Bureau of Energy Efficiency
Ministry of Power, Govt. of India

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

IKI INTERNATIONAL CLIMATE INITIATIVE

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

tabreed

# Andhra Pradesh's $5 Billion Energy Transition

## INVESTMENT OPPORTUNITY THROUGH DISTRICT COOLING

This report is an initiative undertaken as a part of the Memorandum of Understanding signed between Tabreed India and Gesellschaft für Internationale Zusammenarbeit (GIZ)'s 'Energy Efficiency Cooling' programme, jointly implemented with the Bureau of Energy Efficiency (BEE), Ministry of Power, and funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) as part of the International Climate Initiative (IKI), to accelerate adoption of sustainable cooling practices.

Due to rising temperatures and the corresponding surge in air conditioner usage, projections indicate that by 2050, cooling could be responsible for 60% of peak energy demand in India. Drawing upon GIZ's proficiency in sustainable development strategies, notably its collaboration with BEE on district cooling guidelines, and Tabreed's unrivalled experience in the industry, the partnership aims to promote widespread adoption of energy-efficient district cooling systems to deliver on sustainable and holistic economic and human development in India.

**Contact:**

For digital copies of the report, contact:
india@tabreed.ae
For any queries or comments about this report, contact:
piyush.sharma@giz.de | amodi@tabreed.in

**Month of Publication:**

September, 2024

**Report Project Team:**

Tabreed India: Sudheer Perla, Archa Modi, Anubhuti Chopra, Hita
REVOLVE/Kubernein Initiative: Priyanka Bhide, Akash Sahu, Satyam Gadkari
Main Division (Designer): Govind Raikwar

# Table of Content

# Foreword

## Arijit Sengupta, Director, Bureau of Energy Efficiency, Ministry of Power, Government of India

At the Bureau of Energy Efficiency (BEE), we recognize district cooling as essential in addressing India's urban cooling challenges. Extreme heat in India, including Andhra Pradesh, demands innovative solutions that balance cooling needs with energy efficiency. District cooling offers a strategic approach by reducing energy consumption and mitigating peak power demand. Andhra Pradesh's early adoption of district cooling technology in the design of the new state capital, Amaravati, is a significant step forward, showcasing the technology's potential.

Our mission at BEE is to develop policies and strategies aiming to reduce the energy intensity of the Indian economy within the framework of the Energy Conservation Act, 2001. This mission is pursued through the active participation of all stakeholders, promoting accelerated and sustained adoption of energy efficiency across all sectors. In collaboration with GIZ and Tabreed India, BEE is dedicated to advancing district cooling solutions. Our district cooling guidelines are crafted to evaluate the feasibility of these systems during the early planning stages of urban development. By bringing together key stakeholders, BEE strives to drive the widespread adoption of district cooling technologies, ensuring that cities like Aamravati can meet their cooling needs sustainably, support public health, and align with national energy conservation goals.

## Nitin Jain, Programme Head, Energy Efficiency Programmes, Gesellschaft für Internationale Zusammenarbeit (GIZ) India

At GIZ, we see great potential in the integration of district cooling solutions in Andhra Pradesh, specifically Amaravati, the new capital of Andhra Pradesh. This presents a critical step toward advancing energy efficiency and urban sustainability in India. As cities like Amaravati expand, so does the need for sustainable cooling solutions that align with our climate goals. Traditional cooling methods are energy-intensive and contribute to greenhouse gas emissions, while district cooling offers a more efficient alternative that reduces energy consumption and emissions while promoting resource circularity.

GIZ supports the German Government's international cooperation efforts with a global portfolio covering Energy, Environment, Climate Change, Sustainable Urban Development, and Economic Development. In India, we contribute to key initiatives under the Indo-German Partnership for Green and Sustainable Development. Through the 'Energy Efficiency Cooling' program, we collaborate with BEE and Tabreed India to enhance capacity, facilitate knowledge exchange, and promote policy dialogue. By integrating these solutions into Amaravati's urban planning, we aim to set a model for sustainable cooling that not only benefits India but also contributes to global resilience and sustainability.

## Sudheer Perla, Managing Director, Tabreed Asia

The state of Andhra Pradesh is expected to revamp the industrial landscape through landmark policy decisions. It promises to strengthen growth through green solutions including meeting growing cooling demand sustainably. Tabreed is proud to have collaborated with BEE and GIZ to bring together eminent stakeholders for a round table discussion to chart out the course for District Cooling. The accompanying report highlights opportunities and recommends approaches for wider energy efficient cooling adoption that the state can consider. While this can considerably shift the trajectory of the evolution of the state as a pioneer guiding aspirants towards a future-ready state, the pivotal juncture that Andhra Pradesh finds itself also presents an investment opportunity of close to $5 billion for District Cooling. Alongside our commitment to Amaravati, Tabreed is dedicated to continue supporting the people of the state in creating state-of-the-art, climate-smart, energy-efficient cooling systems that fulfils present and future needs.

# Executive Summary

Picture Credit : www.fosterandpartners.com

Cooling is a critical consideration for the state of Andhra Pradesh, which already faces the highest number of heat wave days in South India witnessing temperature as high as 47.7 degrees[1] in 2024. The India Cooling Action Plan estimates that as air-conditioning penetration in the country increases from the current 8% to reach 40% by 2038, cooling demand for buildings, cold-chain, refrigeration, transport and industries will increase installed cooling capacities by 8 times that of 2018[2]. Within the next 5 years alone, the state anticipates **peak power demand to rise by 57%[3] reaching 19.9 GW by 2029,** driven largely by increasing demand for cooling. A business-as-usual response focusing only on renewable energy adoption or standards and labelling with piece meal technology improvements around cooling equipment will be insufficient to meet the state's climate goals. Already recognizing this, Andhra Pradesh's draft Energy Efficiency and Energy conservation Policy 2023-2028[4] highlights the necessity to "promote the use of new and latest technologies for energy conservation"; something which is also being echoed in discussions around the upcoming Industrial policy for the state.

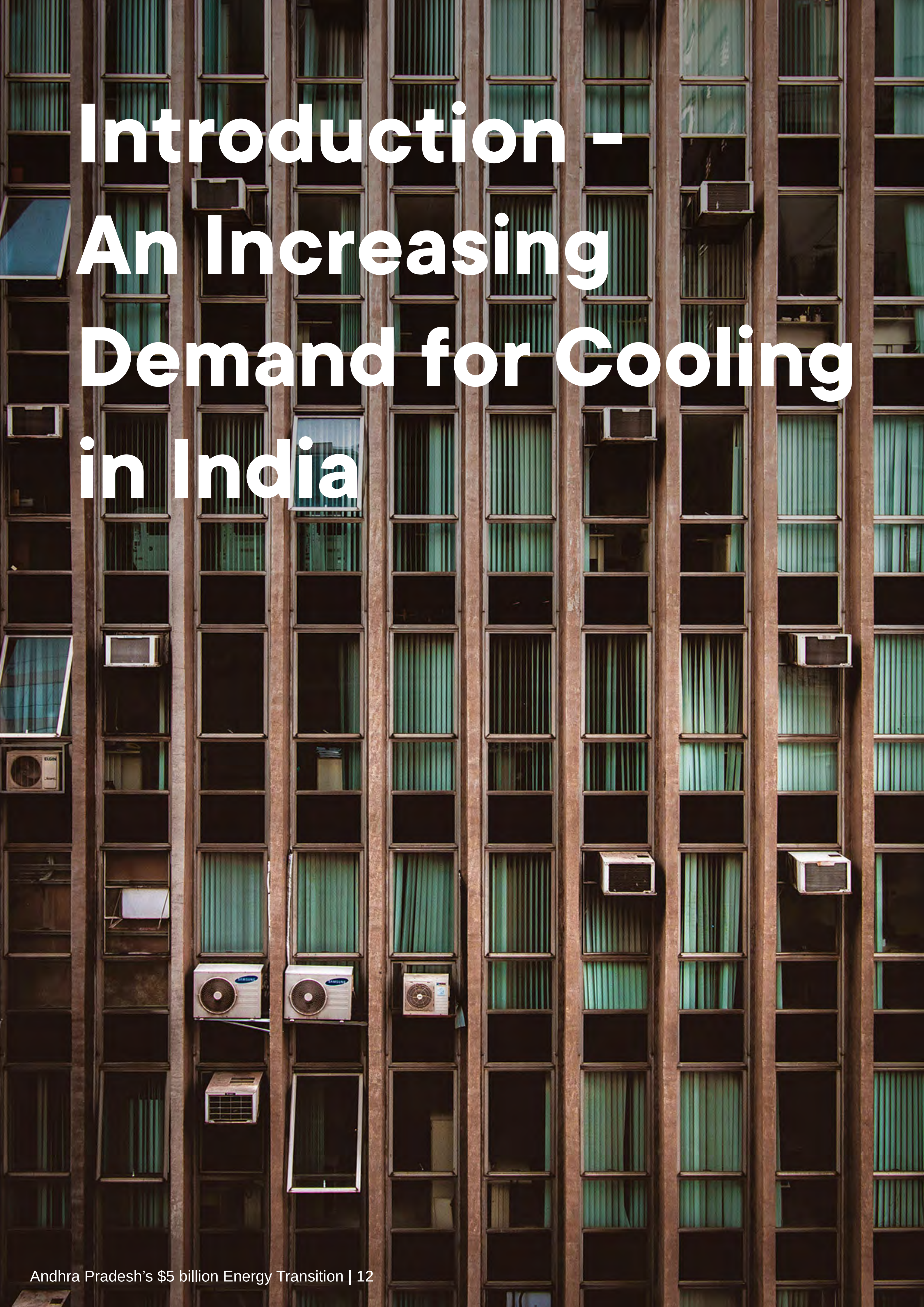
**Solutions such as District Cooling that centralise production and distribution of cooling energy provide the opportunity to take a transformative systems approach.** The technology itself promotes energy efficiency and conservation. It further enables substitution of fossil fuels with renewable energy, and integrates with other technologies such as Sewage Treatment plants, and Waste to Energy plants, to create circular systems that reduce resource wastage and our environmental footprint. Treating cooling as a central utility through District Cooling also democratizes access to cooling services, ensuring affordability and resilience across diverse urban landscapes.

Under the visionary leadership of its Hon. Chief Minister, the state, through Andhra Pradesh Capital Region Development Authority (APCRDA), signed India's first Public-Private Partnership concession with Tabreed in 2019 to develop a 20,000 refrigeration tonnes (RT)[5] District Cooling System for the government complex area within the planned capital city of Amaravati[6] where Tabreed committed to designing the system to deliver 50% electricity demand reduction for cooling prestigious buildings like the High Court, Secretariat amongst others. Basis Amaravati's masterplan, if District Cooling is further incorporated into urban infrastructure planning aspects for all high building density locations, this in turn could **attract USD 4 billion in DCS investments** whilst reducing installed mechanical cooling loads by **700,000 RT** to result in **1.8 GW reduction in power demand** and a corresponding reduction of 2.6 million tonnes in carbon emissions.

Beyond Amaravati, for other mega-projects in the state including the upcoming Bhogapuram Airport, Industries & Manufacturing Clusters like at Jawaharlal Nehru Pharma City, Sri City and the planned Information Technology Zones & Data Centres, the likely cooling demand of 650,000 RT could be met through 475,000 RT of District Cooling **translating into USD 880 million investment potential and over a 500 MW reduction in power demand.** The case studies presented in this report indicate the opportunity that exists for Andhra Pradesh from the adoption of District Cooling in terms of both sustainability and growth.

*Amaravati has the potential to leap-frog other cities both in developed and developing countries to truly establish a template for urban energy, circularity in resource use and more climate inclusive development through adoption of District Cooling & Energy Systems.* ***As a sunrise sector for a sunrise state*** *if scaled across all major commercial developments & industrial clusters of Andhra Pradesh; the investment as well as the returns that will be reaped in the form of green growth will be multi-fold.*

# Introduction - An Increasing Demand for Cooling in India

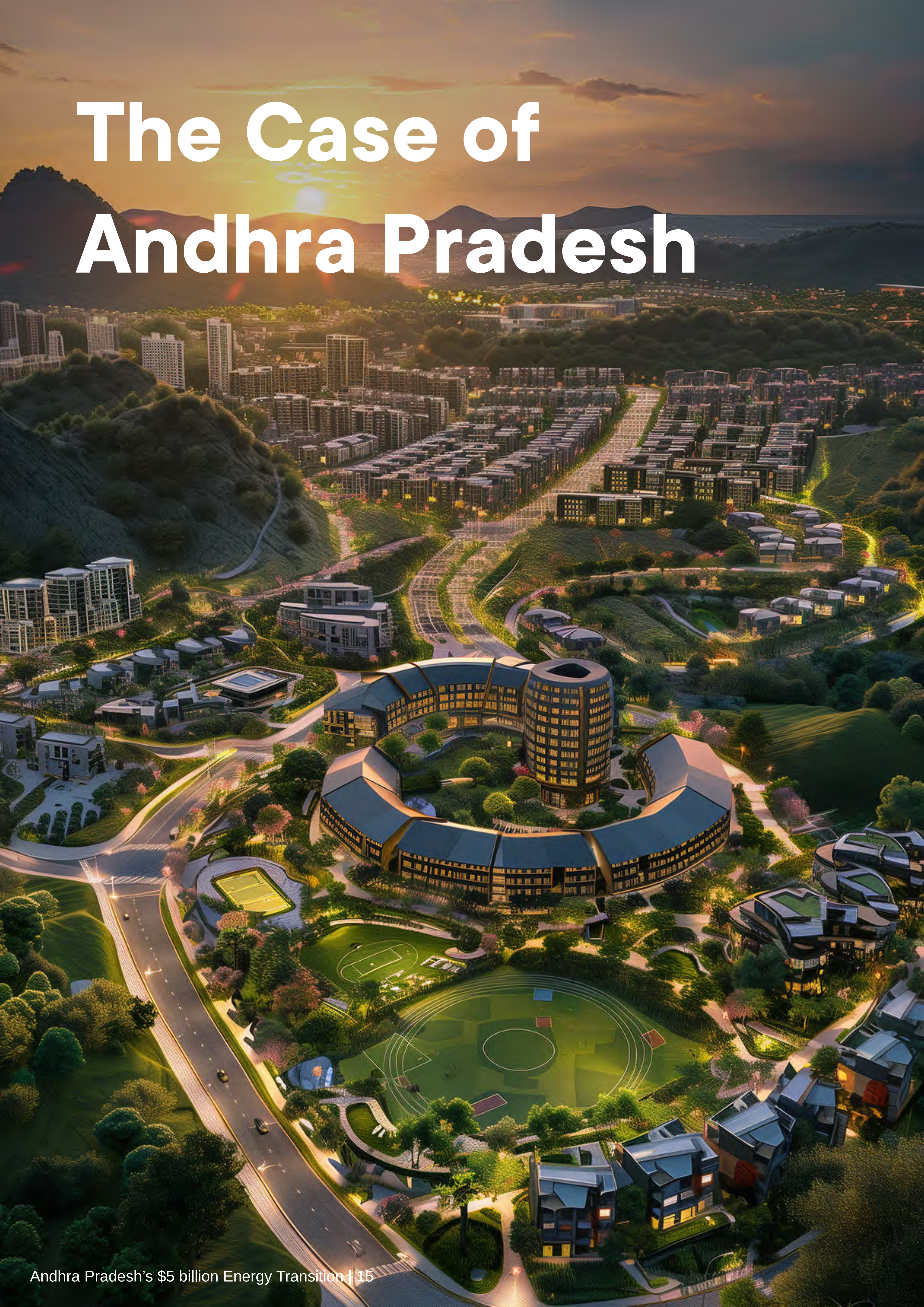


Climate change induced heat stress impacts both economic and social outcomes: in South Asia for example, it is estimated that heat stress can lead to around 12% loss of economic productivity[7] , which in turn can lead to loss of 6% GDP annually. Large sections of India's population live and work in conditions where providing thermal comfort is not even a consideration. In 2024, over an excruciating hot early summer, India recorded[8] 56 deaths and over 25,000 cases of heat stroke (through April and May). According to World Bank estimates, nearly 75% of India's workforce[9], or 380 million people, depend on heat-exposed labour for their livelihood. In animal husbandry[10] an increase in animal illness and mortality per rearing cycle is reported due to increased heat exposure, along with a decline in the quality and quantity of eggs and milk produced. Workers in other allied sectors such as agriculture, metal-working and construction, are frequently[11] exposed to extreme heat that result in lower productivity due to the need for more frequent breaks, and at times a halt in work altogether for certain periods of time.

