MODUL 1. INTRODUCTION TO DISTRICT COOLING
Objective: share fundamental knowledge on district cooling systems (DCS)

By the end of this module, you will be able to:

- Describe the role of district cooling (DC) in the decarbonisation of the building sector;
- Describe understand and discuss fundamentals of DCS including types of projects, networks and components;
- Identify and develop on the main benefits of DCS across various stakeholders;
- Recognise and apply key steps in the development of district cooling systems planning: phases, assessments, stakeholders, etc.;
Tropical climate and increasing extreme climate events such as heat waves make cooling a necessity in India.

- Aggregated cooling demand projected to grow 9x by 2038

- Manifold increase in energy demand (800GW) and emissions (900MMT CO2) as a result of this growth by 2050

**Drivers and cooling projections for 2037**

Source: Climate centre for cities adapted from ICAP
Why business-as-usual is not an option?

India Cooling Action Plan targets for 2037:

- Reduction of cooling demand: 20-25%
- Reduction of refrigerant demand: 20-30%
- Reduction of energy requirements: 25-40%
A District Energy System distributes thermal energy in the form of chilled (district cooling) or hot water (district heating) from a central source to multiple buildings spread over multiple locations through a network of underground pipes for use in space heating/cooling. The thermal energy is usually provided from a central plant, thus eliminating the need for individual systems.
In a nutshell...

DE uses local energy sources that otherwise would be wasted or not used, in order to offer the local market a competitive and high-energy-efficient alternative to the traditional heating and/or cooling solutions.
 MODULE 1. INTRODUCTION TO DISTRICT COOLING

COMPONENTS OF THE SYSTEM

District Cooling (DC)

Local energy sources
Cooling can be extracted from free cooling sources such as lakes, seas or other waterways. Or it can be generated by a district cooling plant in the form of chilled water.

Distribution
Network of underground insulated pipes that carry chilled water from the production site to the demand sites at a pre-determined temperature.

Customer ETS (end-users)
Each building has an Energy Transfer Station (ETS) which is heat exchangers connecting to the secondary networks. They contain an interface to the buildings' own air conditioning circuits.

Image: Devcco
A district cooling system can have multiple cooling generation plants and sources.

Typical cooling generation sources include: electric/absorptive chillers or free cooling sources such as rivers, seas etc.

Trigeneration or combined cooling, heating and power (CCHP) is a method of generating cooling by utilising some of the heat from a power plant by linking it to an absorption chiller.

Other accessories needed for the generation unit are:
- Circulation pumps: chilled/condensed water
- Electricity transformers
- Water supply and treatment systems
- Cooling towers
- Thermal storage systems: ice/chilled water storage
- Central control systems
The **Distribution Network** contains:

- Pre insulated pipes buried underground
- Direct buried network or a utility corridor
- Leakage detective sensors and alarming system
- Booster pumps if needed

**Pre insulated chilled water pipe**

**Leakage sensors & alarming system**

**Utility corridor**
A typical ETS room has:
- Pipe connections or rough-in with knockout panels on exterior wall
- Heat exchangers for space conditioning
- Controls and meters

Normally it is regulated on design and installation as well as maintained by district cooling suppliers.
### COMPONENTS OF THE SYSTEM

#### Storage

Example: 2 days of cooling demand with and without storage

<table>
<thead>
<tr>
<th></th>
<th>No storage</th>
<th>Thermal storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak residual demand</td>
<td>715</td>
<td>633</td>
</tr>
<tr>
<td>Curtailment</td>
<td>50</td>
<td>0.5</td>
</tr>
<tr>
<td>Cost savings (bil.USD/year)</td>
<td>-</td>
<td>9.7 (7.5 with battery)</td>
</tr>
</tbody>
</table>

Source: IEA
What happens to existing systems when connecting to DC?

