# The Risks of Abandoning the 30 Year Normal

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April 2014

Energy Forecasting Meeting

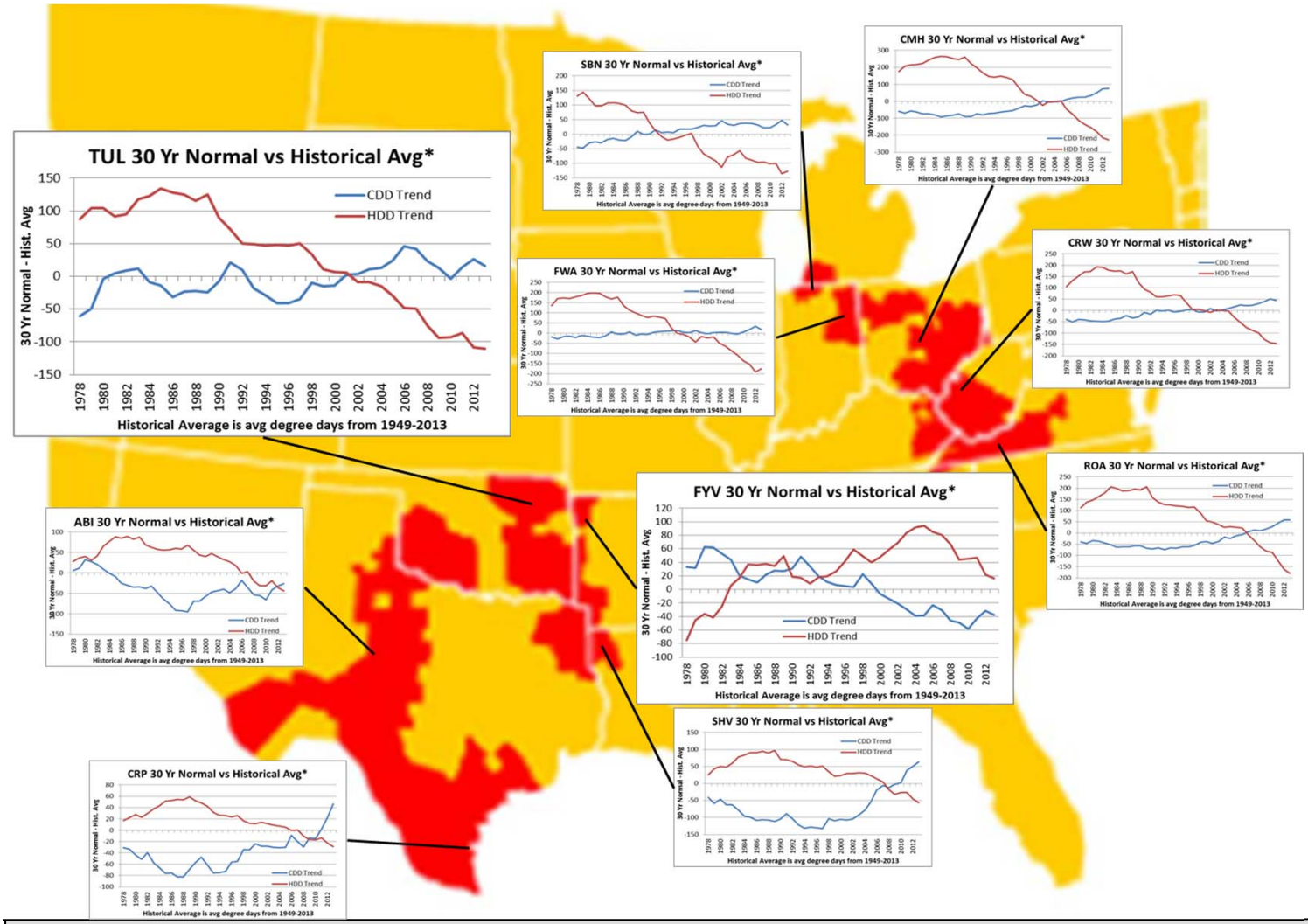
# *Why Switch From a 30 Year Normal?*

- Recently some in the industry have switched from a 30 year normal definition to shorter period definitions (like a 10 year normal) in their weather normalization and load forecasting processes based on the hypothesis that a shorter period normal would better capture more recent warming trends in global temperatures.
- Unfortunately some of these decisions are being made without analyzing the actual local/regional temperature data and without consideration of the increased volatility inherent in the shorter period normal definitions.