**In India the impact of increasing heat is felt strongly in urban areas due to dense concretization, increased vehicular congestion, and reduced tree cover causing Urban Heat Island (UHI) effects.** This is resulting in a direct measurable increase in cooling demand[12] from residential and commercial buildings, cold-chain, refrigeration, transport and industries. The space cooling sector alone is expected to grow 8 times in India[13] by 2038 (compared to 2018 levels) and air-conditioning penetration, which is currently at 8%, is expected to reach 40% by 2038. A business-as-usual response for more energy efficient solutions through standards and labelling, minimal incremental technology improvements and uneven market adoption will not be sufficient. **The increase in energy consumption from cooling is expected to account for 45%[14] of the country's peak energy demand by 2050.** As a result, greenhouse gas emissions from increase in air conditioning and refrigeration are projected to rise 90%[15] [16] above 2017 levels by 2050 perpetuating feedback loops for increased heat stress.


Innovative technologies like District Cooling have the potential to increase water and energy circularity whilst providing a sustainable way of meeting cooling demand. The 2019 **India Cooling Action Plan[17] (ICAP)** includes District Cooling in the mix of solutions proposed for adoption through medium term interventions to be adopted in the country. When combined with innovative green building design through natural and passive interventions and integrating more diversified supply-side solutions like city gas distribution, geo-thermal and waste to energy systems the potential to more rapidly reduce energy demand growth and associated emissions becomes significant. The delivery of District Cooling through innovative business models such as 'Cooling as a Service' (CaaS) can further attract significant private sector investments and make it affordable and accessible to all. The 2023 **District Cooling Guidelines launched by the Bureau of Energy Efficiency** provide a guide on how the adoption of the technology can be made seamless in the Indian context. Cooling may soon become a vital part of India's critical infrastructure, just as our power grid or banking are considered a lifeline of our economy. Innovative technologies which help build environment-friendly and resilient cooling infrastructure will be critical for maintaining economic growth, socio-political harmony, and productivity of human resources. The government has begun laying the framework; however, the adoption of new solutions and technologies will require a transformation of the market[18]. This transformation can be achieved by bringing together diverse stakeholders from government ministries and bodies along with the broader private sector ecosystem. This report seeks to introduce the concept of District Cooling, identify challenges, and present the opportunity for the uptake of District Cooling technology within the context of the state of Andhra Pradesh, with a focus on the greenfield capital of Amaravati.

# The Case of Andhra Pradesh



Andhra Pradesh is India's seventh largest state after bifurcation[19] and creation of the state of Telangana through the Andhra Pradesh Reorganisation Act of 2014. The **state experienced the highest number of heat wave days[20] in South India** (22 days) in 2023. Heat waves[21] have contributed to more deaths than any other natural disaster in Andhra Pradesh and the government launched the Andhra Pradesh Heat Wave Action Plan[22] in 2016 to combat rising heat in the state.

**Growing cooling needs alongside industrial and commercial growth has led to an increase in power consumption,** which stood at 72,400,000 MWh in 2022, and is expected to increase by about 53%[23] to reach 111,378,000 MWh by 2029. The peak demand in the same period is expected to increase by 57%, from 12,653 MW to 19,913 MW. Even as the state power distribution companies recorded lowest technical and commercial power losses in the country, the demand for power in the coming years will require multi-fold measures to reduce the deficits. Estimates indicate[24] a continuous annual energy deficit in the years leading up to 2029. Increased energy consumption invariably leads to increased pollution, and the power sector of Andhra Pradesh accounted for 156.13 Million Tonnes (MT) of $CO_2$ out of the total state emissions of 168.8 MT $CO_2$[25] in 2018.

As with states across India, renewable energy and transition to a gas-based economy is being considered to meet the growing energy demand. The installed capacity of renewable energy in Andhra Pradesh as of June 2024 is 11,067 MW - the 7th highest in the country. The state aims to increase this to 15,786 MW by March 2029[26]. The Government of Andhra Pradesh is taking a proactive approach with its Climate Change and Human Health Plan[27], and a Climate Change Cell. **The Bureau of Energy Efficiency (BEE) has set a target of 6.68 Million Tonnes of oil equivalent of energy savings by 2030[28] for Andhra Pradesh,** aligning with the Government of India's roadmap to reduce total projected carbon emissions by 1 Billion Tonnes by 2030, and


Picture Credit : www.fosterandpartners.com

achieve net zero emissions by 2070, while reducing carbon intensity to less than 45% by 2030. Andhra Pradesh's draft Energy Efficiency and Energy Conservation Policy 2023-2028[29] highlights the necessity to "promote the use of new and latest technologies for energy conservation". Innovative technologies like District Cooling have the potential to rapidly contribute to filling this energy gap.

The establishment of Amaravati[30] as the new capital of Andhra Pradesh began right after the state bifurcation, and since 2016, there have been several developments to formalize the process. **The development of Amaravati creates tremendous opportunity to build city-wide eco-friendly cooling systems. The state government is already taking the lead, and in 2019,** the Andhra Pradesh Capital Region Development Authority (APCRDA) **awarded Tabreed** the contract to **build, own, operate and transfer India's first District Cooling System at Amaravati** developed through a public-private partnership model. The 30-year concession agreement for a contracted cooling capacity of 20,000 refrigeration tonnnes (RT) is a great demonstration of the forward-thinking approach adopted by the state government to meet the upsurge in cooling demand expected in Andhra Pradesh in the coming years.

**The Andhra Pradesh government is also set to introduce a new industrial policy[31] for the period 2024-2029, aiming for a growth rate of 15%[32].** Increased economic development will mean increased construction and infrastructure growth, which in turn will add to the cooling and energy demand of the state. The new policy is expected to absorb the PPP (Public Private Partnership) and P-4 (Public Private People Partnership) models that can support the adoption of sustainable cooling technologies like District Cooling for greenfield projects to systematically reduce power consumption and associated emissions to enable green growth.

# What is District Cooling (DC) and Cooling as a Service (CaaS) Model?

The 2023 District Cooling Guidelines launched by the Indian Bureau of Energy Efficiency, defines **District Cooling as a single cooling network, distributing chilled water to a cluster of buildings to meet their cooling demand as a self-sustaining service.** This centralized system meets the cooling needs of a large, densely occupied space, campus, or network of buildings, occupied by a single user (in airports, malls, hotels) or multiple users (in IT & manufacturing parks, integrated townships and other commercial hubs), through aggregating demand and leveraging diversity factors of varying cooling loads in multiple buildings in a cluster.

A central plant produces chilled water which is circulated through a network of pre-insulated pipes to multiple buildings in a cluster that are connected to the network. A thermal heat transfer using heat exchangers in each building delivers cooling, and the resulting warmer water is re-circulated back to the plant to be chilled again completing a closed loop. Depending on the alternatives or baseline being compared against, **District Cooling can be upto 50% more energy efficient[33], and can reduce peak power demand by upto 40%.** The power source when substituted with renewable energy sources, natural gas through city gas distribution networks, or if combined with a waste to energy plant, the cooling plant can further minimize and in certain unique cases even eliminate dependence on traditional electricity sources. When combined with thermal energy storage solutions, further peak load shaving can also typically be achieved.

District Cooling can help **unlock a number of environmental and social benefits** in addition to the reduction of power demand from aggregation benefits and integration of complementary technologies to accelerate circularity in energy, water and waste use (which will be explored further in subsequent sections). For example, District Cooling, in comparison to conventional systems, can utilize new-generation green refrigerants that support the phasing out of refrigerants with higher global warming potential, thus further reducing greenhouse gas emissions from harmful refrigerant use. Moreover, District Cooling can eliminate leakage of refrigerants through preventive measures, early detection, and containing any leakages leading to minimal impact on the environment.

District Cooling mitigates formation of urban heat islands through heat rejection into sewage treated water or natural water sources such as rivers, seas or lakes. By preventing heat rejection into the surrounding atmosphere, District Cooling dissipates micro-climate feedback loops, which otherwise would further increase the demand for conventional air-conditioning. These systems also eliminate the need for clunky equipment to be placed in basements and rooftop of buildings, thus freeing up space that can instead be used more productively such as the installation of solar panels for on-site power generation or for aesthetic purposes including terrace gardens and recreation. Similarly, the placement of equipment away from buildings reduces vibration and noise leading to a more pleasant outdoor environment, improved air quality, and in turn lower energy consumption for air conditioning.

When it comes to wider adoption in India, initial capital cost is often a concern. Here the **Cooling as a Service (CaaS) business model provides a solution where customers can benefit from pay as you go tariff structures. CaaS is similar to providing utilities like water, gas or electricity, where the end consumer pays a monthly bill for cooling, depending on use,** in a similar fashion to paying electricity bills or gas bills based on meter readings. Under this model, the entire cooling infrastructure is owned, built, financed by the service provider, who also takes care of operations and maintenance. Since a centralised approach to cooling leads to demand aggregation and a drastic decrease in the quantum of cooling equipment required, the CaaS model is found to save **up to 25% of cooling costs for customers on a lifecycle basis.** The potential challenges[34] in a CaaS model around infrastructure planning challenges, tariff controls for end-users, reliability in quality of service, technology upgrades and minimum demand guarantees to make investments bankable can all be mitigated through regulatory models adopted already in many parts of the world or through concession arrangements that follow a certain framework that balances expectations of all stakeholders.

Over the past decade, the District Cooling model has successfully been adopted in several projects in Asian countries. In Singapore[35] for example, there are already robust city-wide regulations in place to essentially govern how the city meets its cooling demand more sustainably. Changi Airport, ST Ang Mo Kio Technopark[36], estimated to be operational by 2025, and Marina Bay (central business district) all use District Cooling Technologies. At Marina Bay, Singapore Power, and the Singapore government came together to invest in the central plant and the District Cooling network on a modular basis. District Cooling systems have been taken up on a large scale in some Indian projects as well. The Government of Gujarat is implementing District Cooling to meet the cooling needs whether for thermal comfort or data-centres at Gujarat International Finance Tec-City (GIFT city) through GIFT's District Cooling system which is expected to reduce mechanical load requirements for cooling from 270,000 RT to 180,000 RT thereby aiming to reduce power demand for cooling from 240 MW to 135 MW. In 2023, following a competitive tender process, the Telangana government awarded Tabreed, Asia's largest PPP concession to develop a **125,000 RT District Cooling System for Hyderabad Pharma City,** which was planned to be the world's largest bulk-drug industrial park where Tabreed committed to invest **$200 million** to meet process-cooling demand for various manufacturing facilities that were planned in the industrial cluster. One of the first Cooling as a Service models, under a 30-year contract, was also made operational in 2023 at **Gurugram's Intellion Park through a strategic alliance between Tata Realty and Infrastructure Limited** and Tabreed India.

# The Science of District Cooling

The District Cooling system provides efficient and sustainable cooling to multiple buildings through a centralized cooling plant that generates chilled water by using a series of key components such as chillers, pumps, and cooling towers etc. The District Cooling plant ensures consistent cooling across connected buildings, optimizing energy use and reducing the need for individual cooling equipment.

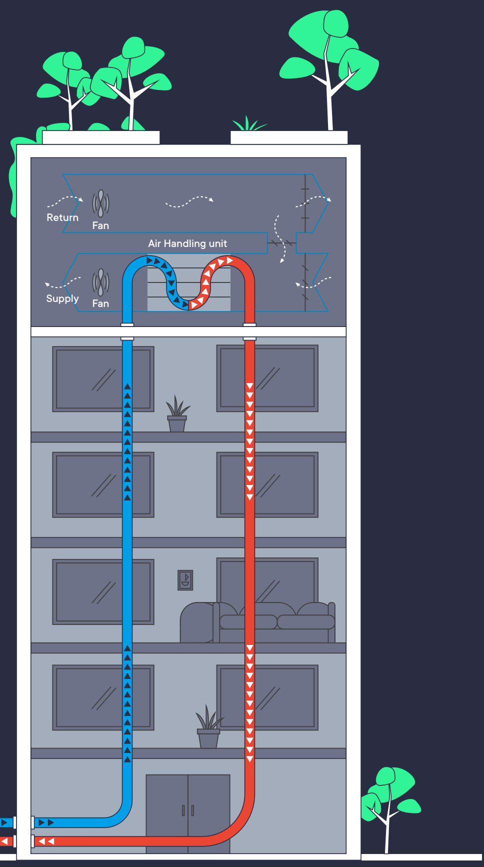
**Chilling the Water in the Chiller:** The process begins at the chiller. The chiller uses a refrigerant to cool water in the evaporator. The refrigerant absorbs heat from the water, reducing its temperature. The refrigerant then goes to the condenser, where it releases heat and gets ready for the next cycle.

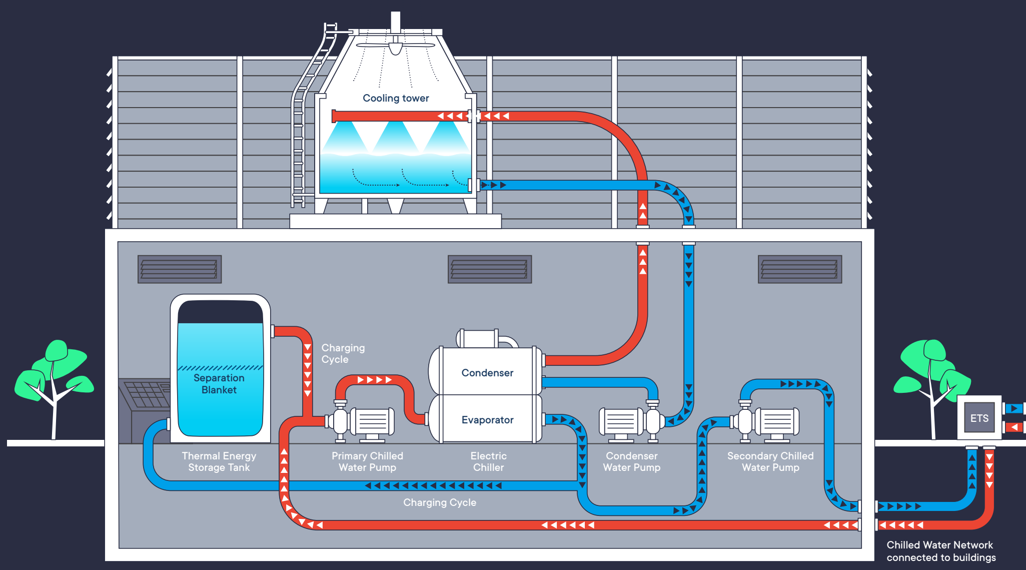
**Pumping Chilled Water to Buildings:** Once the water is chilled, it is pumped through a series of insulated pipes (network) using Secondary Chilled Water Pumps. These pipes transport the cold water to various buildings while minimizing temperature loss.

**Energy Transfer to Building Systems:** The cold water arrives at each building's Energy Transfer Station (ETS) which comprises of plate type heat exchangers, pumps etc. The ETS connects the District Cooling network to the building's internal chilled water circuit (while isolating both the circuits) feeding HVAC systems (such as air handlers or fan coil units), which uses this chilled water to cool the air inside the building.

