Ministerio de Energía
Gobierno de Chile

Agencia de Sostenibilidad Energética

ONED
OFICINA NACIONAL DE ENERGÍA DISTRITAL

UN environment programme

gef global environment facility
INVESTING IN OUR PLANET

CONFERENCIA INTERNACIONAL ENERGÍA DISTRITAL LAC 2025

Septiembre 2025

Speakers/ Oradora, Oradores

- Mr. Zhuolun Chen, UNEP Copenhagen Climate Center

- Ms. Clara Camarasa, UNEP Copenhagen Climate Center

- Mr. Morten Jordt Duedahl, Danish Board of District Heating (DBDH)

UN environment programme

Agenda / Orden del día

Time *(Tiempo)*	Session *(Sesión)*	Speakers *(Oradora, Oradores)*	Content summary *(Resumen del contenido)*
14:30–15:15	Introduction of District Energy *(Introducción de la energía distrital)*	Zhuolun Chen	District energy: concepts, trends, benefits, financing, and city case studies *(Energía distrital: conceptos, tendencias, beneficios, financiación y estudios de casos urbanos)*
15:15–16:00	District Energy Mapping and Planning *(Mapeo y planificación de energía distrital)*	Clara Camarasa	District energy mapping & planning: data, tools, integration with urban goals, and case studies *(Mapeo y planificación de energía distrital: datos, herramientas, integración con objetivos urbanos y estudios de caso)*
16:00–16:45	District Energy Implementation: Experiences & Lessons learnt in Danmark *(Implementación de energía distrital: experiencias y lecciones aprendidas en Dinamarca)*	Morten Jordt Duedahl	Denmark's experience: district heating & cooling implementation, phasing, financing, and business development *(La experiencia de Dinamarca: implementación, fases, financiación y desarrollo empresarial de calefacción y refrigeración urbana)*
16:45–17:30	Video Sharing & Discussion *(Intercambio y debate de vídeos)*	All speakers	Case studies with videos: district cooling retrofits, energy planning tools, CCHP, DBOT, and VR/BIM applications *(Estudios de caso con videos: modernización de sistemas de refrigeración urbana, herramientas de planificación energética, CCHP, DBOT y aplicaciones VR/BIM)*

Part 1: Introduction- Basic concept of district heating and cooling systems in cities, implementation cases & financial mechanisms

Introducción Concepto básico de los sistemas de calefacción y refrigeración distritales en ciudades, casos de implementación y mecanismos financieros

Dr. Zhuolun Chen

Senior Advisor of Energy Efficiency & Green Finance

LEED AP, CMVP, CFA&CFA-Sustainable Investment

2025.9.8 District Energy Training Workshop, Sandiago de Chile

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme

Who Am I?

Zhuolun Chen

- Senior advisor on energy efficiency and green finance in UNEP Copenhagen Climate Center, Division of Climate Change, UNEP
- An experienced engineers with strong academic research background and financial skills
- Nominated expert for UNFCCC Global Goal on Adaptation (GGA), Biennial Transparency Reports (BTRs) and Article 6.2 (Internationally Transferred Mitigation Outcomes, ITMOs) on carbon trading
- Working across innovative technologies, financing mechanisms (e.g. carbon market) and business models, to implement green building, sustainable cooling and heating

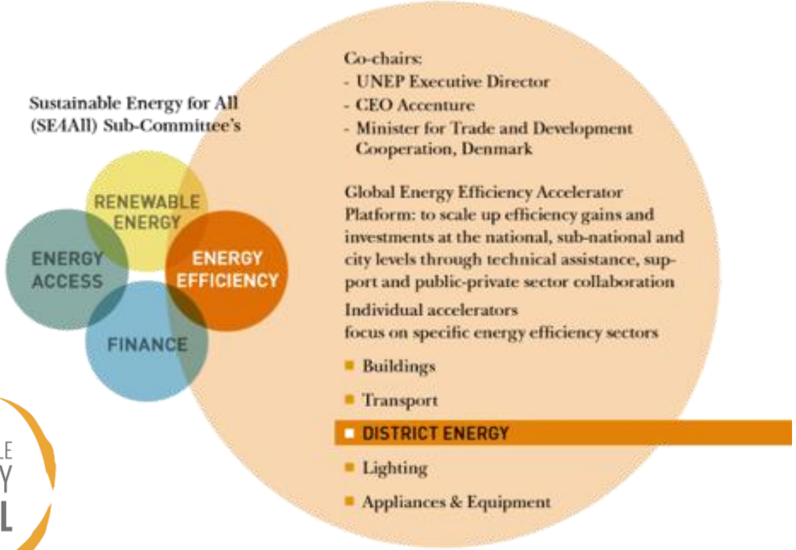
Who Am I?

- Holds PhD in architectural engineering and building science
- Over 25+ years of international project experiences and accredited/chartered skills, worked in 90+ cities of 40+ developed countries, developing countries, emerging economics and small island countries (SIDS)
- Completed 60+ DH/DC/DHC projects in USA & China in different stages of planning, designing, constructing/commissioning, operating (as EPC contractor); Completed 200+ building energy efficiency, HVAC and LEED design, consulting and operating projects
- Accredited LEED AP, Chartered Financial Analyst (CFA) and ESG-investing
- Certified Mechanical Engineer (HVAC) in China

I also would like to know who you are
Please scan the QR and complete the 3 simple questions

También me gustaría saber quién eres Por favor escanea el QR y completa las 3 simples preguntas

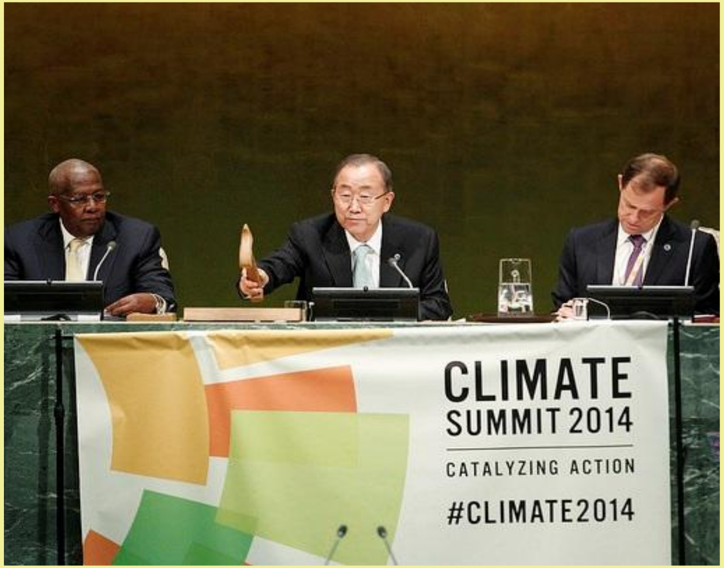
Introduction



SUSTAINABLE ENERGY FOR ALL

Cool Coalition

BEAT THE HEAT
COOL CITIES AND COUNTRIES PAVE THE WAY TO CLIMATE ACTION



Agenda 2030

UN environment programme | copenhagen climate centre

supported by UNOPS

Donors:

gef GLOBAL ENVIRONMENT FACILITY INVESTING IN OUR PLANET

MINISTRY OF FOREIGN AFFAIRS OF DENMARK DANIDA INTERNATIONAL DEVELOPMENT COOPERATION

KIGALI COOLING EFFICIENCY PROGRAM

UN environment programme

Introduction

Sustainable cities & communities

Affordable & Clean Energy

Global Alliance for Buildings and Construction

SUSTAINABLE ENERGY FOR ALL

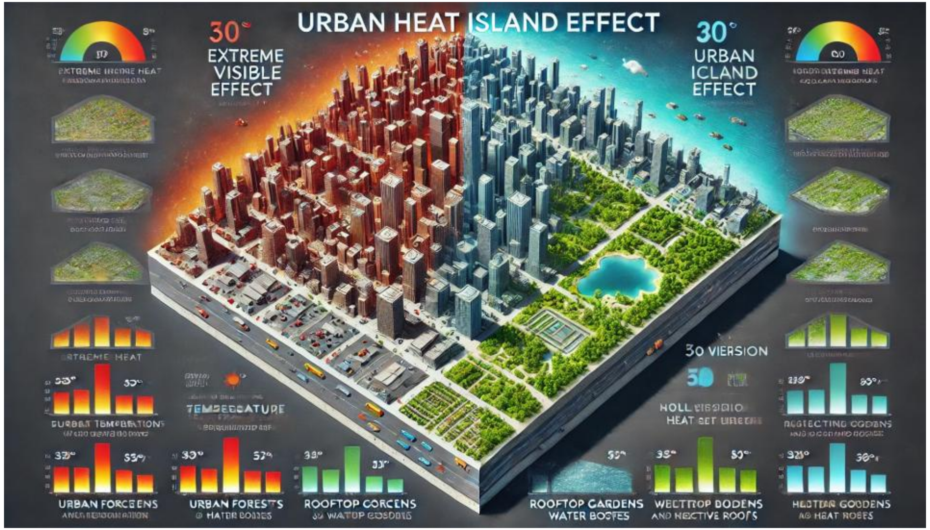
UN environment programme

UN environment programme | copenhagen climate centre

supported by UNOPS

Why cities?

