DISTRICT ENERGY IN CITIES INITIATIVE

E-TRAINING PROGRAM

DISTRICT COOLING DEVELOPMENT

MODULE 3. ENERGY MAPPING AND DATA COLLECTION TO IDENTIFY LONG-TERM OPPORTUNITIES FOR DCS

UN environment programme 50 1972-2022

COPENHAGEN CENTRE ON ENERGY EFFICIENCY
SEforALL EE HUB

LEARNING OUTCOMES

Objective: share insights on energy mapping in district cooling (DC) projects.

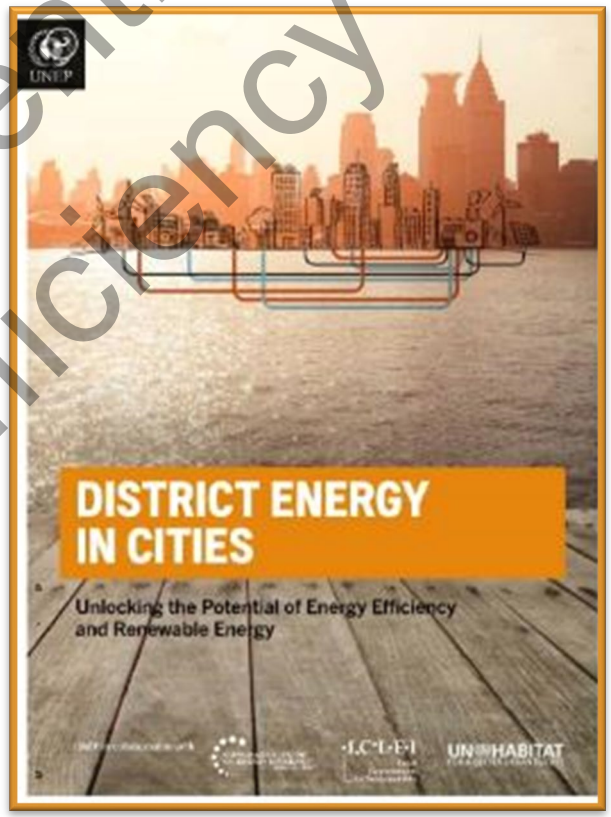
By the end of this module, you will be able to:

- Describe, understand and discuss the role of energy mapping in district cooling planning;
- Characterize main types of energy mappings in district cooling development;
- Recognise and be able to apply key steps in the development of energy mapping across various levels of detail;
- Become aware of best practices in district cooling mapping;

KEY STEPS IN 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**

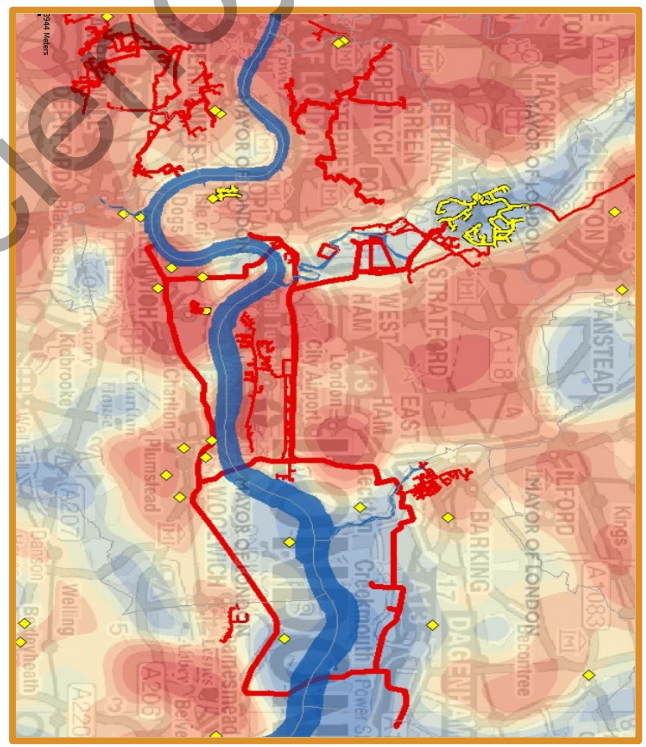


Source: District Energy in Cities. Unlocking the Potential of Energy Efficiency and Renewable Energy

ITS RELEVANCE

Why do mapping in DCS?

- To **identify individual projects, properly expand and connect them in the future**, and link this expansion with other infrastructure development.
- It allows networks that **maximise waste heat recovery** and **targets high energy density areas** leading to more cost-effective solutions.
- Allows zones to be selected where the city can apply its **land-use authority**, and tailor specific incentives.
- Very important for developing **stakeholder engagement.**
- **Raises public awareness** as a visual tool



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

ITS RELEVANCE

Why do mapping in DCS?

Different project types should develop and maintain energy mapping for different reasons

New

- Demonstrate DC in the city and justify expenditure
- Identify initial starter networks and demonstration projects
- Boost confidence in the project and secure private sector investment

Consolidation

- Seek to maximise the connection of waste heat
- Identify potential distributed renewable production
- Optimise interconnection and potential for integration of a district cooling and a district heating network

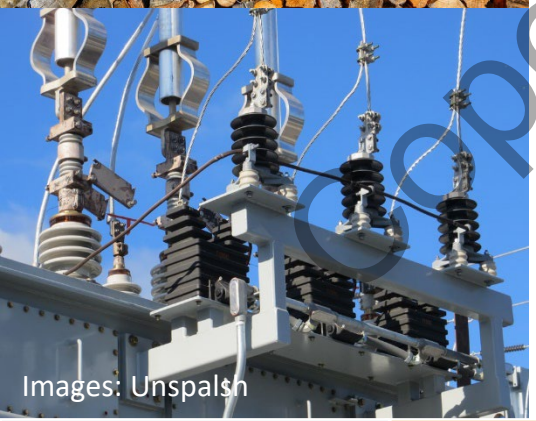
Refurbishment

- Identify potential interconnection or transmission lines
- Understand losses in the network and identify stages or redevelopment
- Identify potential waste heat sources that could be connected
- Attract private sector investment by showcasing potential projects and the strength of data collection

Expansion

- Identify optimum interconnection and pooling of networks
- Identify renewable sources of innovative waste heat
- Attract private sector investment networks
- Identify optimal expansion of network

