

District Cooling System and its Rapid Assessments in Indian cities



DISTRICT ENERGY IN CITIES

A GLOBAL INITIATIVE TO UNLOCK THE POTENTIAL OF ENERGY EFFICIENCY AND RENEWABLE ENERGY



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17 May, 2018

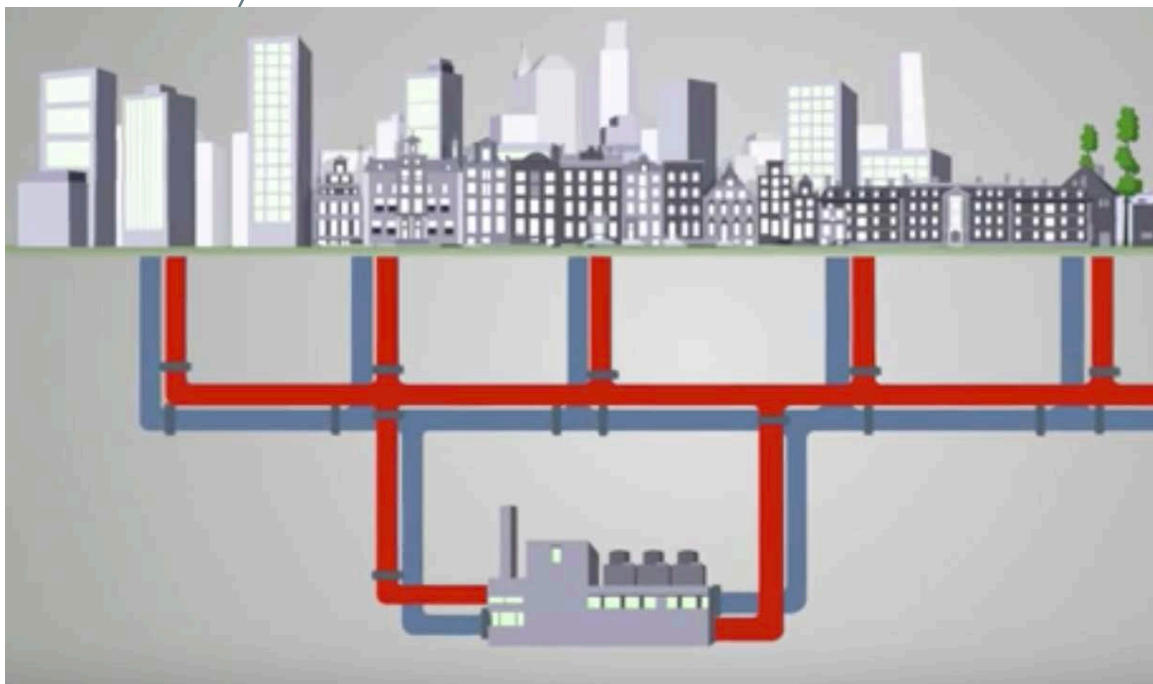
INTRODUCTION



DISTRICT ENERGY
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- District energy systems produce hot water and/or chilled water in highly-efficient centralised plants
- This is sold to buildings in the same neighborhood via networks of underground, insulated pipes
- This piped hot/chilled water is used to provide **sustainable** heating, hot water and/or air conditioning services



Any energy source, renewable, present or future
can be used in the District Energy system

INTRODUCTION

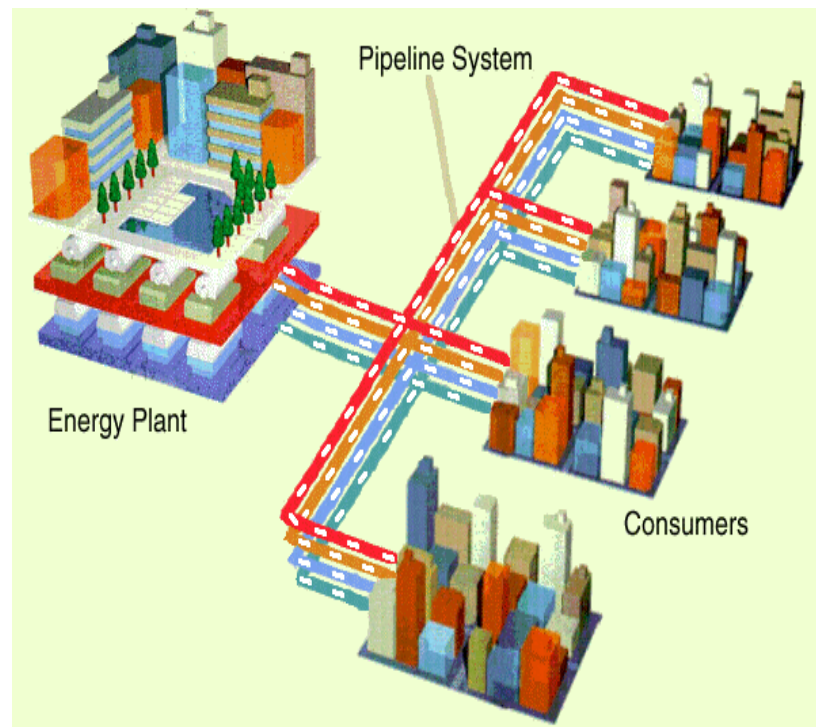


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Definition of District Cooling:

- A system to combine heating/cooling station and end-users through pipeline network
- Belongs to public service, similar to electricity, water, gas etc.
- Cooling sources could include waste heat, electrical cooling, free cooling etc.
- To satisfy the heating and/or cooling demand in order to enhance indoor thermal comfort



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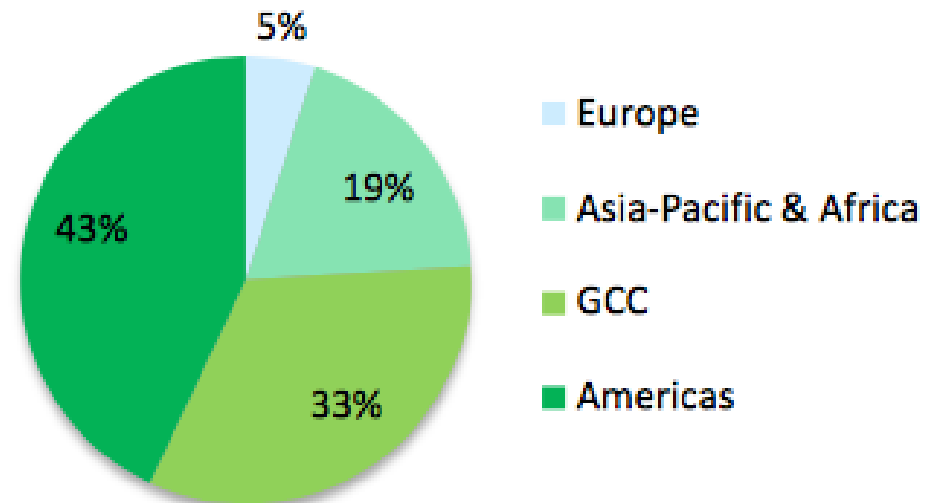


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North America: 18 GW/(25 TWh)
Europe: 2 GW/(3 TWh)
Middle East: 14 GW/(45 TWh)
Japan: 7 TWh

DC market worldwide (2014)