HEAT ISLAND IN CITIES



UN environment programme | copenhagen climate centre

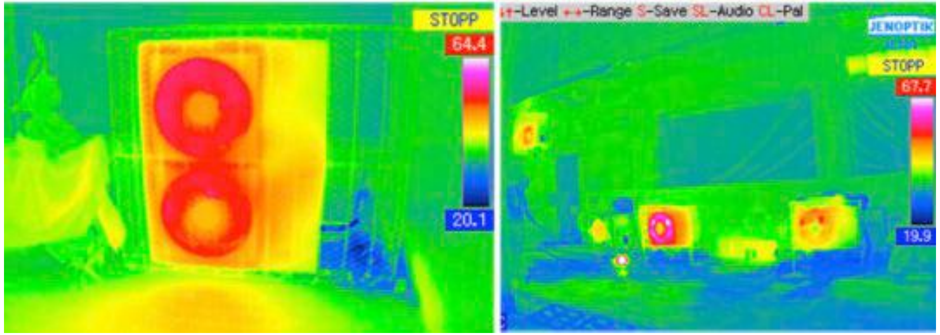
supported by UNOPS

UN environment programme

Why cities?

REPRESENTATIONAL PHOTO - HEAT ISLAND AROUND THE BUILDING

India (2024 summer)



Hongkong

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme

Why cities?

Current status VS. future vision

UN environment programme

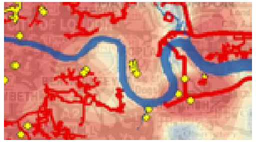
copenhagen climate centre

supported by UNOPS

Why cities?

Regulator: Strategy and Targets

Planner: Integrated energy planning and mapping



Globally, cities represent

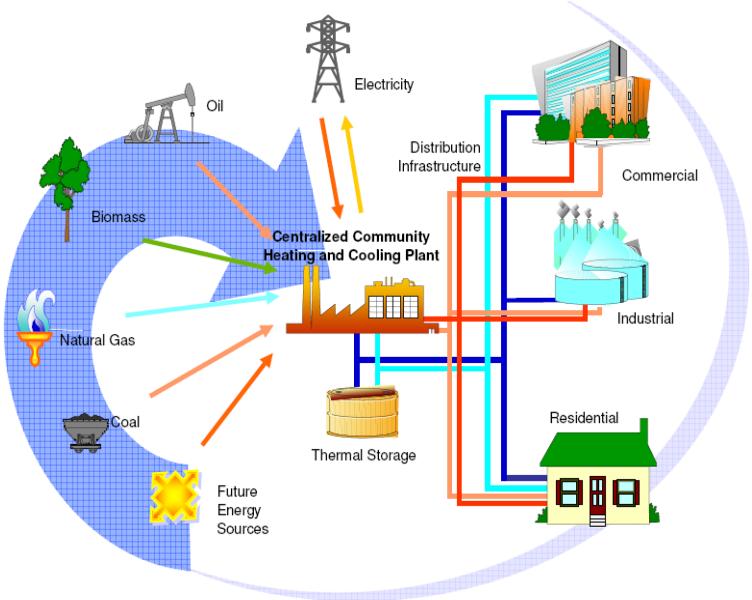
- 60% of population by 2030
- 75% of primary energy demand
- 60% of GHG emission

$ € £ ¥

Facilitating Finance

Consumers and Providers, Coordinators

Introduction: District energy systems



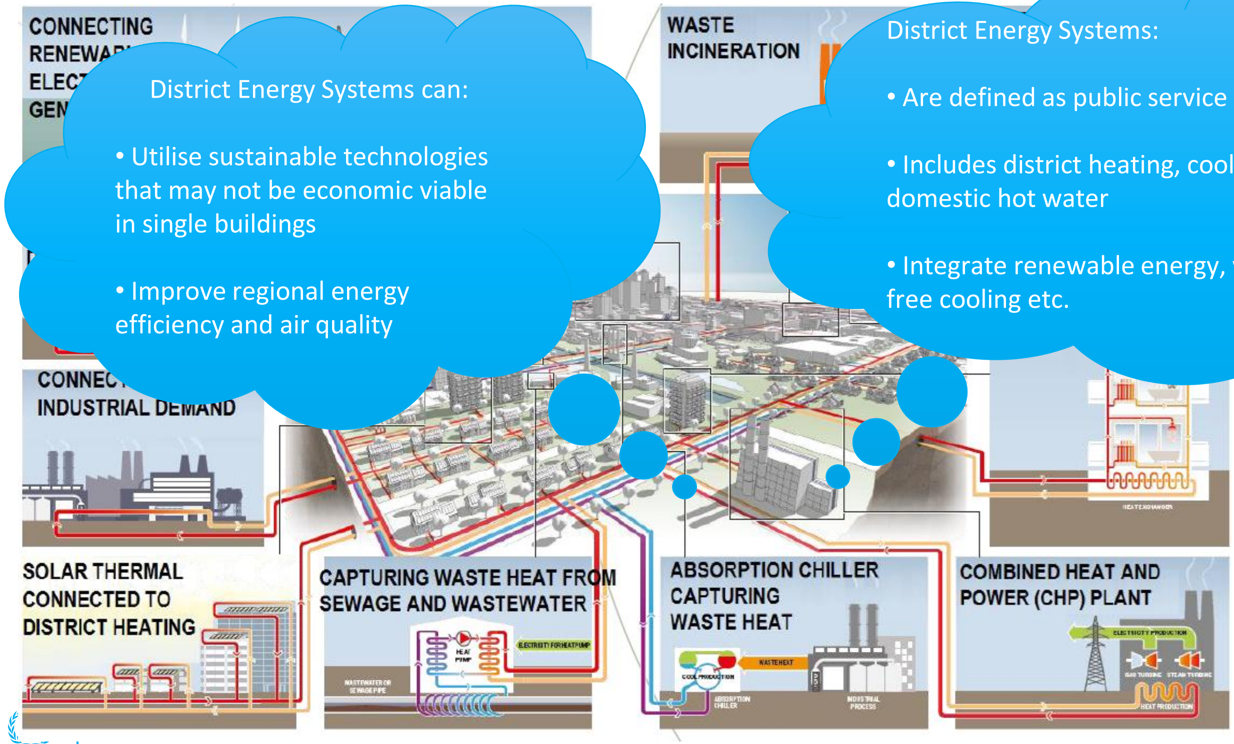
The idea of district energy is to have an efficient and often large-scale production of heating or cooling in a **centralized plant**.

Most times the heating or cooling is **co-generated** with electrical power, which yields a very high efficiency utilisation of the energy input.

The district energy system is unique in the way that it lends itself to an endless range of fuels – it is in other words a **multi-fuel energy system.**

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

Introduction: District energy systems



District Energy Systems can:

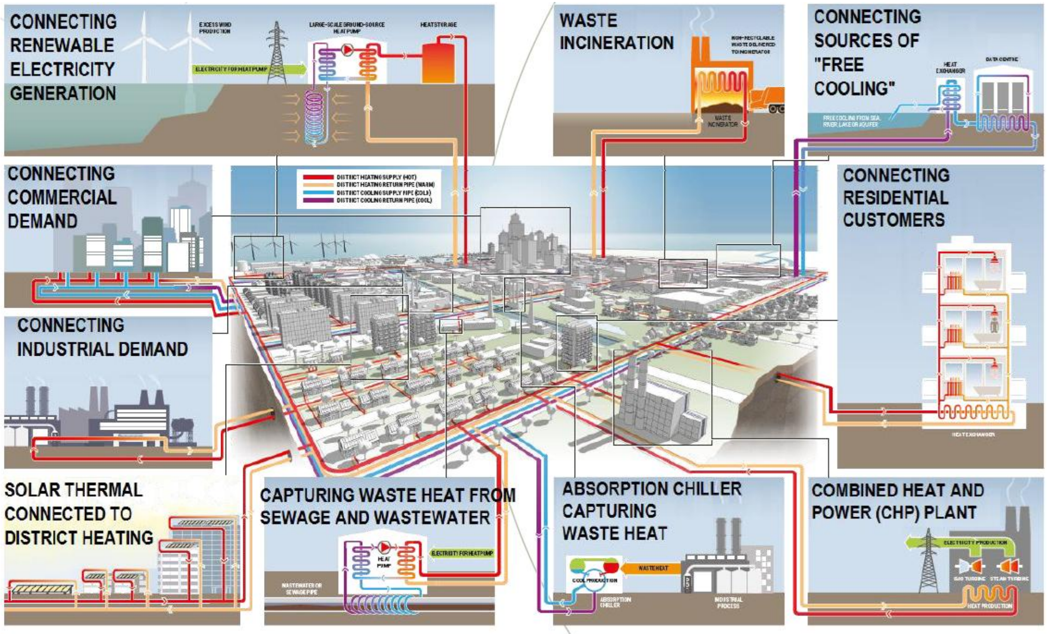
- Utilise sustainable technologies that may not be economic viable in single buildings
- Improve regional energy efficiency and air quality

