



DISTRICT ENERGY
IN CITIES
INITIATIVE

E-TRAINING PROGRAM DISTRICT ENERGY DEVELOPMENT



MODULE 1. INTRODUCTION TO DISTRICT ENERGY





MODULE 1. INTRODUCTION TO DISTRICT ENERGY

LEARNING OUTCOMES

Objective: share fundamental knowledge on district energy systems (DES)

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



Describe the role of district energy (DE) in the decarbonisation of the building sector;



Describe understand and discuss fundamentals of DES including types of projects, networks and components;



Identify and develop on the main benefits of DES across various stakeholders;



Recognise and apply key steps in the development of district energy systems planning: phases, assessments, stakeholders, etc.;

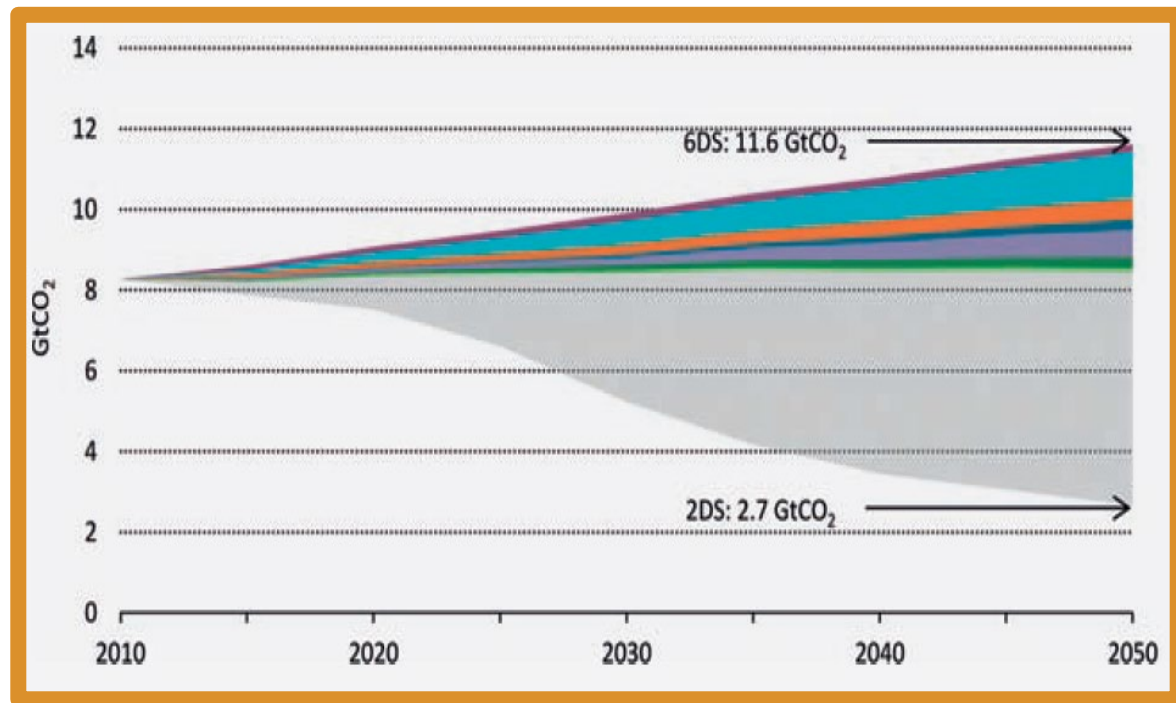
MODULE 1. INTRODUCTION TO DISTRICT ENERGY

THE ROLE OF HEATING AND COOLING

Heating, hot water and cooling account for **60% of the global energy consumption** in buildings, largely met by fossil fuels

- Emissions from the buildings sector need to be **reduced by approximately 75% by 2050**
- Cooling demand will **grow by 625% by 2050** in selected regions of Asia and Latin America (IEA 2°C scenario)

CO₂ emission reductions needed from buildings sector



Source: IEA, 2019



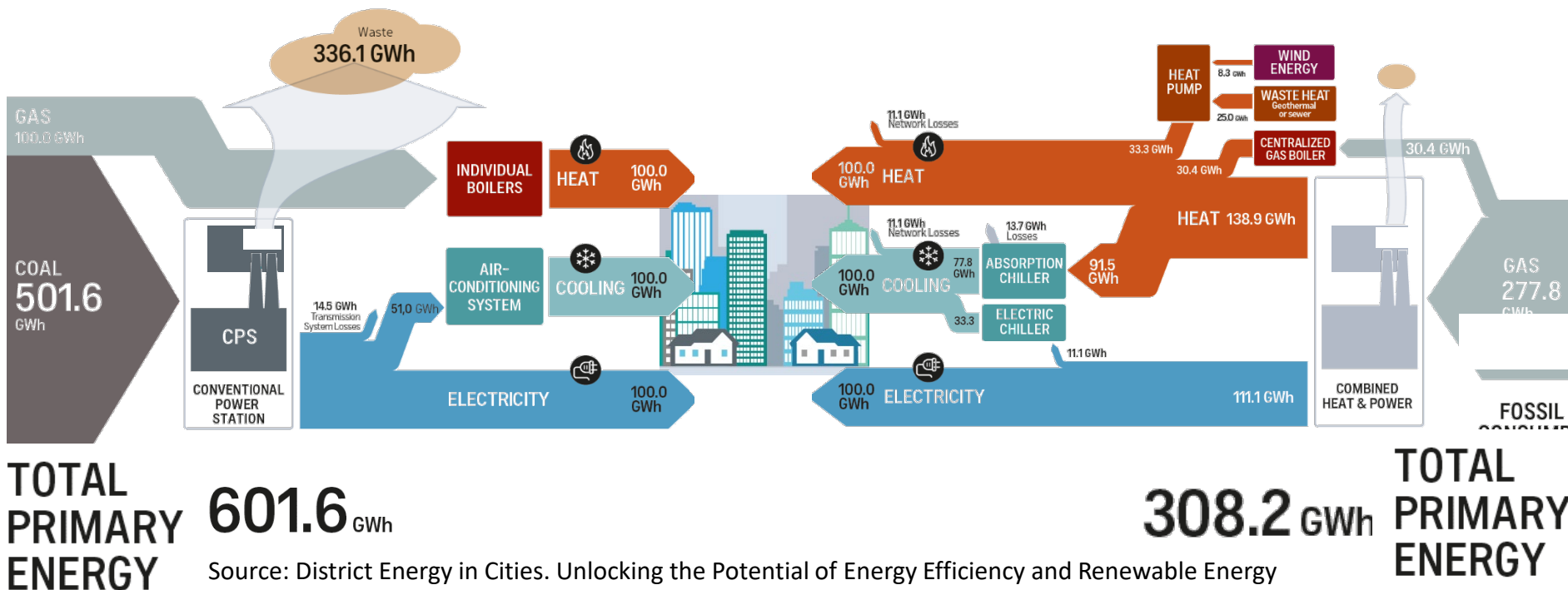
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DISTRICT ENERGY VS BUSINESS-AS-USUAL

