Session F2: M&V + Big Data is your Ticket to Big Savings

M&V Challenges Due to Extreme Weather

9/22/16

Steve Heinz, PE, CEM, CMVP
Founder & CEO
EnergyCAP, Inc.
State College, PA

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The Problem

Background:

Software for M&V for energy conservation programs in over 15,000 K-12 and higher education buildings operated by 800 clients

IPMVP Option C, Whole Facility approach

Problem:

The weather has been so abnormal that the standard method of regression-based baseline weather modeling can be inadequate

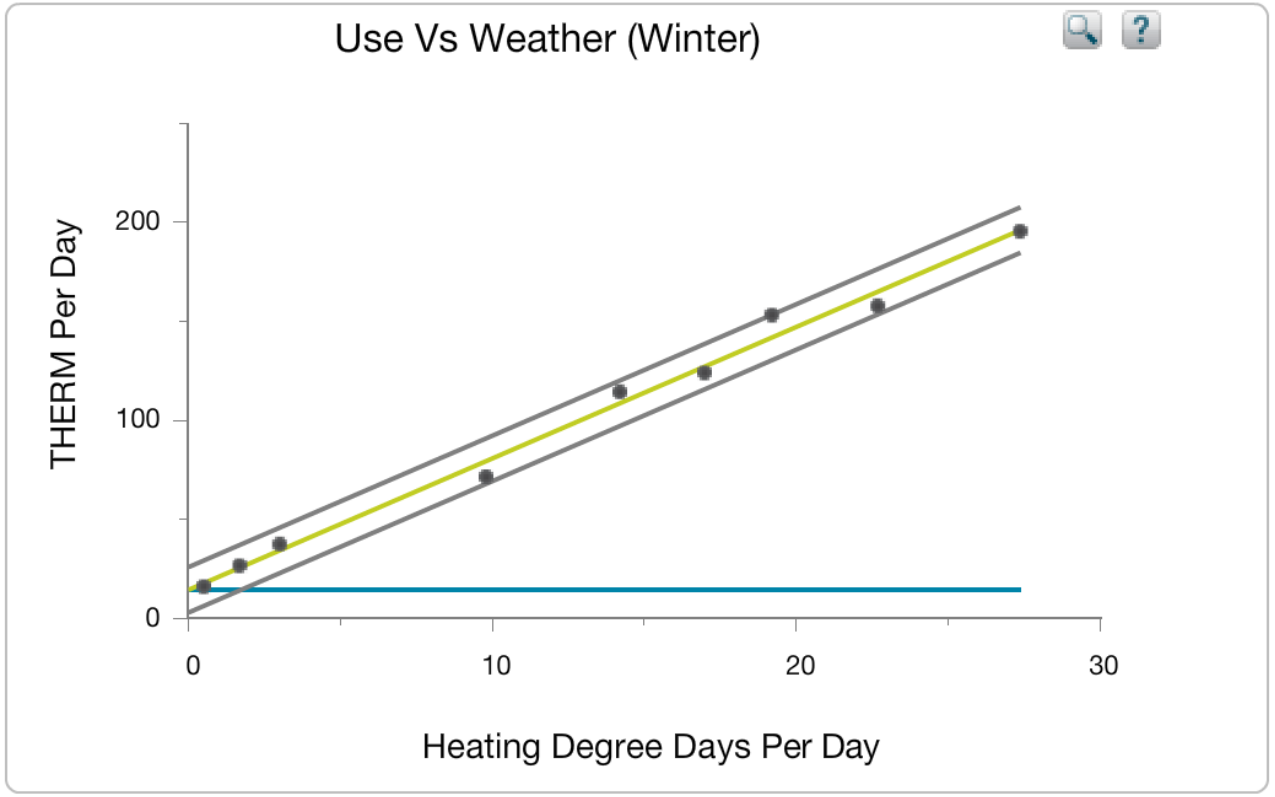
What is the best way to identify and handle extreme weather, considering **cost**, **practicality,** and **fairness** for all parties?

Standard approach:

Linear or non-linear modeling of baseline year use vs. weather

Linear:

Ave daily use vs. ave daily Degree Days



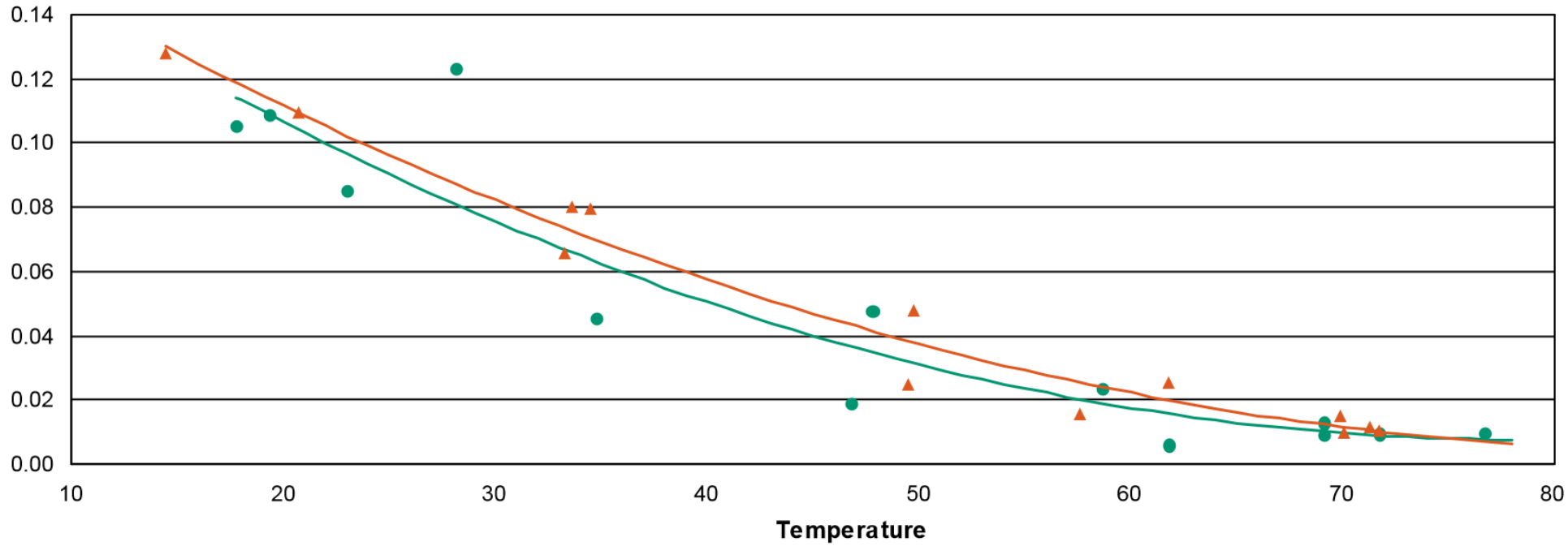
	Sensitive to Weather	R2	Min R2	Base Load (THERM/da	Weather Factor (THERM/HDD)
▶	✓	0.9911	0.3387	14.5	6.61