District Energy Systems:

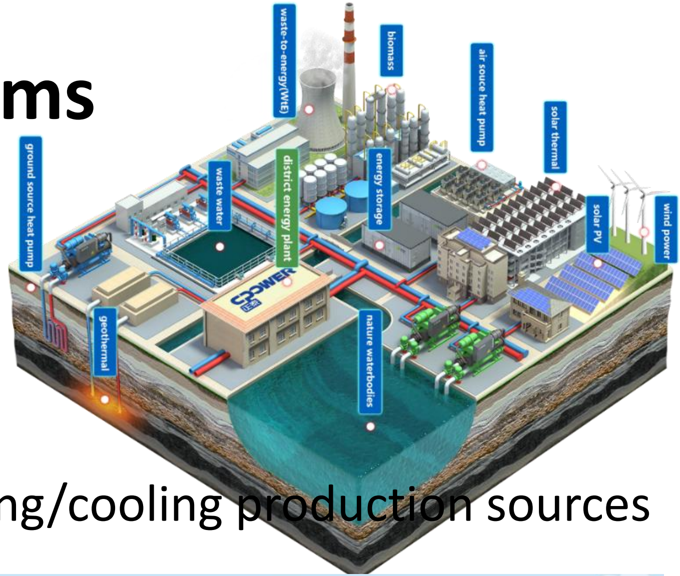
- Are defined as public service
- Includes district heating, cooling and domestic hot water
- Integrate renewable energy, waste heat, free cooling etc.

Modern district energy is considered as key to renewable and efficiency in smart cities

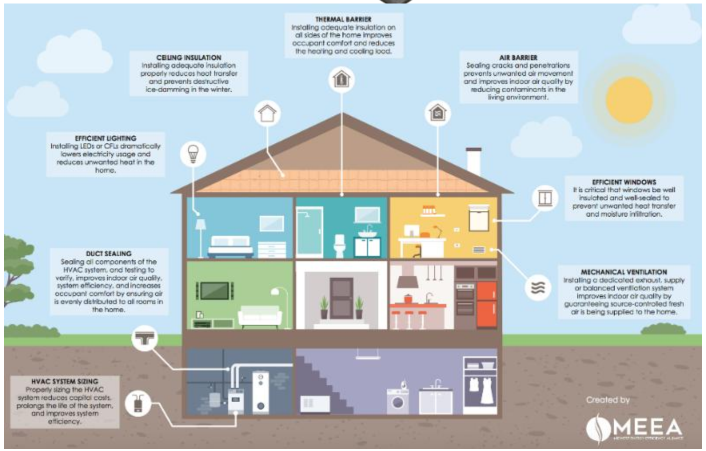
Introduction: District energy systems



District energy systems for heating & cooling



Heating/cooling production sources



Building HVAC system

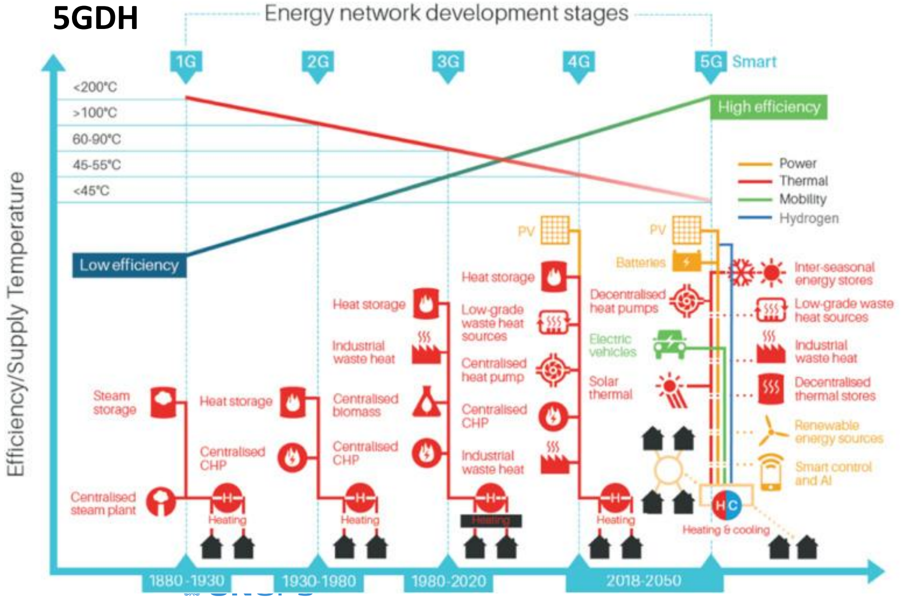
UN environment programme | copenhagen climate centre

supported by UNOPS

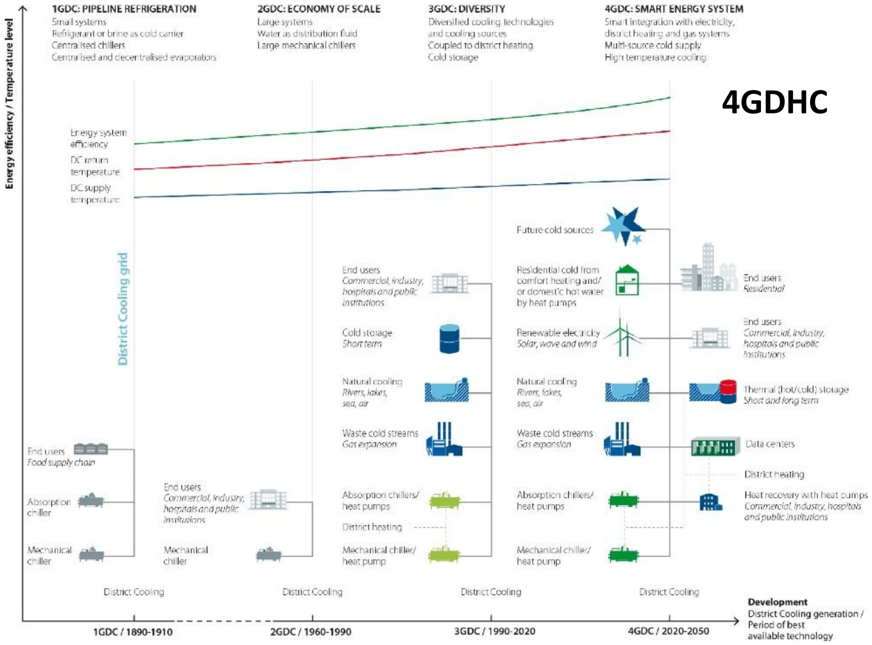
Technologies:
Integration of multi-sector energy systems

- 5th Generation of DH (5GDH)
- 4th Generation of DHC (4GDHC)
- DH & DHC combined system
- Smart energy for smart cities

5GDH

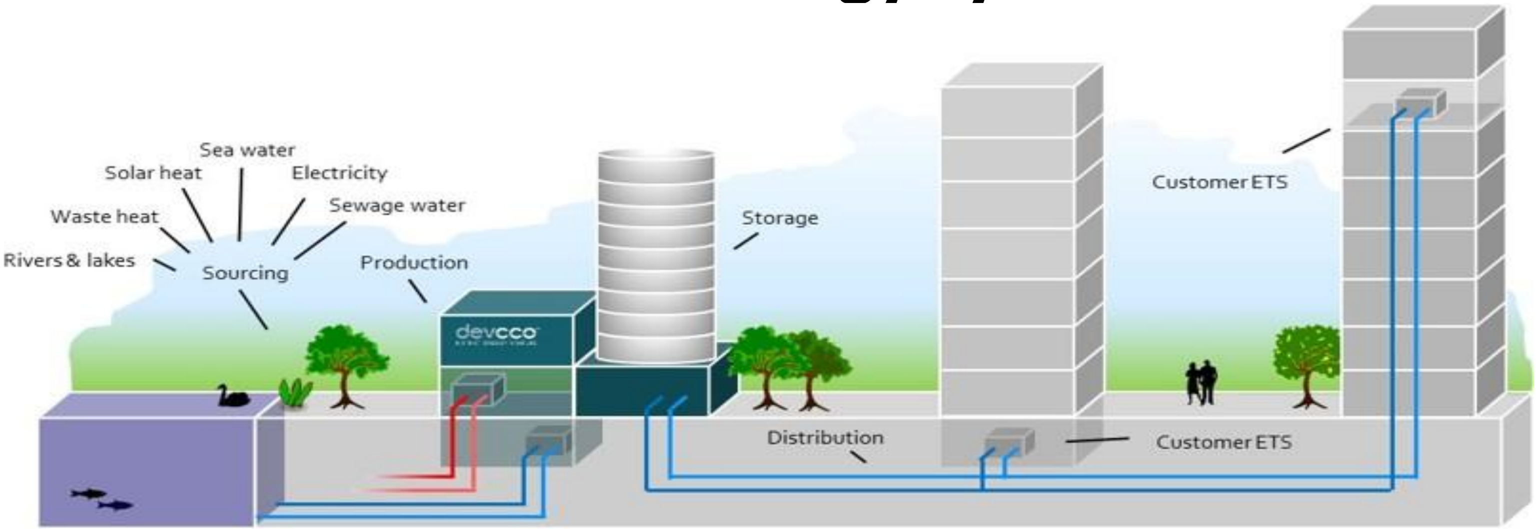


4GDHC



UN environment programme

Introduction: District energy systems



District energy 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.

