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FUTURE-PROOFING INDIA'S COOLING:

An Assessment of District Cooling System Integration within the ICAP Framework

Prepared by

Alliance for an Energy Efficient Economy

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FOREWORD

India's rapid urbanization and economic growth are driving an unprecedented rise in the demand for cooling – an essential service for human comfort, public health, and economic productivity. However, this growing demand also presents a pressing challenge: how to ensure access to cooling while minimizing the strain on energy systems and mitigating the impacts of climate change.

The India Cooling Action Plan (ICAP) charts a clear pathway to meet these goals by promoting sustainable and energy-efficient cooling solutions. Within this framework, District Cooling Systems (DCS) stand out as a transformative approach. By providing centralized, efficient, and low-emission cooling for entire districts or cities, DCS can significantly reduce electricity consumption, ease peak power demand, and lower reenhouse gas emissions –helping to balance development needs with environmental responsibility.

This report, "Future-Proofing India's Cooling: An Assessment of District Cooling System Integration within the ICAP Framework," offers a comprehensive analysis of how DCS can contribute to India's long-term cooling strategy. It highlights the potential of DCS to optimize energy use, improve grid stability, and enhance the resilience of urban infrastructure in the face of extreme heat and growing cooling needs.

The insights presented here underscore that DCS is not only a technical solution but a key enabler of sustainable urban growth. Its adoption can help India move toward a future where cooling is accessible to all, yet aligned with the nation's commitments to energy efficiency and Net Zero by 2070.

I encourage policymakers, planners, and industry leaders to draw on the findings of this report and to collaborate in accelerating the deployment of innovative cooling solutions. Together, we can ensure that India's growth remains both climate-smart and future-ready.

Shri Arijit Sengupta
Director
Bureau of Energy Efficiency

FOREWORD

As temperatures rise and cities grow denser, the need for cooling has become a defining challenge of India's urban future. Over the coming decade, this demand is set to surge – placing increasing pressure on the country's energy systems, affordability, and climate goals. India's own Cooling Action Plan and several national studies make it clear: traditional, buildingby-building cooling alone will not be enough. To meet the scale of this challenge, we must lookbeyond individual solutions toward shared, efficient, and resilient systems. District Cooling offers precisely such an opportunity – an approach that can make India's cooling transition smarter, cleaner, and more sustainable.

Germany has been playing a very active role in not only addressing these issues pertaining to its own land but also supporting the other countries to move towards sustainable living with lesser carbon footprints. Germany has been supporting India in various fields since last 60 years, with an aim of promoting cooperation and involving public-private sectors of both sides in the areas of energy, environment and sustainable economic development. Under the leadership of the Government of India and supported by the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN) as part of the International Climate Initiative (IKI), the Bureau of Energy Efficiency (BEE), with support from GIZ India, is advancing sustainable, energy-efficient cooling solutions that support India's energy transition. GIZ, in collaboration with partners including the Alliance for an Energy Efficient Economy (AEEE) and the United Nations Environment Programme (UNEP), has worked to build stakeholder consensus and develop the District Cooling Guidelines for India, launched in 2023. This District Cooling Roadmap builds on that foundation, outlining actionable strategies to scale DCS nationwide by identifying city and load typologies, proposing regulatory and tariff frameworks for viable business models, and providing guidance on technology selection, financing, and stakeholder engagement.

On behalf of the GIZ India team and the EE-Cool Project PMU, I extend our sincere gratitude to the Ministry of Power, Bureau of Energy Efficiency and all the stakeholders for their continued guidance and support. We hope this Roadmap serves as a catalyst for informed dialogue and coordinated action to overcome implementation challenges, unlock the potential of DCS, and accelerate India's transition to efficient, equitable, and climate-aligned cooling. Implemented at scale, district cooling can help keep India cool – without overheating its energy system.

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ABBREVIATIONS

AC	Air Conditioner
BAU	Business as Usual
CAGR	Compounded Annual Growth Rate
DCS	District Cooling System
ELFHs	Equivalent Full Load Hours
FAR	Floor Area Ratio
GHG	Greenhouse Gas
GW	Gigawatt
GWP	Global Warming Potential
ICAP	India Cooling Action Plan
IEA	International Energy Agency
IT	Information Technology
ITeS	Information Technology Enabled Services
kW	Kilowatt
MtCO2e	Million Tonnes of Carbon Dioxide Equivalent
MWh	Megawatt-Hour
SEZ	Special Economic Zones
tCO2	Tonne of Carbon Dioxide
TR	Tonnes of Refrigeration
TR-h	Tonnes of Refrigeration-Hours
TWh	Terawatt-Hour
VRF	Variable Refrigerant Flow

EXECUTIVE SUMMARY

As India experiences rapid urbanization and economic growth, the projected surge in cooling demand poses significant challenges to the country's energy infrastructure, particularly during peak periods exacerbated by climate change and extreme heat events. The India Cooling Action Plan (ICAP) forecasts an almost eightfold increase in aggregate cooling demand by 2037-38 compared to the 2017-18 baseline. Room air conditioners have been estimated to account for 40-60% of peak electricity load during the hottest hours, highlighting the critical need for innovative solutions to manage this demand.[1]

This report examines the integration of District Cooling Systems (DCS) within the ICAP framework for 2037-38, focusing on its implications for cooling demand, energy efficiency, and peak electricity load management. It evaluates two "what-if" scenarios of DCS integration.

- **Scenario 1**: Low DCS Integration in ICAP Cooling Demand Growth Projection for 2037-38
    - "What if DCS serve a total cooling capacity equivalent to ~2%, with varying contributions from each system type?"
- **Scenario 2**: High DCS Integration in ICAP Cooling Demand Growth Projection for 2037-38
    - "What if DCS serve a total cooling capacity equivalent to ~5%, with varying contributions from each system type?"

Key Findings

Cooling Capacity

DCS integration can significantly reduce reliance on conventional cooling systems:

Low DCS Integration (~2% penetration): Replaces ~15.1 million TR of conventional cooling capacity with ~**10.6 million TR of DCS**, reducing total cooling capacity by **4.5 million TR** from ~710 million TR to ~706 million TR.

High DCS Integration (~5% penetration): Replaces ~33.7 million TR of conventional cooling with ~**23.6 million TR of DCS**, lowering total cooling capacity by **10.1 million** TR to ~700 million TR.

These reductions leverage diverse cooling requirements in mixed-use developments, lowering the environmental impact of cooling.

1 N. Abhyankar, N. Shah, W. Y. Park, & A. Phadke, Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies (Lawrence Berkeley National Laboratory, 2017).

Energy Efficiency

DCS adoption improves energy efficiency, impact shown below:

Low DCS Integration (2%): Reduces cooling electricity consumption by ~3 TWh annually.

High DCS Integration (5%): Saves ~7 TWh, equivalent to the annual site energy generation of four typical thermal power plants in India.

Peak Demand Reduction

DCS can alleviate grid stress during peak hours:

Under the ICAP projections for 2037-38, peak electricity demand for cooling is estimated at ~312 GW.

Low DCS Integration (2%): Reduces peak demand by ~4 GW.

High DCS Integration (5%): Cuts peak demand by ~8 GW.

GHG Emissions

DCS adoption lowers greenhouse gas emissions, both indirect (energy consumption) and direct (refrigerant leakage):

Under the ICAP projections for 2037-38, the total GHG emissions is estimated at ~481 MtCO2e.

Low DCS Integration (2%): Reduces emissions by about 7 $MtCO_2e$, bringing the total to ~474 $MtCO_2e$.

High DCS Integration (5%): Cuts emissions by about 11 $MtCO_2e$, lowering the total to ~470 MtCO2e, equivalent to the carbon sequestration of ~500 million typical trees.

Conclusion

This report underscores the transformative potential of DCS in India's cooling strategy. By adopting DCS, India can transition to a sustainable, energy-efficient cooling landscape, meeting the needs of its growing population while addressing the dual challenges of climate change and energy demand. These insights provide a robust foundation for policymakers and stakeholders to shape a future-ready cooling framework.

1

INTRODUCTION

India's rapidly growing economy and increasing urbanization are expected to drive a significant rise in cooling requirements in the coming years, particularly given the country's currently low penetration of cooling solutions. Combined with rapid climate change and record-breaking temperatures, the demand for cooling is evolving from a luxury to a necessity. The India Cooling Action Plan (ICAP) projects that aggregate cooling demand will increase nearly eightfold by 2037-38 compared to the 2017-18 baseline.[2] The building sector alone is expected to experience the most significant growth, with cooling demand projected to rise nearly 11 times during this period.

Rising extreme heat events are pushing peak electricity demand to unprecedented levels every summer. India's peak demand is projected to grow from 243 GW in 2023-24 to 486 GW by 2037-38.[3] According to the International Energy Agency (IEA), cooling will be a major contributor to India's high peak demand by 2030. Despite relatively low penetration, room air conditioners already account for a significant share of peak demand, as they are predominantly used during peak hours, particularly in major metropolitan areas. By 2040-41, space cooling could account for as much as 80% of residential peak demand.[4]

In this context, innovative and sustainable cooling solutions are critical to addressing the dual challenges of meeting rising cooling needs and managing peak energy demand. District Cooling Systems (DCS) present a viable and energy-efficient alternative to conventional cooling methods, offering significant benefits, including reduced electricity consumption, lower peak energy demand, and decreased greenhouse gas (GHG) emissions.

This analysis explores the potential of DCS in addressing India's cooling needs in an environmentally sustainable manner. It highlights the importance of enabling policy frameworks to promote the widespread adoption of DCS in India, encouraging various actors to adopt these systems as part of their sustainability and energy management strategies.

The report evaluates the impact of varying levels of DCS adoption on the space cooling capacity projected under the ICAP. By examining these scenarios, it aims to provide actionable insights into how DCS integration could reshape India's cooling landscape and contribute to a more sustainable and efficient future. Key parameters analysed include:

- Cooling capacity (tonnes of refrigeration, TR)
- Cooling demand (tonnes of refrigeration-hours, TR-h)

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2 MoEF&CC. 2019. India Cooling Action Plan. [online] Available at: <https://ozonecell.nic.in/wp-content/uploads/2021/09/India-Cooling-Action-Plan-Actionable-Points.pdf>

3 Central Electricity Authority. (2022). Report on Twentieth Electric Power Survey of India (Volume I). New Delhi: Ministry of Power, Government of India. Retrieved from Ministry of Power, Government of India

4 Prayas (Energy Group). (2023). More with less: Insights from residential energy demand assessment using PIER.

- Electricity consumption (TWh or kWh)
- Peak energy demand (GW or kW)
- Greenhouse gas (GHG) emissions, including direct emissions from refrigerant leakages and indirect emissions from electricity consumption (MtCO2e)

This analysis provides a roadmap for integrating DCS into India's cooling strategy, offering both environmental and economic benefits while supporting the country's energy infrastructure in the face of growing demand.