# AEP's Approach to the Issue

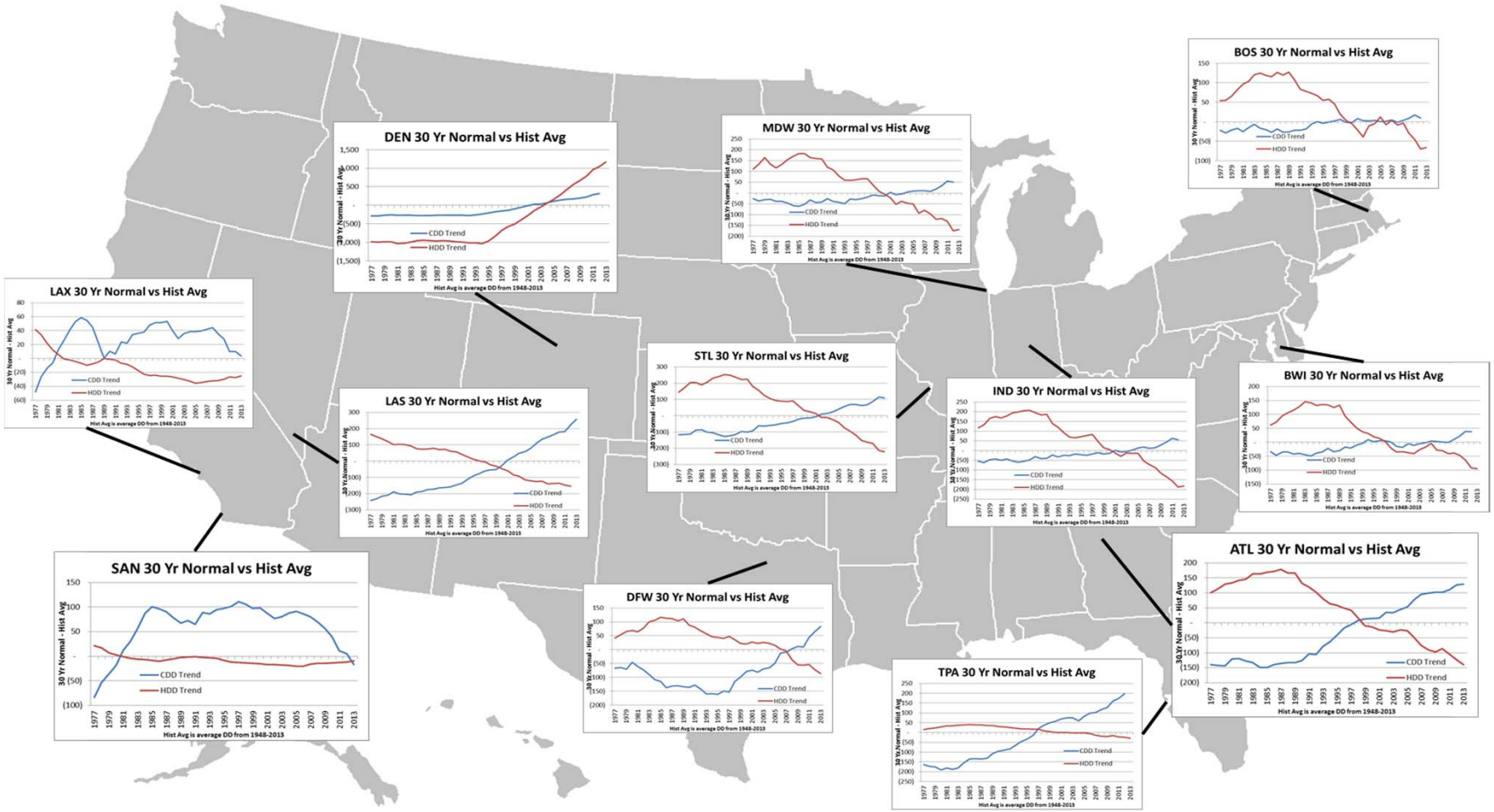
- The first step is to analyze the local weather station data to determine if, in fact, there is a warming trend in our service territory.
- Assuming there is a warming trend, the next step is to test whether or not a 10 year normal (or other shorter period definition) does a better job of capturing the warming trend than the 30 year normal.
- Finally, we need to identify the volatility of the shorter period definitions so that we could appropriately consider the 'opportunity costs' of abandoning the 30 year normal (i.e. What do you *give up* in order to 'better capture' the warming trend in temperatures?).