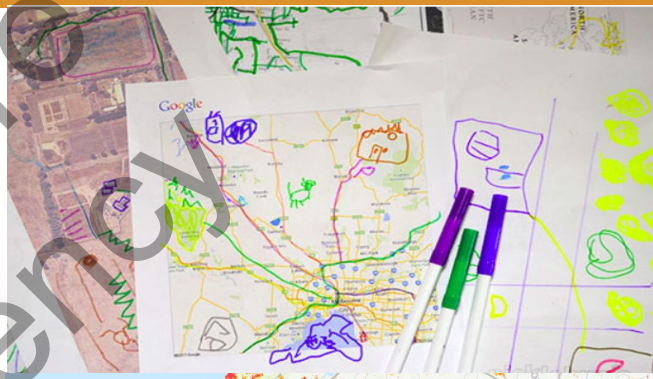
WHAT IS ENERGY MAPPING?

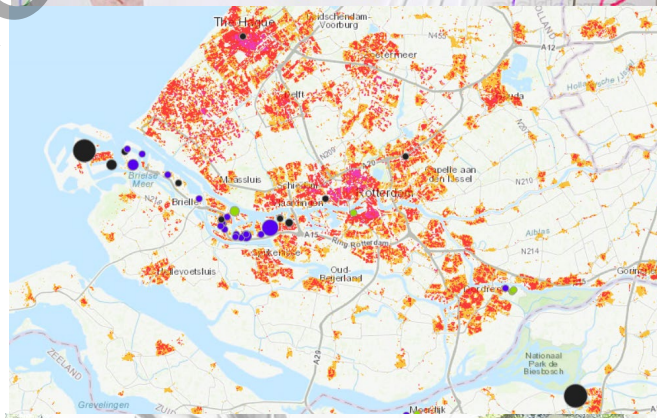


Images: Unspalsh

In District Cooling ...

Energy mapping refers to the **visual representation** of energy and material flow distribution along the system, **related to its geographical location**





Source: District Energy in Cities Initiative

ITS RELEVANCE

Energy maps can contain, among other variables, data on:

- **Existing and projected energy consumption** by sector, fuel source or neighborhood; the resulting emissions and pollution and an understanding of the load profile;
- **Present and future building density** and use type (residential, commercial);
- **Sources of surplus or industrial heat supply and cooling sources** if available;
- **Large energy consumers** and buildings with potential excess cooling capacity (e.g., buildings for events such as a stadium or arena)
- Potential **anchor loads** and their energy consumption;
- **Barriers and opportunities** particular to the **location related** to local energy sources, distribution, transport, land use, development density and character;
- Figure shows the existing heat network in Amsterdam (red lines) with connected load (yellow squares) and suppliers of heat (orange circles). The map also shows potential waste heat sources from hospitals (green circles), data centers (blue circles), supermarkets (yellow circles) and offices (purple circles).

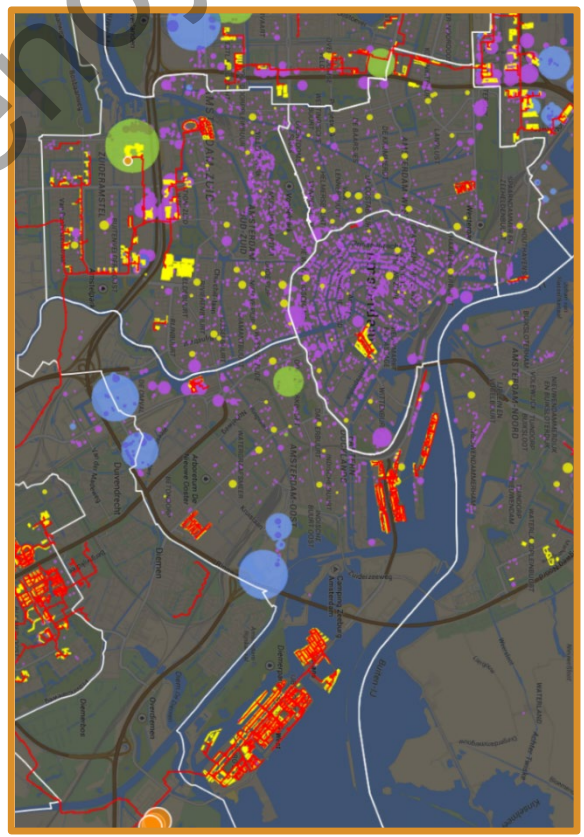


Image: Energy atlas, Amsterdam

PURPOSE & BENEFITS

From an energy system perspective

- **Link locations, distances, heating and cooling demand** needs **spatially**.
- Supports the **development of long-term strategies at local and national level**.
- Identify **potential (new) pilot projects** and/or **interconnection of existing networks** or retrofitting needs.

Image: Deltares, Unsplash

From a process perspective

- Visual tools are an **easy way to present otherwise complex and abstract data to different audiences**.
- Keep **non-technical stakeholders on board**.
- **Enable** stakeholder **understanding** and **discussions**.

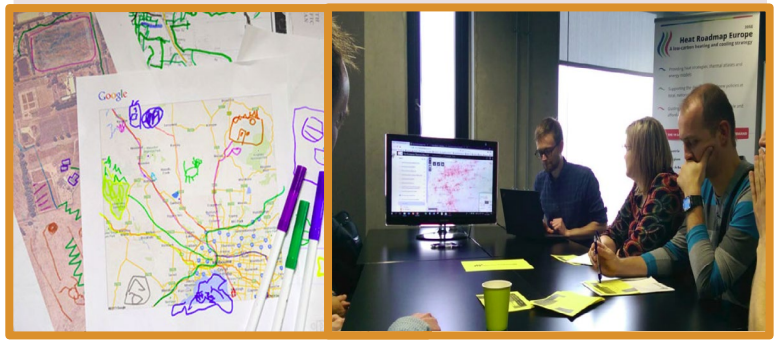
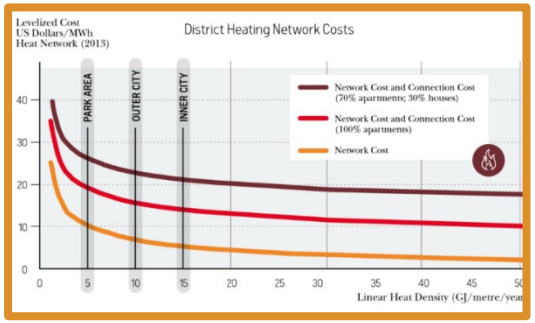


