

# Module 4.5: REALISED PROJECTS AND CASE STUDIES

SHaKE – Sharing Heat and Knowledge on Energy  
Communities

Erasmus+ KA220-HED Cooperation Partnerships in Higher  
Education

Developing institution: Universitat Jaume I de Castellón

Author: Dr. Adrián Mota-Babiloni and Ghad Alarnaot-Alarnaout

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**SHaKE**

Sharing Knowledge on Energy Communities



This subject presents ten representative case studies, each with its conditions and particularities. The aim is to understand the following topics:

- Successful district heating and cooling projects using chillers with different climates
- Performance and energy savings using chillers in DCN
- Design, installing, and operating heat pumps in district heating and cooling projects
- Best practices for integrating heat pumps into district cooling infrastructure, including considerations for system sizing, thermal storage, and control strategies

Case studies will include only district heating networks, and combined district heating and cooling networks.

More case studies can be found in the literature.



# CASE STUDIES

1. DCN James Cook University (Townsville, Australia)
2. DHC Barrio La Pinada (Valencia, Spain)
3. DHC Bristol Redcliff Network Extension (Bristol, United Kingdom)
4. DHC Parc de L'Alba (Cerdanyola del Vallés, Spain)
5. DHC Barcelona (Spain)
6. DHC Greater Stockholm (Stockholm, Sweden)
7. DCN Cold Energy Recovery from Liquefied Natural Gas Vaporization (XXXX)
8. DCN Stockholm City (Stockholm, Sweden)
9. DCN combined with Hydrogen Electrolyzers (Berlin, Germany)
10. DCN for Hotel Resorts (Punta Cana, Dominican Republic)

# 1. DCN JAMES COOK UNIVERSITY (TOWNSVILLE, AUSTRALIA)



# 1. DCN JAMES COOK UNIVERSITY

## Overview

- James Cook University, Townsville, is about 255 hectares of distributed campus with 28 academic buildings.
- The total air-conditioned floor area is 69,000  $m^2$ . The university grew in stages, adding additional buildings incrementally, each with a separate, stand-alone air conditioning plant.
- The refrigeration chillers are in poor condition (up to 35 years old), and the majority will require replacement in the next five years at an estimated cost of 9M \$.
- The existing plant capacity totals approximately 11.5 MW of cooling in 29 locations around the site. will expand the site to include an additional 25,200  $m^2$  of air-conditioned floor area by 2010 and a further 25,000  $m^2$  by 2015.

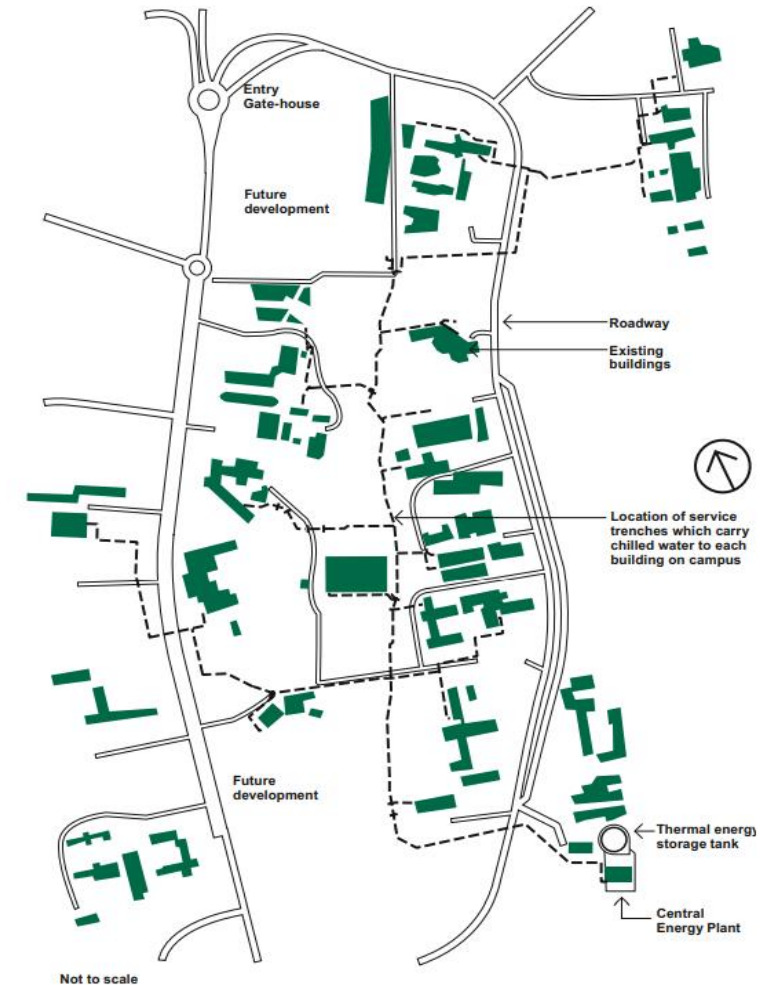


Figure 2: Site Plan of James Cook University, Townsville Campus. (Source: MGF, 2008)

# 1. DCN JAMES COOK UNIVERSITY

## Design

**Thermal Energy Storage (TES)** uses periods of the day or night when the site's cooling demand exceeds the average demand. During these times, the central chilled water plant runs to chill return water (from 15°C) back to chilled water (at 6°C).

The central energy plant (CEP) building houses:

- Three 4.2 MW centrifugal high-efficiency chillers, providing two additional chillers in the future.
- Primary and secondary chilled water pumps (with variable speed drives).
- Condenser water pumps (with variable speed drives).
- Four 5.1MW cooling towers (with variable speed drives on the fans) with provision for a 5th tower.