# Is There A Warming Trend (AEP)?




***With the exception of Fayetteville, AR, there does appear to be a warming trend across AEP's service territory, mostly in the winter temperatures.***

# Is There A Warming Trend (US)?




***Many (but not all) of the sample weather stations selected show a similar warming trend as the AEP weather stations.***

# Is the Trend Statistically Significant?

- A difference of means t-test was conducted to evaluate whether or not temperatures (degree days) in the most recent 30 years (year ending 2013) were statistically different from the temperatures in the prior 30 year period.
- The test was then replicated for the year ending 2009 to see if the relationship has changed in the more recent historical data.
- Every AEP weather station tested except Fayetteville, AR (which didn't show a warming trend on the graph), showed a statistical difference in the heating degree days compared to the previous 30 year period, while half of the stations show a statistical difference in cooling degree days.
- Similar results were discovered for the non-AEP weather stations tested.

**Difference of Means t-Test Probabilities**

*If P > .05, then the most recent 30 years are not significantly different from the previous 30 years*

| | | Year Ending 2013 | | Year Ending 2009 | |
|---|---|---|---|---|---|
| | City | CDD | HDD | CDD | HDD |
| AEP Stations | Abilene, TX | 0.62 | 0.03 | 0.30 | 0.19 |
| | Columbus, OH | 0.00 | 0.00 | 0.06 | 0.00 |
| | Corpus Christi, TX | 0.05 | 0.01 | 0.68 | 0.15 |
| | Charleston, WV | 0.05 | 0.00 | 0.12 | 0.01 |
| | Ft. Wayne, IN | 0.53 | 0.00 | 0.58 | 0.00 |
| | Fayetteville, AR | 0.18 | 0.89 | 0.19 | 0.22 |
| | Roanoke, VA | 0.02 | 0.00 | 0.17 | 0.01 |
| | Shreveport, LA | 0.04 | 0.01 | 0.38 | 0.14 |
| | Tulsa, OK | 0.96 | 0.00 | 0.41 | 0.00 |
| | South Bend, IN | 0.29 | 0.02 | 0.14 | 0.01 |

| | | Year Ending 2013 | | Year Ending 2009 | |
|---|---|---|---|---|---|
| | City | CDD | HDD | CDD | HDD |
| Non-AEP Stations | Atlanta, GA | 0.00 | 0.00 | 0.00 | 0.00 |
| | Dallas, TX | 0.04 | 0.00 | 0.28 | 0.03 |
| | Las Vegas, NV | 0.00 | 0.00 | 0.00 | 0.00 |
| | Los Angeles, CA | 0.47 | 0.09 | 0.35 | 0.00 |
| | San Diego, CA | 0.27 | 0.74 | 0.17 | 0.06 |
| | St. Louis, MO | 0.00 | 0.00 | 0.00 | 0.00 |
| | Boston, MA | 0.49 | 0.01 | 0.41 | 0.32 |
| | Baltimore, MD | 0.09 | 0.00 | 0.26 | 0.05 |
| | Denver, CO | 0.00 | 0.00 | 0.00 | 0.00 |
| | Indianapolis, IN | 0.06 | 0.00 | 0.11 | 0.00 |
| | Chicago, IL | 0.09 | 0.00 | 0.40 | 0.01 |
| | Tampa, FL | 0.00 | 0.00 | 0.00 | 0.01 |

***The t-test confirms the winters over the past 30 years are warmer than they were historically. About half of the stations tested are showing a warming trend in the summers.***

# *Is the 10 Year Normal Statistically Different from the 30 Year Normal?*

- Next, we performed a difference of means t-test to evaluate whether the 30 year normal was statistically different than the 10 year normal.
- The test was replicated every 10 years from 1980 to 2010 and again for the year ending in 2013 to see if there has been any change in the relationship between the two normal definitions over time.
- Only 3 instances out of 100 tests showed a statistical difference between the 30 year normal and the 10 year normal for the AEP weather stations. No station showed a statistical difference in the most recent test (year ending 2013).
- For the non-AEP stations, 13 out of 120 tests showed a statistical difference between the two normal definitions.