About the Assessment

This analysis explores two "what-if" DCS integration scenarios for ICAP cooling capacity projection for 2037-38:

The scenarios are defined as follows:

- **Scenario 1:** Low DCS Integration in ICAP Cooling Demand Growth Projection for 2037-38
  - "What if DCS serve a total cooling capacity equivalent to ~2%, with varying contributions from each system type?"
- **Scenario 2:** High DCS Integration in ICAP Demand Growth Projection for 2037-38
  - "What if DCS serve a total cooling capacity equivalent to ~5%, with varying contributions from each system type?"

These scenarios offer valuable insights into how different levels of DCS integration could impact India's cooling strategy, driving a transition toward a more sustainable and energy-efficient future.

2

COOLING DEMAND PROJECTIONS

ICAP provides projections of working cooling capacity across fiscal years, helping to inform policy decisions and technology investments necessary to meet anticipated demand (Figure 1). The operational (working) cooling capacity, i.e., the total installed capacity minus stand-by capacity, is projected to increase from 147 million TR in 2023-24 to 710 million TR in 2037-38. These projections, which are based on data related to built-up area across India and cooling system sales, serve as a foundational reference for evaluating different cooling scenarios[5].

Multiple technologies could be utilised for space cooling. This analysis focuses on refrigerant-based cooling technologies analysed in ICAP and their displacement with District Cooling, a not-in-kind technology. The technologies analysed include room ACs, chiller systems, VRF systems and packaged DX. The residential sector is assumed to use only Room AC systems. The share of residential room ACs in total cooling capacity increases from 69% in 2023-24 to 82% in 2037-38.

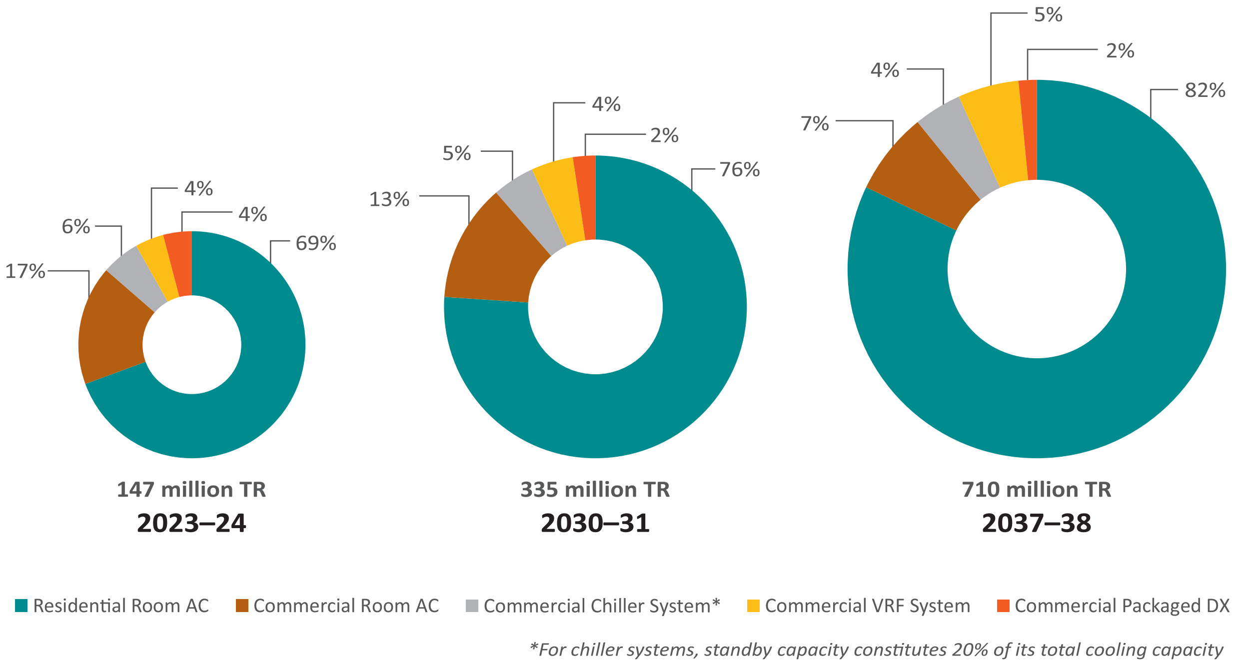


Figure 1: *ICAP's cooling capacity projections (in million TR)*

5 Kumar, Satish, Neha Yadav, Mohini Singh, and Sandeep Kachhawa. (2019). 'Estimating India's Commercial Building Stock to Address the Energy Data Challenge'. Building Research & Information.; MoEF&CC. 2019. 'India Cooling Action Plan'. Ozone Cell, MOEFCC.

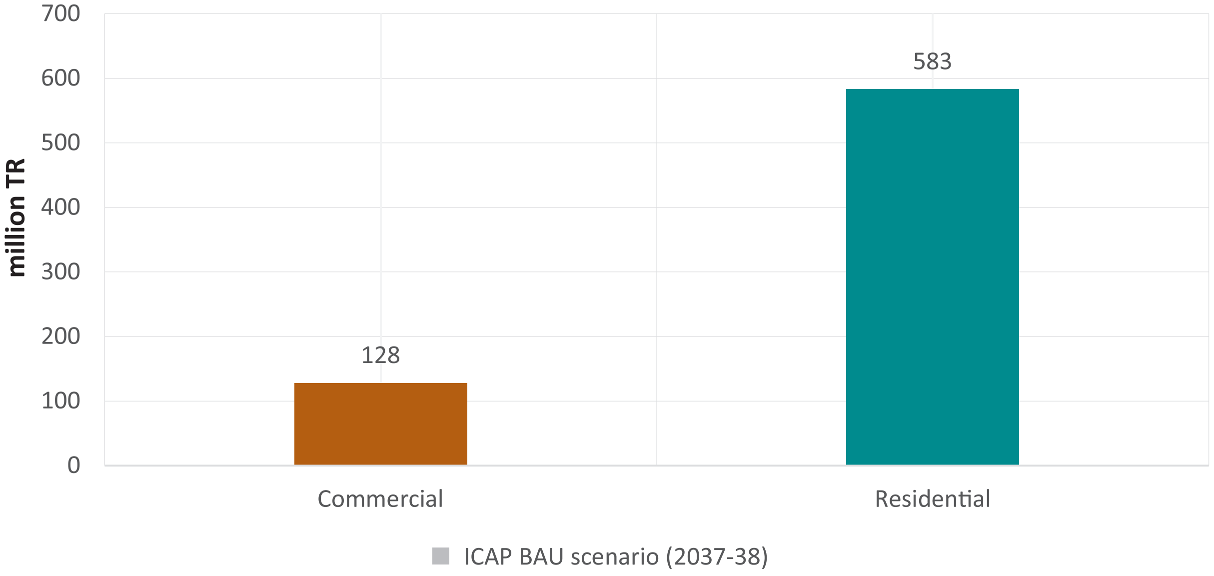


Figure 2: *Operational (Working) cooling capacities in ICAP BAU scenario for residential and commercial buildings in 2037-38*

3

MODEL INPUTS AND ASSUMPTIONS

3.1 Key Inputs and Assumptions

3.1.1 Equivalent Full Load Hours (EFLH) Assumptions

Equivalent full-load cooling hours (EFLH) are the number of hours an air conditioner would have to operate at full load (rated cooling capacity) to equal the amount of cooling delivered by the system over a cooling season. An EFLH of 5000 is considered for 24-hour commercial cooling demand, 2500 for commercial daytime cooling loads and 1500 is considered for residential buildings (Table 1).

Table 1: *Equivalent Full Load Hours (ELFH)*

Building type		Annual EFLH (hours)
Residential buildings	Operation as needed (single-storey, multi-storey)	1500
Commercial buildings	Daytime operational (retail, office, education, and assembly buildings)	2500
	24-hour operational (hospital, hotel, transit, and warehouse)	5000

3.1.2 Energy Efficiency Assumptions

Table 2 outlines the electrical efficiency assumptions for various types of cooling systems. It includes the annual average electrical operating efficiency, measured in kWh/TR-h, to estimate electricity consumption, and the full-load rated efficiency, measured in kW/TR, to determine the connected electrical load.

The analysis assumes a 2% CAGR improvement in efficiency between 2023-24 and 2037-38 under the BAU scenario.

Table 2: *Electrical Efficiency Assumption*

Cooling system type	Annual Average Operating Efficiency (kWh/TRh)	
	2023-24	ICAP BAU 2037-38
RAC	0.88[6]	0.66
Chiller System	1.00[7]	0.75
VRF System	0.65[8]	0.49
Packaged DX	1.26[9]	0.95
DCS	0.80[10]	0.60
Cooling system type	**Full Load Rated Efficiency (kW/TR)**	
	2023-24	**ICAP BAU 2037-38**
RAC	1.17[11]	0.88
Chiller System	1.06[12]	0.80
VRF System	1.13[13]	0.85
Packaged DX	1.26[14]	0.95
DCS	0.94[15]	0.71

6. Rated Indian Seasonal Energy Efficiency Ratio (ISEER) of 4 Wh/Wh for a 3-Star BEE-labelled inverter split air conditioner with a cooling capacity of 1.42 TR (5 kWr).

7. Rated ISEER of 6.25 Wh/Wh (0.56 kWh/TRh) for a 2-Star BEE-labelled water-cooled screw chiller with a cooling capacity of 411 TR (1444 kWr). Assumes 0.06 kWh/TRh each for Energy Conservation and Sustainable Building Code (ECSBC) 2024-compliant chilled water pumps (18.2 W/kWr), condenser water pumps (17.7 W/kWr), and cooling tower fans (17 W/kWr). The Energy Conservation Building Code (ECBC) 2017 was referenced for cooling tower fan efficiency, as this is not specified in ECSBC 2024. Additionally, 0.25 kWh/TRh was assumed for air handling units (AHUs).

8. ISEER of 5.4 Wh/Wh for ECSBC 2024-compliant air-cooled VRF air conditioners with a rated cooling capacity of less than 11.4 TR (40 kWr).

9. Assumes 1.26 kWh/TRh for ECSBC 2024-compliant air-cooled ducted split and packaged air conditioners with a rated cooling capacity exceeding 3 TR (10.5 kWr) and a rated full-load COP of 1.26 kW/TR.

10. Rated ISEER of 9.21 Wh/Wh (0.38 kWh/TRh) for a 5-Star BEE-labelled water-cooled centrifugal chiller with a cooling capacity of 1075 TR (3781 kWr). Assumes 0.05 kWh/TRh each for Super ECSBC 2024-compliant chilled water pumps (14.9 W/kWr) and condenser water pumps (14.6 W/kWr). Assumes 0.06 kWh/TRh for ECBC 2017-compliant cooling tower fans (17 W/kWr), as this is not specified in ECSBC 2024. Additionally, 0.25 kWh/TRh was assumed for AHUs.