BUSINESS-AS-USUAL

MODERN DISTRICT ENERGY SYSTEM

- Lower primary energy consumption
- Recovery of surplus and low-grade heat and cold
- Energy storage at a low cost
- Integration of renewable power in electricity grids



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

BARRIERS TO DISTRICT ENERGY

Long-lasting barriers blocking the potential of district energy systems

- Awareness and misperception
- Local and institutional capacity
- Holistic planning policies, harmonized incentives and regulations
- Regulatory environment
- Finance
- Data/information



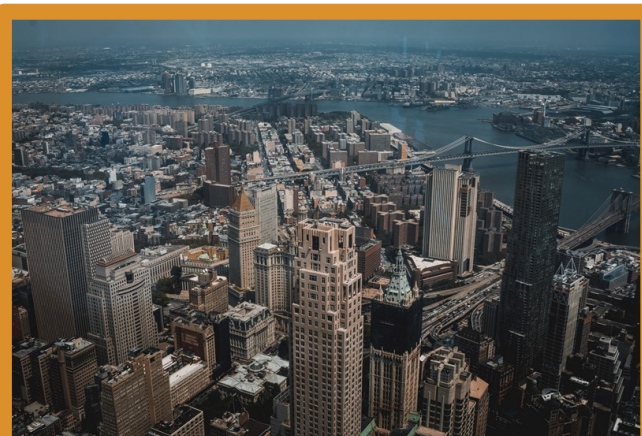
Source: District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DEFINITION OF DISTRICT ENERGY

- Centralize & coordinate production and supply of heating, cooling, DHW and power to **optimise energy efficiency and local resource use**.
- **Underground network of insulated pipes that pump hot or cold water** to multiple buildings in a district, neighbourhood or city.
- Create **synergies between the production and supply** of heat, cooling, DHW and electricity
- **Reduce emissions** (e.g. CO₂, PM_{2.5}, PM₁₀)



Source: top - Unsplash, bottom - Deltares



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

POTENTIAL OF DISTRICT ENERGY



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

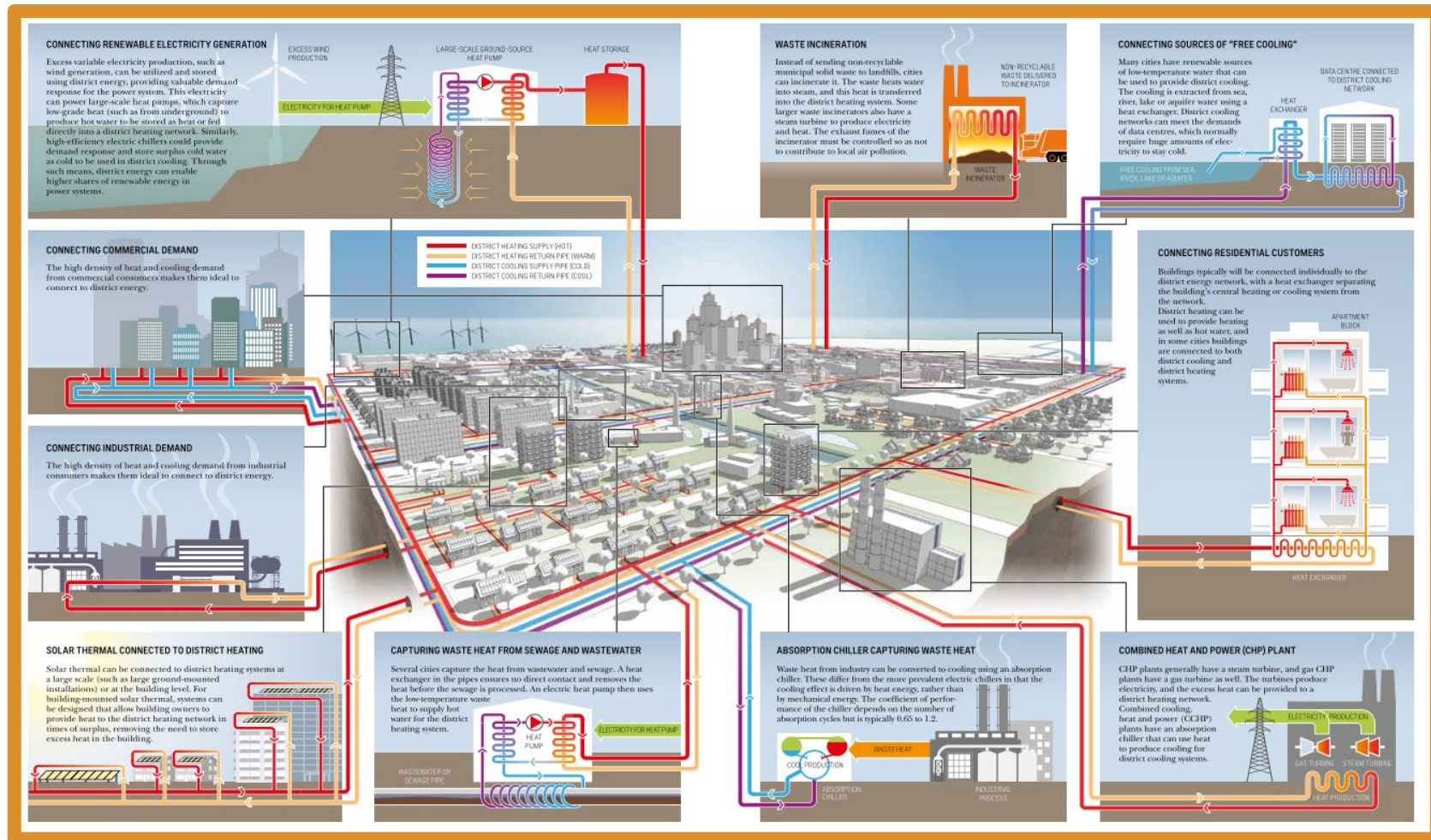


Source: Unsplash



MODULE 1. INTRODUCTION TO DISTRICT ENERGY COMPONENTS OF THE SYSTEM

Components of District Energy Systems (DES)