- For buildings with existing systems, the central chiller unit will be replaced, but the fan coil units or AHUs will remain the same.
- Upon connecting to DC service, calculations are made to determine heat exchanger size that will replace the central unit and meters will be fit in to record temperatures to determine the cooling consumption and calibration is required to match internal system of the building to the DCS.
- Additionally, within the service agreement contract there will be clear requirements on the DC provider to assure quality and reliability of chilled water service including provisions for providing sufficient notice and requirements for measures should the service not meet the standards.
- The service agreement contract will also define the term, duration and pricing scheme.
- The existing system is usually dismantled.
MODULE 1. INTRODUCTION TO DISTRICT COOLING

MULTIPLE BENEFITS TO CITIES

End users
- Comfort
- Convenience
- Flexibility
- Reliability
- Sustainability

Costing
- Reduced installed capacity
- Optimized operations
- Advanced technologies
- Competent manpower
- Incentives

Infrastructure
- Peak power demand reduction (30-35%)
- Reduction in cost to city governments and DISCOMs
- Long term grid balancing services

Environment
- Energy efficiency
- Reduced CO2 emissions (30-35%)
- Water savings (15-20%)
- Refrigerant savings (10-15% over 20 years)

SUSTAINABLE DEVELOPMENT GOALS
- Health and wellbeing
- Sustainable Energy for All
- Sustainable Economic growth
- Infrastructure, Industry, Innovation
- Sustainable Cities
- Climate Change
India is commissioning **3 million sqft.** of commercial space per day.

**Target developments**
- Smart City areas & CBDs
- Integrated townships, campus
- Industrial areas
- Dense brownfield sites
- Gas connections

**Target Consumers**
- Data centers, IT Offices
- Hospitals, hotels, malls, offices, conference centers
- Universities, public offices etc.
- HIG residential

**Control**
- Municipal influence
- Real estate portfolio
- Large consumers

Source: AEEE, 2017
In 2021, India officially ratified the Kigali Amendment of the Montreal Protocol to phase out hydrofluorocarbons (HFCs) — used in refrigeration and air-conditioning that are known to accelerate global warming.

Source: C2E2
**MODULE 1. INTRODUCTION TO DISTRICT COOLING**

**BARRIERS TO DISTRICT COOLING**

- Lack of promotion at national/state level urban development programs
- No contribution from municipal corporations & DISCOMs for inclusion at master planning stage
- Lack of policy drivers: Acts, Codes, Tariffs, fiscal instruments, contracting arrangements
- Non-inclusion in national building regulations (ECBC) & green building certification

- Design risks like under or over projected loads, design temperatures and delta T, act as constraint for opting DCS as strategy for space cooling
- Insufficient research and case studies to support the selection of technologies based on loads and applications

- Higher capital investment requirements discourage technology providers, owners, investors from pushing for DCS
- Phase wise developments leads to phase wise construction of distribution system and hence develops operational risks
- Revenue generation risks due to under or over projected loads

- Non-availability of skilled professionals to design, operate and maintain DC plants
- Lack of awareness among the stakeholders about the benefits of district cooling
- Lack of capacity in government sector to develop master plans with integrating district cooling

Source: National district cooling potential study for India
Interface Issues

Where will this Energy Transfer Station be, who will pay for it and who is responsible for it?

**Cost of work:** Who pays for:
- Constructing cooling plant
- Constructing network
- Constructing plot network
- Installing energy transfer station equipment

**Timing of work:** Who starts:
- Constructing network
- Constructing plot network

**Ownership of each component**
- During term?
- If early termination?
- After term ends?

**Connection charge**
- What does it cover?
- Does it determine plot network or energy transfer station equipment ownership?

Source: King & Spalding
The process of developing long-range policies and actions to help guide the future of a local, national, regional or energy system to be able to introduce DCS in a long-term sustainable way.

What is district cooling systems planning?

The process of developing long-range policies and actions to help guide the future of a local, national, regional or energy system to be able to introduce DCS in a long-term sustainable way.

Energy and emissions mapping & planning

Image: Developing municipal policy and programs to accelerate market transformation in the building sector

Image: Council, the City’s Sustainability Office in City of Surrey
### Types of projects