11. Rated full-load COP for a 3-Star BEE-labeled inverter split air conditioner with a cooling capacity of 1.42 TR (5 kWr) and a rated power consumption of 1.67 kW.

12. Rated full-load COP of 0.63 kW/TR for a 2-Star BEE-labelled water-cooled screw chiller with a cooling capacity of 411 TR (1444 kWr) and a rated power consumption of 256.9 kW. Assumes 0.06 kW/TR each for ECSBC 2024-compliant chilled water pumps (18.2 W/kWr), condenser water pumps (17.7 W/kWr), and cooling tower fans (17 W/kWr). ECBC 2017 was referenced for cooling tower fan efficiency, as this is not specified in ECSBC 2024. Additionally, 0.25 kW/TR was assumed for AHUs.

13. Rated full-load COP for a 12 HP (~9.6 TR) side-discharge VRF unit.

14. Rated full-load COP for ECSBC 2024-compliant air-cooled ducted split and packaged air conditioners with a rated cooling capacity exceeding 3 TR (10.5 kWr).

15. Rated full-load COP of 0.53 kW/TR for a 5-Star BEE-labelled water-cooled centrifugal chiller with a cooling capacity of 1075 TR (3781 kWr) and a rated power consumption of 570 kW. Assumes 0.05 kW/TR each for Super ECSBC 2024-compliant chilled water pumps (14.9 W/kWr) and condenser water pumps (14.6 W/kWr). Assumes 0.06 kW/TR for ECBC 2017-compliant cooling tower fans (17 W/kWr), as this is not specified in ECSBC 2024. Additionally, 0.25 kW/TR was assumed for AHUs.

3.1.3 Peak load-related assumptions

Peak load diversity across systems including DCS due to the non-simultaneity of the occurrence of peak loads across India is assumed to be 50% under the ICAP BAU scenario. This diversity is a result of operational and weather variations.

3.1.4 Indirect and direct emissions-related assumption

The indirect emissions in 2037-38 are calculated based on electricity consumption using a grid emission factor of 0.43 tCO2/MWh, corresponding to the Central Electricity Authority's (CEA, 2023)[16] projections for 2031-32. The direct emissions are calculated using the share of refrigerants used in each cooling system type (mentioned in Table 3), their refrigerant charge rate[17] and global warming potential.

Table 3: *Share of refrigerants used in various cooling systems in 2037-38 (Source: Author's analysis)*

Refrigerant	Cooling system	Share of refrigerant (%)
R-22	RAC	5%
R-32		65%
R-454B		5%
R-290		25%
R-134A	Chiller System	30%
R-513A		40%
R-290		5%
R-717		10%
R-1233zd		5%
R-514A		10%
410A	VRF System	20%
R-407C		10%
R-454B		10%
R-32		60%
410A	Packaged DX	20%
R-407C		10%
R-454B		10%
R32		60%

16. CEA. (2023). 'National Electricity Plan'. Ministry of Power.

17. 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.; IPCC, 2023: Climate Change 2023: Synthesis Report. IPCC.

3.2 Other Assumptions

Various other modelling assumptions are presented in Tables 4 and 5.

Table 4: *Life of cooling systems, annual replacement ratio and refrigerant charge rate (Source: Author's analysis)*

Cooling systems	Life of cooling systems (Years)	Annual replacement ratio (%)	Refrigerant charge rate (kg/TR)
Room AC	10	9%	0.7
Chiller system	25	16%	1.0
VRF system	25	5%	0.8
Packaged DX	25	10%	0.9
DCS	30	-	-

Table 5: *Global warming potential of refrigerants*[18]

Refrigerants	Global Warming Potential
R-22	1810
R-32	675
R-410A	2088
R-407c	1774
R-290	3
R-134A	1430
R-513A	629
R-123	325
R-1233zd	3.9
R-454B	466
R-514A	2

3.2.1 DCS-related assumptions

- Since chilled water supply temperatures rise corresponding to ~2-3 km (pre-insulated pipe) network length, 3% distribution network losses are considered.
- While calculating the peak electricity demand for District Cooling Systems, an additional 30% reduction (on top of the Full Load Rated Efficiency of 0.94 kW/TR) is assumed due to integration of thermal energy storage systems.

18. IPCC. (2022). Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press., doi:10.1017/9781009325844.

3.3 Cooling demand met under the base case

The 'cooling demand met' (Figure 4) was calculated from the 'working cooling capacity' using the estimated annual Equivalent Full Load Hours (EFLH) for different building types, as detailed in (Table 1).

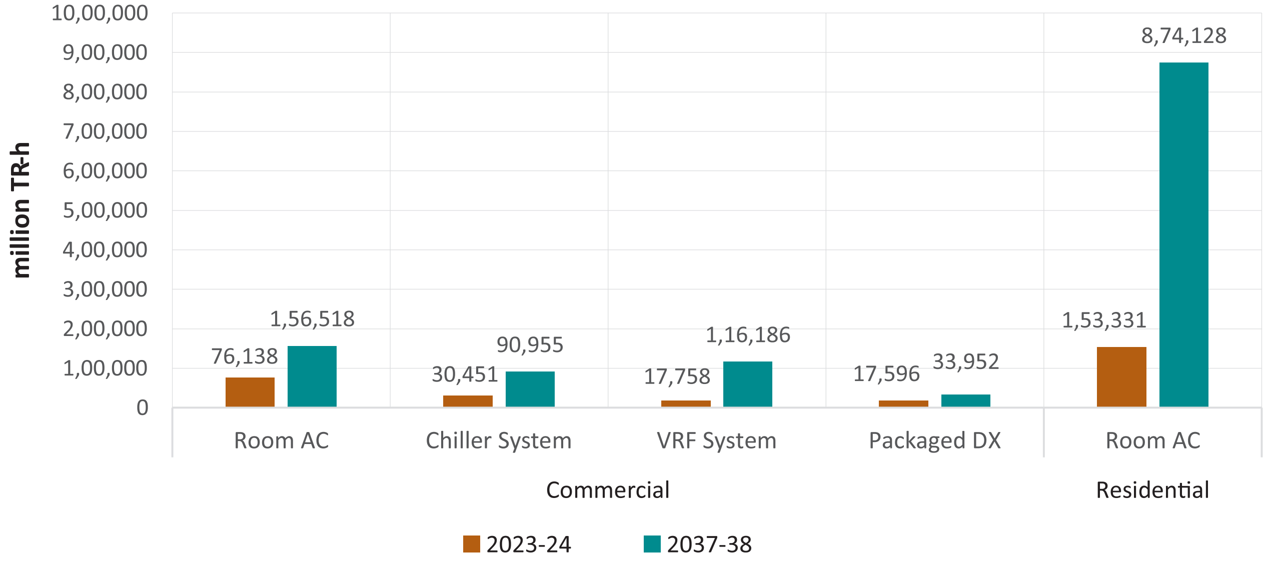


Figure 3: *System-wise cooling demand in 2023-24 and 2037-38 based on ICAP*

Subsequently, electricity consumed (Figure 4 below) for each case was calculated from the cooling demand met (Figure 3 above) using the assumed annual average operating efficiency factors provided in Table 2 for different cooling system types which combine both high and low sides.

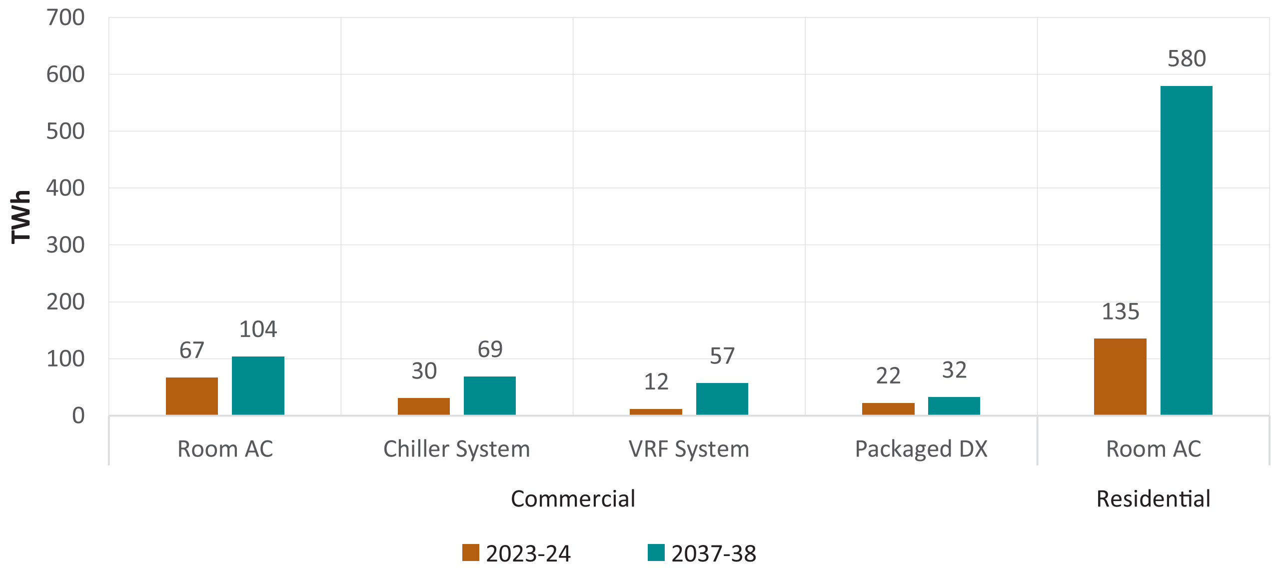


Figure 4: *System-wise electricity consumption in 2023-24 and 2037-38 based on ICAP*

4

INTEGRATING DISTRICT COOLING SYSTEMS INTO FUTURE COOLING CAPACITIES

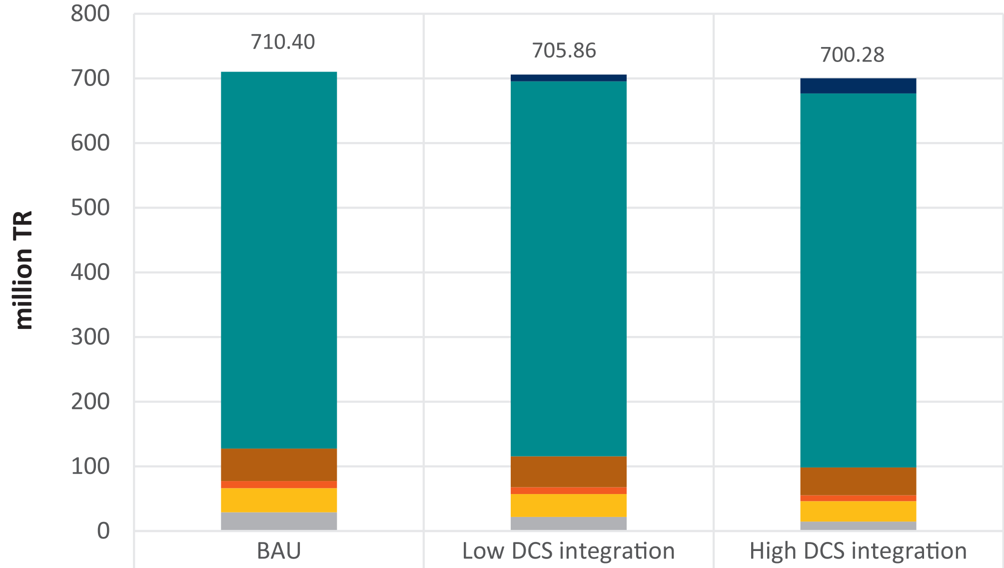
Integrating DCS into future cooling capacities can generate at least 30% reduced primary energy consumption and peak load compared to conventional cooling systems. DCS leverages the diversity of cooling loads across multiple buildings within a cluster, allowing for optimised operation and maximum efficiency throughout the entire load profile of space cooling requirements. Unlike individual cooling units, which often function at reduced efficiency, DCS can adapt to varying demands in real-time, resulting in significant reductions in installed capacity and energy consumption.