**Difference of Means t-Test Probabilities**

*If P > .05, then the most recent 10 years are not significantly different from the previous 30 years temperature data.*

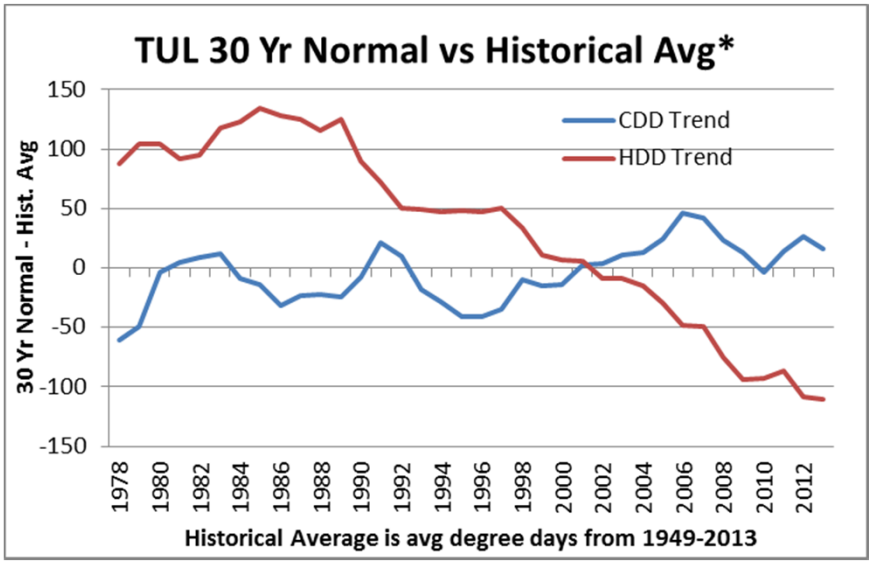
| | | Year Ending 2013 | | Year Ending 2010 | | Year Ending 2000 | | Year Ending 1990 | | Year Ending 1980 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CDD | HDD | CDD | HDD | CDD | HDD | CDD | HDD | CDD | HDD |
| AEP Stations | ABI | 0.58 | 0.41 | 0.51 | 0.37 | 0.90 | 0.12 | 0.99 | 0.86 | 0.29 | 0.26 |
| | CMH | 0.25 | 0.30 | 0.41 | 0.22 | 0.29 | 0.16 | 0.59 | 0.20 | 0.59 | 0.75 |
| | CRP | 0.16 | 0.41 | 0.38 | 0.32 | 0.98 | 0.05 | 0.88 | 0.91 | 0.36 | 0.67 |
| | CRW | 0.50 | 0.54 | 0.98 | 0.68 | 0.88 | 0.54 | 0.02 | 0.17 | 0.44 | 0.82 |
| | FWA | 0.76 | 0.71 | 0.72 | 0.76 | 0.79 | 0.38 | 0.39 | 0.11 | 0.83 | 0.74 |
| | FYV | 0.90 | 0.74 | 0.38 | 0.67 | 0.78 | 0.56 | 0.42 | 0.31 | 0.70 | 0.70 |
| | ROA | 0.18 | 0.12 | 0.31 | 0.05 | 0.61 | 0.36 | 0.23 | 0.63 | 0.31 | 0.89 |
| | SHV | 0.09 | 0.54 | 0.17 | 0.58 | 0.40 | 0.15 | 0.90 | 0.76 | 0.18 | 0.65 |
| | TUL | 0.35 | 0.67 | 0.61 | 0.57 | 0.39 | 0.36 | 0.39 | 0.21 | 0.95 | 0.58 |
| | SBN | 0.86 | 0.76 | 0.84 | 0.85 | 0.70 | 0.96 | 0.41 | 0.30 | 0.29 | 0.28 |