Image: Heat Roadmap Europe

MODULE 3. ENERGY MAPPING IN DISTRICT COOLING

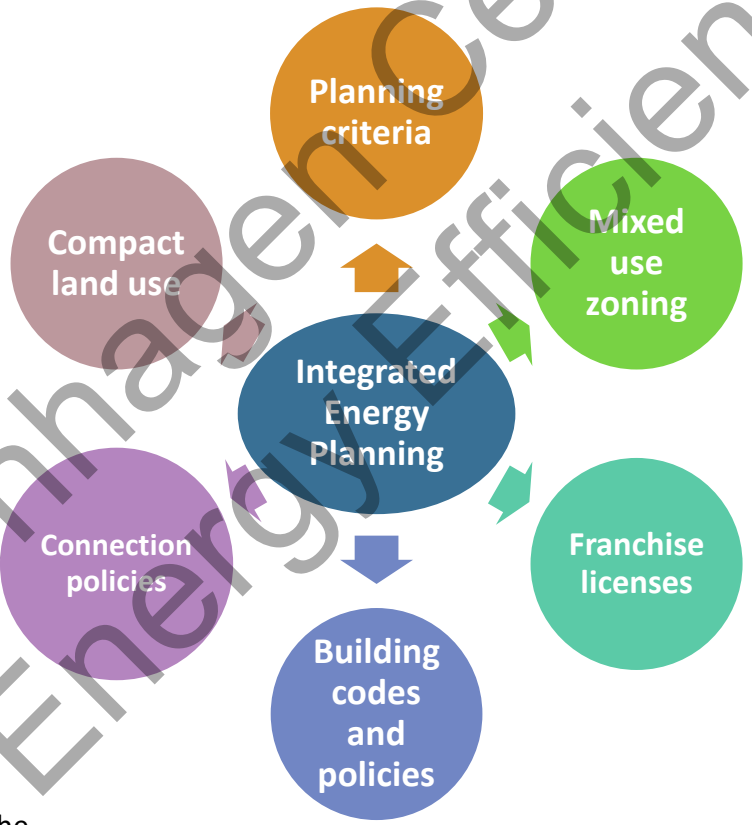
CHARACTERIZATION OF ENERGY MAPPING

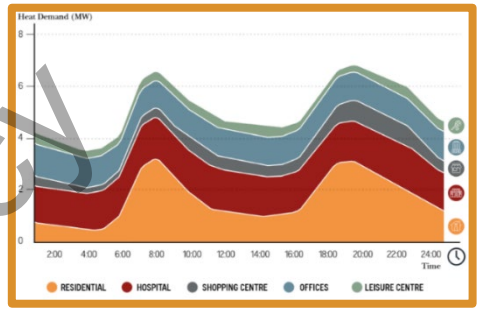


- **Key to calculate network costs > *Energy mapping required***

- **Zonal or city-wide mandatory connections**
- **Density bonus > *Energy mapping required***
- **Connect (unless)**
- **Subsidies for connection**

Integrated Energy Planning





- **Zoning**
- **New development policies > *Energy mapping required***

- **Control development**
- **Mandate connection**
- **Regulate tariffs**
- **Protect consumers**
- **Competition to win franchise**

- **Building requirements and certification**

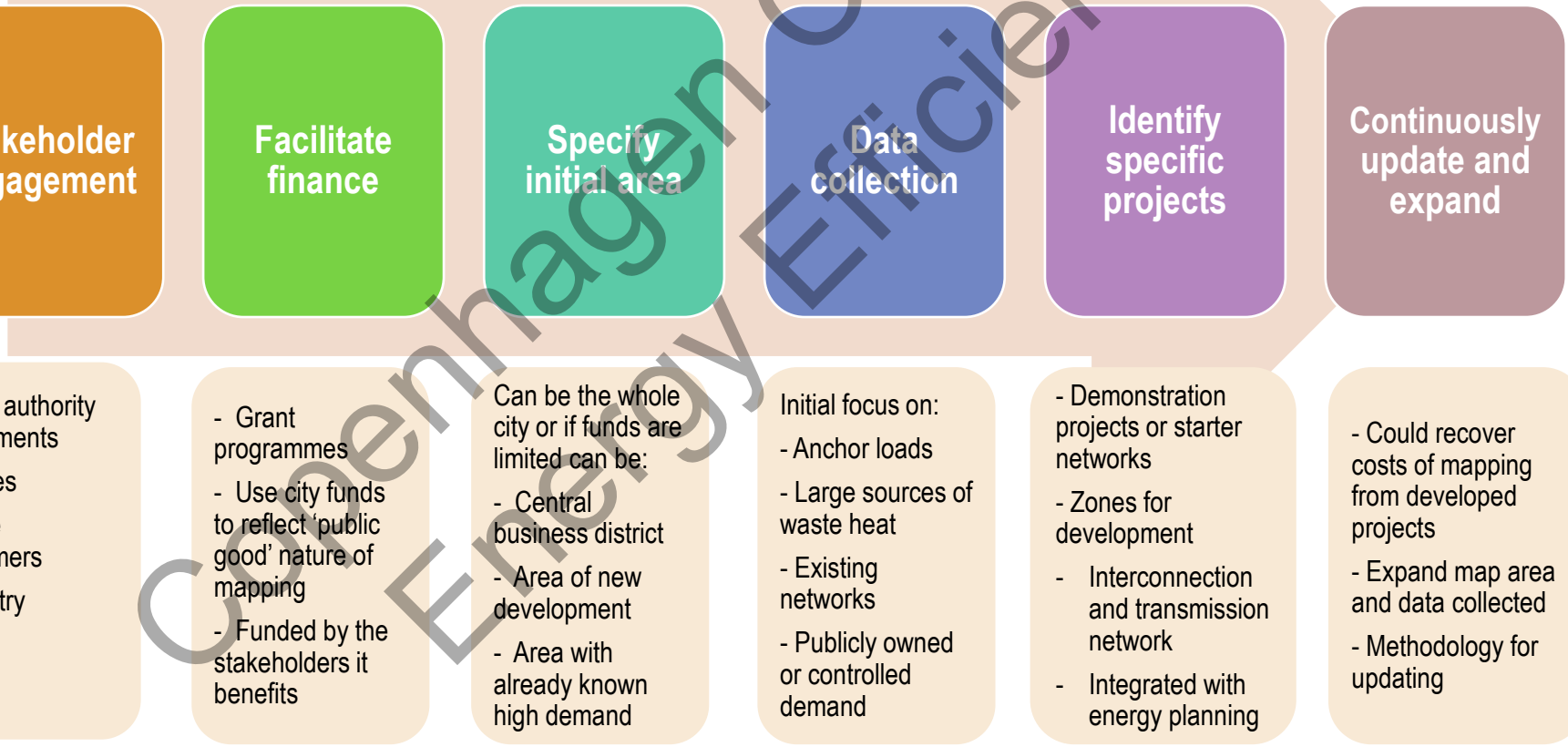
[Further details in Module 4!]