This analysis assumes DCS to replace different conventional cooling technologies with varying contributions from each system type.

Table 6: *Share of Cooling Technologies Replaced by District Cooling Systems under Low and High Integration Scenarios*

Building Type	Cooling System Type	Low DCS Integration	High DCS Integration
Commercial	Room AC	5%	15%
Commercial buildings	Chiller System	25%	50%
	VRF System	5%	15%
	Packaged DX	5%	15%
Residential	Room AC	0.50%	0.75%
Net on Total Cooling Capacity		2.13% (~2%)	4.75% (~5%)

The final installed cooling capacity of these DCS facilities would account for a cooling load reduction of 30% over what was replaced in the conventional scenario. This reduction is due to an assumed cooling load diversity of 70% owing to the mixed development nature of localities with DCS potential. While the total cooling capacity falls with the ~2% and ~5% integration of DCS to ~706 and ~700 million TR, the total 'cooling demand met' remains the same at 1271 billion TR-h.



	BAU	Low DCS integration	High DCS integration
Either Comm. / Resi. DCS		10.60	23.62
Residential Room AC	582.75	579.84	578.38
Commercial Room AC	50.25	47.74	42.71
Commercial Packaged DX	10.90	10.36	9.27
Commercial VRF System	37.30	35.44	31.71
Commercial Chiller System	29.20	21.90	14.60

Figure 5: *Change in cooling capacity of ICAP BAU scenario with DCS integration cases in 2037-38*

Adoption of DCS can also provide a substantial reduction in energy consumption.

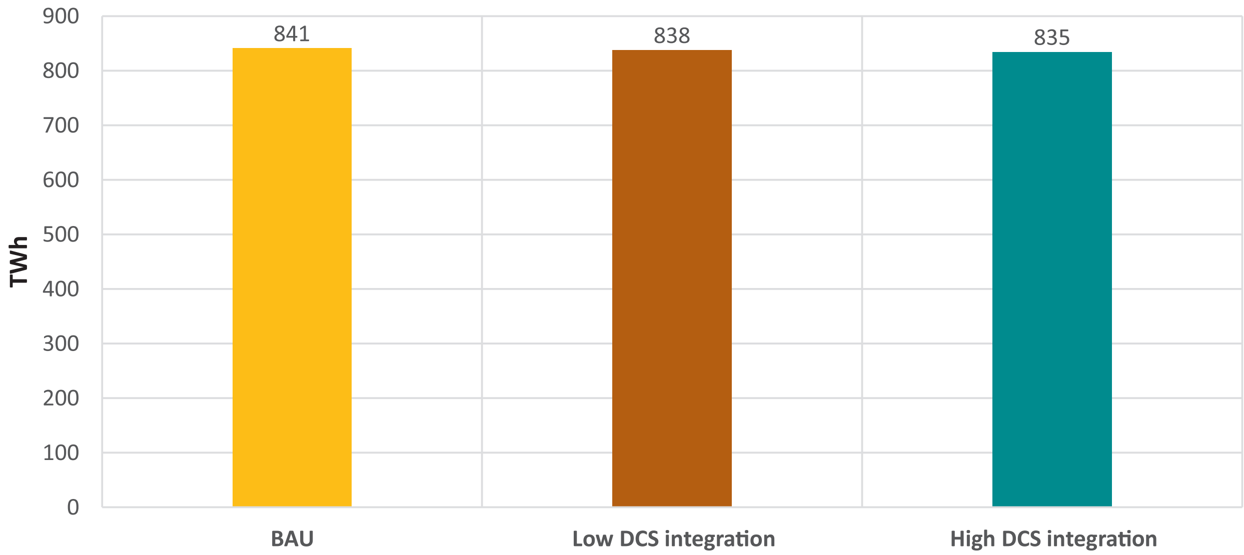


Figure 6: *Reduction in electricity consumption with the integration of DCS in 2037-38*

The peak energy demand that would be required to meet the cooling demand is estimated by utilising the connected electrical load derived from system efficiency in kW/TR. A peak load diversity of 50% across systems is also factored in considering the non-simultaneity of the occurrence of peak loads across India owing to operational and weather variations. Additionally, a 30% peak load reduction was accounted for DCS systems in ICAP BAU due to potential thermal energy storage systems.

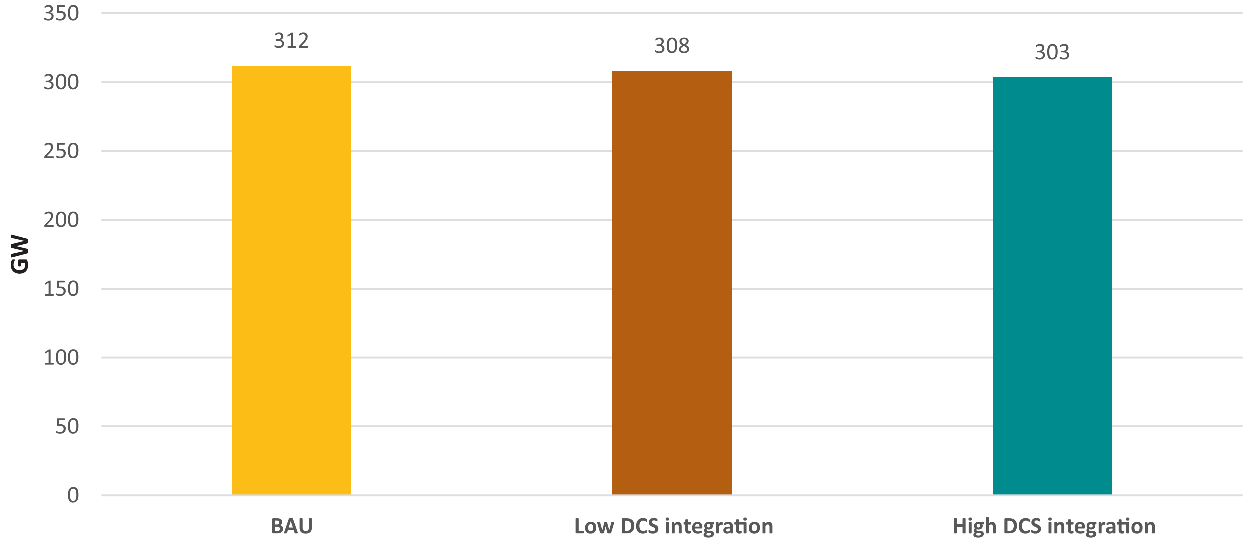


Figure 7: *Required peak energy demand with the integration of DCS in 2037-38*

Adoption of DCS also reduces both direct (refrigerant-based emissions) and indirect (emissions from electricity use) emissions. The indirect emissions are calculated from electricity consumed considering an emission factor of 0.43 tCO_2/MWh[19] in 2037-38. The direct emissions from refrigerant leakage are calculated using the share of refrigerants (Table 4) used in each cooling system type, their refrigerant charge rate[20] and global warming potential.

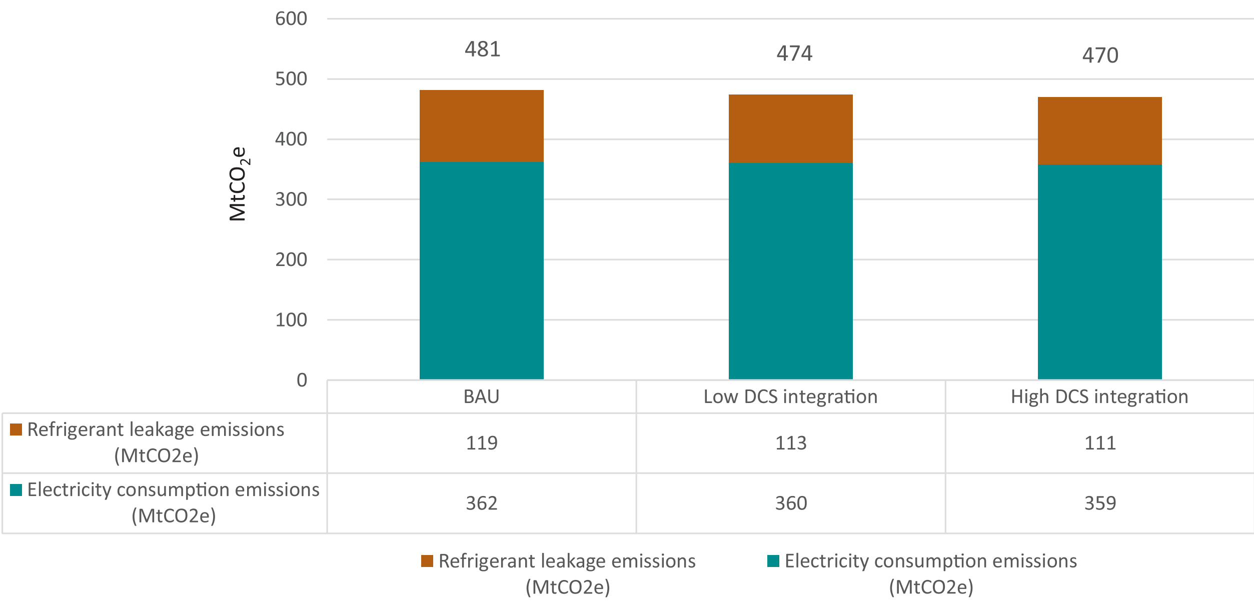


Figure 8: *Direct and indirect emission with DCS integration cases within ICAP scenarios in 2037-38*

19. CEA. (2023). 'National Electricity Plan'. Ministry of Power.

20. 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.; IPCC, 2023: Climate Change 2023: Synthesis Report. IPCC.

5

EXPLORING THE FEASIBILITY OF DCS INTEGRATION CASES

The previous section examined the impact of integrating DCS into future cooling capacities as an efficient alternative for conventional cooling systems. The projected impact is estimated using ~2% and ~5% DCS integration under the ICAP-BAU scenario. This section will explore whether such levels of DCS integration are feasible in India.