Source: ADB report 2016

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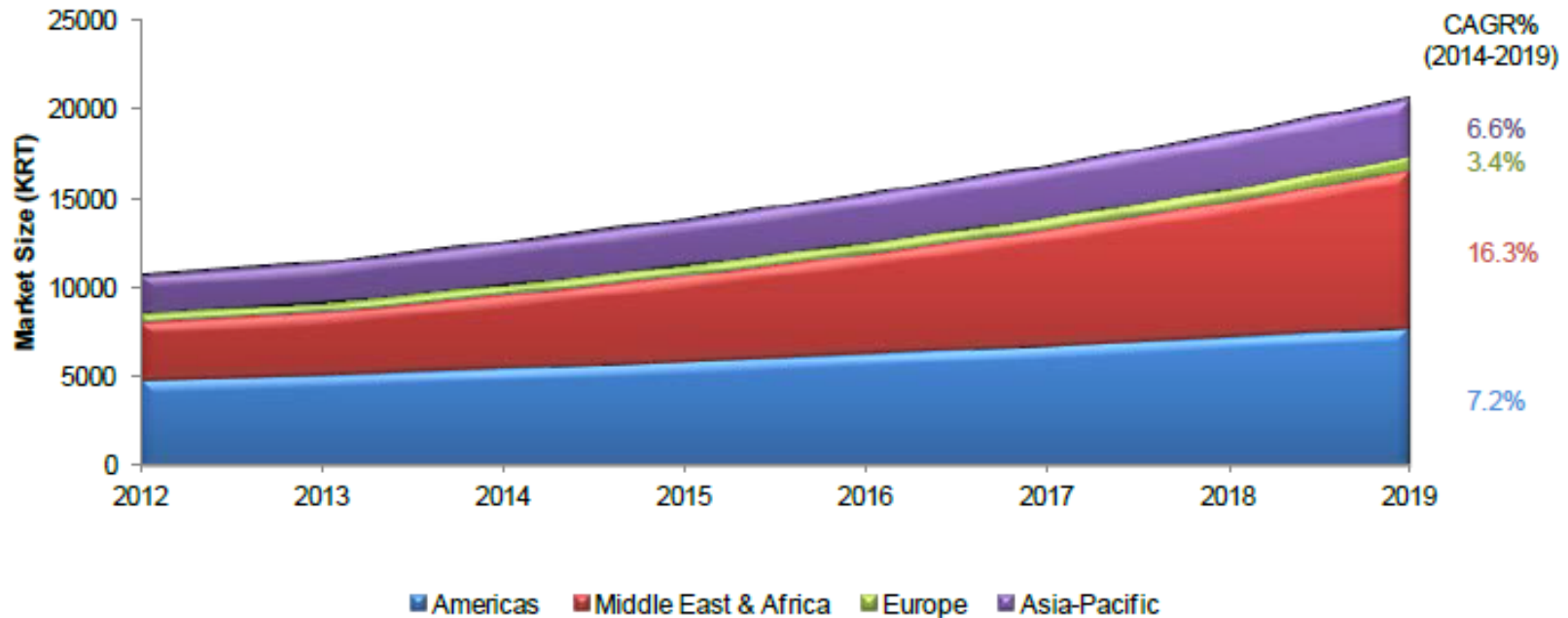


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District Cooling has a global growth of 10,3% annually to 2019 - driven by high growth in Middle East and Asia

District Cooling market development 2012-2019



Source: Market & Markets 2014; "District Cooling Market, Global Trend and Forecast 2012-2019"

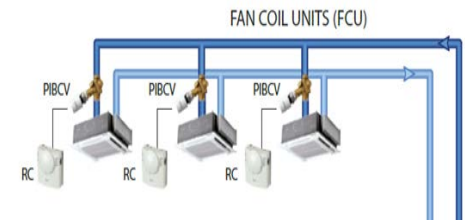
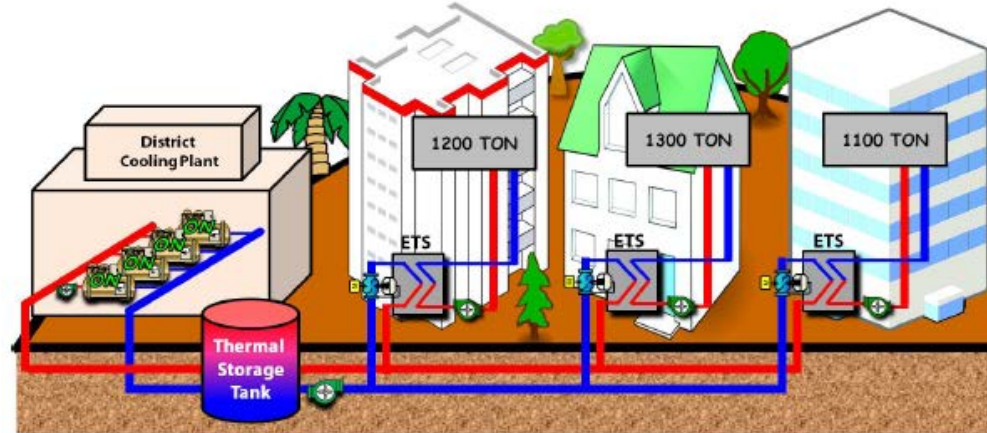
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What is included in a District Cooling system ?



Supply source
(DC plant)

Distribution System
(Network)

End-users
(Metering systems,
internal AC)