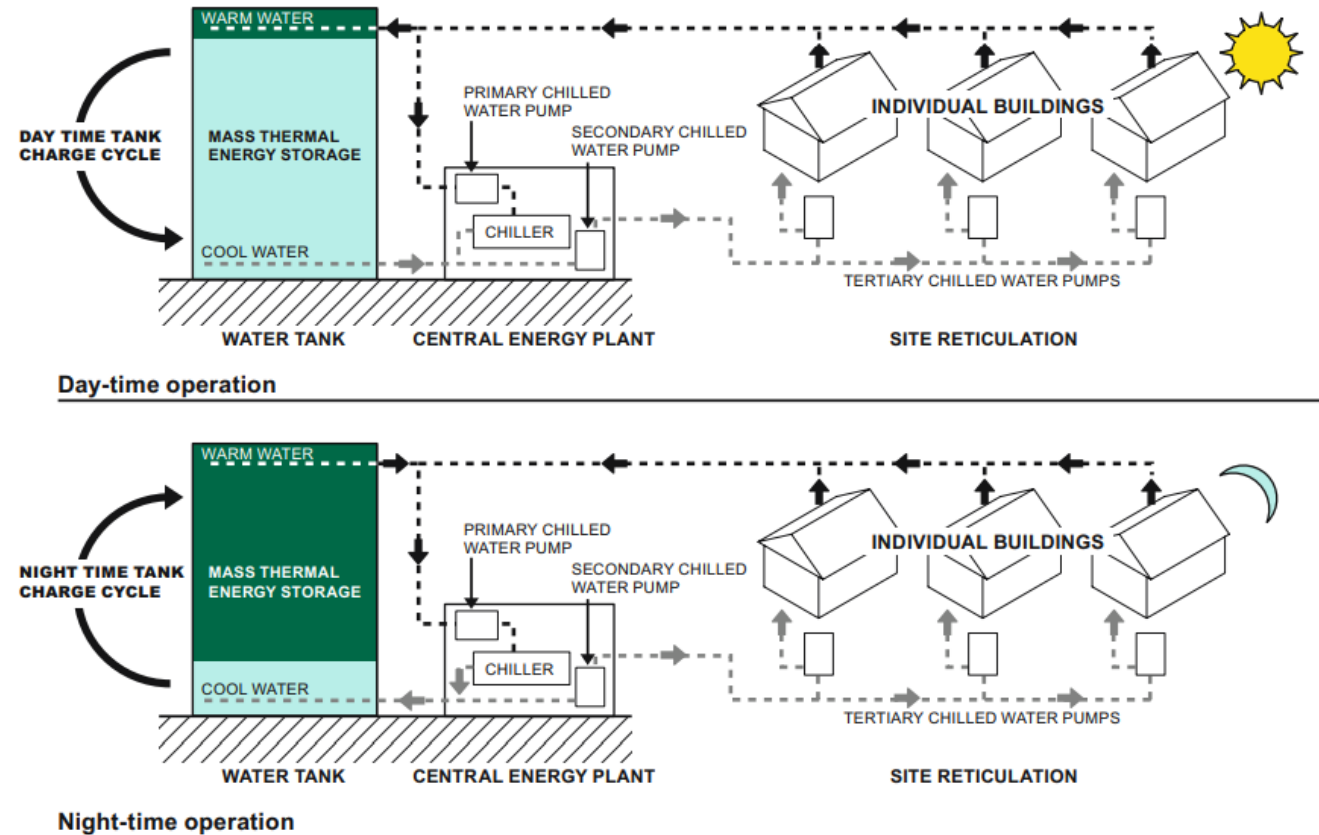


Figure 3: Process Flow Chart (Source: MGF, 2007)

# 1. DCN JAMES COOK UNIVERSITY

## Design

The 12 mega liter TES tank contains specially engineered top and bottom water diffusers, which allow water to leave or enter the tank without turbulence.

The chiller and water storage facility is located in the southeast part of the campus at a sufficient elevation to ensure that the water level in the thermal storage tank represents the highest point in the chilled water network, thus ensuring the static head.

The central energy plant has a design **Coefficient Of Performance (COP is a measure of efficiency) of 6** at summer conditions of 33°C dry bulb and 27°C wet bulb.

The water is distributed to 7.8 km of underground uninsulated piping, fed to each building.

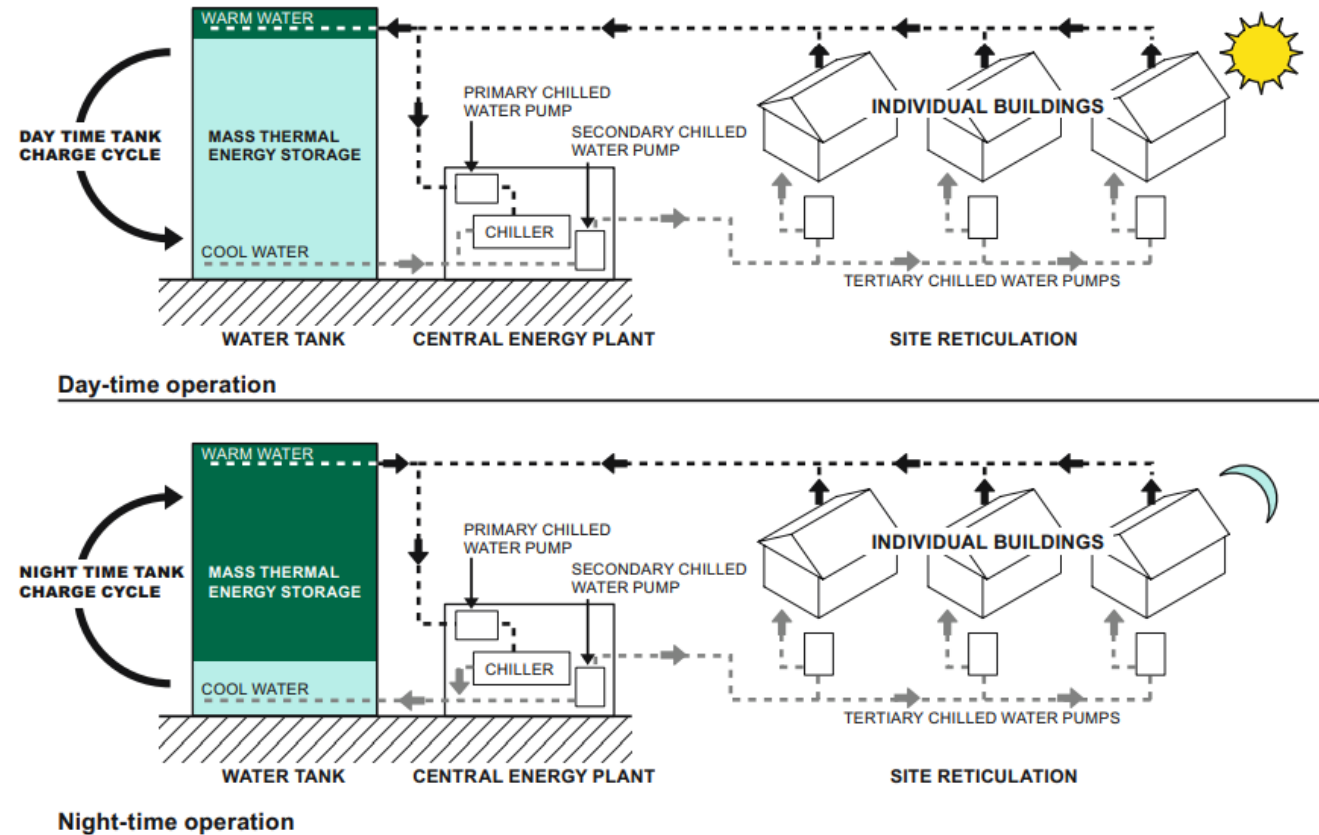


Figure 3: Process Flow Chart (Source: MGF, 2007)