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

MODULE 3. ENERGY MAPPING IN DISTRICT COOLING

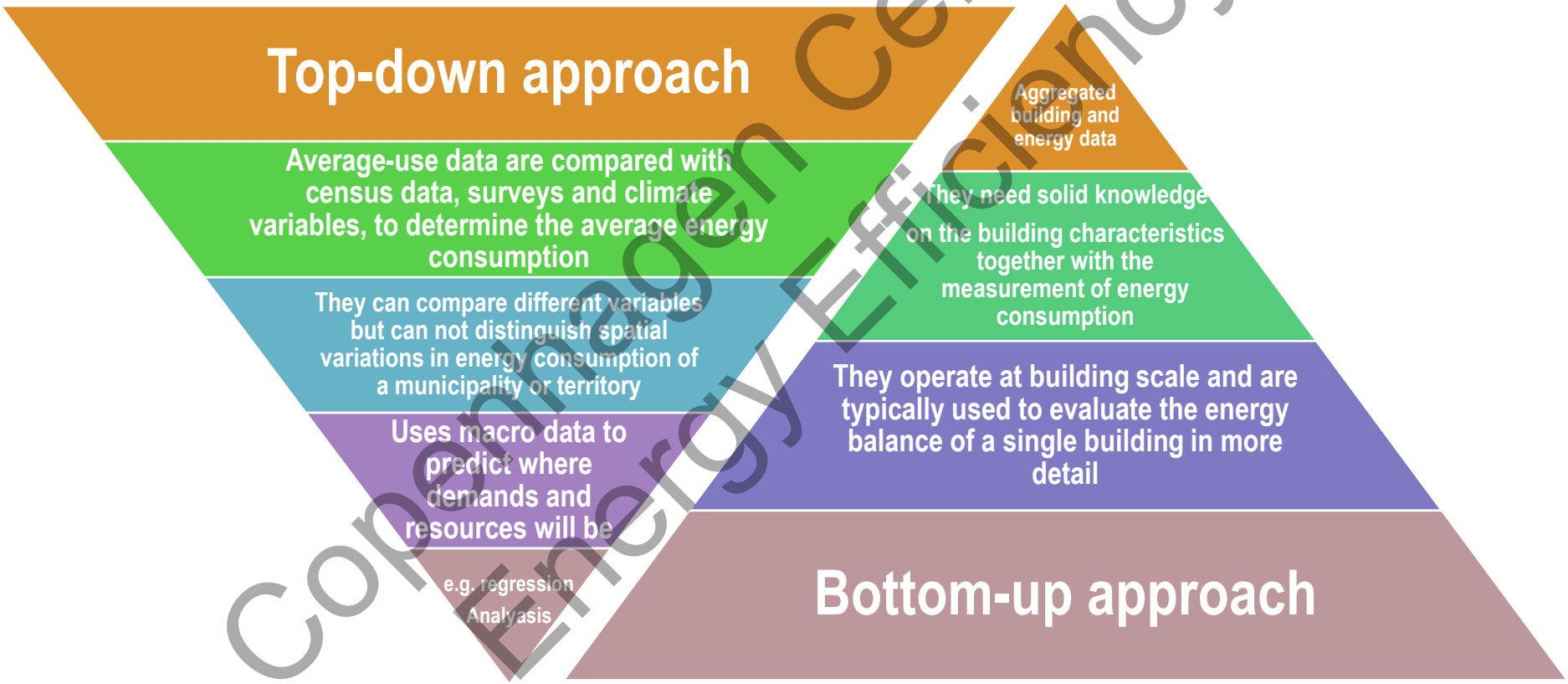
CHARACTERIZATION OF ENERGY MAPPING

Process of developing Energy Mapping



CHARACTERIZATION OF ENERGY MAPPING

"Top-down" versus "Bottom-up" Energy Mapping



Types of Energy Mappings along District Cooling Development Phases

CHARACTERIZATION OF ENERGY MAPPING

Use mapping strategically to achieve the right answers

1. Initial mapping
> Where should efforts focus on?

- Broad scope: national, regional and city scale
- High uncertainty, low data needs
- Relatively quick

Average time required: 1-2 months approx.

2. Mapping for detail
> Should a feasibility study be encouraged?

- Local scale (district)
- Higher level of certainty, but some assumptions
- Relatively time consuming

Average time required: 1-3 months approx.

3. Mapping for feasibility
> Can we financially /technically assure the feasibility of the project?

- Local scale (district)
- Highly specific scope
- High level of certainty
- Time consuming

Average time required: 3-4 months approx.

→ Increasing data and cost requirement →

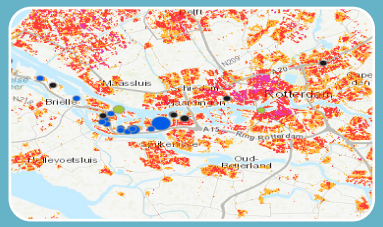
→ Increasing certainty →

CHARACTERIZATION OF ENERGY MAPPING

What level of data is necessary for each type of mapping?