Standard approach:

Linear or non-linear modeling of baseline year use vs. weather

Non-Linear (Quadratic):

Ave Use/Ft^2 vs. ave Mean Daily Temp (dry bulb or wet bulb)



Objective:

Adjust baseline to current conditions

IPMVP states:

Savings = (Baseline Period Energy – Reporting Period Energy) +/- Adjustments

(Ref: IPMVP Core Concepts April 2016, EVO 10000-1:2016)

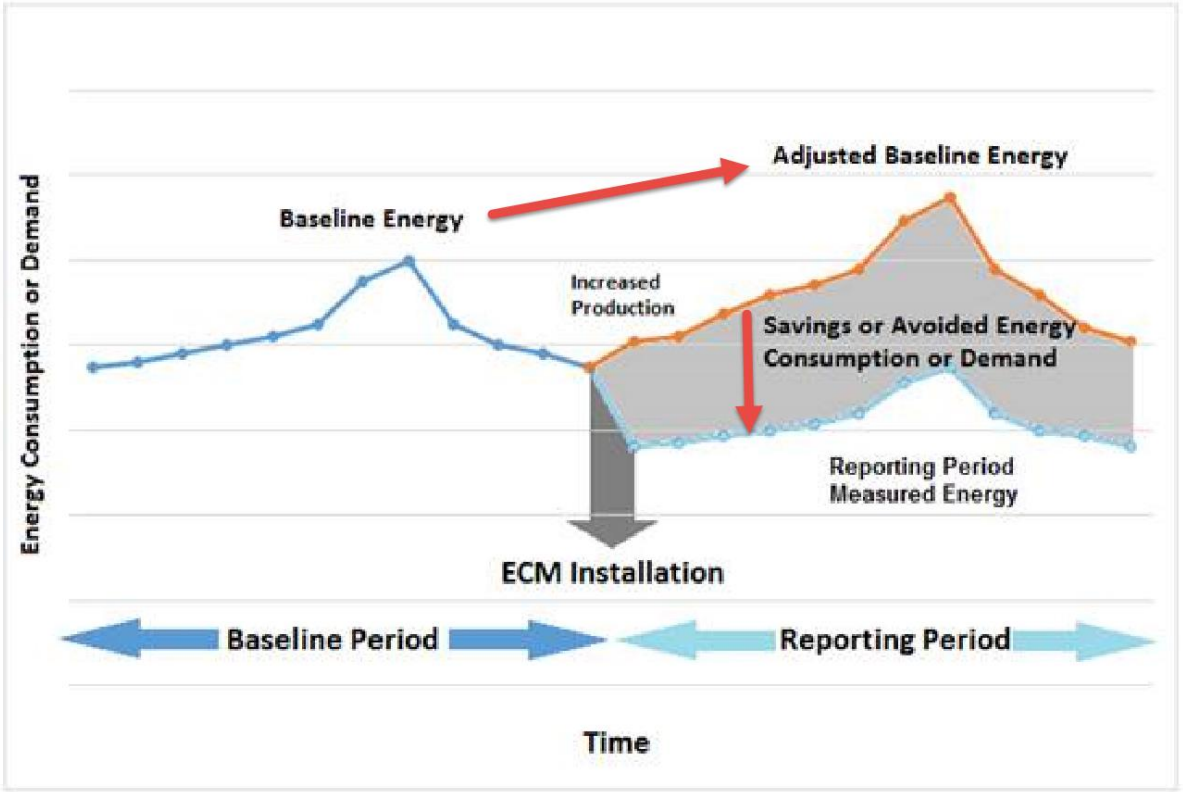
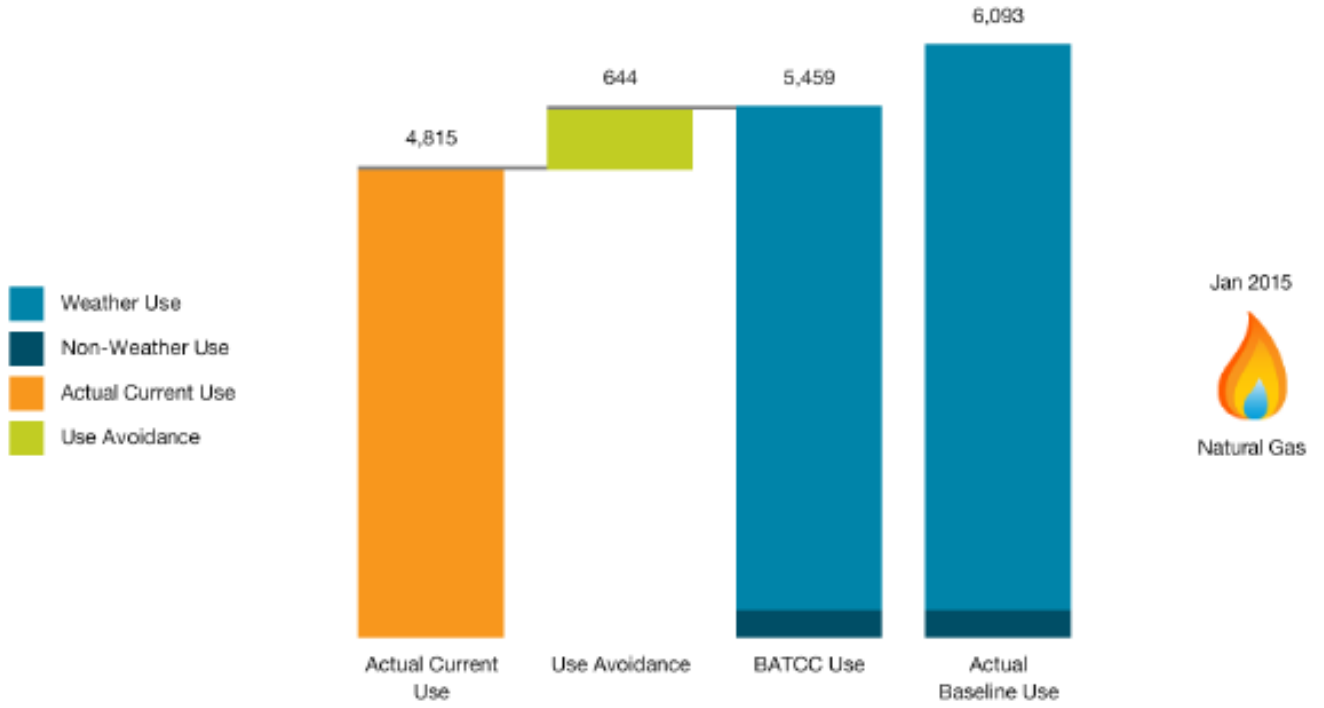