# 1. DCN JAMES COOK UNIVERSITY

## Main conclusions

1. **System efficiency improvements:** Key features that enhance efficiency include the central plant's control strategy, high-voltage chiller motors, optimized CEP piping arrangement, and the use of underground chilled water piping, all of which contribute to cost savings and system flexibility.
2. **Capital cost savings:** Using high-voltage motors and avoiding low-voltage transformers eliminates transformer losses and additional infrastructure, saving \$800,000 in capital costs.
3. **Chilled water reticulation:** Using MDPE pipes instead of insulated ones reduces costs, minimizes joints, and offers flexibility for future expansions.
4. **Energy and efficiency gains:** A higher temperature differential (9°C) reduces pumping energy and pipe size, resulting in lower energy consumption and long-term savings.
5. **Environmental and economic impact:** The project will reduce energy costs by \$990,000, lower the site's Maximum Demand by 4.5 MW, and cut greenhouse gas emissions by 12,000 tons of CO<sub>2</sub>e.



## 2. BARRIO LA PINADA (VALENCIA, SPAIN)



## 2. BARRIO LA PINADA

### Overview

**Barrio La Pinada** is a private urban development located in Paterna, close to the city of Valencia, which is expected to cover **320,000 m<sup>2</sup>**.

Barrio La Pinada is a new urban development that has yet to start construction. This provides the opportunity to create the network from scratch, matching the characteristics of a new network case study.

The total demand to be satisfied is 9.4 GWh (7.52 residential and 1.88 commercial).

The supply is also a new construction using RES (renewable energy system) as its source. Specifically, 60% of the demand will be covered using DCL (design cooling load) geothermal energy and the remaining 40% using aerothermal heat pumps. Even though this division is acknowledged, to perform a conservative case study, the costs considered will be those of a geothermal power plant, which are higher and thus more restrictive.

The main characteristics of the supply are presented in the table.

	Supply
<b>Technology</b>	Geothermal/Aerothermal
<b>Fuel used</b>	Electricity
<b>Maximum capacity</b>	5 MW
<b>Fixed costs</b>	200,000 €
<b>Capacity costs</b>	500 €/Kw
<b>Annual O&amp;M costs</b>	30 €/kW
<b>Supply costs</b>	1.4 c€/kWh

## 2. BARRIO LA PINADA

### Network topology

Barrio La Pinada plans to connect all the neighborhood's demands to the district heating and **cooling** network, so almost all buildings were set as required.

The only ones left out of the case study were two at the southernmost end of the development, which correspond to a school. This choice is because those buildings have already been constructed and thus will not be part of the upcoming development. 73 buildings were connected, covering 100% of the proposed demand and only leaving out the school.

The optimization determines that only 3.3 MW of the available capacity (5 MW) would be needed to cover the project's demand. The associated capital investment of 2.14M € aligns with other geothermal energy developments.



## 2. BARRIO LA PINADA

### Network solution

Pipework solution	
Length	6.76 km
Total Cost	1.35 M€
Linear Cost	200 €/m
Losses	1.85 GWh/year
Capacity	3.88 MW

Pipework solution	
Total Capacity Required	3.88 MWp
Output	11.05 GWh/year
Capital cost	2.14 M€
Operating cost: O&M	0.12 M€/year
Operating cost: heat production	0.15 M€/year

Demand solution	
Total Peak Demand	6.16 MW
Demand	9.2 GWh/year
Revenues	0.405 M€/year

## 2. BARRIO LA PINADA

### Analysis

The most important fact to consider when analyzing the project's financials is the decision not to consider economic profitability as the development's main driver. Instead, Barrio La Pinada aims to provide its inhabitants with clean and innovative technology while maintaining a price that is not prohibitive for modest dwellings.

To achieve this, the case study's methodology has been modified. Instead of setting the tariff and allowing the tool to decide which demands to connect for the project to be profitable, an initial tariff was defined and then reduced until the minimum positive NPV (considering a time horizon of 50 years and a discount rate of 3%) was achieved. Thus, the minimum profitable tariff (15 €/kW + 3,4 c€/kWh) was obtained, which explains the project's low NPV.

	Capital cost	Operating cost	Operating revenue	NPV
Pipework	-1.35 M€	-	-	-1.35 M€
Heat supply	-2.14 M€	-0.27 M€/year	-	-9.35 M€
Demands	-	-	0.41 M€/year	-10.74 M€
Emissions	Not included at this stage			
<b>Network</b>	<b>-3.49 M€</b>	<b>-0.27 M€/year</b>	<b>0.41 M€/year</b>	<b>0.06 M€</b>