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme

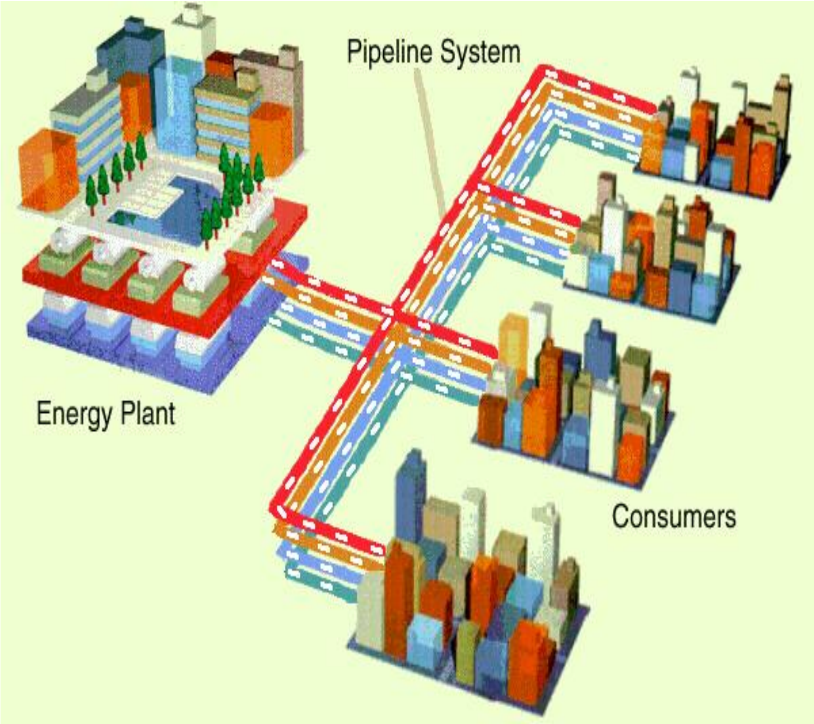
What is district heating?

- Video 1: Different types of sustainable technologies in district heating systems

Introduction: District cooling in cities

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.
- **Targeted customers**: industrial/process cooling (warehouse, data centre), city complex, public buildings (hospital), commercial buildings, luxury residential buildings



What is district cooling?

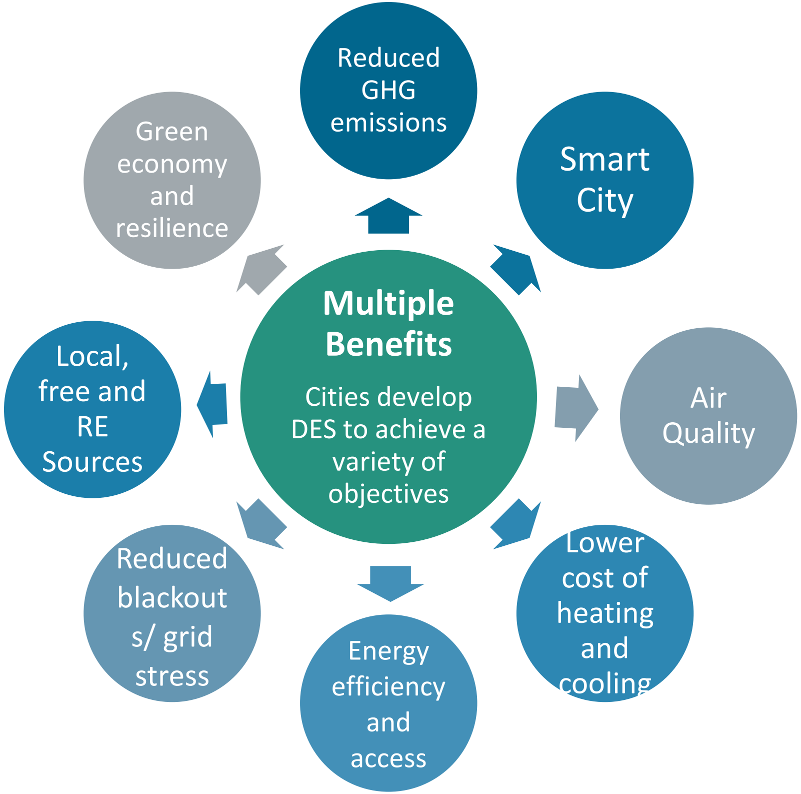
- Video 2: Commercial district cooling system in Guangzhou, China

Why district energy system?

Multiple Benefits to Meet Multiple Goals

St. Paul, USA
Reduce 275,000t of coal annually, SO_2 emissions reduced by 60% US$12 million in energy dollars kept local

Paris uses river water for cooling and saw reduction of 50% in primary energy consumption; 50% CO_2, 90% in hydrofluorocarbon emissions; 65% in water consumption



India launched 'smart city mission' as their national policy, and promised to reduce CO2 by 50% in selected smart cities as their National Determined Commitments (NDHC)

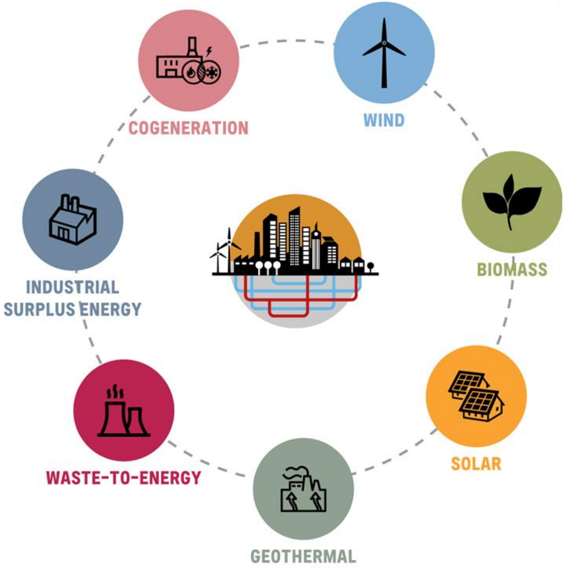
Copenhagen, Denmark: Recycling waste heat saves 655,000t of CO_2 reductions annually, while also displacing 1.4 million barrels of oil.

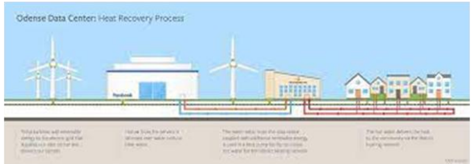
UN environment programme | copenhagen climate centre
supported by UNOPS
UN environment programme

Multiple benefits of district energy for cities

District energy systems are an important part of heating and cooling sector decarbonisation, as they allow for the integration of flexible and clean energy sources into the energy mix, which could be challenging at the individual building level in urban dense areas.

Toronto Deep Lake District Cooling(Canada)





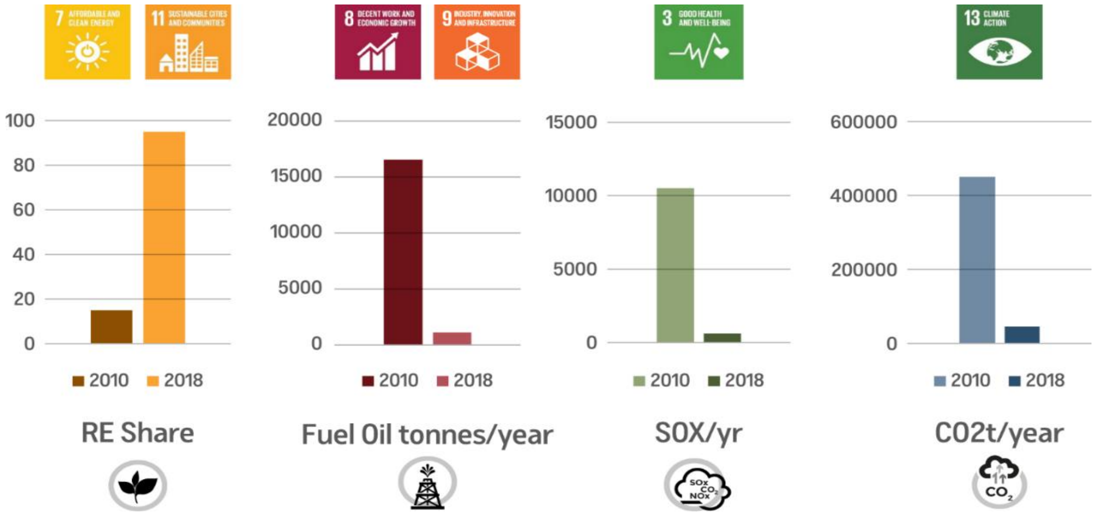
Waste Heat recovery from Facebook Data Center in Odensee (Denmark)

Waste to energy Issy les Moulineaux(France)

Geothermal DH plant Gentilly(France)

Why district energy system?

