |
| 1588 | | 50 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | |
| 1589 | | 60 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | |
| 1590 | | | | | | | | | | | | | | | | | | | |
| 1591 | | | | | | | | | | | | | | | | | | | |
| 1592 | | Least-cost Segments for SegmentGroup " 44 ", annual households: 5790.64713574063, segment group (Gas FAF, Gas Tank | | | | | | | | | | | | | | | | | |
| 1593 | | | Electricity Price (2006$/MWh) | | | | | | | | | | | | | | | | |
| 1594 | Price (2006$/MMBTU) | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | | | | | | | | |
| 1595 | | 0 | 734 | 734 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | |



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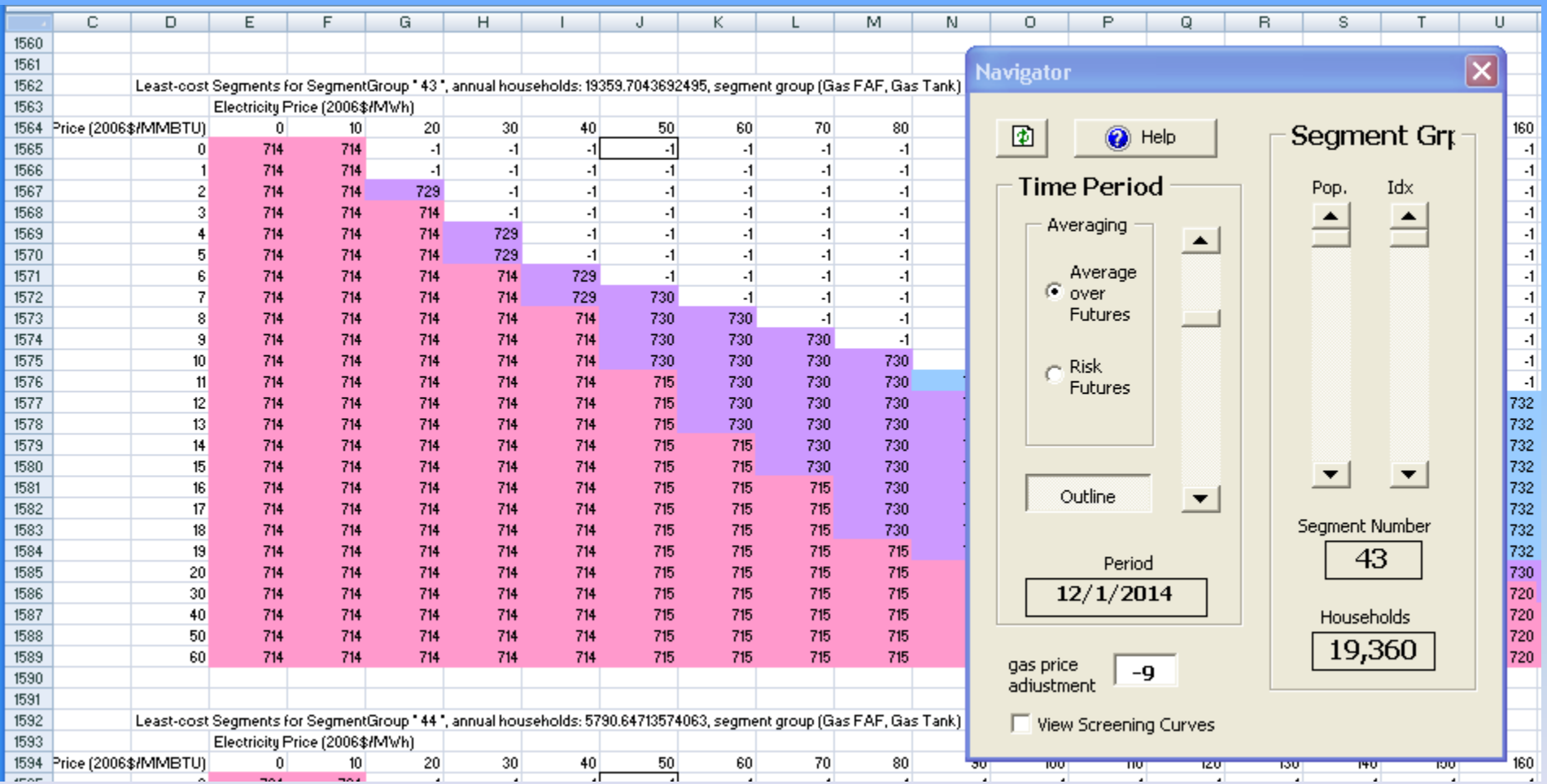

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| 1563 | | | Electricity Price (2006$/MWh) | | | | | | | | | | | | | | | | |
| 1564 | Price (2006$/MMBTU) | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | | | | | | | | 160 |
| 1565 | | 0 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | -1 |
| 1566 | | 1 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | -1 |
| 1567 | | 2 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | -1 |
| 1568 | | 3 | 714 | 714 | 714 | -1 | -1 | -1 | -1 | -1 | -1 | | | | | | | | -1 |
| 1569 | | 4 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | | | | | | | | -1 |
| 1570 | | 5 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | -1 | | | | | | | | -1 |
| 1571 | | 6 | 714 | 714 | 714 | 714 | 729 | -1 | -1 | -1 | -1 | | | | | | | | -1 |
| 1572 | | 7 | 714 | 714 | 714 | 714 | 729 | 730 | -1 | -1 | -1 | | | | | | | | -1 |
| 1573 | | 8 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | -1 | -1 | | | | | | | | -1 |
| 1574 | | 9 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | 730 | -1 | | | | | | | | -1 |
| 1575 | | 10 | 714 | 714 | 714 | 714 | 714 | 730 | 730 | 730 | 730 | | | | | | | | -1 |
| 1576 | | 11 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | | | | | | | | -1 |
| 1577 | | 12 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | | | | | | | | 732 |
| 1578 | | 13 | 714 | 714 | 714 | 714 | 714 | 715 | 730 | 730 | 730 | | | | | | | | 732 |
| 1579 | | 14 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 730 | 730 | | | | | | | | 732 |
| 1580 | | 15 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 730 | 730 | | | | | | | | 732 |
| 1581 | | 16 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | | | | | | | | 732 |
| 1582 | | 17 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | | | | | | | | 732 |
| 1583 | | 18 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 730 | | | | | | | | 732 |
| 1584 | | 19 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | 732 |
| 1585 | | 20 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | 730 |
| 1586 | | 30 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | 720 |
| 1587 | | 40 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | 720 |
| 1588 | | 50 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | 720 |
| 1589 | | 60 | 714 | 714 | 714 | 714 | 714 | 715 | 715 | 715 | 715 | | | | | | | | 720 |
| 1590 | | | | | | | | | | | | | | | | | | | |
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| 1593 | | | Electricity Price (2006$/MWh) | | | | | | | | | | | | | | | | |
| 1594 | Price (2006$/MMBTU) | | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | | | | | | | | 160 |