### 3. DHC BRISTOL REDCLIFF NETWORK EXTENSION (BRISTOL, UNITED KINGDOM)



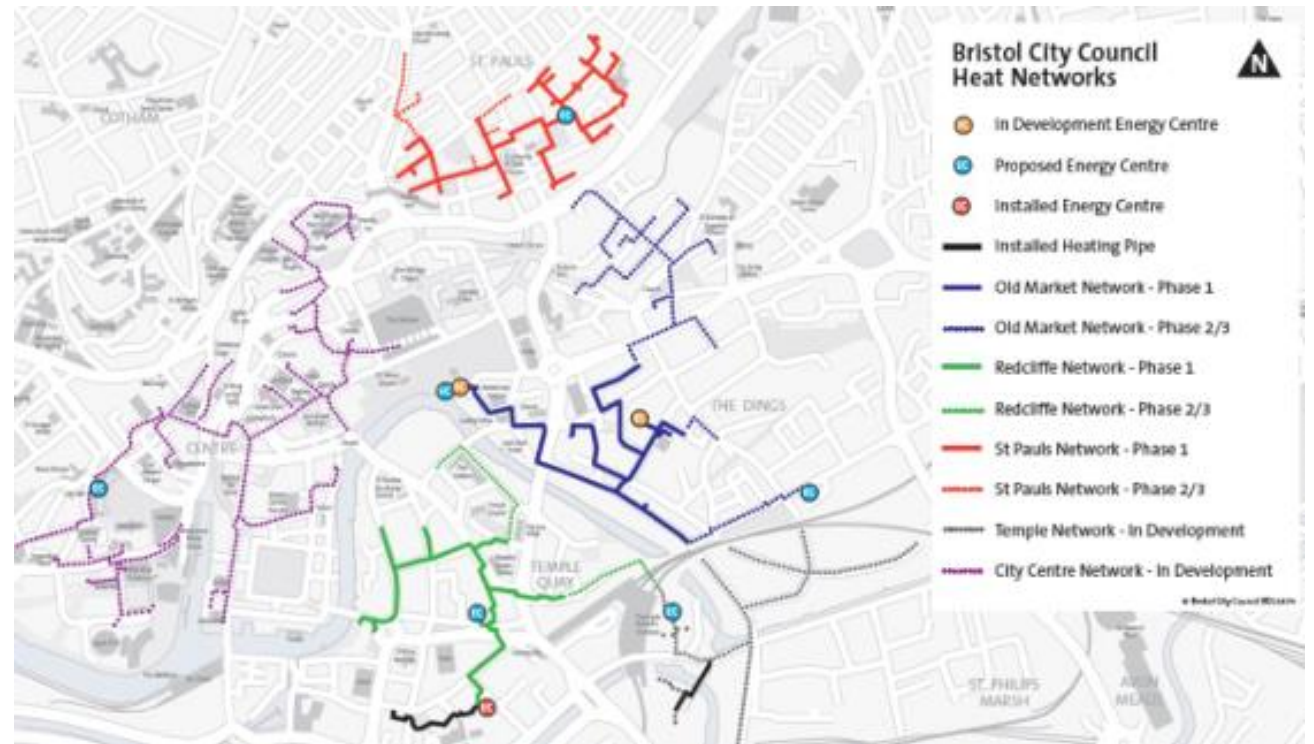
# 3. DHC BRISTOL REDCLIFF NETWORK EXTENSION

## Overview

**Bristol City Council** has been actively planning heat networks for over 10 years to help deliver affordable, low-carbon heat across the city and contribute to its net-zero carbon target by 2030.

The Council has initially been developing a City Centre network that it hopes to expand in the future. It will use low—or zero-carbon heat sources such as waste heat, local waterways, and old mine workings.

This case study considers expanding the development network comprising eight new buildings by adding one or more buildings. The broader network plan will ultimately connect around 60, mostly existing buildings.



# 3. DHC BRISTOL REDCLIFF NETWORK EXTENSION

## Key findings (1)

### 1. Accuracy of THERMOS Modeling

- The final heat network design modeled in THERMOS was compared with a detailed hydraulic model.
- A total of 47 pipes were analyzed, representing 1,365 meters out of the 5,969-meter network.
- Results indicated that 70% of the pipe segments matched exactly in size, while 97% were within one size difference.
- These findings suggest that THERMOS can be a reliable proxy for detailed hydraulic modeling.

### 2. Load Expansion and Capacity Assessment

- To evaluate available capacity, additional loads were introduced in two branches of the network.
- Due to the lack of as-built heat capacity data, pipe size was used as the primary parameter.
- The approach involved incrementally increasing building loads at the end of network lines until the as-built pipe size was exceeded.
- This method provides a rapid estimation of spare capacity, allowing quick assessments for new load requests.



# 3. DHC BRISTOL REDCLIFF NETWORK EXTENSION

## Key findings (2)

### 3. Pipe Sizing and Load Impact Analysis

- A specific network section was examined where a 160mm pipe was installed.
- THERMOS calculated that only a 100mm pipe was required, confirming sufficient capacity for new connections.
- When two new loads (1.75MW and 2MW) were introduced, the required pipe size increased to 150mm.
- Since the installed pipe size is 160mm, this suggests that full capacity is nearly reached.

### 4. Energy Center Capacity Review

- The diversified peak load at the energy center was initially 5.05MW.
- With the additional loads, the peak load increased to 7.37MW.

## 4. DHC PARC DE L'ALBA (CERDANYOLA DEL VALLÉS, SPAIN)



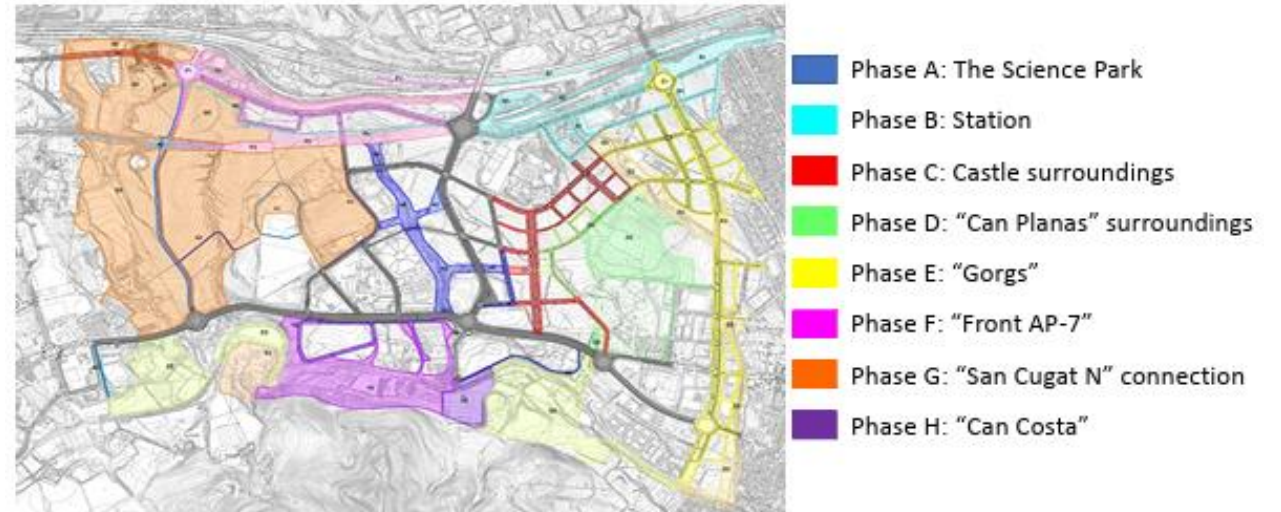
# 4. DHC PARC DE L'ALBA

## Overview and Motivation for Network Expansion

Parc de l'Alba already operates a profitable district energy network and aims to expand it progressively in line with urban development.