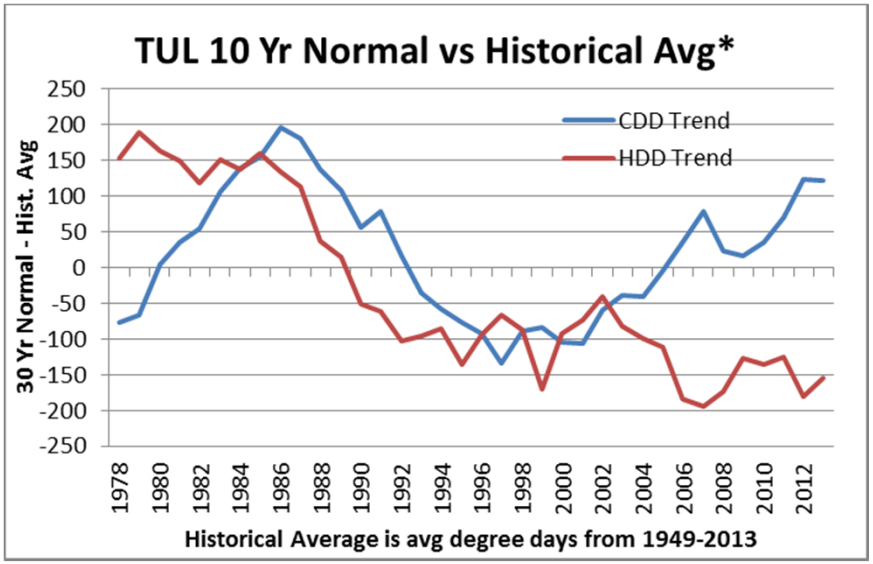
| | | Year Ending 2013 | | Year Ending 2010 | | Year Ending 2000 | | Year Ending 1990 | | Year Ending 1980 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CDD | HDD | CDD | HDD | CDD | HDD | CDD | HDD | CDD | HDD |
| Non-AEP Stations | ATL | 0.44 | 0.86 | 0.98 | 0.95 | 0.29 | 0.08 | 0.01 | 0.11 | 0.74 | 0.95 |
| | DFW | 0.03 | 0.21 | 0.20 | 0.21 | 0.43 | 0.08 | 0.93 | 0.88 | 0.58 | 0.74 |
| | LAS | 0.00 | 0.05 | 0.00 | 0.11 | 0.18 | 0.10 | 0.39 | 0.13 | 0.20 | 0.65 |
| | LAX | 0.77 | 0.67 | 0.29 | 0.64 | 0.94 | 0.03 | 0.37 | 0.49 | 0.57 | 0.32 |
| | SAN | 0.96 | 0.95 | 0.23 | 0.58 | 0.17 | 0.12 | 0.28 | 0.75 | 0.17 | 0.52 |
| | STL | 0.34 | 0.56 | 0.55 | 0.36 | 0.68 | 0.09 | 0.05 | 0.12 | 0.72 | 0.37 |
| | BOS | 0.39 | 0.48 | 0.65 | 0.83 | 0.82 | 0.52 | 0.72 | 0.39 | 0.38 | 0.55 |
| | BWI | 0.24 | 0.60 | 0.71 | 0.92 | 0.84 | 0.55 | 0.68 | 0.41 | 0.97 | 0.12 |
| | DEN | 0.04 | 0.00 | 0.01 | 0.00 | 0.08 | 0.08 | 0.05 | 0.76 | 0.94 | 0.70 |
| | IND | 0.19 | 0.58 | 0.42 | 0.43 | 1.00 | 0.20 | 0.51 | 0.24 | 0.85 | 0.82 |
| | MDW | 0.84 | 0.81 | 0.92 | 0.97 | 0.59 | 0.17 | 0.63 | 0.35 | 0.54 | 0.56 |
| | TPA | 0.24 | 0.91 | 0.16 | 0.94 | 0.25 | 0.03 | 0.30 | 0.44 | 0.09 | 0.83 |

***While the previous test indicated there was a warming trend across most of AEP's service territory, this test shows that in most cases (97% of the time), the 10 year normal is no better at capturing the trend than the 30 year normal.***