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# Largest Segment Groups

| Existing SH | Existing WH | Water heater size | Household | Basement | Gas Availability | Air Conditioning | Existing SH energy | Existing WH energy | Total Annual Potential | Average house size (ft^2) | cumulative | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas FAF | Gas Tank | X<=55 | SF | No | Existing | No | gas | gas | 19,360 | 1,900 | 19,360 | 14.9% |
| Gas FAF | Gas Tank | X<=55 | SF | Yes | Existing | No | gas | gas | 12,739 | 2,250 | 32,099 | 24.7% |
| Gas FAF | Electric Resistance | X<=55 | SF | No | Existing | No | gas | elc | 9,242 | 1,900 | 41,341 | 31.9% |
| Electric Zonal | Electric Resistance | X<=55 | SF | No | M | No | elc | elc | 7,771 | 1,500 | 49,112 | 37.9% |
| Electric Zonal | Electric Resistance | X<=55 | MF | No | M | No | elc | elc | 7,076 | 1,050 | 56,188 | 43.3% |
| Gas FAF | Electric Resistance | X<=55 | SF | Yes | Existing | No | gas | elc | 6,811 | 2,250 | 62,999 | 48.6% |
| Gas FAF | Gas Tank | X<=55 | SF | No | Existing | Yes | gas | gas | 5,791 | 1,900 | 68,789 | 53.0% |
| Electric Zonal | Electric Resistance | X<=55 | SF | No | E | No | elc | elc | 4,763 | 1,500 | 73,552 | 56.7% |
| Electric Zonal | Electric Resistance | X<=55 | MF | No | E | No | elc | elc | 4,337 | 1,050 | 77,889 | 60.1% |
| Gas FAF | Gas Tank | X>55 | SF | No | Existing | No | gas | gas | 2,970 | 1,900 | 80,859 | 62.3% |
| Gas FAF | Gas Tank | X<=55 | SF | Yes | Existing | Yes | gas | gas | 2,840 | 2,250 | 83,699 | 64.5% |
| Electric FAF | Electric Resistance | X<=55 | SF | No | M | No | elc | elc | 2,735 | 1,900 | 86,434 | 66.6% |
| Electric Zonal | Electric Resistance | X<=55 | SF | Yes | M | No | elc | elc | 2,590 | 1,900 | 89,023 | 68.6% |
| Gas FAF | Electric Resistance | X<=55 | SF | Yes | Existing | Yes | gas | elc | 2,336 | 2,250 | 91,359 | 70.4% |
| Heat Pump | Electric Resistance | X<=55 | SF | No | M | Yes | elc | elc | 2,294 | 1,900 | 93,653 | 72.2% |
| Gas FAF | Electric Resistance | X<=55 | SF | No | Existing | Yes | gas | elc | 2,241 | 1,900 | 95,894 | 73.9% |
| Gas FAF | Gas Tank | X>55 | SF | Yes | Existing | No | gas | gas | 1,954 | 2,250 | 97,849 | 75.4% |
| Electric FAF | Electric Resistance | X<=55 | SF | No | E | No | elc | elc | 1,676 | 1,900 | 99,525 | 76.7% |
| Electric Zonal | Electric Resistance | X<=55 | SF | No | M | Yes | elc | elc | 1,645 | 1,500 | 101,170 | 78.0% |
| Electric Zonal | Electric Resistance | X<=55 | SF | Yes | E | No | elc | elc | 1,587 | 1,900 | 102,757 | 79.2% |
| Electric FAF | Electric Resistance | X<=55 | SF | Yes | M | No | elc | elc | 1,421 | 2,250 | 104,178 | 80.3% |
| | ... plus 74 others ... | | | | | | | | | | | |
| Source: w kSht "Units", w kbk "C:\Backup\Plan 6\Studies\Model Development\Direct Use of Gas\101004 Study\FCM 08 XSN.xlsm" | | | | | | | | | | | 129,693 | total |

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# Outline

- Review of March 7, 2011 Presentation
- Results presented to the Regional Technical Forum (RTF) Friday, March 18, 2011
- Next steps

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# Plan Comparisons

**L814e - Selector fixed at zero**

| Sim | Cnsrvn_Lost Opportunity | Cnsrvn_Dispatchable | DRAC | DRSH | DRAG | DRIN | CCCT_CY_Dec09 | CCCT_CY_Dec13 | CCCT_CY_Dec15 | CCCT_CY_Dec17 | CCCT_CY_Dec19 | CCCT_CY_Dec21 | CCCT_CY_Dec23 | SCCT_CY_Dec09 | SCCT_CY_Dec13 | SCCT_CY_Dec15 | SCCT_CY_Dec17 | SCCT_CY_Dec19 | SCCT_CY_Dec21 | SCCT_CY_Dec2 | Selector value | Total Study Costs (Mean) | TailVaR90 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | selector | | | |
| **6142** | 20 | 50 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 756 | 756 | 1,134 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78,927 | 129,293 |
| **6843** | 20 | 90 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 756 | 756 | 756 | 0 | 0 | 0 | 0 | 0 | 162 | 162 | 0 | 78,957 | 129,135 |
| **1175** | 60 | 100 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3,402 | 3,402 | 3,402 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 80,364 | 127,504 |
| **2234** | 70 | 100 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3,402 | 3,402 | 3,402 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 80,594 | 127,498 |
| **6700** | 20 | 90 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 756 | 756 | 756 | 0 | 0 | 0 | 0 | 162 | 162 | 162 | 0 | 78,965 | 129,136 |

source: C:\Backup\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110607 P4 Whitefish\[Illustrations 110607 00.xlsx]L814e