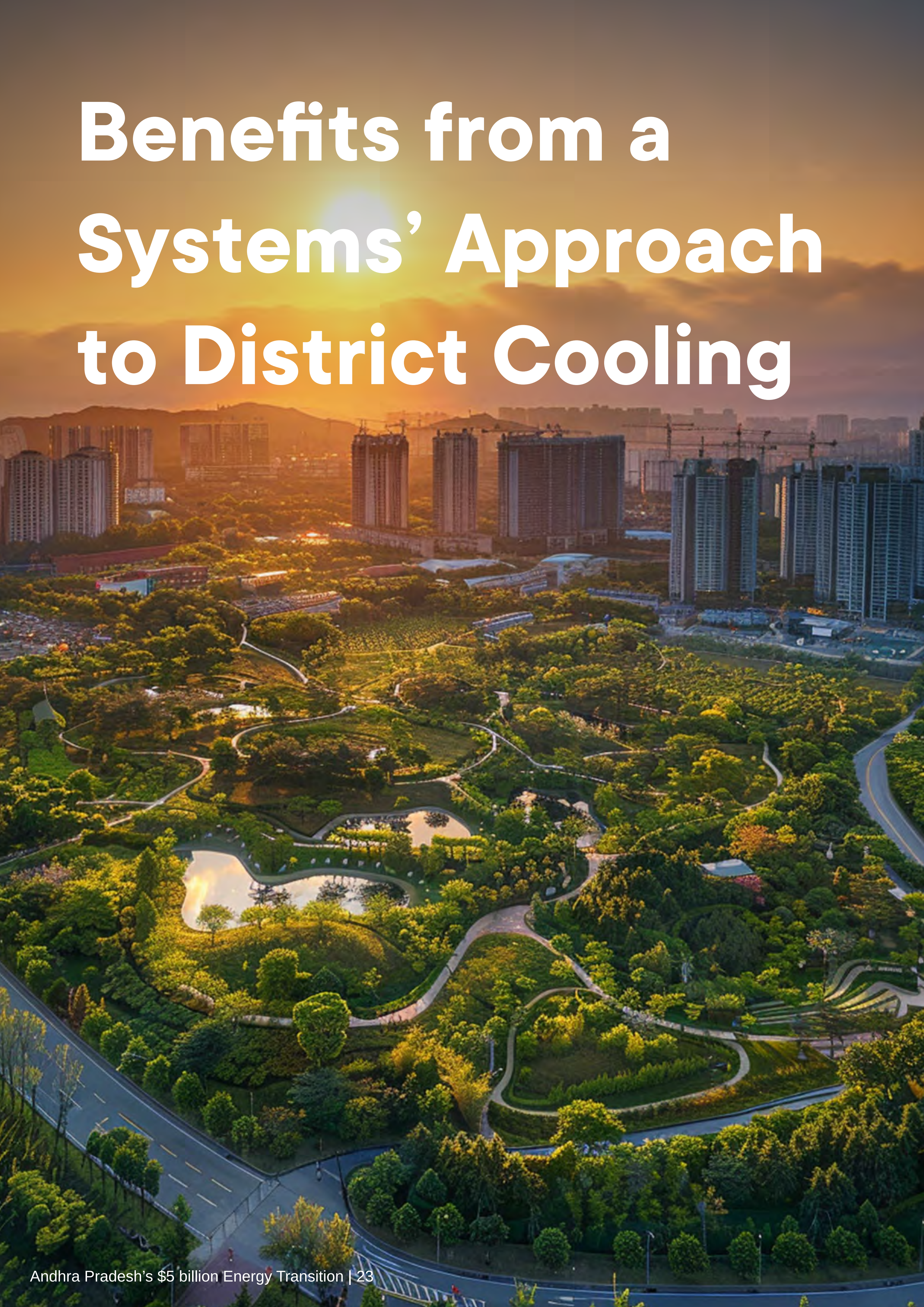
**Return of Warmed Water to Central Plant:** As the District Cooling network chilled water absorbs heat from the buildings via ETS, it warms up. This warm water is then returned to the District Cooling plant for re-chilling through a separate set of return pipes.

**Heat Rejection in the Cooling Tower:** In the District Cooling plant, the warm water is sent to the chiller for next cooling cycle while this heat is dispersed into the environment via cooling towers. This completes the cycle, allowing it to continue.

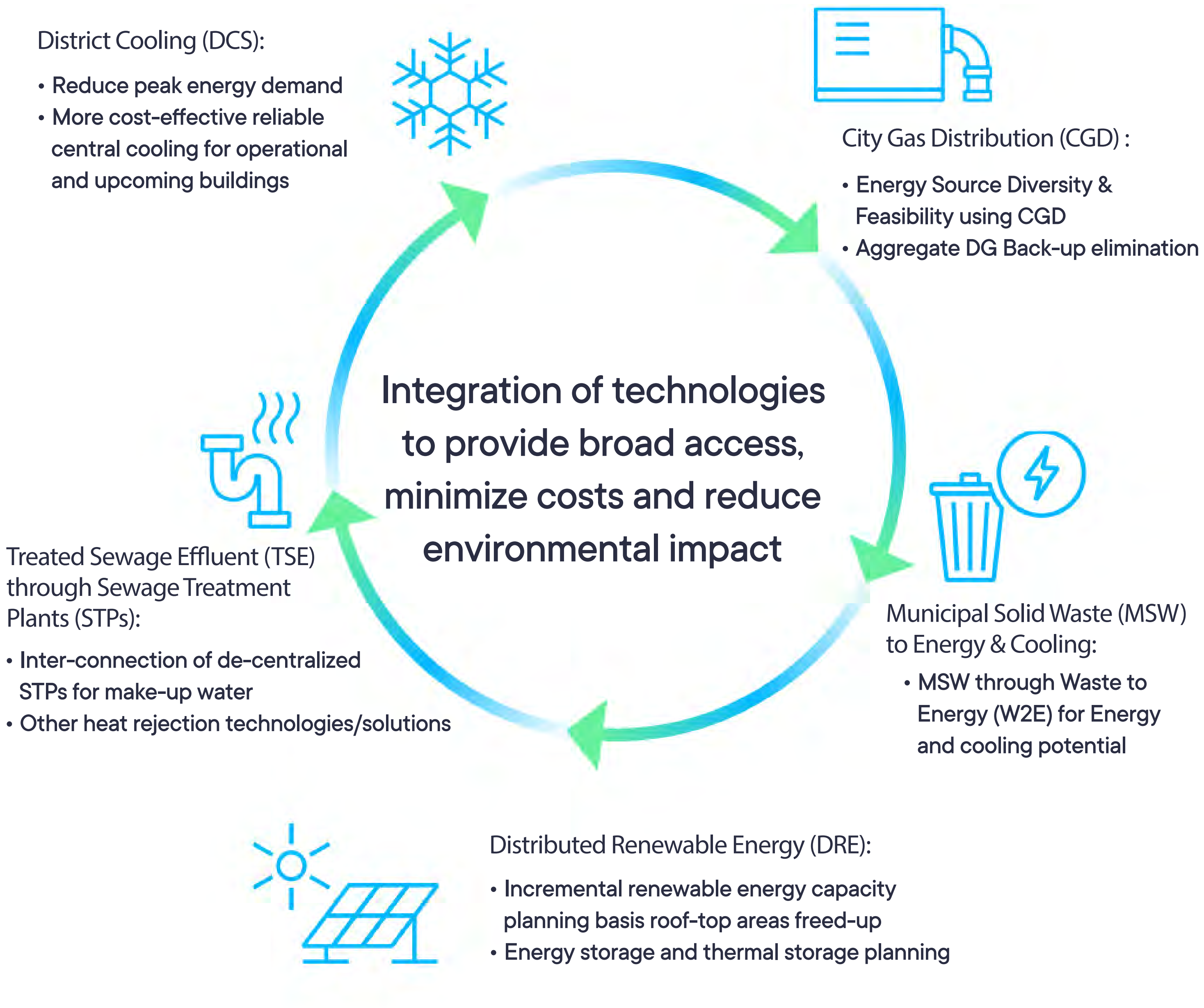


# Benefits from a Systems' Approach to District Cooling



A circular economy[37] or systems approach aims to minimize waste and promote sustainable use of natural resources through smarter product design, longer use, and recycling. Earth has finite resources, and immediate measures need to be taken to limit our consumption and resource use to stay within planetary boundaries. Currently, **only 7.2% materials used in the world are cycled back into the economy,** highlighting the vast scope for the systems approach to address multiple crises at the intersection of climate change and human welfare. When planned well, **District Cooling's biggest advantage is in the way it lends itself for integration with a range of technologies and systems** such as City Gas Distribution Systems, Waste to Energy Plants (W2E), Traditional Power Plants, Liquified Natural Gas (LNG) Regassification Terminals and Sewage Treatment Plants (STP) that one, improve resource efficiency and two, promote the use of ancillary technologies.



## Water Efficiency

Like much of peninsular India, the state of Andhra Pradesh has been vulnerable to increasing heat stress that impacts water demand. In 2024, a large percentage of Urban Local Bodies (ULBs) in the state faced severe shortages[38] in drinking water. In April of 2024, as per data from the Central Water Commission, **live storage available in key reservoirs was at 17% of total capacity.** The city of Amaravati, which is being developed as the new capital for Andhra Pradesh, is projected to have a water demand of 886 Million Litres Per Day (MLD) by 2050[39].

District Cooling can help reduce the dependency on potable water sources using treated sewage effluent (TSE) from STPs. Integration with **District Cooling can increase the commercial viability of STPs that remain underutilized despite the growing demand for water in India.** Although India's STP capacity has seen substantial increase in the last few years, there is a significant gap in the use of treated wastewater, which leads to underuse. Currently, only 28% of waste[40] **water from urban centers (20,236 MLD) is treated for re-use,** whereas the rest is discharged into water bodies. The use of treated water for District Cooling has been successful in other states, as can be seen in various commercial developments with captive cooling plants including RMZ's One Paramount in Chennai and Tata Realty's Intellion Park in Gurugram among many others.

The 'National Framework on Safe Reuse of Treated Water' was launched in 2023, however, Andhra Pradesh has had a 'Policy on Wastewater Reuse & Recycle for Urban Local Bodies[41]' since 2017. As of 2017, the state **produced approximately** 1068 MLD of wastewater[42]. In 2018, Visakhapatnam Sewerage and Recycled Water Project was commissioned with an expected capacity of 187 MLD (treated wastewater and recycled water). Additionally, under the Kurnool Sewerage Project, several STPs are planned to be set up in various locations at Kurnool to divert and treat the sewage water drained in the Tungabhadra River. **District Cooling can exponentially enhance the viability of existing and upcoming STPs.** The only consideration to be kept in mind is the quality of treatment to ensure it doesn't affect the longevity of cooling equipment.

District Cooling systems can also meet its water requirements from natural sources such as lakes, rivers, or oceans without affecting aquatic life, and when the source is cold enough, the use of electricity for chilling the water can be eliminated.

## Renewable Power & Thermal Energy Storage

Adoption of renewable energy like rooftop or utility scale solar can also be enhanced through the integration and adoption of District Cooling systems. Andhra Pradesh has a target of achieving installed renewable energy capacity of 15,786 MW by 2029. The New & Renewable Energy Development Corporation of Andhra Pradesh Ltd. aims to boost rooftop solar through its Solar Power Policy[43]. **District Cooling can free up building rooftop space,** traditionally occupied by cooling towers in captive cooling plants or outdoor units in conventional air conditioning systems, which can then be used to install rooftop solar.

The use of Thermal Energy Storage (TES) solutions, that are far more technically viable and cost-effective alternatives to Battery Energy Storage Systems (BESS), could minimise the need for large-scale energy storage projects to address concerns around variability in renewable power generation and demand. The **Government of Andhra Pradesh** has been actively exploring thermal energy storage, and **as early as 2018 had unveiled the world's first ever thermal battery plant[44]**. This is even more pertinent since peak loads are observed primarily due to a burgeoning **demand for cooling,** which **constitutes 60-70% of all energy demand in commercial buildings.**

Currently, no state in India has a comprehensive strategy for storing green energy and ensuring round-the-clock energy supply. While progress has been made in BESS, it still falls short in terms of commercial viability. In comparison, TES is a **time-tested technology that is an integral part[45] of District Cooling systems to allow buildings to reduce demand from the power grid and also serve as back-up in crunch-times.** TES tanks when integrated with District Cooling can reduce mechanical load requirement and thus the associated power demand for cooling, **freeing up the grid's capacity for other uses.** Secondly, TES supports **demand side management to smoothen the power demand curve** by shaving the peaks through use of chilled water stored in TES tanks during these peak hours to **prevent peak demand stress exerted on the power distribution grids.** An innovative TES material is being tested by Plaksha University in Mohali, Punjab, in partnership with Tabreed in India, to meet night-time cooling demand of residential or hostel buildings in the campus. To minimize the grid reliance, the tanks are proposed to be charged with solar energy during the day and discharged at night to address the issue of renewable energy's supply variability.

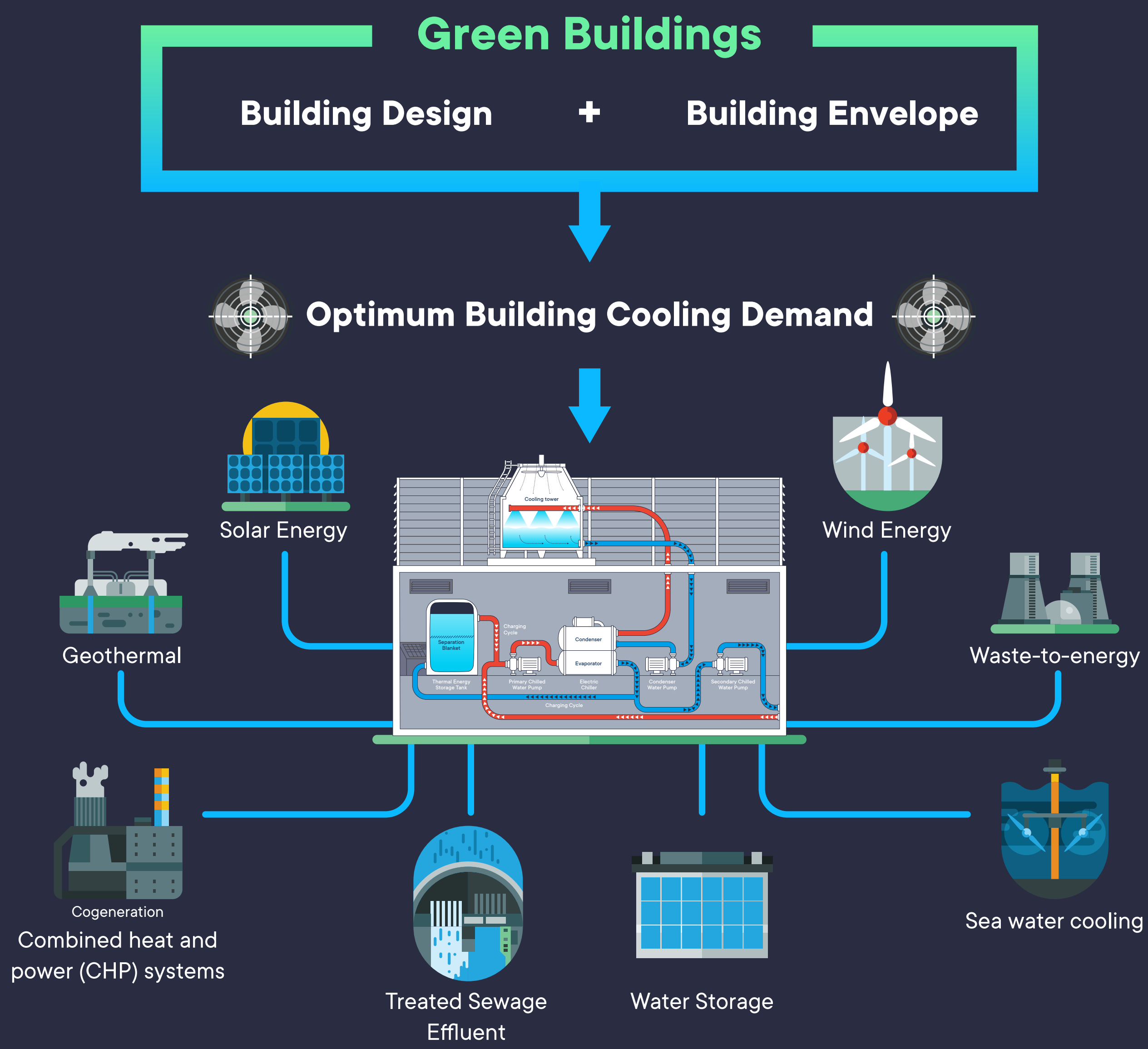
## Alternate Energy Sources

The integration of Waste-to-Energy (W2E) plants with District Cooling systems also increases their viability by allowing **utilization of waste heat** as well as providing **a source of anchor demand through District Cooling plants.** Upto 60% input energy generated through conventional power plants is wasted through the generation, transmission and distribution cycle; this waste heat not available for end-use is over 70% for Waste-to Energy (W2E) plants, if their only purpose is incineration to generate electricity. Where waste heat is recovered and utilized through absorption chillers to power the District Cooling system, there will be an increase in viability of W2E plants. Further, the District Cooling plant could provide cooling for the W2E or power plant, creating a circular loop. A number of W2E plants[46] are operational in Andhra Pradesh including the 15 MW plants in Guntur[47] and Visakhapatnam[48]. Establishment of W2E plants can be further scaled to solve for the problem of increasing municipal waste generation, which stood at 6,850 tons per day[49] in 2020 in Andhra Pradesh and is projected to grow to 3,820 tons per day by 2050 in Amaravati.

