DISTRICT ENERGY IN CITIES INITIATIVE

E-TRAINING PROGRAM
DISTRICT COOLING DEVELOPMENT

MODULE 6. BUSINESS MODELS, FINANCING OPTIONS AND PROCUREMENT OF SOUND SUSTAINABLE DISTRICT COOLING SYSTEMS

UN environment programme 50 1972-2022

COPENHAGEN CENTRE ON ENERGY EFFICIENCY
SEforALL EE HUB

LEARNING OUTCOMES

Objective: share insights on business models, financing options and procurement of sound sustainable district cooling systems

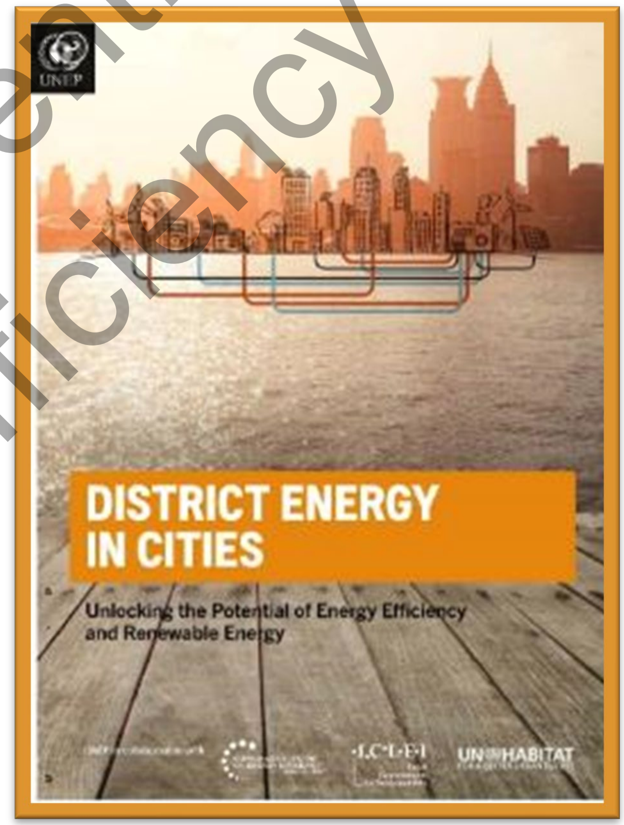
By the end of this module, you will be able to:

- Describe, understand and discuss the importance of developing business models for sound & sustainable DCS
- Recognise and apply the key steps in developing business models for sustainable DCS
- Define key actions from local authorities to ensure this
- List the strengths and limitations of each of the business models

ROLE OF BUSINESS MODELS

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

ROLE OF BUSINESS MODELS

The role of a solid business model in District Cooling projects

- Leverage lower cost to finance needed to ensure investment
- Attract & engage investors, operators, utilities, consumers, local authorities
- Cater projects' good functioning and operations of the project
- Ensure project stability and longevity

"A mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model"
Chesbrough, 2009

DEFINITION

Main components of a business model are …

Core Strategy	Strategic Resources	Partnership network	Customer interface
• Business mission • Product/market scope • Basis for differentiation	• Core competencies • Strategic assets	• Suppliers • Partners • Other key relationships	• Target customer • Fulfilment and support • Pricing structure

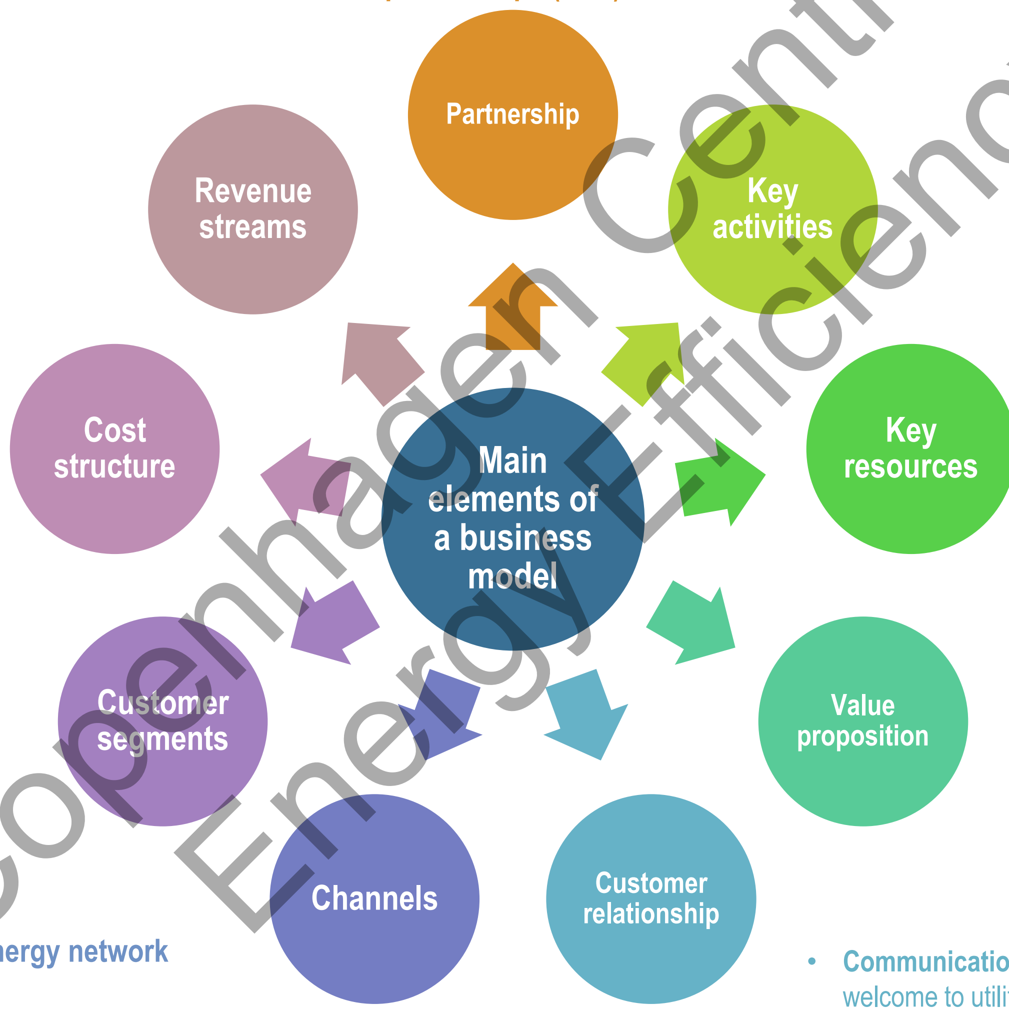
"A plan for the successful operation of a business, identifying sources of revenue, the intended customer base, products, and details of financing"
Harvard business review, 1998.

ELEMENTS OF BUSINESS MODELS

- E.g. public and private partnerships (PPP)

- Cooling sales
- Power sales
- Connection charges
- Ancillary services
- Capacity payments

- Planning & construction of network system
- Monitoring & control mechanisms



- District cooling typically has high CAPEX & relatively low OPEX

- Financial
- Technical
- Fuel resources

- Grouped according to locations, building uses or energy demands
- Special segments: (risk of) energy poverty and "prosumers"

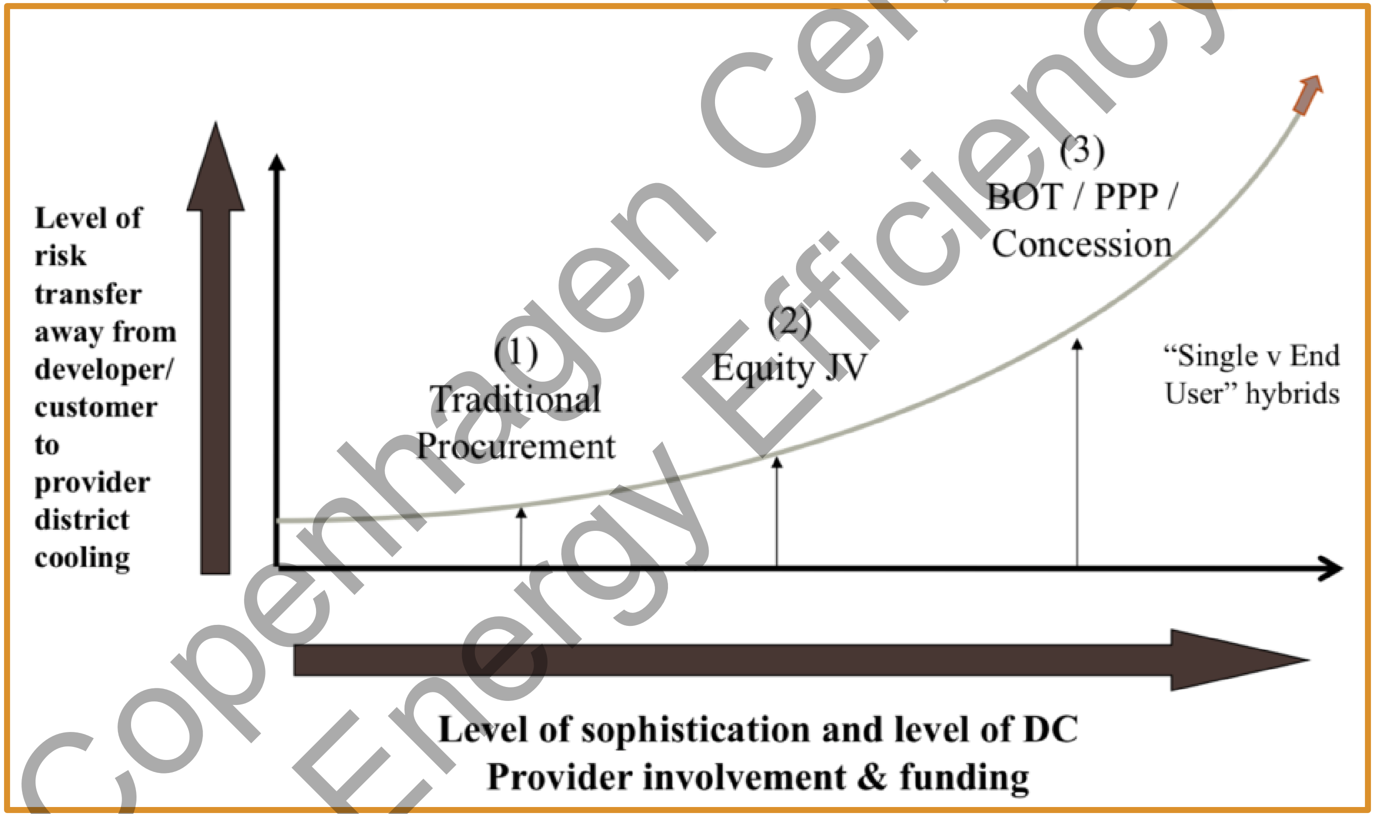
- Individual end-users level
- Societal level (local/national)

- Physical distribution energy network
- Ownership structure

- **Communication between utility & end-user** is during; welcome to utility, bill receipt, season change, rate change & contract anniversary.