5.1 Analysing IT-ITES SEZs

IT/ITeS buildings are among the largest consumers of refrigerant-based space cooling globally. India has designated Special Economic Zones (SEZs) specifically for IT/ITeS businesses. Data on the total allocated area for 220 notified IT/ITeS SEZs as of 2022 was analysed. The utilised area for each SEZ was estimated based on the state-wise share of utilised land, and the built-up area was calculated using the maximum Floor Area Ratio (FAR) specified for major cities in the respective states. This built-up area was converted into air-conditioned space, which formed the basis for estimating cooling capacity in India's IT/ITeS SEZs for 2023-24. The total cooling capacity for these SEZs is estimated at approximately 1.2 million TR.

By setting a threshold of 5,000 TR of cooling capacity as the eligibility criterion for a merchant District Cooling System (DCS) installation, about 0.92 million TR of cooling capacity in IT/ITeS SEZs could potentially be converted to DCS in 2023-24. This potential rises to ~2.29 million TR by 2037-38, which can be effectively met through merchant DCS plants.

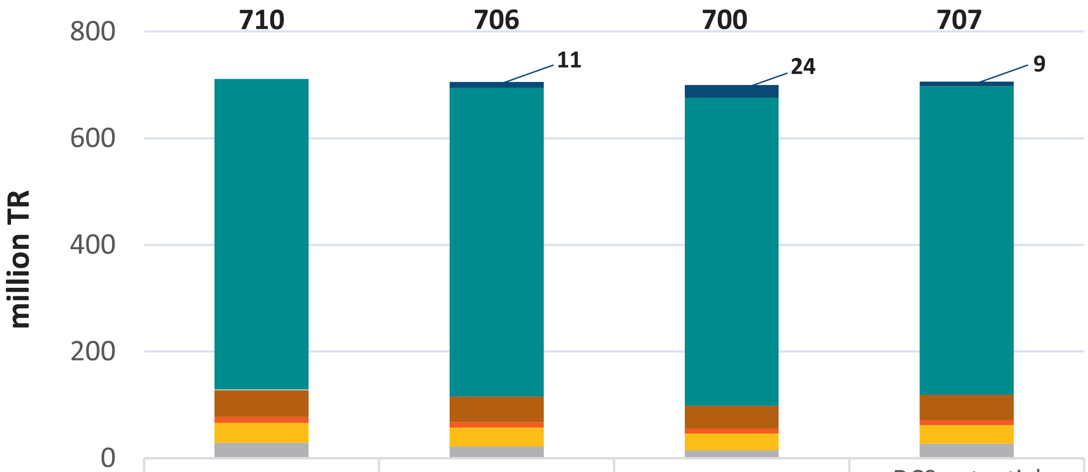
To provide context, the total cooling capacity for office buildings in India in 2023-24 is estimated at 18 million TR, out of the total commercial building cooling capacity of 47 million TR. Apart from office buildings, the commercial building segment includes hospitals, hotels, retail spaces, educational institutions, assembly places, transit hubs, and warehouses. By 2037-38, the total cooling capacity for office buildings in India is projected to reach ~44 million TR, while the overall commercial building cooling capacity is expected to grow to 135 million TR.[21]

The estimated ~2.29 million TR of DCS-ready cooling capacity in IT/ITeS SEZs by 2037-38 represents just 5% of the total office building cooling capacity and 2% of the total commercial building cooling capacity. Comparable levels of cooling demand are evident across other building typologies, both within and outside SEZs. **Consequently, achieving the projected DCS integration scenarios under the ICAP cooling demand growth projections—2% (~11 million TR) or 5% (~24 million TR) penetration in overall cooling demand by 2037–38—is both realistic and attainable.** For scale, the low and high DCS integration scenarios by 2037–38 are equivalent to approximately 550 and 1,200 DCS plants of 20,000 TR each, respectively. In practice, however, plant capacities are highly variable, ranging from ~5,000 TR for campus-scale systems to more than 50,000 TR for city-scale networks.

21. Kumar, Satish, Neha Yadav, Mohini Singh, and Sandeep Kachhawa. (2019). 'Estimating India's Commercial Building Stock to Address the Energy Data Challenge'. Building Research & Information.

5.2 Comparing the results with the National District Cooling Potential Study for India

The National District Cooling Potential Study[22] for India under the District Energy in Cities initiative in 2021 analysed the projected commercial and residential development in 21 Tier 1 and Tier 2 cities of India. The study followed a bottom-up approach using data from city master plans in the selected cities. The study concluded that under an optimistic scenario, it is projected that around 9 million TR of space cooling in new commercial buildings can be tapped by district cooling systems in these 21 cities, which would need about 274 district cooling plants by 2037-38. It can be observed from Figure 9 that the DCS installations potential estimated under the study are similar to the low DCS integration scenario (ICAP BAU) of the current study.



	ICAP-BAU	Low DCS integration (2%)	High DCS integration (5%)	DCS potential estimated by EESL study
Either Comm. / Resi. DCS	0	11	24	9
Residential Room AC	583	580	578	579
Commercial Room AC	50	48	43	48
Commercial Packaged DX	11	10	9	9
Commercial VRF System	37	35	32	35
Commercial Chiller System	29	22	15	27

Commercial Chiller System | Commercial VRF System | Commercial Packaged DX
Commercial Room AC | Residential Room AC | Either Comm. / Resi. DCS

Figure 9: *Comparing the cooling capacity of scenarios with that of the EESL-UNEP study's optimistic scenario*

22. EESL, UNEP, C2E2, & PwCPL. (2021). National District Cooling Potential Study for India. New Delhi.

6

PARAMETRIC ANALYSIS

A parametric analysis was conducted to evaluate how varying key assumptions and input parameters affect the outcomes of DCS integration into future cooling capacities. By examining the influence of factors such as energy efficiency and usage levels, this analysis provides insight into the robustness of the projected impacts and identifies which variables most significantly influence results. Sensitivity analysis is essential in understanding the range of possible scenarios and uncertainties, helping to refine planning and policy recommendations for DCS implementation under different conditions and assumptions.

6.1 Framework for the parametric analysis

The analysis focuses on adjusting two key variables: efficiency levels and Equivalent Full Load Hours (EFLH) (usage levels) for the four primary cases outlined in Section 1.1. This approach results in a total of 18 projections, as summarized in Table 7.

Table 7: *Framework for the parametric analysis*

S. No.	Projection Name	Parameters		
		Type	Scenario 1: Low DCS Integration in ICAP BAU	Scenario 2: High DCS Integration in ICAP BAU
1	Balanced Projections	Efficiency	Balanced Efficiency Improvement	Balanced Efficiency Improvement
		EFLH	Moderate Usage	Moderate Usage
2	Aggressive Efficiency Improvement Projections	Efficiency	Aggressive Efficiency Improvement	Aggressive Efficiency Improvement
		EFLH	Moderate Usage	Moderate Usage
3	Conservative Efficiency Improvement Projections	Efficiency	Conservative Efficiency Improvement	Conservative Efficiency Improvement
		EFLH	Moderate Usage	Moderate Usage
4	High Usage Projections	Efficiency	Balanced Efficiency Improvement	Balanced Efficiency Improvement
		EFLH	High Usage	High Usage

S. No.	Projection Name	Parameters		
		Type	Scenario 1: Low DCS Integration in ICAP BAU	Scenario 2: High DCS Integration in ICAP BAU
5	Low Usage Projections	Efficiency	Balanced Efficiency Improvement	Balanced Efficiency Improvement
		EFLH	Low Usage	Low Usage
6	Aggressive Efficiency Improvement & High Usage Projections	Efficiency	Aggressive Efficiency Improvement	Aggressive Efficiency Improvement
		EFLH	High Usage	High Usage
7	Conservative Efficiency Improvement & High Usage Projections	Efficiency	Conservative Efficiency Improvement	Conservative Efficiency Improvement
		EFLH	High Usage	High Usage
8	Aggressive Efficiency Improvement & Low Usage Projections	Efficiency	Aggressive Efficiency Improvement	Aggressive Efficiency Improvement
		EFLH	Low Usage	Low Usage
9	Conservative Efficiency Improvement & Low Usage Projections	Efficiency	Conservative Efficiency Improvement	Conservative Efficiency Improvement
		EFLH	Low Usage	Low Usage

6.1.1 Efficiency levels

Table 8: *Balanced Efficiency Improvement*

	2023-24	BAU	
			2037-38
	Annual Average Operating Efficiency Assumption (kWh/TRh)	CAGR (from 2023-24 to 2037-38)	Annual Average Operating Efficiency Assumption (kWh/TRh)
RAC	0.88	-2%	0.66
Chiller System	1.00	-2%	0.75
VRF System	0.65	-2%	0.49
Packaged DX	1.26	-2%	0.95
DCS	0.80	-2%	0.60
	2023-24	BAU	
			2037-38
	Rated Full Load Efficiency (kW/TR)	CAGR (from 2023-24 to 2037-38)	Rated Full Load Efficiency (kW/TR)
RAC	1.17	-2%	0.88
Chiller System	1.06	-2%	0.80
VRF System	1.13	-2%	0.85
Packaged DX	1.26	-2%	0.95
DCS	0.94	-2%	0.71

Table 9: *Aggressive Efficiency Improvement*

	2023-24	BAU	
			2037-38
	Annual Average Operating Efficiency Assumption (kWh/TRh)	CAGR (from 2023-24 to 2037-38)	Annual Average Operating Efficiency Assumption (kWh/TRh)
RAC	0.88	-3%	0.57
Chiller System	1.00	-3%	0.65
VRF System	0.65	-3%	0.42
Packaged DX	1.26	-3%	0.82
DCS	0.80	-3%	0.52
	2023-24	BAU	
			2037-38
	Rated Full Load Efficiency (kW/TR)	CAGR (from 2023-24 to 2037-38)	Rated Full Load Efficiency (kW/TR)
RAC	1.17	-3%	0.76
Chiller	1.06	-3%	0.69
Chiller System	1.13	-3%	0.74
Packaged DX	1.26	-3%	0.82
DCS	0.94	-3%	0.61

Table 10: *Conservative Efficiency Improvement*

	2023-24	**BAU**	
			2037-38
	Annual Average Operating Efficiency Assumption (kWh/TRh)	**CAGR (from 2023-24 to 2037-38)**	**Annual Average Operating Efficiency Assumption (kWh/TRh)**
RAC	0.88	-1%	0.76
Chiller System	1.00	-1%	0.87
VRF System	0.65	-1%	0.56
Packaged DX	1.26	-1%	1.09
DCS	0.80	-1%	0.69
	2023-24	**BAU**	
			2037-38
	Rated Full Load Efficiency (kW/TR)	**CAGR (from 2023-24 to 2037-38)**	**Rated Full Load Efficiency (kW/TR)**
RAC	1.17	-1%	1.02
Chiller System	1.06	-1%	0.92
VRF System	1.13	-1%	0.98
Packaged DX	1.26	-1%	1.09
DCS	0.94	-1%	0.82