The initial focus is on commercial and educational buildings, potentially extending to residential areas.

Expanding to individual residential customers presents management challenges due to the large number of end users. The expansion is structured into different phases



## 4. DHC PARC DE L'ALBA

### Scenarios considered

**Base scenario (buildings that are already included in the construction plans and the plots for public facilities placed in their way)**

Heat demand	63 GWh/year
Cold demand	165 GWh/year

**Scenario 1 (includes, in addition to what has been included in the base scenario, all the additional public facilities and the residential plots)**

Heat demand	77 GWh/year
Cold demand	170 GWh/year

### Scenario 2

This scenario includes the same buildings as Alternative Scenario 1. In this case, all the plots for public facilities will be included as required, thus forcing their connection to the network, and the residential buildings will remain as optional.

## 4. DHC PARC DE L'ALBA

### Considerations

The emissions considered in this case study were provided:

- $CO_2$  emissions: 0.202 kg/kWh.
- Emissions cost: 40 €/t  $CO_2$ .

Network construction costs and energy sale tariffs have been elaborated and validated through conversations with Parc de l'Alba. The following tariffs have been used for the study:

- Unit charge: 3.3 €/kWh.
- Capacity charge: 28 €/kWp/year.

In the capacity charge, the one-off connection costs of 152 EUR/kW have also been merged and spread over the time horizon considered for the project.

# 4. DHC PARC DE L'ALBA

Comparison between the base scenario and its two alternatives

	<b>Total supply capacity (MW)</b>	<b>Connected buildings</b>	<b>Demand satisfied (GWH/yr)</b>	<b>Total network length (km)</b>	<b>Capital costs (M€)</b>	<b>NPV (M€)</b>
Base scenario	60,5	82	140.88	8.9	27.42	14.95
Alternative 1	60,5	97	140.87	10.34	28.76	13.61
Alternative 2	60,5	102	141.43	12.89	31.01	11.50

## 5. DHC BARCELONA (SPAIN)



## 5. DHC BARCELONA (SPAIN)

### **Phased Modular Development**

- The district heating and cooling (DHC) system began operation in 2012 and follows a three-phase expansion plan.

### **Phase 1 (2011-2012) – Initial Infrastructure**

- Includes a biomass plant, gas boilers, conventional and industrial chillers, and a partial distribution network.
- Covers “La Marina” and “Zona Franca,” initially industrial areas that will transition to mixed-use with new residential developments.

### **Phase 2 (2017-2019) – Integration of Surplus Cold Recovery**

- Utilizes surplus cold from the LNG regasification process.
- Includes ice storage facilities and a transport network for distributing recovered cold, primarily serving the port area.

### **Phase 3 (2017-2024) – Network Expansion**

- Aims to connect 15 million m<sup>2</sup> of heated floor area.

# 5. DHC BARCELONA (SPAIN)

## Key facts and location

DH market share	N.a.
Heating & Cooling capacity	DH: 23 MW (target: 40 MW) DC: 14 MW (target: 70 MW + 36 MW ice storage)
Heat & Cold production	DH: 12 GWh/y (target: 59 GWh/y) DC: 7.6 GWh/y (target: 54 GWh)
Km network (double-pipe)	12 km (target: 36 km)
CO <sub>2</sub> emissions	DH: 94.9 kg/MWh DC: 0 kg/MWh (net emissions, compensated with CHP electricity production)



# 5. DHC BARCELONA (SPAIN)

## 1. Gradual Expansion & Adaptive Energy Mix

- The system is designed for phased growth, integrating various energy sources and operational strategies over time.

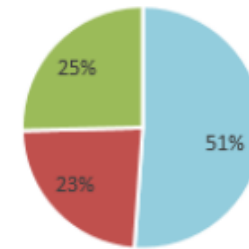
## 2. Main Energy Production & Storage Facilities

- Biomass Plant: 10 MWth / 2 MWe capacity, fueled by garden and regional forest biomass (base load).
- Gas Boilers: Used for peak demand coverage.
- Surplus Cold Recovery: Captures cold from LNG regasification at Barcelona's Enagas LNG terminal, utilizing previously wasted thermal energy.
- Cold Storage: Located in Zona Franca, featuring multiple storage tanks.
- Smart Control System: SCADA-based optic-fiber system enables real-time monitoring and optimization, following a smart grid approach.

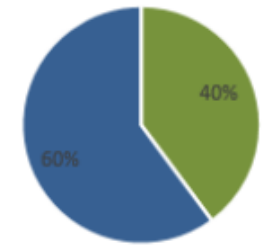
## 3. LNG Terminal Integration

- The Enagas terminal has 760,000 m<sup>3</sup> LNG storage and a 1.95 million m<sup>3</sup>(n)/h emission capacity.
- Ecoenergies' approach recovers cold from -160 °C LNG, reducing energy waste.
- Contractual terms are still under negotiation, but surplus cold is expected to be provided at no cost by Enagas.

DC Production mix (2030)



DH Production mix (2030)



■ SURPLUS COLD ENAGAS ■ STORAGE ■ ELECTRICITY ■ BIOMASS ■ NATURAL GAS

Fuel sources used for DH and DC in Ecoenergies Barcelona 2014

# 5. DHC BARCELONA (SPAIN)

## Demand and Supply in Barcelona's Energy Market

1. Climate & Energy Demand
  - Barcelona has a subtropical-Mediterranean climate, with mild winters (~1150 HDD) and high cooling demand.
  - Heating demand is relatively low, while cooling demand continues to grow.
2. Current Energy Sources & Consumption
  - Heating: Mainly natural gas-based individual solutions.
  - Cooling: Primarily electricity-based systems.
  - Solar Thermal Integration: Due to the Solar Thermal Ordinance (1999), new and refurbished buildings must incorporate solar thermal for domestic hot water (DHW).
  - Energy Use:
    - Existing buildings: ~80 kWh/m<sup>2</sup>/year.
    - New buildings: ~45 kWh/m<sup>2</sup>/year.
3. Market Structure
  - Consumers can freely select their gas and electricity suppliers.
  - The market is moderately concentrated, with 5-6 suppliers covering 90% of total energy supply.