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# Plan Comparisons

**L814d - Selector optimized**

| Sim | Cnsrvn_Lost Opportunity | Cnsrvn_Dispatchable | DRAC | DRSH | DRAG | DRIN | CCCT_CY_Dec09 | CCCT_CY_Dec13 | CCCT_CY_Dec15 | CCCT_CY_Dec17 | CCCT_CY_Dec19 | CCCT_CY_Dec21 | CCCT_CY_Dec23 | SCCT_CY_Dec09 | SCCT_CY_Dec13 | SCCT_CY_Dec15 | SCCT_CY_Dec17 | SCCT_CY_Dec19 | SCCT_CY_Dec21 | SCCT_CY_Dec23 (selector) | Selector value | Total Study Costs (Mean) | TailVaR90 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **4386** | 20 | 30 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1134 | 1134 | 1134 | -7 | 76,243 | 120,798 |
| **262** | 50 | 80 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 378 | 378 | 378 | 0 | 0 | 0 | 0 | 1134 | 1134 | 1134 | -9 | 77,837 | 119,703 |
| **592** | 50 | 80 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 378 | 378 | 378 | 0 | 0 | 0 | 0 | 972 | 1134 | 1134 | -10 | 77,970 | 119,700 |
| **189** | 60 | 100 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 378 | 378 | 378 | 0 | 0 | 0 | 0 | 1620 | 1620 | 1620 | -9 | 78,405 | 119,660 |
| **4501** | 30 | 40 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 378 | 378 | 378 | 0 | 0 | 0 | 0 | 648 | 972 | 972 | -6 | 76,400 | 120,667 |

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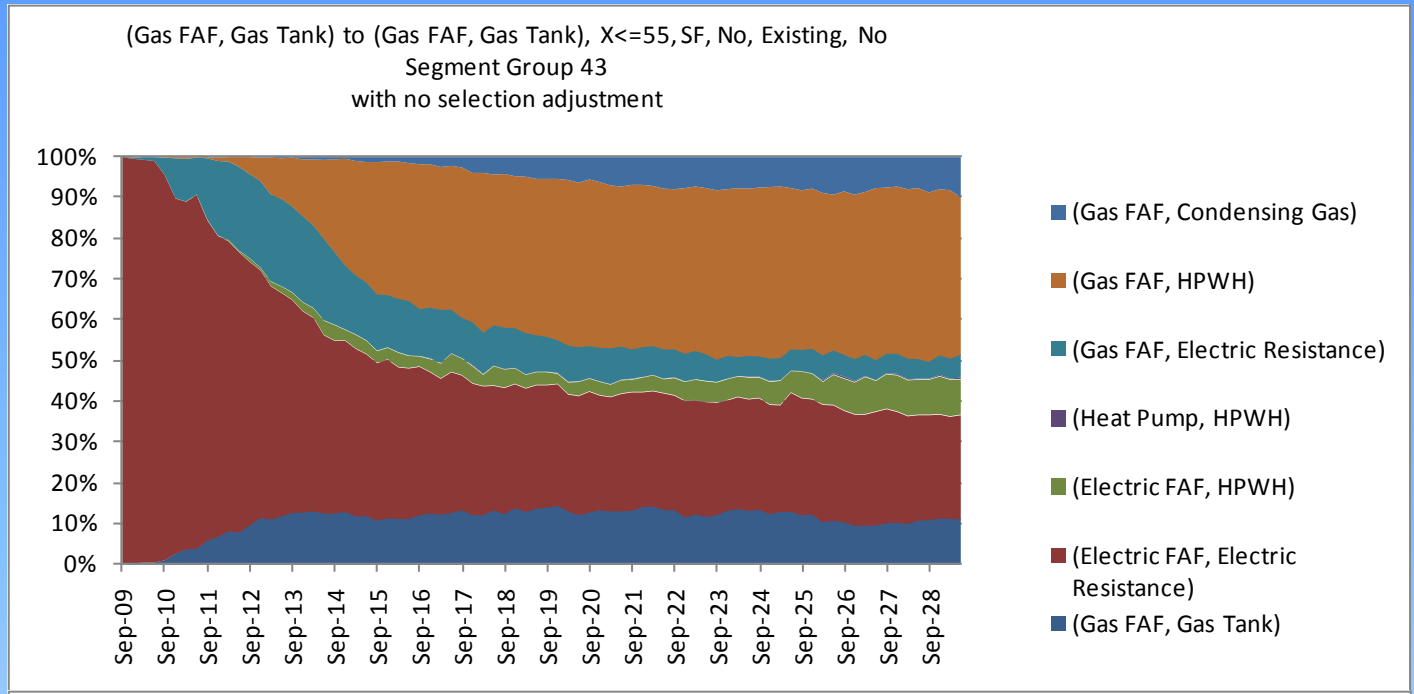


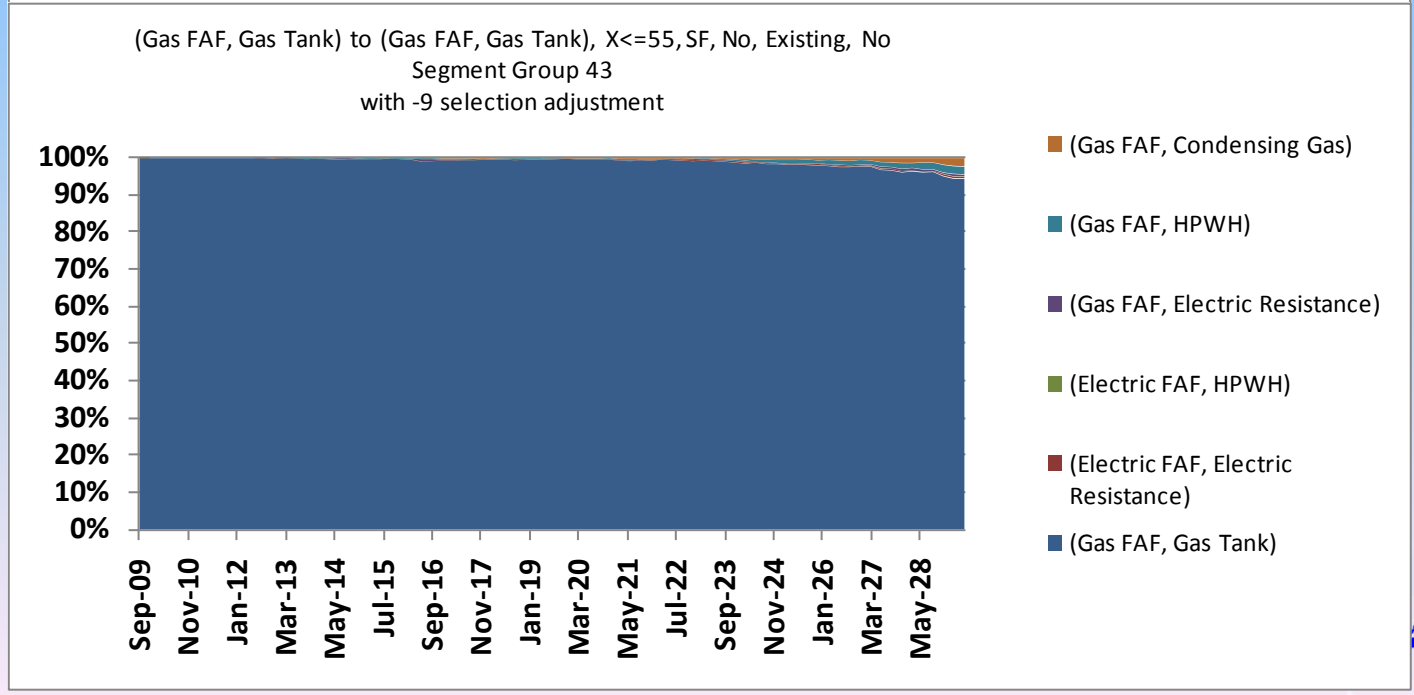


# Effect of the Selector on the Move to Gas

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# Preliminary Observations

(to be disavowed if attributed)