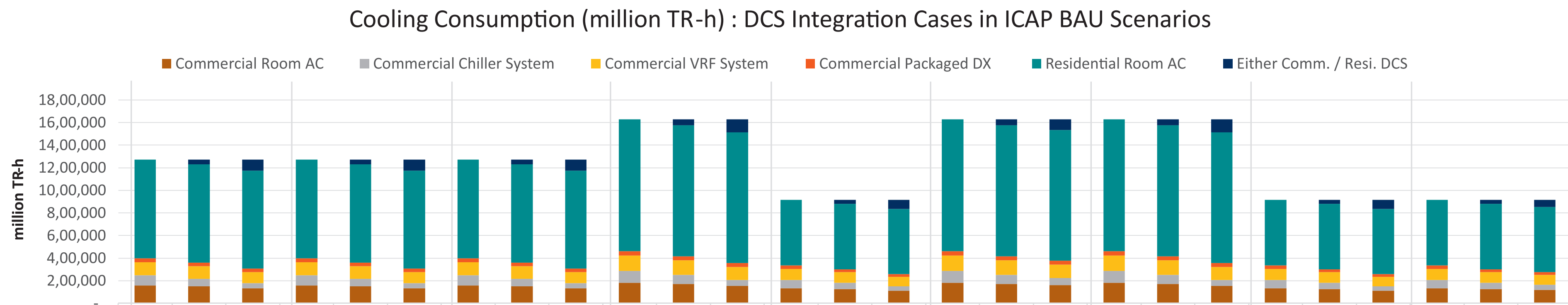
6.1.2 Usage levels

Table 11: *Usage levels across building types*

	Moderate Usage		**High Usage**		**Low Usage**	
	EFLH	**% Annual Operation**	**EFLH**	**% Annual Operation**	**EFLH**	**% Annual Operation**
Residential buildings	1500	17%	2000	23%	1000	11%
Commercial buildings-Daytime operational	2500	29%	3000	34%	2000	23%
Commercial buildings-24-hours operational	5000	57%	5500	63%	4500	51%

6.2 Analysis and results

The impact of changes in efficiency and usage levels are observed for four key variables – cooling demand met, electricity consumption required to meet the cooling demand, peak load catering to the installed capacity and total emissions.

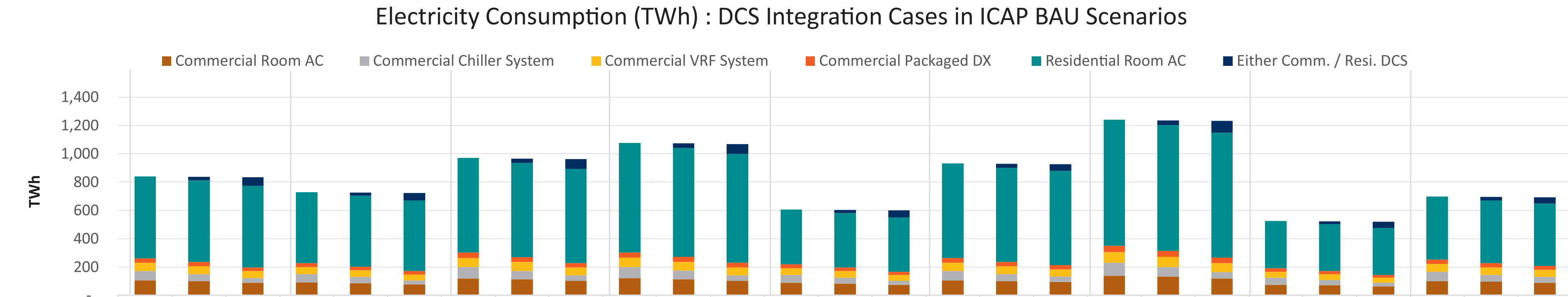


	Balanced			Aggressive Efficiency Improvement			Conservative Efficiency Improvement		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		42,442	98,032		42,442	98,032		42,442	98,032
Residential Room AC	8,74,128	8,69,757	8,67,572	8,74,128	8,69,757	8,67,572	8,74,128	8,69,757	8,67,572
Commercial Packaged DX	33,952	32,255	28,860	33,952	32,255	28,860	33,952	32,255	28,860
Commercial VRF System	1,16,186	1,10,376	98,758	1,16,186	1,10,376	98,758	1,16,186	1,10,376	98,758
Commercial Chiller System	90,955	68,216	45,477	90,955	68,216	45,477	90,955	68,216	45,477
Commercial Room AC	1,56,518	1,48,692	1,33,041	1,56,518	1,48,692	1,33,041	1,56,518	1,48,692	1,33,041

	High Usage			Low Usage			Aggressive Efficiency Improvement & High Usage		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		50,010	1,14,901		34,874	81,163		50,010	91,708
Residential Room AC	11,65,503	11,59,676	11,56,762	5,82,752	5,79,838	5,78,381	11,65,503	11,59,676	11,56,762
Commercial Packaged DX	39,402	37,432	33,492	28,502	27,077	24,227	39,402	37,432	34,967
Commercial VRF System	1,34,836	1,28,094	1,14,610	97,536	92,659	82,905	1,34,836	1,28,094	1,19,656
Commercial Chiller System	1,05,555	79,166	52,777	76,355	57,266	38,177	1,05,555	79,166	62,653
Commercial Room AC	1,81,642	1,72,560	1,54,396	1,31,394	1,24,824	1,11,685	1,81,642	1,72,560	1,61,193

	Conservative Efficiency Improvement & High Usage			Aggressive Efficiency Improvement & Low Usage			Conservative Efficiency Improvement & Low Usage		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		50,010	1,14,901		34,874	81,163		34,874	62,187
Residential Room AC	11,65,503	11,59,676	11,56,762	5,82,752	5,79,838	5,78,381	5,82,752	5,79,838	5,78,381
Commercial Packaged DX	39,402	37,432	33,492	28,502	27,077	24,227	28,502	27,077	25,433
Commercial VRF System	1,34,836	1,28,094	1,14,610	97,536	92,659	82,905	97,536	92,659	87,034
Commercial Chiller System	1,05,555	79,166	52,777	76,355	57,266	38,177	76,355	57,266	46,257
Commercial Room AC	1,81,642	1,72,560	1,54,396	1,31,394	1,24,824	1,11,685	1,31,394	1,24,824	1,17,247

Figure 10: *Cooling consumption (million TR-h) for different DCS integration cases in ICAP BAU scenarios*

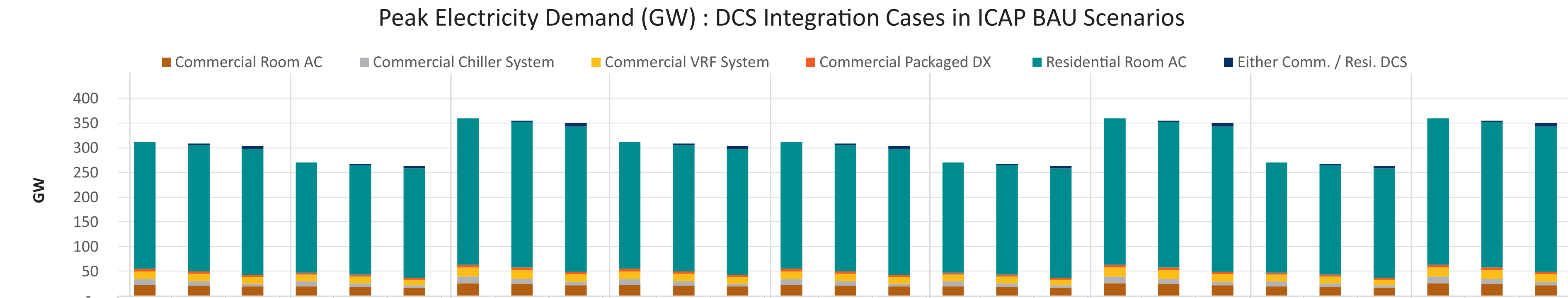


	Balanced			Aggressive Efficiency Improvement			Conservative Efficiency Improvement		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		26	61		23	53		30	70
Residential Room AC	580	577	575	502	500	498	668	665	663
Commercial Packaged DX	32	31	27	28	27	24	37	35	32
Commercial VRF System	57	54	48	49	47	42	66	62	56
Commercial Chiller System	69	51	34	59	45	30	79	59	40
Commercial Room AC	104	99	88	90	85	76	120	114	102

	High Usage			Low Usage			Aggressive Efficiency Improvement & High Usage		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		31	71		22	50		27	49
Residential Room AC	773	769	767	386	385	384	670	666	665
Commercial Packaged DX	37	36	32	27	26	23	32	31	29
Commercial VRF System	66	63	56	48	45	41	57	54	51
Commercial Chiller System	80	60	40	58	43	29	69	52	41
Commercial Room AC	120	114	102	87	83	74	104	99	93

	Conservative Efficiency Improvement & High Usage			Aggressive Efficiency Improvement & Low Usage			Conservative Efficiency Improvement & Low Usage		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		36	82		19	44		25	45
Residential Room AC	891	887	884	335	333	332	446	443	442
Commercial Packaged DX	43	41	37	23	22	20	31	30	28
Commercial VRF System	76	72	65	41	39	35	55	52	49
Commercial Chiller System	92	69	46	50	37	25	66	50	40
Commercial Room AC	139	132	118	75	72	64	100	95	90

Figure 11: *Electricity consumption (TWh) for different DCS integration cases in ICAP BAU scenarios*

