District Cooling Case Studies by Tabreed in India

09 May 2023

Singapore

Strictly Private and Confidential

Tabreed: the world's largest public listed cooling utility

87 plants
District Cooling Plants

1.35 million RT of delivered cooling capacity

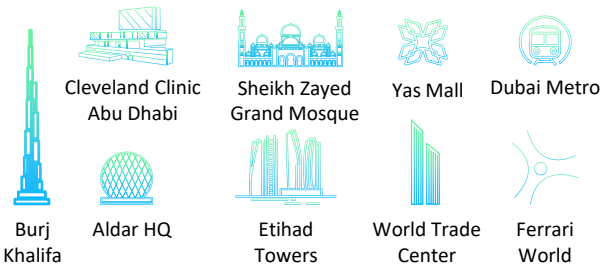
450 MN+
Sft of area served

1.1 GW
Power infrastructure avoided

2.3 billion kWh
energy consumption saved in 2022 compared to alternatives

1.3 mn tons
Elimination of CO_2 emissions

Cooling services provider to several iconic buildings



Investment Grade (Fitch-BBB, Moody's-Baa3). DFM Listed with two majority shareholders.

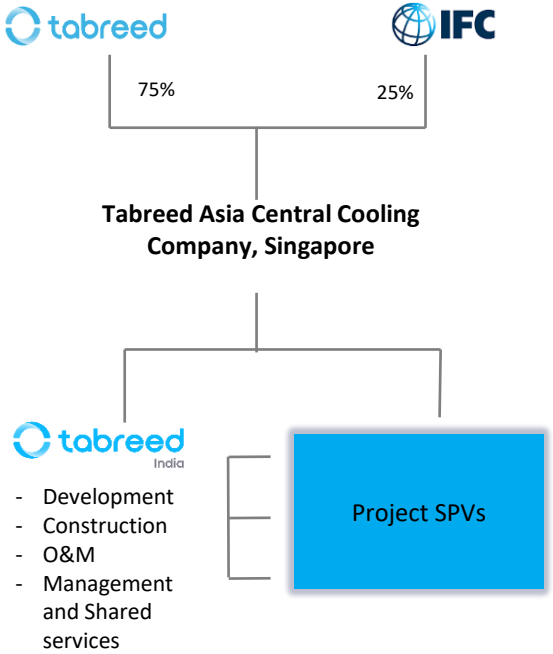
MUBADALA

Investment fund 100% owned by the Government of Abu Dhabi with c. $250bn in assets under management.

ENGIE

Amongst largest global independent power producers (c. 100 GW) and leader in low-carbon energy & services.

Presence in Asia and India



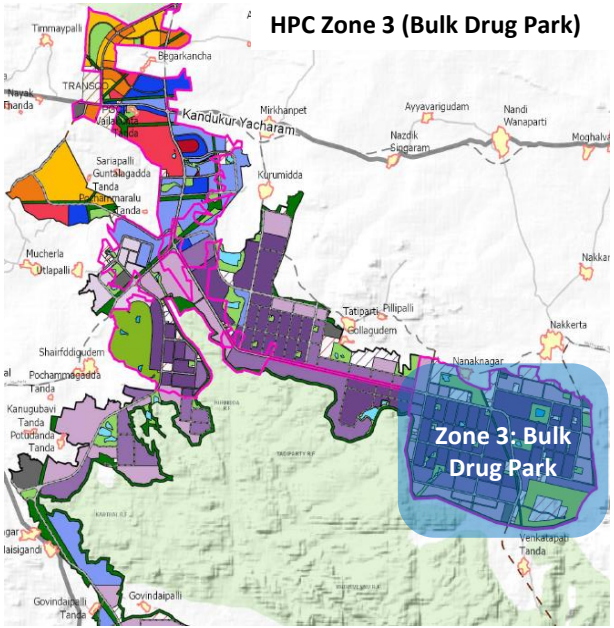
Case Study 1

Hyderabad Pharma City (HPC) Project: Key Highlights

1. Hyderabad - Largest pharma manufacturing eco-system in the world, outside of China
2. Project of National Importance
3. Symbiotic co-existence across pharmaceutical value chain (bulk-drug, API/Intermediaries, Formulation, support infrastructure)

