24/7 Carbon-Free Energy for Data Centers

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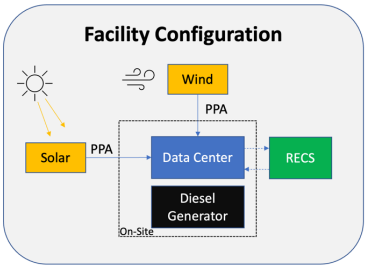
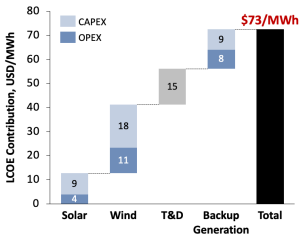
Executive Summary

- Data centers are a rapidly growing market where customers are increasingly demanding 24/7 load-matching carbon-free electricity. Current best-in-class practices call for power purchase agreements (PPAs) from intermittent renewables that meet or exceed total datacenter need. This does not always match datacenter demand, which is remarkably steady and consistent across time.
- We propose a 80 MW solar facility and 120 MW wind facility as the power generation facility for a 50 MW datacenter.
- Green hydrogen – hydrogen synthesized from water, powered by renewable energy - is a promising potential storage and backup solution but requires large capex reductions.
- Datacenters can be powered by 100% renewable power at current price deltas of $15/MWh. We expect this premium to decline as hydrogen round-trip efficiency (RTE) increases and as more production of fuel cells drives down capital cost

Current best-in-class practice is to sign PPAs to secure net 100% renewable power supply, does not address backup needs, which are currently met by dirty on-site diesel generation





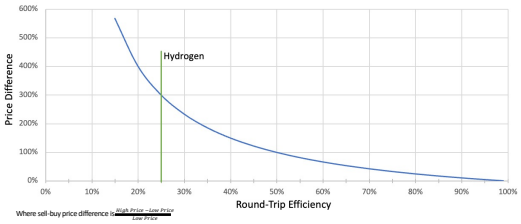
- Datacenters have remarkably steady loads, around 90-95% of maximum capacity for >90% of the year
- Intermittent renewables – wind and solar – inherently do not match the steady load profile of the use case
- This mismatch is currently handled by REC trading, but does not allow for a truly "green" datacenter
- Even if never needed to compensate for grid failures, diesel generators need regular startup tests, requiring them to run ~ 90 hours per year.
  - In addition to carbon emissions, diesel generators release a variety of other pollutants that degrade air quality in the local area

Green hydrogen is a compelling solution for long-duration energy storage, but inefficiencies preclude economic viability

Offsite hydrogen is infeasible due to inefficiencies of system, insufficient price swings

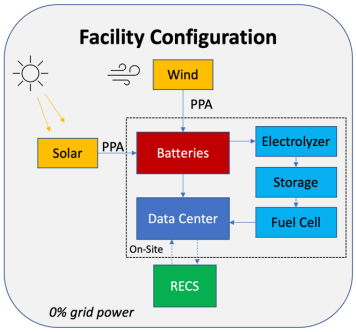
Hydrogen system inefficiencies
25% RTE multiplies fuel costs by 4x
300% price swings required

Advantages of other storage tech
Lithium-ion storage has a round-trip efficiency close to 90%, requiring only an 11% price swing to be profitable.

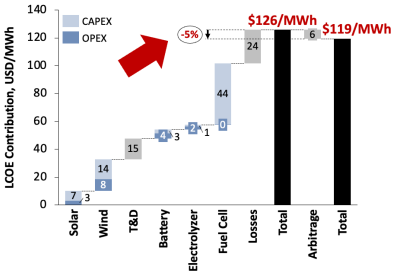


- Off-site production could have efficiencies of scale, but these are offset by the overall total roundtrip efficiency
  - There are further inefficiencies from transportation of hydrogen over long distance. Trucking is energy intensive, while long-distance pipelines remain commercially unproven

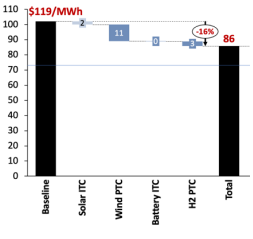
On-site hydrogen production, storage, and fuel cells enable economically viable fully clean generation



Unsubsidized costs of each component piece



Costs after subsidies



- Batteries provide 4 hours of backup, smoothing shortfalls in wind or solar generation, as well as short power outages
  - Batteries also ensure that the electrolyzer can run as close to 100% of the time as possible
- An on-site electrolyzer utilizes excess wind or solar power to generate green hydrogen, which is then stored on-site
- Longer gaps between renewable generation can be smoother over by the fuel cell and stored hydrogen
- Grid outages up to 96 hours are covered by on-site stored hydrogen
- The fuel cell also takes the place of on-site diesel generation, completely decarbonizing the entire operation

Conclusion

- The IRA's production and investment tax credits reduce total system LCOE to $86/MWh, roughly a 15% premium to the baseline all-in energy cost for a renewable energy powered datacenter
- On-site electrolyzers and storage are preferable to costly and as-yet-unproven distribution of the volatile gas