Source: District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

COMPONENTS OF THE SYSTEM

District Cooling (DC)

Local energy sources

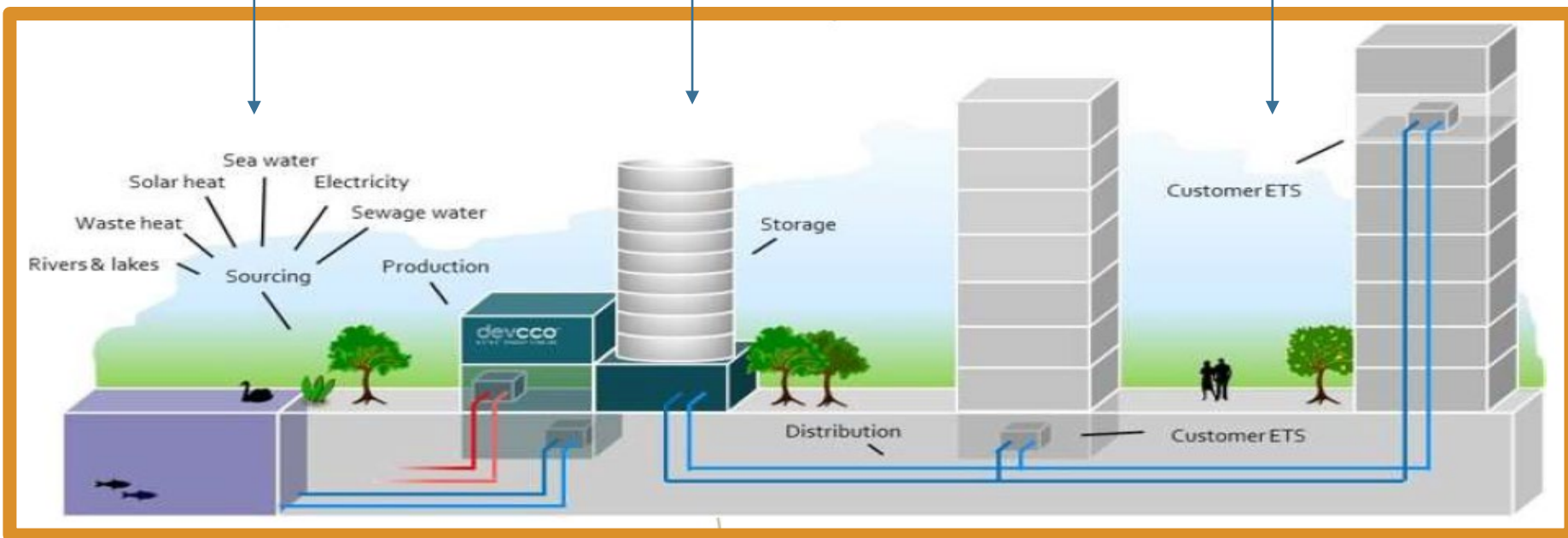
Cooling can be extracted from free cooling sources such as lakes, seas or other waterways. Or it can be generated by a district cooling plant in the form of chilled water

Energy storage

With the help of a storage unit, energy collected in the valleys of consumption can be distributed in the peaks of consumption. The storage unit stores chilled water from the cooling plant

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.



Source: Devcco



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

COMPONENTS OF THE SYSTEM

District Heating (DH)

Local energy sources

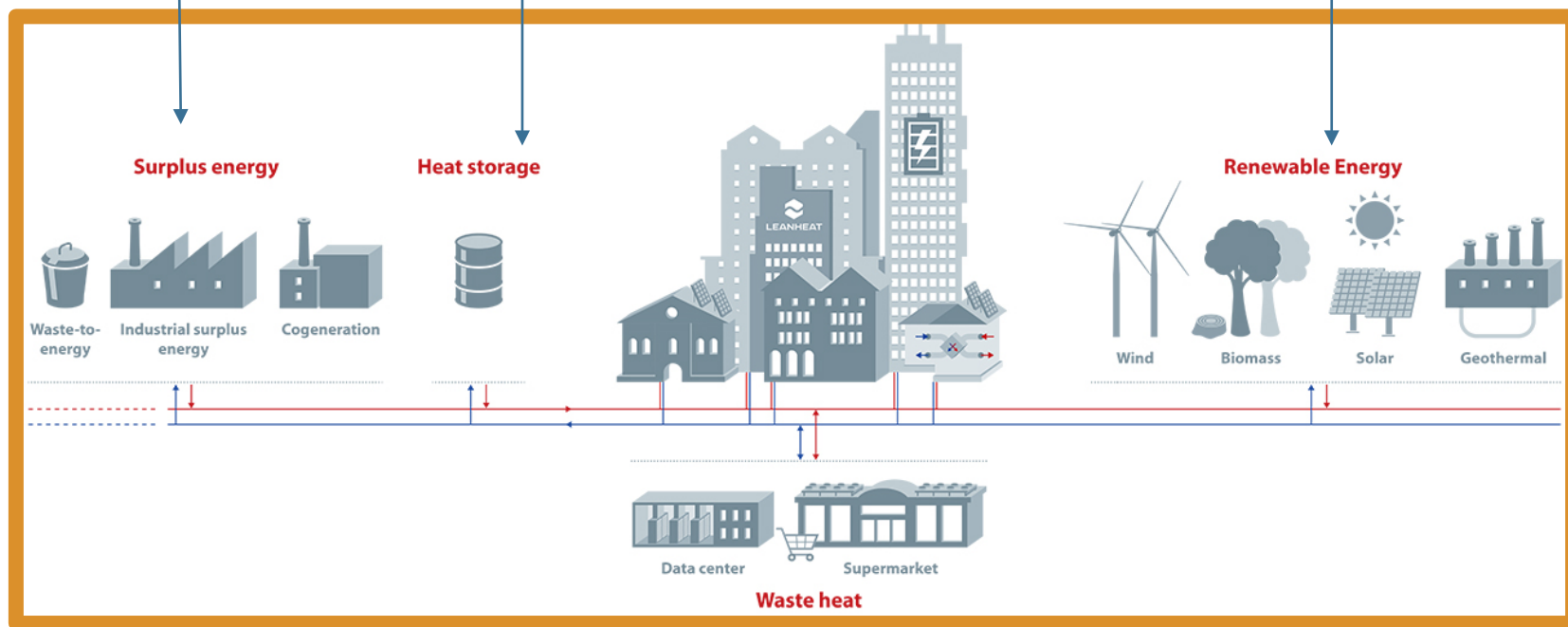
Surplus energy can be collected from waste to energy plants and through industrial sources and CHPs. Energy can also be extracted from waste heat.