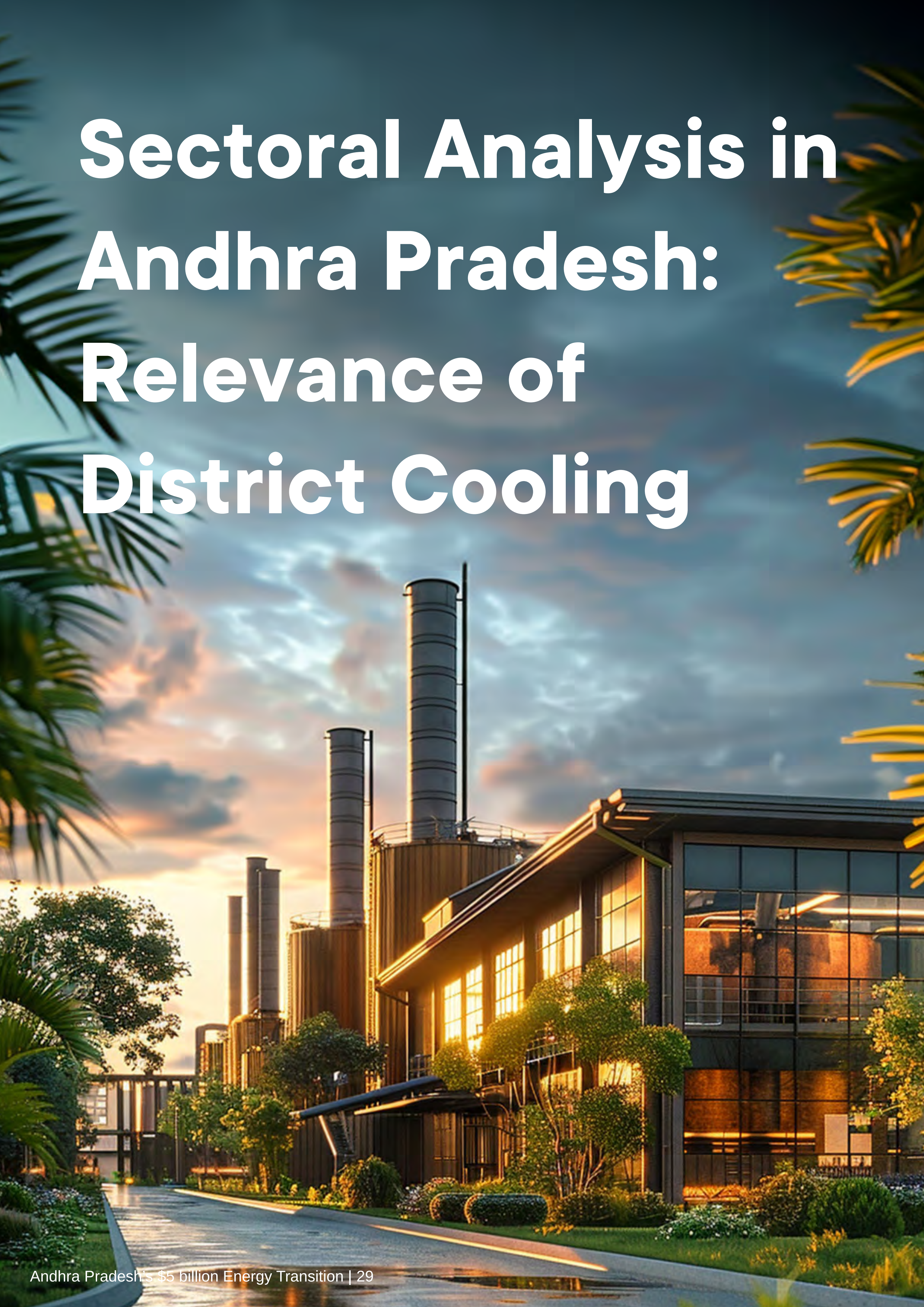
Similarly, City Gas Distribution (CGD) operators often struggle with viability due to lack of demand; District Cooling plants can use gas as an alternate source of fuel to provide anchor demand to make CGD operations more viable. Furthermore, by l**everaging gas as an alternate fuel, District Cooling plants can eliminate the need for grid power, partially, and diesel gensets for power back-up,** completely.

## District Energy accelerating the circular economy in Amaravati for sustainable development

Amaravati checks all the boxes to be the world's most advanced smart and eco-friendly city, given its potential to **"develop in a sustainable, environment friendly, highly functional and resilient model"**. The government is keen to invest in renewable energy and judicious use of water resources[50] to allow for a sustainable business environment and prevent congestion as is the case in most other large Indian cities. About 35% of Amaravati's electricity is expected to come from renewable sources, while water bodies and vegetation will expectedly cover 30% of its area. According to development plans, more than 50%[51] of the treated wastewater in Amaravati will be used for District Cooling. Wastewater Treatment Plants (STPs) are expected to cover the entire city of 217 sq km and produce 681 MLD of treated water[52] in 2050, with 12 STPs covering 13 sewerage zones in the city. Similarly, power demand in the city by 2050 will be 2,706 MW[53], met by public and private providers. The target is to ensure 24/7 power supply to the residents of the city and improved infrastructure such as smart metering, and smart street lighting.



# Sectoral Analysis in Andhra Pradesh: Relevance of District Cooling



We highlight below the key sectors where there is a large market opportunity for adoption of District Cooling. To exemplify the benefits of the technology within the sectors, **a study of some of the most prominent brownfield and greenfield establishments in Andhra Pradesh has been undertaken.** These examples bring out the stark contrast to the business-as-usual approach, highlighting the environmental and financial costs that may otherwise come to the state. In comparison with other states, Andhra Pradesh still has tremendous industrial and commercial space cooling developmental potential and the steps that the state takes in the next few years from a regulatory standpoint can change the trajectory of development followed by the state.

# 1. Space Cooling: Commercial & Residential Building Infrastructure

The building sector, comprising of commercial, retail, hospitality, educational institutions, hospitals, retail in India, is responsible for 33%[54] of total electricity consumption, of which 57%[55] goes towards cooling requirements alone. As of 2023, residential **buildings in Andhra Pradesh have a share of 27.5% of state's total energy consumption, while commercial buildings including industries, have a share of 35%.**

The largest share of cooling demand in India comes from space cooling in buildings and is projected to grow from 66.5 MN RT in 2017 to 268 MN RT by 2030. While room air-conditioners (window/split ACs) and non-refrigerant based cooling systems such as fans and air-coolers form the largest pools of cooling technologies used in residential buildings, space cooling in commercial and retail buildings is more reliant on chiller systems, packaged direct expansion (DX) systems, and variable refrigerant flow (VRF) systems. The estimated growth in installed chiller base in India is projected to rise from 5 MN RT in 2017 to 14 MN RT in 2030. Accordingly, the commercial sector has the highest potential of adopting District Cooling to maximize energy savings.

Andhra Pradesh has set a target to be the most energy efficient state[56] of India by 2028 through the Andhra Pradesh Energy Conservation Policy 2023-2028, where one of its objectives is "Ensuring Sustainability through the profitable and efficient use of resources to provide sustainable energy supply". The **state government aims to reduce energy consumption of the buildings to ensure sustainability, and maximise use of renewable energy for buildings.**

India's Bureau of Energy Efficiency (BEE) brought out the Energy Conservation Building Code[57] (ECBC) in 2007 to improve energy efficiency of new commercial buildings. About 23 states in the country have adopted the code that aims to reduce energy consumption and carbon emissions through adoption of innovative urban design and installation of green technologies. Andhra Pradesh adopted the ECBC in 2014[58] which is expected to **reduce energy consumption of buildings by at least 25-30%.** The present energy demand of the commercial building sector in Andhra Pradesh is around 3,117 million units, and implementing ECBC can save around 900 million units annually.

## Case Study: People's Capital of Amaravati (Greenfield)

The Andhra Pradesh Capital Region Development Authority (APCRDA), tasked with developing 217 sq. km. of Amaravati city in 2014, divided it into nine thematic zones including Knowledge, Sport, Media, and Government. The city's master plan, developed by Fosters + Partners, was designed with sustainability in mind, aiming to **reduce ambient temperatures by up to 3 degrees celsius through 51% green cover and to lower energy demand by 30% through energy-efficient designs.** In 2024, the central government announced a financial support package of USD 1.79 Billion for Amaravati's development and the APCRDA released the revised master plan for **Amaravati Government Complex in June 2024.** An area of approximately 1,575 acres in this project will have specific zoning regulations and focus will be on planned and sustainable growth. The state government has finalised an action plan to give green ratings to all buildings in Amaravati, while **APCRDA has reiterated that all cooling provisions[59] in Amaravati will be met through District Cooling** systems.

In line with this, APCRDA focused initial development efforts on the Amaravati Government Complex (AGC), issuing a Request for Proposal (RFP) in May 2018 for the provision of District Cooling services through a 32-year public-private partnership (PPP) concession, targeting a capacity of 20,000 RT. Tabreed was selected as the preferred bidder, and the concession was signed in 2019. **Amaravati** successfully embraced the benefits of District Cooling in what was to be **India's first PPP concession.** The concession approach combines **financial innovation with environmental sustainability,** setting a precedent for other Indian cities to follow, with the contractual structure designed to balance risks between the public and private stakeholders.



Picture Credit : www.fosterandpartners.com

## Highlights of the Amaravati District Cooling Concession Structure under PPP Model

**Land and Right of Way**

Provision of utility land plot and single window clearance system with right of way for infrastructure planning

**Exclusivity**

Exclusivity for cooling services to key buildings to ensure predictable demand in spite of phased development

**Flexibility and Scalability**

Flexibility for future expansion to meet rising demands, ensuring the infrastructure remains adaptable to the city's growth trajectory.

**Concession Term**

32 years concession period for benefits to be demonstrated whilst keeping end-user costs lower than cost for alternative cooling solutions.

**Robust Force Majeure Regime**

To enhance bankability, mitigate project risks and thereby ensure lowest cooling tariffs can be achieved through the concession period.

**Risk Allocation**

Strong performance-linked payment and penalty mechanisms to govern reliability, efficiency, orientation to global leading health, safety and environment standards.

**Investment Obligations**

Provider undertakes all capital and replacement capex investments and must demonstrate financing capability to protect interests of the overall masterplan.

**Innovation for Capacity Under Utilization**

Grantor allowed to sell to 3rd parties if contracted capacity remains un-utilized. Beyond contracted capacity, where surplus capacity is still available, the Provider is allowed to sell such surplus to 3rd parties through a revenue sharing model between the Parties.

**Bulk-offtake and Demand Guarantees**

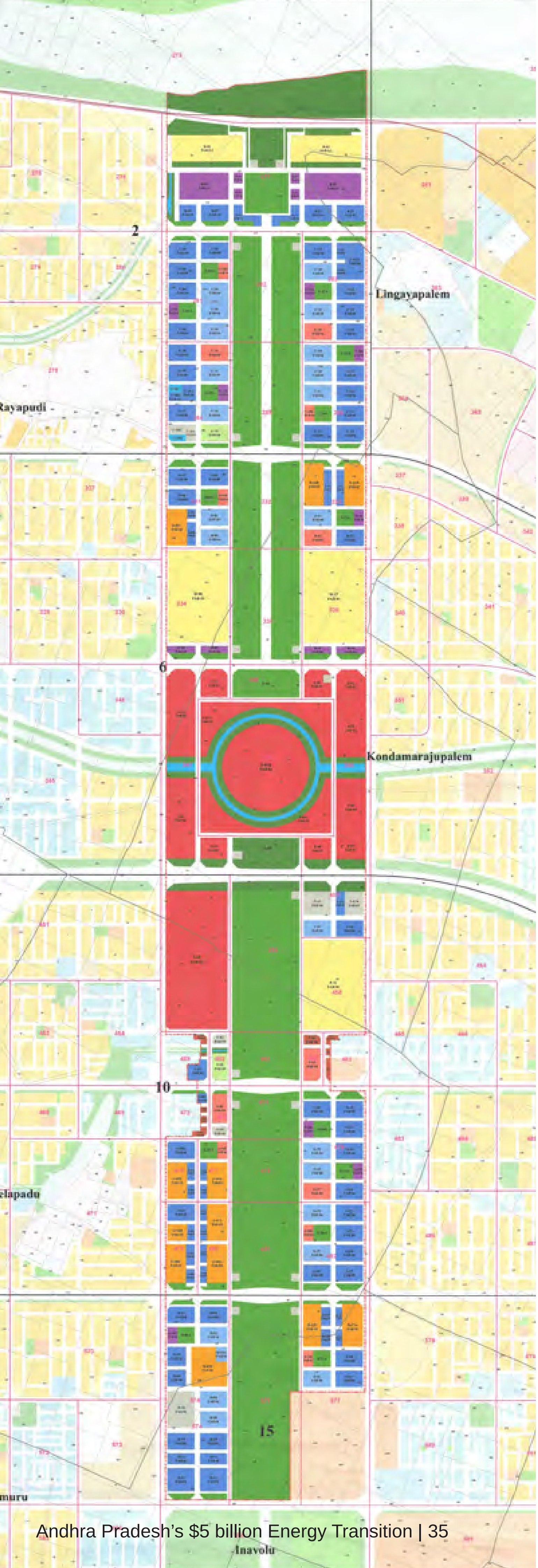
Government guarantees offtake of cooling services and a long stop date for Phase 1 post which Grantor is obligated to start paying fixed charges, to ensure the project becomes bankable (similar to market benchmarks for the renewable energy sector)

**Revenue Model**

With a two-part tariff structure,

Fixed Demand Charge towards capital cost recovery with pre-agreed tariff escalation mechanisms similar to power purchase agreements with minimum offtake requirements to provide investment viability to the developer.

Consumption Charge towards recovery of utilities cost, chemicals, & O&M costs. Indexation based on a combination of WPI (commercial – electricity) and CPI (industrial workers).




## Benefits the Proposed District Cooling System would Deliver for Amaravati Government Complex include:

**25%**
**reduction in installed cooling capacity** enabled from aggregation of demand, reduced redundancy.

**50%**
**reduction in power demand** and associated infra requirements vis-à-vis stand-alone systems.

**40 Million kWh**
**per annum lower power consumption** from improved energy efficiency of a DCS system versus stand-alone, conventional cooling systems.

**22,750 tonnes**
of annual $CO_2$ emissions reduction.

**ZERO**
**refrigerant leakage** use of Zero Ozone Depleting Potential (ODP), low Global Warming Potential (GWP) refrigerant.

**150 million litres**
**annual potable water savings** when treated-sewage effluent is made available.

**20%**
**lower lifecycle cost** vis-à-vis stand-alone, conventional cooling systems.

## DCS Potential in and around AGC: Attracting Investment of more than USD 500 Million

Several commercial and residential buildings are planned to be developed in the periphery of the Amaravati Government Complex, alongside hotels and institutions including XLRI, NID, IT parks like HCL, Department of Post, LIC, NABARD, SBI, etc. However, District Cooling has not been planned for such residential and other buildings coming up in the area yet. If DCS was to be planned and expanded to serve neighbouring residential and other mix-use, the broader mechanical load and power demand of the region could be optimized even further.