CHARACTERIZATION OF BUSINESS MODELS

Business models in DCS based on ownership type



Source: King & Spalding

CHARACTERIZATION OF BUSINESS MODELS

Business models in DCS based on ownership type

Single ownership, completely public

- Owned by local authority or public utility with transferable ownership
- Governed by public sector
- Control of local authority on distribution network, connections and tariff policies
- Financed by grants, public debts at lower interest rates

Hybrid ownership PPP

- Owned by special purpose vehicle (SPV)*
- Operation & design are handled by SPV
- Local authority involves in tendering process
- Major finance from district cooling service provider

Split ownership, tender based/concession contract

- Split ownership between private & public sector
- Land, distribution network maybe owned by public sector and equipment/machinery maybe owned by private sector
- Governed by board of members from from private and public sector representatives
- Multiple sources of financing are available

Single ownership, completely private

- Owned by private sector
- Governed and controlled by private party with small representation by local authorities
- Financed by private party, local authorities can contribute to governance

Source: National DC potential study, India

CHARACTERIZATION OF BUSINESS MODELS

Contractual structure of business models

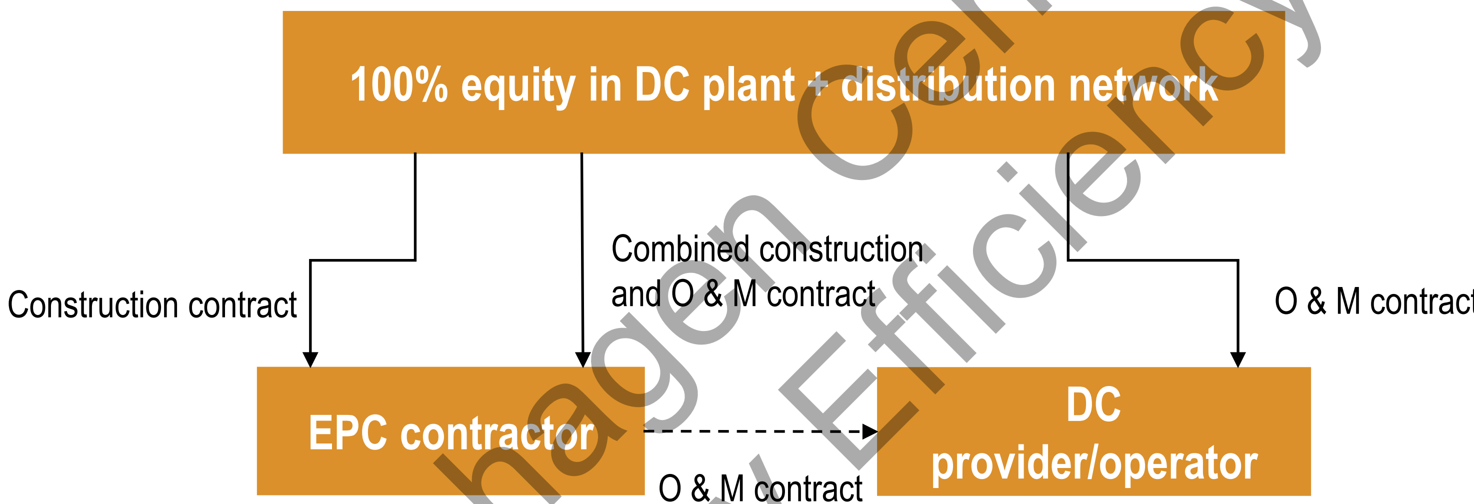
Depending upon the ownership model, comprehensive contracts must be developed to cover the following issues:

- **Ownership**: To streamline who pays for which of the cost component of district cooling in case of PPP models. Lease agreements in case of tender based / concessions contract.
- **Power and water supply:** To reserve power in the grid (with its tariff structure) and provision of standby supply in case of outages. In case of CHP plants tariff structure for GAS or steam (with its tariff structure) must be in place. Similar contracts for water supply for cooling tower (with its tariff structure) and standby arrangement in case of outages.
- **Tariff structure for chilled water:**
  - Connection charge - To cover the cost of connecting a consumer with the common distribution network
  - Capacity charge – To cover the operation and maintenance (routine/lifecycle) of the distribution network
  - Consumption charge – The cover the rate at which chilled water will be distributed to consumers (INR/BTU) and captive issues
- **Profit / revenue spread:** to cover distribution of profit, reimbursement, royalties, etc. among the stakeholders of the PPP or JV
- **Termination and end of term issues:** To cover ownership and transfer of assets during or after the contract term

Source: National DC potential study, India

CHARACTERIZATION OF BUSINESS MODELS

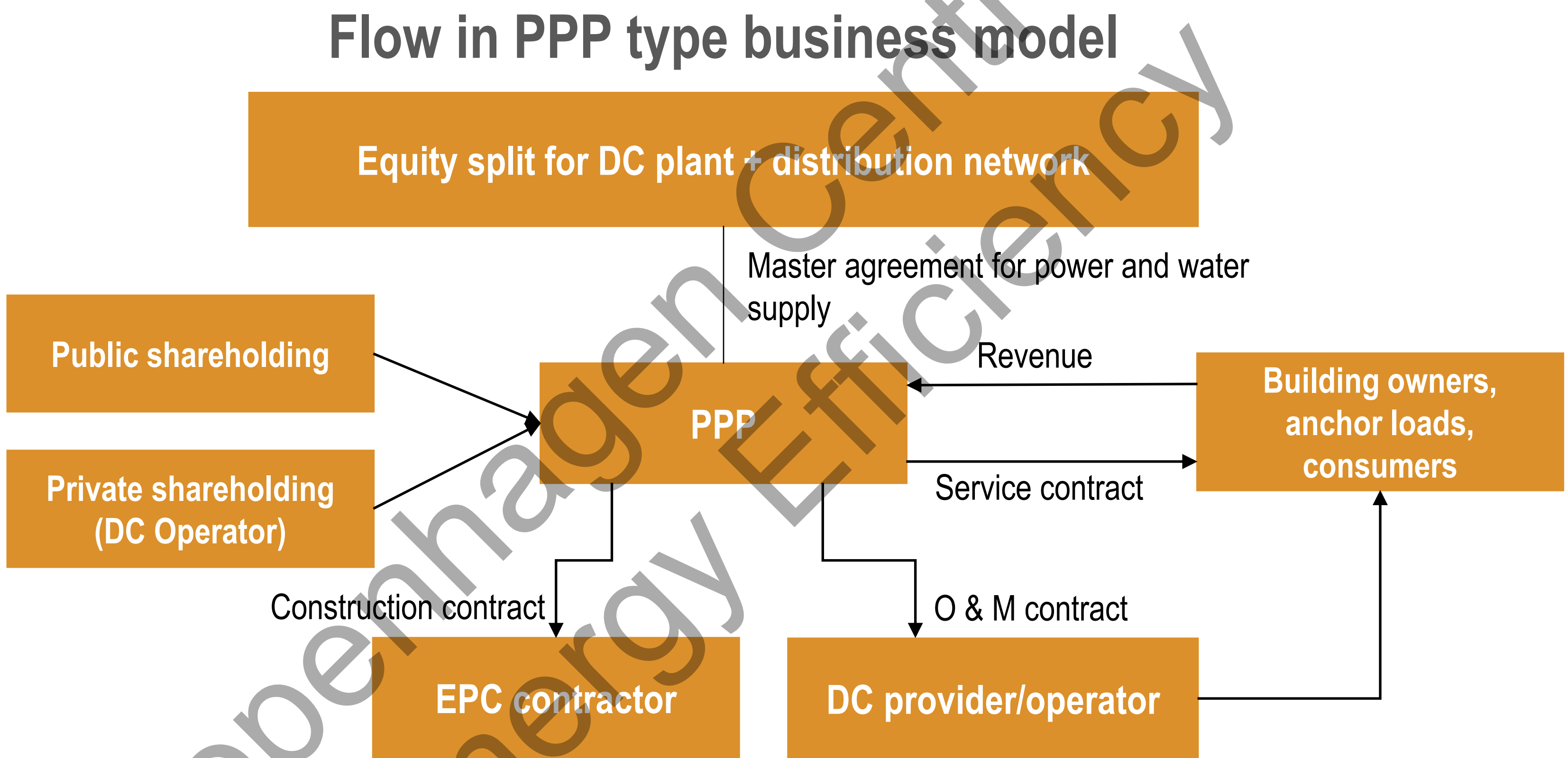
Flow in single-ownership type business model



- The owner contracts out the construction of plant, distribution network and interface to an engineering, procurement and construction (EPC) contractor
- Short duration contracts for district cooling operation and maintenance can be given to EPC contractor or a 3rd party
- Minimum transfer of risk
- This model can be converted to hybrid ownership with suitable contracts in place

Source: National DC potential study, India

CHARACTERIZATION OF BUSINESS MODELS

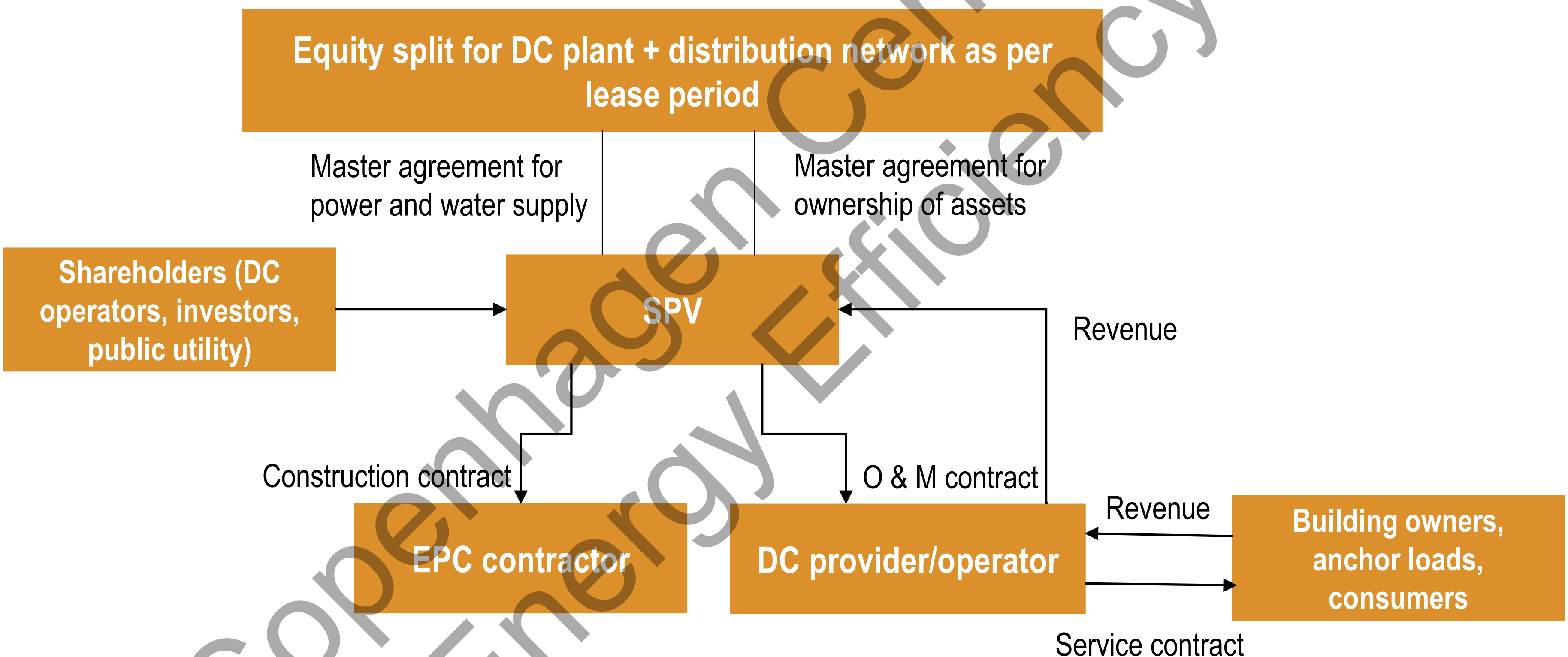


- Cost is shared by equity partners as per their expertise
- Risk is also shared as per equity distribution Risk is efficiently transferred to the SPV
- Operation is run by District cooling provider