Thermal energy storage (TES)

It allows excess energy to be stored and used hours, days or months later, at scales ranging from the individual process to entire district.

Local renewable sources

Large solar or geothermal power stations can be installed to directly produce heating. Power stations operating on biomass can also be installed.



Source: Danfoss

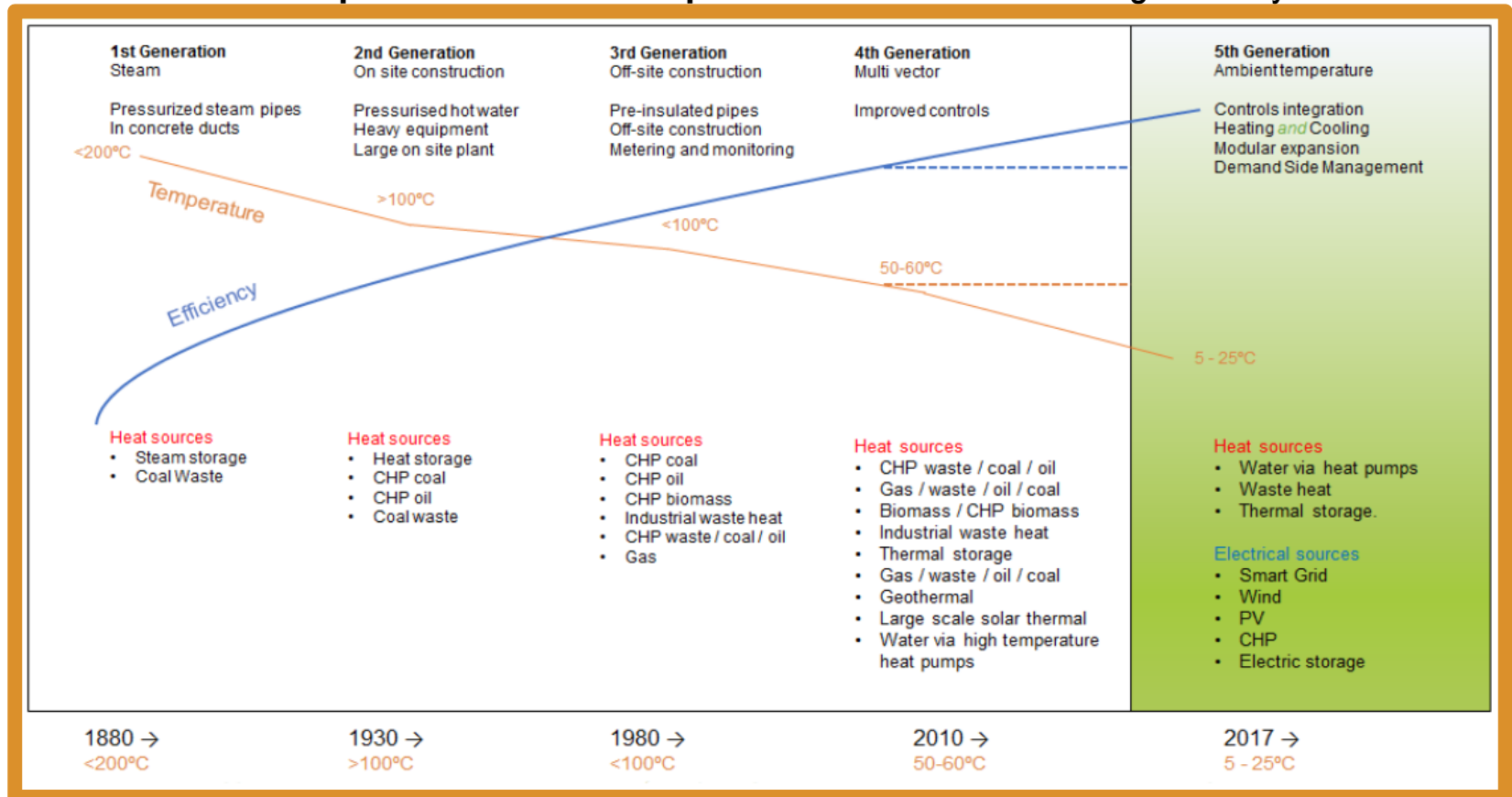


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EVOLUTION OF DISTRICT ENERGY SYSTEMS

Evolution of District Energy Systems

District energy systems have evolved through **five generations** and with each generation the **efficiency** has improved while the **temperatures** have reduced significantly.