# Capturing Trend or Volatility?

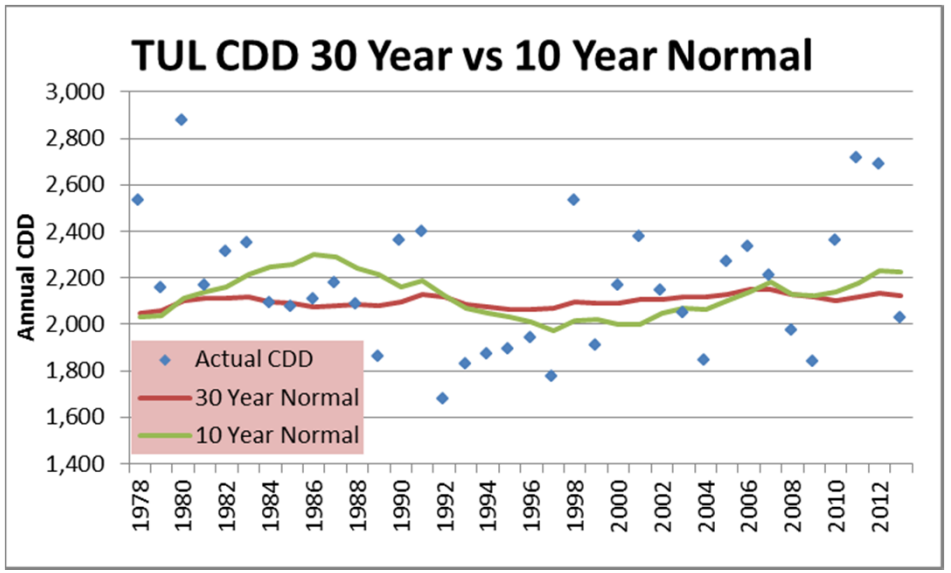
- The 30 year normal clearly captures a warming trend in Tulsa temperatures (both CDD & HDD).
- The 10 year normal is capturing more volatility than trend, especially with cooling degree days.
- As a result, the 10 year normal 'bounces around' a lot more than the 30 year normal, which is not a desired characteristic of a true 'normal'.