Available and high quality data – *Mapping for detail and mapping for feasibility*

- Readily available data to get a good overview of target areas and project pipelines
- Easy transition towards more detailed levels of feasibility
- Examples: countries with cadastres; cities with measured/managed DH systems



Estimated or modelled data – *Mapping for detail and mapping for feasibility*

- Not exact, but can provide a good representation of the spatial dimension and a good indicator of areas where more precised data could be useful
- Useful to understand priority areas, demand and resource density, develop potential project pipelines and discuss general planning approaches.

Little to no data – *Initial mapping*

- Knowledge can be generated based on stakeholder discussions and (informal) knowledge source
- Can be used to understand priority areas and data gaps
- Where to start: look at electricity or gas bills, contact building owners, the local utility

INITIAL MAPPING

Key aspects of Initial Mapping

- **Main objective: where you can do the further mapping**
  - Identification of high density areas
  - Identification of local sources for district cooling
  - Building number and use
  - Energy demand

- **Main steps:**
  - Map relatively high cool demand
  - Map potential local sources of energy
  - Mark potential needs of the city and future developments (e.g. urban development plans)

- **Data needed**
  - Population map (Census)
  - Map of economic activity (i.e. service buildings)
  - General knowledge on the conditions and needs in the area (can be local knowledge)

Image: (1) Heat Roadmap, sketches (2) Aiguasol, Informe de Avance nº1 Coyhaique

MAPPING FOR DETAIL

Key aspects of Mapping for Detail

- **Main objective: Viability + High potential options of DCS**
  - Quantification of cool demand
  - Quantification of cool resources
  - Enabling factors for high potential options

- **Main steps:**
  - Map cool demand per building/hub
  - Map local sources of energy for high potential options
  - Map urban planning and development

- **Data needed**
  - Estimated/avaliable data on:
    - Demand
    - Local climate conditions
    - Building stock composition
    - Technology options and assumptions
    - Costs: energy, technologies, construction, staff salaries etc.
    - Urban plans and regulatory frameworks

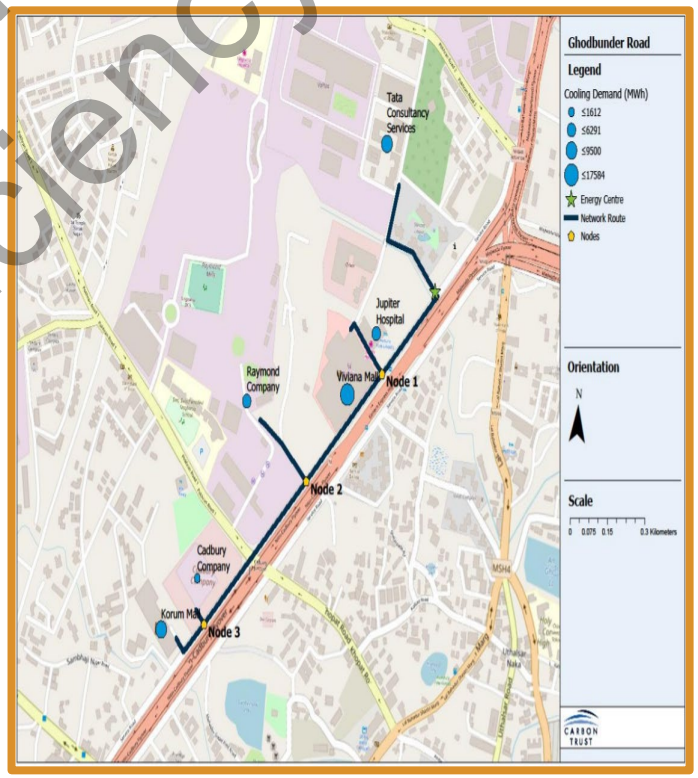


Image: Ghodbunder Road, India. Carbon Trust

MAPPING FOR FEASIBILITY

Key steps in Mapping for Feasibility

1. Data collection
- Identify urban limits and permitted land use of each area
- Characterize buildings typologies and existing cooling systems

2. Digital graphic base construction
- Graphic map construction to visually represent urban characteristics
- Softwares: QGIS, gVSIG, GRASS GIS, SAGA GIS, i.a.

3. Assignment of data to graphic elements
- Geo-reference data collected to the blocks in the software

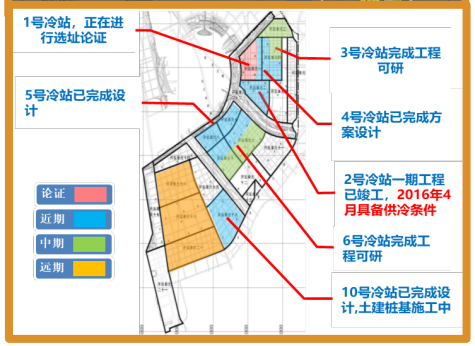
4. Energy demand calculation
- Perform simulations to determine energy demand

5. Energy consumption and emissions
- Perform calcualtions with standard data to determine emissions and savings potential by constructing scenarios

Both **available and estimated or modelled data** will be required

Average, maximum & minimum figures: 1 Dec 2007 - 31 Jan 2008; Tuesdays, Wednesdays & Thursdays only (excluding 25, 26, 27 Dec 2008; 1, 2 Jan 2008)

Time	Average kW	Maximum kW	Maximum Date	Minimum kW	Minimum Date
00:00	4,036.1	4,481.6	Wed, 30 Jan 2008	3,616.8	Wed, 19 Dec 2007
00:15	4,028.6	4,460.0	Wed, 30 Jan 2008	3,624.8	Wed, 19 Dec 2007
00:30	4,020.1	4,430.8	Wed, 5 Dec 2007	3,614.8	Thu, 24 Jan 2008
00:45	4,032.2	4,370.0	Wed, 30 Jan 2008	3,651.2	Thu, 24 Jan 2008
01:00	4,052.0	4,345.2	Thu, 10 Jan 2008	3,731.2	Thu, 24 Jan 2008
01:15	4,044.1	4,329.2	Thu, 11 Jan 2007	3,731.6	Thu, 24 Jan 2008
01:30	4,034.8	4,351.6	Wed, 30 Jan 2008	3,738.0	Tue, 18 Dec 2007
01:45	4,036.2	4,384.4	Wed, 30 Jan 2008	3,765.6	Thu, 24 Jan 2008
02:00	4,039.1	4,389.2	Wed, 30 Jan 2008	3,676.4	Thu, 24 Jan 2008
02:15	4,039.6	4,332.0	Wed, 30 Jan 2008	3,642.4	Thu, 24 Jan 2008
02:30	4,026.0	4,327.6	Wed, 30 Jan 2008	3,610.4	Thu, 24 Jan 2008
02:45	4,045.9	4,349.6	Wed, 30 Jan 2008	3,737.2	Thu, 24 Jan 2008