Source: ICAX, UK



MODULE 1. INTRODUCTION TO DISTRICT ENERGY TOWARDS ATTAINING SDGs

Reduced fuel poverty

Paris Agreement and
NDC Kigali Agreement

Improved air quality in
cities through reduced
use of fossil fuels

Defined in Habitat III
New Urban Agenda

Integration of
renewables and
efficiency

Reduced blackouts
Improved resilience
of cities

Local jobs and reduced
energy imports



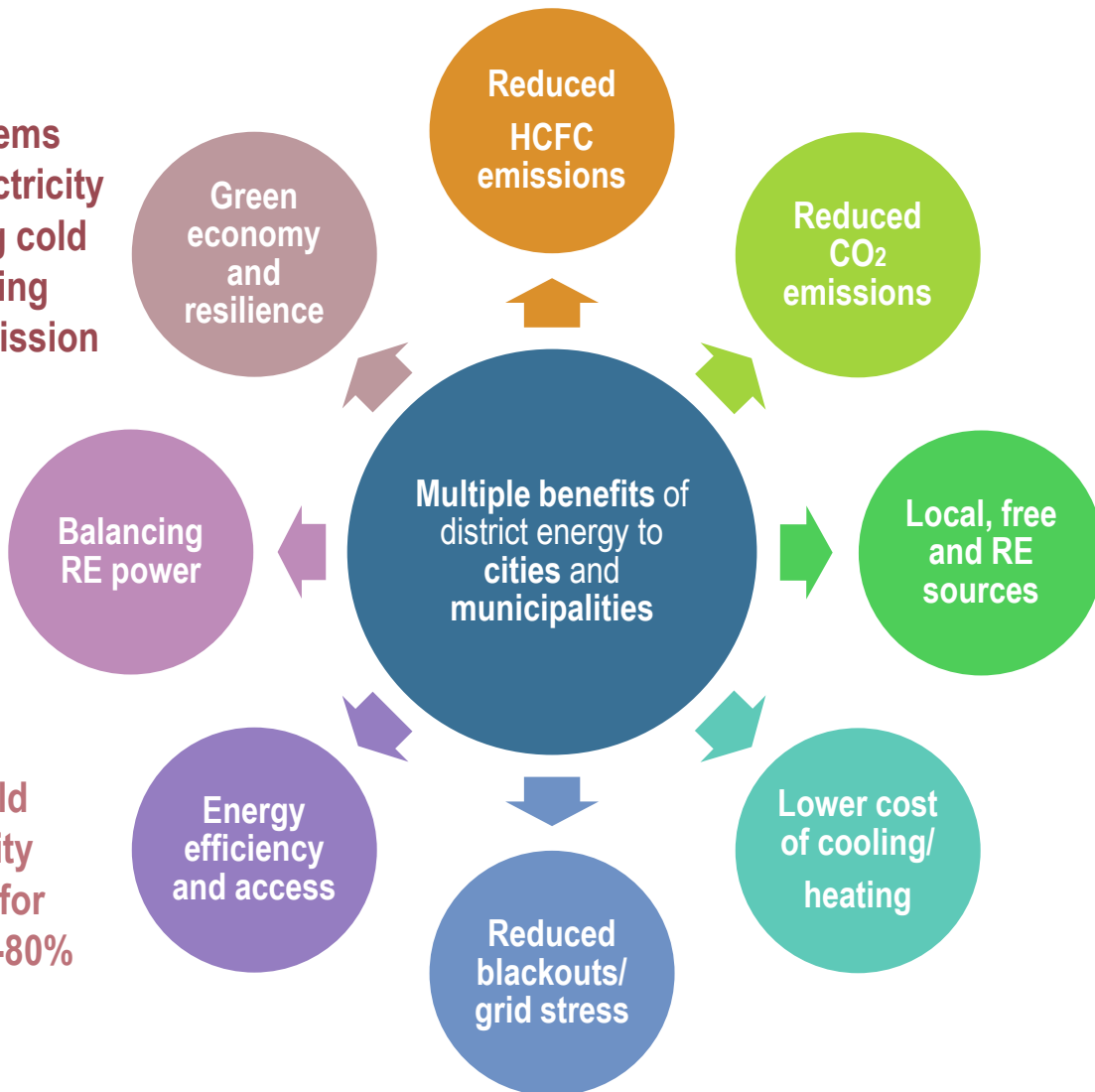


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MULTIPLE BENEFITS TO CITIES

Most DC systems shift peak electricity demand using cold storage lowering power transmission investment

GIFT City could lower electricity consumption for cooling by 65-80%



350K tons of CO₂ reduced per year by powering 50% of Paris' district heating with renewable energy

Paris reduced refrigerant emissions from cooling by 90%

Dubai provides cooling that is 30-40% cheaper than stand-alone systems



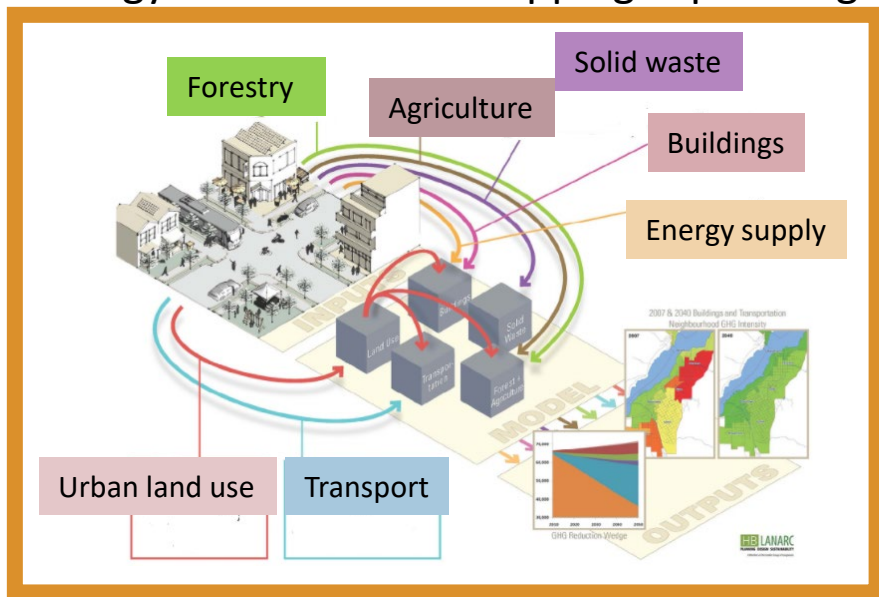
MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DEFINITION OF DISTRICT ENERGY PLANNING

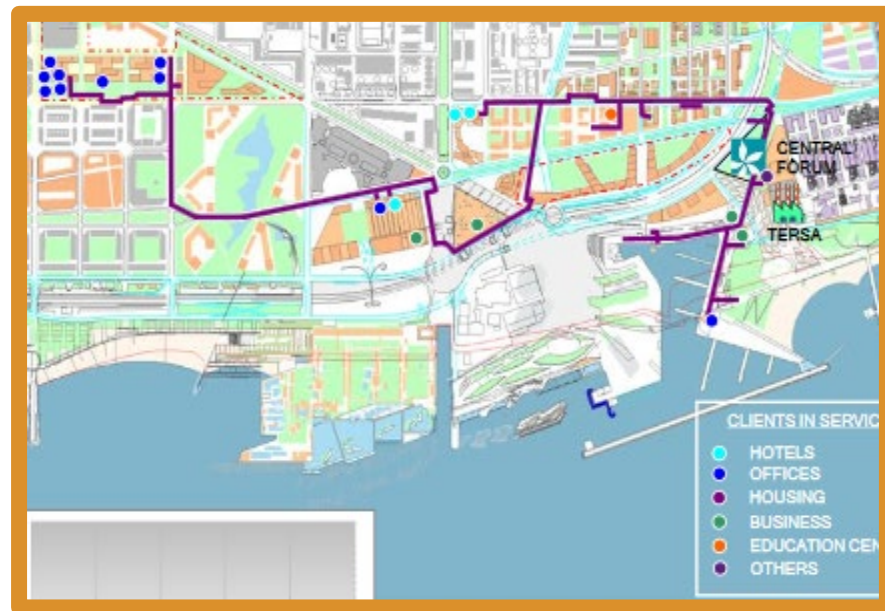
What is district energy systems planning?