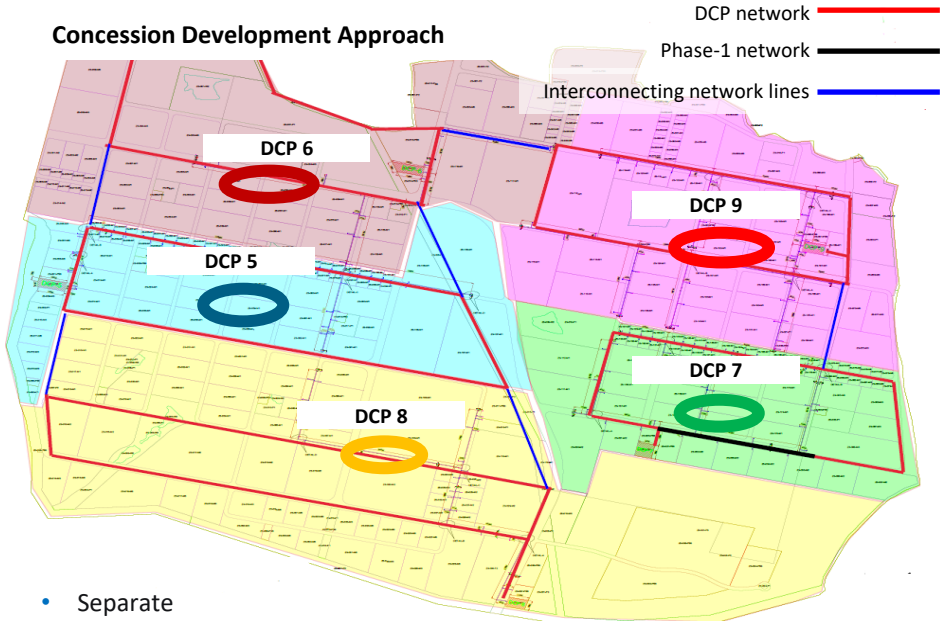
4. Infrastructure to attract 0.5 mn employment in Indian Pharma sector and US$ 9.7 BN in investments
5. Commitment to Sustainability (Zero Discharge, Renewable Energy, DCS, DHS amongst others)
6. Ecosystem to facilitate Pharma research in India
7. Integrated Ecosystem facilitating cost efficiencies and ease of doing business through plug and play infrastructure

HPC Bulk Drug Park (Zone 3): Concession Development Approach



Zone 3 (Bulk Drug Park) will consist of Core industries **(56% of total area)** incl. bulk drugs, Active Pharmaceutical Ingredients (API), formulation, with allied and support industries in the fringes.

Concession Development Approach



- Separate concession for utilities.
- **Pre-agreed tariffs** committed to units as part of land allotment strategy.
- Installed cooling capacity of **125,000 RT met through 5 nos. inter-connected DCPs of 25,000 RT each**, with **initial phase for min 2,500 RT;** pharma units to manage secondary side process cooling requirements independently.

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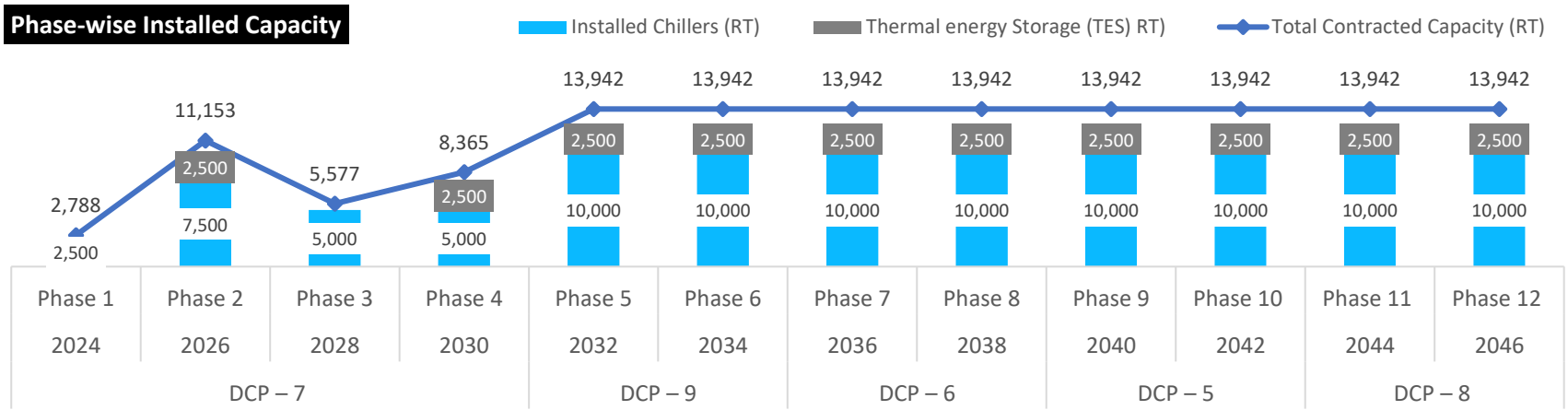
DCS: Capacity Planning and Design Considerations