- The initial RPM selection probably got over 75% of the 130,000 per year of households correct:
  - Homes with gas appliances that might otherwise move to electric appliances (50,000+ per year) should *stay with* gas appliances (NEW FINDING), but …
    - If we do not expect to displace future generation turbines then electric heat pump water heaters may be better than gas water heating appliances. (Work forthcoming….)
  - Small, multi-family households in areas that would require a gas main are probably best served with electric zonal space heating and resistance hot water tanks
    - The “best plan” selector value did not change this outcome

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# Preliminary Observations

(to be disavowed if attributed)

- Where the initial selection criterion probably got it wrong:
  - Some households were converted to gas when, in fact, they would have been best served by electric appliances
    - Larger single-family homes (26,000 per year) requiring gas mains
  - Some households were converted to gas, although the best outcome will depend on displacing new turbines in the future
- CO2 emissions were about the same, irrespective of the conversions

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# Remaining Work

- We will try an alternative selection method that provides the optimizer with better granularity:
  - Lock down selections that we feel are pretty stable
  - Aggregate segment groups that appear to be sensitive to similar issues, such as opportunity to defer new turbines
  - Provide the optimizer several knobs for picking the best outcomes for each aggregate group

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# Remaining Work

- What will be the impact of revised conservation supply curves?
  - These currently assume a specific replacement policy
    - Conversion to more efficient electric appliances introduces double-counting
    - Conversion to gas removes the opportunity entirely
  - This will result in some reduction in the benefits of remaining on or converting to natural gas

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# Remaining Work

- How well aligned are the factors influencing consumer "fuel selection" with the least-cost and risk choices identified by the RPM?

- Staff intends to address this question by conducting a comparative analysis of the cost of space and water heating using electricity or natural gas systems and retail energy prices
  - Focus on major market segments that RPM indicates are "switching."
  - Use range of gas and electric prices representative of those found in PNW

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# Thermodynamic Efficiency – Water Heating

| System | Annual Use (MMBtu) | System Efficiency | Generation Efficiency* | T & D Efficiency | Net Delivered Efficiency |
|---|---|---|---|---|---|
| Electric Resistance | 11 | 100% | 50% | 91% | 46% |
| HPWH | 5 | 211% | 50% | 91% | 96% |
| Gas Tank | 17 | 66% | 100% | 96% | 63% |
| Condensing Gas | 10 | 119% | 100% | 96% | 115% |
| Tankless Gas | 13 | 86% | 100% | 96% | 83% |

*Assumes CCCT Heat Rate of 6,800 Btu/kWh

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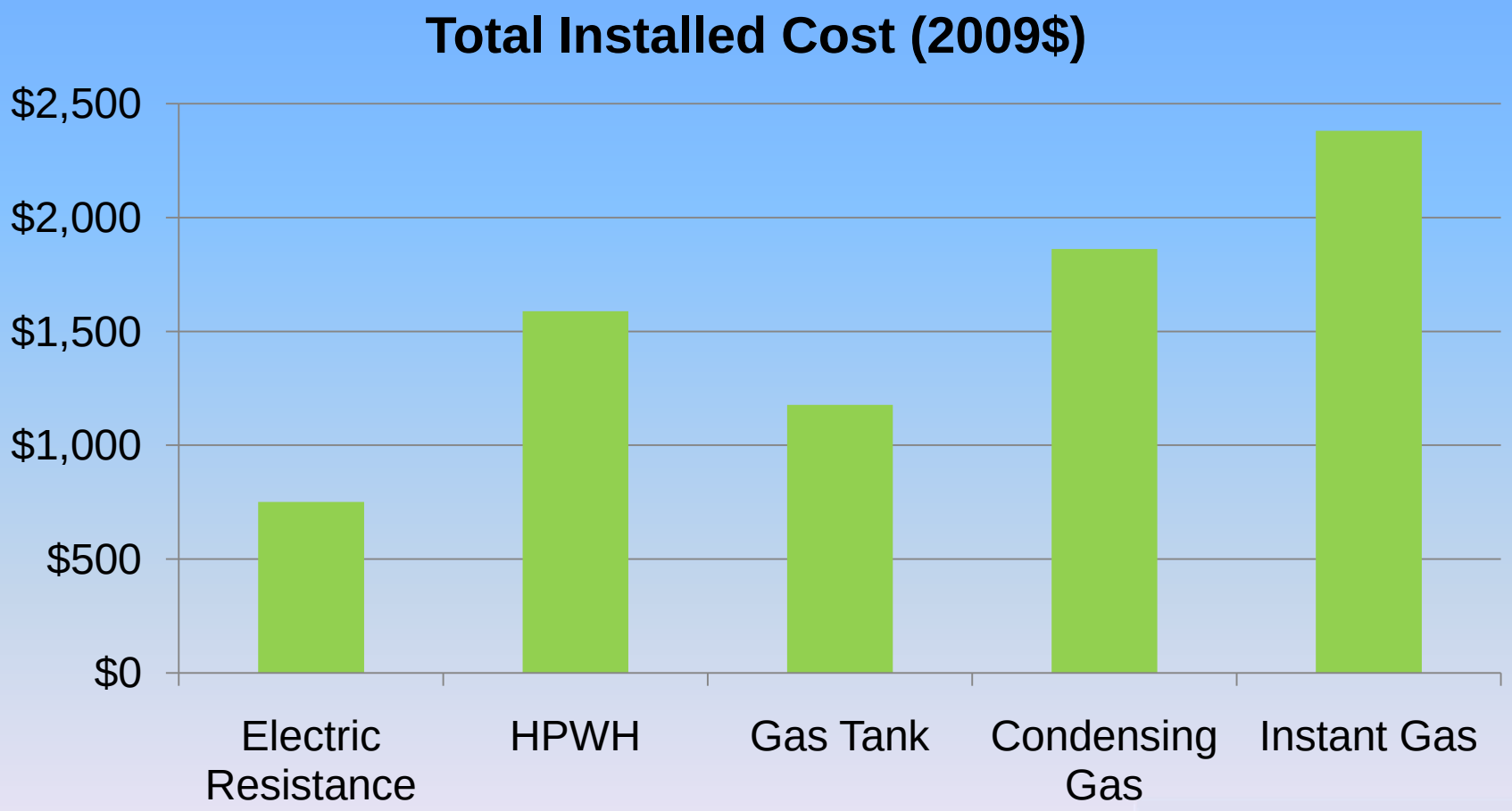
# First Cost of Water Heating Options