## District Heating and Cooling (DHC) Market & Pricing

1. Regulation & Tariff Management
  - DHC is regulated by the Barcelona City Council through the public company Tersa, which manages concession contracts.
  - Operators must provide competitive pricing compared to conventional energy sources.
2. Price Competitiveness of DHC
  - District Heating (DH):
    - EUR 42/MWh (excluding VAT & connection costs).
    - ~10% cheaper than natural gas (including fuel, O&M, and equipment costs).
  - District Cooling (DC): EUR 38/MWh, 5-12% cheaper than electricity.
  - Industrial Consumers (B2B Model): Pricing negotiated case by case.
3. Demonstrating Competitiveness: Mercabarna Case Study
  - Large-scale electricity measurement campaign conducted by Ecoenergies.
  - Identified potential replacement of 32 GWh/year of electricity demand with DC.
  - Estimated savings:
    - 20% reduction in electricity costs.
    - 8,730 tCO<sub>2</sub> reduction in emissions.

## 6. DHC GREATER STOCKHOLM (STOCKHOLM, SWEDEN)



# 6. DHC GREATER STOCKHOLM

## DHN Overview

### DH as a Key Decarbonization Strategy

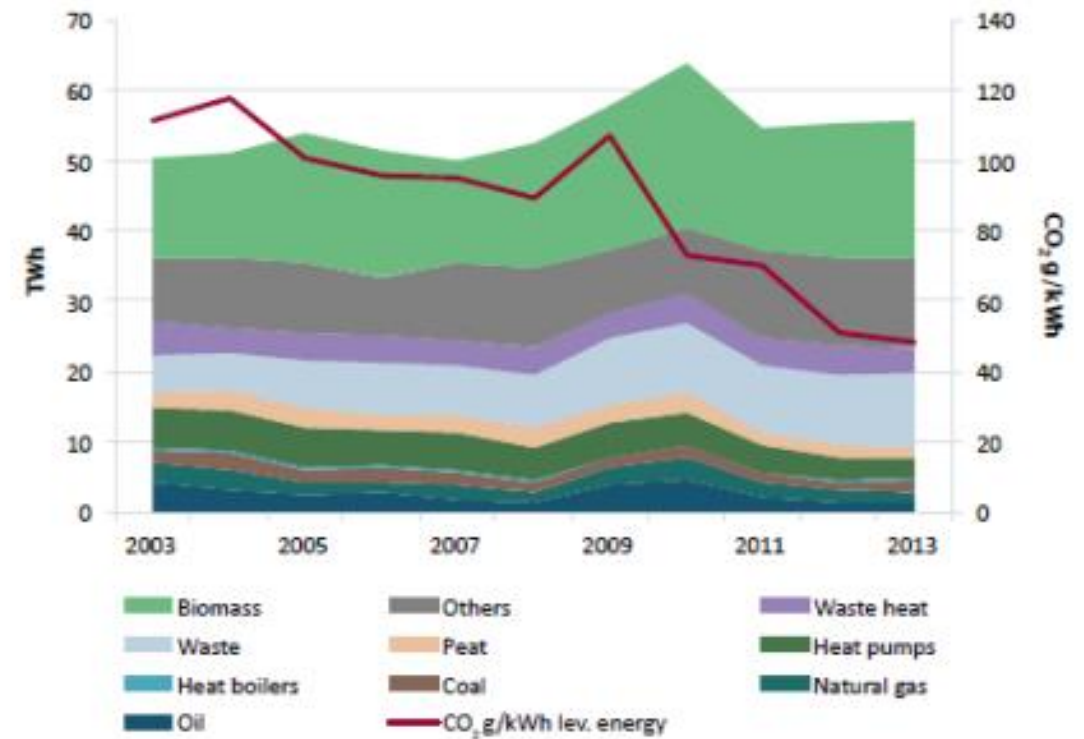
- Sweden aims for carbon neutrality by 2045 and sees DH as a major enabler.
- Shift from 100% fossil fuels (mainly oil) in the 1970s to only 6% today (mainly natural gas).
- Fuel transition drivers:
  - 1970s oil crisis prompted the move away from fossil fuels.
  - Recent acceleration in adopting sustainable energy sources.

### Current Energy Sources in DH

- Biomass (mainly through CHP plants).
- Waste-to-energy.
- Surplus heat recovery.
- Renewable electricity (via heat pumps and electric boilers).

### Impact on CO<sub>2</sub> Emissions

- Fuel mix evolution between 2003-2013 shows a significant decline in CO<sub>2</sub> emissions.
- DH has been instrumental in decarbonizing Sweden's heat supply.



# 6. DHC GREATER STOCKHOLM

## Growth of District Cooling (DC) in Sweden

### 1. Rapid Expansion

- Growth rate of ~20% annually.
- First DC network in Västerås (1992).
- Significant increase in DC supply since then, as shown in Figure 78.

### 2. Key Drivers of DC Growth

- Rising cooling demand due to higher comfort standards.
- Cost-saving potential attracts big cooling consumers (offices, data centers, supermarkets).

### 3. Use of Free Cooling

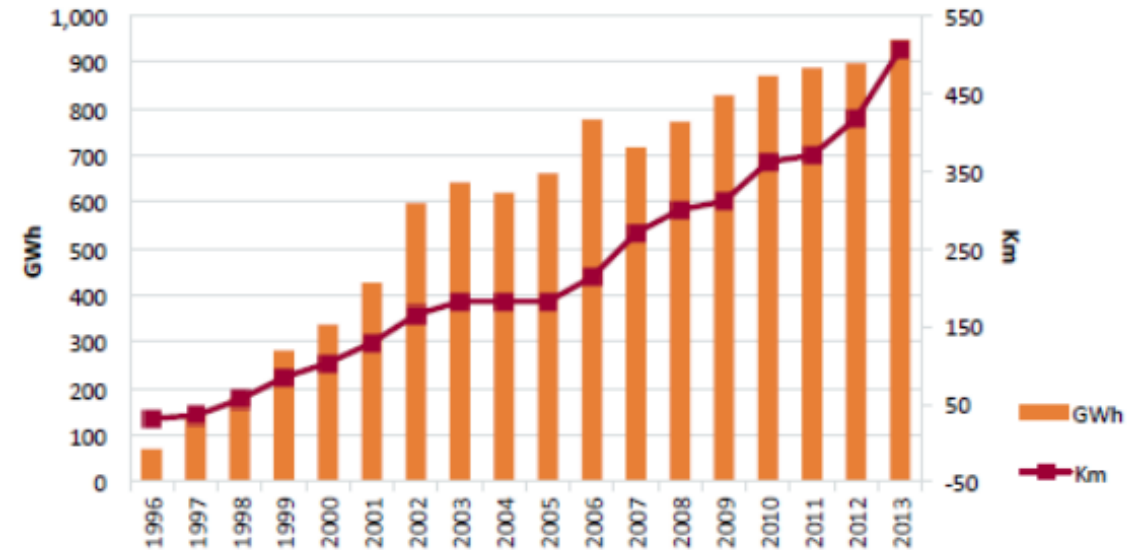
- Many networks utilize natural cold sources like seawater and lakes.
- Reduces energy consumption and improves system efficiency.