<table>
<thead>
<tr>
<th>New</th>
<th>Consolidation</th>
<th>Refurbishment</th>
<th>Expansion</th>
</tr>
</thead>
</table>
| • District energy has a very low market share (0–15 per cent).     | • Very mature market for district energy with above 50 per cent of the market share for heating or cooling of buildings. | • High market share of district energy.  
• However systems need some refurbishment in order to increase customer confidence, energy efficiency and profitability. | • District heating and cooling systems appear in some areas, but the total market share remains low (15–50 per cent).  
• Genuine interest in increasing the market share.  
• Geographical and in terms of energy system complexity. |
| • The city is in the process of stimulating district energy, with small starter networks or demonstration projects envisioned. | • E.g. Denmark, Frankfurt, Gothenburg, Seoul | • E.g. Many cities in China, Russia, Mongolia, and Eastern and South-eastern Europe | • E.g. Rotterdam, Dubai, Vancouver, Paris, Tokyo, Toronto, Milan |
**MODULE 1. INTRODUCTION TO DISTRICT COOLING
KEY CONCEPTS IN DC PLANNING**

Greenfield and Brownfield for end user development status

<table>
<thead>
<tr>
<th>Greenfield</th>
<th>Brownfield</th>
</tr>
</thead>
<tbody>
<tr>
<td>The process of developing new DCS over a region that has never been developed or partially under construction.</td>
<td>The process of developing a DCS over a region that was previously developed with existing buildings. There can even be existing DCS systems.</td>
</tr>
<tr>
<td><strong>Pros:</strong> larger pieces of real estate ideal for future expansion and zoning classification can be accessed, optimum pipe network and power plant location</td>
<td><strong>Pros:</strong> located in the city centre and not in remote areas.</td>
</tr>
<tr>
<td><strong>Cons:</strong> usually located outside city centres that might require additional infrastructure upgrades but those are offset by more accessible land costs</td>
<td><strong>Cons:</strong> require adjustments to already existing preliminary conditions (e.g. buildings, zones, etc.), limited space for power plants and setting up substations inside existing buildings</td>
</tr>
</tbody>
</table>

Source: National district cooling potential study for India
Key Steps in District Cooling planning

1. **Assess** existing energy and climate policy objectives, strategies and targets and identify catalysts.
2. **Strengthen** or develop the institutional multi-stakeholder coordination framework.
3. **Integrate** district energy into national and/or local energy strategy and planning.
4. **Map** local energy demand and evaluate local energy resources.
5. Determine relevant **policy design** considerations.
6. Carry out **project pre-feasibility** and viability.
7. **Develop** business plan.
8. **Analyse** procurement options.
9. **Facilitate** finance.
10. **Replicate**.

ICAP analyses current and future cooling demand and sets targets for reduction.

Room air conditioner stock projections

Source: ICAP
Why is a multi-stakeholder coordination framework required?

- The benefits of a citywide, multi-stakeholder district cooling system are too widespread to motivate any single stakeholder to commit the resources required to drive this facilitation process.
- Engagement from all stakeholders in the development of district cooling ensures cost-effectiveness and reduces risk.
- Bringing the multiple stakeholders together under a ‘coordination framework’ formalises stakeholder engagement and provides a platform and focal point for collaboration.
- Coordination framework can take many forms such as a dedicated unit in local government or an external public private partnership.

[Further details in Module 2!]
Steps in establishing a multi-stakeholder coordination framework

1. Champion and catalyst to begin process
2. Identify relevant stakeholders
3. Map stakeholders to understand their motivations
4. Prioritize stakeholders based on interest and influence
5. Decide a structure of coordination
6. Engage with stakeholders to resolve barriers

[Further details in Module 2!]
How can integrated energy planning further sustainable cool?

- To ensure cost-effective district cooling, cities need to analyse the interaction between energy, land use and infrastructure – including waste, water, buildings and transport.
- Cities can require energy planning to be integrated within all new infrastructure development, including planning for district cooling.
- Cities will have some control of local planning and can exert this authority to ensure optimal conditions for district cooling such as mixed-use zoning and the encouragement of high energy density areas (compact land use).
- Integrated energy planning can allow a city to promote and/or designate areas or zones that have favourable conditions for district cooling development or expansion, and to apply tailored policies or financial incentives.