Phase-wise Installed Capacity



- Each DC Plant to be built in a **phased, modular manner** to help **reduce pre-investment** except as required for plant main headers, civil works and foundation, networks, etc.
- Thermal Energy Storage (TES) proposed from Phase-2 to allow **flexibility in O&M, optimize power consumption costs** due to ToD electricity tariffs, and enable **demand-side management** through **load shifting**
- **Refrigerant Leak Detection System (RLDS) & Refrigeration Recovery Unit (RRU)** proposed to manage refrigerant leak, re-use and recovery
- **Plant design efficiency** in the range of **0.80-0.85** ikW/RT; Chilled water supply/return temperature at DCP: 5 ± 1ºC / 14℃ ± 1 ℃
- **Each DC Plant sized at 25,000 RT: 20,000 RT Mechanical + 5,000 RT TES tank,** considering **2,500 RT chillers** except Phase 1
- Plant room fire fighting & alarm systems, CCTV, access control and UPS; No DG back-up power due to reliability of power supply for the pharma city

Contractual considerations

Tender mechanics

- Competitive bidding process with single stage technical and financial bid submission but two-stage evaluation

Tariff structure

- Connection charge per RT (one time); not considered for competitive evaluation
- Capacity tariff in INR/RT/month; to be escalated @5% p.a.
- Consumption tariff in INR/RTh based on actual metered consumption; to be adjusted for change in utility tariffs

Concession structure

- Concession term 33 years; can be up to 40 years depending on timing of future phases
- TSIIC to be the concession grantor; pharma companies to be the end customers

Offtake guarantee

- Offtake guarantee by concession grantor limited to the first phase of 2,500 RT
- Exposure to risk of delay in future expansion as well as to that of end-user creditworthiness

Phase-wise expansion with some pre-investment

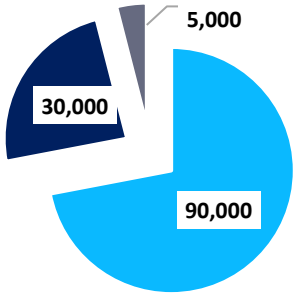
- Future expansion to be initiated basis minimum 90% utilization of current capacity
- Some pre-investment in Phase 1 of 2,500 RT, i.e. civil Works and foundation for 50% of 25,000 RT, that is, 12,500 RT, and plant main headers to be sized for full 25,000 RT

Other key contractual aspects

- Payment security mechanisms
- Termination payments

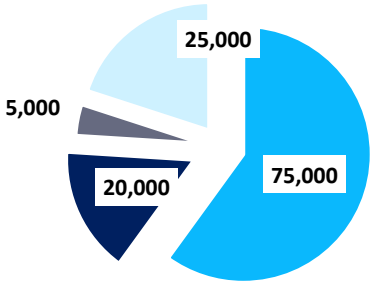
Conventional vs. DCS: Energy, Water and Carbon Emission Savings