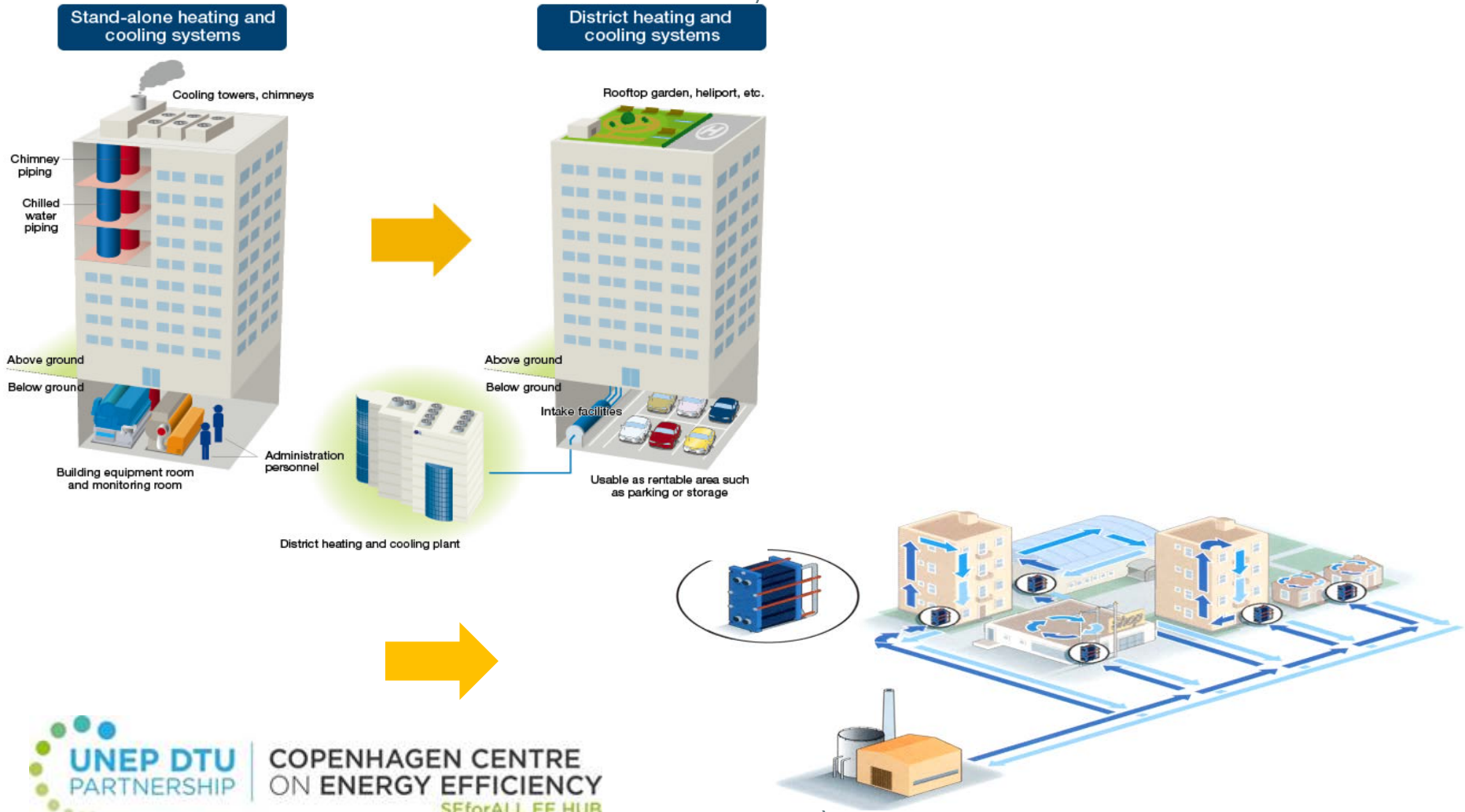
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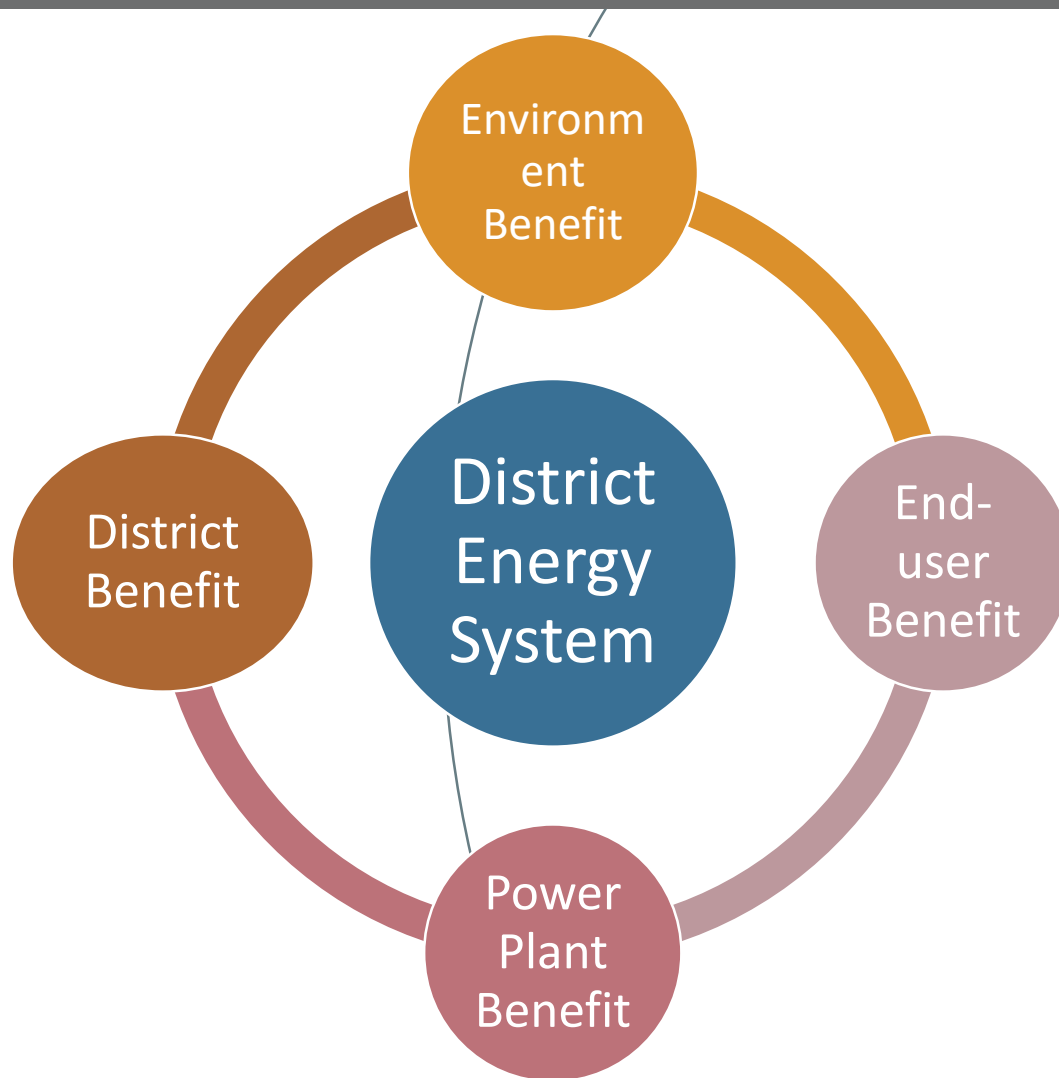
What does a District Cooling system change?



BENEFITS OF DISTRICT COOLING



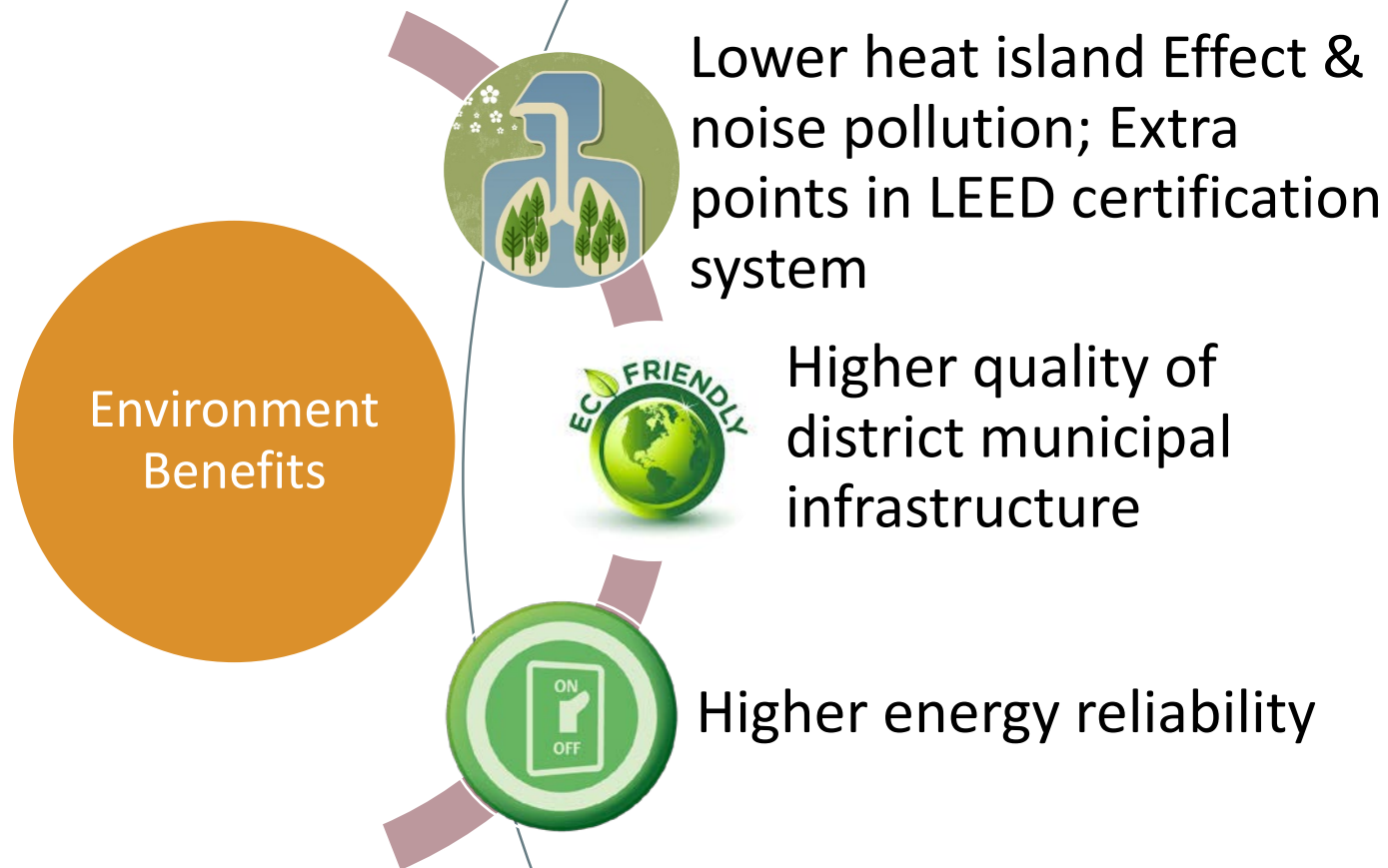
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BENEFITS OF DISTRICT COOLING