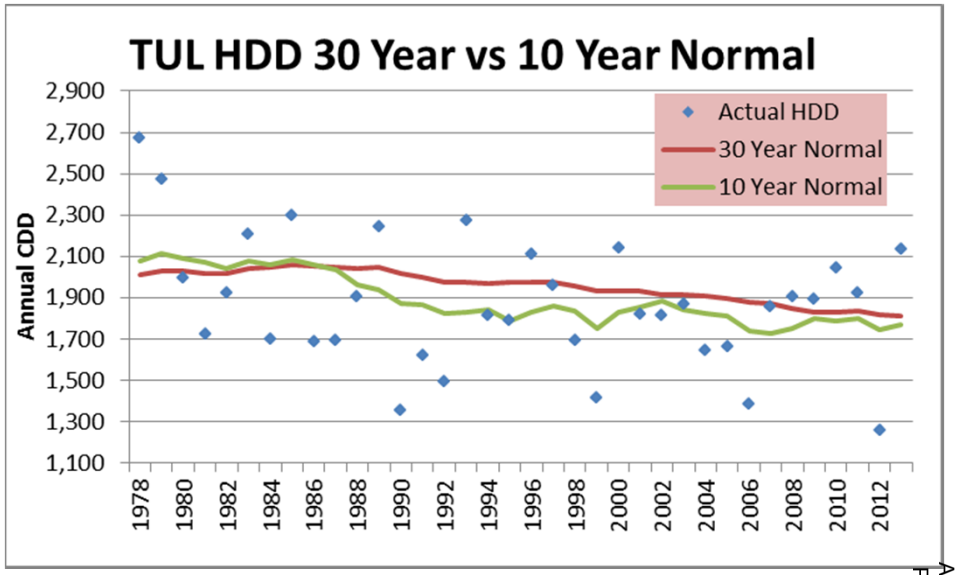


# Extreme Outlier Influence

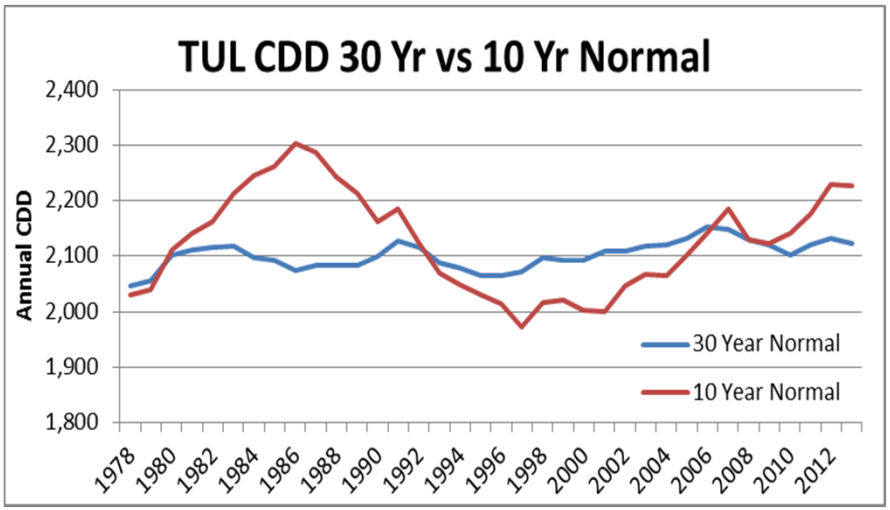
- The 10 year normal is more volatile and more vulnerable to extreme outliers than the 30 year normal.
- An extreme outlier has a much bigger influence on the 10 year normal (10%) as compared to the 30 year normal (3.3%).
- The 30 year normal still captures the recent warming trend without introducing unnecessary volatility to the normal definition.

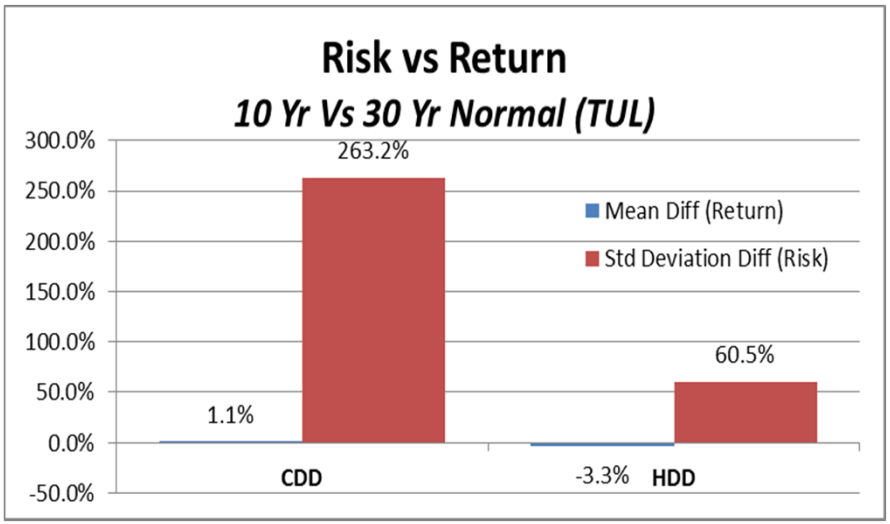


# Risk vs. Return

- While the 10 year normal is not statistically different from the 30 year normal, the volatility of the 10 year normal is substantially greater, which creates more risk for a utility if it used a 10 year normal for billing determinants in a rate case.
- Similar issues could arise if a 10 year normal is used in load forecasting (i.e. Did the long term load forecast change because this year's definition of normal changed from last year?)