Figure 2 Savings or Avoided Energy Consumption or Demand

View Savings: Visualization of the process

BATCC=Baseline (after it has been)
Adjusted to Current Conditions (of weather and other major variables)



Weather Sensitivity	Use/Degree	R2
Summer	N/A	N/A
Winter	7.55	0.9810

BATCC Use:	5,459 THERM
Actual Use:	- 4,815 THERM
Use Avoidance:	644 THERM

BATCC Cost:	$5,276
Actual Cost:	- $4,654
Cost Avoidance:	$622

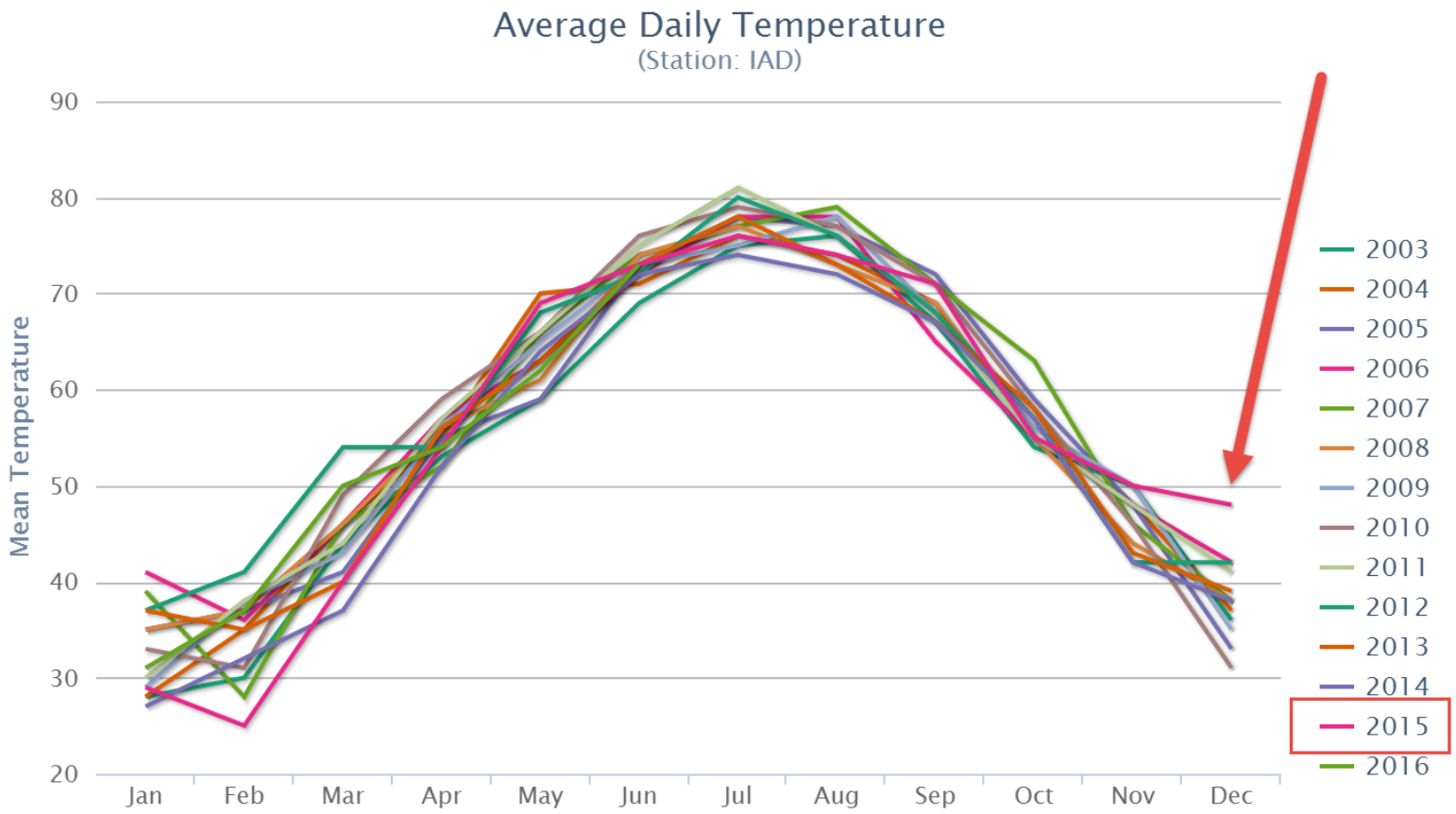
How to identify extreme weather?

