Trading TCO for PUE?

A Romonet White Paper: Part I

Executive Overview

Most data center vendors claim to improve Power Usage Effectiveness (PUE). The problem with this is that focusing on reducing PUE makes little financial or environmental sense for many enterprises and multi-tenant data center (MTDC) operators.

Most organizations lack accurate operational and financial data to effectively analyze, model and predict how their facilities should, and actually do, behave or compare with others.

We demonstrate this with one data center design that, when modeled using Romonet's platform, actually showed **no financial or environmental benefits, despite a reduction in PUE.**

The initial $500,000 investment would actually deliver **an overall lifetime loss of $400,000**.

It is critical to understand the accuracy of any TCO claim, terms such as total cost of ownership (TCO) and return on investment (ROI) mean nothing when analyses are based on weak proxy indicators, e.g. 'free cooling hours' or carefully selected edge cases.

Many published analyses contain claims which are based on inaccurate or irrelevant estimations that yield lower than claimed or no overall savings in the real world.

Modeling your data center should not be based on guesswork, as Romonet explains in this paper.

The Example Data Center

So, how was the aforementioned loss of $400,000 identified? The data center modeled was:

- A new build 1.2MW IT load facility according to Tier III standards
- Direct outside air economizers and two modern IT equipment environmental ranges
- Good quality components, reasonable balance of capital cost and total cost of ownership

The 'what if' scenario was: **should we add adiabatic[1] cooling capability to the Air Handling Units (AHU)?** In theory, this enables the data center to operate without mechanical cooling for more of the year.

The instinctive response to the proposed change is: yes, free cooling means better energy efficiency, especially in an arid climate such as New Mexico, as long as water costs are controlled. The issue is that the adiabatic components are expensive to purchase and maintain.

These are the challenges data center owners meet on a daily basis. Should we use non-contained air flow or contained air flow (Appendix 1)? What is 'free cooling' really worth to us? Is the climate too hot or too dry?

It is common to assess the performance of cooling initiatives by comparing how many 'free cooling' hours per year are achievable. There are many 'rules of thumb' about x% savings for each degree change in temperature or mistaking 'free cooling hours' as a proxy for cost savings.

The table and graph on the following page show how much of the year our site would spend in full free cooling, full mechanical cooling or in partial free cooling with mechanical top-up.

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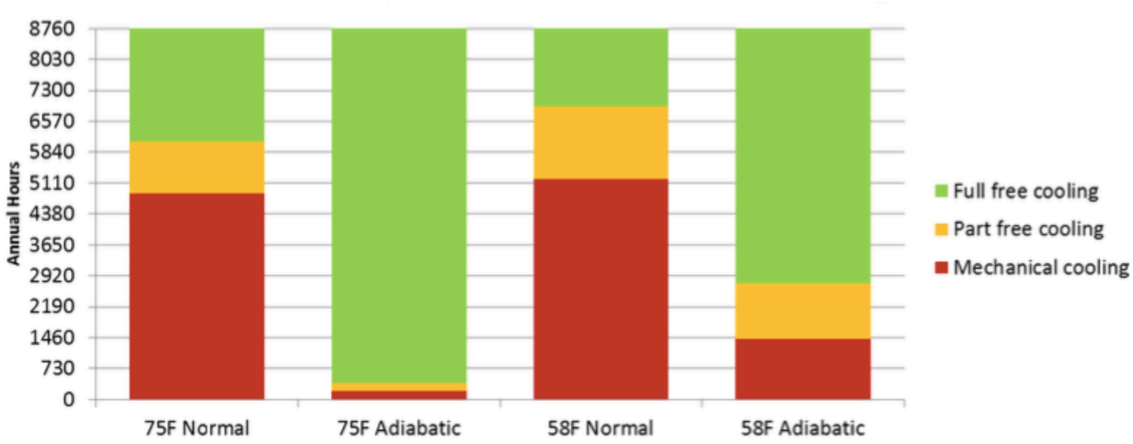
[1] *Adiabatic – evaporative cooling and humidification*

Condition	Normal 75°F	Adiabatic 75°F	Normal 58°F	Adiabatic 58°F
Full free cooling (no compressor)	30%	96%	21%	69%
Partial free cooling (part compressor)	14%	2%	20%	15%
Full Mechanical Cooling	56%	2%	59%	16%



Calculations, Not Assumptions

With these results in mind, surely the adiabatic option is the correct choice due to its significant increase in free cooling hours compared to the standard outside air system? The answer lies in accurate predictive analysis. To evaluate the potential cost savings from the cooling strategies, the following conditions were used:

- A base power cost of $0.058 / kWh
- IT kW load – 1,000 kW average
- Cooling overhead fudge factor – 25% overhead to approximate the cost of cooling each kW of IT load

The expected operational cost savings were:

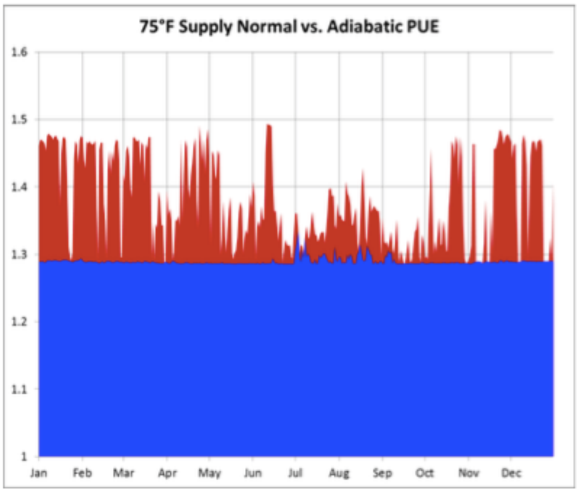
	Normal 75°F	Adiabatic 75°F	Normal 58°F	Adiabatic 58°F
Mech. Cooling Hours	6,090 hours	380 hours	6,929 hours	2,747 hours
Mech. Cooling kWh	1,522,500	95,000	1,732,250	686,750
Mech. Cooling $	$88,305	$5,510	$100,471	$39,832
Predicted Annual Saving		$82,795		$60,639
Predicted 10 Year Saving		$827,950		$606,390

Simple mathematics aside, despite being derived using a reasonable formula, **these estimates are completely incorrect**.

This is partly because of factors such as climate interactions and varying mechanical compressor efficiency. More importantly, it is because they are based on an irrelevant and deeply misleading metric.

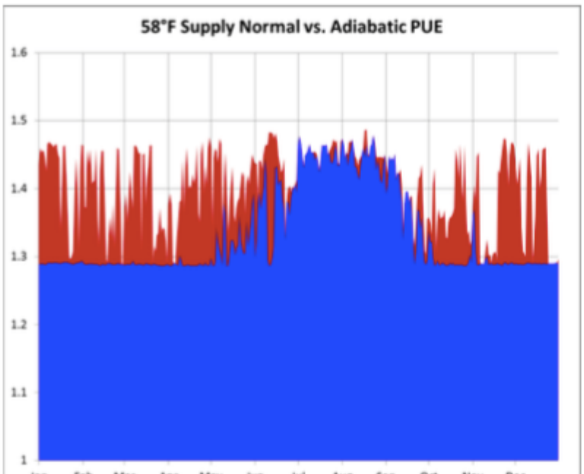
PUE – Understanding Why

This leads us to more detailed analyses. The charts below show full hourly simulations of both normal (red) and adiabatic (blue) designs operating at both air supply temperatures.[2]



The first chart shows that with adiabatic cooling, the PUE is almost flat for the whole year, meaning almost no mechanical cooling.

Without the adiabatic option, there is more mechanical cooling, but predominantly in the winter when outside air is too dry to be supplied to the data hall, not in the summer where you might normally expect.



The second chart shows at 58°F, even with adiabatic cooling, the data center relies heavily on mechanical refrigeration. In the summer, the air is too hot or humid.

The non-adiabatic option is fairly constant in its use of mechanical cooling, both during winter and summer.

Water: The Precious Resource

Predicted water consumption is as critical to many operators now as energy profiling. The acquisition, logistics, filtration, storage and pricing of water is crucial to controlling operational costs in the data center.

To meet the minimum IT humidity and temperature targets the humidifier sections of the adiabatic systems must use water, whenever outside air is used this humidity must be added constantly unlike a traditional, recirculating air system.

Next, the water consumption cost calculations[3] were modeled against a reasonable sample price for the region ($22 per 1,000 gallons).

The results (Appendix 2) found the 75°F adiabatic option **cost $17,805** and **the 58°F option $9,170**.

When this is applied to an accurate prediction methodology, the real financial outcomes become much clearer.

[3] *Water consumption calculated by determining water requirement to meet change in air moisture. 50% overhead added to account for water lost from flushing and other processes (conservative estimation).*

When The Savings Don't Mount Up

Given the low water costs, you would expect there is still hope for savings from the adiabatic investment.

So how did we arrive at the conclusion that the operational investment would actually cost the data center $400,000?

First we evaluated both adiabatic options over a 10-year period with a 7% discount rate and flat water and power costs for the period.

In fact, if price inflation for power and water were included, **the losses would have been even larger**.