Source: National DC potential study, India

CHARACTERIZATION OF BUSINESS MODELS

Flow in Concession type business model



- The SPV acquires the ownership of assets during the lease period
- Tender process draws out the best results and costs
- Risk is efficiently transferred to the SPV

Source: National DC potential study, India

CHARACTERIZATION OF BUSINESS MODELS

DC business models for real estate developers

	Traditional	Equity JV	Full Concession
Developer Equity	**100% Developer equity** • Developer retains risk but has full control • O&M or management can be contracted • Potential sale or concession post-completion	**<50% Developer equity** • Equity partner shares cost and risk • Partner may bring operational expertise	**0% Developer equity** • Max risk transfer • 25 – 50 year BOT contract • 3rd party finance
Potential Equity Investors	None – 100% Developer equity	Developer equity/DE operators/Other equity investors	DE operators/Other equity investors
DE Operations	Internal/O&M or Management contractor	All DC providers	All DC providers

Source: King and Spalding for District Energy in Cities Initiative

BUSINESS MODEL RECOMMENDATIONS FOR INDIA

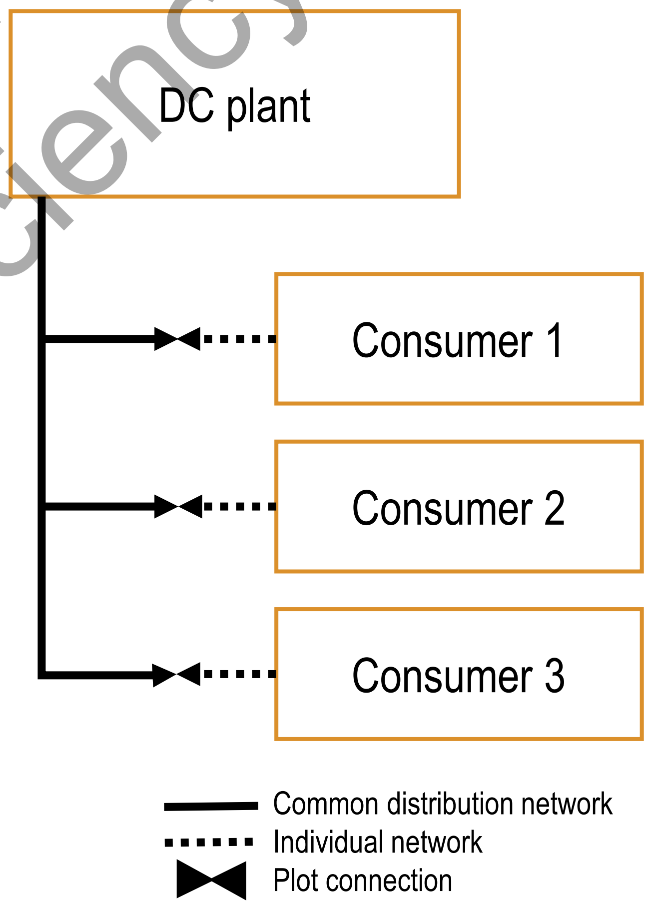
Risks can be mitigated by the involvement of private sector players through JV's, PPP etc. with expert DC service companies. Private sector interest and participation in these projects can be increased by:

- **Special power and water tariff**: Tariff for power and water for such projects must be regulated in such a manner that the ROI becomes lucrative for the DC service companies.
- **Finance at low interest rates**: The public sector with its involvement can secure finance at lower rates of interest for the DC service companies. This can be done by public sector acting as a guarantor/underwriter for loans.
- **Contracting experts**: In India there is a dearth of lawyers' with expertise in drawing complex contracts for PPP and tender based business models for district cooling. Help can be taken from international contracting experts, for executing transparent structures for boosting stakeholder confidence and easy replication for future opportunities.
- **Availability of reliable power:** The paramount requirement for district cooling viability is the availability of reliable power source. If the power supply is not reliable the investors / sponsors have to provision for the standby arrangements such as DG sets etc. This substantially increases the finance and land requirements for the project and dampens the interest of stakeholders. Separate substations and transmission routes should be provided by the government in order to increase private sector interest for such projects.

COSTING

Major cost components of DC project

- Land/lease costs for DC plant
- Equipment/Machinery costs
- Construction & laying costs for common distribution network
- Construction & laying costs for individual network/plot connections
- Costs for metering equipment for individual network/plot connections



FINANCIAL INSTRUMENTS

Who pays for what?

Depends on Business Model

1. DCP
- Master developer (traditional model)
- SPV but pass through to customers (Equity JV/Concession models)

2. DCN
- Master developer (Traditional model)
- Various upfront/reimbursement options (Equity JV/Concession models

3. Plot network /ETS room
- Customer under all models

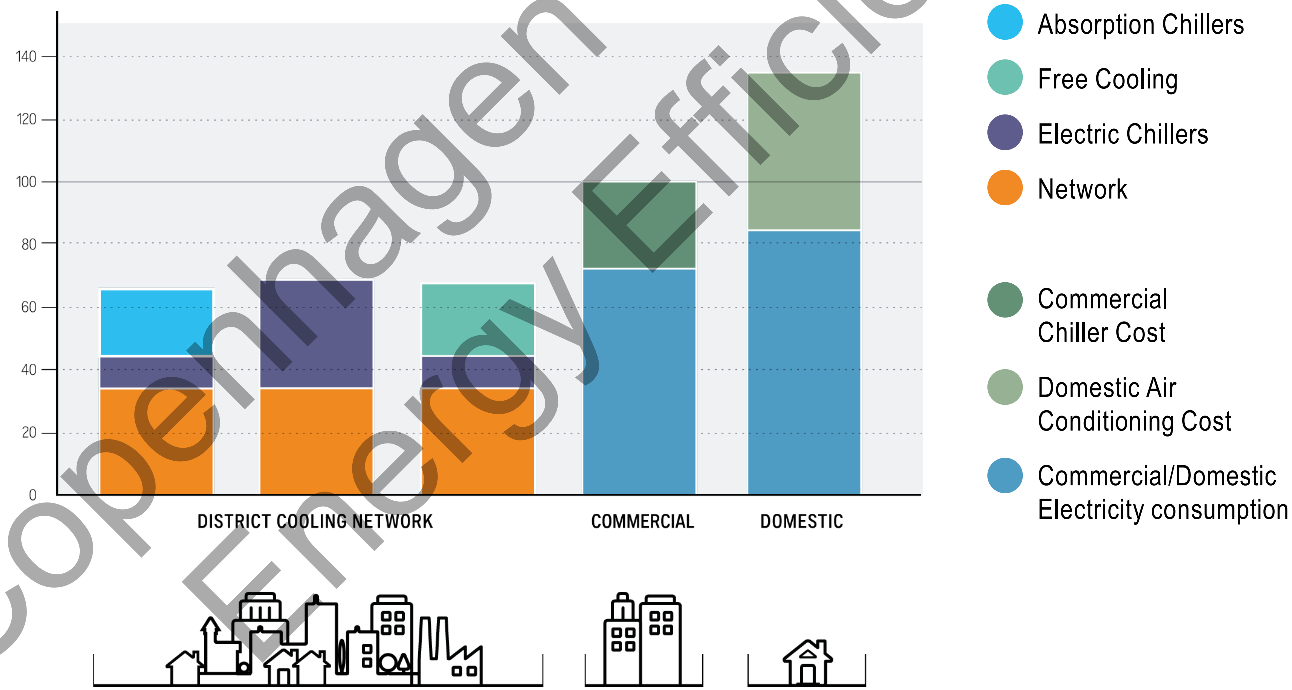
4. ETS equipment
- SPV but pass through to customers under connection charge

Source: King & Spalding

COSTING

How much does District Cooling cost?

Due to its ability to use waste heat, higher efficiency cooling and thermal storage along with avoiding individual energy solutions and their maintenance and over-capacity district cooling can be delivered **far cheaper** than conventional cooling systems, with much **lower carbon emissions and fossil fuel consumption in energy dense areas.**



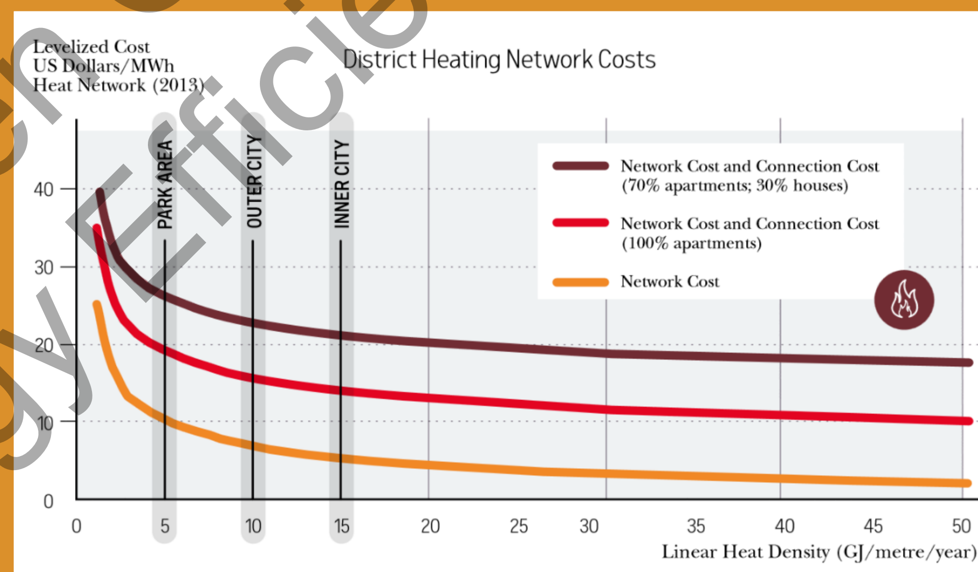
Source: District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy

COSTING

How much does District Cooling cost? - Importance of load density

Load density is crucial to reducing the cost of the cool network. Cities should ensure that the majority of appropriate demand is connected to the DCS through land-use policies, subsidies and advocacy.

- **'New' cities** beginning to develop DC should focus on 'priority zones' with high load density to prove the technology.
- **'Expanding' cities** should be designing their city to have a higher load density and more mixed use zoning to optimise investments.
- **'Consolidated' cities** may have paid off a lot of CAPEX and can start connecting less dense neighbourhoods and interconnecting systems.
- **'Refurbishment' cities** should focus on maintaining high customer connection.



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

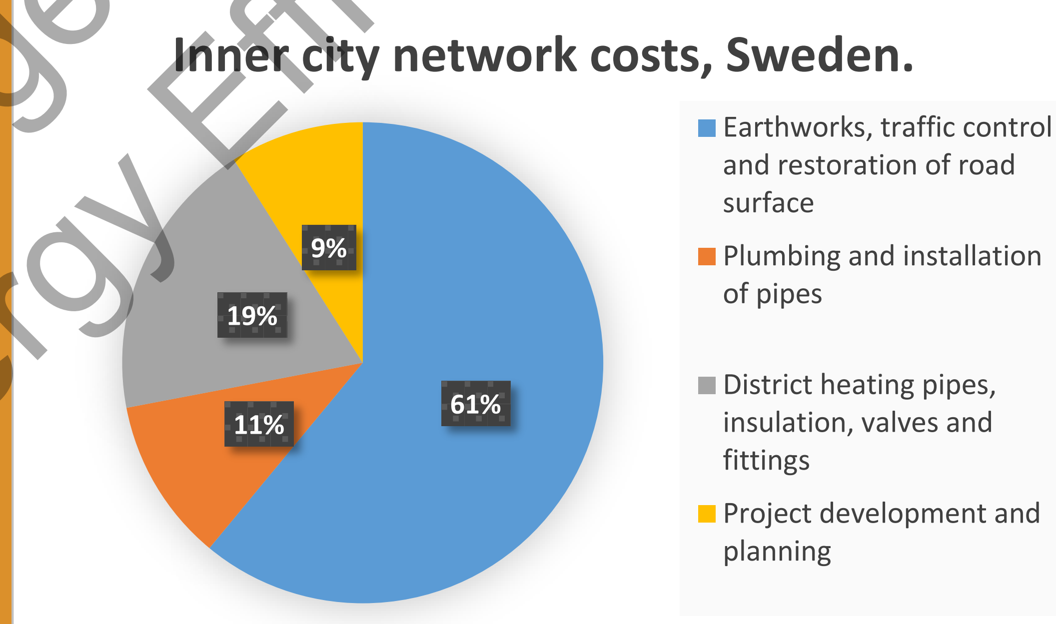
COSTING

How much does District Cooling cost? - Coordination and capacity

- **Strong coordination between different city functions** within a 'multi-stakeholder coordination framework' is vital to reducing costs.
- Capacity within local stakeholders for assisting projects through planning process **reduces the planning and development costs (~20% of investment)**.

