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tabreed
Sustainable Cooling

Cooling Residential Developments

- Options & Economic evaluation

Cooling Residential Developments

About Tabreed

A About Tabreed

- Tabreed is a publically listed company having investment grade rating with Mubadala (Abu Dhabi Government) and Engie (French utility player having assets across the globe) being the two largest shareholders.
- Current portfolio comprises of 74 district cooling plants operating and serving over 1.1 million RT of cooling pan GCC developed over past 20 years.
- As part of its expansion plan to grow in India, earlier this year Tabreed executed a concession agreement with AP government to provide cooling for the upcoming Government Complex being developed in Amaravati.

B Tabreed's residential Portfolio

- Residential- 12% of the total portfolio (~130+kRT)
- 50+ residential towers served
- World's largest DC plant in Qatar (130 kRT) currently serving 30+ residential towers (60+kRT) amongst others

Learnings

- Whilst for most of GCC region cooling is a necessity, for many places cooling residential developments is still considered luxury
- Major issues faced by DC Providers in providing services to residential development are:

Issues faced with implementing DC among residential		Potential Solutions
Overestimation of cooling demand	Common pain point across cooling industry	- Flexible modular DC structure to initially plan lower capacity with provision to quickly ramp up if required
Perception of DC being very expensive	Monthly payment increases in lieu of paying upfront capital costs	- Customer education on Life Cycle cost analysis
Requirement for end users to pay fixed fee irrespective of consumption	Commercial model adopted by DC providers	- Higher diversity from mixed use development could reduce the burden of capital costs to residential end users - Alternatively, capital costs for DC to be recouped upfront- ensuring only O&M cost recovery from end users

ANNEXURE: System Efficiencies

System Efficiency (kWh/RT)

Window and Split/ Multi-Split Systems — 1.6-2.0

- Window ACs ("packaged systems"): condenser and evaporator in a single box
- Split systems: condenser located outside the building; piping carries refrigerant to the air handling unit on the inside of the building

- Refrigerant in the condenser rejects heat directly to outside air using fans to cool the heat exchange coils
- Refrigerant is the only coolant material in the system

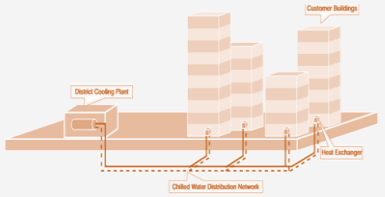
Air Cooled Chillers/ VRV — 1.1-1.5

Standalone Water Cooled Chillers — 0.9-1.1

- Condenser and refrigerant reject heat to water
- Water pumped to a cooling tower and circulated using fins to expel heat to the atmosphere

- Centralized production of chilled water using water cooled chillers
- Chilled water distributed to buildings in large development area (district) via underground insulated pipeline

District Cooling System — 0.8-1.0



Key Considerations for determining Cooling Solutions

	Air Cooling / VRV	District Cooling
Load Diversity	▪ Decentralized solution requires 10% - 15% redundancy in installed capacity	▪ Considering the mixed-use development, DC will benefit from diversity in the load pattern
Development Phasing Plan	▪ Long development ramp up plan would favor Air cooled /VRV systems	▪ Ramp-up over considerably mid-short term would favor DC systems
Occupancy Ramp-up	▪ Lower upfront capex; smaller impact on end-user tariffs in case of slower occupancy ramp-up	▪ Suggested development ramp-up over considerably mid-short term; ensuring optimal tariff for end users
Cooling Density	▪ Better option at lower cooling density	▪ Higher cooling density favorable for DC system
Power Infrastructure	▪ High power infra capex	▪ Supports developer in optimizing power availability; and lower power infra capex
Efficiency and Emissions	▪ Lower electrical efficiency ▪ Higher emissions	▪ Higher electrical efficiency ▪ Lower emissions promote “Green Building” status
O&M Costs	▪ Higher O&M costs due to decentralization	▪ Lower O&M costs due to centralization
Building Design Flexibility	▪ Rooftops to be occupied by chillers	▪ Greater flexibility in building designs (penthouses, solar panels, etc.)
Availability of Land Plot	▪ Does not require dedicated plot	▪ Considered only if a dedicated plot available for DC plant
Aesthetics	▪ Rooftop chillers lead to significant noise pollution and heat island effect	▪ Higher aesthetic appeal – better acoustic management and off-site presence of the plant