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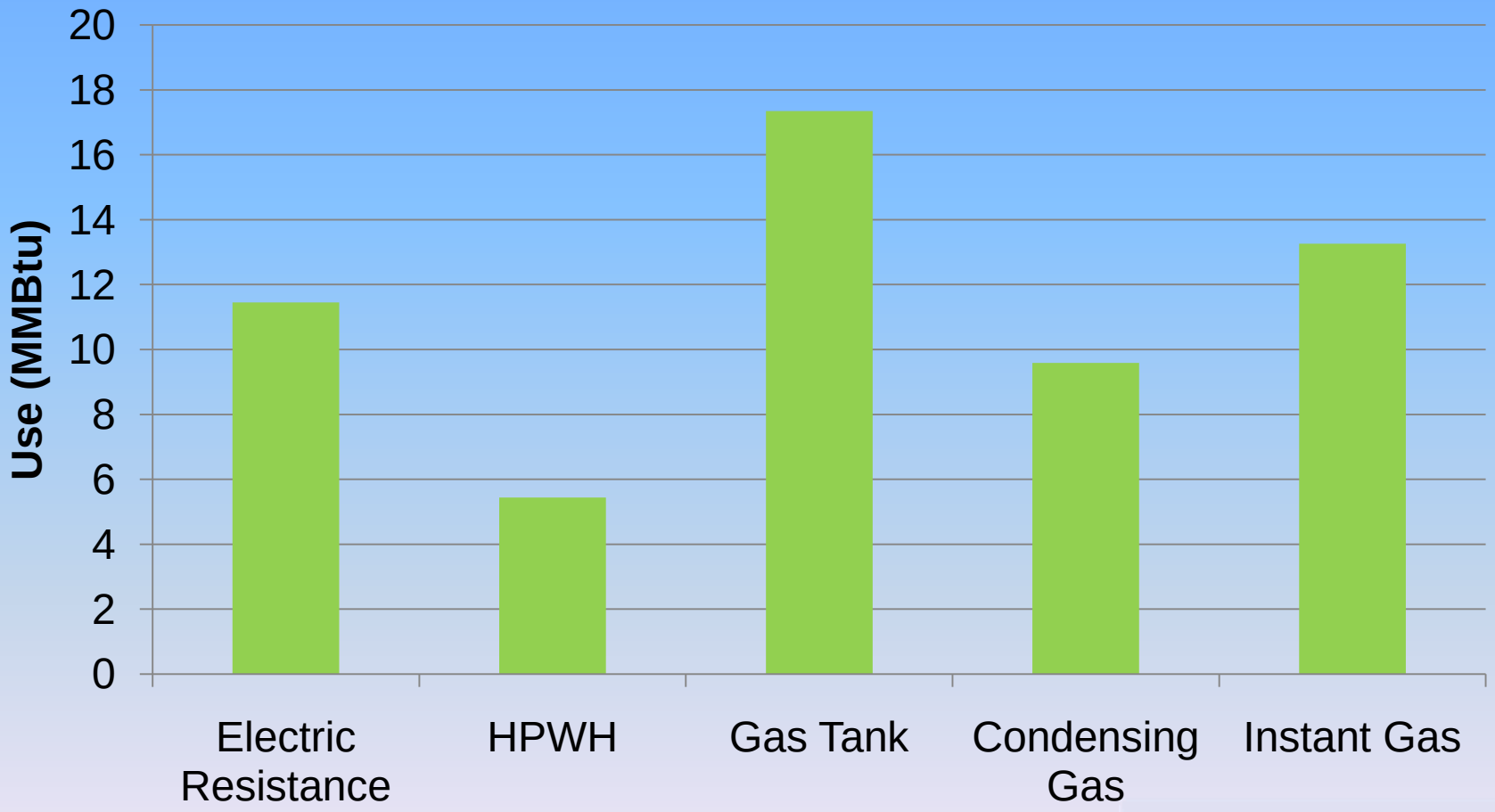
# Annual Water Heating Use

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# Thermodynamic Efficiency – Space Heating

| System | Annual Use (MMBtu) | System Efficiency | Generation Efficiency* | T & D Efficiency | Net Delivered Efficiency |
|---|---|---|---|---|---|
| Zonal | 33 | 100% | 50% | 91% | 46% |
| Electric FAF | 38 | 87% | 50% | 91% | 40% |
| Ductless HP | 20 | 167% | 50% | 91% | 76% |
| Heat Pump (HSPF 8.2) | 23 | 141% | 50% | 91% | 64% |
| Heat Pump (HSPF 9.0 w/PTCS) | 14 | 229% | 50% | 91% | 104% |
| Gas FAF | 42 | 78% | 100% | 96% | 75% |