- **Huge potential for sharing cost** of earthworks with other utilities, transport/area development & road surfacing works which dramatically **reduces cost**.

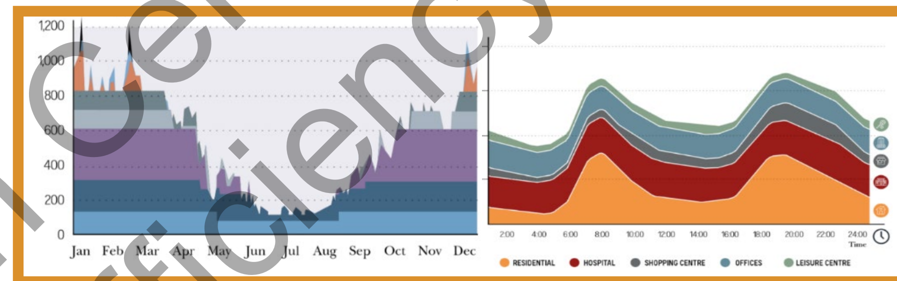
- The **influence of earthworks on the cost** (61%) in inner city is a major reason why the cost of network can vary so much between cities.

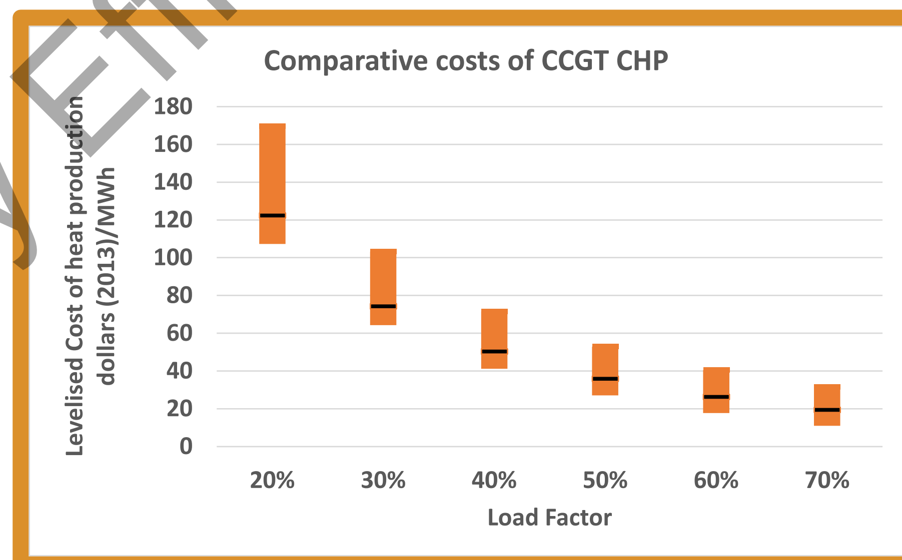


COSTING

How much does District Cooling cost? – Anchor loads and storage

- **Having a heat or cool profile that is very seasonal** will mean low utilization for heat capacities, such as CHP, meaning higher costs. Connecting **anchor loads** such as swimming pools can ensure higher utilization outside the traditional heating/cooling season.
- A heat or cool profile which fluctuates from low to high across an average day can mean low utilization and higher costs. **Storage of heat or cool** can avoid this and for DC, can avoid electricity demand during peak periods. **Anchor loads** also reduce the range between daily low & high demand.





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

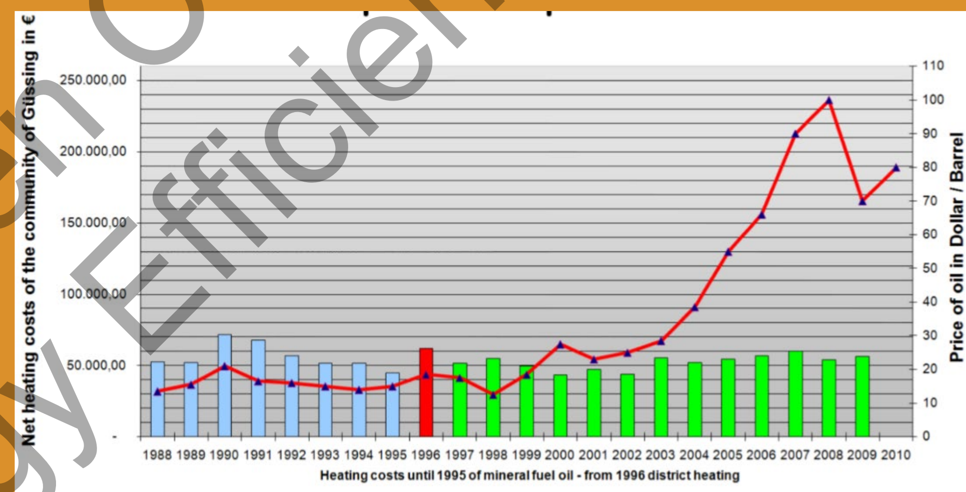
Note: CHP heat tariff in graph calculated from required return after electricity revenue

COSTING

How much does it cost? - Disconnection from fossil fuel prices

- **Higher efficiency, use of waste heat and renewables** means DC uses less fossil fuels and is thus **more resilient to fossil fuel price increases** and will enable a **steadier price for heat or cool.**
- However, decreases in fossil fuel prices may make alternative technologies seem cheaper, especially in the absence of a strong carbon price or mechanism for levelling the playing field.

Güssing's district heat price managed to disconnect from the oil price as the city became more energy independent



Fossil fuel price projections will be accounted for in the feasibility study of the project.
'New' cities may use gas, coal or electricity which can initially compete with conventional technologies and may reduce short term risk.

Source: Solutions gateway Starting district heating in existing cities and developments

COSTING

Benchmarks for DCS Costs (Based on experience from China)

Technology	Cost in China (USD/TR)
Absorption Chiller	300-350
Electric Chiller	250-300

Pre-insulated pipe size (mm)	Cost in China (USD/m)
300	69.23
350	78.46
400	84.62
450	95.38
500	112.31
600	130.77
700	149.23
800	156.92
900	178.46
1000	198.46
1100	218.46
1200	246.15
1300	300.00

Source: DES Initiative

HOW TO FINANCE DC PROJECTS?

Types of Financing

Most of the projects are **public sector funded** because of its ability to **secure finance at lower interest rates**. Even in private sector projects, public sector can **facilitate private sector** in securing finance at lower interest rates by acting as a **guarantor or underwriter**. Some of the examples of public and private sources of finance are summarized in below

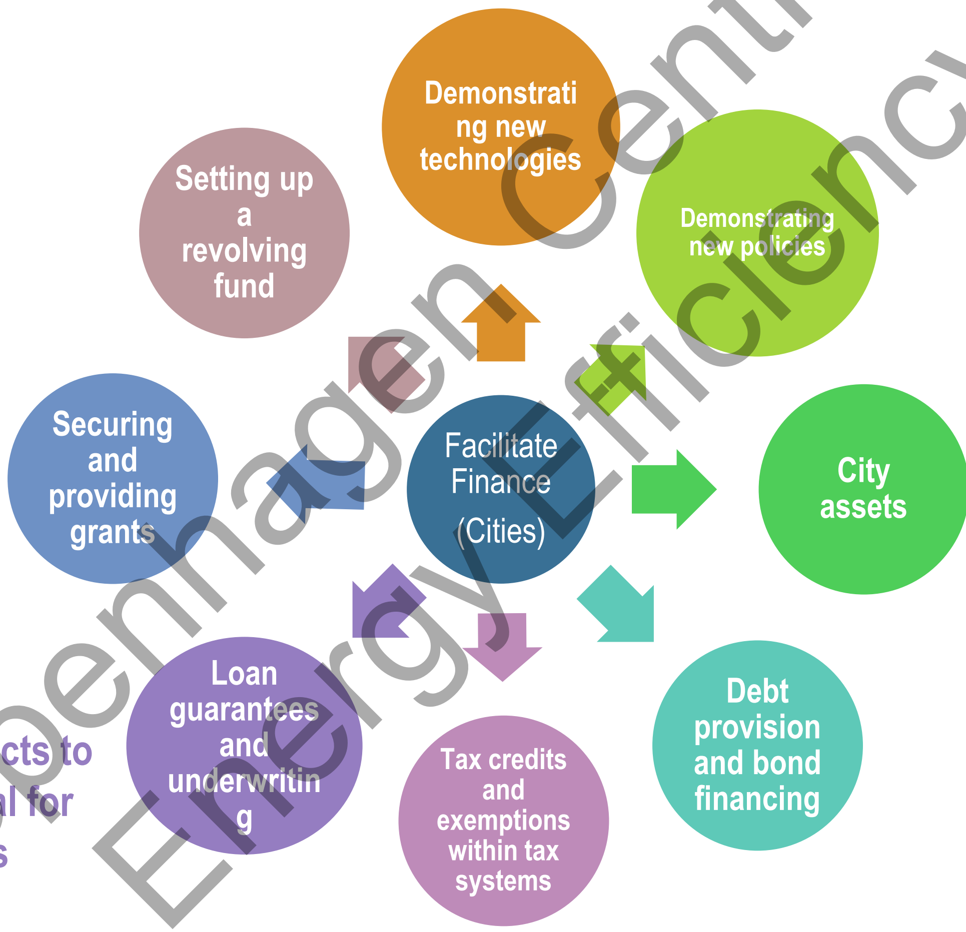
Private Finance	Public Finance
• Private sector debt, equity • Financing from DC providers • Venture capital and business angels	• Grants • Public debt at low interest • Development bank loans at low interest • City level subsidies • Energy revolving funds

FINANCIAL INSTRUMENTS

'New' cities can set up a revolving fund to create multiple starter networks

Cities can provide grants to projects and/or attract national/international grants

City's can guarantee projects to lower the cost of debt; vital for socially important projects



Demonstration of policies can leverage private sector investment in other networks

City assets like land, public-rights-of-way & access to publicly owned anchor loads, reduce risk of projects

Many cities use their access to cheaper debt to lower the financial cost of a project

FINANCIAL INSTRUMENTS

Investor understanding of investments per project phase

Project phase	Risk exposure	Financial instrument	Possible financing body
1. Feasibility	Demand Permits Competition Credit Price External impacts…	Grant	National or international funding
2. Development	Same as above	Grant or Project Owner	Same as above or project owner funds
3. Construction	Construction, fixed asset	Loan	Infrastructure fund
4. Operation	Operational, Market	Loan	Pension fund, Insurance, Infrastructure fund
5. Reinvestment	Market	Corporate funding	Owner (municipality/ city/ private company)

Source: DHC Think tank to Unlock Investments in DH

INSTRUMENT #1

Demonstration Projects

"By demonstrating new technologies, new policies and demonstrating institutional capacity, cities lower the perceived risks to private investors, local governments and other funding sources and prove the commercial viability of district energy". ***District Energy in Cities Initiative, UNEP, 2014***

CASE STUDY: Vancouver

- City owned demonstration project: Southeast False Creek Neighbourhood Energy Utility (SEFC NEU).
- City-owned greenfield district heating network using waste heat from sewage.
- Financially structured like a private sector project to prove commercial viability.
- Demonstrated new connection policies in the city.
- Has led to one new district heating system and the switching of two other systems from gas to renewables.