MAPPING FOR FEASIBILITY

1. Data collection

- The data availability and sources will very much **depend on the country or city**
- Data required from buildings:

Data needs	Level of importance	Data source	If data is not available
Building typology	High	Census	Previous studies, site visits
Building use (residential, non-residential, mixed)	High	Census	Previous studies, site visits
Year of construction	High	Census	Books, reports, alternative database (e.g. SII 2018)
Constructed area (m2/building)	High	Census	Books, reports, alternative database (e.g. SII 2018)
Material: outer wall	High	Census	Books, reports, alternative database (e.g. SII 2018)
Material: roof and floor	High	Census	Books, reports, alternative database (e.g. SII 2018)
Material: insulation	High	-	Books, reports, alternative database (e.g. SII 2018)
Material: further characteristics on the constructive status of the building	Medium-high	-	Books, reports, alternative database (e.g. SII 2018)
Number of people living	Medium-low	-	Surveys
Geo-reference	High	Census	Previous studies, site visits

MAPPING FOR FEASIBILITY

1. Data collection

- The data availability and sources will very much **depend on the country or city**
- Data required on existing cooling systems:

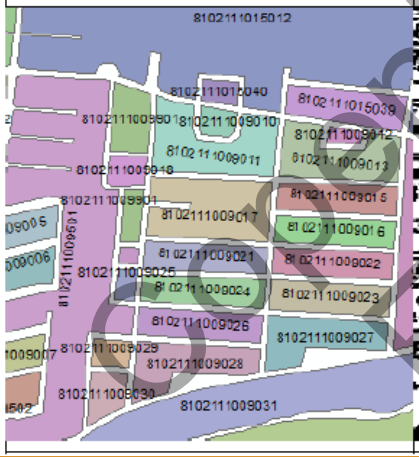
Data needs	Level of importance	Data source	If data is not available
Type of cooling systems in each building	High	Previous studies / existing databases	Surveys
% of use of each system per building	Medium	Previous studies / existing databases	Surveys
Energy demand per building or dwelling	High	Previous studies / Calculated based on above	-
Local emission factors of pollutants by energy source	High	Previous studies	Studies from other regions or cities
GHG emission factors by energy source	High	Previous studies	Studies from other regions or cities

MAPPING FOR FEASIBILITY

2. Digital graphic base construction

- **City "blocks**" are identified and unique ID assigned to each block based on their planning codes
- A block is defined as the smallest collection of buildings surrounded by streets
- Map will represent **potential uses, permitted uses and restrictions in regulatory terms**

Manzanas INE (Censo 2017)



Base gráfica SII, formato pdf

Base de datos de predios de SII con asignación de Área Homogénea

UH UNIDAD HOMOGENEA	Código SII de la muna	mero de Manzana	mero de Predia	Número correlativo de la línea de nstrucción	Código del material estructural de la línea construcción	Código del material estructural de la línea construcción	Código de calidad de la línea de nstrucción	Año de la línea de nstrucción	Superficie de la línea de construcción (sin decimales, en m2 o m3 según tipo de nstrucción)	Código de destino de la línea de nstrucción
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HBB067	8207	3196	4	1	E	Madera	4	2013	45	H
HBB067	8207	3196	1	1	E	Madera	4	2013	45	H
HBB067	8207	3195	32	1	E	Madera	4	2013	45	H
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HBB067	8207	3195	29	1	E	Madera	4	2013	45	H
HBB067	8207	3195	28	1	E	Madera	4	2013	45	H
HBB067	8207	3195	27	1	E	Madera	4	2013	45	H
HBB067	8207	3195	24	1	E	Madera	4	2013	45	H

MAPPING FOR FEASIBILITY

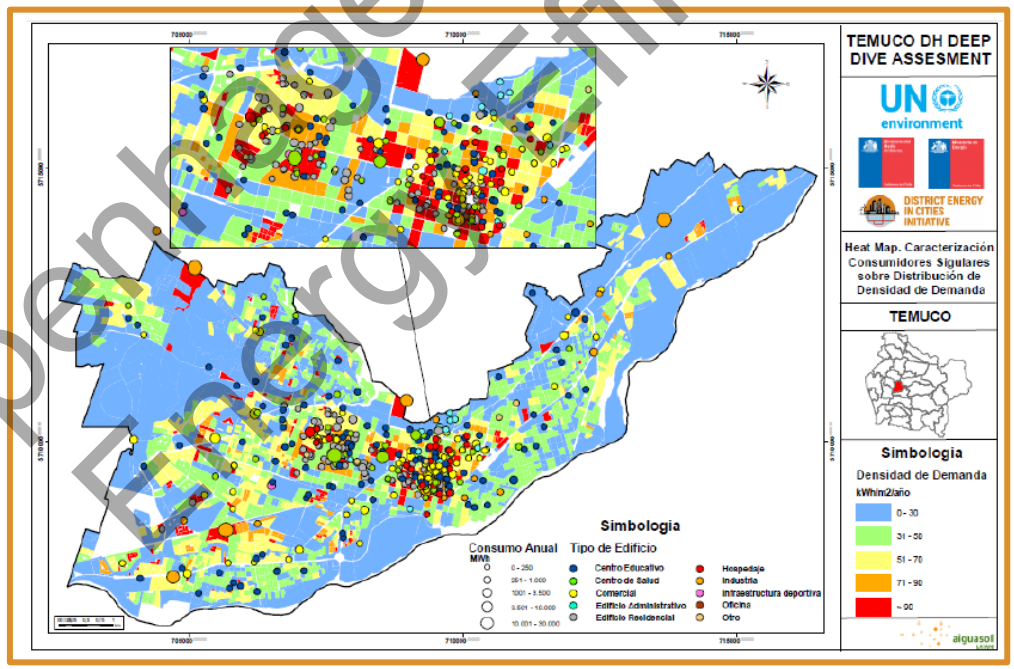
3. Assignment of data to graphic elements