*Assumes CCCT Heat Rate of 6,800 Btu/kWh

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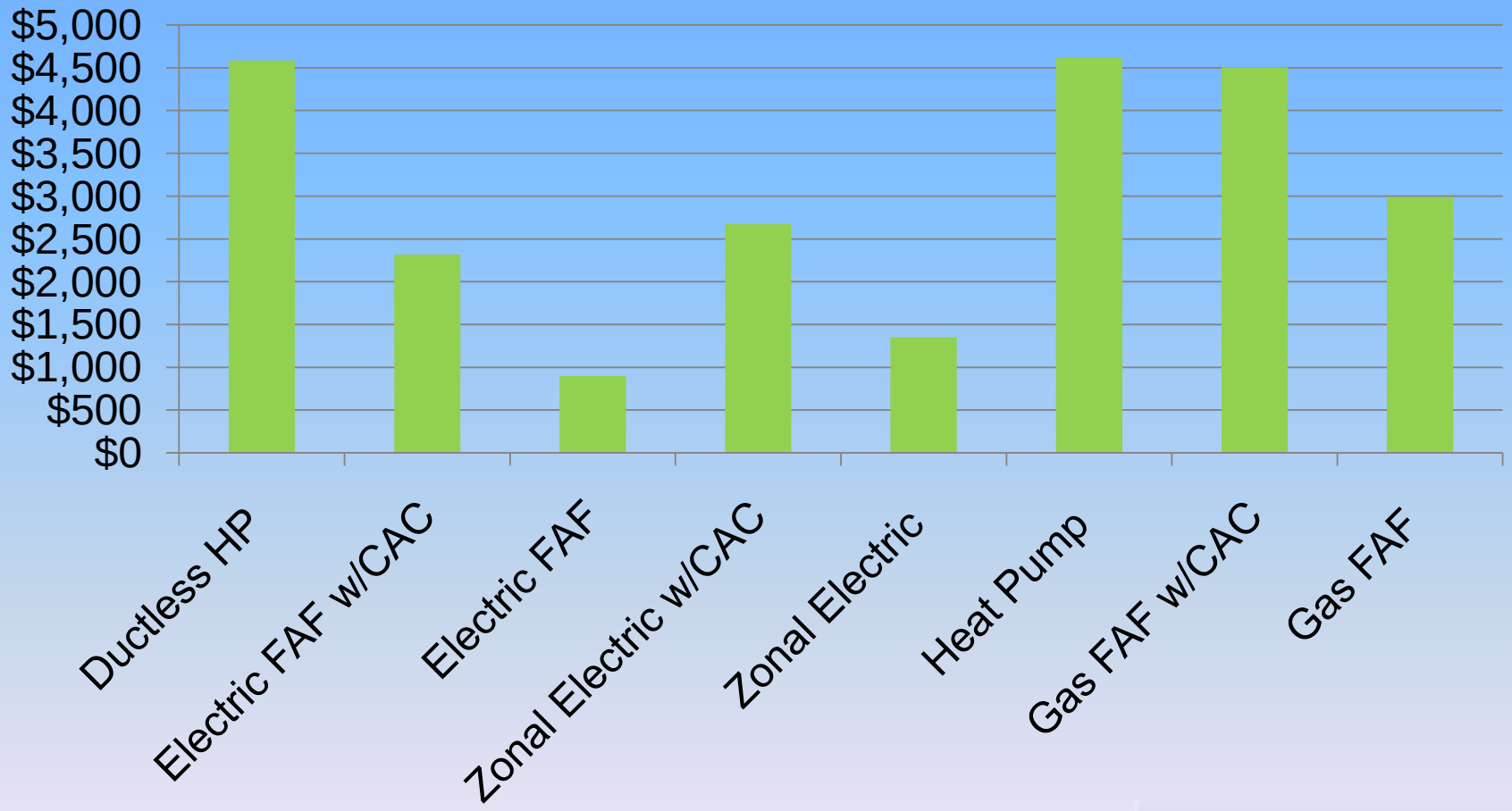
# First Cost of Space Conditioning Options

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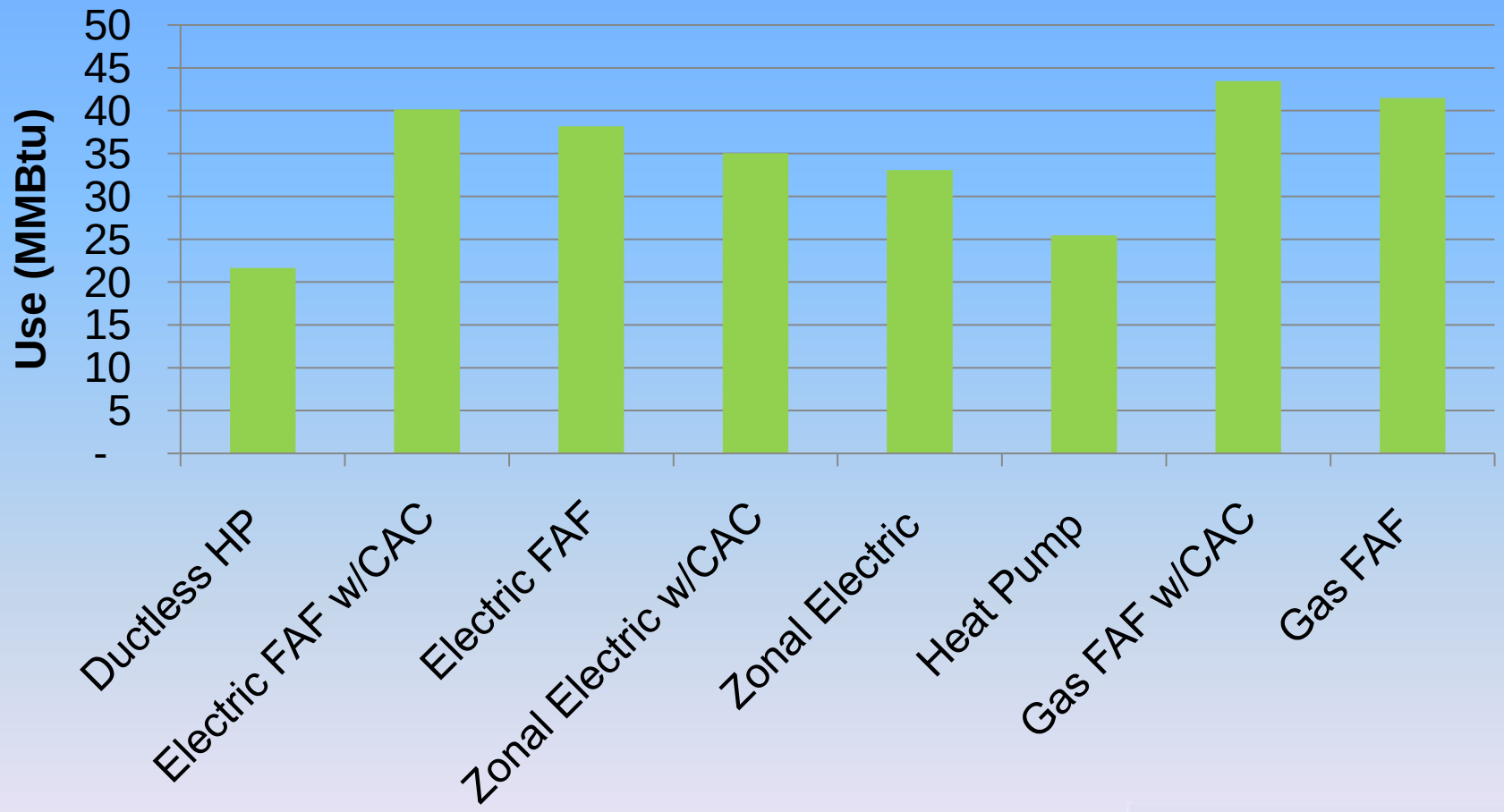
# Annual Space Conditioning Use

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*Questions?*

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# Reserve Slides

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# $CO_2$ Considerations

- Gas water and space heating appliances do typically produce less $CO_2$ than electric appliances, except in the case of heat pumps
- We did not see significant differences due to policy, however
- Reasons for such a small difference include
  - The small absolute potential, less than 3 million tons of potential over 20 years, irrespective of direction
  - Significant economic hurdles for conversion in either direction, except for HPWH