Source: Sauder, Integrated community Energy system Business Case Study

GREEN BONDS

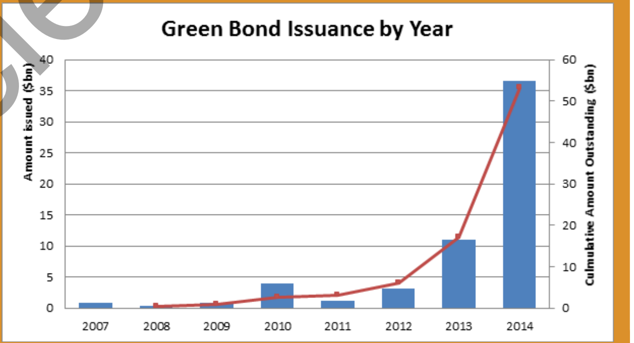
Definition

"Green bond is a debt security that is issued to raise capital specifically to support climate related or environmental projects". ***World Bank, 2014***

CASE STUDY: Gothenburg, Sweden

- City council adopted 12 local environmental quality objectives with associated intermediate objectives
- Green projects form a portfolio of assets eligible for financing and refinancing by green bonds (e.g. RE, EE, clean transport, green buildings…)
- The green bond supports the decarbonisation of the DH by 2030: 0.065 kgCO2/kWh (2018)

… Other examples are Johannesburg and Paris



Source: climatebonds.net, GreenGothenburg.se

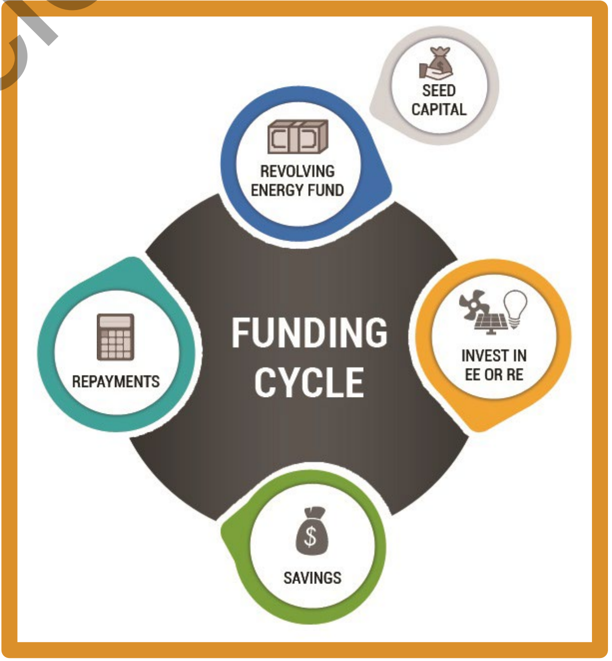
REVOLVING FUNDS

Definition

"Revolving fund is an amount of money that exists in order to finance something, but from which any loans must be replaced in order that the full amount is available again". **Cambridge Dictionary**

CASE STUDY: Toronto Atmospheric Fund (TAF)

- Set in 1991 with US$20.2 million from selling a city-owned building
- Promotes testing and scaling up of solutions in renewable energy, energy efficiency and reduced fossil fuel consumption
- Re-invest profits into new projects
- Supported the implementation of a tri-generation system financially and with know-how



Source: 100% Renewables

CITY LEVEL SUBSIDY

Definition

"A subsidy is a form of financial aid or support extended to an economic sector (business or individual) generally with the aim of promoting economic and social policy". **Meyers, N**

CASE STUDY: Paris Urban Heating Company (CPCU)

- The municipality owns 33% share in the CPCU
- CPCU's targets on heat production are:
  - 50% renewable or recovered heat in 2015
  - 60% by 2020
- If 50% target is met, a national incentives will reduce VAT on heat by 5.5% to costumers
- The concession contract sets a cap for the heat delivered against the share of renewables
- For those living in social housing, the city enforces a special law

Source: District Energy in Cities, unlocking the potential of Energy Efficiency and Renewables

LAND VALUE CAPTURE (LVC)

Definition

"Land Value Capture is a policy approach that enables communities to recover and reinvest land value increases that result from public investment and government actions". ***OECD***

Highlights

- **Applicable to new development areas** (e.g. around new train station) and new cities.
- In Latin America **transition of land from rural to urban** can **increase land value** by 400%.
- Capture land-owner windfalls from land value increase to finance new infrastructure investment.
- Typically used to finance the infrastructure (e.g. train or metro) that leads to the land-value increase but high potential to finance district heating infrastructure.
- Use **land-use policies** such as mixed use zoning and compact land use to design areas to be high potential for district heating.
- Finance district heating development using DB-LVC.
- China will be using DB-LVC for high-potential urban areas around new transit stations to finance infrastructure investment and district heating.

PROCUREMENT IN DES

- **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.

- DCS tend to be **natural monopolies**. **Requires price regulation** to ensure:
  - Undersupply; overprice
  - Normally, treat them as a public good
  - Re-structuring of city´s urban plan

REGULATORY INSTRUMENTS

Price regulation models

True cost pricing

- **Benefits:** works well when interests are aligned in keeping prices down
- **Challenges:** it does not control increasing spending in for example operation and maintenance, increasing depreciation time, or increasing salaries.

Price cap

- **Benefits:** ensures prices remain below the political set threshold
- **Challenges:** fairly rigid model that often does not include room for local conditions

No price regulation

- **Benefits:** a simple method that does not require detailed regulation and can potentially realise efficient prices if proper (competition) mechanisms are in place
- **Challenges:** it does not sufficiently account for sunk-costs made by customers who connect to district heating system

DCS tend to be **natural monopolies**. This requires **price regulation** to ensure undersupply; overprice

REGULATORY INSTRUMENTS

Tariff structuring

<table>
<tr><th colspan="2">Component description</th><th>Cost recovery</th></tr>
<tr><td>Connection fee (USD/TR)</td><td>Connection fee</td><td>Cost recovery for costs associated with connecting each customer to the network, e.g. from valve chamber of the distribution network to the ETS room and the ETS requirement</td></tr>
<tr><td rowspan="2">Declared load charge rate (USD/TR/Yr)</td><td>Declared load charge rate – capital cost recovery</td><td>Capital cost recovery for the DCP and the distribution network up to the connection chamber within each plot/building

This should cover debt principle and interest and equity return</td></tr>
<tr><td>Declared load charge rate – fixed O&M recovery</td><td>Fixed O&M (labour, lifecycle maintenance, routine maintenance)
For a calendar year, means the lower of :
1. 3% p.a. and
2. The change in [Country] Consumer price index, expressed as a percentage from the prior calendar year to the current calendar year</td></tr>
<tr><td rowspan="3">Consumption charge rate (USD/TR-hr)</td><td>Electricity</td><td>Electricity utility authority rate pass through</td></tr>
<tr><td>TSE water</td><td>TSE water utility authority rate pass through</td></tr>
<tr><td>Chemicals</td><td>For a calendar year, means lower of
1. 3% p.a. and
2. The change in [Country] Consumer price index, expressed as a percentage from the prior calendar year to the current calendar year</td></tr>
</table>

Source: King & Spalding

REGULATORY INSTRUMENTS

District Heating Regulation

Company

Customer

State

- No 'one size fits all' regulatory model for the sector
- Models range from heavy regulation (overly bureaucratic and prescriptive) to a 'light touch' approach with no price regulation
  - Impact on likelihood of private sector participation
- **National Governments** may enact an overarching national law which governs the sector, or it may be covered by wider energy sector legislation
- **Regulation** may also be necessary to ensure that the sector contributes to national objectives for renewable energy or CO_2 reductions
  - Alternatively, this can be accomplished indirectly through carbon pricing or taxation of fossil fuels
- Correct balance that **protects consumer rights**, enables utility operators to cover costs, make a reasonable profit and **incentivise investment in the sector** (especially needed for decarbonisation)

REGULATORY INSTRUMENTS

Consumer protection policies: The case of Singapore

- High opportunity district cooling zone identified.
- 2011 District Cooling Act mandates connection which ensures business model is sustainable
- Tariff regulations ensure consumers protected from high prices
- Future financial gain shared with customers

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

TENDERING DC PROJECTS

What is tender and RFP?

Tender

•Refers to the process whereby governments and financial institutions invite bids for large projects that must be submitted within a finite deadline.

•A tender offer is a public solicitation to all shareholders requesting that they tender their stock for sale at a specific price during a certain time.

RFP

•A request for proposal (RFP) is a project announcement posted publicly by an organization indicating that bids for contractors to complete the project are sought.

•The RFP defines the project, for the company that issues it as well as the companies that respond to it.

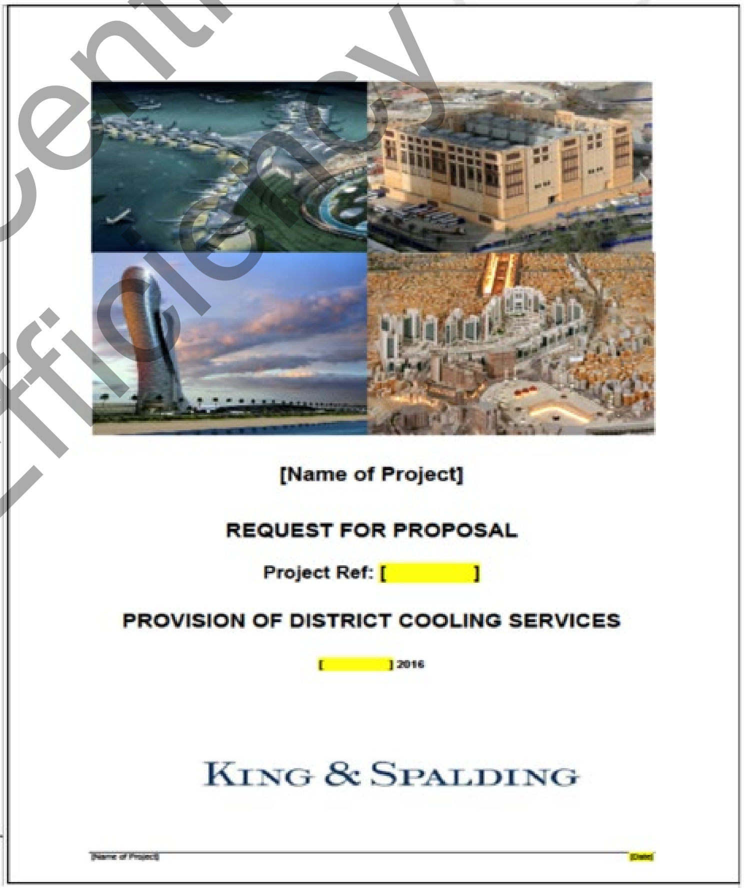
•The RFP describes the project, its goals, and the organization that is sponsoring it and outlines the bidding process and contract terms.

•RFPs are used by most government agencies and many private companies and organizations.

TENDERING DC PROJECTS

Why tender?