Reported monthly savings suddenly diminish

Monthly review of weather data vs. prior years

Case #1: Extremely mild winter weather

Extremely mild Nov and Dec 2015



Source: www.WeatherDataDepot.com

Monthly total Heating Degree Days

Cumulative Seasonal Heating Degree Days (Station: IAD View Map)

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
2003 - 2004	0	0	12	217	546	1282	2265	2989	3418	3644	3663	3665
2004 - 2005	0	0	1	169	511	1195	1968	2594	3183	3353	3436	3436
2005 - 2006	0	0	5	130	489	1305	1865	2528	2976	3094	3132	3132
2006 - 2007	0	0	18	216	562	1116	1762	2634	3068	3343	3373	3373
2007 - 2008	0	0	7	75	488	1151	1904	2555	2991	3157	3217	3217
2008 - 2009	0	0	1	192	662	1327	2261	2873	3379	3561	3593	3593
2009 - 2010	0	0	2	147	444	1206	2024	2831	3149	3256	3305	3305
2010 - 2011	0	0	1	124	531	1427	2352	2966	3453	3614	3639	3639
2011 - 2012	0	0	10	190	529	1088	1774	2320	2536	2727	2730	2730
2012 - 2013	0	0	6	162	678	1232	1929	2617	3224	3407	3478	3478
2013 - 2014	0	0	12	151	661	1307	2314	3086	3769	4022	4057	4057
2014 - 2015	0	0	9	145	686	1342	2275	3237	3843	4023	4036	4040
2015 - 2016	0	0	0	171	471	831	1709	2369	2671	2888	2961	2961

