Trading TCO for PUE?

A Romonet White Paper: Part 2

Executive Overview

In the first part of this white paper series on PUE (Power Usage Effectiveness), we demonstrated the importance of accurate data center modeling.

The paper's use-case was a prospective data center design that, despite displaying a reduced PUE from a future cooling upgrade, would deliver no financial benefits.

The analysis concluded an initial $500,000 investment on adiabatic designs would actually generate a **financial loss** of **$400,000** for the company.

Using that same data center design for this paper's analysis, we have selected two other operational scenarios to address the following questions:

1. What about investing in **solar power**?
2. How can **water consumption** affect data center total cost of ownership?

These findings should prove how critical precise data center modeling is when considering your next investment.

Shining Suns

Having since disregarded the use of adiabatic coolers[1] - saving $500,000 in the process - the next question is:

With that regained capital, what would happen if the sum was spent on solar photovoltaic renewable energy?

To model this 'what if' scenario accurately we need two measurements:

- Solar panel cost data
- The expected sunlight for the year

Solar power installations are frequently quoted as '$ per peak kW'. This calculation provides the capital cost of installation – essentially, the peak kW capacity when the sun is overhead on a clear day.

A cost of **$2,000 per kW peak** (kWP[2]) was used in this model – this allows for a peak solar capacity of 250 kW from the full $500,000 capital.

Understandably, this peak does not apply to 24 hours of a day. Darkness overnight, mornings and evenings all offer less sunlight, as do cloudy periods (granted, a rarity in New Mexico[3]).

To compensate, the same climate data used in white paper part 1 has been used, although with a typical year of solar radiation added.

This data can now be used for a detailed approximation of the annual energy output of the PV farm.

As before, our analysis considers both 75°F and 58°F contained airflow temperature control options (each of which consist of dry and adiabatic variants).

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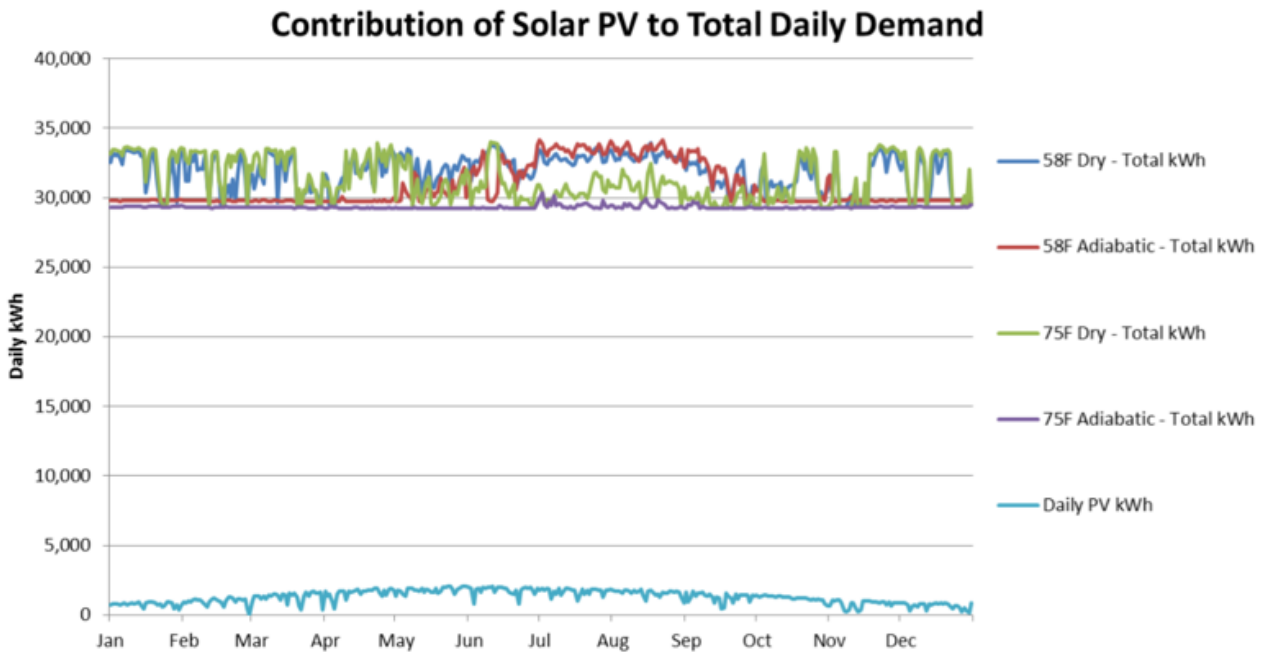
[1] *PUE White Paper part 1*

[2] *Based on oversupply of solar PV to the market from China and resulting falling prices at the time of writing – US market figures.*

[3] *The location chosen in part 1 of this white paper series.*



The chart above shows the daily kWh demand from our previous analysis for each of the four options.