In the below table, we compare the mechanical capacity requirement of these developments, for which land has been allotted, if District Cooling is implemented vis-à-vis standalone systems that will otherwise be installed by the upcoming buildings in the vicinity of AGC.

| SN | End-Use | Built Up Area (million sft) | Standalone Cooling Load (RT) | District Cooling Load (RT) |
|---|---|---|---|---|
| 1 | Residential & Hotels | 8.5 | 27,000 | 13,000 |
| 2 | Offices & Business Parks | 18.0 | 57,000 | 37,000 |
| 3 | Institution & Hospitals | 97.2 | 310,000 | 200,000 |
| 4 | Convention Centres, Exhibition Halls | 18.0 | 57,000 | 37,000 |
| **Total** | | **141.7** | **451,000** | **287,000** |

## Subsidized Cooling for Peripheral Residential Developments through AGC DCP:

From what we understand, whilst APCRDA no longer intends to pursue 'Rosella Happy Nest', a residential complex planned to be developed in the vicinity of AGC, the case study conducted in the past demonstrated that for the 12 planned residential towers that had an aggregate cooling demand of 12,600 RT, integration with the AGC District Cooling System could reduce incremental cooling capacity requirement to just 4,000 RT.

| Particulars | Units | Business as Usual (BAU) -Split/Ductless Systems | District Cooling System (AGC) |
|---|---|---|---|
| Peak Cooling Demand | RT | 12,600 | |
| Installed Cooling Load | RT | 12,600 | 4,000 |
| Power Load | MW | 9 | 3.2 |
| System Efficiency | ikW/RT | 1.3 | 0.8 |


Picture Credit : www.fosterandpartners.com

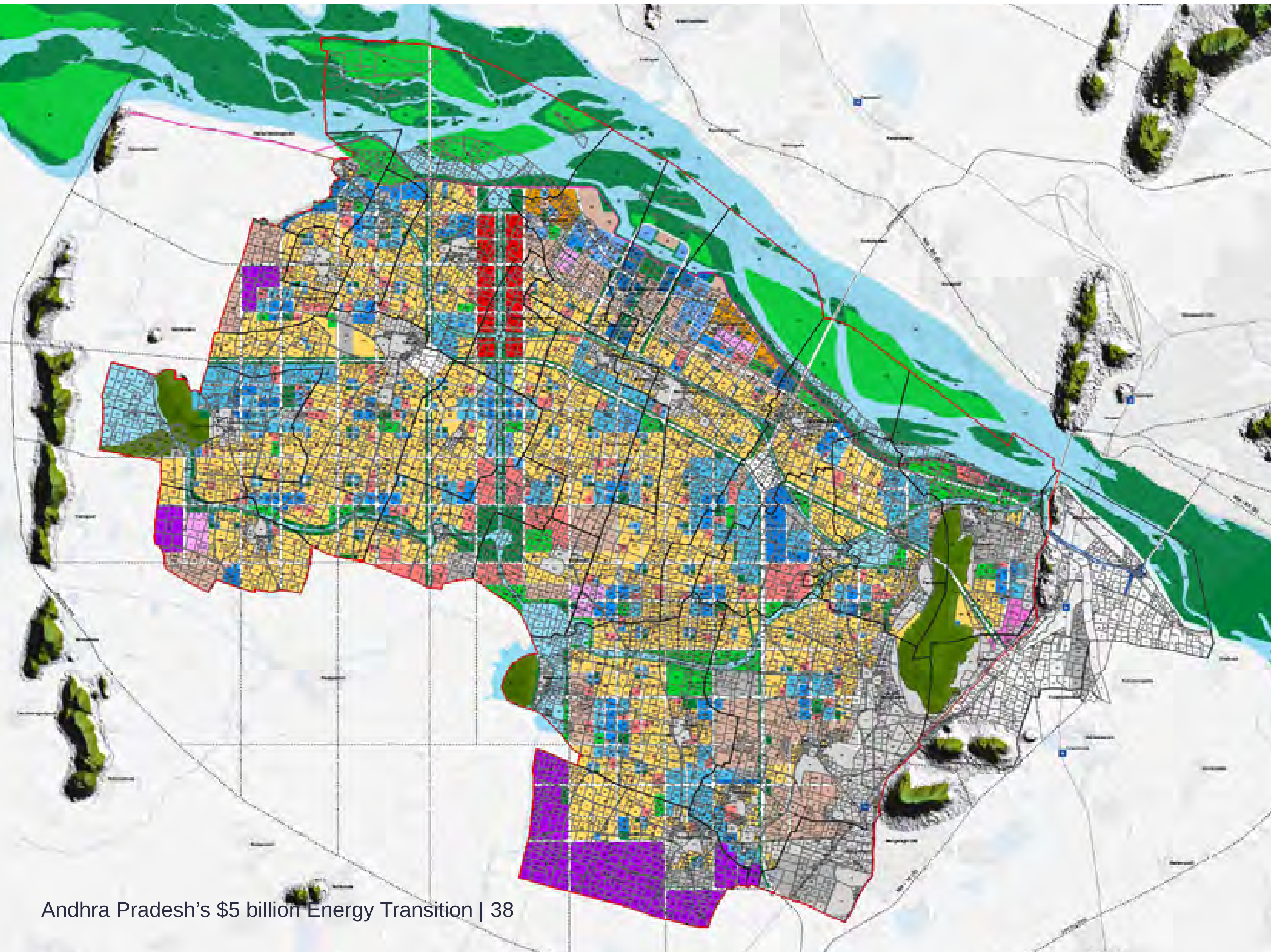
This reduction in mechanical capacity (~36%) translates to fewer resources needed to cool buildings (~33% annual reduction in energy consumption and ~30% annual reduction in water consumption), lower greenhouse gas emissions (~33%), and reduced wear and tear on cooling infrastructure, leading to longer system lifespans and lower maintenance costs. Furthermore, due to the much lower installed load, a **20% reduction can be expected in investments required for cooling infrastructure.** This savings could be redirected towards other critical areas of the city's development, such as public services, infrastructure, or technology, enhancing the overall quality of life for residents and making the city more attractive for investors.

| Particulars | Units | Business as Usual (BAU) | District Cooling System (DCS) |
|---|---|---|---|
| Peak Cooling Demand | RT | 451,000 | |
| Installed Cooling Load (Mechanical + TES) | RT | 450,000 | 290,000 |
| Thermal Energy Storage | RT | - | 40,000 |
| Power Load | MW | 540 | 200 |
| System Efficiency | ikW/RT | 1.20 | 0.80 |
| Annual Power Consumed | Million kWh | 1,350 | 900 |
| Water Consumption | Kilo-litre per day | 30,800 | 21,500 |
| Capex | INR Cr | 5,600 | 4,400 |
| Annual Utility Cost Savings | INR Cr | | 550 |
| Annual CO2 Emission Savings | Tonnes | | 410,000 |

## Broader District Cooling Potential for Amaravati Greenfield City

Given the scale of development for Amaravati as a capital city with land allotment planned for various end uses including residential, offices, IT parks, hotels, institutions, hospitals, convention centres, APRCRDA could consider zoning the high density development areas which in aggregate could attract more than **USD 4 Billion in investments for either stand-alone or interconnected District Cooling plants** through-out the capital city as demonstrated below, placing Amaravati at par or even ahead of the world's most energy efficient and decarbonized cities.

| SN | Land-Use | Area allocated (sq km) | Standalone Cooling Load (RT) | District Cooling Load (RT) |
|---|---|---|---|---|
| 1 | Residential & Hotels | 60.8 | 1,648,500 | 1,335,300 |
| 2 | Offices & Business Parks | 21.0 | 632,500 | 430,200 |
| 3 | Institution & Hospitals | 11.5 | 312,000 | 239,000 |
| 4 | Convention Centres, Exhibition Halls | 12.3 | 317,000 | 215,500 |
| **Total** | | **105.6** | **2,910,000** | **2,220,000** |



# Achieving this Vision: Policy Recommendations to Implement District Cooling in Amaravati

Several cities in the world including modern ones like Singapore, Dubai and Abu Dhabi have through an enabling regulatory environment made the adoption of District Cooling successful. Common policy elements that the Andhra Pradesh government could consider to bring this vision for a more energy-efficient and de-carbonized Amaravati are outlined below:

1. **Zoning:** Earmarking high building density areas in the city masterplan to assess socio-economic feasibility of District Cooling. Based on capital and energy costs for standalone and District Cooling systems, where District Cooling will be more cost effective than other conventional forms of cooling to consider a Zoning strategy to incorporate District Cooling within their infrastructure and masterplans.

2. **Mandating:** Consider policy tools such as mandating adoption of District Cooling within these zones and incorporate mandating elements through building permits, approval of environment impact assessments and sanctioned power demand.

3. **Licensing:** A licensing regime based on a pre-agreed criterion of nomination could be considered to ensure provision of cooling by technically and financially competent private sector players. Criteria can include adherence to latest technology standards, innovative financing capabilities, flexibility in infrastructure development and O&M expertise.

4. **Utility Status:** To allow allotment of utility plots to build a District Cooling plant typically adjacent to a sub-station and for clear guidelines around right of way and easements for district cooling networks.

5. **Simplified Permitting:** Developments that choose to sign up for District Cooling can have a prioritized, fast-track approval process.

6. **Tariff Controls and Service Standards:** Pre-defined mechanisms to ensure that whilst the investment case is achieved by the licensed service provider, adequate controls are put in place for optimal end-user tariffs and performance indicators for service reliability and efficiency.

7. **Social Mandate:** District Cooling systems set up in proximity to developments of vulnerable communities can have a social mandate to ensure District Cooling piping network expands to these areas to provide subsidized or free thermal comfort.

Beyond Amaravati, the developments that are currently in operation (brownfield) and those that are in the process of being built (greenfield) in the state of Andhra Pradesh offer different but significant opportunities for energy efficiency. **Brownfield developments,** through appropriate retrofits including super-efficient chillers, cooling towers, pumps, etc. can impact the energy efficiency of the building by providing savings on power and water bills. Whereas for **greenfield developments,** early interventions through design and planning can significantly reduce the upfront mechanical installed capacity and with it, the energy demand from the grid.


## Case Study: Siripuram in Vishakhapatnam (Brownfield)

Visakhapatnam is one of the most economically progressive cities in Andhra Pradesh. The Visakhapatnam Metropolitan Regional Development Authority (VMRDA), the urban development agency of Visakhapatnam, as a part of the Smart City and other urban planning initiatives intended to build a mixed-use development comprising of commercial, retail, hospitality developments along with multilevel car parking facility (greenfield) near Siripuram junction.

**Siripuram, spread over ~60 acres, is an urban commercial centre with large number of buildings** including VMRDA Administrative Building, WNS Global Services Corporate Office, VUDA Children Arena, Gurajada Kalakshetram, Dutt Island Building, Akashavani Radio Station, Government Circuit House, etc.

Air-conditioning for such office spaces is generally through standalone cooling systems for each building, not taking advantage of campus and building level diversity and resulting in additional redundancy at each building level. In comparison to conventional cooling systems, often designed on an ad-hoc basis, an outsourced model for cooling such as Cooling as a Service (CaaS) can provide cooling in a far-more cost-effective and efficient manner. However, there are challenges to adoption of such models due to tenants' preference towards cost plus models which encompasses payment for utilities on actual consumption plus a margin. Such models tends to pass on operational inefficiencies to tenants, given unavailability of market benchmarks for cooling and electrical efficiency.

Given the density of this micro-market and changing climatic conditions, measures to address extreme heat can go a long way to showcase viability and benefits of sustainable cooling technologies through demonstration projects. Such standalone buildings are ideal for integration with merchant **District Cooling models which can attract up to USD 15 Million in investments.**

## Advantages of Adopting District Cooling:

| Particulars | Units | Business as Usual (BAU) | District Cooling |
|---|---|---|---|
| Peak Cooling Demand | RT | 13,000 | |
| Installed Cooling Load (Mechanical + TES) | RT | 13,000 | 8,700 |
| Thermal Energy Storage (TES) | RT | | 1,000 |
| Power Load | MW | 16 | 6 |
| System Efficiency | ikW/RT | 1.2 | 0.8 |
| Annual Power Consumed | Million kWh | 39 | 26 |
| Water Consumption | Kilo-litre per day | 890 | 620 |
| Capex | INR Cr | 135 | 110 |
| Annual Utility Cost Savings | INR Cr | | 16 |
| Annual CO2 Emission Savings | Tonnes | | 11,800 |

As seen in the table, despite the buildings having similar end-use, the installed mechanical load can be reduced by ~20% through leveraging diversity benefits at campus level; by virtue of outsourced, professionally managed operations and maintenance of the cooling system, asset longevity can be ensured, while keeping in mind the energy efficiency aspects and lifecycle costs.

## Case Study: Bhogapuram Airport in Visakhapatnam (Greenfield)

The construction of the GMR Visakhapatnam International Airport (Bhogapuram Airport) is a significant development in Andhra Pradesh, promising to become a key infrastructure hub in the region. Located strategically about 40 kilometers northeast of Visakhapatnam and 15 kilometers southeast of Vizianagaram, **this greenfield airport is set to become India's 7th largest airport by area and 15th by passenger traffic upon its projected completion in 2026.** Once fully operational, it is expected to serve as the primary international gateway to Andhra Pradesh.

The airport, spanning about 2,300 acres with an estimated cost of USD 566 Million, is being developed in three phases, under a public-private partnership (PPP) between the Andhra Pradesh government and the GMR Group. The airport is being designed as a smart airport, with a strong focus on environmental sustainability and social development through an inclusive approach.

Most airports in India provide space cooling through large, centralised air conditioning plants, which are captive by nature, and don't serve land-side developments. Examples of airports in India that have DCS for air-side development include Delhi Airport (~20,000 RT), Mumbai Airport (~20,000 RT), Chennai Airport (~12,000 RT) and Kolkata Airport (~12,000 RT). The absence of outsourced cooling concessions models in airports is primarily due to **the current hybrid aero-tariff regulation models in India that link revenue to asset base,** disincentivizing capex for air-side developments being done through outsourced opex models. Secondly, on the land-side, there is a **preference to lease/sell plots for developers to plan cooling as appropriate than integrated approach to utilities** including District Cooling, sewage treatment or waste to energy systems.

Below is a brief overview of how adoption of a District Cooling system for the airport can prove to be advantageous when compared to the Business-as-Usual approach:

| Particulars | Units | Business as Usual (BAU) | District Cooling System (DCS) |
|---|---|---|---|
| Peak Cooling Demand | RT | 20,000 | |
| Installed Cooling Load (Mechanical + TES) | RT | 20,000 | 15,000 |
| Thermal Energy Storage | RT | - | 3,000 |
| Power Load | MW | 22 | 11 |
| System Efficiency | ikW/RT | 1.10 | 0.90 |
| Annual Power Consumed | Million kWh | 79 | 65 |
| Water Consumption | Kilo-litre per day | 2,000 | 1,400 |
| Annual Utility Cost Savings | INR Cr | | 19 |
| Annual CO2 Emission Savings | Tonnes | | 13,000 |

A Thermal Energy Storage (TES) system, adjacent to the DCS, will result in reduction in chiller capacity of 3,000 RT as well as a further reduce power demand by 3 MW. Time of use tariffs if applicable can provide further benefits, reducing power bills associated with cooling.

One common misconception related to implementation of District Cooling is the large, upfront capital requirement or pre-investment needed, especially when there is limited visibility on future expansion plans such as those for airports which are dependent on demand uptake. **District Cooling enables modular build out of the cooling infrastructure** based on occupancy and upcoming cooling requirements, thus, minimizing pre-investment. **The total capex requirement for setting up a DCS for Bhogapuram Airport is approximately USD 21 Million, translating into 10% savings when compared to a conventional cooling system.** Furthermore, this approach of phased development of cooling infrastructure allows newer and more efficient technologies to be integrated within the District Cooling system, rather than being locked in old, inefficient and often irrelevant technologies. In this case, too, with long airport development timelines (c. 20 years), DCS can enable modular phased capex deployment.

Furthermore, as the land-side development comes up, integration of all District Cooling plant rooms can be explored to facilitate dynamic load management and enhance operational efficiencies from centralized O&M through automation.

# 2. Industries, Manufacturing Facilities & Airports

Andhra Pradesh ranked 13th in attracting FDI inflows with amounts roughly equal to USD 850 Million[60] between 2019 and 2023. The state exports[61] of merchandise stood at USD 19.32 Billion in 2023, with marine products being the largest contributor. **In 2019-2020, about 44 large and mega industrial projects worth USD 3.03 Billion of investment were set up** in the state along with MSMEs exceeding 10,000 in number, worth USD 404 Million. Around 386 MoUs in the industrial arena were signed[62] at the Global Investors Summit in 2023 which will help create 6 lakh jobs.

As a robust industrial belt of the country, Andhra Pradesh supplies some of the largest share of products and services within the country and the world. **The industry sector, excluding IT services, contributes to around 23%[63] of the state GDP.** On the other hand, IT and electronics sector in Andhra Pradesh, with **three successful Electronics Manufacturing Clusters, already contributes[64] to 10% of India's electronic production.** A new industrial corridor, connecting Amaravati with Guntur, Prakasam and Kurnool districts, will be significant in boosting connectivity in the region and upscaling industrial growth[65].