Source: www.WeatherDataDepot.com

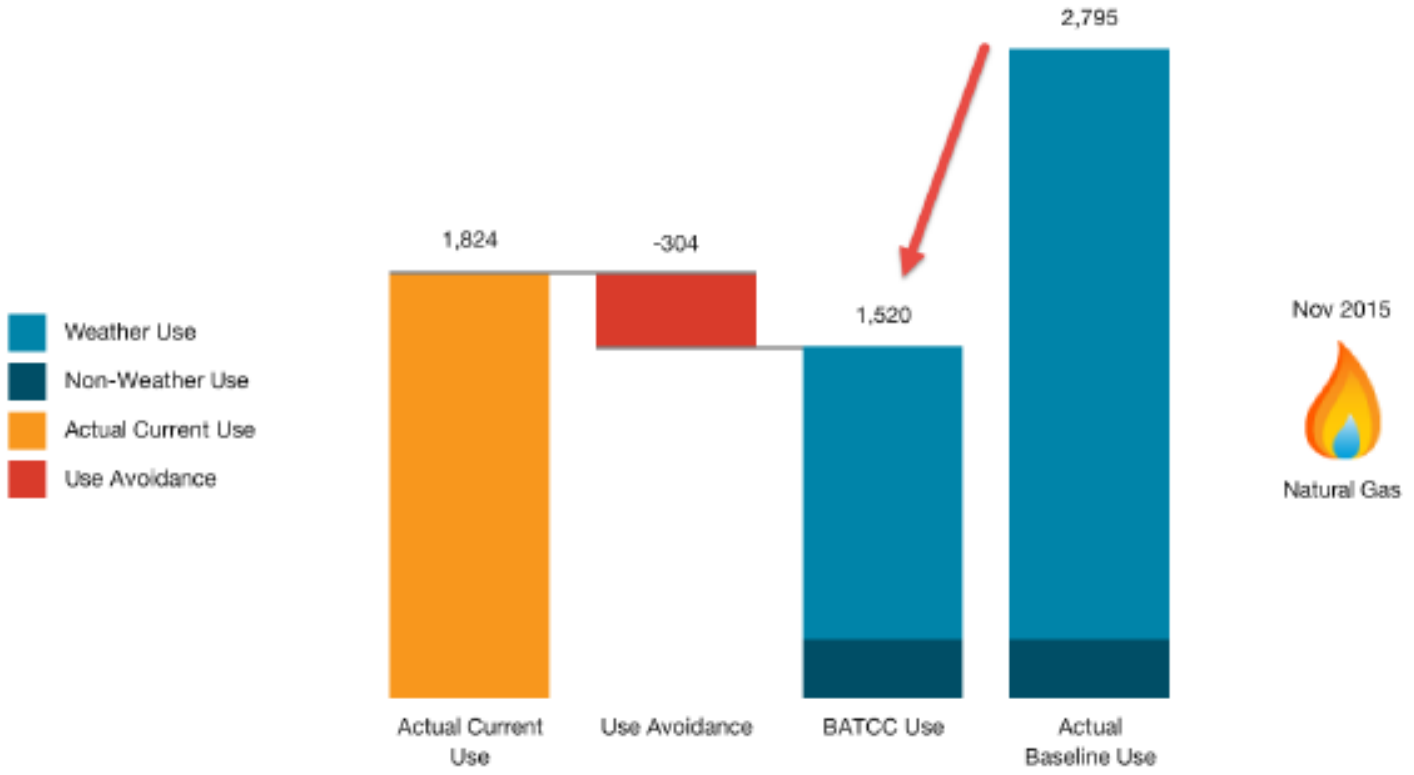
Average monthly temperature

Average Daily Temperature (Station: IAD View Map)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	28	30	44	53	59	69	75	76	67	54	50	36
2004	28	35	46	55	70	71	76	74	69	55	48	37
2005	35	37	41	55	59	73	78	77	72	59	48	33
2006	41	36	46	57	63	72	78	78	65	55	48	42
2007	39	28	46	52	66	74	77	79	71	63	46	38
2008	35	37	46	56	61	74	77	73	69	55	44	38
2009	29	38	43	56	65	73	75	78	68	56	50	35
2010	33	31	49	59	66	76	79	77	71	58	46	31
2011	30	38	44	57	66	75	81	76	68	55	48	41
2012	37	41	54	54	68	72	80	76	68	57	42	42
2013	37	35	40	56	63	73	78	73	67	58	43	39
2014	27	32	37	52	64	72	74	72	67	57	42	38
2015	29	25	40	54	69	73	76	74	71	55	50	48
2016	31	37	50	54	62	73						

Source: www.WeatherDataDepot.com

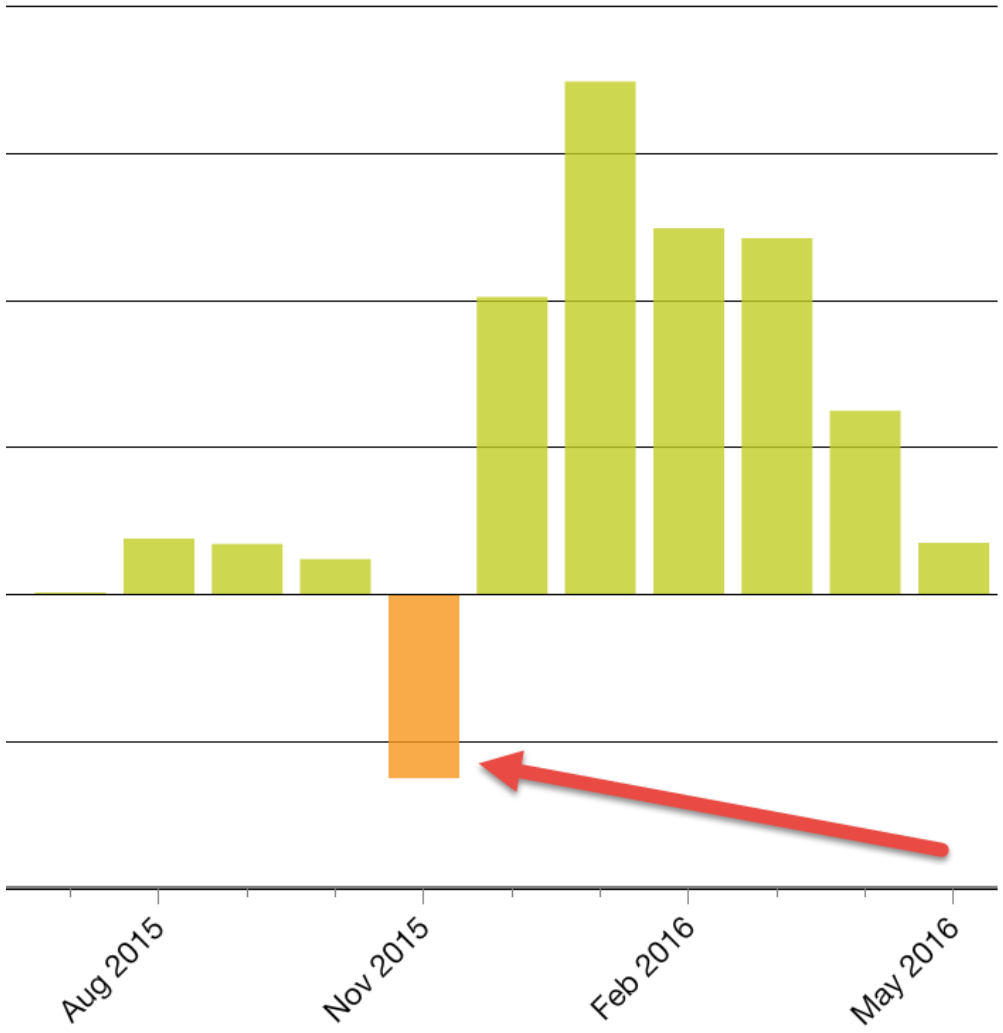
Mild weather causes a downward baseline adjustment



Weather Sensitivity	Use/Degree	R2
Summer	N/A	N/A
Winter	6.61	0.9911

BATCC Use:	1,520 THERM	**BATCC Cost:**	$1,253
Actual Use:	- 1,824 THERM	**Actual Cost:**	- $1,504
Use Avoidance:	-304 THERM	**Cost Avoidance:**	-$251

All months have calculated savings *except* the mild winter weather month shows a loss. Is that due to a one-month lack of energy conservation effort?



Observation:

When mild winter weather occurs in December, it doesn't cause as much of a usage reduction as indicated by the regression model. An equal number of degree days in October would result in lower usage.

Due to:

Early morning warm-up period due to cooler overnight temperatures, lower humidity, extended hours of darkness, overheating?

M&V Options (Evaluated by cost, practicality, fairness)

- Stick with established methodology
- Use a more sophisticated model (hourly, high/low, multivariate?)
- Ignore this month using *No Loss/No Gain rule.*
- Adjust the baseline for apparent non-standard building operating practices
- Selectively ignore just highly abnormal days

It was observed that mild weather was attributable to two periods of extreme mild temperatures. Recommended solution is to limit the *no loss/no gain* to these limited number of days. Low **cost** to implement, **practical** across many buildings, **fair** to all parties (although potentially understating cost avoidance by a small amount).