Key to Renewables & Efficiency in Smart Cities



RE – increased by 75%

Fuel Oil Use Reduced by 93% (1million dollars savings a year)

SO_X reduced by 94%

CO_2 reduced by 91%

District Energy project examples

Commercial Potential:

- Facilitate cities and/or municipalities break down their long-term goals of air pollution reduction, energy efficiency enhancement etc. to on-ground building energy efficiency and district energy projects

- Develop district energy projects with different investment requirement, capacity/size and locations.

- Through different stages of tech-eco analysis, make sure the projects developed are bankable and with reasonable profit for private sector investors.

DISTRICT HEATING
Waste heat

Investment:
US$1.8M
IRR: **13%** over 50 years
Payback: **7.6 years**
Annual Revenue:
US$455,000

SAN PEDRO
Chile

DISTRICT COOLING

Investment:
US$50M
IRR: **11.7%** over 30 years
Payback: **8.2 years**
Annual Revenue:
US$8M

CYBERJAYA
Malaysia

DISTRICT COOLING

Investment:
US$16.4M
IRR: **21.1%** over 40 years
Payback: **6.1 years**
Annual Revenue:
US$12M

THANE *(projected)*
India

DISTRICT HEATING
Refurbishement

Investment:
US$22M
IRR: **6.25%** over 25 years
Payback: **14 years**
Annual Revenue:
US$13M

BANJA LUKA,
Bosnia and Herzegovina

DISTRICT COOLING

Investment:
US$187.5M
IRR: **14.5%** over 20 years
Payback: **6.7 years**
Annual Revenue:
US$59M

MEDINI
Malaysia

DISTRICT HEATING
Trigeneration

Investment:
US$715M
IRR: **8%** over 20 years
Payback: **10.8 years**
Annual Revenue:
$171M

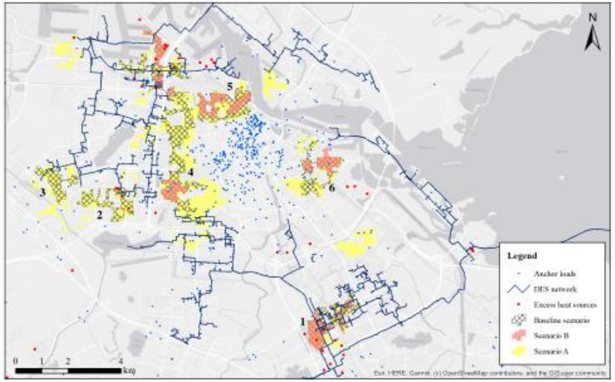
ZHUHAI
China

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme

Technologies:
Integration of energy planning to city master plan



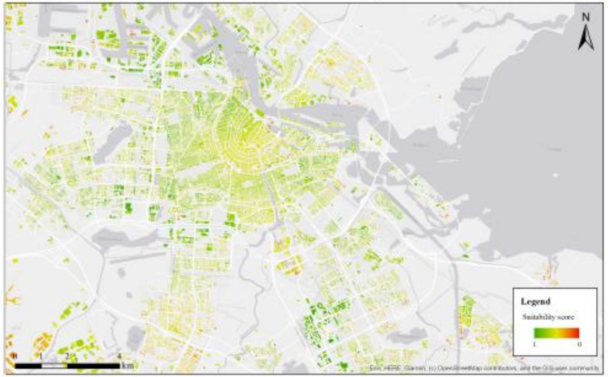


Table A.3: Criteria aggregation parameters derived for Scenario A

	Input	Factor weight	Trade-off degree	Decision risk level
MCE 1	F1 - Sufficient cooling demand F2 - Sufficient heating demand	0.25 0.75	full trade-off	medium risk
MCE 2	F3 - Access to free cooling sources F4 - Unlock solar energy potentials F5 - Access to excess heat sources	0.30 0.20 0.50	no trade-off	low risk
MCE 3	F6 - Utilize existing DES networks F7 - Minimize heat losses F8 - Reduce capital expenditures F9 - Target mixed land-use	0.50 0.15 0.25 0.10	full trade-off	medium risk
MCE 4	O1 - Satisfy local energy demand O2 - Integrate local energy sources O3 - Enhance cost-effectiveness	0.20 0.30 0.50	full trade-off	medium risk

Decision-support information	1	2	3	4	5	6
Area	1.35 km^2	0.76 km^2	0.66 km^2	3.33 km^2	1.41 km^2	0.93 km^2
Number of buildings	950	2 451	3 424	10 019	4 595	2 919
Annual cooling demand	10 179 MWh	6 140 MWh	6 610 MWh	49 976 MWh	23 873 MWh	179 713 MWh
Annual heating demand	115 136 MWh	73 277 MWh	83 969 MWh	624 426 MWh	314 880 MWh	218 985 MWh
Average final suitability score	0.83	0.81	0.78	0.76	0.75	0.74
Range in final suitability score	0.41	0.47	0.25	0.66	0.41	0.42
Average suitability score for G1	0.62	0.77	0.95	0.81	0.95	0.76
Average suitability score for G2	0.80	0.68	0.58	0.67	0.83	0.58
Average suitability score for G3	0.91	0.83	0.90	0.77	0.75	0.74
Initial investments	3.13 MEUR	1.98 MEUR	2.26 MEUR	16.86 MEUR	8.47 MEUR	9.97 MEUR
Emission reductions	43 Mton CO_2/year	27 Mton CO_2/year	31 Mton CO_2/year	229 Mton CO_2/year	115 Mton CO_2/year	135 Mton CO_2/year

Heating & Cooling plan for Amsterdam

Technologies:
Integration of energy planning to city master plan

Energy demand assessment

What is each building's cooling/heating and electricity demand?

Network Assessment

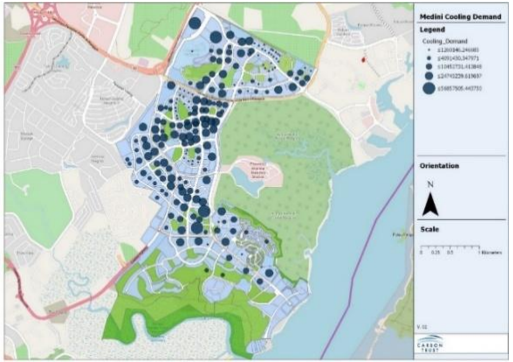
What buildings should we connect?
What is the optimal route for the piping?
What is the preferred location for the energy centre?

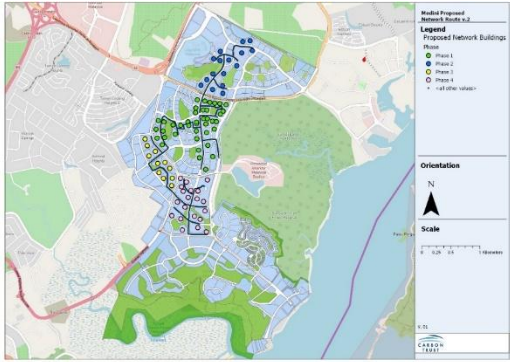
Energy centre: central plant options

What technologies are viable options to produce cooling/heating in this area?
What is the size of the plant required?