### 4. Main Clients

- Office buildings.
- Data centers.
- Supermarkets.

### 5. Future Outlook

- The upward trend is expected to continue as demand and sustainability goals grow.



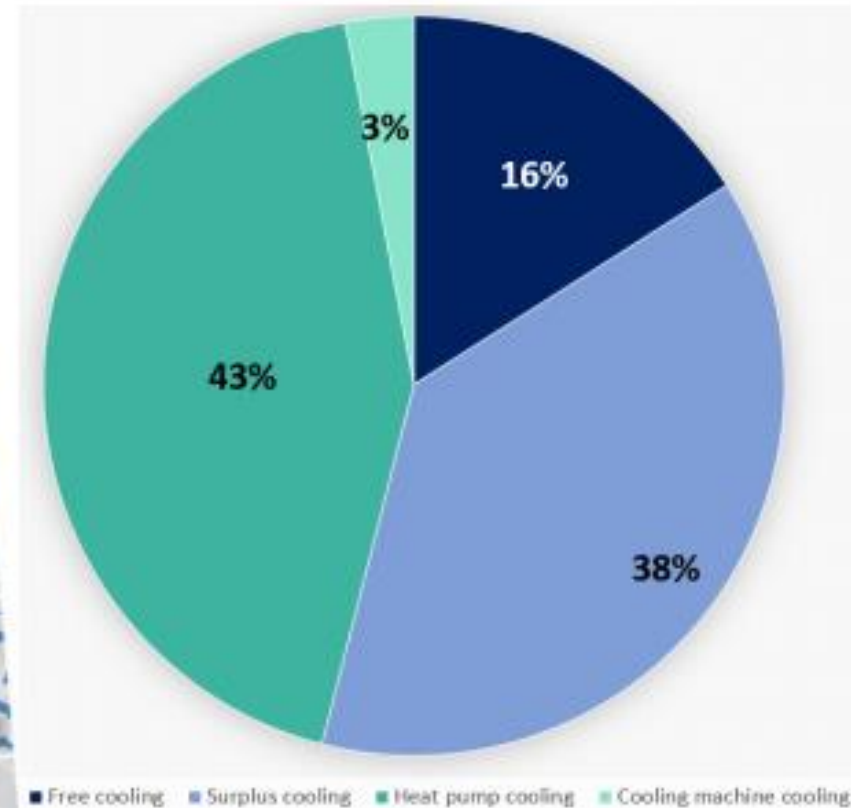
# 6. DHC GREATER STOCKHOLM

## Key facts

DH market share	80% (area covered by DH)
Heating & Cooling capacity	DH: 3600 MW DC: 220 MW
Heat & Cold production	DH: 7.4-10.8 TWh/y DC: 380-440 GWh/y
Km network (double-pipe)	DH: 1330 km DC: 200 km
CO <sub>2</sub> emissions	DH: 0.136 kg/MWh DC: 0 kg/MWh (certified renewable electricity)

- Large system: Average 8 TWh/y, ~10 000 clients, direct supply to 6 municipalities
- Public-private partnership: The DHC system is owned and operated by Fortum Värme AB (50 % City of Stockholm, 50 % Fortum Heat & Power)
- Flexible and optimised DH production:
  - 7 CHP plants (fuelled by biofuels, waste or fossil fuels)
  - Heat pumps
  - Electric boilers
  - Several HOBs (fuelled by bio-oils or fossil oils)
- District Cooling: One major system in the city centre, and several smaller ones around.
- Above 50 % of sales produced through free cooling from the sea and other water bodies

# 6. DHC GREATER STOCKHOLM



# 7. DCN COLD ENERGY RECOVERY FROM LIQUEFIED NATURAL GAS VAPORIZATION (XXXX)



# 7. DCN COLD ENERGY RECOVERY FROM LIQUEFIED NATURAL GAS VAPORIZATION

## Background

- Buildings consume ~40% of global energy; cooling demand is rising.
- Global residential cooling demand: 300 TWh (2000) → 4000 TWh (2050) → 10,000 TWh (2100).
- Cooling demand is harder to predict than heating, affected by solar radiation, internal gains, and urban heat islands.

## District Cooling Systems (DCSs)

- Centralized cooling solution for multiple buildings.
- Components: Generation unit, distribution network, customers, heat rejection system.
- Recognized as Best Available Technology (BAT) in the EU.

## Waste Cold Energy from LNG

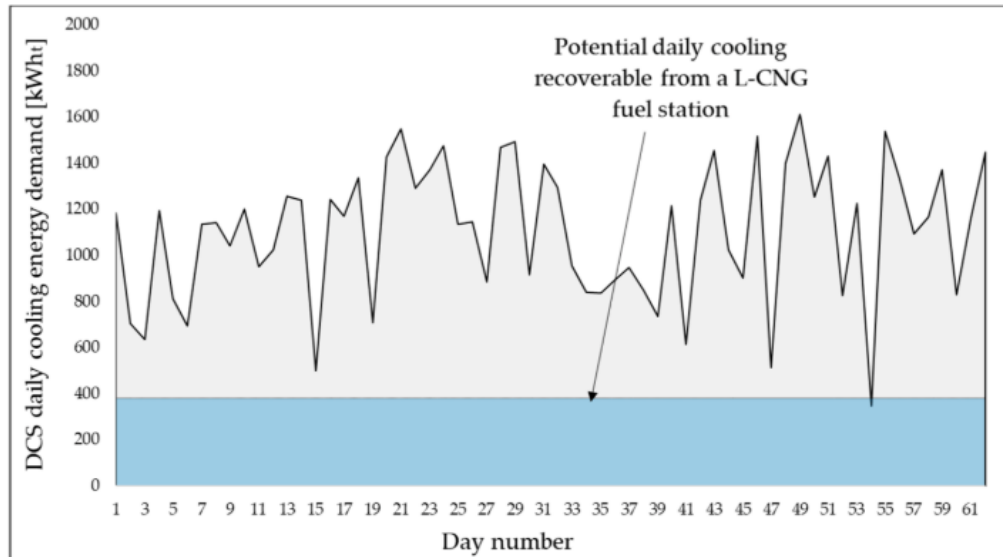
- LNG regasification releases significant cold energy (~1245 MWh/year in Italy from L-CNG stations).
- Potential for free cooling, reducing electricity demand in air conditioning.
- No prior studies on coupling DCSs with L-CNG cold energy recovery.