1. Required by law/rules
2. Transparency
3. Seek VFM
4. Efficiency
5. Competitive tension
6. Risk allocation negotiation advantages
7. Bankability
8. Execute on the DES structuring report



Source: King & Spalding

TENDERING DC PROJECTS

Tendering tips for DC projects

1. Develop a comprehensive procurement plan
2. Conduct a “project bankability” test
3. Conduct EOI
4. Short list qualified bidders
5. Conduct RPF process and issue RFP versions of project agreements
6. Develop clear output specification
7. Develop clear evaluation methodology
8. Allow limited feedback, Q&A and face to face sessions
9. Ring fence negotiation points with PB
10. Capacity building - lessons learned

Source: King & Spalding

TENDERING DC PROJECTS

Key elements of RFPs

1. Approximately 70 pages
2. Introduce the DC project and its components
3. Explain: Technical, commercial and legal expectations
4. Outline proposed business model and explain each legal agreement
5. Provide a clear and realistic timetable
6. Provide instruction to bidders on competing bids
7. Set clear evaluation criteria
8. Request tender return schedules

Example of RFP – Table of contents

Table of Contents

Timetable - 4 weeks to produce

Source: King & Spalding

TENDERING DC PROJECTS

Example of Appendices to RFP:

1. Form of bidder conformation
2. Form of tender bond
3. Forms of project agreements
4. Form of preferred bidder letter
5. Bidder tariff and BCFM
6. Technical requirements
7. TR projections
8. Location plans
9. DCN design plans

Example of RFP return schedules:

Volume 1: Technical proposal

1. Bidder corporate information
2. TR assessment
3. Technical method statement and submission
4. Project implantation schedule
5. List of proposed DCN contractors

Volume 2: Commercial proposal

1. Executed tender bond
2. Financial statements
3. Tariff proposal
4. BCFM and Financing methodology
5. Comments on project agreements

Source: King & Spalding

TENDERING DC PROJECTS

Example of compressed RFP timeline

Timetable	Activity
11 April 2018	Kick-off Meeting
1/ 2 May 2018	Internal meeting with client and advisors: • contracting strategy/offtake models; • phasing/load; • technical responsibilities; • financial considerations and tariff; • approach to next steps.
8/ 9 May 2018	Meeting with (bi-lateral or bidders) : • introduction to proposed contracting strategy; • outline of roadmap; • initial high level discussions.
22 May 2018	Submission of initial internal drafts of documents (RFP document plus legal contracts) for discussion with client.
5 June 2018	Internal meeting to discuss initial drafts with client and advisors.
11 June 2018	Issuance of documents to bidders
19 July 2018	Deadline for proposal response from bidders
19 July 2018 - 2 August 2018	Internal consideration of proposal and clarification questions, report to Committee to proceed.
5 - 23 August 2018	Negotiations.
11 October 2018	Financial Close.

Source: King & Spalding

TERMS OF REFERENCE (TOR)

- In DC projects, Terms of Reference define the purpose and structure of the project. They show how the project in question will be defined, developed and verified.
- They consist of:
  - vision, objectives, scope and deliverables (i.e. what has to be achieved)
  - stakeholders, roles and responsibilities (i.e. who will take part in it)
  - resource, financial and quality plans (i.e. how it will be achieved)
  - Work breakdown structure and schedule (i.e. when it will be achieved)
- ToR are created during the earlier stages by the founders of the project. They are documented and presented to the project sponsors for approval. Once the terms have been approved, the members of the project team have a clear definition of the scope of the project. They will then be ready to progress with implementing the remaining project deliverables.
- The Terms of Reference sets out the activities and analysis required to develop a Detailed Project Report.

DETAILED PROJECT REPORT (DPR)

- After the planning and the designing part of a project are completed, a DPR is prepared. It is an extensive and elaborative outline of a project, which includes essential information such as the resources and tasks to be carried out in order to make the project turn into a success.

- A DPR for a DCS project has the following main components:

- An initial technical and cost-benefit analysis and modelling of alternative DCS technical options including: alternative plant locations and network design, use of alternative refrigerants, trigeneration, RDF boilers, waste-to-energy connection, solar PV PPA, solar thermal, renewable heat, thermal storage, hot water provision and options for residential connection and billing

- Determination of costs for business as usual (equipment, O&M, space requirements, replacement costs, etc.) and analyse paying capability of different customer types

- Details on key plant requirements and their viability implications including the arrangements for peak and backup capacity. This should include details of technology types, sizing and phasing of plant, safety considerations (e.g. for gas, HFO, ammonia etc.), thermal storage, required chilled water temperature, expected EFLH of equipment, water supply (including Treated Sewage Effluent), other relevant associated plant and temporary supply options for upcoming buildings

DETAILED PROJECT REPORT (DPR)

- Plant sizing and configuration scenarios, operating parameters and operational strategy technically and financially best matched to the identified cooling and power demand profiles, the number and type of each chiller, their utilisation, thermal and electrical output rating, where applicable. Suitable diversity factors should be identified that take account of the nature of the individual cooling loads and used to inform appropriate plant sizing and phasing that reflect latest international best practice in this field

- Network phasing and connection requirements and account for these implications on the future proofing of the energy centre design and plant operation conditions.

- Assessment of existing utilities infrastructure including gas and electrical grid import/export connections for compatibility with energy centre(s) connection requirements, capacity availability to import/export and to determine the technical and cost implications in relation to the scheme.

- Fuel choice and supply including gas and electricity network constraints, gas and electricity tariff regime and purchasing of Open Access electricity.

- Energy centre location and potential opportunities for third-party hosting of central plant. Initial plant design and constraints

- Third-party heat sources and local renewables that could augment the district cooling network.

- Evaluation of noise and heat island effects from the cooling towers in DC plants to nearby buildings, environmental benefits, including GHG emission reduction, low-GWP refrigerant phasing, annual saving in electricity and water consumption etc.

DISTRICT
ENERGY
IN CITIES

CASE STUDIES

Yerevan, Armenia Source: Unsplash

CASE STUDY: THANE, INDIA

Hiranandini Estate: Greenfield site

- Hiranandini estate is a township in Thane spanning across 300 acres.
- Existing and future energy demands arise from commercial offices, data centers and a hotel.
- Estimated demands:
  - Peak cooling demand: 11,295 TR
  - Annual cooling consumption: 39,075 MWh/yr
  - Total electricity consumption: 93,938 MWh/yr

Source: Hiranandini group

Following a review of the technology options for the supply of chilled water, two primary options for district cooling at Hiranandani Estate were analyzed: **Electric Chiller & Trigeneration**

CASE STUDY: THANE, INDIA

Hiranandini Estate: Key project parameters

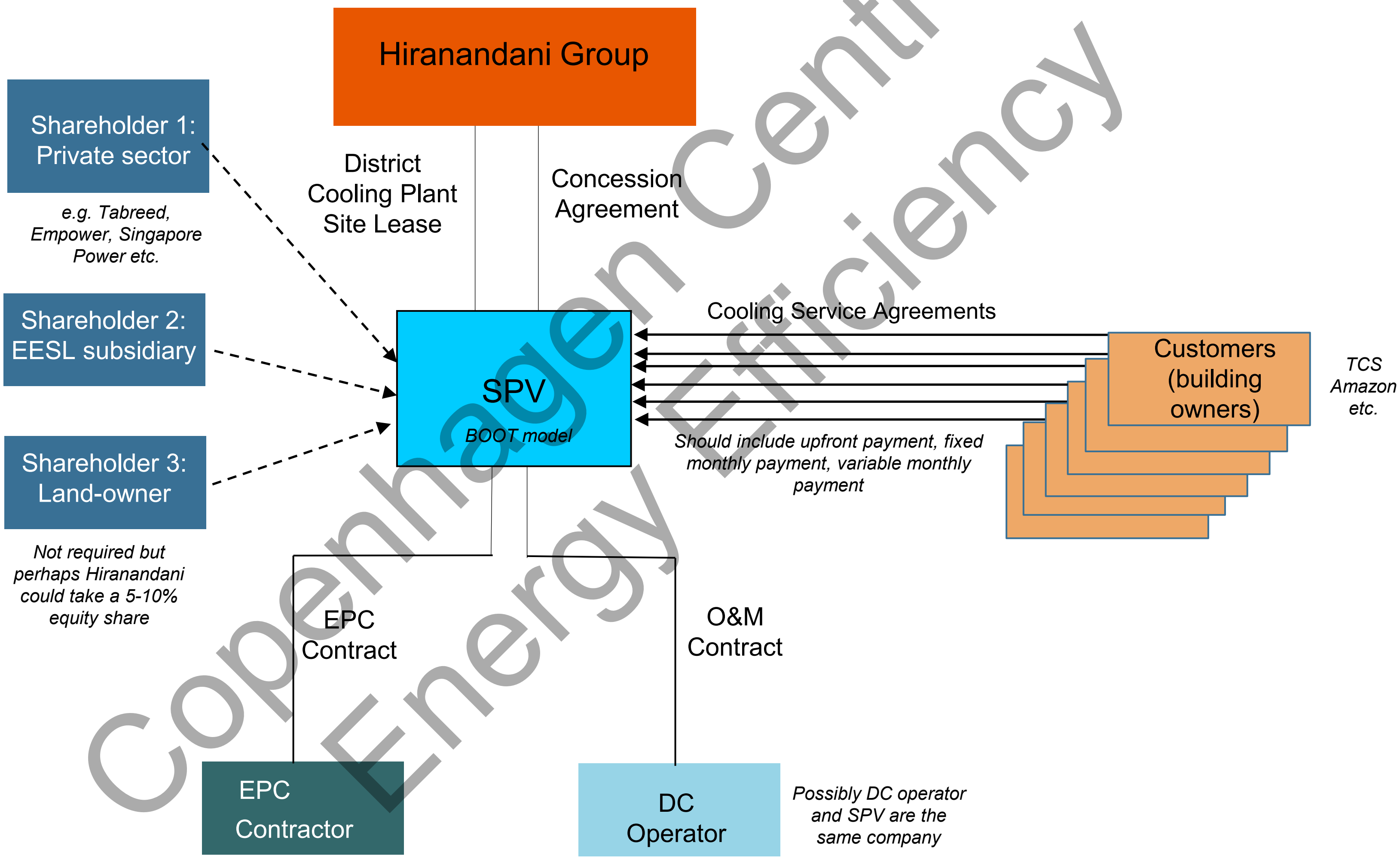
Hiranandani network summary	
Total cooling demand	38,888,334 ton.hr/yr
Peak cooling demand (total of all buildings) Note: diversity factor of 80% is applied to this demand	11,295 TR
Option 1: Electric chiller capacity	9,754 TR
Option 2: Tri-generation option capacities	Gas CHP 4 units, total of 12.8 MWe Absorption chiller 2,682 TR Auxiliary electric chiller 7,076 TR
Number of cooling connections	6
Number of phases	2 – IT Building 2 connected in second year, IT Building 3 connected in third year
Key cooling loads	IT Building 1, 2 & 3 TCS 1
Assumed operating temperatures at peak demand	flow 5°C, return 11°C

	Electric Chillers		Tri-generation	
	20 year	40 year	20 year	40 year
Capital costs (incl. 17% contingency)	₹ 1,16,03,99,058		₹ 1,95,07,60,553	
IRR (pre-tax)	23.4%	23.3%	18.7 %	19.5%
NPV	₹61,30,05,061	₹74,87,27,806	₹42,25,24,736	₹63,50,45,446
Simple Payback	5.4 years	5.6 years	6.4	6.5
Annual savings to customers relative to benchmark	₹ 6,06,32,056		₹ 8,96,87,849	
Lifetime carbon savings[2]	89,002 tCO_2e	1,97,071 tCO_2e	2,87,780 tCO_2e	4,78,403 tCO_2e