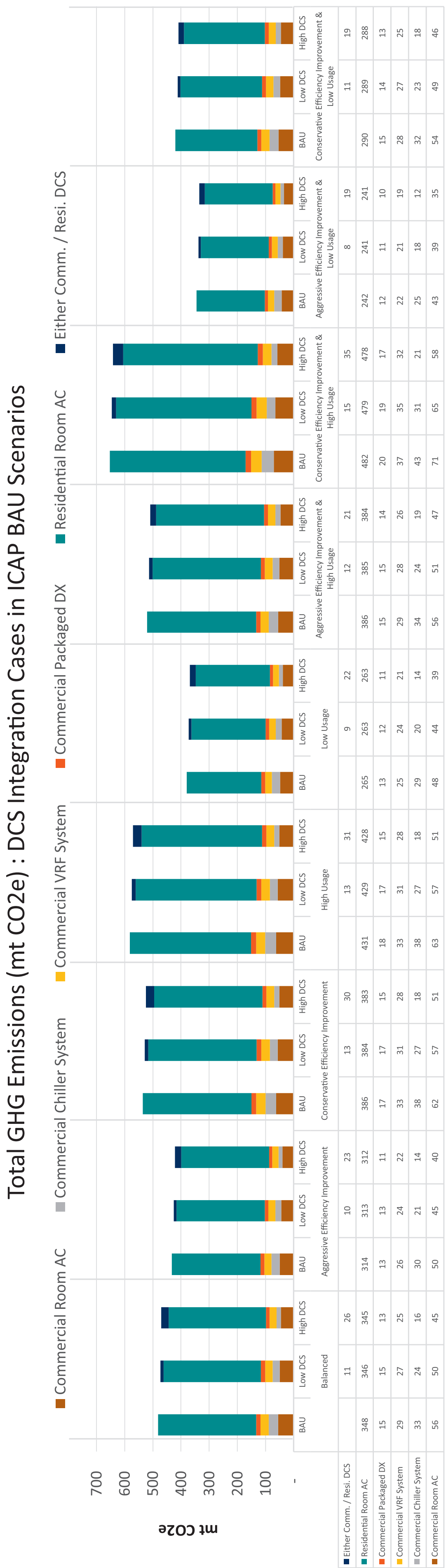


	Balanced			Aggressive Efficiency Improvement			Conservative Efficiency Improvement		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		3	6		2	5		3	7
Residential Room AC	257	256	255	223	221	221	296	295	294
Commercial Packaged DX	5	5	4	4	4	4	6	6	5
Commercial VRF System	16	15	14	14	13	12	18	17	16
Commercial Chiller System	12	9	6	10	8	5	13	10	7
Commercial Room AC	22	21	19	19	18	16	26	24	22

	High Usage			Low Usage			Aggressive Efficiency Improvement & High Usage		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		3	6		3	6		2	5
Residential Room AC	257	256	255	257	256	255	223	221	221
Commercial Packaged DX	5	5	4	5	5	4	4	4	4
Commercial VRF System	16	15	14	16	15	14	14	13	12
Commercial Chiller System	12	9	6	12	9	6	10	8	5
Commercial Room AC	22	21	19	22	21	19	19	18	16

	Conservative Efficiency Improvement & High Usage			Aggressive Efficiency Improvement & Low Usage			Conservative Efficiency Improvement & Low Usage		
	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS	BAU	Low DCS	High DCS
Either Comm. / Resi. DCS		3	7		2	5		3	7
Residential Room AC	296	295	294	223	221	221	296	295	294
Commercial Packaged DX	6	6	5	4	4	4	6	6	5
Commercial VRF System	18	17	16	14	13	12	18	17	16
Commercial Chiller System	13	10	7	10	8	5	13	10	7
Commercial Room AC	26	24	22	19	18	16	26	24	22

Figure 12: *Peak electricity demand (GW) for different DCS integration cases in ICAP BAU scenarios*



Scenario	Case	Either Comm. / Resi. DCS	Residential Room AC	Commercial Packaged DX	Commercial VRF System	Commercial Chiller System	Commercial Room AC
Balanced	BAU		348	15	29	33	56
	Low DCS	11	346	15	27	24	50
	High DCS	26	345	13	25	16	45
Aggressive Efficiency Improvement	BAU		314	13	26	30	50
	Low DCS	10	313	13	24	21	45
	High DCS	23	312	11	22	14	40
Conservative Efficiency Improvement	BAU		386	17	33	38	62
	Low DCS	13	384	17	31	27	57
	High DCS	30	383	15	28	18	51
High Usage	BAU		431	18	33	38	63
	Low DCS	13	429	17	31	27	57
	High DCS	31	428	15	28	18	51
Low Usage	BAU		265	13	25	29	48
	Low DCS	9	263	12	24	20	44
	High DCS	22	263	11	21	14	39
Aggressive Efficiency Improvement & High Usage	BAU		386	15	29	34	56
	Low DCS	12	385	15	28	24	51
	High DCS	21	384	14	26	19	47
Conservative Efficiency Improvement & High Usage	BAU		482	20	37	43	71
	Low DCS	15	479	19	35	31	65
	High DCS	35	478	17	32	21	58
Aggressive Efficiency Improvement & Low Usage	BAU		242	12	22	25	43
	Low DCS	8	241	11	21	18	39
	High DCS	19	241	10	19	12	35
Conservative Efficiency Improvement & Low Usage	BAU		290	15	28	32	54
	Low DCS	11	289	14	27	23	49
	High DCS	19	288	13	25	18	46

Figure 13: *Total GHG emissions (mt CO2e) for different DCS integration cases in ICAP BAU scenarios*

It can be observed that, as efficiency improves, electricity consumption in TWh falls. Consequently, a reduction in emissions is also observed. In the case of usage levels, more electricity is required to meet the cooling demand as ELFH increases. This trend extends to cooling demand met as well as total emissions. Therefore, enhancing efficiency while reducing usage has positive effects across all parameters and proves advantageous for planning future cooling systems.

7 CONCLUSION

DCS can play a critical role in addressing India's future cooling needs in an environmentally sustainable manner. By offering a clear pathway to reducing electricity consumption and GHG emissions, DCS integration can be a key strategy for the future of urban cooling in India.

The analysis reveals that even modest levels of DCS integration can significantly reduce the required cooling capacity. Under a low integration scenario (2% penetration), approximately 15.1 million TR of conventional cooling capacity could be replaced with 10.6 million TR of DCS, bringing the total national cooling capacity down by 4.5 million TR from ~710 million TR to ~706 million TR. With higher DCS integration (5% penetration), around 33.7 million TR of conventional cooling could be replaced by 23.6 million TR of DCS, reducing total capacity further by 10.1 million TR and bringing it down to ~700 million TR. These reductions highlight the efficiency gains achievable by leveraging diverse and mixed-use cooling requirements through centralized systems.

In terms of energy efficiency, DCS adoption can substantially lower electricity use for cooling. Under low DCS integration (2%), the annual reduction in cooling-related electricity consumption is estimated at ~3 TWh, while a higher integration scenario (5%) could deliver savings of ~7 TWh—equivalent to the annual output of about four typical thermal power plants in India. These savings translate directly into lower operating costs and reduced grid dependency, particularly during high-demand summer months.

DCS implementation also has a pronounced effect on peak electricity demand. Under the ICAP projections for 2037–38, the peak cooling demand is expected to reach ~312 GW. DCS integration at 2% could lower this by about 4 GW, while 5% penetration could cut peak demand by nearly 8 GW. This reduction would help alleviate grid stress, enhance reliability, and defer the need for costly capacity additions.

A critical outcome of DCS integration is its contribution to reducing GHG emissions, both from lower electricity use and reduced refrigerant leakage. Under the ICAP projections for 2037–38, total GHG emissions from cooling are estimated at ~481 $MtCO_2e$. With 2% DCS integration, emissions could fall by ~7 $MtCO_2e$, reaching ~474 $MtCO_2e$, and with 5% integration, by ~11 $MtCO_2e$, lowering total emissions to ~470 $MtCO_2e$. The latter reduction is comparable to the carbon sequestration potential of approximately 500 million trees, underscoring the environmental significance of DCS adoption.

Given these benefits, integrating DCS in new large-scale commercial, residential, and mixed-use developments should be encouraged by urban development authorities. This can help leverage the load diversity that would exist in such high-density settlements. Given the high cooling load potential in IT/ITeS SEZs, specific policies should target DCS integration within these zones. SEZs with cooling capacities above a certain threshold should be required to adopt or transition to DCS.

At the same time, the focus needs to be on improving efficiency and lowering usage levels across cooling systems. This can bring about an additional reduction in electricity consumption and emissions. Increased awareness and policy support can enable DCS as a viable alternative towards cooling in the densely utilised Indian urban centres.

The shift toward District Cooling Systems represents a significant step forward in addressing India’s cooling needs in a sustainable manner. By embracing DCS, India can achieve not only its cooling demands but also its broader energy and climate objectives. The findings of this analysis make a compelling case for prioritizing DCS integration as a core element of India’s future cooling strategy, ultimately contributing to a more resilient, efficient, and sustainable urban environment.

ANNEXURE

DCS eligible IT/ITES SEZs in 2037-38

Table 12: *DCS eligible (> 5000 TR cooling potential) IT/ITES SEZs in 2037-38 (Source: Author's analysis)*

S. No.	Name of the Developer	Type of SEZ	State code	DCS eligible Cooling capacity 2037-38 (TR)
1	Andhra Pradesh Industrial Infrastructure Corporation Limited (APIIC)	IT/ITES	AP	15,030
2	HCL Technologies Ltd.	IT/ITES	AP	5,016
3	Gujarat Industrial Development Corporation	IT/ITES	GJ	19,565
4	Ganesh Infrastructure Private Limited	IT/ITES	GJ	22,856
5	Aqualine Properties Private Limited	IT/ITES	GJ	19,449
6	Tata Consultancy Services Limited	IT/ITES	GJ	7,210
7	Calica Construction and Impex Private Limited	IT/ITES	GJ	7,637
8	Gujarat Industrial Development Corporation	IT/ITES	GJ	15,553
9	DLF Ltd.	IT/ITES	HR	8,053
10	DLF Cyber City Developers Ltd.	IT/ITES	HR	5,503
11	GTV Tech SEZ Pvt. Ltd. (Formerly Dr. Fresh Healthcare Pvt. Ltd.)	IT/ITES	HR	13,593
12	Metro Valley Business Park Private Limited	IT	HR	6,030
13	Gurgaon Infospace Ltd.	IT/ITES	HR	6,026
14	ASF Insignia SEZ Private Ltd. (Canton Buildwell Private Limited)	IT/ITES	HR	10,383
15	Candor Gurgaon One Realty Projects Pvt. Ltd. (Formerly Unitech Realty Projects Ltd.)	IT/ITES	HR	5,483

S. No.	Name of the Developer	Type of SEZ	State code	DCS eligible Cooling capacity 2037-38 (TR)
16	Ascendant Estates Private Limited	IT/ITES	HR	6,776
17	Perpetual Infracon Private Limited	IT/ITES	HR	11,670
18	Anant Raj Industries Ltd.	IT/ITES	HR	5,379
19	Mittal Infratech Private. Limited.	IT/ITES	HR	5,858
20	ITPG Developer Pvt. Ltd. (Formerly G.P. Realtors Private Limited)	IT/ITES	HR	13,769
21	Goldsouk International Gems & Jewellery SEZ Pvt. Ltd.	IT/ITES	HR	8,709
22	G.P. Realtors Private Limited	IT/ITES	HR	14,713
23	Orient Craft Infrastructure Limited	IT/ITES	HR	14,287
24	DLF Limited (SEZ-I)	IT/ITES	HR	12,558
25	DLF Limited (SEZ-II)	IT/ITES	HR	12,898
26	Infopark	IT/ITES	KL	19,407
27	Electronics Technology Parks-Kerala	IT/ITES	KL	7,466
28	Electronics Technology Parks-Kerala	IT/ITES	KL	20,508
29	Kerala State Information Technology Infrastructure Limited	IT/ITES	KL	14,593
30	Kerala State Information Technology Infrastructure Limited	IT/ITES	KL	6,172
31	Kerala State Information Technology Infrastructure Limited	IT/ITES	KL	7,996
32	Kerala State Information Technology Infrastructure Limited	IT/ITES	KL	10,708
33	Electronics Technology Parks- Kerala (Technopark)	IT/ITES	KL	11,573
34	Sutherland Global Services Private Limited	IT/ITES	KL	6,019
35	Smart City (Kochi) Infrastructure Limited	IT/ITES	KL	55,868
36	Infoparks Kerala	IT/ITES	KL	24,572
37	Kerala State Information Technology Infrastructure Limited (KSITIL)	IT/ITES	KL	7,029
38	Electronics Technology Parks- Kerala	IT/ITES	KL	10,536
39	Electronics Technology Parks- Kerala	IT/ITES	KL	19,550