Cooling load split for conventional system

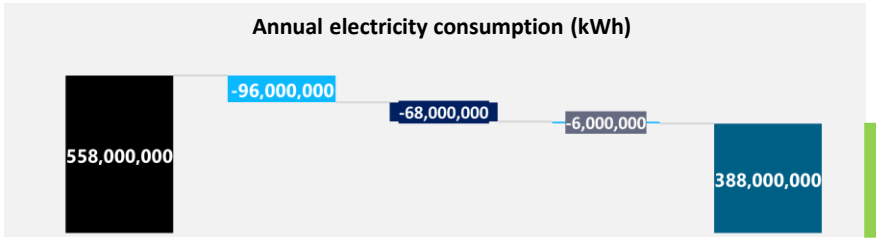


- Space Cooling met thru Chillers
- Process Cooling @ 6 deg C temperature
- Refrigeration System @ (-)15 deg C temperature
- Space Cooling met thru Thermal Energy Storage

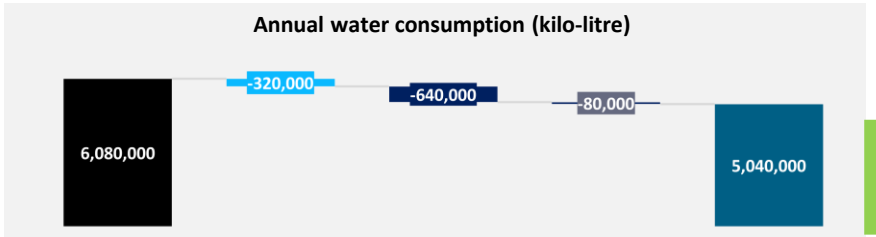
Cooling load split for district cooling system



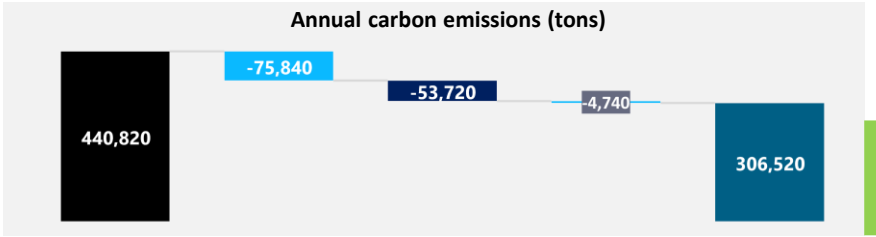
Conventional system	Space cooling (Chillers + TES)	Process cooling at 6 deg C temp	Refrigeration system at -15 deg C temp	District Cooling System



Annual Savings in Electricity Consumption of 170 GWh (~30%)



Annual Savings in Water Consumption of 1040 Mega-Litre (~17%)



Annual Savings in Carbon Emissions of 134 Million Tons (~30%)

1) # Based on EFLH of 4000
*2) *Conventional plant efficiency of 1.10 kW/RT for space and process cooling and 1.50 kW/RT for refrigeration system based on water cooled screw chillers*
3) ^Tabreed DCS efficiency of 0.8 kW/RT for space and process cooling based on water cooled centrifugal chillers
4) 1.20 kW/RT for refrigeration system- Chilled water from DCS being used as condenser water for brine refrigeration chiller
5) Water efficiency of 12 litres per RT for space and process cooling and 16 litres/RT for refrigeration system for conventional system
6) Water efficiency of 10 litres per RT for space and process cooling and 12 litres/RT for refrigeration system for DCS

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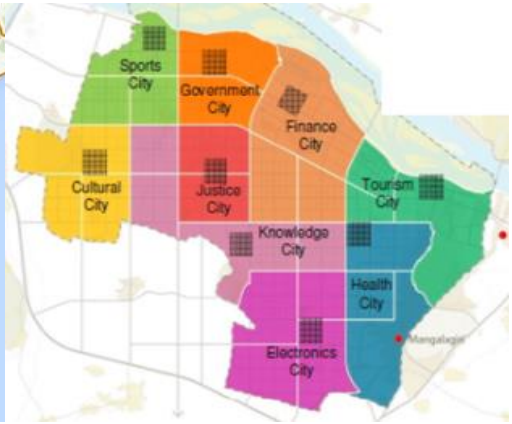
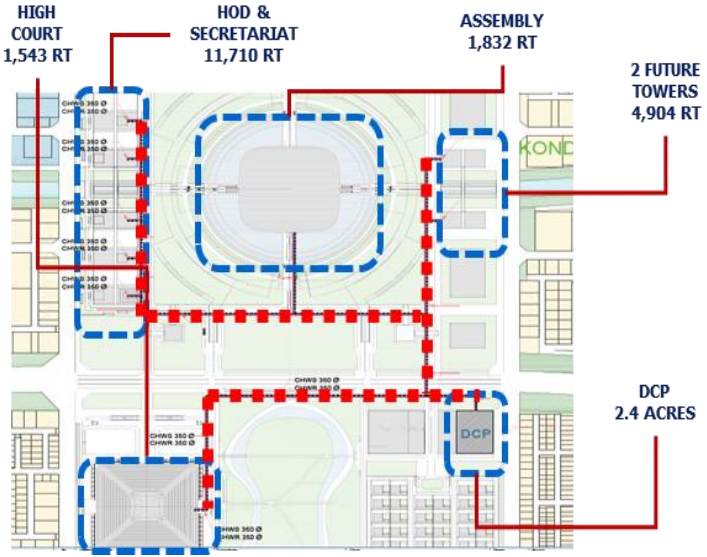
Case Study 2