Capital cost differences are next. The additional cost to fit the AHUs with adiabatic sections is $500,000. A further $10,000 per annum is added for maintenance and treatment.

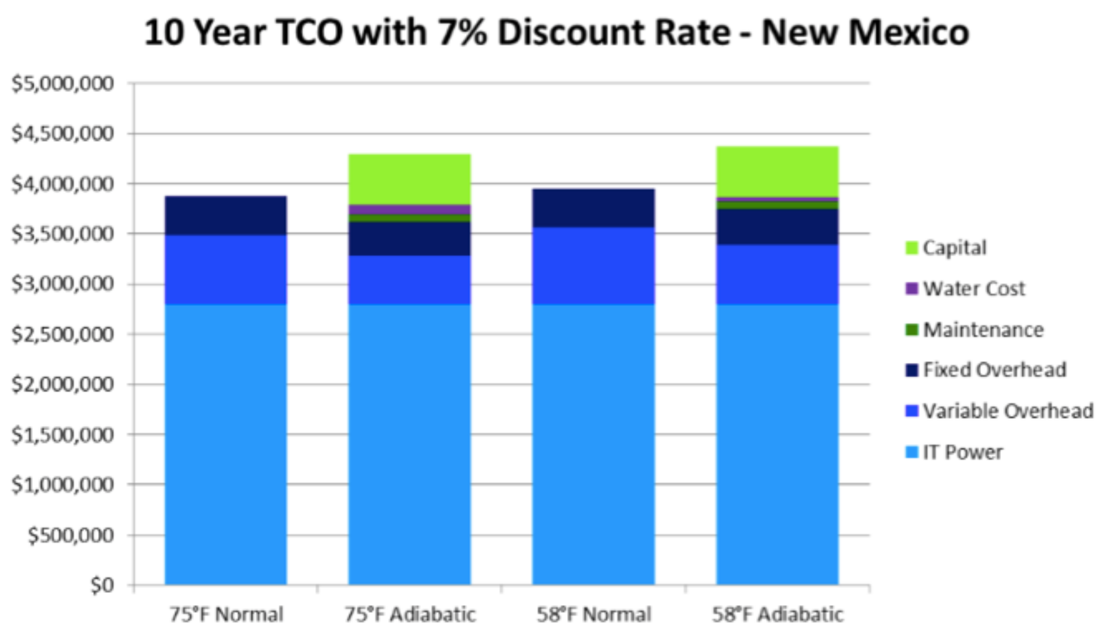
The IT power draw is modeled as rising for the first four years from 250 kW to 1MW, before remaining at 1MW for the remaining years. The average utility energy cost is $0.058 per kWh.

As shown below, **the small reduction in operating energy costs cannot offset the initial capital investments.**

Despite deliberately selecting a climate to favor the engineering decision, there was still no financial argument to support the additional capital expenditure.

	Capital Cost	10 Year PV Saving
Adiabatic 75°F	$500,000	**-$415,000**
Adiabatic 58°F	$500,000	**-$421,000**

Whether building, expanding, consolidating, acquiring or managing a data center, next time you have a financial or operational decision to make, do not rely on speculation to deliver your business outcomes. Instead ensure you model with accuracy and the correct data.



Appendix

Appendix 1 – ASHRAE Class A1 Ranges and Control Boundaries

Parameter	Non-Contained Air Flow	Contained Air Flow
Max IT Inlet Temperature	21°C / 70°F	24°C / 75°F
Supply Air Temperature	14.5°C / 58°F	24°C / 75°F
Minimum Humidity	20% RH at 21°C	20% RH at 24°C
Maximum Humidity	17°C dew point (~75% RH)	17°C dew point (~65% RH)

Appendix 2 – Water Consumption Calculation Methodology

	Adiabatic 75°F	Adiabatic 58°F
Humidification Hours	4,657	3,376
Annual Liters (H2O)	1,551,000	696,000
Adiabatic Cooling Hours	1,226	2,122
Annual Liters (H2O)	493,000	357,000
Total Annual H2O	2,045,000	1,053,000
Annual H2O (Incl. Losses)	3,067,000	1,580,000
Annual Water Cost	$17,805	$9,170

About Romonet

Established in 2006, Romonet provides the data center industry's only end-to-end, cloud-based management platform built on a native Big Data architecture. This combination of modeling, simulation, financial and infrastructure performance services provides customers with the capability to accurately provision, predict, model and control their owner-operated, leased and public cloud estates, associated natural resources and their immediate and long-term capacity.

Romonet's platform is the simplest commercially viable method to enable the CFO and CIO to accurately understand the most strategic asset in a company's portfolio. This value extends through to the engineering teams responsible for maintaining a data center's availability, quality of service and performance management. www.romonet.com