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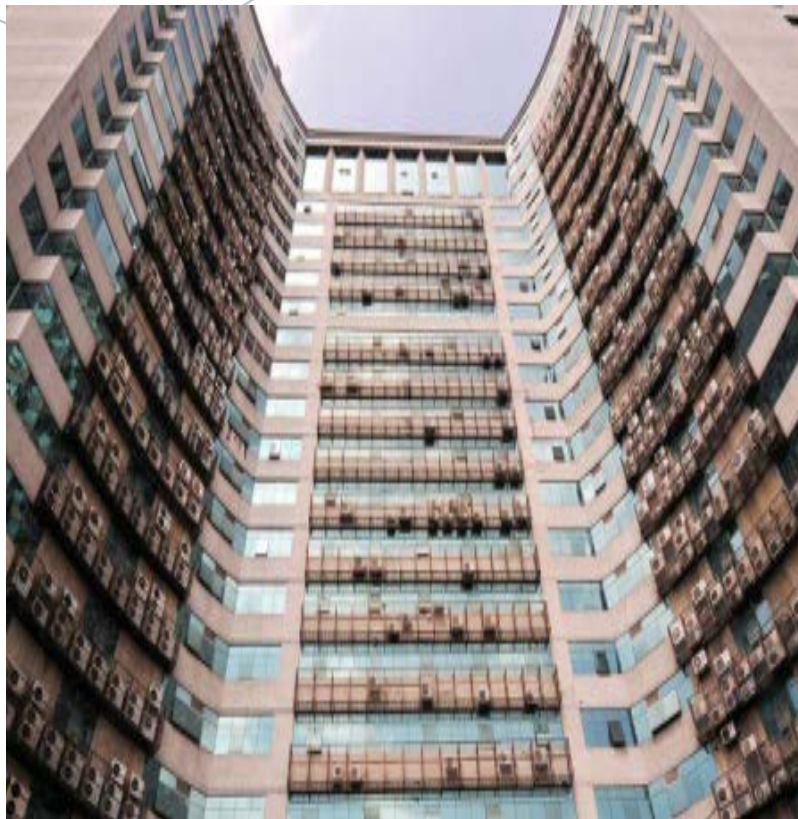


BENEFITS OF DISTRICT COOLING



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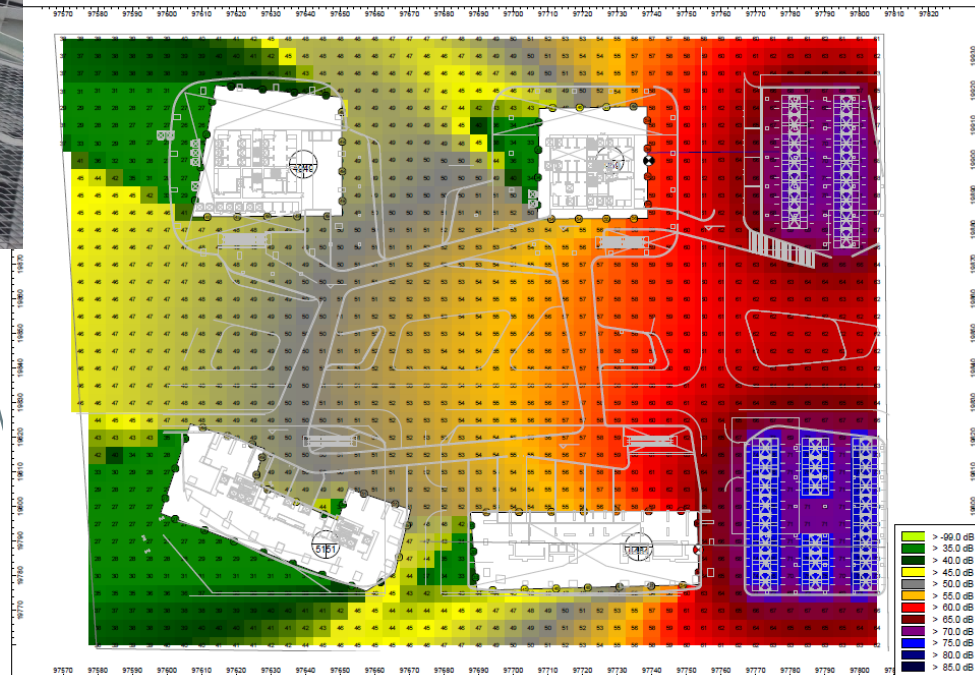
UN 
environment



BENEFITS OF DISTRICT COOLING



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COPENHAGEN CENTRE
ON ENERGY EFFICIENCY
SEforALL EE HUB

BENEFITS OF DISTRICT COOLING



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Benefits of Green Building rating system (LEED ND)

Extra 3-5 points for District Cooling system.



BENEFITS OF DISTRICT COOLING



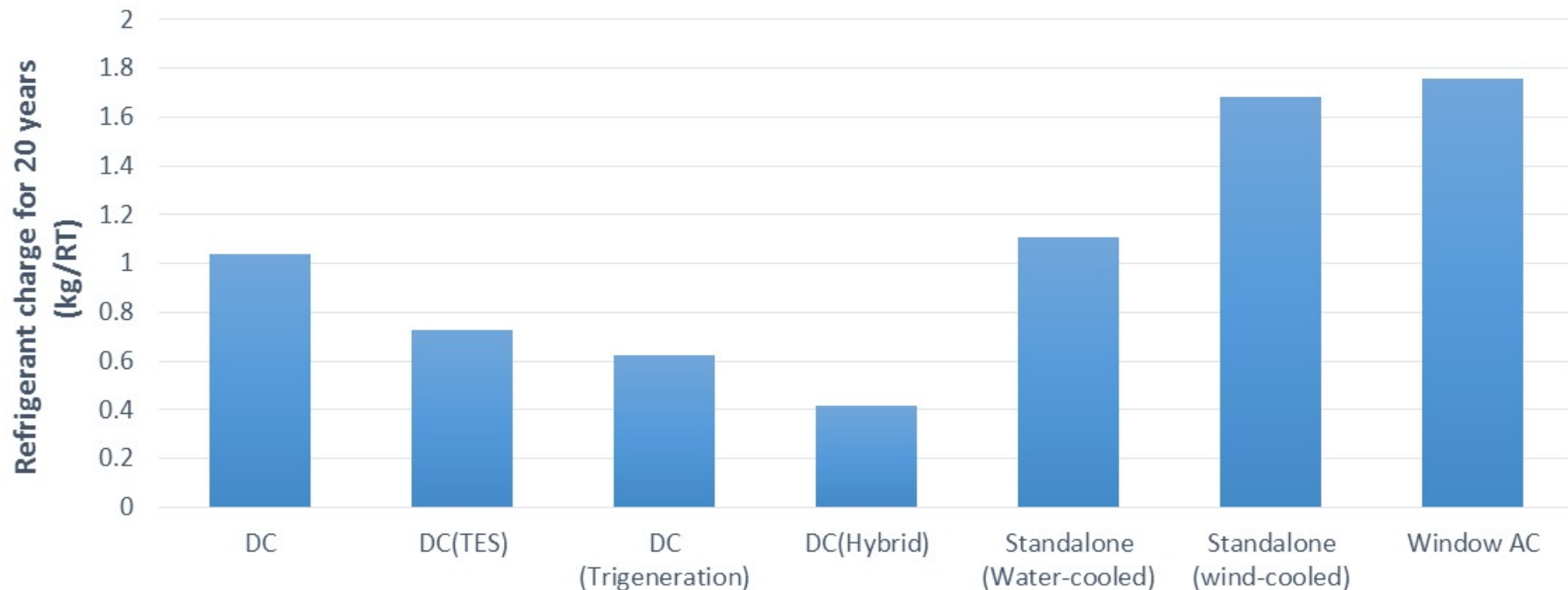
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Contribution to refrigerant phasing out