Case Study for a project in India

Case Study

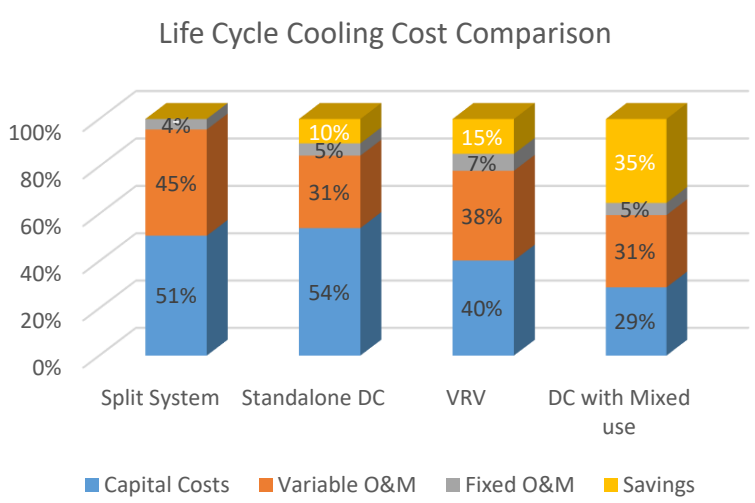
A Details of development

- For a commercial development already planned to connect to DC, the master developer wanted to evaluate cooling options for the residential development being planned in nearby vicinity
- Residential development details:
  - ~2 mn SFT sellable area over 8 towers
  - Cooling load estimate for standalone split AC of ~8,500 RT
  - Due to internal diversity, cooling load required to be provided by DC- 5,000 RT
  - By planning DC, master developer could reduce overall power infra requirement for the residential development by 9.6MW (Efficiency of 1.6 for Split Vs 0.8 for DC system)

B Two layered evaluation for cooling cost burden on end user

- Initial evaluation was based on life cycle cost for cooling to evaluate the most economical form of cooling.
- Secondary evaluation was based on monthly burden on cooling costs for end users
- Technologies evaluated were:
  - Split Acs
  - Rooftop VRVs
  - Standalone centralized DC Plant
  - Connection to existing DC Plant 2 Kms away

Life cycle cost analysis



- Split AC is the most expensive for end user mainly due to its inefficiency compared to VRV and DC system
- Standalone DC System is more efficient (lowest O&M Cost) however has higher Capital cost compared to VRV System
- Lifecycle cost of Standalone **DC system is 10% lower** and of **VRV is 15% lower** than Split AC systems
- However the most efficient form of cooling a residential development is through a Mixed use DC system
  - Diversity of ~65% can be achieved:- DC infra for 10kRT commercial development plus 5kRT Residential development requires only 10kRT DCP
  - Due to lower upfront cost, mixed use DC system could be as much as **35% more cost efficient** compared to Splits

Summary

Choosing optimal solution

Evaluation based on case by case basis:

A. Standalone one off small residential development- **Split System**

B. Standalone large residential development – **Building level VRV Systems**

C. Mega residential development with multiple residential towers – **Building level VRV Systems or Central DC Systems**

D. Mega mixed use development with 30% to 40% residential development – **Central DC Systems**

Proposed commercial structures

Cases where centralized DCP or even building level VRV systems make more economical sense, the proposed commercial approach for residential development should be as below:

- **For Capital cost recovery:**
  - Total Capital cost for Cooling system application (DC or VRV) should be recovered upfront from unit owners
  - Cost per SFT charged by developer to unit owners increases by 4% to 7% due to allocation of Cooling costs
  - However compared to unit owner investing in Split System, the capital cost of centralized system is lower by 15% to 25%

- **Monthly Operating Costs:**
  - Considering Central DC and Building level VRV systems are more efficient, the burden on unit owner/end user would be much less for monthly cooling bill.
  - **With VRV systems-** monthly bill for unit owners / end users expected to reduce by **8% to 12%**
  - **With Centralized DC systems-** monthly bill for unit owners / end users expected to reduce by **25%** to **30%**

Summary