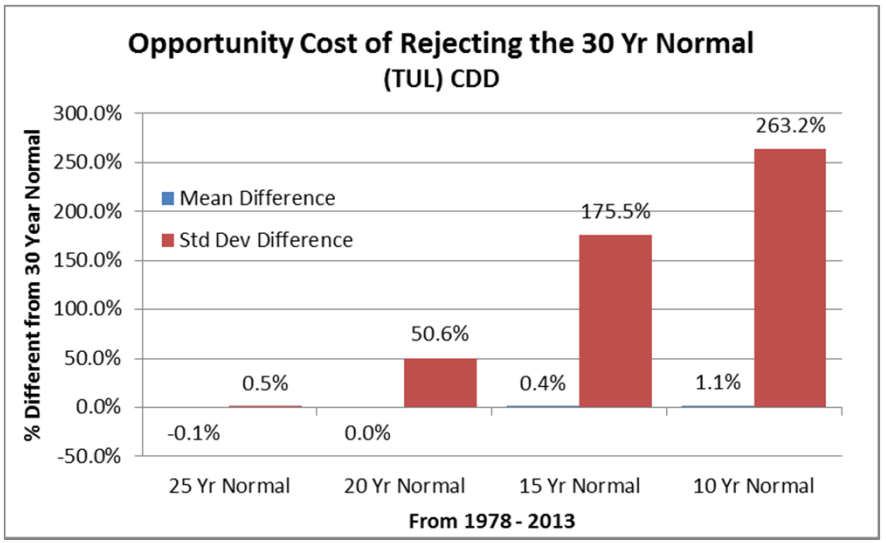


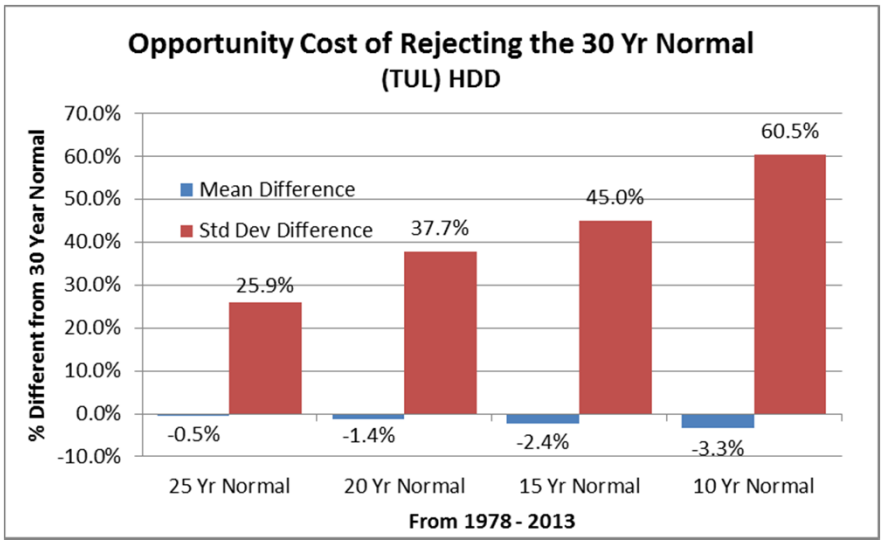




| Station | | | 30 Year Normal | 10 Year Normal | % Different |
|---|---|---|---|---|---|
| TUL | CDD | Mean | 2,102 | 2,126 | 1.1% |
| | | Standard Deviation | 25.18 | 91.45 | 263.2% |
| | HDD | Mean | 1,956 | 1,890 | -3.3% |
| | | Standard Deviation | 77.21 | 123.92 | 60.5% |

# What About Other Definitions of Normal?

- We did most of our testing comparing the 30 year normal to the 10 year normal, based on the assumption that the differences would be the most pronounced.
- As expected, comparisons to other period definitions of normal yields similar, though less severe results.
- The implies '*what you get*' by switching from a 30 year normal (mean differences) may not be worth '*what you would have to give up*' (stability in your normal definition), given the volatility of shorter period normals.



# Conclusions

- There does appear to be a general warming trend across most of the AEP service territory, although there are exceptions both within and outside of the AEP footprint. Each company should test for a warming trend based on the local weather data.
- The 30 year normal does adequately capture the trend in temperatures without introducing the volatility that is inherent in shorter period definitions of normal.
- More than 9 times out of 10, the 10 year normal is not statistically different from the 30 year normal, even though the volatility of the 10 year normal is substantially greater.
- Shorter period normal definitions are more vulnerable to extreme outliers since the outlier is given substantially more weight than in the traditional 30 year normal.
- There is a greater risk that a utility will not be able to recover the authorized revenue requirement when the rates are set from billing determinants that were weather normalized based on shorter period definitions than the 30 year normal.
- Each company should consider the opportunity cost of switching from the 30 year normal before making the change.