- Montreal Protocol
- Kigali Agreement

Refrigerant Charge VS Technologies



BENEFITS OF DISTRICT COOLING



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Benefits of end-users

- Cooling source: pumps, chillers, cooling towers
- Electricity & water supply system to cooling source
- Sensors, control/monitor parts for cooling source
- Installation & construction fee
- Electricity/Transformers connection fee to the grid

Save
investment

- No cooling source in the building
- Less electricity & water supply equipment

Save
maintenance fee

- Less spaces for mechanic rooms
- Can be changed to parking lots or other purposes

Extra
income

RAPID ASSESSMENT OF FIVE INDIAN CITIES



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City selection:

- Partner consultations
- Smart Cities Mission
- Geographical diversity
- Medium-sized cities
- Local stakeholder connections
- Growth rate

Report authors:



City-visits and analysis supported by:



International
Finance Corporation



EMPOWER
ENERGY
SOLUTIONS

INTRODUCING THE CITIES



**DISTRICT ENERGY
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RAJKOT

- 22nd FASTEST GROWING CITY GLOBALLY
- POPULATION TO DOUBLE BY 2031
- 10,000 ACs SOLD ANNUALLY
- 500 FOUNDRY UNITS PRODUCING WASTE HEAT

BHOPAL

- 8.7 SQ. KM OF NEW COMMERCIAL DEVELOPMENT BY 2031
- 2.6 SQ. KM OF NEW INDUSTRIAL DEVELOPMENT BY 2031
- 200 BANKS & INSURANCE COMPANIES
- 100 HOSPITALS

THANE

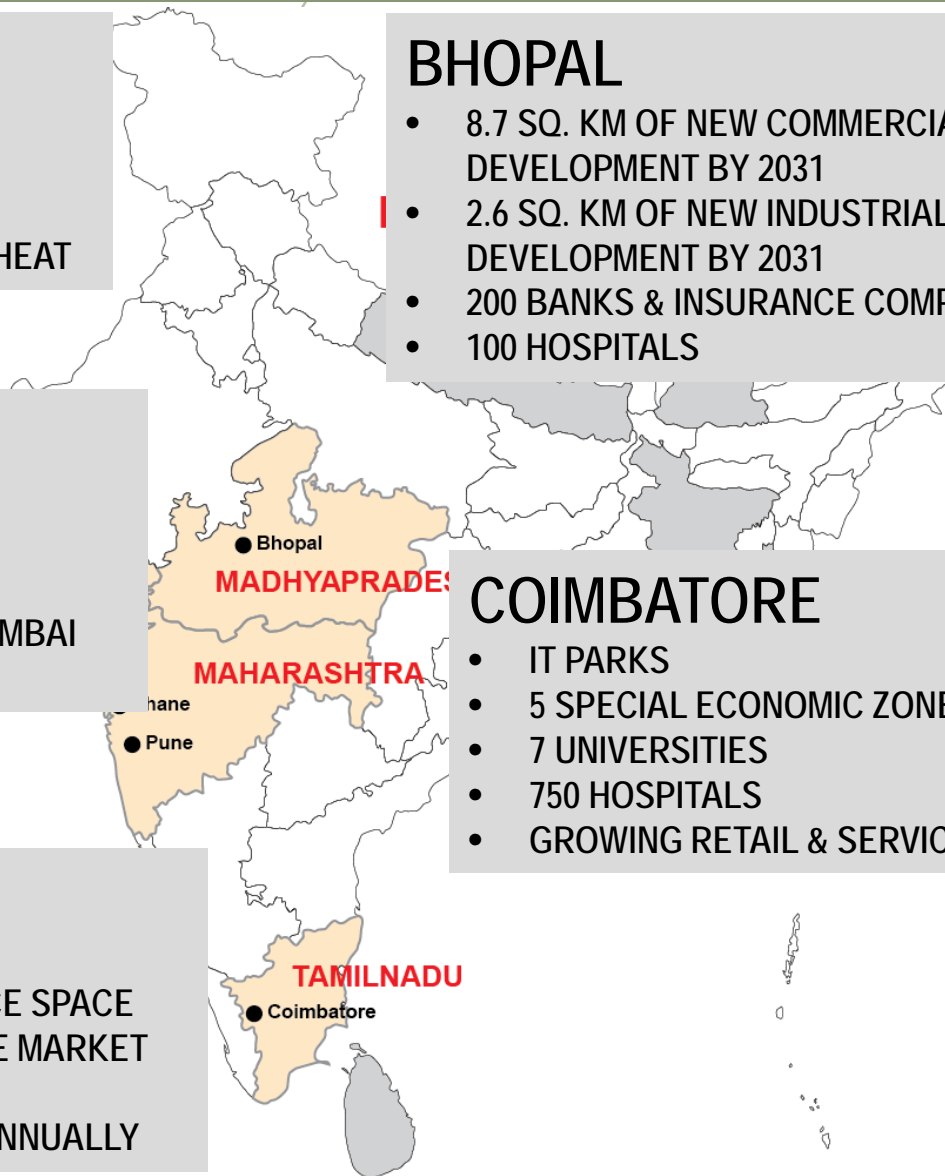
- FAST GROWING IT AND RETAIL SECTOR
- LARGE TOWNSHIPS AND IT PARKS
- DEVELOPING AT FAST PACE – FASTEST GROWING REAL ESTATE MARKET IN MUMBAI
- HOT AND HUMID CLIMATE

PUNE

- IT HUB: 35 IT PARKS & 16 SEZs
- 10% OF INDIA'S OCCUPIED OFFICE SPACE
- TOP 4 CITIES FOR RETAIL ESTATE MARKET
- 25 NEW TOWNSHIPS
- MALL SPACE GROWING @ 15% ANNUALLY

COIMBATORE

- IT PARKS
- 5 SPECIAL ECONOMIC ZONES
- 7 UNIVERSITIES
- 750 HOSPITALS
- GROWING RETAIL & SERVICES SECTOR



IMPACTS OF SPACE COOLING



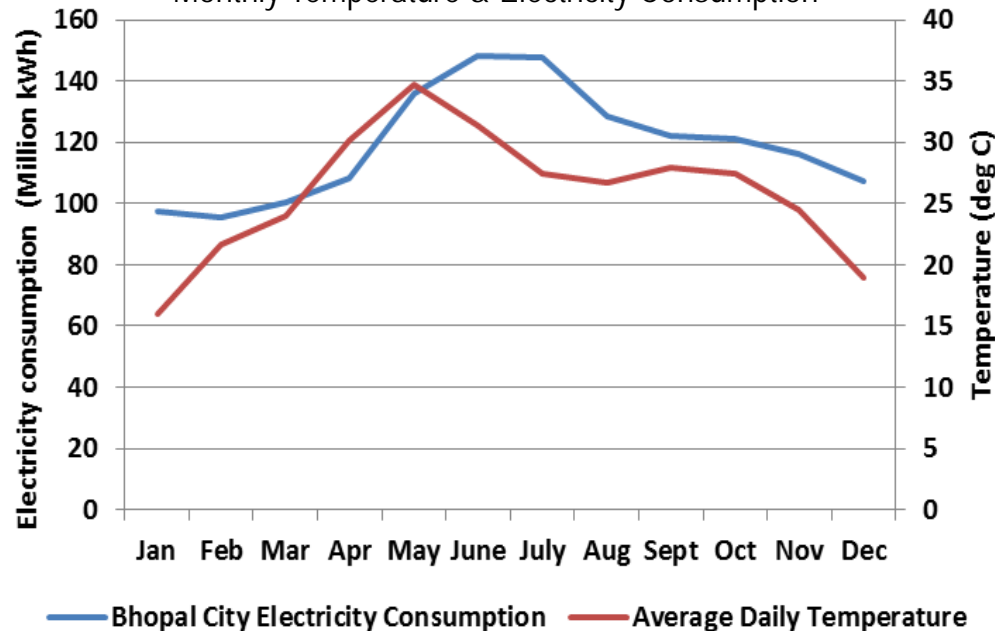
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IN THE CITIES



Bhopal

Monthly Temperature & Electricity Consumption



Situation:

- Seasonal electricity consumption
- Cooling is hidden under electricity demand in winter & summer
- Grid stress and investments to meet peak cooling

Recommendations

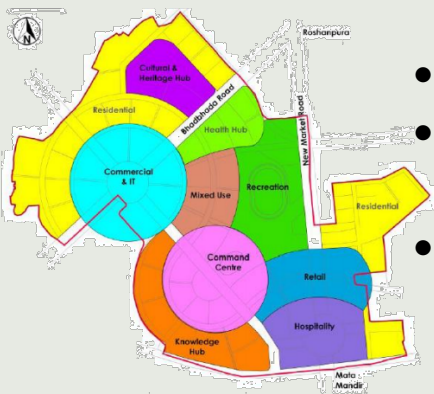
- Map and quantify urban cooling demand
- Increased policy focus on cooling as separate thematic
- Promote urban solutions to city space cooling
- Asses the role of district cooling in flattening load curve & smart grid

Monthly electricity consumption (GWh)	Highest month	Lowest month	Percentage increase
Bhopal	147.92	95.39	55%
Coimbatore	204.01	184.13	11%
Pune	457.02	366.9	25%
Rajkot	143.97	101.94	41%
Thane	256.597	180.205	42%



IDENTIFYING HIGH POTENTIAL DISTRICT COOLING PROJECTS

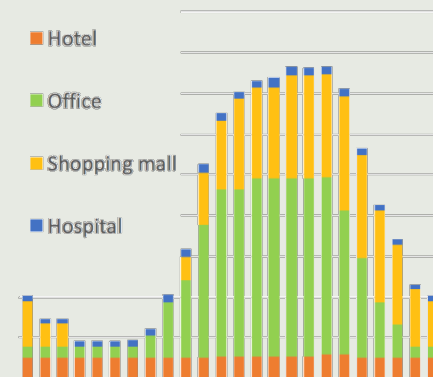
Dense urban area



- FAR > 2.5
- Max. project diameter: 1-1.5km
- Not a residential area

Mixed use

- Data centres, IT Offices
- Hospitals, hotels, malls, offices, conference centres
- Universities, public offices etc.



Development type



- Anchor load
- Demand > 8000TR
- Floorspace > 200,000 sqm
- Initially greenfield is best

Control

- Municipal influence
- Large stakeholders
- Limited number of stakeholders





IDENTIFYING HIGH POTENTIAL

R.A. TECH-ECO ANALYSIS TOOL

Rapid assessment tech-eco analysis tool

Calculation data input
moduler

Calculation Modulers

Technical analysis
moduler

Finacial analysis
moduler

Economic analysis
moduler

Output

Building archetype

Design day hourly
cooling profile

DC plant planning
requirements

Eco benefits: GHG
emission, refrigerant
phasing out

Life cycle payment
(DC vs. Standalone)

Annual energy and
water consumption

O&M fees, cash flow

Payback year & IRR

Cooling demand

Investment

Energy tariff

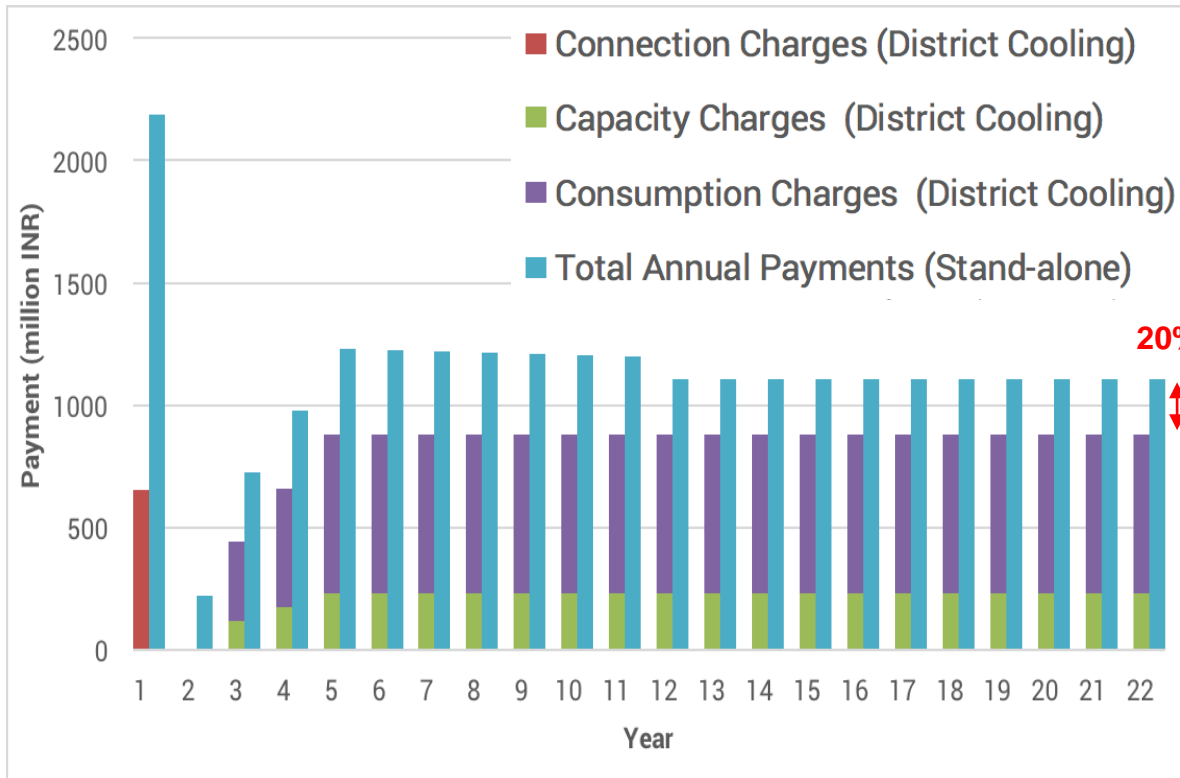
Thermal Energy
Storage

APPROACH TO FINANCIAL



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ANALYSIS

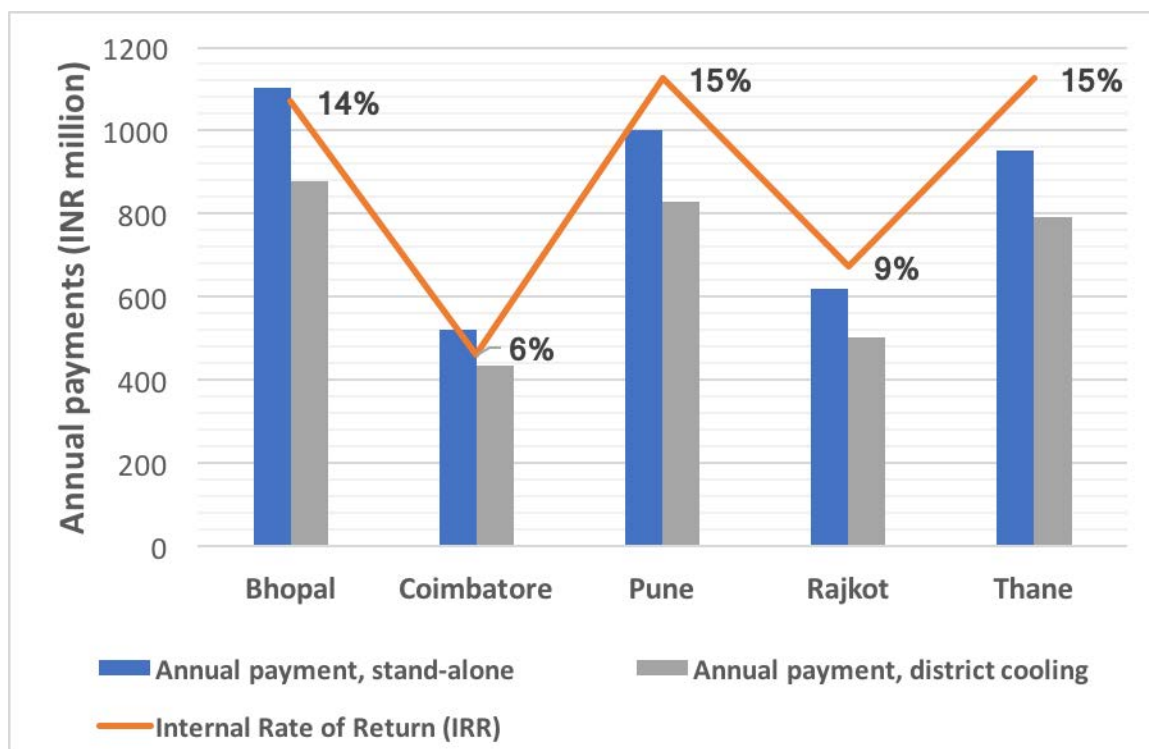


- Modelling of cooling loads based on building efficiency, occupation and climate
- Conservative cost and cooling load inputs
- High-level operational & financial analysis
- District cooling tariffs set to below stand-alone cooling costs