- The **associated data from the database is linked to each "block"** which determines, no. of dwellings, people per block, built area of each building (based on building-to-land ratio or FAR) etc.
- Software**:** QGIS, gVSIG, GRASS GIS, SAGA GIS, i.a

MAPPING FOR FEASIBILITY

4. Energy demand calculation

- **Specific cooling demand** assigned to each building based on typology. One method to determine this is from modelling and simulation of each typology (e.g. DesignBuilder)
- The **annual cooling demand** is then calculated as the product of the built-up area of the building by its specific annual standard consumption

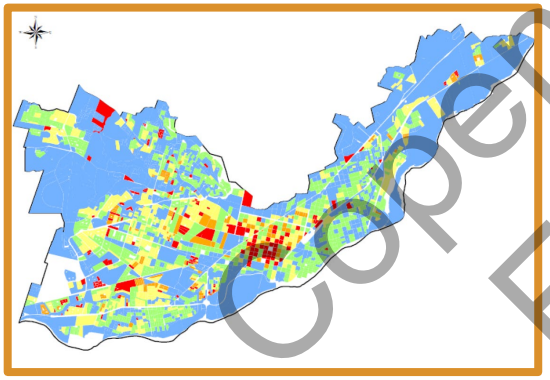


MAPPING FOR FEASIBILITY

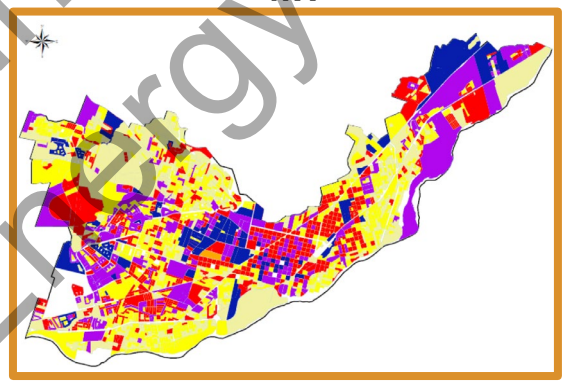
5. Energy consumption and emissions

- Using the **performance and emission factors** stipulated for individual cooling systems, the energy consumption is calculated, separated by type of energy source, and the emissions associated with it.
- This data is then **overlaid with several** maps such as population, pollution, weather condition etc. to identify priority areas for DC development

kWh/m²/y



kW



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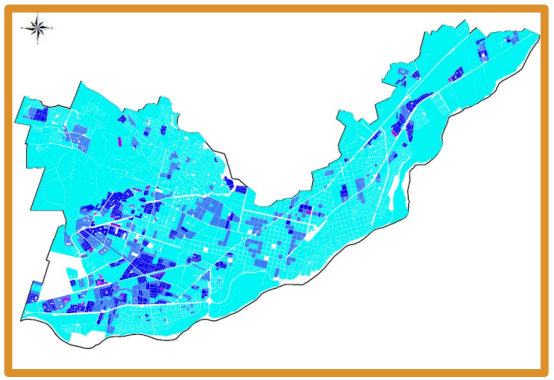


DISTRICT ENERGY IN CITIES

CASE STUDIES

Amsterdam, Netherlands Source: Unsplash

CASE STUDY: AMSTERDAM, NETHERLANDS

Initial mapping: What data can we get from master planning documents?

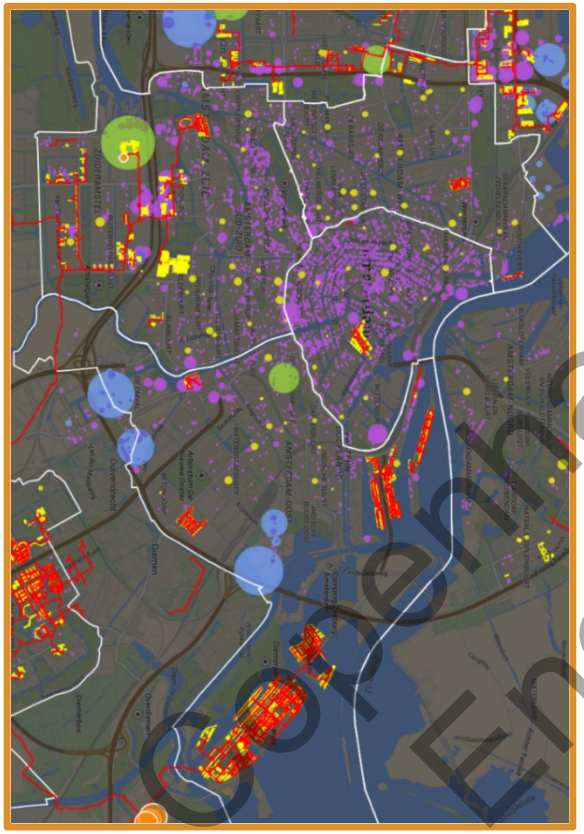


Image: Energy Atlas Amsterdam

- Infrastructures: roads, utilities (water/electricity/heating/gas/cooling), transportation etc.
- Buildings: type, built-up-area, floor area ratio (FAR),
- Future development plans
- GIS and/or AutoCAD and/or SketchUp, etc.