	MDT	HDD
1	43	12
2	52	3
3	44	11
4	40	15
5	40	15
6	39	16
7	43	12
8	41	14
9	38	17
10	49	6
11	49	6
12	55	0
13	59	0
14	63	0
15	54	1
16	45	10
17	47	8
18	40	15
19	35	20
20	35	20
21	47	8
22	55	0
23	60	0
24	67	0
25	64	0
26	56	0
27	60	0
28	48	7
29	46	9

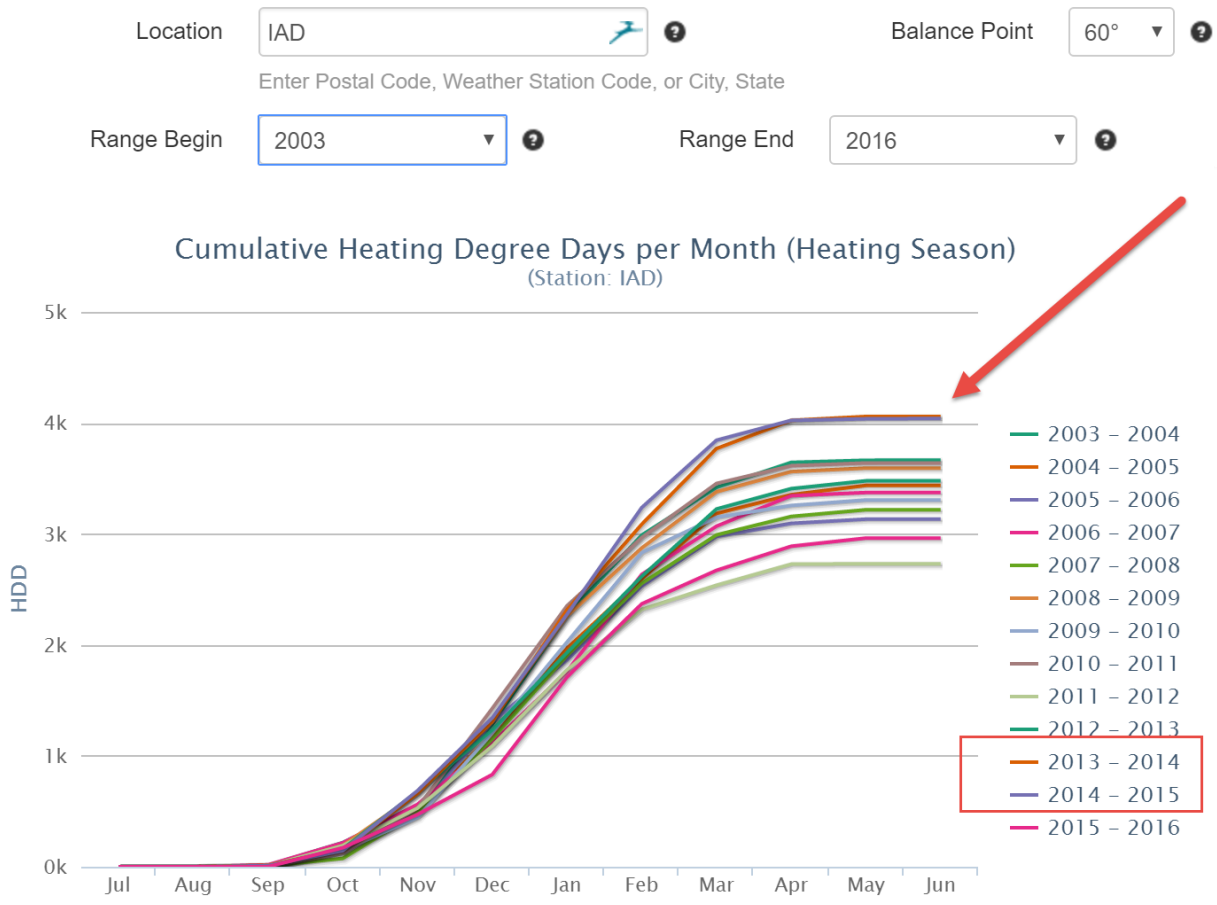
Would Big Data help in this situation?

Interval data for gas usage would be very useful

It would allow more granular scrutiny of usage patterns during ten mild weather days

Case #2: Extremely cold winter weather

“Polar vortex” winters of 13-14 and 14-15



Source: www.WeatherDataDepot.com

Heating season total Heating Degree Days

Cumulative Seasonal Heating Degree Days (Station: IAD View Map)