GENERIC ARCHETYPE ANALYSIS ACROSS FIVE CITIES

Comparison of IRR and of annual district cooling payments made by consumers vs payments by those using stand-alone systems



Drivers:

- Power prices
- Cooling load

Improving IRR:

- Lower power costs (e.g. solar provision)
- VAT pricing
- Project design

BENEFITS OF DISTRICT COOLING



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Electricity-based district cooling (without thermal storage)

CO ₂ savings	30-35%
Life cycle refrigerant saving (20 years)	10-15%
Water savings (compared to water-cooled chillers)	15-20%
Electricity demand reduction.	30-35%
Peak power demand reduction	30-35%

Best practice technologies:

Thermal storage

- *Peak power reduction up to 50%*

Incorporation of renewables (e.g. solar, waste to energy, waste heat etc.):

- *CO₂/electricity savings/peak reduction > 50%*

Socio-economic benefits:

Local jobs, space saving in chiller room and on roofs, urban heat island effect, noise, lower cooling costs, end-users do not have to maintain complicated cooling systems

CITY RECOMMENDATIONS



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	Bhopal	Coimbatore	Pune	Rajkot	Thane
Smart city	Green	Green	Green	Green	Green
Solar city program	Green	Green	Green	Green	Green
Baseline GHG assessment	Red	Green	Green	Green	Green
Low GHG plan / target	Red	Orange	Red	Green	Green
City-wide efficiency & renewables target	Green	Green	Green	Green	Green
Efficiency & renewable target by sector	Red	Green	Orange	Green	Green
Zonal renewable energy target	Red	Red	Green	Green	Green
Zonal building efficiency target	Green	Red	Red	Red	Green

Red: Not developed, **Orange:** Under development, **Green:** Existing policy

Recommendations

- Establish a multi-stakeholder coordination group (e.g. Smart City SPV)
- Monitor and GIS map cooling demand
- Impact study of cooling demand to justify city action
- Assess how DC can meet city goals/targets
- Incorporation of DC in Smart City Plans
- Develop city strategy and target for DC
- 'High priority' and 'medium priority' zones for DC development (e.g. smart city area, SEZs, CBDs)
- DC incorporated in zonal plans to meet target

CITY RECOMMENDATIONS



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	Bhopal	Coimbatore	Pune	Rajkot	Thane
Mandates on SWH and/or PV by sector	Red	Green	Green	Green	Green
Mandates on centralised HVAC	Red	Red	Red	Green	Red
Green building policy	Red	Orange	Green	Orange	Orange
Mandate on water re-use in cooling	Red	Green	Red	Red	Red
Mandates on building certification	Orange	Red	Green	Red	Red
FAR bonus linked to certification	Red	Red	Green	Green	Red
Property tax rebate for SWH installation	Red	Red	Green	Green	Green
Direct investment in energy projects	Green	Green	Green	Green	Green
Public buildings to demonstrate	Green	Green	Green	Green	Green

Red: Not developed, Orange: Under development, Green: Existing policy

Recommendations

- Use local planning authority and building regulations to promote DC
- Zonal mandates on DC ready-buildings
- Zonal mandates on assessing DC development/connection
- Franchise zones/concession areas
- **Incentives:** FAR bonuses, tax rebate, meeting sustainability criteria
- Ensure DC-connected buildings benefit from incentives linked to certifications (e.g. GRIHA & ECBC)
- Use public buildings to anchor DC
- Low cost renewable power
- City-led demonstration projects



THANE

CITY OVERVIEW

- Large scale mix-use development
- Plans for 10 MW solar PV, green buildings & net zero buildings
- Piloting and advocating innovative RE & EE technologies and mechanisms
- Demonstrated solar cooling and thermal storage of cooling by Thane Municipal Corporation
- Recently increased FSI by 0.3
- Centralized cooling prevalent in buildings
- Mandates and incentives for SWH





HIRANANDANI ESTATE

- Fast expanding mixed-use development including business park, IT offices, residential, hospital, educational facilities
- Replication potential
- TMC willing to incentivize DC development – property taxes, lower land cost, low cost solar power

Results of Techno-economic assessment

DC system size: 16,100 TR

IRR: 17%

Payback: 10 years

Investment: INR 2.2 billion (\$36 million)

Benefits: 7.5 million kWh/yr saved

Site details

300-acre integrated township

Built-up area assessed for DC:

Hotel: 1.7%, Office: 59% , Mall:
19.7%, School: 19.7%

Total floor area: 2,982,896 sq. feet





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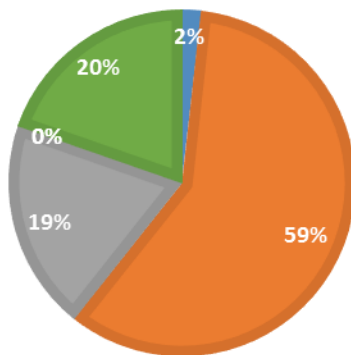




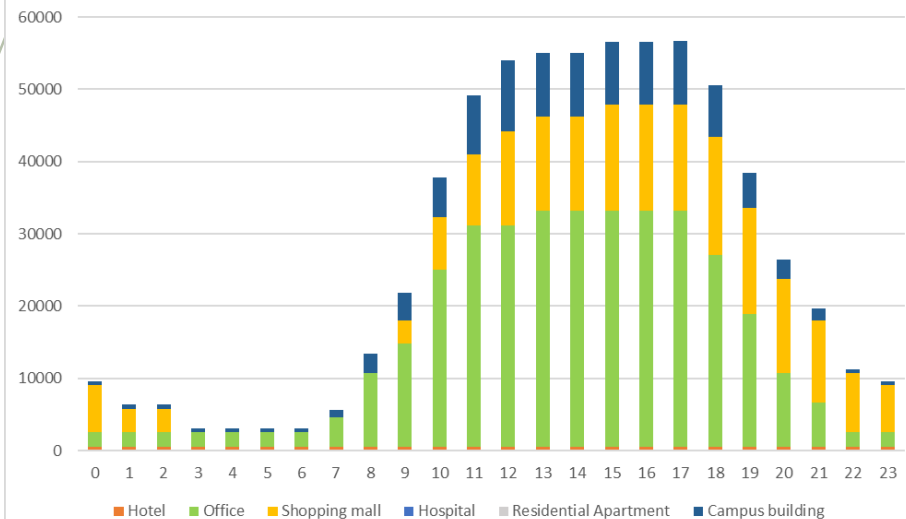
Rapid assessment output template: technical analysis