In addition, the available daily energy output of the 250kWP solar panel farm is shown to allow us to compare.

In the best case, the contribution is **~ 4.5%** – a nominal advantage.

Solar Expenses

Despite the minor contribution, it is still worth assessing the solar PV's impact on data center total cost of ownership.

This requires estimations of how the cost of electricity will change over the time of the investment.

At the time of writing, US power costs are expected to remain low due to shale gas and other market forces, although energy security pressures may cause the value of solar power to increase over the prospective timeframe.

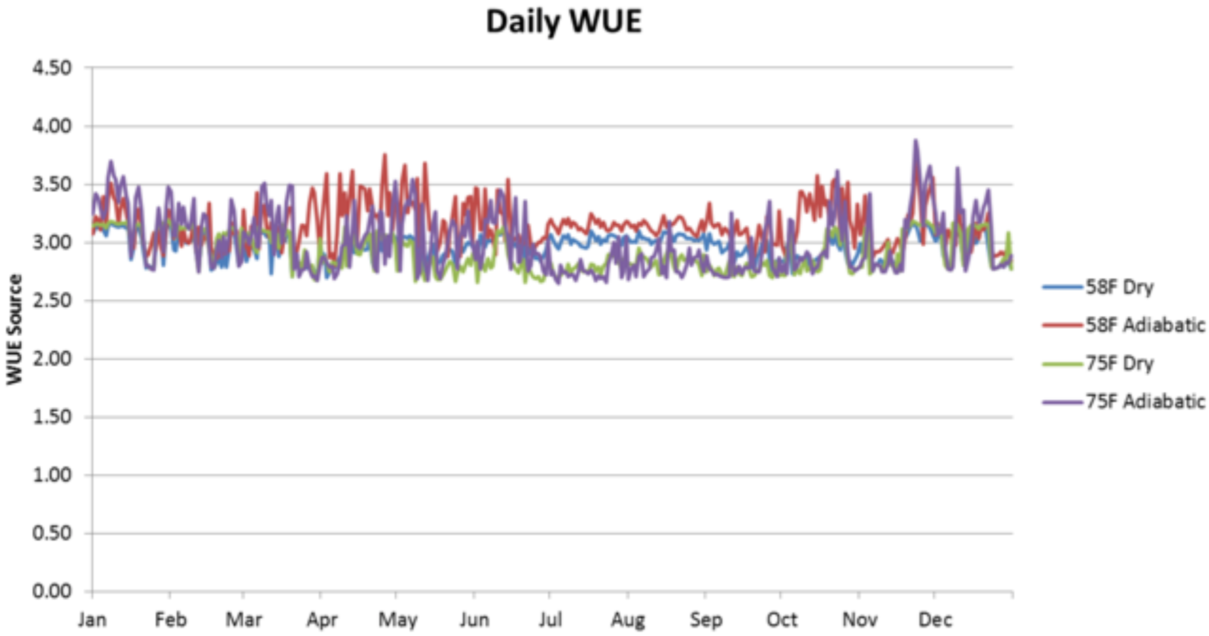
One of the oddities of this investment is that in many cases it would be better for the data center operator to locate the solar panels in an area with a feed-in energy tariff structure.

That would enable the data center to sell produced power to the grid operator for a **greater income compared to the potential savings** achieved by co-locating the panels with the data center and no surplus to feed back.

With this in mind, the results (Appendix 1) conclude that the total return on investment is better than with adiabatic coolers, but still not positive. This is modeled with energy costs kept flat and the same 7% discount rate.

To break even at the 20-year point, we would need the value of power generated by the solar panels to increase annually 0.9% less than our investment discount rate, or 6.9%.

This is potentially possible from legislative changes, either with feed-in tariffs or a government applied cost of carbon, however it is questionable whether this level of investment analysis should be part of the data center or a separate undertaking.



Watering The Data Center

With solar power analyzed, next is water consumption.