As industrialisation in Andhra Pradesh surges, especially with Amaravati's growth, cooling needs of these multiple industries will come to the forefront. A sustainable way of meeting the growing cooling needs will be essential, given commitment to reduce carbon emissions, minimise wastage of natural resources, and ensure sustainable development. In the neighbouring state of Telangana for example the **government has incorporated District Cooling for Hyderabad Pharma City (HPC) - one of the largest pharmaceuticals industrial parks in India.** The HPC masterplan envisages 5 interconnected District Cooling plants of 25,000 RT each, totalling 125,000 RT to be built in a modular fashion basis demand ramp-up through a Design Build Finance Own Operate and Transfer (DBFOOT) concession of **a value equivalent to USD 400 Million for which Tabreed was awarded the tender.** A District Cooling system will help HPC achieve ~35% lower mechanical load, ~ 50% savings in power demand and associated infra requirements vis-à-vis stand-alone systems, 1,040 mega litres (~18%) annual water savings and 170 GWh (~25%) per annum lower power consumption requirements and 0.13 million tonnes per annum reduction in carbon emissions.

The upcoming **Industrial Policy of Andhra Pradesh is focused on achieving a 15% growth trajectory** by enhancing ease of doing business, upskilling the workforce, and providing robust infrastructure support across key sectors such as Pharmaceuticals, Food Processing, Electronics, Textiles, MSMEs, and IT. A core **emphasis of the policy is on driving energy efficiency and cost reductions through the adoption of green energy solutions,** including renewable energy sources and hydrogen. The policy aims to foster industrial development that is aligned with sustainability goals, making Andhra Pradesh a hub for industries that prioritize environmental responsibility alongside economic growth.

Intervention potential and benefits from District Cooling for some of the operational or upcoming industrial clusters in the state are provided below.

## Case Study: Jawaharlal Nehru Pharma City (JNPC) in Visakhapatnam (Brownfield + Greenfield)

Jawaharlal Nehru Pharma City (JNPC), situated in the city of Visakhapatnam, is **India's first pharmaceutical hub for Bulk Drug, Chemical and Allied Manufacturing units.** It is a 2,400-acre industrial park focused on providing world-class facilities and amenities conducive to establishing and seamlessly operating pharma industries. JNPC caters to more than 104 industries which include some of the world's leading international pharmaceutical giants including Pfizer, Mylan Laboratories, Eisai Pharma Technology (I) Pvt Ltd, PharmaZell Pvt Ltd, SNF (I) Ltd, among others.

The project was designed to offer a hassle-free production environment and allow pharmaceutical industries to leverage economies of scale to save up to 40% of the project cost through lower transport costs between co-located firms, reduced waste through the re-use of by-products as inputs in complementary industries, and shared warehousing and other infrastructure. **The environmental infrastructure at JNPC** includes a green belt of 353 acres, a 12 MLD capacity effluent treatment plant with multiple effect evaporator, solid waste management facility and 20 MLD water treatment.

**While JNPC incorporates most of the green elements in its approach, it missed out on District Cooling.** This would have not only helped reduce the burden on the grid by reducing mechanical load and associated power demand but also made financial sense due to savings in power and water costs. Furthermore, waste heat produced in the process of manufacturing drugs could have been used to power the District Cooling system, further reducing reliance on grid electricity. Additional resources such as neighbouring waterbodies could have served as heat rejection sinks. Industries are generally categorized as a “hard to abate” sector, and hence any scope to minimize carbon footprint associated with the sector should be fully exploited.

Below is a brief overview of how a District Cooling system can prove to be more advantageous when compared to a conventional cooling system. A total of 6 District Cooling plants, interconnected with a combined installed mechanical capacity of 120,000 RT could be considered. The District Cooling plants can be supplemented by thermal energy storage tanks (TES) to further optimize power load.

| Particulars | Units | Business as Usual (BAU) | District Cooling System (DCS) |
|---|---|---|---|
| Peak Cooling Demand | RT | 160,000 | |
| Installed Cooling Load (Mechanical +TES) | RT | 160,000 | 120,000 |
| Thermal Energy Storage (TES) | RT | - | 20,000 |
| Power Load | MW | 192 | 80 |
| System Efficiency | ikW/RT | 1.20 | 0.80 |
| Annual Power Consumed | Million kWh | 480 | 320 |
| Water Consumption | Kilo-litre per day | 11,000 | 7,600 |
| Annual Utility Cost Savings | INR Cr | | 190 |
| Annual O&M Cost | INR Cr | 6.40 | 3.60 |
| Capex | INR Cr | 1,700 | 1,800 |
| Annual CO2 Emission Savings | Tonnes | | 145,000 |

As we can see, while the capex may be higher for a District Cooling system due to significant civil and infrastructural works including laying of piping and network, even without considering environmental benefits, the savings on utility and O&M in District Cooling will pay back many times over.

## Case Study: Sri City in Tirupati (Brownfield + Greenfield)

Sri City, the largest industrial park in South India, spans 7,500 acres in Andhra Pradesh's Tirupati district, just 55 km from Chennai. As a top business destination, it features a multiproduct Special Economic Zone (SEZ), Domestic Tariff Zone (DTZ), Free Trade & Warehousing Zone (FTWZ), and Electronics Manufacturing Cluster. Hosting 220 companies from 30 countries, Sri City offers excellent connectivity via NH-16, four deep-water ports within 100 km, two international airports within 75 km, and a railhead just 25 km away. It provides uninterrupted power, potable water, advanced sewage treatment, and ready-built facilities for seamless operations. Its Indian Green Building Council (IGBC) Gold rating highlights its commitment to sustainability, earning it recognition as India's most innovative sustainability project.

Sri City's unwavering commitment to environmental stewardship garnered international acclaim. Its dedication to green practices, evident in its infrastructure development and innovative initiatives, earned it the prestigious title of **"India's most innovative sustainability project of the year"**. This recognition cemented Sri City's position as a global leader in sustainable development, offering a blueprint for environmentally conscious growth.

However, District Cooling is a missed opportunity at this park. Given the sheer size and scale of Sri City, incorporation of District Cooling can further raise Sri City's green accolades. By centralizing cooling demand, District Cooling boosts energy efficiency, lowers emissions, and ensures reliable service, maximizing uptime. This fits seamlessly into Sri City's vision for sustainable, smart growth, supporting its leadership in environmentally conscious development. **A 250,000 RT District Cooling plant in Sri City can be set up at a cost of USD 380 Million.**

In the table below, we demonstrate the possible savings that can still be achieved if District Cooling is adopted by Sri City in a phased manner, bringing in an investment of USD 380 Million. This could be implemented through 10 interconnected DCPs of 25,000 RT each including a Thermal Energy Storage system of 2,500 RT respectively. The capacity can be deployed in phases, with initial capacity being deployed for greenfield units coming up in the near future.

**~30%** **lower mechanical load and improvement in electrical efficiency** enabled from aggregation of campus demand and use of industrial grade water cooled, centrifugal chillers.

**50-60%** **savings in power demand** and associated infra requirements vis-à-vis stand-alone systems through integration of TES, reduced mechanical cooling load and better efficiency which frees up grid capacity.

**10 million** **units of lower energy consumption** given DCS average electricity efficiency of 0.8 kW/RT as compared to 1.20 kW/RT for stand-alone, conventional cooling systems.

Picture Credit : www.indospace.in

In close coordination with the State Industrial Development Corporation and municipality, dedicated utility plots will have to be identified, preferably near electrical sub-stations for allocation to the provider for setting up DCPs. Over time, the provider will acquire existing captive cooling plants within Sri City units for an upfront purchase consideration, and ensuring minimal disruption and downtime, will connect the loads to District Cooling systems while decommissioning the captive cooling systems. **An enabling policy framework which requires industrial units to mandatorily connect to District Cooling according to a pre-defined rate card can give a huge impetus** to the District Cooling scheme coming to fruition in Sri City. Once a District Cooling system is deployed, the possibilities for other supply systems to be integrated are innumerable, as mentioned in the 'Benefits from a System's Approach to District Cooling' section of this report.

| Particulars | Units | Business as Usual (BAU) | District Cooling System (DCS) |
|---|---|---|---|
| Peak Cooling Demand | RT | 370,000 | |
| Installed Cooling Load (Mechanical +TES) | RT | 370,000 | 250,000 |
| Thermal Energy Storage (TES) | RT | - | 25,000 |
| Power Load | MW | 444 | 180 |
| System Efficiency | ikW/RT | 1.20 | 0.80 |
| Annual Power Consumed | Million kWh | 2700 | 1800 |
| Water Consumption | Kilo-litre per day | 62,000 | 43,000 |
| Annual Utility Cost Savings | INR Cr | | 868 |
| Annual CO2 Emission Savings | Tonnes | | 825,000 |

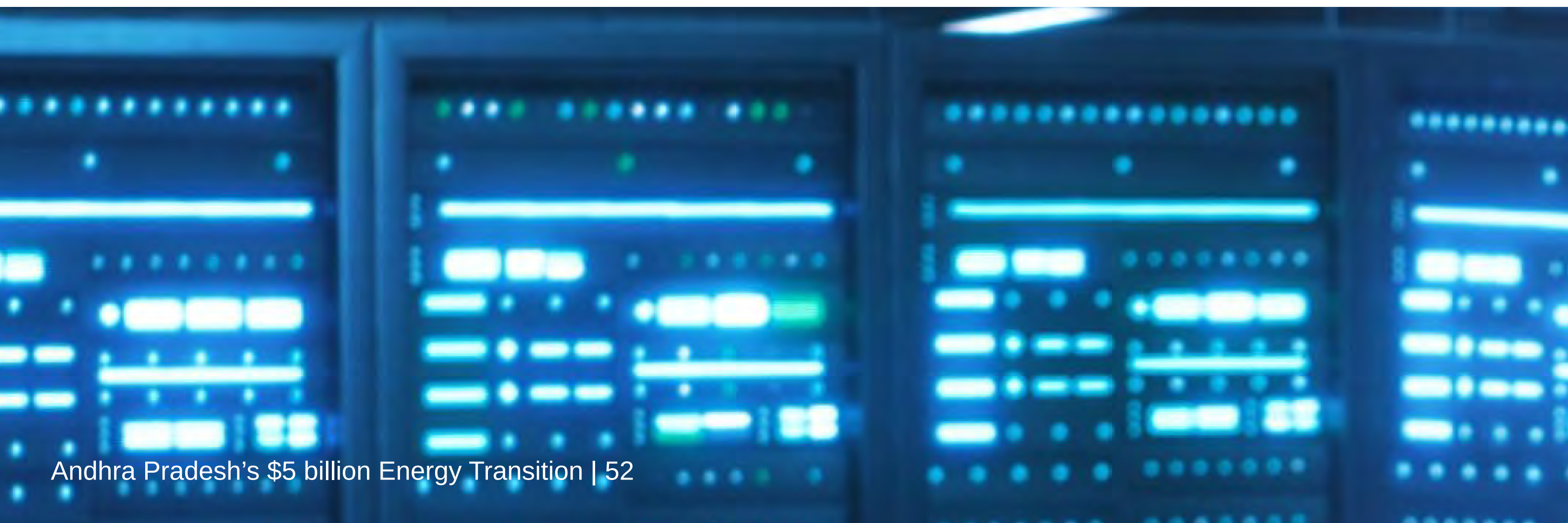
# 3. IT and Data Centres

**India is the 13th largest data centre market in the world with 138 data centres.** It is anticipated that 45 new data centres with a combined 13 million square feet and 1,015 MW of capacity will be built in the country by the end of 2025. **The data centre industry was valued at USD 4.35 Billion in 2021, and is predicted to grow by 132%[66] to reach USD 10.1 Billion in 2027.** The appetite for data centres in India is growing and Andhra Pradesh is being seen as a preferred destination for new projects.

One such data centre is planned in Vishakhapatnam by the Adani Group worth approximately USD 2.6 Billion[67] to provide a boost to the local technology ecosystem in the region. The project, "Integrated Data Center and Technology Business Park", will have a data centre with 300 MW[68] capacity, a technology and business park, and a skill development center. The state government has identified and allocated 130 acres in Madhurawada and 60 acres in Kaluppada for the project. These projects are part of the agreement signed between Adani Enterprises and the Andhra Pradesh government in 2019 for development of data centres with 5 GW capacity and a value of USD 8.3 Billion.

As Andhra Pradesh scales its data centre ambitions, the associated energy demand will rise significantly. A **substantial portion of this demand – around 40% - will stem from cooling systems,** which, aside from IT equipment, represent the largest energy consumers[69] within data centres. Secondly, data centres are typically rated according to the Uptime Institute's tier classification system, which evaluates their ability to maintain operational uptime in an ascending order. As new facilities are developed in Andhra Pradesh, the importance of Tier III and Tier IV ratings with respective uptime requirements of 99.982% and 99.995% will be critical to ensure uninterrupted operations. This means redundancies will be required for both power and cooling systems for maintaining resilience and preventing downtime.

The challenge, then, is to meet the rising energy and cooling demand from data centres in a more sustainable way without compromising uptime requirements. District Cooling systems offer an innovative solution, providing reliable, centralized cooling while potentially reducing energy consumption and mitigating environmental impacts. **Integrated District Cooling systems could enhance redundancy plans by offering centralized backup cooling for multiple data centres within a region, optimizing resource use while maintaining high levels of service availability.** To avoid duplication of investments and isolated approaches, planning for data centre clusters in Andhra Pradesh should consider comprehensive, multi-facility cooling solutions. One strategy could involve implementing a central backup District Cooling system that serves a cluster of data centres, thereby reducing the need for individual redundancy investments, lowering operational costs, and enhancing sustainability by minimizing energy waste.



## Case Study: Data Center and Technology Business Park in Vishakhapatnam (Greenfield)

An 'Integrated Data Centre and Technology Business Park' is being planned in Madhurawada, Vishakhapatnam, to boost local technology ecosystem in the region. The proposed project will house a 200 MW data centre park (powered with 100% renewable energy), an IT Business Park, a skill university, and a recreation centre. **The project will empower the State's information and technology sector** along with the education, entertainment, and recreation sectors to generate jobs for local communities and open new gateways of growth in the region.

The project, costing USD 238 Million, proposes the construction will spread across a land parcel of 130 acres, with 82 acres allocated for the data centre, 28 acres for the business park, 11 acres for the skills university, and 9 acres for the recreational park. The construction is expected to last 7 years, beginning in 2023. Andhra Pradesh, with its geographical advantages including ample availability of renewable energy and a long coastline, is well positioned to host data centre parks not only for our country but also for those nations that are short on land or energy.

The IT industry is responsible for a significant share of global electricity use. According to the International Energy Agency, **data centre operations together with the data transmission network are responsible for over 2% of the global electricity consumption in 2020.** With sizeable growth expected in the industry, this share is expected to rise, making sustainability more difficult for businesses and even countries. Cooling makes up close to 40% of the total energy consumed by a data centre and is critical to safely operate computing equipment and yield maximum performance. Given cooling is a mission critical service, a near-zero uptime is needed to ensure minimal impact to business.

While the energy consumption of this sector is significant, the benefits of the services offered, and the economic activity supported by data centre services are many times larger. As such, there is an urgent need to decarbonize the sector as much and as fast as possible, using sustainable cooling as one of the levers. This is where a District Cooling system comes into picture. For the upcoming **Integrated Data Centre & Technology Business Park in Andhra Pradesh,** two District Cooling plants could be considered, **with an investment potential of USD 150 Million,** to be set up next to each other or within the same utility bloc: DCP 1 for data centre: ~75,500 RT (with N+2 redundancy) & DCP 2 for business park, skill university and recreation park: ~5,700 RT

## Several other technical design elements should be kept in mind to optimize plant performance:

1

While the two buildings can be housed in a dedicated utility plot, it is preferable to have **separate networks** for both to prioritize efficiency as the **cooling temperatures and requirements of the data centre** (15°C to 20°C chilled water temperature) would **differ from that of the business park** (7°C to 12°C chilled water temperature).

2

Assuming that the data centre's total capacity of 200 MW is distributed/ divided between 10 buildings of 20 MW each, there will be a requirement for **energy transfer stations** in each building to cater to **varying temperature needs of the buildings.** ETSs are critical for regulating and distributing chilled water, ensuring the right temperature is supplied based on the operational requirements of each building. They also enhance energy efficiency by managing demand variations across the network and reducing energy losses.