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 DES in a long-term sustainable way.

Energy and emissions mapping & planning



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



Source: Council, the City's Sustainability Office in City of Surrey



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

KEY CONCEPTS IN DE PLANNING

Types of DE projects

New

- District energy has a very low market share (0–15 per cent).
- The city is in the process of stimulating district energy, with small starter networks or demonstration projects envisioned.
- *E.g. London, GIFT City, Port Louis, Kuwait City, Sydney, Christchurch, Marina Bay*

Consolidation

- Very mature market for district energy with above 50 per cent of the market share for heating or cooling of buildings.
- *E.g. Denmark, Frankfurt, Gothenburg, Seoul*

Refurbishment

- High market share of district energy.
- However systems need some refurbishment in order to increase customer confidence, energy efficiency and profitability.
- *E.g. Many cities in China, Russia, Mongolia, and Eastern and South-eastern Europe*

Expansion

- 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.
- *E.g. Rotterdam, Dubai, Vancouver, Paris, Tokyo, Toronto, Milan*

Source: Own elaboration



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

KEY CONCEPTS IN DE PLANNING

Greenfield and Brownfield for end user development status

Greenfield

The process of developing new DES over a region that has never been developed or partially under construction.

Pros: larger pieces of real estate ideal for future expansion and zoning classification can be accessed, optimum pipe network and power plant location

Cons: usually located outside city centres that might require additional infrastructure upgrades but those are offset by more accessible land costs

Brownfield

The process of developing a DES over a region that was previously developed with existing buildings. There can even be existing DES systems.

Pros: located in the city centre and not in remote areas.

Cons: require adjustments to already existing preliminary conditions (e.g. buildings, zones, etc.), limited space for power plants and setting up substations inside existing buildings

Source: District Energy in Cities. National district cooling potential study for India

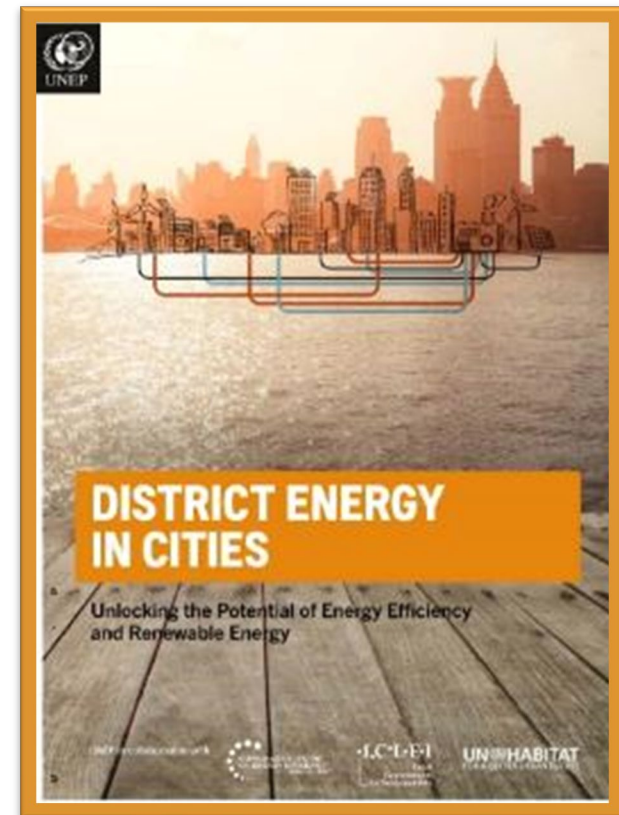


MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

Key Steps in District Energy 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**