[Further details in Module 4!]
MODULE 1. INTRODUCTION TO DISTRICT COOLING

DISTRICT COOLING PLANNING

4. MAP local energy demand and evaluate local energy resources

Steps in energy mapping process:

- Stakeholder engagement
- Facilitate finance
- Specify initial area
- Data collection
- Identify specific projects
- Continuous updating and expansion

[Further details in Module 3!]
5. **DETERMINE** relevant policy design considerations

- Mandates for renewables and waste heat
- Social housing focus
- Interconnection and transmission

Chains of arrows are present in the diagram leading to different sections:

- Connection policies
- Tariff regulation
- Policies to develop district cooling
- Policies for municipal utilities
- Levelling playing field
- Planning policies
- Waste tariff regulation

- Protect consumers
- Limit profits and pass on costs
- Next available technology
- Other policies may come from national level

- Encourage waste heat connection
- Cost of connection and cost of redundancy
- Ability to guarantee supply

**[Further details in Module 5!]**
Light touch requires prior knowledge of the viability of DES in different cities within a country and an understanding of cities.

Rapid assessment technical, economic and environmental potential. policy gaps and energy and GHG saving potential.

Source: Adapted from Carbon Trust

Further details in Module 6!
Business models in DES based on ownership type

Level of risk transfer away from developer/customer to provider district cooling

Level of sophistication and level of DC Provider involvement & funding

Source: King & Spalding

[Further details in Module 6!]
Procurement options will depend on the business plan and degree of private sector involvement.

Designing a procurement package that will attract strong bids from the private sector can require experience in local authorities or municipal utilities and capacity building is key to ensuring procurement is high quality and competitive.

International and national support in capacity building for cities, as well as city-twinning and inter-city support can ensure that cities have appropriate experience in designing procurement packages and contracts with the private sector.

If district cooling is to be developed under a concession contract, the procurement package is an opportunity for the local authority to control and direct private sector investment.

Many cities procure the private sector on short-term design and build contracts.
‘New’ cities can set up a revolving fund designed to create multiple starter networks.

Cities can provide grants to projects but also attract national and international grants on the projects behalf.

Cities can guarantee projects to lower the cost of debt, which may be important for socially important projects.

Demonstration of policies and technologies can leverage private sector investment in other networks.

City assets such as land, public-rights-of-way and access to publicly owned anchor loads can reduce risk of projects.

Many cities use their access to cheaper debt to lower the financial cost of a project and use their influence to ensure the project’s success.

[Further details in Module 6!]

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**MODULE 1. INTRODUCTION TO DISTRICT COOLING**

**DISTRICT COOLING PLANNING**

**FACILITATE finance**

- Setting up a revolving fund
- Demonstrating new technologies
- Demonstrating new policies
- Securing and providing grants
- Loan guarantees and underwriting
- Tax credits and exemptions within tax systems
- Debt provision and bond financing
- City assets

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**BEST PRACTICES**

**KEY STEPS**

**BENEFITS & BARRIERS**

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**CONTEXT**

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**DEFINITION**

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CASE STUDIES

MODULE 1. INTRODUCTION TO DISTRICT COOLING

CASE STUDIES: DISTRICT HEATING

GIFT City, India

- Greenfield industrial zones with power and utilities supply
- 8 MW Siemens Gas Turbine, powers absorption chillers
- Chilled water is supplied to nearby industries (e.g. Michelin tyre plant)

- Large compression chillers with planned 180,000 TR capacity
- Thermal storage being implemented to reduce peak demand
- Electricity demand reduction by nearly 44%
- DC pipes placed in multi-utility tunnels alongside other utilities

Gulf JP, Thailand

Copenhagen Centre on Energy Efficiency
PORT LOUIS, MAURITIUS

- Developing district cooling to serve the business district and save 40,000 tons of CO$_2$ per year
- Pump seawater from 1000m deep at 5$^\circ$C
- Received $1 million grant from African Development Bank for development costs
- Could reduce country’s peak power by 6%

CAIRO, EGYPT

- Fast growing district cooling market
- Developing National District Cooling Code to overcome barriers, accelerate growth
- Supports city planners, creates an Energy Authority, and establishes legislation
Some examples of DCS in India are:

- GIFT City, Ahmedabad – 180,000 TR capacity (at full long-term capacity)
- DLF cyber city (trigeneration based) – 78,000 TR capacity
- Delhi Airport – Approx. 20,000 TR capacity
- Mumbai Airport – Approx. 20,000 TR capacity
- Chennai Airport – Approx. 12,000 TR capacity
- Kolkata Airport – Approx. 12,000 TR capacity
- Dhirubhai Ambani Knowledge City, Navi Mumbai - Approx. 12,000 TR capacity
- Infosys (various campuses) – Approx. 50,000 TR (approx.)
- Pragati Maidan, Delhi - Approx. 12,000 TR capacity (In Construction)
- India International Convention Centre, Delhi – Approx. 10,000 TR capacity (In Construction)