3

A **TES system** (~5,000 RT) is recommended for **backup cooling mechanism** ensuring uninterrupted cooling and to avoid the lag between power failure and switching on the gensets. A short span of even 5 mins can have exponential repercussions and damage equipment. The TES system can use the stored energy to supply the chilled water to maintain data centre temperatures during the restoration time.

4

**Water cooled chillers** (0.60-0.80 kWh/RT) could be considered for the plant instead of usually deployed air-cooled chillers (efficiency of 1.20-1.50 kWh/RT), which are more energy intensive and have a larger footprint, requiring substantial open space either on the ground or terrace.

5

A central District Cooling plant will **free up valuable rooftop space,** that can utilize Andhra Pradesh's solar power potential. The rooftop solar system can meet upto potentially 20-30% of the building's electricity requirements, cutting the energy expenses while also promoting sustainability.

6

Similarly, a central District Cooling plant will **reduce operations and maintenance** as compared to the individual cooling systems which employ separate teams for operations & maintenance.

| Particulars | Units | Business as Usual (BAU) | District Cooling System (DCS) |
|---|---|---|---|
| Peak Cooling Demand | RT | 84,000 | |
| Installed Cooling Load (Mechanical +TES) | RT | 84,000 | 81,200 |
| Thermal Energy Storage (TES) | RT | - | 5,000 |
| Power Load | MW | 123 | 61 |
| Weighted Average System Efficiency | ikW/RT | 1.47 | 0.80 |
| Annual Power Consumed | Million kWh | 1,025 | 517 |
| Water Consumption | Kilo-litre per day | 18,575 | 12,900 |
| Annual Utility Cost Savings | INR Cr | | 390 |
| Annual O&M Cost | INR Cr | 4.2 | 2.4 |
| Annual CO2 Emission Savings | Tonnes | | 427,600 |
| Capex | INR Cr | 1,000 | 1,220 |

# 4. Warehouses and Cold Chains

Agricultural cold chain is critically under-developed in India. According to the India Cooling Action Plan, this is especially the case for agricultural packhouses, refrigerated transport and logistics. The lack of availability of cold-chain is estimated to lead to an average of 15-20% loss[70] of food in India. This amounts to about **50% of all post-harvest food loss in the country.** Even as India faces high malnutrition and hunger, it wastes 80 million tonnes of food at retail and consumer levels, which is only second to China in the world. The reason behind this wastage is **lack of cooling and refrigeration[71] infrastructure.** As most producers are small farmers, they don't have access to these facilities easily. An increase in heat due to changing climate can worsen the problem. Moreover, farmers today receive less than half the wholesale price for their produce and for perishable goods. Increasing access to cold chain infrastructure can help reduce food loss, expand market connectivity, protect the quality and safety of food, increase farmers' revenues and improve the resilience of farmers and the rural communities in which they are located.

Agriculture is one of the primary occupations and economic activities in Andhra Pradesh. It contributes more[72] than 29% to the state GDP, and has been the target for scientific and ecological improvement through government initiatives[73] like the 'Andhra Pradesh Community-Managed Natural Farming'. Given the economic significance of agricultural products, and its processing and storage, cold chains infrastructure is essential in the state. The state has also emerged as a **leading fish producer with more than 40%[74] of the share of India's fisheries. It has 2 fishing harbours with 65 cold storages, 64 processing plants, and 235 ice plants supporting the fishing industry.** With a potential of 1.74 lakh hectares of brackish water area and about 8 lakh hectares of freshwater resources to tap into, the industry can grow profitably with ethical periodical bans[75], sufficient attention and resource investment by the state.

Needless to say, the development of this industry will bring with it the need for increased cooling, both for supporting infrastructure like cold storage and process-


ing plants like food processing industries. The government of India created the **'Action Plan for Cold Chain & Post Harvest Infrastructure Development' 2017-2022 for greater focus on developing infrastructure** that helps promote the fisheries sector. Given the highly perishable nature of the product, the aim is to develop facilities like cold storage[76] which avoid wastage. In addition, programmes such as[77] the **'Pradhan Mantri Matsya Sampada Yojana' provides financial assistance to beneficiaries covering areas like post-harvest infrastructure,** gaps in production quality and technology, and strengthening supply chains. Fisheries & Aquaculture Infrastructure Fund helps in development of cold storage and network, fish processing units, and ice plants.

At the state level, the government has aimed to **construct a cold storage facility[78] at the village level,** with every four 'Rythu Bharosa Kendras' set to have one cold storage facility. In 2022, permission to build 945 cold storage facilities in Rayalaseema districts was granted, which struggle with increased heat in the summers. **As cold storage facilities steadily increase in Andhra Pradesh, a sustainable approach to meeting cooling requirements is key for the state's developmental plans.** While this is a more nuanced segment, wherein applicability of District Cooling needs to be assessed on a case-by-case basis, the technology offers pathways in which this can be done without harming the environment, and ensuring food and economic security for the people of Andhra Pradesh.

## Case Study: Kakinada SEZ LNG Re-Gasification Terminal (Greenfield)

The Kakinada SEZ, spanning 7,440 acres with the adjacent 1,589-acre Kakinada Gateway Port land, is rapidly emerging as an industrial hub, attracting a variety of industries, especially in sectors like petroleum, chemicals, and petrochemicals (PCPIR). Additionally, the region is poised for further development with the approval of a Bulk Drug Park by the Central Government.

A key project in the region is H-Energy's Floating Storage Unit (FSU) LNG re-gasification terminal. **The terminal will serve as a vital hub in the "Hub and Spoke" model,** supporting LNG distribution to other terminals and demand centres across India and neighbouring countries. With FSU capacity of 170,000-210,000 m3 capacity and a re-gasification capacity of 4 million tonnes per annum (MMTPA), the terminal is designed to supply re-gasified LNG via pipelines and through trucks to regions across Eastern and Southern India.

**One of the notable environmental opportunities here is the utilization of waste cold energy generated during LNG re-gasification.** Waste cold, a by-product of converting LNG from a liquid to a gas, is an energy source with zero carbon emissions. Globally, such waste cold has been used in various applications, from power generation to industrial cooling. In a few cases, as in Barcelona and Marina Bay, Singapore, waste cold has been directly integrated into District Cooling systems for urban real estate developments.

In India, according to the National Centre for Cold-Chain Development (NCCD), there is potential to capture up to 500,000 RT of stranded cold from operational and proposed LNG terminals, including the one in Kakinada. This potential could help meet cooling demands while supporting sustainable energy use.

Assuming East Coast Concessions Private Limited operates its onshore vaporizer (4 MMTPA capacity) at **40% capacity utilization,** the stranded cold produced could exceed **15,000 RT.** This waste cold energy has the potential to meet the 24/7 space cooling needs of up to **5 million square feet** of air-conditioned real estate if commercially harnessed. Given this substantial potential, **East Coast Concessions in partnership with a District Cooling service provider** could consider developing a **District Cooling scheme, attracting an investment of up to USD 75-100 Million,** to serve cooling needs of existing and upcoming industrial and commercial developments in Kakinada SEZ and nearby areas.

Picture Credit : https://images.dngroup.com

## A Broad Schematic for the Initial Design of the System:

**Harnessing Cold**

LNG re-gasification, where liquefied natural gas (LNG) at −162°C is converted back to natural gas at atmospheric temperature, releases substantial cold energy. This **stranded cold** can be captured at **−50°C** and used for **cold-chain applications** through LNG-Propylene Glycol heat exchangers. Paired with **thermal energy storage tanks,** this cold energy would circulate through a closed primary loop. The secondary loop would distribute the cold through appropriate pumping systems, providing **chilled water** to various real estate developments via Energy Transfer Stations (ETS).

---

**Distributing Cold**

A 15 to 30-kilometer chilled water distribution network could be laid through the Kakinada SEZ and other nearby areas where cold storage, warehousing and fishery projects are either in place or under construction, alongside large industrial projects. This network would likely include several water crossings and may involve Horizontal Directional Drilling (HDD) at key points, such as road crossings, to minimize disruption.

---

**Commercial Benefits**

At 80% capacity utilization, this facility could provide up to 30,000 RT of uninterrupted cooling to support more than 8 million square feet of air-conditioned area, using a zero-emission energy source. This system would offer several key advantages:

**Peak Energy Savings**

Up to 40 MW in peak energy demand reduction.

**Annual Energy Reduction**

An estimated 300 GWh of energy savings, leading to a proportional reduction in $CO_2$ emissions.

**Water Savings**

The system would save over 300 million liters of potable or grey water annually, compared to conventional water-cooled systems.

---

**Payback**

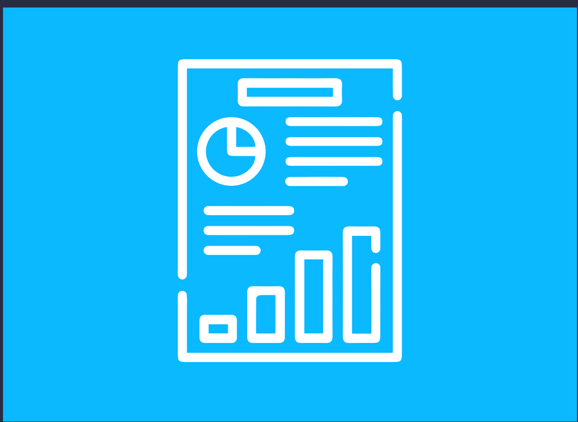
Assuming no cost for utilizing the stranded cold, the payback period for the District Cooling provider could range from **7 to 12 years,** depending on the capacity utilization and based on a **20% reduction in life-cycle costs** compared to traditional cooling solutions.

## Policy Recommendations to Incorporate District Cooling in the Upcoming Andhra Pradesh Industrial Policy

Basis our experience, we provide below recommendations to incorporate District Cooling in the industrial policy to further the objective of adoption of green energy solutions by the clusters under development.

### 1. Identify Cooling-Intensive Clusters:

Many industries depend on precise temperature control to ensure product quality and operational efficiency. For example, the pharmaceutical sector requires stringent climate control to maintain the stability of medical products, while the textile and automotive industries need cooling to manage humidity and prevent damage to fabrics and machinery. **Identifying cooling-intensive** clusters will help focus efforts and streamline the adoption of District Cooling.

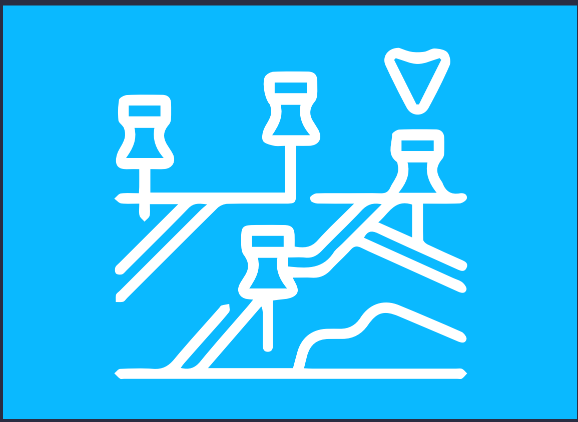


### 2. Mandatory Pre-feasibility Studies:

Pre-feasibility studies must be a mandatory part of the **infrastructure planning process before any tendering process** to evaluate the benefits of adopting District Cooling. These studies should analyse potential **synergies with circular economy principles** by integrating District Cooling with sources such as common effluent treatment plants, waste-to-energy plants, gas distribution networks, and renewable power generation.

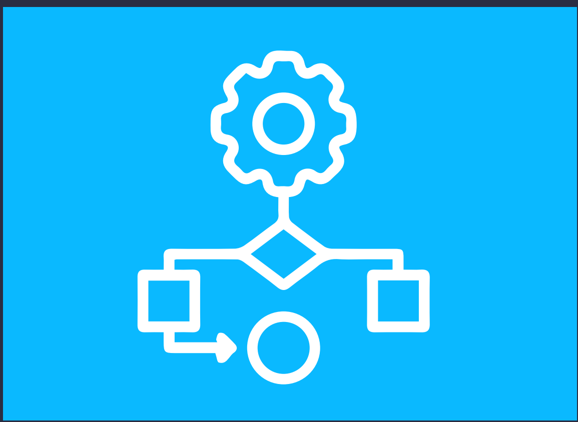
### 3. Mandating:

After evaluating District Cooling as a cost-effective, environmentally sustainable, and operationally efficient solution, **policy measures should mandate its adoption in cooling-intensive clusters.** All new units in these clusters would be required to utilize District Cooling. For example, the Hyderabad Pharma City in Telangana incorporated District Cooling into its masterplan after a feasibility study confirmed its benefits. To ensure compliance, this was mandated as part of the land allotment strategy, with educational materials provided to allottees on the system's advantages.



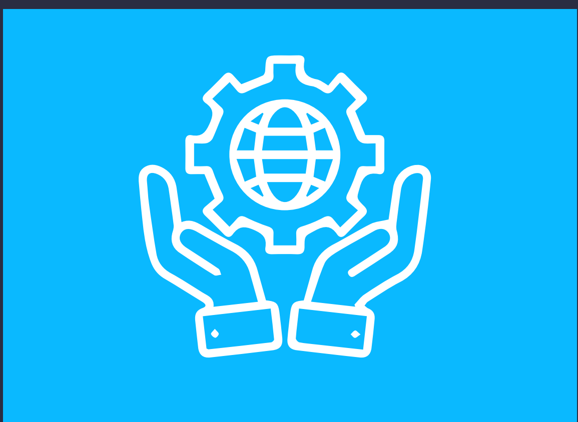
## 4. Land Allotment Strategy:

As part of the mandatory adoption framework, District Cooling should be integrated into the land allotment process. The nodal body will provide educational materials explaining how District Cooling works and its benefits, such as reduced power bills, lower lifecycle costs, and alignment with climate commitments. Additionally, a **transparent rate card** should be made available, detailing the cost of cooling services in the same manner as other utilities like water and electricity.



## 5. PPP Framework:

The state's successful experience with PPP models, such as the Amaravati Government Complex District Cooling project, demonstrates how public-private collaboration can drive rapid adoption. PPPs facilitate faster deployment of large-scale District Cooling infrastructure, attract private investment, and alleviate the financial burden on the state. This approach should be considered the **preferred business model for engaging District Cooling service providers.**



## 6. Governance:

A dedicated governance model should be established through, for instance, a District Cooling Tariff Committee. This committee, comprising representatives from the government (grantor), service provider, and customers (industrial units), would handle **grievance redressal and adjustments to charges.** Any of the three parties can request adjustments within a specified framework, prior to project commencement.

# Way Forward

Large-scale adoption of District Cooling will require several changes in the ecosystem. While some of these will be long term, others may be more easily achievable in the short term. We present a few immediate steps that can be taken in the direction for greater adoption:

### 1. Policy and Regulatory Support:

To foster growth of District Cooling, the government should establish clear policies and regulatory frameworks that promote and incentivize the adoption of District Cooling systems. As part of the masterplan, **zoning** can be done to identify high-density urban clusters, followed by **mandating** District Cooling within such clusters to mitigate urban heat island effect. District Cooling may be perceived as an extra regulatory burden due to a layer of complexity to it. However, fiscal and non-fiscal incentives, streamlined **permitting processes** for projects that incorporate District Cooling, etc. can help dismantle this perception. Additionally, setting mandatory **energy efficiency standards** and linking the same to **annual reporting** for maintaining green building certifications can drive the transition towards more sustainable cooling solutions.

### 2. Pre-feasibility Studies for District Cooling for Integrated Urban Planning:

At the building infrastructure level, ECBC guidelines provide a framework to catalyze adoption of energy efficient systems like District Cooling. **Integrating District Cooling into urban planning** and development strategies is crucial. While the state government's development plans for Amaravati do incorporate District Cooling, the implementation would be successful with **awareness among all stakeholders.** Pre-feasibility studies on a case-by-case basis can provide much needed information for planners and developers, who could consider cooling needs early in the design process including **maximizing sustainability and circular use of materials.** A further push for **mandatory undertakings of pre-feasibility studies for large developmental projects** across Andhra Pradesh, including through public-private partnership model, will be useful to understand viability of the District Cooling system for projects of that magnitude. It can help provide a more accurate picture of District Cooling opportunities for the market, investors, developers, and also the state authorities.