Source: Thane district cooling pre-feasibility studies, DES Initiative

CASE STUDY: THANE, INDIA

Hiranandini Estate: SPV model



Source: King & Spalding

CASE STUDY: THANE, INDIA

Recommendations

- The suggested business model should be further assessed and consulted on during Detailed Project Report preparation
- Negotiations with building owners needed by experienced DC operator as it is sensitive
- Concession agreement ensures future buildings will be connected
- Invite private sector to propose different models and contracting structures
- Suggest residential is also considered (would have different contracting model)

CASE STUDY: THANE, INDIA

The role of local government

PLANNER AND REGULATOR

- Land classified as high priority and medium priority zones for DC development
- Set targets specifically for DC sector
- GIS mapping and develop DC benchmarks

FACILITATOR OF FINANCE

- Attract funding for project from multi-lateral development banks, state and national level grants etc.
- Pool investment with other municipalities

PROVIDER AND CONSUMER

- Use public buildings to anchor new district cooling development
- Mandate that specific building types are developed as district cooling ready
- Ensure planned green building incentives promote DC development

COORDINATOR AND ADVOCATE

- Organize and co-ordinate multi-stakeholder group
- Establish a “sustainable energy delivery unit” or include within the smart city SPV

CASE STUDY: YEREVAN, ARMENIA

Status of DHN

- No domestic fossil fuel resources, import natural gas, DH supply up until 1990s
- Today: individual heat solutions: wood, kerosene, electricity, gas boilers
- District heating on existing network 60% > expensive domestic gas-fired boilers
- Low-reliability, poor maintenance, heat losses, low collection rates

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

CASE STUDY: YEREVAN, ARMENIA

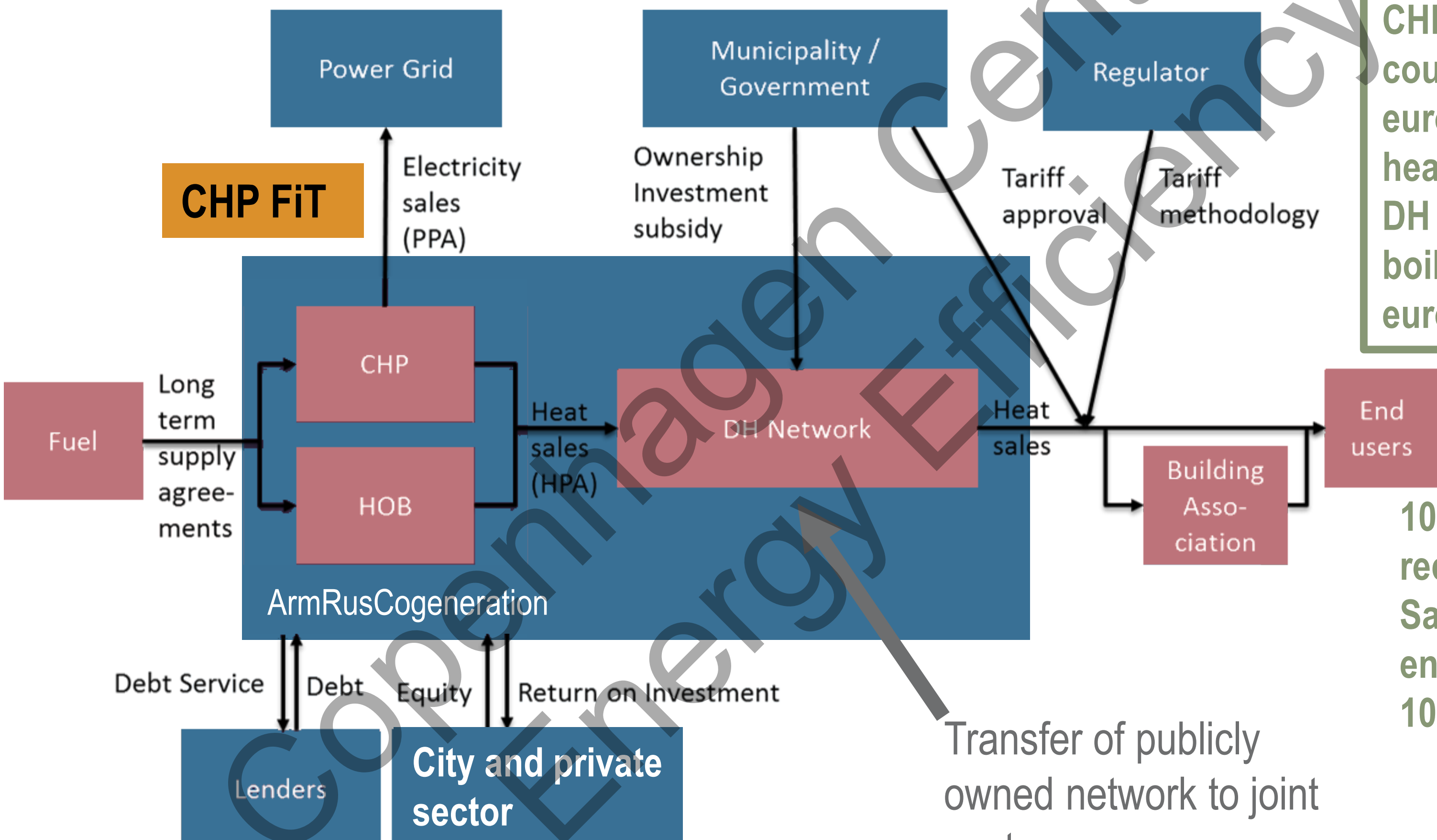
Pilot project in Yerevan

- Cogeneration on DHN could deliver 16 AMD/kWh of heat compared to boiler houses on DHN delivering 22.7 AMD/kWh **if electricity is used**
- ArmRusCogeneration CJSC, restore network, build CHP
- Yerevan minority shareholder
- Government Decision guaranteeing purchase at favourable price of electricity produced by new cogeneration units of the district heating project.

Image: Cat

CASE STUDY: YEREVAN, ARMENIA

Joint venture model



CHP on DHN could deliver 28 euros /kWh of heat compared to DH connected boiler 40 euros/kWh

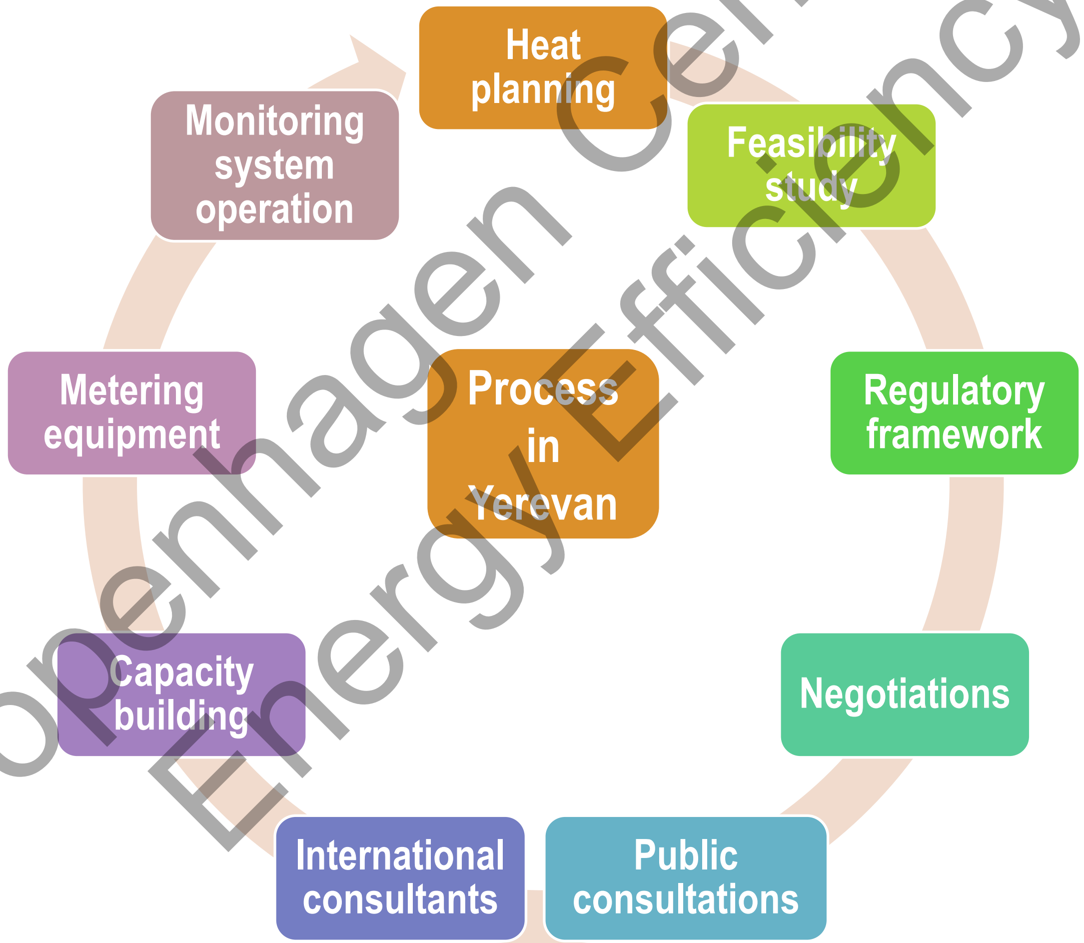
10,000 residents reconnected. Save 50.2GWh of energy and 10,200 tCO2eq

Transfer of publicly owned network to joint venture

ArmRusCogeneration CJSC (Yerevan minority stakeholder)

CASE STUDY: YEREVAN, ARMENIA

Process of developing DES in Yerevan



CASE STUDY: YEREVAN, ARMENIA

The role of local governments

PLANNER AND REGULATOR

Worked with national government to apply

- multi-part heat tariff < alternative
- preferential electricity feed-in tariff (internalizing benefit of heat in the electricity price) < marginal price

FACILITATOR OF FINANCE

- Free use of municipally owned DH infrastructure to enable PPP demonstration project.
- Leveraged more than 9 million USD of FDIs for restoration of district heating system

PROVIDER AND CONSUMER

- Utilising municipally owned district heat companies as an investment vehicle for upgrading networks.
- Setting waste heat tariff from steel plant to pay off investment in connection.

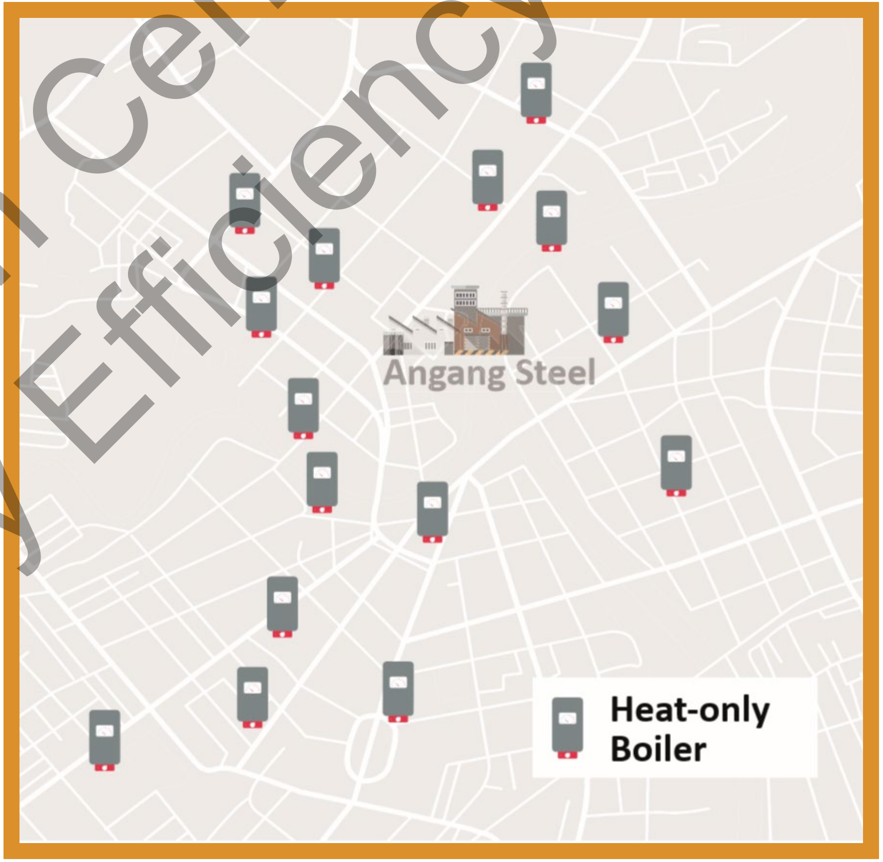
COORDINATOR AND ADVOCATE

- Cities role will be in coordinating multiple district heat companies.
- Advocating system to other cities in the region.