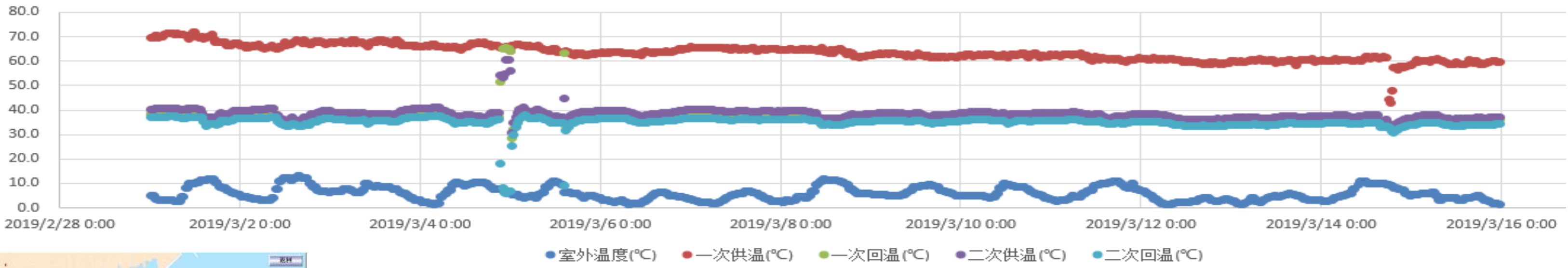
Economic assessment

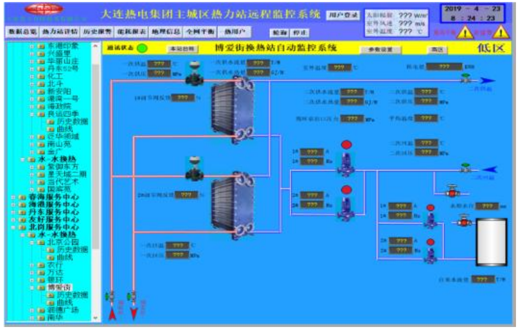
Does the project overcome the hurdle rate?
What is the project's net present value?
What is the project's internal rate of return?





Technologies:
Integration of energy planning to city master plan





supported by UNOPS

UN environment programme

District heating and cooling projects implementation by UNEP

- Working in over 62 cities of 25 developing countries and emerging economics since 2016.
- The purpose of our work is to unlock investments from private sector for district energy systems through pilot projects/demonstrations.

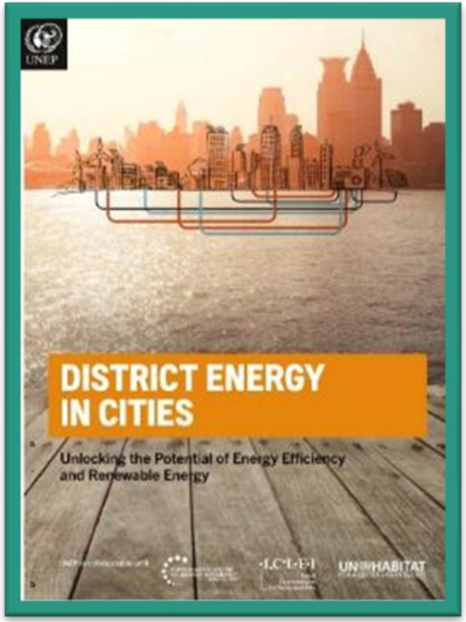
UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme

District energy project development procedure

1. ASSESS	existing energy and climate policy objectives, strategies & target & identify catalysts
2. STRENGTHEN	or develop the institutional multi-stakeholder coordination framework
3. INTEGRATE	DC into national and/or local energy strategy and planning
4. MAP	local energy demand and evaluate local energy sources
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. SET	measurable, reportable and verifiable project indicators



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

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme

District energy project development procedure

1

Mapping & planning

- Local energy source: free cooling? Waste heat? Renewable? Geothermal?
- Demand: Industrial or space heat/cool? Reliability
- Short/medium/long-term development plan
- Potential connection-encouraging policy

2

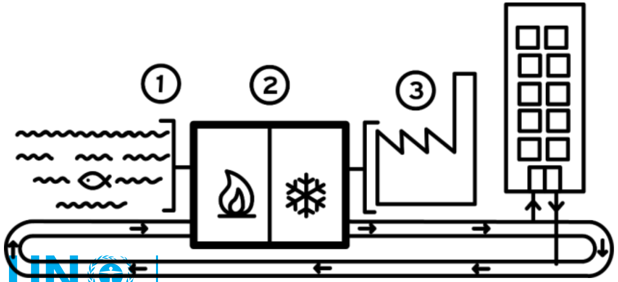
Tech-eco analysis

- Rapid assessment: narrow down potential zones, possible tech solutions, economic payback and environmental impacts
- Combination of technical solutions for high efficiency, reliability and economic viable

3

Pilot project

- Potential incentive policies
- Business model
- Guidelines and standards (Design, MRV etc.)
- Financial support mechanism (Bankable projects)



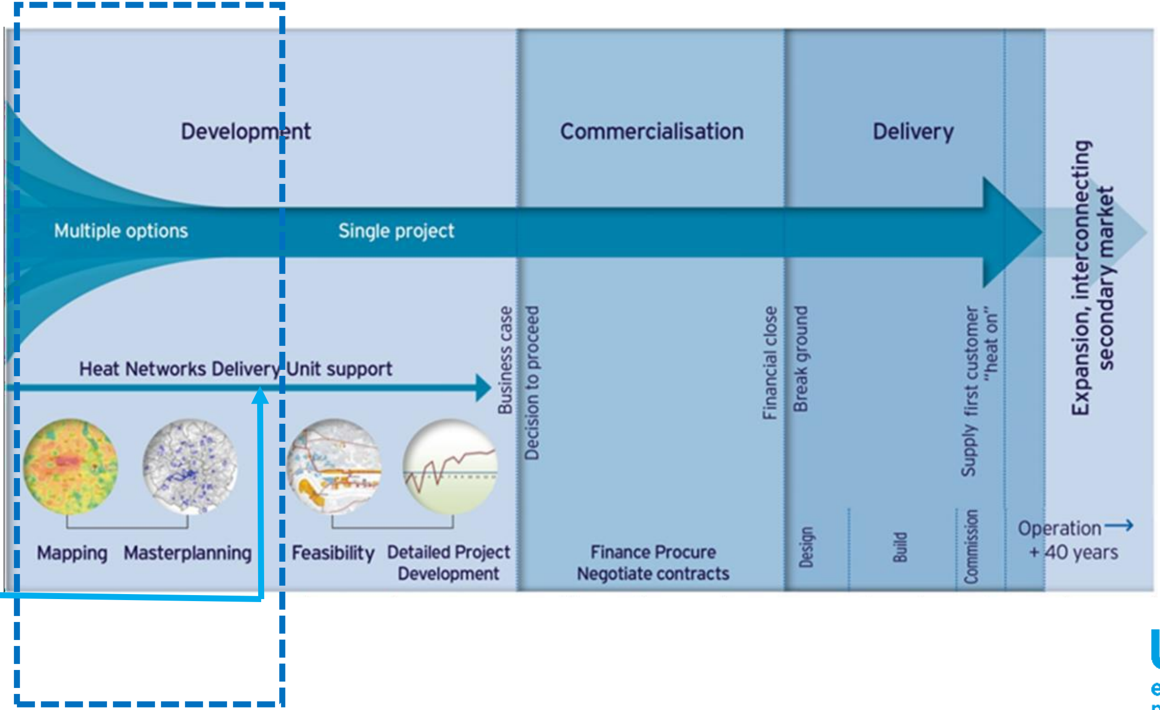
Scale up from demonstrations/pilot projects to other learning cities/projects

District cooling project development procedure

Deep dive assessment: integrated tech solutions for bankability & environmental benefits

<u>**Light touch**</u> w/ municipality & stakeholders

<u>**Rapid assessment**</u> for potential tech solutions, policy gaps and scenario for energy & GHG savings



Pre-feasibility

UN environment programme

copenhagen climate centre

supported by UNOPS

UN environment programme

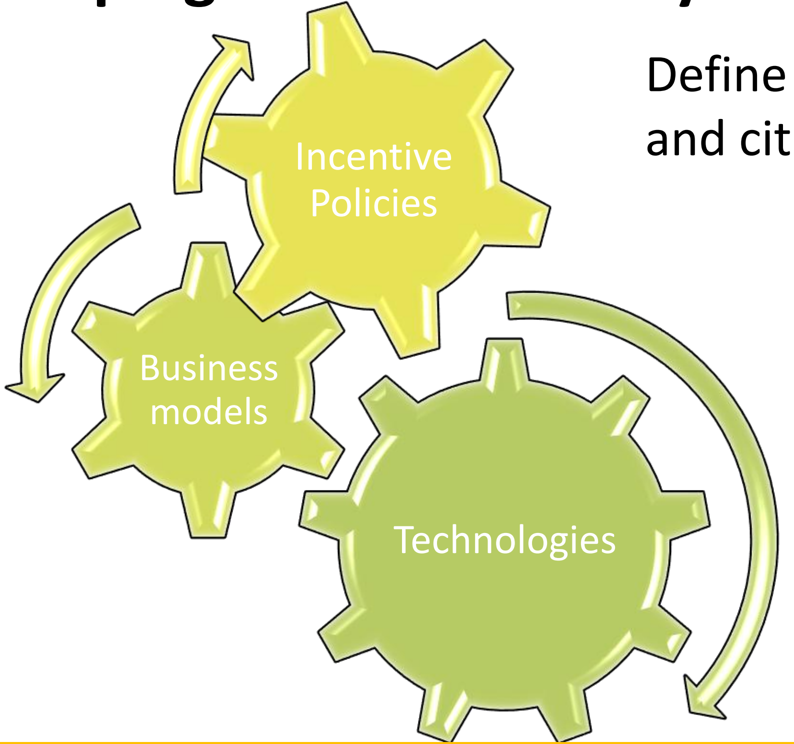
What are the challenges for implementing district energy projects in cities of developing countries?