BUILT-UP AREA ANALYSIS IN THE REGION

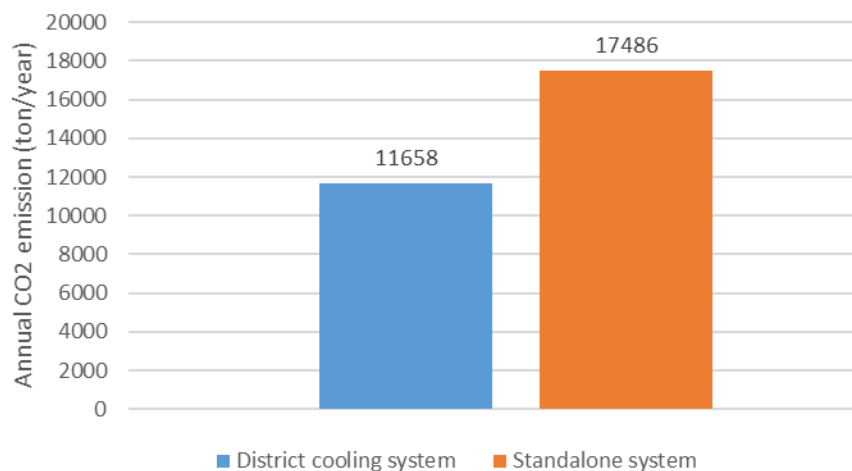
■ Hotel ■ Office ■ Shopping mall
 ■ Hospital ■ Residential Apartment ■ Campus building



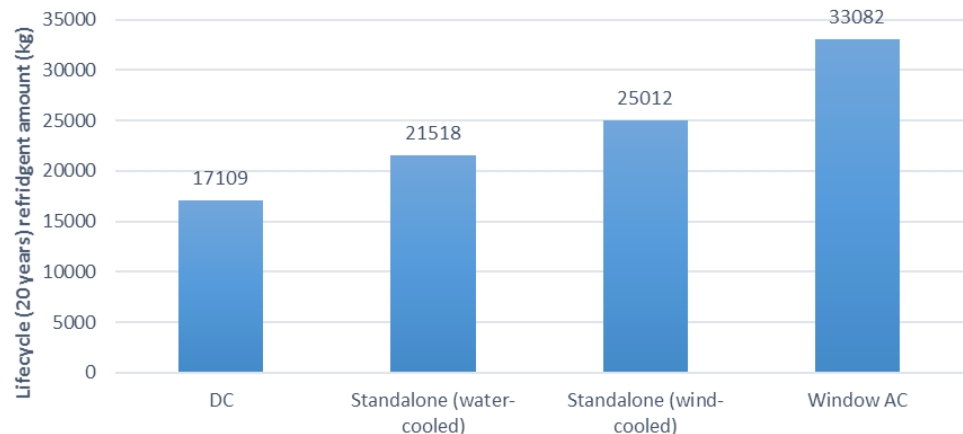
HOURLY COOLING DEMAND PROFILE



Annual CO2 emission by different cooling system



Refridgent amount of different technical solutions





Rapid assessment output template: Financial analysis

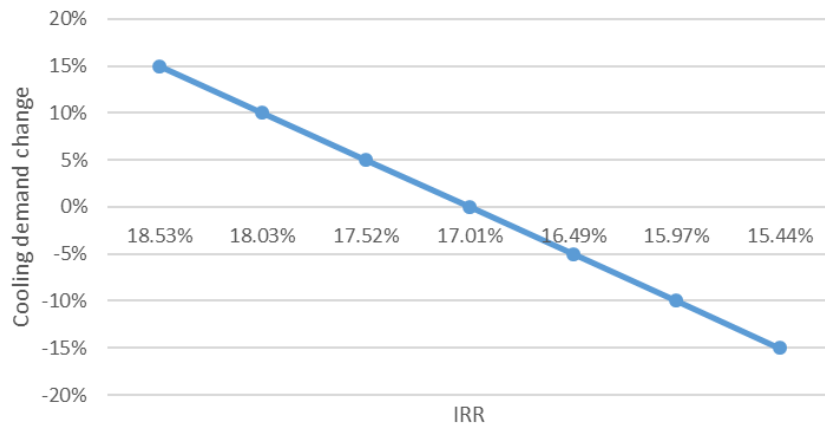
Life cycle payment of district cooling system and standalone system



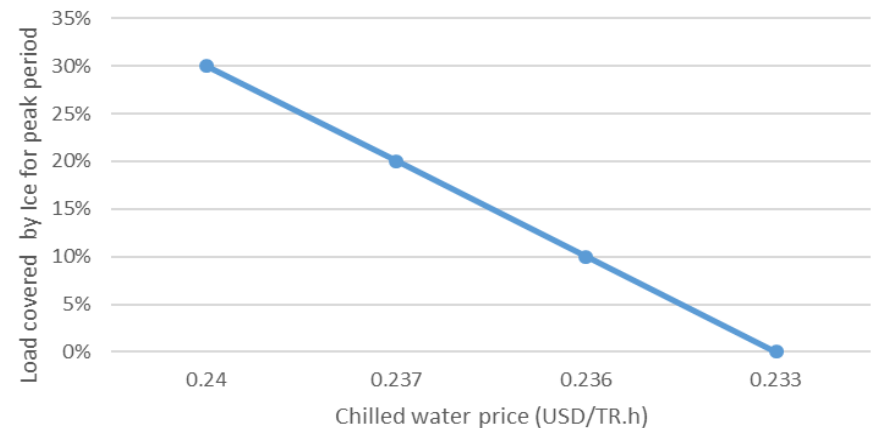


Rapid assessment output template: Economic sensitive analysis

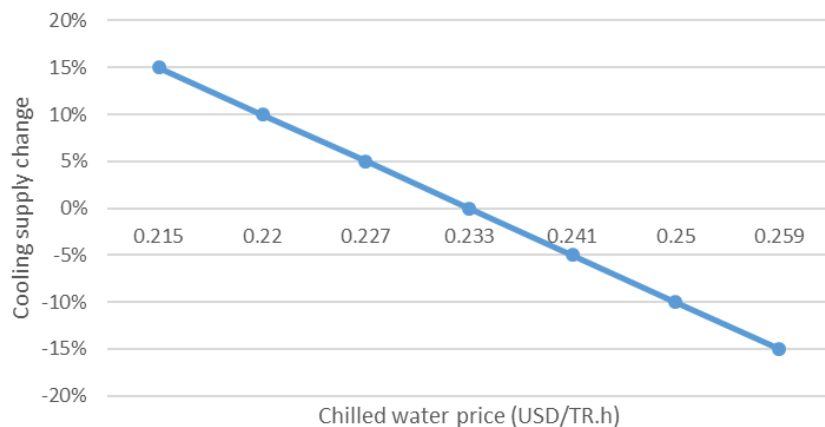
Cooling supply percentage VS. IRR



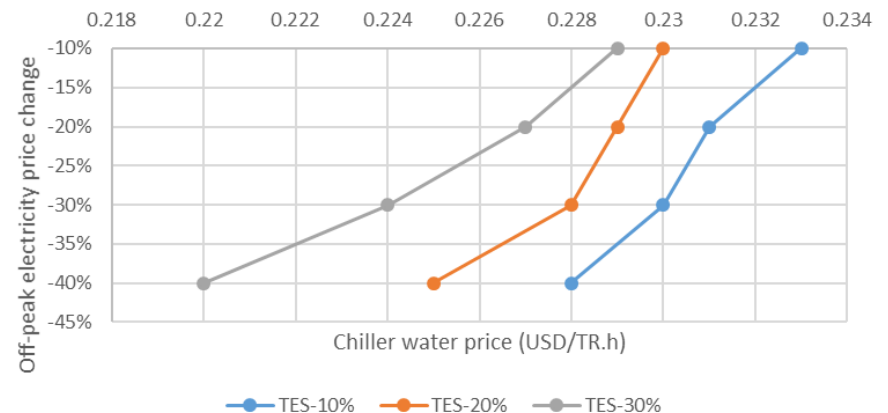
TES-Ice VS. Chilled water price



Cooling supply percentage VS. Chilled water price



Off-peak electricity price VS. Chilled water price





IDENTIFYING HIGH POTENTIAL

R.A. TECH-ECO ANALYSIS TOOL

Next steps:

1. Calibrate with benchmarking data
2. Adapt to other countries for widely use
3. Contain more DES system types, including tri-generation



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THANK YOU!



For more information on the Global District Energy in Cities Initiative, please visit the website or contact:

<http://www.districtenergyinitiative.org/>

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ON ENERGY EFFICIENCY
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