For large and dense mix-use developments in India, district cooling makes techno-commercial sense over individual chiller plants

Source: National DC potential study for India
Some of the main aspects we have seen in this module are:

- DE aims to use **local energy sources** that otherwise would be wasted or not used, in order to offer for the local market a **competitive and high-energy-efficient alternative** to the traditional heating and/or cooling solutions;

- It has been established as a key technology in **decarbonising building cooling sector** by utilizing local, renewable sources of cold;

- DC helps **cities align themselves with SDGs** while providing multiple technical benefits such as HCFC reduction, CO2 emission reduction, reduction in peak power demand, reduced cost of cooling etc. while also providing **benefits to the stakeholders** involved;

- DCS projects can be divided into various types based on **market share** (new, consolidation, refurbishment & expansion) and **end user development** status (greenfield & brownfield)
District cooling planning is the process of developing long-range policies and actions to help guide the future of a local, national, regional or energy system to be able to introduce DCS in a long-term sustainable way.

It can be divided into ten key steps:

1. Assess existing energy and climate policy objectives, strategies;
2. Strengthen or develop the institutional multi-stakeholder coordination framework;
3. Integrate district energy into national and/or local energy strategy and planning;
4. Map local energy demand and evaluate local energy resources;
5. Determine relevant policy design considerations;
6. Carry out project pre-feasibility and viability;
7. Develop business plan;
8. Analyse procurement options;
9. Facilitate finance;
10. Replicate.
THANK YOU FOR COMPLETING THIS E-MODULE!

For more information about the initiative or this Training, please visit the following websites or contact:

www.districtenergyinitiative.org
unep.org
c2e2.unepdtu.org
In the upcoming modules, you will learn about ...

Module 2
- Stakeholder coordination for district cooling development

Module 3
- Energy mapping and data collection to identify long-term opportunities for district cooling systems

Module 4
- Strategy development: Incorporating district cooling into local energy and low carbon systems

Module 5
- Carbon heating and cooling strategies

Module 6
- Business models for sound sustainable district cooling systems
## Module 1. Introduction to District Cooling
### Interface Responsibilities

<table>
<thead>
<tr>
<th>Component</th>
<th>Design, construction &amp; installation</th>
<th>Ownership</th>
<th>Testing</th>
<th>Interface risk</th>
<th>Operation &amp; management</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC plant (DCP)</td>
<td>Provider</td>
<td>Provider will be granted leasehold rights over the DC plot</td>
<td>Provider</td>
<td>Provider- interface with DN</td>
<td>Provider</td>
</tr>
<tr>
<td>Plot network</td>
<td>Provider</td>
<td>Provider, until payment in full by customer of connection charge under a CSA, then title transfers to customer</td>
<td>Provider at plot boundary valve chamber</td>
<td>See distribution network</td>
<td>Provider</td>
</tr>
<tr>
<td>ETS equipment</td>
<td>Provider</td>
<td>Provider, until payment in full by the customer of the connection charge under a CSA, then title transfers to customer</td>
<td>Provider</td>
<td>Provider- interface with plot network</td>
<td>Provider</td>
</tr>
<tr>
<td>Distribution network (DN)</td>
<td>Design: Initially master developer (MD) then novated to provider on signing master agreement Construction: Initially MD then novation/direct engagement by provider if timing works</td>
<td>Provider will be granted easement/lease rights over the DN</td>
<td>Provider</td>
<td>Provider- interface between plot network and DN and between DN and DCP</td>
<td>Provider</td>
</tr>
<tr>
<td>Meters (bulk)</td>
<td>Provider</td>
<td>Provider</td>
<td>Provider</td>
<td>NA</td>
<td>Provider</td>
</tr>
<tr>
<td>Meters (end-user)</td>
<td>Location, design &amp; installation: MD/Customer Specification &amp; procurement: Provider</td>
<td>Provider</td>
<td>Provider</td>
<td>NA</td>
<td>Provider</td>
</tr>
</tbody>
</table>

Source: King & Spalding