- Lack of local capacity
- Lack of data
- **Design marketable, investable or bankable projects**
- Bridging the gap between the regulatory level and ground level
- Long-term support to local authorities
- Communication and awareness raising
- **Standardisation and transferability**

What are the financial barriers in new markets?

- Building energy efficiency projects and district energy system projects needs more time (normally 5-7 years from beginning or more) for the demand to grow, and the benefits become steady and secure afterwards.
- District energy systems are cheaper over the long term, with 90%+ of costs related to operation & maintenance. Large savings are potential with short payback periods during operation.
- Higher upfront cost of district energy technology (competing against cheap and inefficient tech), with lower life-cycle cost when considering the financial benefits on operation.

How to develop and implement district energy projects in cities of developing countries? – Key Tri-angle



Define the roles of municipalities and cities

Suitable business models to enable the investment environment

Cost-effective technologies to integrate multiple sectors for higher systemic efficiency

Combining suitable incentive policies, business models and cost-effective technologies can accelerate the implementation of carbon neutral communities and scale up after demonstration.

How to implement district energy systems
-Innovative Business model: Cooling as a Service (CaaS)

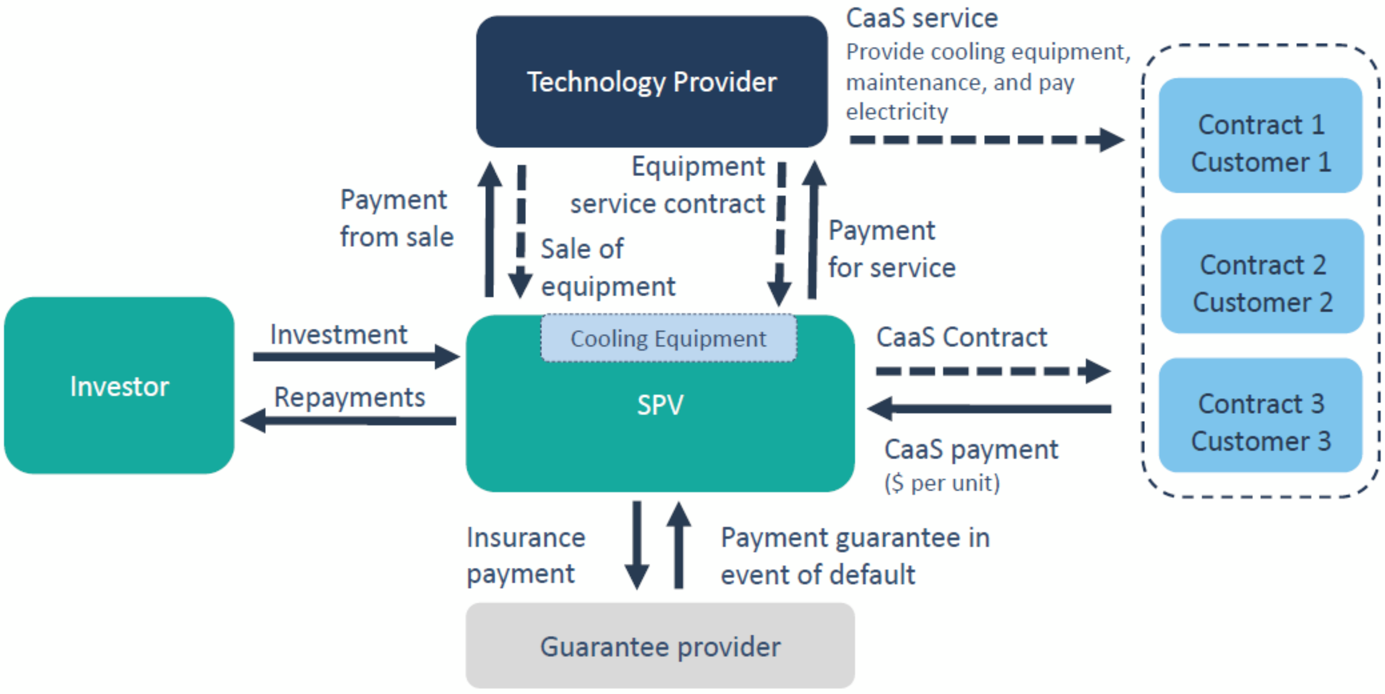
Greenfield Developments
DC systems incorporated in the project

- Optimum capacity as per load profile
- Vendor agnostic sourcing – procurement synergies
- Reduced capex costs
- End to end project execution
- 100% HVAC investment (upfront and lifetime) under long term concession structures – yearly fixed payments for concession tenure
- Cooling agreements are 20-30 years
- KPI/SLA based operations at guaranteed efficiency
- 15-25% reduction in Opex

Brownfield Developments – existing cooling systems divested, and Cooling-as-a-Service

- Cooling assets acquired using a concession structure – future cash flow-based valuation model
- Digitization and asset optimization;
- Efficiency improvement
- All retrofits, snags, periodic enhancements etc. taken care of - yearly fixed payments for concession tenure
- Cooling agreements are 20-30 years
- Reliable HVAC operations at guaranteed efficiency; single point of contact for all cooling services

How to implement district energy systems
-Innovative Business model: Cooling as a Service (CaaS)



City Climate Fund – Qingdao, China (2021)

ADB: Sovereign Loan 100M USD

GREEN CLIMATE FUND: Loan 100M USD

AFD: Sovereign Loan 70M EURO

KFW: Promotion Loan 100M EURO

UNEP CCC+DENA: Support KfW to develop IPS

UNEP CCC: Support Green Investment Fund to draft investment pipeline

Municipal Development Fund (LP, 25%)

Private investment (LP, 34%)

Asset Mangement (GP, 0.1%)

Shandong Qingdao Green Investment Fund (LP, 40%)

Qingdao City Climate Fund

Direct investment for green infrastructure

SPVs for eco industrial parks

SPVs for sustainable projects, e.g. RE, waste, water

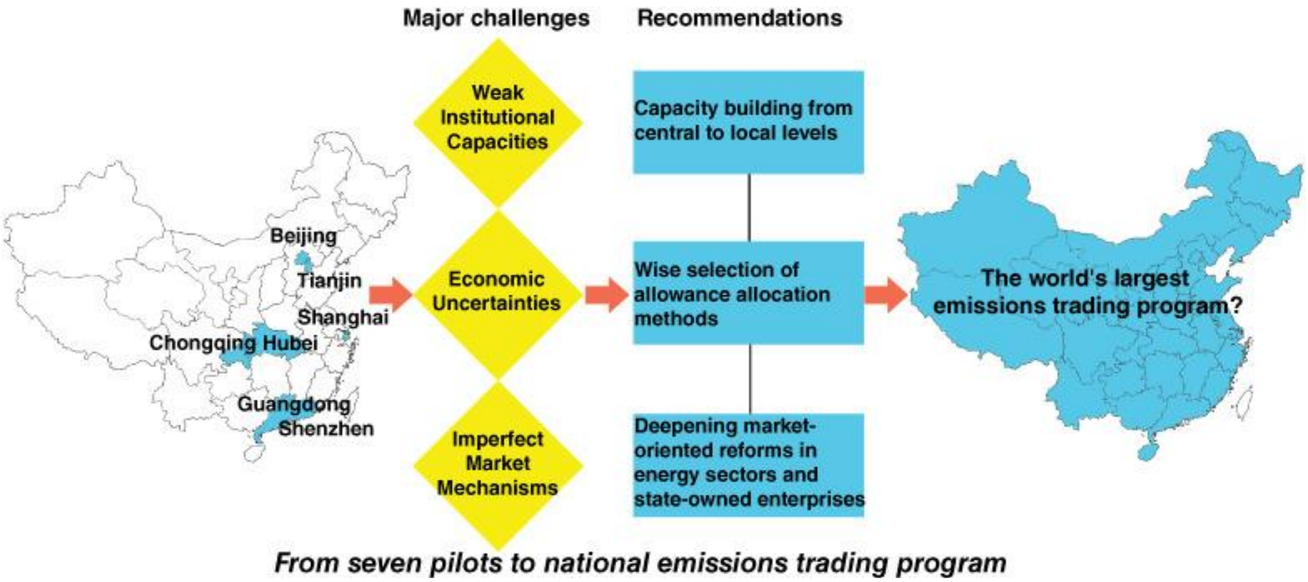
SPVs for retrofitting projects, e.g. BEE, green building