Amaravati Government Complex: Project Overview

- Andhra Pradesh Capital Region Development Authority (APCRDA) established to develop **new capital city spread over an area of 217 sq.km**
- Divided into 9 theme cities – Government, Knowledge, Health, Electronics, Tourism, Start-up, Media, Sports, Finance





- Amaravati Government Complex (AGC) detailed master plan design completed by Foster + Partners with CH2M and **estimated cooling load of 20,000 RT**
- AGC envisaged to spread across an **area of 6 sq.km comprising of 6 blocks** (1 sq.km each) and comprises:
  - **Block E & F - Government Administration Buildings (scope for proposed DC Project)**
- Future opportunity **for additional 120 kRT if DC adopted for commercial developments** (~3.3 sq.km) in AGC

DCS: Power infra savings

1 Significant savings in Power Infra

	Installed Capacity (Diversity Benefits)		TES Capacity		Peak Electricity Efficiency		Power Infra Requirement
DC System	80%[1]*20 kRT[3]	−	2.5 kRT	×	0.9 kW/RT	=	12 MW
Stand-alone WC system	115%[2]*20 kRT	−	NA	×	1.1 kW/RT	=	25 MW
Stand-alone AC system	115%[2]*20 kRT	−	NA	×	1.5 kW/RT	=	35 MW

Savings in Power load

13 MW (52%)

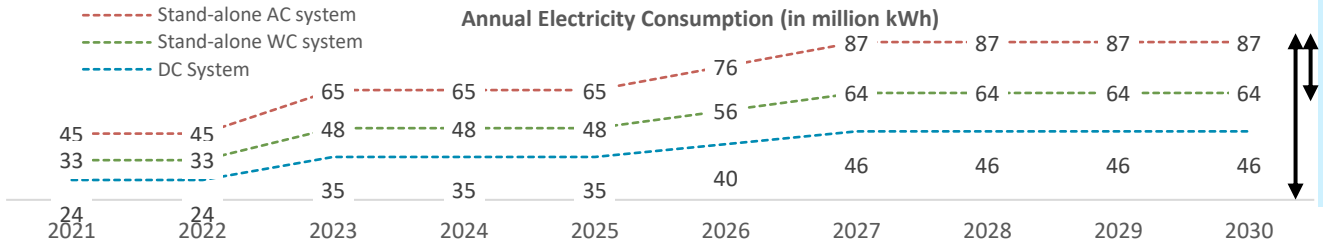
23 GW (65%)

3. Provision to install full 20 kRT capacity if required; further, Demand Charge payable on lower of installed capacity and actual demand

2 Considerable lower energy requirements in DC

DC System average Electricity Efficiency at 0.8 kWh/RTh[1]
as compared to **1.1 or 1.5 kWh/RTh** for stand-alone WC or AC system

20-40 million kWh
annual energy savings for a typical 20,000 RT cooling load



Savings in annual energy consumption

12-23 million kWh (25%)

20-40 million kWh (45%)

1. Lower annual average for electricity efficiency in DC

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DCS: Energy and water savings