Source: District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy

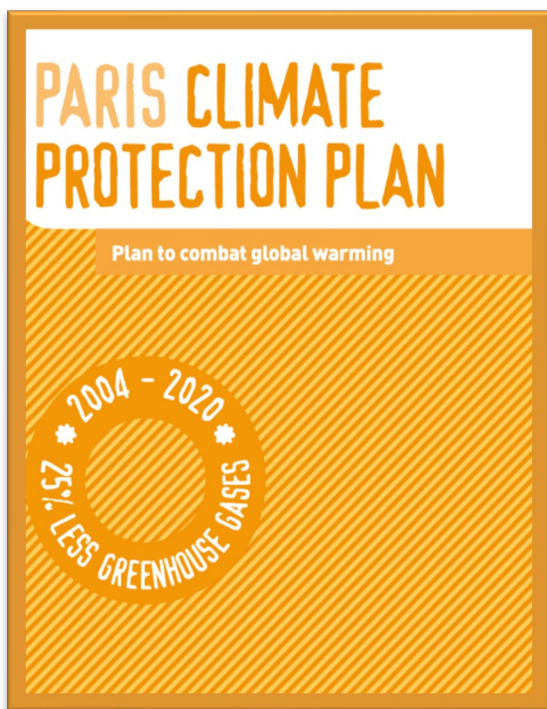


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DISTRICT ENERGY PLANNING

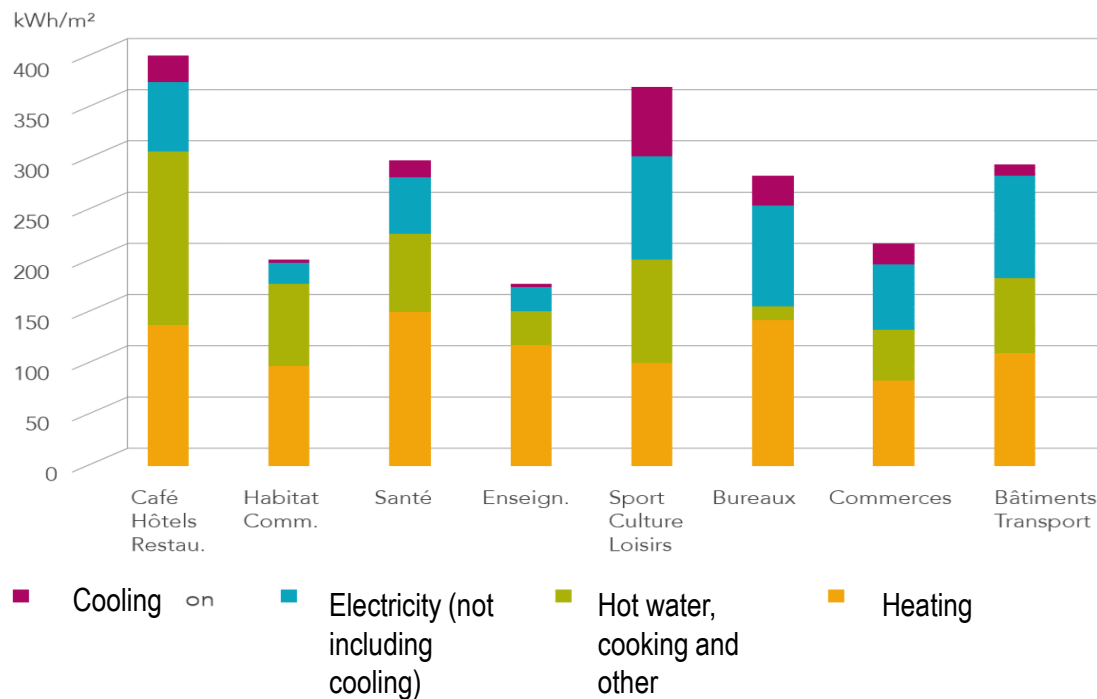
1.

ASSESS existing energy and climate policy objectives, strategies and targets, and identify catalysts



Source: District Energy in Cities Initiative

Annual energy consumption by building type in Paris (2009)





MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

2.

STRENGTHEN or develop the institutional multi-stakeholder coordination framework

Why is a multi-stakeholder coordination framework required?

- The benefits of a citywide, multi-stakeholder district energy 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 energy 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!]



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

2.

STRENGTHEN or develop the institutional multi-stakeholder coordination framework

Champion
and catalyst
to begin
process

Identify
relevant
stakeholders

Decide the
structure of
coordination

Define
benefits for
each
stakeholder

Resolve
barriers by
coordinating
with relevant
stakeholders

Accelerate
DE
development
(communication,
influence)

[Further details in Module 2!]



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

3.

INTEGRATE district energy into national and/or local energy strategy and planning

How can integrated energy planning further sustainable heat/cool?

- To ensure cost-effective district energy, 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 energy.
- Cities will have some control of local planning and can exert this authority to ensure optimal conditions for district energy 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 energy development or expansion, and to **apply tailored policies or financial incentives**.

[Further details in Module 4!]



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

4.

MAP local energy demand and evaluate local energy resources



[Further details in Module 3!]



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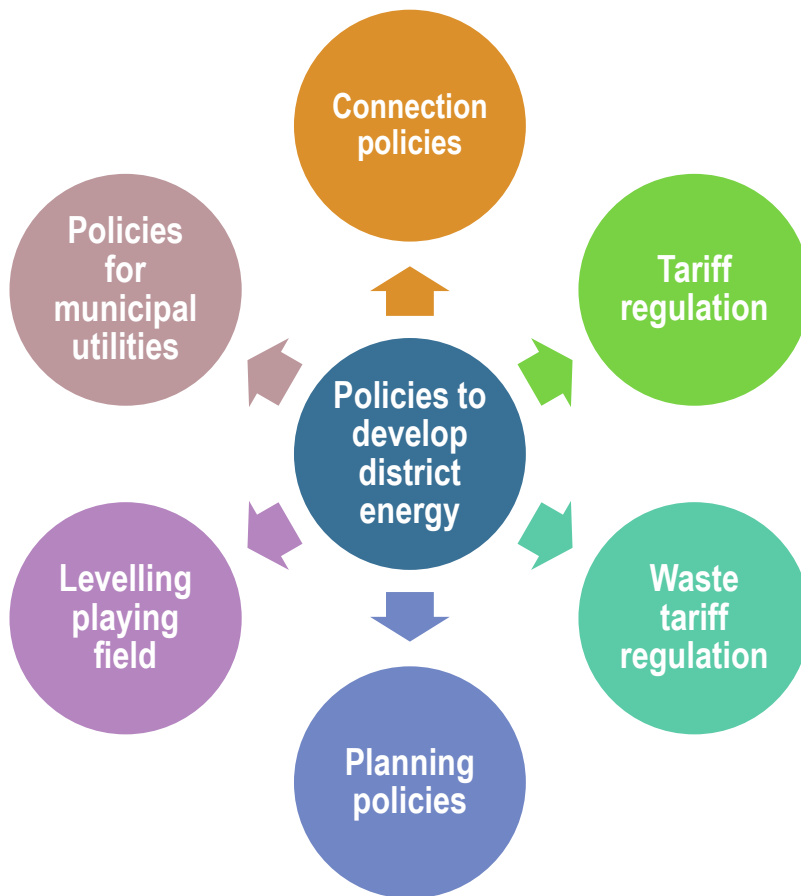
DISTRICT ENERGY PLANNING

5.

DETERMINE relevant policy design considerations

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

- CHP FiT
- Municipal subsidies or fiscal benefits
- Pass through of national energy subsidies
- Other policies may come from national level



- 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!]



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

6.

CARRY OUT project pre-feasibility and viability

Finance

- Some cities place the bonus **of financing and developing feasibility studies** on private investors.
- A **revolving fund model for feasibility studies** can **accelerate multiple starter networks** in 'new' cities.

Capacity building

- City should work with consultants to **ensure local capacity building through the feasibility process** to make feasibility studies cheaper, easier and less risky in the future.
- Feasibility studies **may direct local authorities to local policy requirements**, which can then be tested and validated.

Data and coordination

- **Feasibility studies are cheaper, easier and more robust when strong data is available.**
- **Coordination between different departments** such as a clear planning process for district energy and ready-access to relevant stakeholders **makes feasibility studies cheaper and more effective.**



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

6.

CARRY OUT project pre-feasibility and viability

Key aspects in prefeasibility and feasibility studies

Load density

- Load density **can reduce the cost of the heat or cool network.**
- Cities **should ensure that the majority of appropriate demand is connected to the DES** through land-use policies, subsidies and advocacy.