Water has a direct cost impact on a data center and one that will likely increase in the future, especially in areas pressured by sustained drought.

The resource must be efficiently sourced, stored, distributed, used and recycled – all of which incur substantial costs. The environmental impact is also critical.

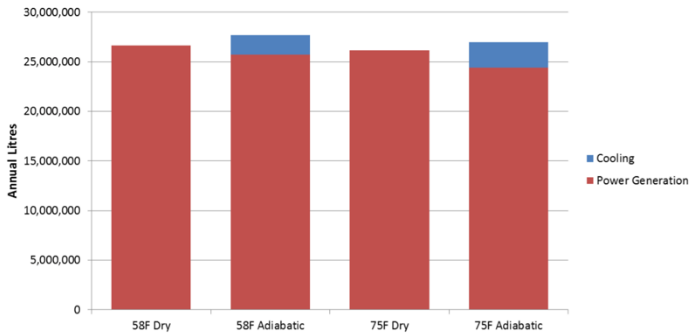
To assess water within the context of 'free cooling' initiatives, we must ascertain whether there is a net increase or decrease in consumption.

This extends beyond the WUE[4] metric used by many 'green dashboards'. These often exclude water used within a data center's energy supply.

This paper's WUE variant includes electricity-related water. Our modeled data center uses more water than dry designs, but substantially less than those with cooling towers. However, **does it use less water?**

Liquid Expenditures

As the following bar graph outlines, our analysis contains several interesting findings.



The water requirement of all four systems shows **no significant difference** between each.[5]

The order of preference does vary across winter and summer periods as water consumption in the adiabatic humidifiers is traded with consumption at the power station for mechanical cooling. The chart shows the minor variations, although the adiabatic options do use more supply.

Furthermore, the DX mechanical cooling provides anything up to 7kW of cooling for every 1kW of power consumed; meaning that adiabatic options **would need to be 3.5 times more efficient**[6] than the cooling

[4] http://www.thegreengrid.org/~/media/WhitePapers/WUE

[5] The model relied on the Energy Water Intensity Factor (EWIF) for New Mexico – 2.38 litres per kWh – from source three. This was applied to derive the total water consumption for each system.

[6] *Thermoelectric generation based on steam turbines is generally ~ 33% efficient producing electricity rejecting the remaining 67% source energy as heat, so the power station must reject twice as much heat energy as it supplies in electricity to power our DX chillers.*

systems at the power station to keep up.

Financial Considerations

These findings show the importance of realistic, accurate figures when evaluating investments and infrastructure decision-making within the data center.

In fact, these calculations have been generous to the adiabatic systems – in many cases, the **water treatment and losses could be 2x the actual requirement**.

This analysis used an estimate of 1.5 and still the adiabatic options came out worse.

Crucially, other locations could have different water intensities of power generation, many lower. It is also not uncommon to see similar case studies in this area use unrealistically poor baselines, unnecessarily restrictive controls and a neglecting of the improvements in mechanical cooling efficiencies in recent years.

One consideration – it remains challenging to compare water with source energy, as in most cases the relationship between the two is independent and complex.

For example, in the U.S. Pacific North West and Northern Europe, water is easily available with a low environmental and energy impact. In contrast, California and the South West United States are suffering severely.[7]

Ultimately, the crux of the two papers' analyses show that simple 'rules of thumb' or 'free cooling hours' metrics are ineffective in assessing data center performance.

In many cases, the behaviors on show are counter-intuitive. In other words, before committing to any new investment, model how the change will impact total cost of ownership and actual cost, no matter how straightforward the change may be.

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[7] *The result of this means you cannot currently sensibly compare the WUE of data centers unless the use-cases have the same PUE.*

Appendix

Appendix 1 – Solar PV investment at 0% power cost increase

Year	Annual PV kWh	Cost per kWh	Annual Saving PV	NPV
1	472,490	$0.058	$27,704	-$472,596
2	472,490	$0.058	$25,612	-$446,984
3	472,490	$0.058	$23,936	-$423,048
4	472,490	$0.058	$22,370	-$400,678
5	472,490	$0.058	$20,907	-$379,771
10	472,490	$0.058	$14,906	-$294,049
15	472,490	$0.058	$10,628	-$232,931
20	472,490	$0.058	$7,578	-$189,354

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

info@romonet.com | +1 415 578 0049 | +44 20 8256 0250