3 Lower lifecycle cost vis-à-vis stand-alone systems

20% lower lifecycle cost
vis-à-vis stand-alone AC system

6% lower lifecycle cost
vis-à-vis stand-alone WC system

Lifecycle Cost Comparison

4 DCS to have flexibility for using TSE instead of Potable Water

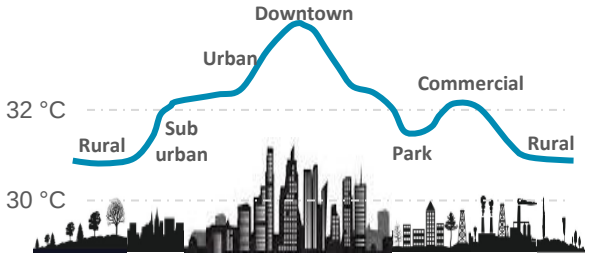
TSE based capacity in place of potable water

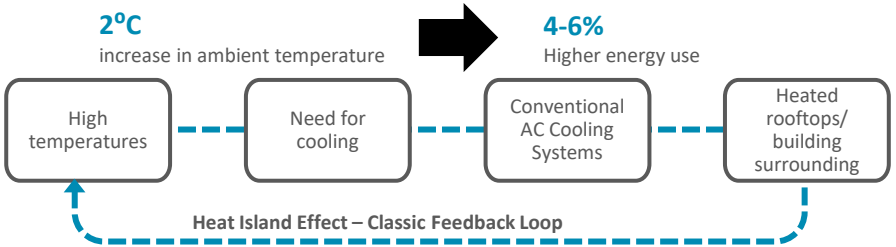
350 million liters
annual potable water savings for a typical 20,000 RT of cooling load

5 Carbon Footprint and Heat Island Effect – lower energy consumption in DC resulting in lower GHG emissions; heat control at centralized plant

20-40 million kWh
annual reduction in energy

10,000-20,000 tons
annual elimination of CO2 emissions





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Case Study 3

Tabreed-MAHAPREIT District Energy (DE) Scheme in Mumbai

Objective:

Identify the market potential for district energy projects in Mumbai, to then develop, invest and operate under suitable PPP concessions. Initial focus on brownfield developments at Bandra-Kurla Complex and Thane-Belapur Road

Project Goals

1. Electricity from grid: 50%-70% target reduction vs baseline
2. Water: 30% TSE use reduction vs baseline. 100% potable water replacement for make-up water
3. Circularity: Integrate gas, sewage and solid waste use into project aspects
4. Emissions: Near-Zero for built environment. Zero refrigerant leaks/consumption
5. Urban Heat Island: Baseline and track
6. FDI & Capital Investments: TBD
7. Employment Generation & Inclusion: TBD

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Integration of technologies for responsible and efficient urban resource use

Municipal Solid Waste (MSW) to Energy & Cooling:

MSW through Waste to Energy (W2E) for Energy and cooling potential

Treated Sewage Effluent (TSE) through Sewage Treatment Plants (STPs):

- Central vs inter-connection of de-centralized STPs for make-up water.
- Other heat rejection technologies/solutions

City Gas Distribution (CGD) Integration:

- Energy Source Diversity & Feasibility using CGD
- Aggregate DG Back-up elimination

Integration of technologies to provide **broad access, minimize costs and reduce environmental impact**

Distributed Renewable Energy (DRE):

- Incremental renewable energy capacity planning basis roof-top areas freed-up
- Energy storage and thermal storage planning

District Cooling (DCS):

- To reduce peak energy demand, associated GHGs, refrigerant use and provide cost-effective reliable central cooling for operational and upcoming buildings
- Central Cooling Plant(s) Vs Inter-connection of de-centralized cooling plants

Exploration Phase to establish development case for the DE Scheme

Objective: To establish **technical, regulatory and business model feasibility to implement district energy schemes** in each identified area to provide a hypothetical development case to pursue the scheme into the next stage for pre-feasibility.