Anchor loads and storage

- Having a **seasonal heat or cool profile mean low utilization for some heat capacity**, such as CHP, meaning higher costs.
- **Connecting anchor loads** (swimming pools, data centres, low temperature industry) **can ensure higher utilization outside of the heating/cooling season.**

Disconnect from fossil fuels

- **Higher efficiency, use of waste heat and increased renewables use means more a more resilient to fossil fuel price increases DE.**
- **Enable a steadier price for heating and/or cooling and for cities to become more energy independent.**

[Further details in Module 6!]





MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

7.

DEVELOP business plan

Business models in DES based on ownership type

Fully public models

- High degree of control
- Potentially high degree of coverage
- Medium/low returns
- High public risk

PPP/hybrid models

- Medium degree of control
- Coverage based on negotiations
- Medium/high returns
- Medium public risk

Privately owned models

- Low degree of control
- High returns
- Medium/low public risk

Source: District Energy in Cities. Unlocking the potential of Energy Efficiency and Renewables

[Further details in Module 6!]



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

8.

ANALYSE procurement options

- 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 energy 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.

[Further details in Module 6!]



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

DISTRICT ENERGY PLANNING

9.

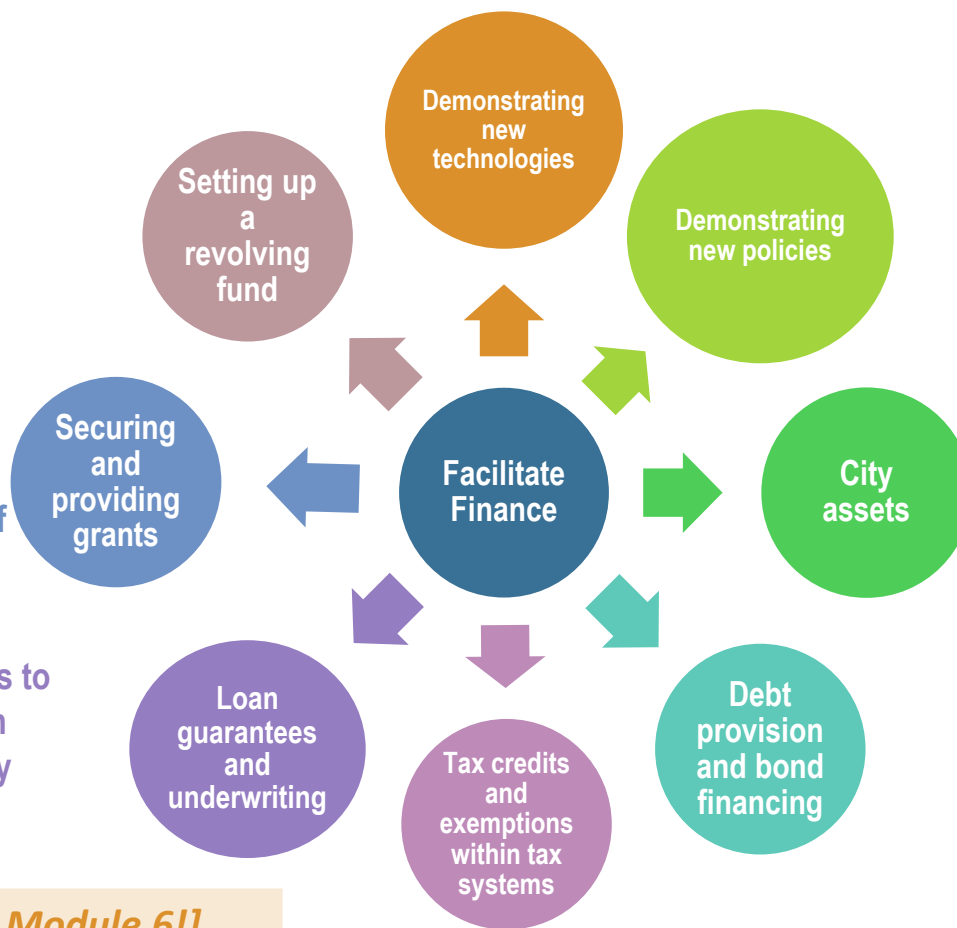
FACILITATE finance

‘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

[Further details in Module 6!]



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



DISTRICT
ENERGY
IN CITIES

CASE STUDIES



Paris, source: District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

CASE STUDIES: DISTRICT COOLING

PORT LOUIS, MAURITIUS



Source: Sotraviv Ltd.

- Developing district cooling to serve the business district and save **40,000 tons of CO₂** per year
- Pump seawater from 1000m deep at 5°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

Source: Unsplash



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

CASE STUDIES: DISTRICT HEATING

PARIS, FRANCE



- **4GW** (thermal) production facilities producing steam for the network.
- Nearly **50% renewable**
- **3 Waste-to-energy plants** avoid the emission of 800,000 tCO₂ per year, these are not owned by CPCU.
- Production: 5.5 TWh of heat and 1 TWh of electricity per year

- **District heating on existing network 60% > expensive domestic gas-fired boilers**
- The initial phase of DE solution could save up to **10,200 tons of CO₂-eq** annually by connecting 10,000 residents.

Source of both images: District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy

YEREVAN, ARMENIA





MODULE 1. INTRODUCTION TO DISTRICT ENERGY

KEY TAKEAWAYS (I/II)

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 heating/cooling sector** by utilizing local, renewable sources of heat and cold;
- DE helps **cities align themselves with SDGs** while providing multiple technical benefits such as HCFC reduction, CO2 emission reduction, utilization of local & free RE sources, reduced cost of heating/cooling etc. while also providing **benefits to the stakeholders** involved;
- DES projects can be divided into various types based on **market share** (new, consolidation, refurbishment & expansion) and **end user development** status (greenfield & brownfield)



MODULE 1. INTRODUCTION TO DISTRICT ENERGY

KEY TAKEAWAYS (II/II)

Some of the main aspects we have seen in this module are:

- District energy 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 DES 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



E-TRAINING PROGRAM

DISTRICT ENERGY DEVELOPMENT

In the upcoming modules, you will learn about ...

Module 2

- Stakeholder coordination for district energy development

Module 3

- Energy mapping and data collection to identify long-term opportunities for district energy systems

Module 4

- Strategy development: Incorporating district energy into a local energy and low carbon systems

Module 5

- Carbon heating and cooling strategies

Module 6

- Business models for sound sustainable district energy systems