CASE STUDY: ANSHAN, CHINA

The current problem

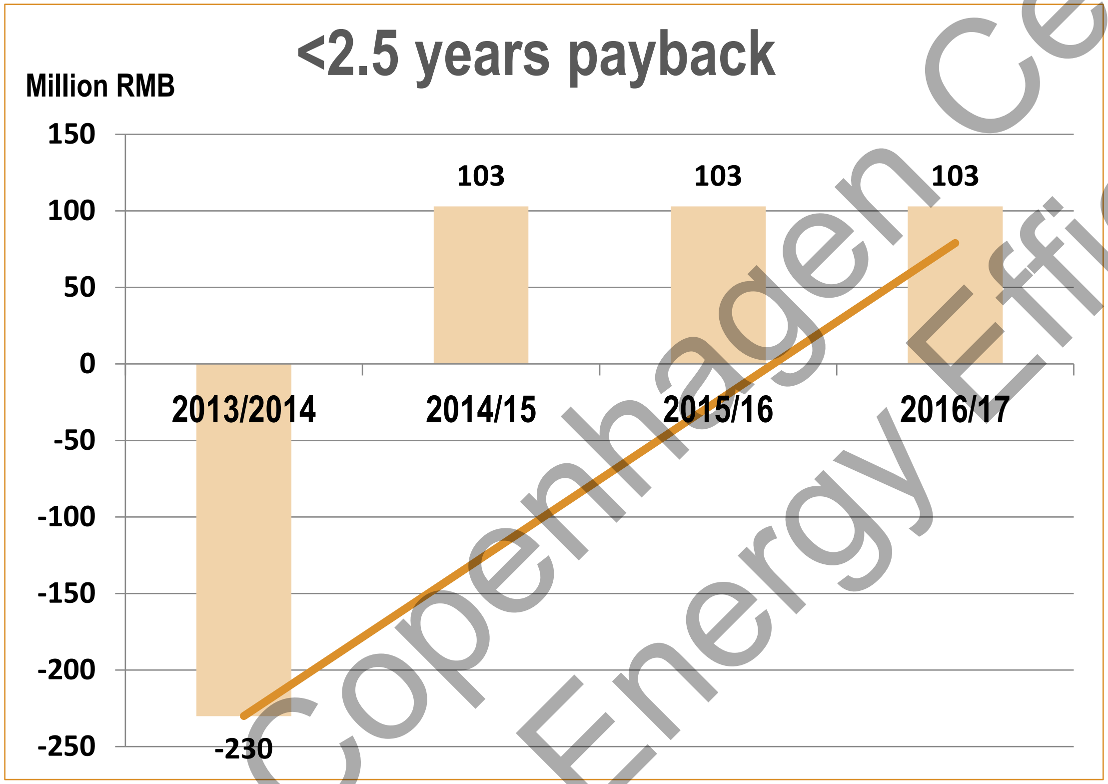
- 42 different district heating companies, some networks owned by the city and some are privately owned.
- High pollution levels with current system: fined US$1.3 million in 2013 by Liaoning province for high levels of PM10, SO2 and CO2.
- Some networks have overheating and under-heating.
- Lack of hot water connections means networks are underutilised.



Source: Danfoss

CASE STUDY: ANSHAN, CHINA

Investing in waste heat



Source: Danfoss

220 MW available surplus heat (1st phase)

Yearly energy saving	**830,000 MWh**
Coal savings	**173,000 tons**
C02 emission savings	**290,000 tons**
Yearly savings	103 million RMB (**15 million euros**)
Investment	200-230 million RMB (**30 – 35 million euros**)

CASE STUDY: ANSHAN, CHINA

The role of the private sector

- Local government worked with Danfoss and COWI to design more sustainable and integrated heating solutions for the city.
- Danfoss supplied heat exchangers for waste heat connection to steel plant
- The new transmission line will be owned and operated by a joint venture that is 60% city owned and 40% private. The construction will be sub-contracted to individual contractors.
- All existing district heat companies will remain, purchasing heat from the central transmission company.

CASE STUDY: ANSHAN, CHINA

The role of local governments

PLANNER AND REGULATOR

- Developed with the help of private sector a new strategy for district heat development in city.
- City's focus on pollution reduction is key driver in transforming system.

FACILITATOR OF FINANCE

- Directly financing majority of improvements in the city including connection of waste heat and a transmission line.
- Large city investment has leveraged private investment in transmission line.

PROVIDER AND CONSUMER

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- Setting waste heat tariff from steel plant to pay off investment in connection.

COORDINATOR AND ADVOCATE

- Cities role will be in coordinating multiple district heat companies.
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CASE STUDY: ANSHAN, CHINA

Benefits for the private sector

- Danfoss bring international expertise in district heating development
- Anshan use less coal and thus pollute less.
- Investment provided from private sector in transmission line reduces risk to city and allows funds to be used elsewhere.

Image: Rincewind42

KEY TAKEAWAYS

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

- **Business models are key to ensure a stable and viable DES service** during its complete life-cycle (development, operation, end-of-life)
- **Business model can have a large influence on a project's perceived risk and funding costs**
- **No single model is applicable everywhere**
- **DES business models based on ownership type, these are**: Fully public model, PPP/hybrid and Privately owned.
- **The relative involvement of the public or private sector depends broadly on two factors: (1)** return on investment for project investors, and (2) degree of control and risk appetite of the public sector.
- **The city can facilitate finance through various instruments**, such as: demonstrating new technologies, new policies, creating city assets, debt provision and bond financing, tax credits and exemptions, loan guarantees and underwriting, securing and providing grants, or setting up a revolving fund.
- **Regulation can act as an incentive, particularly in less mature DE markets**

RECOMMENDATIONS

Some recommendation for business models, finance and procurement are:

- **Publicly-owned infrastructure** is often recommendable since it will often require significant efforts of community engagement
- Identify where **competition** can be introduced, for example in the production parts through tenders
- Continuous communication between various **stakeholders**
- **Removal of regulatory barriers** as well as **optimising and simplifying the regulations** at the local and national level, should be promoted.
- Picking low-hanging fruits: **start with high-demand consumers** – while making sure the full potential can be exploited
- Frameworks for providing **low-cost financing options** and avoiding (unnecessary) administratively-heavy processes is an important precondition to effectively engage communities and industries.
- Development of **insurance schemes** to de-risk renewable sources such as geothermal
- Set up a **comprehensive district energy governance scheme**, including price regulation, ownership and legislation

CONGRATULATIONS!
YOU HAVE NOW COMPLETED THIS E-TRAINING!

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

www.districtenergyinitiative.org

UN environment programme 50 1972-2022

unep.org

COPENHAGEN CENTRE ON ENERGY EFFICIENCY SEforALL EE HUB

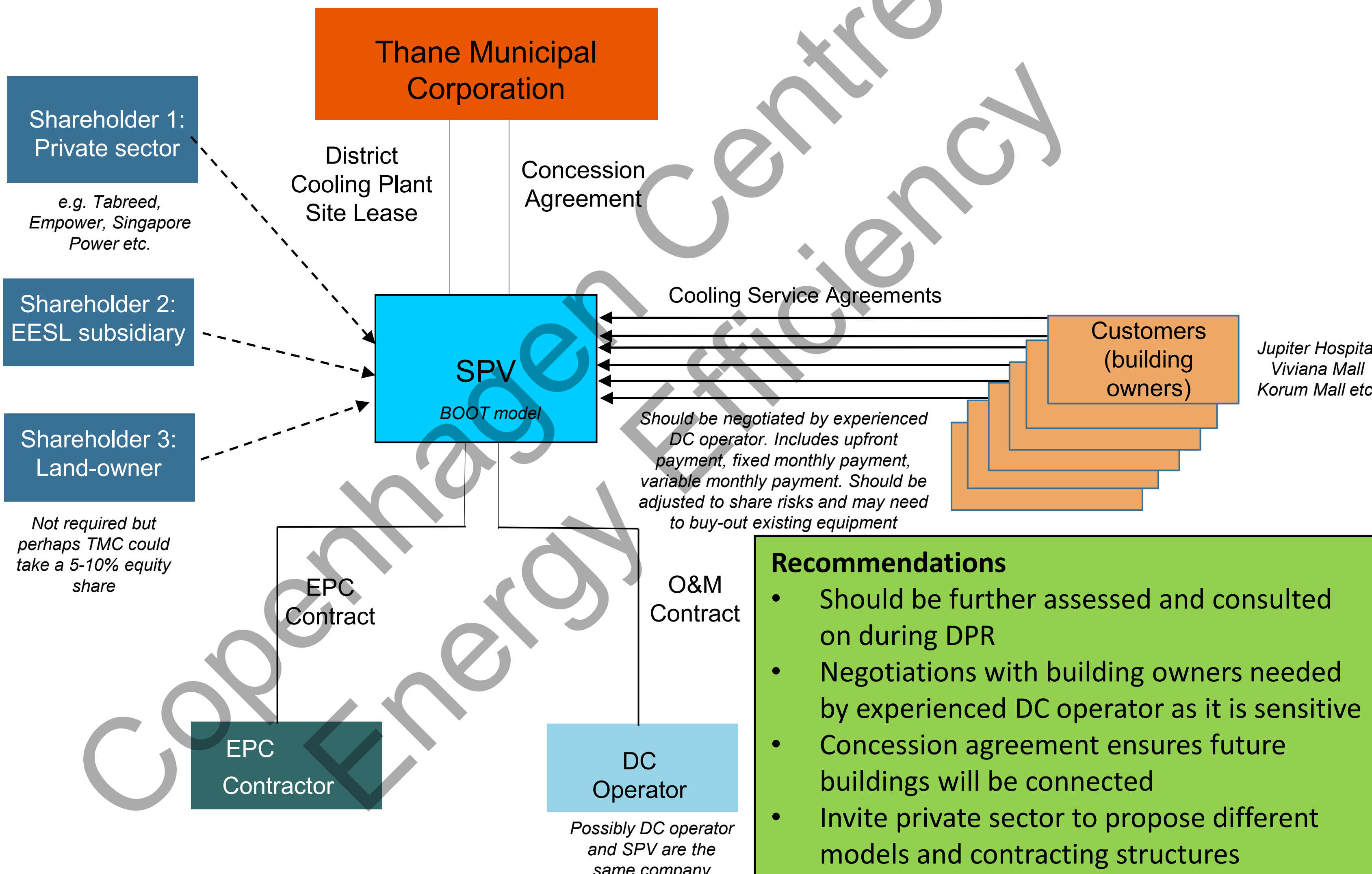
c2e2.unepdtu.org

BUSINESS MODEL

DISTRICT ENERGY IN CITIES INITIATIVE

RECOMMENDATION - BROWNFIELD

UN environment



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King & Spalding