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# $CO_2$ Considerations

| Water Heating (BTU/h) Dwelling & Size | MF | SF | |
|---|---|---|---|
| System | X<=55 | X<=55 | X>55 |
| Condensing Gas | 1,143 | 1,143 | 1,908 |
| Electric Resistance | 1,860 | 2,720 | |
| Gas Tank | 1,344 | 1,980 | |
| HPWH | 884 | 1,292 | 1,483 |
| Instant Gas | 1,047 | 1,527 | 1,751 |

Source: C:\Backup\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110607 P4 Whitefish\[Illustrations 110607 00.xlsx]Space Conditioning

These calculations assume gas consumption for any electricity is produced by a CCCT with heat rate of 7100 BTU/kWh (6th Plan)

| Space Heating BTU/h Sq ft and Basement | 1050 | 1450 | 1500 | 1900 | | 2250 |
|---|---|---|---|---|---|---|
| System | No | No | No | No | Yes | Yes |
| Ductless HP | 1,438 | 2,878 | 3,446 | 4,712 | 4,084 | 4,613 |
| Electric FAF | 2,465 | 5,250 | | 9,063 | | 8,304 |
| Electric Zonal | 2,385 | 4,797 | 5,743 | 7,854 | 6,807 | 7,688 |
| Gas FAF | 1,288 | 2,743 | 3,439 | 4,736 | 3,937 | 4,339 |
| Heat Pump | 1,438 | 3,624 | | 5,572 | | 4,939 |

| Space Heating BTU/h/ft^2 Sq ft and Basement | 1050 | 1450 | 1500 | 1900 | | 2250 |
|---|---|---|---|---|---|---|
| System | No | No | No | No | Yes | Yes |
| Ductless HP | 2.74 | 3.97 | 4.59 | 4.96 | 4.30 | 4.10 |
| Electric FAF | 4.70 | 7.24 | | 9.54 | | 7.38 |
| Electric Zonal | 4.54 | 6.62 | 7.66 | 8.27 | 7.17 | 6.83 |
| Gas FAF | 2.45 | 3.78 | 4.59 | 4.98 | 4.14 | 3.86 |
| Heat Pump | 2.74 | 5.00 | | 5.87 | | 4.39 |

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# $CO_2$ Considerations

| Existing SH | Existing WH | Water heater size | Household | Basement | Gas Availability | Air Conditioning | Existing SH energy | Existing WH energy | Total Annual Potential | Conversion to Gas to improve CO2 emissions | | cumulative | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gas FAF | Gas Tank | X<=55 | SF | No | Existing | No | gas | gas | 19,360 | NA | | 19,360 | 14.9% |
| Gas FAF | Gas Tank | X<=55 | SF | Yes | Existing | No | gas | gas | 12,739 | NA | | 32,099 | 24.7% |
| Gas FAF | Electric Resistance | X<=55 | SF | No | Existing | No | gas | elc | 9,242 | WH | | 41,341 | 31.9% |
| Electric Zonal | Electric Resistance | X<=55 | SF | No | M | No | elc | elc | 7,771 | NE | | 49,112 | 37.9% |
| Electric Zonal | Electric Resistance | X<=55 | MF | No | M | No | elc | elc | 7,076 | NE | | 56,188 | 43.3% |
| Gas FAF | Electric Resistance | X<=55 | SF | Yes | Existing | No | gas | elc | 6,811 | WH | | 62,999 | 48.6% |
| Gas FAF | Gas Tank | X<=55 | SF | No | Existing | Yes | gas | gas | 5,791 | NA | | 68,789 | 53.0% |
| Electric Zonal | Electric Resistance | X<=55 | SF | No | E | No | elc | elc | 4,763 | NE | | 73,552 | 56.7% |
| Electric Zonal | Electric Resistance | X<=55 | MF | No | E | No | elc | elc | 4,337 | NE | | 77,889 | 60.1% |
| Gas FAF | Gas Tank | X>55 | SF | No | Existing | No | gas | gas | 2,970 | NA | | 80,859 | 62.3% |
| Gas FAF | Gas Tank | X<=55 | SF | Yes | Existing | Yes | gas | gas | 2,840 | NA | | 83,699 | 64.5% |
| Electric FAF | Electric Resistance | X<=55 | SF | No | M | No | elc | elc | 2,735 | NE | | 86,434 | 66.6% |
| Electric Zonal | Electric Resistance | X<=55 | SF | Yes | M | No | elc | elc | 2,590 | NE | | 89,023 | 68.6% |
| Gas FAF | Electric Resistance | X<=55 | SF | Yes | Existing | Yes | gas | elc | 2,336 | WH | | 91,359 | 70.4% |
| Heat Pump | Electric Resistance | X<=55 | SF | No | M | Yes | elc | elc | 2,294 | NE | | 93,653 | 72.2% |
| Gas FAF | Electric Resistance | X<=55 | SF | No | Existing | Yes | gas | elc | 2,241 | WH | | 95,894 | 73.9% |
| Gas FAF | Gas Tank | X>55 | SF | Yes | Existing | No | gas | gas | 1,954 | NA | | 97,849 | 75.4% |
| Electric FAF | Electric Resistance | X<=55 | SF | No | E | No | elc | elc | 1,676 | SH+WH | | 99,525 | 76.7% |
| Electric Zonal | Electric Resistance | X<=55 | SF | No | M | Yes | elc | elc | 1,645 | NE | | 101,170 | 78.0% |
| Electric Zonal | Electric Resistance | X<=55 | SF | Yes | E | No | elc | elc | 1,587 | NE | | 102,757 | 79.2% |
| Electric FAF | Electric Resistance | X<=55 | SF | Yes | M | No | elc | elc | 1,421 | NE | | 104,178 | 80.3% |
| | … plus 74 others … | | | | | | | | | | | | |
| Source: w kSht "Units", w kbk "C:\Backup\Plan 6\Studies\Model Development\Direct Use of Gas\101004 Study\FCM 08 XS | | | | | | | | | | | | 129,693 | total |

| | |
|---|---|
| NA | no opportunity to convert from electricity to gas for CO2 emission reduction |
| NE | not economic |
| WH | water heater only |
| SH | space heater only |

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# Existing Segments Groups

- Segment groups were determined primarily by existing circumstances
  - Existing space heating appliance
  - Existing water heating appliance
  - Single- or multi-family building
  - Whether or not a gas main is available, and if so, whether service already exists or an extension from the gas main is necessary
  - Whether or not there was a basement
  - Whether or not there was air conditioning