Initial mapping can act as a **tool** to **communicate** and **raise awareness**

CASE STUDY: THANE, INDIA

Mapping for detail

Objectives:

- Identify potential DC projects using GIS mapping
- Spatial analysis of cooling demands, upcoming building developments, assessment of renewable and waste heat options
- Identify opportunity zones which can be used to develop long-term plans on DC

Outcomes:

- TMC can use its zoning authority to create 'high' and 'medium' priority zones for DC, based on energy mapping results and using benchmarks for district cooling viability (e.g. cooling demand density)
- The city could then attach specific conditions to building permits within these zones that encourages development of DC

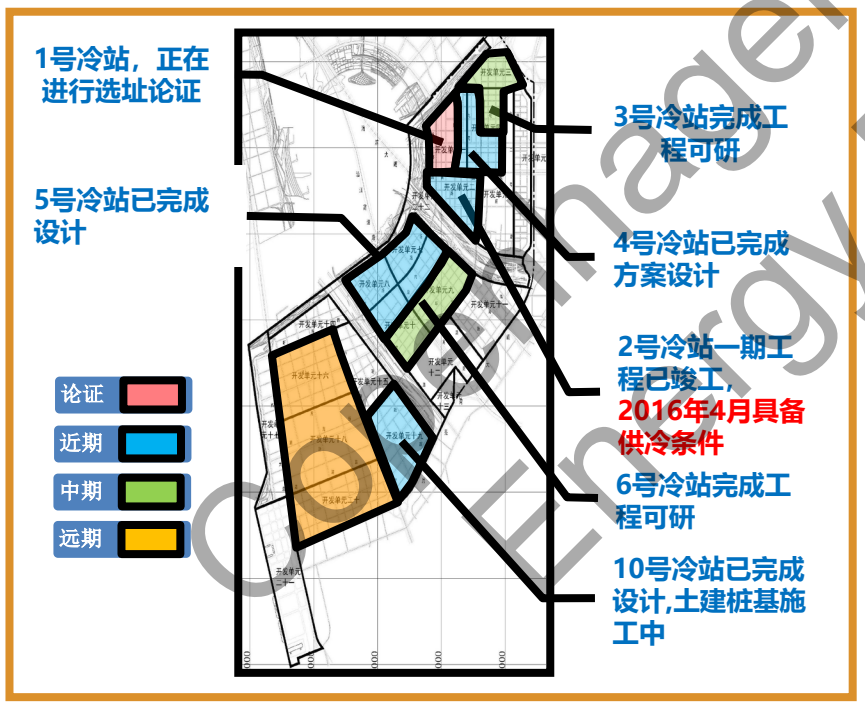
Image: Mapping and analysis by TMC and ICLEI

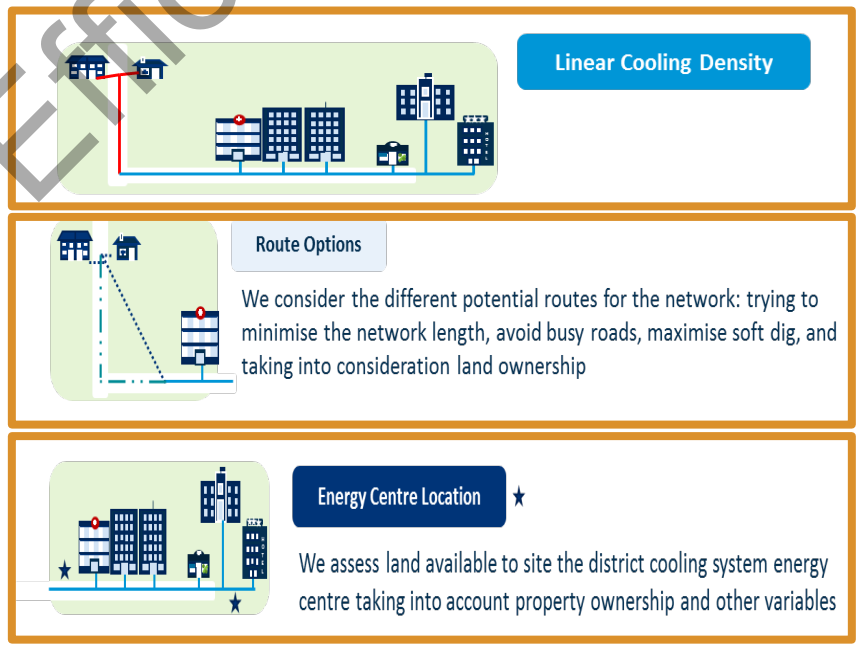
CASE STUDY: QIANHAI, CHINA

Mapping for feasibility

- Largest DCS in the world (47,000 RT), mapping was crucial
- Determined cooling density, pipe network design, and optimum location of energy production centres (13,000 sqmt)

Shenzhen Qianhai Energy Investment Development:





Source: Shenzen Qianhai Energy Investment

SYNTHESIS AND CONCLUSIONS

Strengths

- Visually understand heating and cooling demands
- Visual tool to foster comprehension and communication among stakeholders
- Development of long-term energy strategies at local and national level
- Interlinks across various systems
- Identify the opportunities for development, extension, retrofitting and interconnection of existing networks
- Links to spatial and geographical elements with energy systems and flows
- Stimulate business investment and project development
- Identify long-term opportunities for district cooling systems

Limitations

- Highly dependent on data availability
- Oftentimes data not available (e.g. data sensitive to privacy concerns)
- Lack of local expertise in conducting energy mappings

KEY TAKEAWAYS

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

- **Energy mapping** is important to
  - Link heating and cooling demand needs, locations, distances, and calculate infrastructure costs and DCS viability
  - Enable stakeholder discussions
  - Identify potential projects
  - Develop a city-wide district cooling long term strategy
- Mapping approaches can be **bottom-up or top-down**
- There are **three main types of bottom-up energy mapping,** each of which has an increasing data, cost requirement and certainty, namely:
  - Initial mapping
  - Mapping for detail
  - Mapping for feasibility
- The **type and scope of mapping** can be defined by**:**
  - The purpose of the mapping
  - The phase of the project it is embedded in
  - If there is already DCS in place or not
- **In practice, data availability and reliability can be an important limiting factor**
- The main drivers should be **sustainability and common welfare**

RECOMMENDATIONS

Some recommendations for energy mapping process:

- Use energy mapping as an effective tool to communicate the benefits and viability of DC to stakeholders and raise awareness among the general public
- Allocate funds required to carry out the energy mapping process from the city, grants or private investors
- While gathering the data for energy mapping, special focus should be on anchor loads, large sources of waste heat, existing networks and large publically owned demand
- Energy mapping can begin with initial mapping for a small pilot area and expand in detail and area covered when more funds are available and as DC systems prove their viability in the pilot areas

THANK YOU FOR COMPLETING THIS 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

DISTRICT ENERGY IN CITIES INITIATIVE

E-TRAINING PROGRAM
DISTRICT COOLING DEVELOPMENT

In the upcoming modules, you will learn about …

Module 4

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

Module 5

- Carbon heating and cooling strategies

Module 6

- Business models for sound sustainable district cooling systems