UNEP CCC: Support Ciy Climate Fund to assess pre-feasibility of sustainable projects, develop disclosure framework for projects' GHG emissions and M&V for scope 2/3

District Heating REIT of Jinan City Energy Group (2025)

- **First REIT** on **district heating** as municipal public service infrastructure in China
- Moblized **900m RMB (125m USD)** as REIT issued through Shanghai Stock Exchange in Feb. 2025
- Knowledge sharing through **Sino-Danish Clean & Sustainable District Heating Virtual Knowledge Center** with the city-own utility since 2021
- UNEP Disrict Energy in Cities Initiative, UNEP CCC and Danish Energy Agency supported **Jinan city (pilot city of GEF-6)** for long-term district heating planning, technical & financial assessment of potential sustainable district heating retrofitting projects as well as heat-pump-based district heating & cooling new projects since 2018
- UNEP CCC supported Jinan city for detailed sustainable technologies implementation plan & **financial investment pipeline/IPS** since 2021

Carbon credit & carbon trading in district cooling

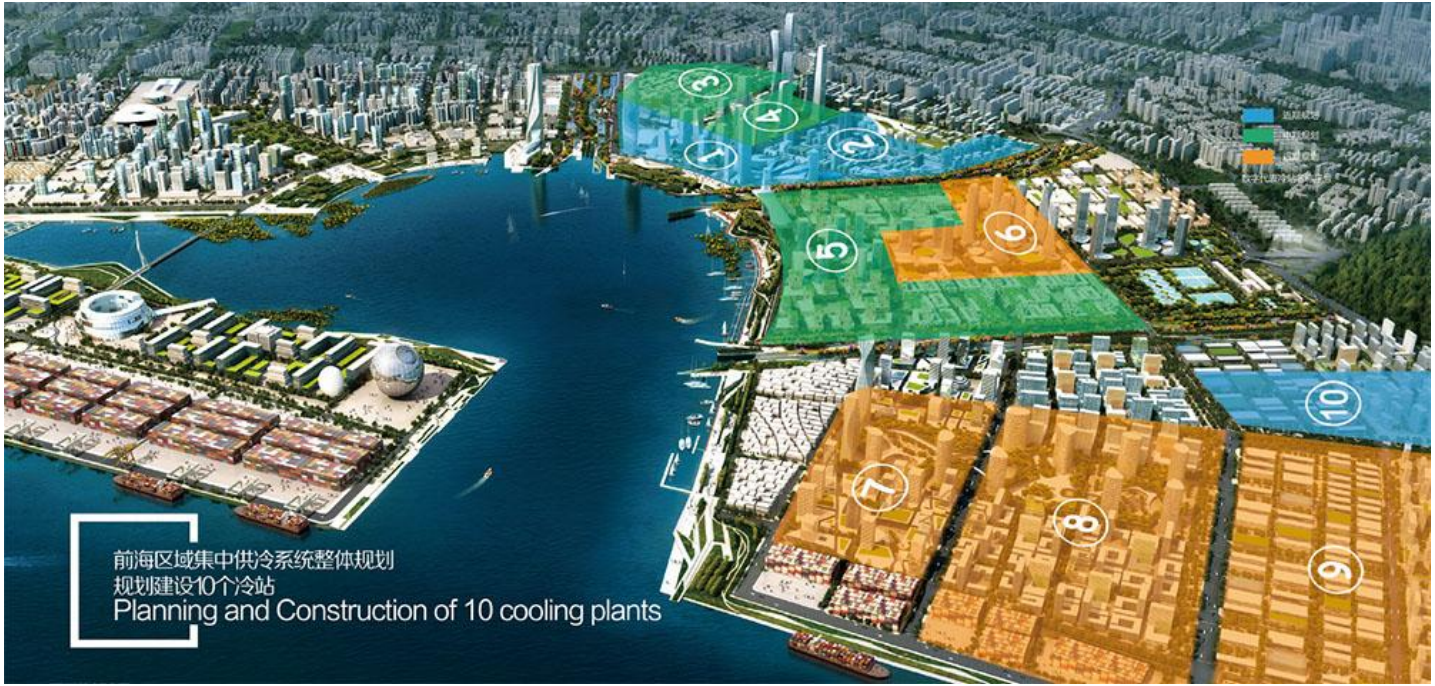


- 2023 UN Global Climate Action Award: *Shenzhen Emissions Trading Scheme Design*

Carbon credit & carbon trading in district cooling

- Methodology standard development for carbon credits
  - ➢ Business-As-Usual (BAU) scenario: normal centralized cooling systems in standalone buildings
  - ➢ District cooling scenario
  - ➢ Carbon reduction calculations
  - ❖ **Direct reduction of GHG emission in DC**: refrigerants with low GWP
  - ❖ **Indirect reduction of GHG emission in DC**: electricity & water consumption
  - ❖ **GHG emission in value chain (Scope 3)**: Construction-Commission-Operation & Maintenance

Carbon credit & carbon trading in district cooling



Carbon credit/CCER/ITMOs & carbon trading mechanisms in district cooling

序号	内容	数值
1	2022 年广东电网整个空调期内的最高电力负荷Q_{MAX}'	14333×10^4kW
2	2022 年广东电网整个空调期内的平均负荷P' Q_{ACMAX}	7032.165×10^4kW
3	高峰时段削峰电量	1119.156×10^4kWh
4	低谷时段填谷电量	2106.509×10^4kWh
5	冰蓄冷空调系统100%负荷下所需最高电力负荷	17760 kW
6	未采用冰蓄冷系统100%负荷下所需最高电力负荷	21321 kW
7	空调季节该地区电网的总供电量S	7870.34×10^8kWh
8	该地区发电厂的平均用电率ε	5.4%
9	该地区发电厂供电煤耗率q	308.04 g/kWh
10	该地区在空调期内的发电量∑Q	4441×10^8kWh
11	标准煤的排放因子EF_C	2.66 tCO_2e/t标煤

采用冰蓄冷系统时的电网负荷率： $\gamma' = P' / Q_{MAX}' = 49.0628\%$

未采用冰蓄冷系统的电网负荷率：

$$\gamma = P/Q_{MAX} = \left(\frac{E_{\square} + E_1}{24n} + \frac{E_{pls} - E_{vf}}{24n} \right) \times \frac{1}{Q'_{MAX} + (Q_{ACMAX} - Q_{CCMAX})} = 49.0608\%$$

电网负荷率每变化 1%，供电煤耗所对应的变化量：

$$B = \frac{\gamma Q_{MAX}}{\frac{1}{24n}\sum\frac{Q}{1+\varepsilon}} \times q = 0.9179\ \gamma$$ ，因此 B 为 9.179 g/kWh

移峰填谷减排量： $ER_2 = (\gamma' - \gamma) \times B \times S \times 10^{-6} \times EF_C =$ **385 tCO_2**

'District cooling carbon credit methodologies' for AR6.2 ITMOs & AR6.4

In discussions with JICA(Japan) and MAS (Singapore) for adapting as JCM/ITMO method

Thank you very much!

Dr. Zhuolun Chen

email： zhuolun.chen@un.org

LinkedIn

WeChat

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme 50 1972-2022

Part 4: Case studies via video, group reflections, and open discussion on implementation

Estudios de caso a través de vídeo, reflexiones grupales y debate abierto sobre la implementación

Dr. Zhuolun Chen

Senior Advisor of Energy Efficiency & Green Finance

LEED AP, CMVP, CFA&CFA-Sustainable Investment

2025.9.8 District Energy Training Workshop, Sandiago de Chile

UN environment programme | copenhagen climate centre

supported by UNOPS

UN environment programme

Video case 3: Next generation of energy planning tool for cities/states/provinces: GIS+LCA

- To support policy decisions in city-level sustainable development plans
- To link projects with priority ranking in investment to the city climate fund

Video case 4: District cooling for brownfield retrofit

- Using district cooling system to retrofit brownfield projects with shopping malls, high-rising commercial office buildings and luxury hotels (photoes in 2014/2015)

Video case 5: One-stop solutions for heating, cooling and power

- The Combined Cooling, Heating and Power (CCHP) system solved the districts' development energy bottle neck
- State-owned EPC & utility operator – SPIC, provided one-stop solutions for long-term support of sustainable development for the island of Hengqing, Zhuhai

Video case 6: Implementing district cooling with green buildings from planning stage

- Design-Build-Operate-Transfer (DBOT) model for Shenzhen and Hongkong district cooling projects
- Government agency of EMSD Hongkong: the first district cooling regulation in 2015 (three readings since 2013)
- Included District Cooling as one of the key mitigation technologies in the Biannual Transparency Report (BTR) to UNFCCC

Video case 7: Virtualization for DHC

Open discussion: Anything you want to discuss with the speakers

Discusión abierta: Cualquier cosa que quieras discutir con los ponentes

Thank you very much!

Dr. Zhuolun Chen

email： zhuolun.chen@un.org

LinkedIn

WeChat