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# New Segment Groups

| Existing System | | |
|---|---|---|
| Space Heating (SH) | Water Heating (WH) | **Segment groups** |
| **FAF Electric** | Electric Resistance | 20 |
| **FAF Electric** | Gas Tank | 10 |
| **Gas FAF** | Electric Resistance | 10 |
| **Gas FAF** | Gas Tank | 10 |
| **Heat Pump** | Electric Resistance | 10 |
| **Heat Pump** | Gas Tank | 5 |
| **Zonal Electric** | Electric Resistance | 20 |
| **Zonal Electric** | Gas Tank | 10 |
| | **Grand Total** | **95** |

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# 20 New Segment Groups

## Associated with FAF Electric and Electric DHW

| Existing SH | Existing WH | Water heater size | Household | Basement | Gas Availability | Air Conditioning | Determine retrofit baseline: Retro SH | Determine retrofit baseline: Retro WH |
|---|---|---|---|---|---|---|---|---|
| FAF Electric | Electric Resistance | X<55 | SF | No | E | No | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | SF | No | E | Yes | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | SF | No | M | No | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | SF | No | M | Yes | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X>=55 | SF | No | E | No | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X>=55 | SF | No | E | Yes | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X>=55 | SF | No | M | No | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X>=55 | SF | No | M | Yes | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | E | No | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | E | Yes | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | M | No | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | M | Yes | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | E | No | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | E | Yes | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | M | No | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | M | Yes | FAF Electric | HPWH |
| FAF Electric | Electric Resistance | X<55 | MF | No | E | No | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | MF | No | E | Yes | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | MF | No | M | No | FAF Electric | Electric Resistance |
| FAF Electric | Electric Resistance | X<55 | MF | No | M | Yes | FAF Electric | Electric Resistance |

source: C:\Backups\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110104 DUG RTF\[New Segment Groups 110104.xlsm]Illustration 2

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# New Segments

| | Retrofit systems | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| space heating➔ | | | FAF Electric | | | | | Gas FAF | | | | | Heat Pump | | | | | Zonal Electric | | | | | Ductless HP | | | | | Grand Total |
| water heating➔ | Electric Resistance | Gas Tank | HPWH | Instant Gas | Condensing Gas | Electric Resistance | Gas Tank | HPWH | Instant Gas | Condensing Gas | Electric Resistance | Gas Tank | HPWH | Instant Gas | Condensing Gas | Electric Resistance | Gas Tank | HPWH | Instant Gas | Condensing Gas | Electric Resistance | Gas Tank | HPWH | Instant Gas | Condensing Gas | |
| **Existing system** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **FAF Electric** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Electric Resistance | 12 | 12 | 20 | 20 | 20 | 12 | 12 | 20 | 20 | 20 | 12 | 12 | 20 | 20 | 20 | 12 | 12 | 20 | 20 | 20 | | | | | | 336 |
| Gas Tank | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | | | | | | 168 |
| **Gas FAF** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Electric Resistance | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | | | | | | 168 |
| Gas Tank | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | | | | | | 168 |
| **Heat Pump** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Electric Resistance | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | | | | | | 168 |
| Gas Tank | 3 | 3 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 5 | | | | | | 84 |
| **Zonal Electric** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Electric Resistance | | | | | | 12 | 12 | 20 | 20 | 20 | | | | | | 12 | 12 | 20 | 20 | 20 | 12 | 12 | 20 | 20 | 20 | 252 |
| Gas Tank | | | | | | 6 | 6 | 10 | 10 | 10 | | | | | | 6 | 6 | 10 | 10 | 10 | 6 | 6 | 10 | 10 | 10 | 126 |
| **Grand Total** | **39** | **39** | **65** | **65** | **65** | **57** | **57** | **95** | **95** | **95** | **39** | **39** | **65** | **65** | **65** | **57** | **57** | **95** | **95** | **95** | **18** | **18** | **30** | **30** | **30** | **1470** |

source: C:\Backups\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110104 DUG RTF\[New Segment Groups 110104.xlsm]all segments - count

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# 20 segments

Associated with

Electric FAF and Electric DHW ⟶ Gas FAF Electric and Instant Gas DHW

| Existing SH | Existing WH | Water heater size | Household | Basement | Gas Availability | Air Conditioning | Retro SH | Retro WH |
|---|---|---|---|---|---|---|---|---|
| FAF Electric | Electric Resistance | X<55 | MF | No | E | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | MF | No | E | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | MF | No | M | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | MF | No | M | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | No | E | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | No | E | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | No | M | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | No | M | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | E | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | E | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | M | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X<55 | SF | Yes | M | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | No | E | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | No | E | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | No | M | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | No | M | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | E | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | E | Yes | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | M | No | Gas FAF | Instant Gas |
| FAF Electric | Electric Resistance | X>=55 | SF | Yes | M | Yes | Gas FAF | Instant Gas |

source: C:\Backups\Plan 6\Studies\Model Development\Direct Use of Gas\Presentations\110104 DUG RTF\[New Segment Groups 110104.xlsm]Illustration 2

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# Summary of Fuel Conversion Resource Findings

| Study | Technical Potential | Cost-Effective Potential | Resource Potential |
|---|---|---|---|
| Lazar | 1448 | | |
| Bonneville | | | 385 |
| Beyers | 1370 | 854 | 630 |
| Aos & Blackmon | 1483 | 1038 | 845 |
| Council Staff | 1445 | 733 | 170 - 430 |

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# History: Council Fuel Choice Policy

- Plan is intended to be fuel neutral
  - Monitor effect of incentives on fuel choice
- Fuel conversion is not conservation and not a resource
- Preference for thermally balanced cogeneration
- Market based approach

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# 1994 Study

- Growing attractiveness of natural gas-fired combined cycle combustion turbines motivated the Council to take another look at “fuel switching” or “total energy efficiency”.

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# 1994 Study Addressed

- Thermal efficiency of residential end-use technologies
- Cost effectiveness of fuel switching
- Assessed recent trends in fuel choice
- Reviewed Council history on fuel choice
- Proposed a Council policy statement on fuel choice

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# What Studies Show

- Thermodynamic efficiency is not same as economic efficiency
- Economic efficiency depends on:
  - Amount of Energy Used
    - House size
    - Thermal efficiency of shell and equipment
    - Climate zone
  - Energy prices and escalation assumptions
  - Conversion costs
    - Gas service extension
    - Equipment conversion costs
    - Avoided capacity costs

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# Environmental Considerations

- The 1994 study showed that increased direct use of natural gas would:
  - Increase nitrous oxide and carbon monoxide emissions
  - Reduce carbon dioxide emissions
  - Reduce sulfur oxide emissions
  - Insignificant effects on suspended particulates and VOCs

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