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
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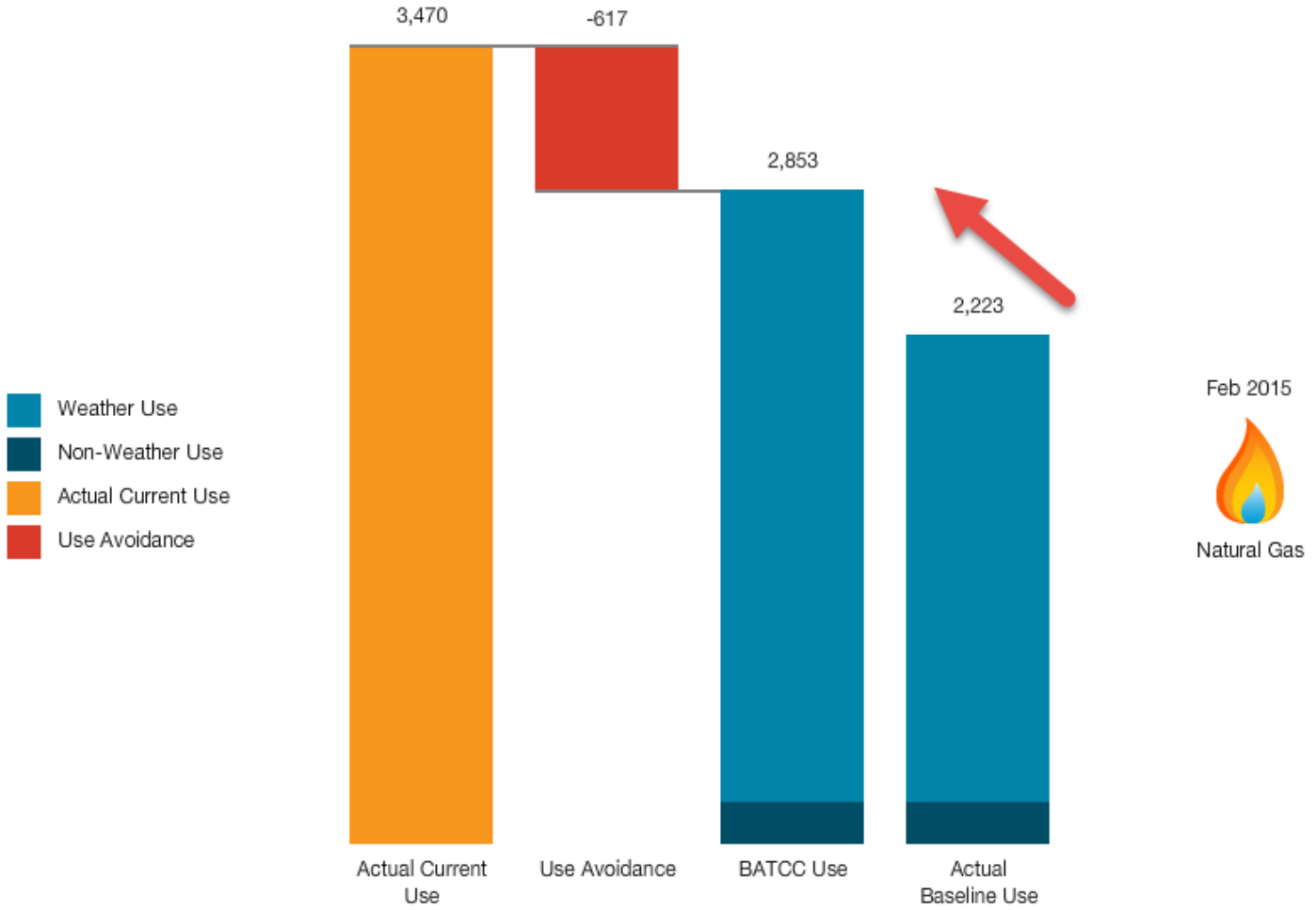
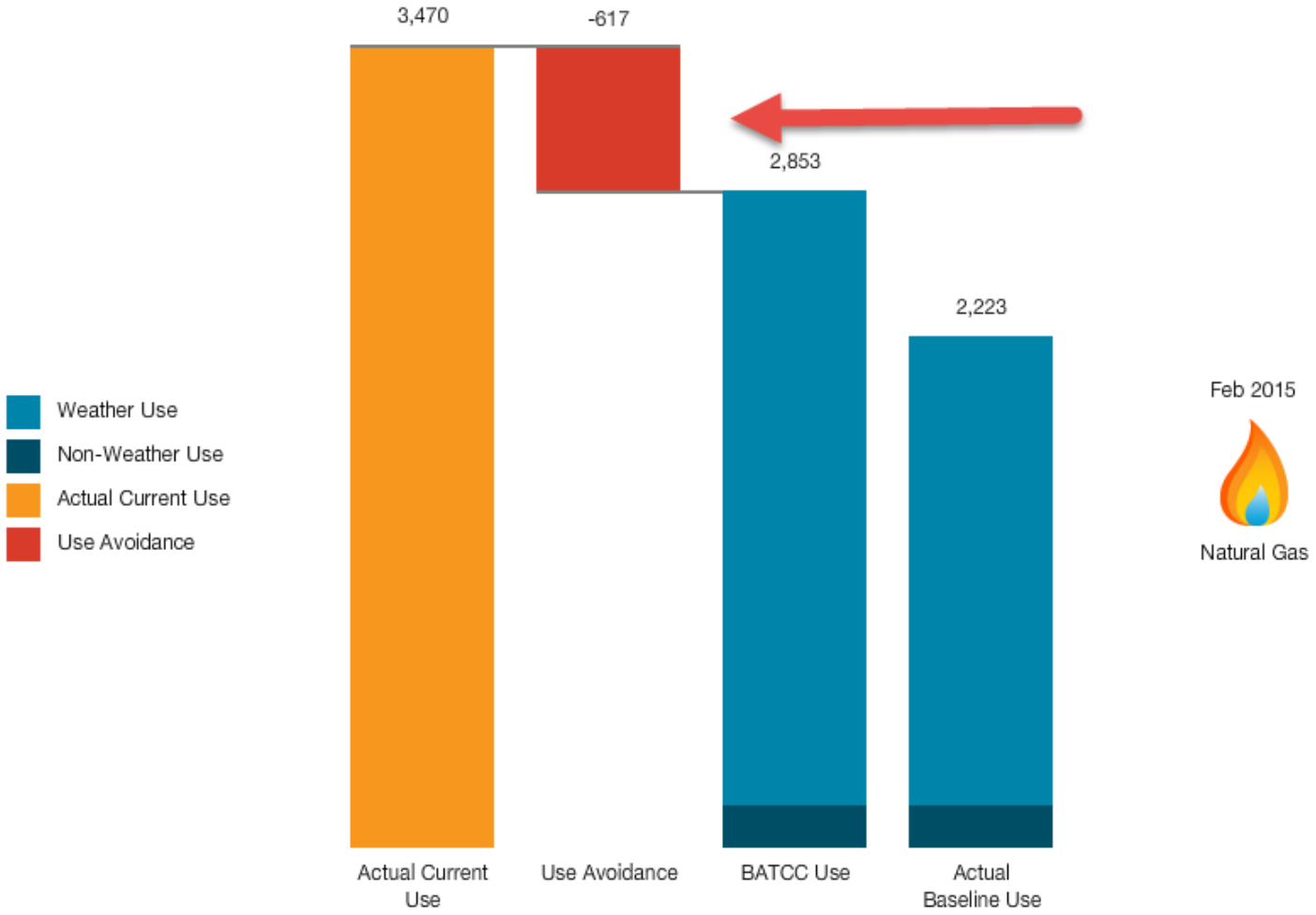
2015 - 2016	0	0	0	171	471	831	1709	2369	2671	2888	2961	2961