Methodology:

- Sophisticated **technologies** incl. **urban energy modelling tools, hyperspectral satellite imagery or ground penetrating radar studies** that have already been applied in the emerging market context.
- **Available data from govt. authorities at city and state level** to supplement and verify data received through technologies
- **Tabreed** and its shareholder **ENGIE's capabilities in planning, designing and developing district energy systems**

Geometry data:

Sources	Data
Photogram LiDaR	3D city model
Satelite Imagery	Building footprint Elevation

Building Information data:

Sources	Data
Town planning scheme	Water supply and sewage infrastructure
	Transportation
	Electricity grid
Local weather stations	Climate Data
3D city model	Context and surroundings

Energy use data:

Sources	Data
Utility bills	Annual/monthly electricity, gas, and water consumption
MSEDCL, etc.	Reports by DISCOM

Urban Energy Modelling

Archetype & Occupancy data:

Sources	Data
MMRDA and other authorities/ Field Survey/ IPCs	Occupancy pattern
	EPD &LPD Mode of operation
	Set point temperatures
	Mechanical systems
	Building construction details

Urban Infrastructure:

Sources	Data
Town planning scheme	Water supply and sewage infrastructure
	Transportation
	Electricity grid
Local weather stations	Climate Data
3D city model	Context and surroundings

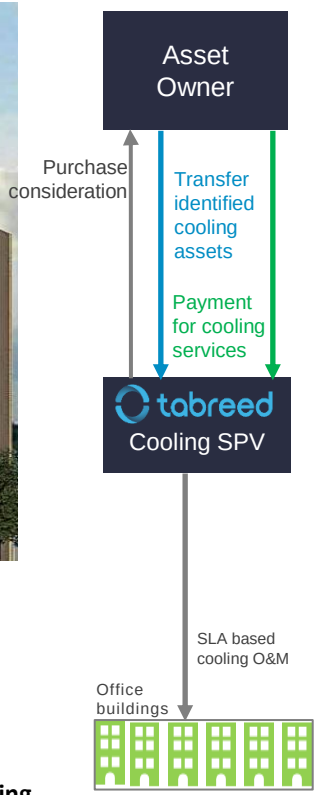
**Developed by leading institutions incl. CEPT Research & Development Foundation, MIT's Sustainable Design Lab, Bentley Systems, University College London's Energy Institute amongst others.*

Annexure

Private real estate development in Delhi NCR: acquisition + greenfield

Anchor Transaction: Acquisition and development of cooling infrastructure

IT SEZ | 3.5 mn sft | Platinum | 6,600 RT cooling



A Strategic Partnership

- District cooling and cooling as a service concessions for commercial developments
- Operational cooling assets acquired to implement value accretive opex models.
- Open-book collaborative partnership to design, finance and build green-field assets

B Asset Acquisition & Expansion

- High side and Low Side cooling assets acquired by a 100% owned SPV
- SPV set-up (as a co-developer in SEZ) to own and operate assets.
- Pre-agreed mechanism for cooling asset expansion for new buildings in campus

C Cooling Services

- 30 year concession to provide primary & secondary side cooling services
- Capital Recovery from developer. O&M Costs recovered through CAM charges
- Utilities (Electricity, Water & Discharge). End to End Efficiency commitment
- Pre-agreed sinking fund for replacement capex recovered through CAM charges

D Long Term O&M

- Grand-fathering regime (1-3 years) for continuity in Operations & Maintenance
- O&M transition to in-house. Reliability Centered Processes with clear KPIs/SLAs

Private greenfield development in Hyderabad (contract negotiation stage)

Developer's Initial Approach

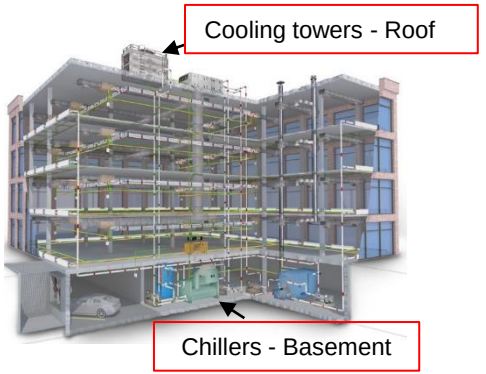
> 10 Acre masterplan

3 Grade A towers

~5.2 Mn SFT usable area

14,250 RT total peak cooling demand

> 15,000 RT planned installed capacity



Developers approach to cooling infra
(standalone plant rooms for each building)

Tabreed's District Cooling Proposal

33% reduction in installed mechanical capacity

30% reduction in plant room footprint.
One plant room to serve all buildings.

> 5.5 MW Reduction in power demand & electrical infra

> 15 GWH Reduction in lifetime power consumption

100% funded Phase wise investment by Tabreed

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India

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