### 3. Legal Framework for Mitigating and Sharing Risks:

Given the nascency of District Cooling technology and the complexity of multi-party contracts involved, establishing a comprehensive legal framework is essential to facilitate its large-scale adoption. This framework should include clearly defined roles, responsibilities, and expectations of all parties involved, **Service Level Agreements** (SLAs) that specify performance standards, response times for maintenance and repairs, and penalties for non-compliance, pricing structure including ongoing service fees and any variable charges based on usage, terms for the termination of the contract, etc. In addition, to safeguard interests of the consumer only **licensed** District Cooling players that are technically and financially competent be allowed to participate in tenders. Further, contractual mechanisms can ensure strict adherence to **technical standards** including trigger points for replacement and retrofits, preventing dependence on obsolete systems thereby mitigating risks linked to **technology lock-in.**

### 4. Cooling as a Utility:

The state government in Andhra Pradesh has taken steps to position **cooling as a basic requirement,** such as in its policy handbook for Amaravati development. It would be even more beneficial to advance this positioning as a **public utility good**. That way, cooling as a commodity can become accessible to most sections of the society through a CaaS model. Cooling provision needs to be treated same as that of utilities like water, gas and electricity. Recognizing cooling as an essential utility will facilitate the development of centralized District Cooling systems, and the supporting infrastructure, which can provide energy-efficient and cost-effective cooling solutions across built environment. Such an investment in cooling infrastructure should be made as early as possible while the city is in a stage of crucial development. This can serve as an example for all other developing regions of the state and the country. The application of District Cooling at mass-level urban infrastructure and planning can help energy transition on a corresponding scale, which is useful for the state's emissions target.

### 5. Innovative Business and Partnership Models:

Enabling pre-investment and financing options for initial expenditure that goes into setting up of the District Cooling systems, with spreading awareness among key stakeholders about its long-term benefits for the ecosystem. Exploring feasible business and partnership models for recovery of initial cost such as **public private partnership** or CaaS. When cooling is treated as a necessary public utility, through the PPP model, investment in the entrenched network that needs to be built upfront could be taken care of by relevant government agencies, while the plant itself would be the responsibility of the District Cooling provider. Such a model also necessitates a **minimum demand** promised by the government while the utility ensures that they review, update and meet specific **efficiency metrics** ensuring technical advancements and compliance with best practices. District Cooling is currently viewed only as a technology and not a market model. There is a need to familiarize the market players to it in a better way.

### 6. Awareness:

At the larger citizen level, greater information and knowledge sharing about cooling alternatives, such as District Cooling, with involvement of government, private sector, and civil society representatives in the form of workshops will be helpful. Engagement with local government bodies to understand regional differences, hurdles and suitability, can assist to devise programs for large-scale implementation at city or village levels.

### 7. Training and Capacity Building:

Building the necessary technical expertise to design, implement, and manage District Cooling systems is essential. Offering training programs and certification courses for engineers, architects, urban planners, and other stakeholders can ensure that the workforce is equipped with the skills needed to support the widespread adoption and maintenance of District Cooling systems.


### 8. Showcase Projects and Case Studies:

Implementing pilot projects in different regions can demonstrate the feasibility and benefits of District Cooling. These projects can serve as case studies to showcase best practices, identify challenges, and provide valuable data to inform future developments. Successful pilot projects can also build confidence among stakeholders and attract further investment.

In conclusion, the overall outlook of potential savings through planning and early intervention is immense, especially for new developments and projects in the presence of a government support policy. The case of Amaravati can be a prime study in understanding the scope of transition to cleaner technologies, especially in new developing cities. Through diligent, collaborative, and targeted measures, upcoming projects can benefit from the aggregation of District Cooling systems in not only Amaravati but the entire state of Andhra Pradesh. The acknowledgment by the government ecosystem about the need for this transition is the basis for formidable progress in the coming time. It also bodes well for the state's broader decarbonization and circularity goals. The pathways that the state is building are promising and cooperation from all involved stakeholders, the road towards sustainable cooling is not difficult, nor far away.

## About Tabreed India

Tabreed India Private Limited is a wholly owned subsidiary of Tabreed Asia Central Cooling Company — a 75/25 joint venture between National Central Cooling Company PJSC (Tabreed UAE) and the International Finance Corporation (IFC).

Since inception Tabreed has partnered with State governments and organisations to deliver District Cooling solutions, while also leveraging India's innovative technology ecosystem. In 2019, Tabreed was awarded India's first public-private partnership (PPP) concession for providing 20,000 RT of District Cooling services to the Amaravati Government Complex. In 2023, Tabreed secured a landmark 32-year concession to develop Asia's largest PPP District Cooling project for 125,000 RT at Hyderabad Pharma City, and partnered with Tata Realty to deliver 6,600 RT through the Cooling as a Service (CaaS) model to their premium commercial campus in Gurugram. In 2024, Tabreed expanded its innovation portfolio by collaborating with Plaksha University under the IFC TechEmerge program to pilot phase-change based thermal storage for energy-efficient night-time cooling. Additionally, it is actively working with IIT Jammu to establish cooling test beds for advanced research. Leveraging its world-class design, engineering, and operational expertise, Tabreed India is committed to building local capabilities while seamlessly implementing global best practices to drive sustainable cooling solutions across the country.

## About Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is a German federal enterprise with worldwide operations. GIZ supports the German Government in the field of international cooperation for sustainable development. The current thematic areas of GIZ in India are – Energy, Environment, Climate Change and Biodiversity, Sustainable Urban Development and Sustainable Economic Development. The Federal Ministry for Economic Cooperation and Development (BMZ), the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), as well as the Federal Ministry for Economic Affairs and Climate Action (BMWK), are the main commissioning parties of GIZ in India. Other clients include Indian public sector clients, the European Union and foundations. The Government of India has launched numerous important initiatives to address the country's economic, environmental and social challenges, and GIZ is contributing to some of the most significant ones under the umbrella of the Indo-German Partnership for Green and Sustainable Development.

## About Bureau of Energy Efficiency (BEE)

The Government of India has set up Bureau of Energy Efficiency (BEE), under the Ministry of Power (MoP), on 1st March 2002 under the provision of the Energy Conservation Act, 2001. The mission of Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles with the primary objective of reducing energy intensity of the Indian economy within the overall framework of the Energy Conservation Act, 2001. This will be achieved with active participation of all stakeholders, resulting into accelerated and sustained adoption of energy efficiency in all sectors. The BEE coordinates with designated consumers (DCs), designated agencies, and other organizations and recognizes, identifies, and utilizes the existing resources and infrastructure, in performing the functions assigned to it under the EC Act. BEE launched DCS guidelines to give impetus to sustainable cooling in India.

## References


1. Sravani, N. (2024). Worst of the summer this year is likely over in Andhra Pradesh, says IMD. The Hindu.
Source

2. Ministry of Environment, Forest & Climate Change. (2019). India Cooling Action Plan.
Ministry of Environment, Forest & Climate Change.
Source

3. Andhra Pradesh Electricity Regulatory Commission. (2023). State Electricity Plan.
Source

4. Andhra Pradesh State Energy Conservation Mission. (2023). Energy Conservation Policy.
Source

5. United Nations Environment Programme, & Energy Efficiency Services Limited. (2021).
National District Cooling Potential Study for India. UNEP and EESL.
Source

6. Shivangini. (2024). Will Amaravati become new greenfield IT capital of AP?
Experts say Krishna River to bring sustainability and tourism. Mint.
Source

7. Fox, T., Sayin, L., & Peters, T. (2023). The Hot Reality: Living in a +50°C World. Centre for Sustainable Cooling.
Source

8. Fernandes, J. (2024). Heatwave: 56 Heat-related Deaths, 25,000 Heatstroke Cases Reported in India from March to May.
Source

9. World Bank. (2022). Climate Investment Opportunities in India's Cooling Sector. World Bank Group.
Source

10. Chandrashekar, N. (2024). Rising temperature, falling income: Heat stress in the informal sector. India Development Review.
Source

11. Shagun. (2024). ILO flags risk of excessive heat to 2.4 billion workers globally; Indian workers among those at high risk. Down to Earth.
Source

12. Ministry of Environment, Forest & Climate Change. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change.
Source

13. Ministry of Environment, Forest & Climate Change. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change.
Source

14. Ministry of Environment, Forest & Climate Change. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change.
Source

15. United Nations Environment Programme, & International Energy Agency. (2020).
Cooling Emissions and Policy Synthesis Report: Benefits of cooling efficiency and the Kigali Amendment. UNEP, Nairobi and IEA, Paris
Source

16. United Nations Environment Programme, & International Energy Agency. (2020).
Cooling Emissions and Policy Synthesis Report: Benefits of cooling efficiency and the Kigali Amendment. UNEP, Nairobi and IEA, Paris
Source

17. Ministry of Environment, Forest & Climate Change. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change.
Source

18. Fox, T., Sayin, L., & Peters, T. (2023). The Hot Reality: Living in a +50°C World. Centre for Sustainable Cooling.
Source

19. Kurmanath, K. V. (2024). A clean break of capital on June 2 for AP and Telangana, but messy parts of split remain. The Hindu BusinessLine.
Source

20. Down to Earth. (2024).
Source

21. Andhra Pradesh Revenue (Disaster Management) Department. (2016). Heat Wave Action Plan of Andhra Pradesh.
Source

22. Andhra Pradesh Revenue (Disaster Management) Department. (2016). Heat Wave Action Plan of Andhra Pradesh.
Source

23. Andhra Pradesh Electricity Regulatory Commission. (2023). State Electricity Plan.
Source

24. Andhra Pradesh Electricity Regulatory Commission. (2023). State Electricity Plan.
Source

25. GHG Platform India. (2022). Trend Analysis of GHG emissions of Andhra Pradesh: 2005 to 2018.
Source

26. Andhra Pradesh Electricity Regulatory Commission. (2023). State Electricity Plan.
Source

27. National Centre for Disease Control. (2024). State Action Plan for Climate Change and Human Health (SAPCCHH): Andhra Pradesh.
Source

28. Andhra Pradesh State Energy Conservation Mission. (2023). Energy Conservation Policy: Final Draft
Source

29. Andhra Pradesh State Energy Conservation Mission. (2023). Energy Conservation Policy: Final Draft.
Source

30. Andhra Pradesh Capital Region Development Authority. (2020). About Amaravati.
Source

31. Aluri, S. (2024, August 13). Andhra Pradesh to develop new industrial development policy for 2024-2029. The Times of India.
Source

32. New Indian Express. (2024). New industrial policy should win trust of investors: CM Chandrababu Naidu to officials.
Source

33. Realty Plus Magazine. (2023). District Cooling For Decarbonizing Real Estate Sector.
Source

34. Abramskiehn, D., & Richmond, M. (2019). Cooling as a Service (CaaS) Lab Instrument Analysis. The Lab.
Source

35. SP Group. (n.d.). District Cooling and Heating.
Source

36. ST Life. Augmented Blog. (2022). Breakthrough: Singapore's Largest Industrial District Cooling System at ST's AMK TechnoPark, 1st Industrial Project for SP Group.
Source

37. UNDP Climate Promise. (2023). What is circular economy and why does it matter?
Source

38. The Hindu. (2024). Half of urban local bodies facing water shortage in Andhra Pradesh.
Source

39. Amaravati Development Corporation, & Andhra Pradesh Capital Region Development Authority. (2017). Smart City Amaravati Integrated Infrastructure Master Plan. Scribd.
Source

40. Bassi, N., Gupta, S., & Chaturvedi, K. (2023). Reuse of Treated Wastewater in India: Market Potential and Recommendations for Strengthening Governance. Council on Energy, Environment and Water (CEEW).
Source

41. Municipal Administration & Urban Development, Government of Andhra Pradesh. (2017). Policy On "Wastewater Reuse & Recycle for Urban Local Bodies" in Andhra Pradesh.
Source

42. Municipal Administration & Urban Development, Government of Andhra Pradesh. (2017). Policy On "Wastewater Reuse & Recycle for Urban Local Bodies" in Andhra Pradesh.
Source

43. Energy, Infrastructure & Investment Department, Government of Andhra Pradesh. (2018). Andhra Pradesh Solar Power Policy 2018.
Source

44. Indian Express. (2018). Thermal Battery Plant Unveiled in Andhra Pradesh: What Is Thermal Battery?
Source

45. District Energy St. Paul. (n.d.). Thermal Storage, District Energy.
Source

46. New & Renewable Energy Development Corporation of Andhra Pradesh. (n.d.). List of Project Developers.
Source

47. Power Technology. (2024). Power Plant Profile: Guntur Waste to Energy Plant, India.
Source

48. Power Technology. (2024). Power Plant Profile: Visakhapatnam Waste to Energy Plant, India.
Source

49. Andhra Pradesh Municipal Administration and Urban Development Department. (2020). National Mission for Clean Ganga Monthly Progress Report for October 2020.
Source

50. Shivangini. (2024). Will Amaravati become new greenfield IT capital of AP? Experts say Krishna River to bring sustainability and tourism.
Source

51. Amaravati Development Corporation, & Andhra Pradesh Capital Region Development Authority. (2017). Smart City Amaravati Integrated Infrastructure Master Plan. Scribd.
Source

52. Amaravati Development Corporation Ltd., & Andhra Pradesh Capital Region Development Authority. (2017). Smart City Amaravati Integrated Infrastructure Master Plan.
Source

53. Amaravati Development Corporation Ltd., & Andhra Pradesh Capital Region Development Authority. (2017). Smart City Amaravati Integrated Infrastructure Master Plan.
Source

54. Department of Science, Technology and Environment, Puducherry Climate Change Cell. (2022). Energy Benchmarking Guidelines for Climate Proofing Buildings in U.T. of Puducherry.
Source

55. Kumar, S., Sachar, S., Kachhawa, S., Goenka, A., Kasamsetty, S., & George, G. (2018). Demand Analysis of Cooling by Sector in India in 2027. Alliance for an Energy Efficient Economy.
Source

56. Andhra Pradesh State Energy Conservation Mission. (2023). Energy Conservation Policy: Final Draft.
Source

57. Bureau of Energy Efficiency, Government of India, Ministry of Power. (n.d.). Energy Conservation Building Code (ECBC).
Source

58. Natural Resources Defense Council. (2014). Indian State of Andhra Pradesh Adopts Energy Conservation Building Code, Becoming a National Leader in Building Efficiency.
Source

59. Akbar, S. (2019). Green mission: Amaravati buildings to get centralised cooling system. The Times of India.
Source

60. India Brand Equity Foundation. (n.d.). Industrial Development & Economic Growth in Andhra Pradesh.
Source

61. India Brand Equity Foundation. (n.d.). Industrial Development & Economic Growth in Andhra Pradesh.
Source

62. Rao, G. S. (2024). Phenomenal growth seen in industries, infrastructure in Andhra Pradesh. The Hindu.
Source

63. Government of Andhra Pradesh. (2020). Andhra Pradesh Industrial Development Policy 2020-23.
Source

64. Invest India. (n.d.). Business & Investment Opportunities in Andhra Pradesh.
Source

65. Samdani. (2024). Industries dept to explore avenues to bolster growth. The Times of India.
Source

66. India Brand Equity Foundation. (2023). Making India a Global Hub for Data Centre and Cloud Solutions. India Brand Equity Foundation.
Source

67. Kurmanath, K. V. (2023). Adani Group begins work on ₹21,844 crore data centres in Visakhapatnam, to create 50,000 Jobs. The Hindu BusinessLine.
Source

68. Adani Group. (2023). Adani to build India's first Integrated data center & technology business park in Andhra Pradesh.
Source

69. Bogoslaw, D. (2024). Too darn hot: Data centers need to cool off. Venture Capital Journal.
Source

70. Cool Coalition. (2023). India - Cool Coalition.
Source

71. Parija, P. (2024). Rotten Bananas in a Scorching India Expose Climate's Food Cost. Bloomberg UK.
Source

72. Directorate of Economics and Statistics, Andhra Pradesh. (n.d.). Agriculture & Farmers' welfare in Andhra Pradesh.
Source

73. NITI Aayog. (n.d.). Andhra Pradesh- Natural Farming.
Source

74. The Economic Times. (2024). Andhra Pradesh rides the wave, leads India's fishing and aquaculture sector with 41% share. The Economic Times.
Source

75. National Fisheries Development Board. (2021). World Fisheries Day 2021 Best Marine State in India – Andhra Pradesh.
Source

76. Department of Animal Husbandry, Dairying and Fisheries. (2017). Cold Chain and Post Harvest Infrastructure Development- 2022 Action Plan.
Source

77. Ministry of Cooperation. (2024). Fisheries in Co-operatives.
Source

78. Samdani. (2022). AP govt to construct cold storages in all villages. The Times of India.
Source