Source: www.WeatherDataDepot.com

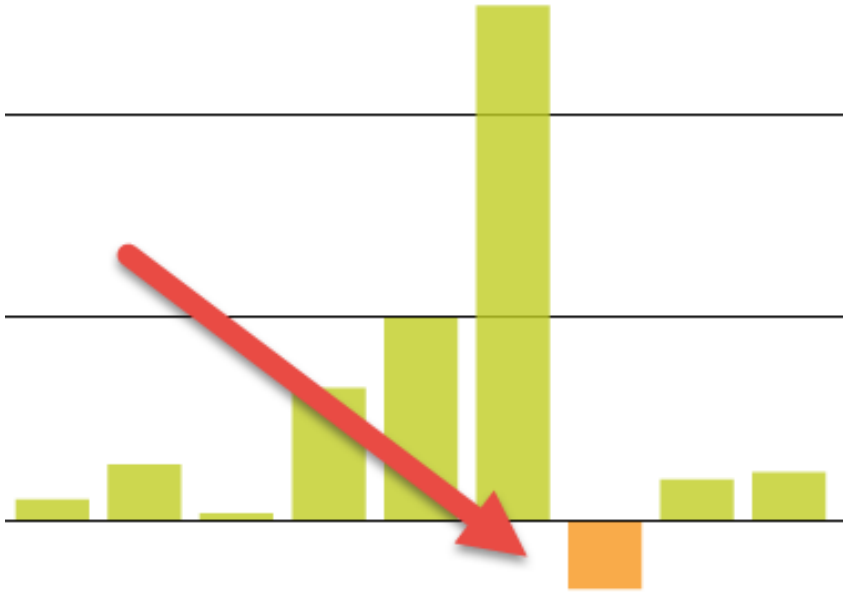
Severe cold weather causes an upward baseline adjustment



But the adjustment doesn't seem to be enough; there is still a calculated loss in record-cold Feb '15



And Feb ‘15 is the only month with a calculated loss. Was this due to lack of energy management effort or something else?



Observation:

Severe winter weather causes some buildings to be operated in “freeze protection” mode, driving up energy usage.

These points fall outside of the weather adjustment regression model because there are no such freeze protection points represented in the model.

M&V Options (Evaluated by cost, practicality, fairness)

- Stick with established methodology
- Use a more sophisticated model (hourly, high/low, multivariate?)
- Ignore this month using *No Loss/No Gain rule.*
- Adjust the baseline for apparent non-standard building operating practices
- Selectively ignore just highly abnormal days

Extreme Jan-Feb weather was not limited to several distinct and limited periods of cold weather patterns

	Base Year			
	MDT	HDD	CDD	TDD
1	30	30	0	30
2	34	26	0	26
3	31	29	0	29
4	49	11	0	11
5	35	25	0	25
6	20	40	0	40
7	16	44	0	44
8	12	48	0	48
9	29	31	0	31
10	17	43	0	43
11	23	37	0	37
12	35	25	0	25
13	30	30	0	30
14	25	35	0	35
15	29	31	0	31
16	31	29	0	29
17	29	31	0	31
18	37	23	0	23
19	36	24	0	24
20	34	26	0	26
21	29	31	0	31
22	37	23	0	23
23	32	28	0	28
24	37	23	0	23
25	40	20	0	20
26	35	25	0	25
27	29	31	0	31
28	27	33	0	33
29	25	35	0	35
30	29	31	0	31
31	25	35	0	35

	Base Year			
	MDT	HDD	CDD	TDD
1	30	30	0	30
2	35	25	0	25
3	29	31	0	31
4	38	22	0	22
5	29	31	0	31
6	23	37	0	37
7	32	28	0	28
8	44	16	0	16
9	36	24	0	24
10	34	26	0	26
11	35	25	0	25
12	29	31	0	31
13	19	41	0	41
14	28	32	0	32
15	12	48	0	48
16	11	49	0	49
17	18	42	0	42
18	18	42	0	42
19	11	49	0	49
20	10	50	0	50
21	21	39	0	39
22	39	21	0	21
23	25	35	0	35
24	12	48	0	48
25	22	38	0	38
26	31	29	0	29
27	26	34	0	34
28	21	39	0	39

The selected solution was to create special baseline adjustments based on building simulations of “freeze protection” building operating mode.

This solution is fair but expensive/time-intensive and requires high skill level.

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Would Big Data help in this situation?

Interval data for gas usage would be very useful

It would allow more granular scrutiny of usage patterns during extreme cold weather days

Strategically placed indoor temperature sensors could indicate the need for “freeze protection” practices

Conclusions

Extreme weather creates challenges for M&V calculations. Calculations must:

- Comply with the M&V Plan
- Be fair to all parties
- Be acceptable to all parties
- Be practical to implement (cost, skill level, ability to be audited/scrutinized)

Big Data in the future has the potential of making the extreme weather adjustment process more accurate and fair

Q&A