S. No.	Name of the Developer	Type of SEZ	State code	DCS eligible Cooling capacity 2037-38 (TR)
40	Kerala State Information Technology Infrastructure Limited	IT/ITES	KL	24,074
41	Parsvnath Infra Ltd	IT/ITES	KL	10,160
42	Vikas Telecom Private Limited (formerly Vikas Telecom Limited)	IT/ITES	KN	12,032
43	RMZ Ecoworld Infrastructure Pvt. Ltd. (formerly Adarsh Prime Projects Private Limited)	IT/ITES	KN	6,390
44	GV Tech Parks Pvt. Ltd. [(formerly Tanglin Development Ltd.(formerly Global Village SEZ)]	IT/ITES	KN	14,670
45	Shyamaraju and Company (India) Pvt. Ltd. (formerly Divyasree Technopark)	IT/ITES enabled services	KN	11,636
46	Cessna Business Park Pvt. Ltd. (formerly Cessna Garden Developers Pvt. Ltd.)	IT/ITES	KN	9,620
47	Manyata Embassy Business Park	IT/ITES	KN	14,369
48	HCL Technologies Ltd.	IT/ITES	KN	5,872
49	Information Technology Park Limited	IT/ITES	KN	5,813
50	Infosys Limited (Formerly Infosys Technologies Limited)	IT/ITES	KN	7,208
51	Infosys Technologies Limited	IT/ITES	KN	66,100
52	Pritech Park (formerly Primal Projects Private Limited)	IT/ITES	KN	7,855
53	Bagmane Construction Pvt. Ltd	IT/ITES	KN	6,609
54	Karle Infra Pvt. Ltd.	IT/ITES	KN	5,816
55	Gopalan Enterprises (India) Private Limited.	IT/IT enabled services	KN	5,513
56	Brigade Enterprises Pvt. Ltd.	IT/ITES	KN	5,410
57	Gopalan Enterprises (India) Private Limited.	IT/ITES	KN	7,642
58	Karnataka Industrial Areas Development Board (KIADB)	IT/ITES	KN	35,064
59	Larsen & Toubro Limited	IT/ITES	KN	6,342

S. No.	Name of the Developer	Type of SEZ	State code	DCS eligible Cooling capacity 2037-38 (TR)
60	Brigade Properties Pvt. Ltd. (Formerly Brookefields Real Estates and Projects Pvt. Ltd., Brooke Bond Real Estates Private Limited)	IT/ITES/BPO/E H	KN	5,732
61	Renaissance Designbuild Private Limited	IT/ITES	KN	5,411
62	Infosys Technologies Limited	IT/ITES	KN	13,072
63	Gulf Oil Corporation Limited	IT/ITES	KN	6,492
64	Wipro Limited.	IT/ITES	KN	10,444
65	Infosys Limited	IT/ITES	KN	9,316
66	Karnataka Industrial Areas Development Board (KIADB)	IT/ITES	KN	6,497
67	EON Kharadi Infrastructure Private Limited	IT/ITES	MH	6,379
68	WIPRO Limited	IT/ITES	MH	7,088
69	Syntel International Private Limited	IT/ITES	MH	5,670
70	The Manjri Stud Farm Private Limited	IT/ITES	MH	5,596
71	Infosys Technologies Limited	IT/ITES	MH	11,160
72	Maharashtra Industrial Development Corporation Limited (MIDC)	IT/ITES	MH	79,029
73	Serene Properties Private Limited	IT/ITES	MH	7,074
74	Embassy Office Parks Pvt. Ltd. (formerly Dynasty Developers Private Limited and Pune-Embassy Project Private Limited)	IT/ITES	MH	9,674
75	Sunstream City Private Limited (formerly M/s. Zeus Infrastructure Private Limited)	IT/ITES	MH	20,232
76	Suyog Realtors Pvt. Ltd.	IT/ITES	MH	6,092
77	Infosys Ltd.	IT	MP	8,662
78	Tata Consultancy Services Limited	IT/ITES/BPO/ KP O	MP	6,659
79	Odisha Industrial Infrastructure Development Corporation (IDCO)	IT/ITES	OR	33,951
80	Odisha Industrial Infrastructure Development Corporation (IDCO)	IT(Knowledge Park)	OR	52,171

S. No.	Name of the Developer	Type of SEZ	State code	DCS eligible Cooling capacity 2037-38 (TR)
81	Tata Consultancy Services Limited	IT	TN	23,688
82	Syntel International Private Limited	IT/ITES	TN	9,739
83	IG3 Infra Limited (ETL Infrastructure Services Limited)	IT/ITES	TN	8,776
84	Hexaware Technologies Limited	IT/ITES	TN	9,133
85	Gateway Office Parks Private Limited (formerly M/s. Shriram Properties and Infrastructure Private Limited)	IT/ITES	TN	8,416
86	KGISL Infrastructure Pvt. Ltd. (formerly Coimbatore Hitech Infrastructure Pvt. Ltd.)	IT/ITES	TN	42,556
87	DLF Infocity Developers (Chennai) Ltd.	IT/ITES	TN	14,469
88	Electronics Corporation of Tamil Nadu (ELCOT)	IT/ITES	TN	18,764
89	Electronics Corporation of Tamil Nadu Limited (ELCOT)	IT/ITES	TN	126,755
90	Bayline Infocity Ltd. (Formerly ETA Technopark Private Limited)	IT/ITES	TN	8,608
91	Cognizant Technology Solutions India Pvt. Ltd.	IT/ITES	TN	13,714
92	SNP Infrastructure LLP (formerly SNP Infrastructure Pvt. Ltd.)	IT/ITES	TN	8,503
93	Electronics Corporation of Tamil Nadu Limited (ELCOT)	IT/ITES	TN	41,423
94	Rudradev Township Private Limited	IT/ITES	TN	25,772
95	Electronics Corporation of Tamil Nadu Limited (ELCOT)	IT/ITES	TN	9,714
96	Electronics Corporation of Tamil Nadu Limited (ELCOT)	IT/ITES	TN	71,786
97	Electronics Corporation of Tamil Nadu Limited (ELCOT)	IT/ITES	TN	55,214
98	Tril Infopark Ltd.	IT/ITES	TN	8,502
99	Electronics Corporation of Tamil Nadu Limited (ELCOT)	IT/ITES	TN	58,128

S. No.	Name of the Developer	Type of SEZ	State code	DCS eligible Cooling capacity 2037-38 (TR)
100	Electronics Corporation of Tamil Nadu Limited (ELCOT)	IT/ITES	TN	97,453
101	Jay Gee Hitech Infraventures Pvt. Ltd	IT/ITES	TN	9,868
102	Highland Valley Corporation Pvt. Ltd.	IT/ITES	TN	26,561
103	TATA Consultancy Services Limited	IT/ITES	TN	6,368
104	Tech Mahindra Limited (formerly Satyam Computer Services Limited)	IT/ITES	TG	5,063
105	Sundew Properties Ltd. (formerly K. Raheja IT Park (Hyderabad) Pvt. Ltd. to Sundew Properties Pvt. Ltd.)	IT/ITES	TG	5,915
106	TCS Ltd. (formerly CMC Limited)	IT/ITES enabled services	TG	8,687
107	Sanghi SEZ Private Limited	IT/ITES	TG	85,391
108	Indu Techzone Private Limited	IT/ITES	TG	25,343
109	Lanco Hills Technology Park Private Limited	IT/ITES	TG	5,244
110	Brahmani Infratech Private Limited	IT/ITES	TG	25,609
111	Maytas Enterprises SEZ Private Limited	IT/ITES	TG	6,733
112	Telangana State Industrial Infrastructural Corporation Ltd.(TSIIC) [Formerly Andhra Pradesh Industrial Infrastructural Corporation Ltd.(APIIC)]	IT/ITES	TG	6,953
113	DivyaSree NSL Infrastructure Private Limited	IT/ITES	TG	5,012
114	J. T. Holdings Private Limited	IT/ITES	TG	11,952
115	Rudradev Infopark Pvt. Ltd.	IT/ITES	TG	5,168
116	Stargaze Properties Private Limited.	IT/ITES	TG	29,094
117	Information Technology and Communication Department (IT and C), Government of Andhra Pradesh through Hyderabad Urban Development Authority (HUDA)	IT/ITES	TG	20,082
118	Hill County SEZ Private Limited (Formerly Maytas Hill County SEZ Private Limited)	IT/ITES	TG	12,602
119	WIPRO Limited	IT/ITES	TG	17,247

S. No.	Name of the Developer	Type of SEZ	State code	DCS eligible Cooling capacity 2037-38 (TR)
120	Telangana State Industrial Infrastructural Corporation Ltd.(TSIIC) [Formerly Andhra Pradesh Industrial Infrastructural Corporation Ltd.(APIIC)]	IT/ITES	TG	5,970
121	Genpact India Business Processing Private Limited	IT/ITES	TG	8,537
122	Cognizant Technology Solutions India Pvt. Ltd.	IT/ITES	TG	6,830
123	Infosys Limited	IT	TG	76,375
124	Tata Consultancy Services Limited	IT/ITES	TG	12,805
125	Ansal IT City and Parks Limited	IT/ITES	UP	7,698
126	HCL Technologies Ltd.	IT/ITES	UP	5,143
127	WIPRO Limited	IT/ITES	UP	5,121
128	Unitech Infra Con Limited	IT/ITES	UP	5,121
129	Gallant Infrastructure Private Limited	IT/ITES	UP	8,408
130	HCL IT City Lucknow Private Limited	IT/ITES	UP	6,250
131	TATA Consultancy Services Limited	IT/ITES	UP	5,037
132	M.L. Dalmiya and Company Limited	IT/ITES	WB	29,656
133	Candor Kolkata One Hi-Tech Structures Pvt. Ltd. (Formerly Unitech Hi-tech Structures Limited)	IT/ITES	WB	11,957
134	Tata Consultancy Services Limited	IT/ITES	WB	9,887
135	DLF Limited	IT/ITES	WB	6,401
136	Bengal Shriram Hi-tech City Private Limited	IT/ITES	WB	14,834
				2,286,630

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