# 7. DCN COLD ENERGY RECOVERY FROM LIQUEFIED NATURAL GAS VAPORIZATION

## Case study

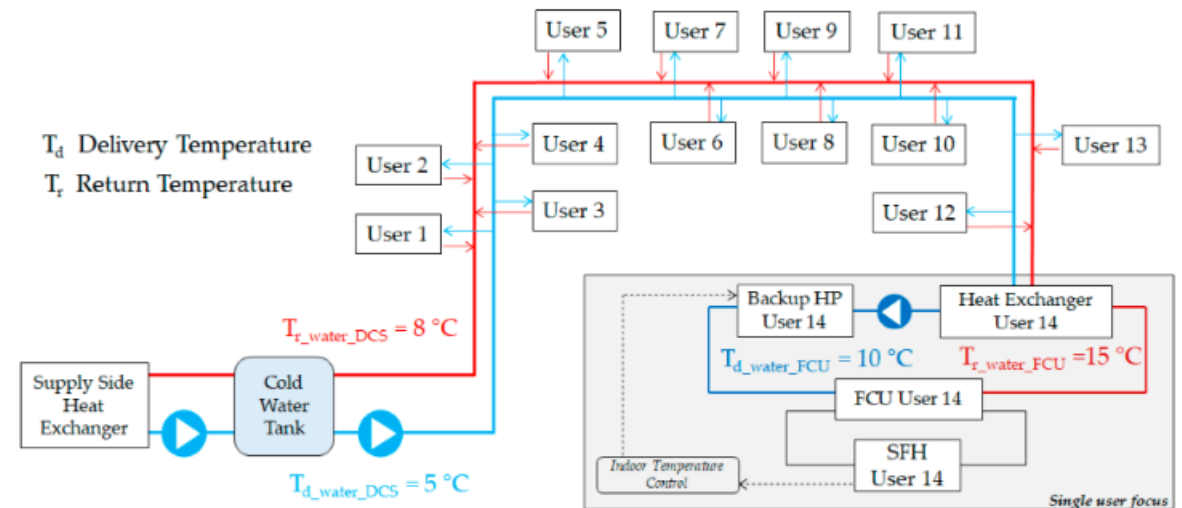
### Cold Energy Potential

- Annual LNG consumption in L-CNG stations: 5400 t/year
- Cold energy wasted during regasification: 830 kJ/kg LNG
- Recoverable cold energy:
  - ~380 kWht/day (if operating 365 days/year)
  - ~550 kWht/day (if excluding weekends, 253 days/year)



### Cooling Power Profiles

- P1: Constant supply (10 h/day, 365 days/year)
- P2: Constant supply (excluding weekends & lunch breaks)
- P3: Variable profile with peak at 6–7 p.m.



# 7. DCN COLD ENERGY RECOVERY FROM LIQUEFIED NATURAL GAS VAPORIZATION

## Simulation Results

### Reference Case

- Separate cooling systems: Fan coil units powered by a heat pump
- Cooling demand (July–August): 47 MWht
- Electricity consumption: 17 MWh

### Free Cooling Power Analysis

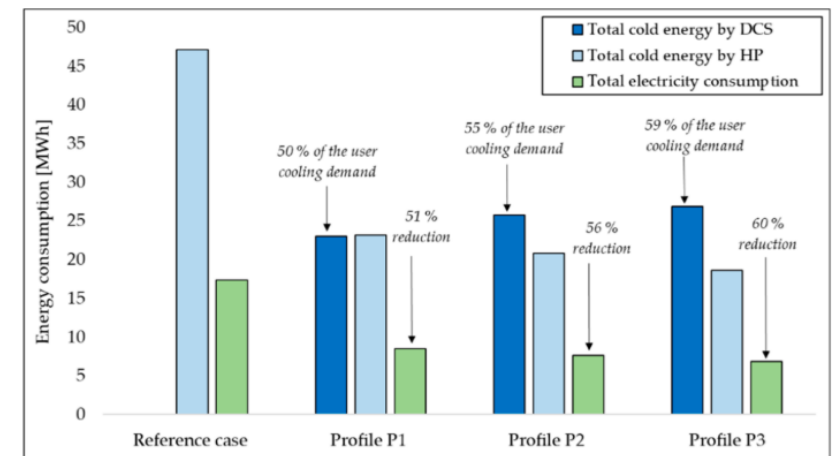
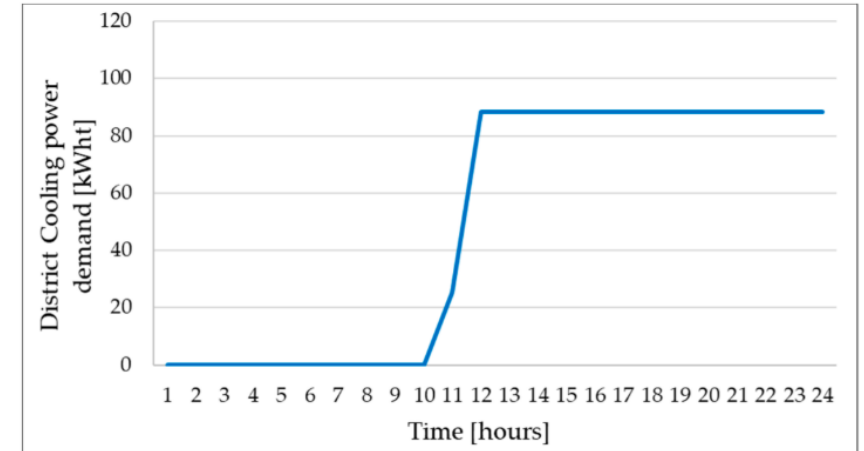
- DCS directly connected to the heat exchanger (no TES):
- P1 (constant supply): 50% cooling demand covered, 52% electricity savings
- P2 (weekday adjustment): 58% electricity savings
- P3 (variable supply): Less efficient due to demand-supply mismatch

### Thermal Energy Storage (TES) Impact

- 60 m<sup>3</sup> tank introduction:
- P3 case: 59% cooling demand covered, 60% electricity savings
- P1 & P2 cases: Minimal impact due to regular supply
- Enables better demand-supply balance

### TES Sizing Considerations

- Optimal range: 30–90 m<sup>3</sup>
- Smaller tanks: Insufficient thermal inertia
- Larger tanks: Increased heat losses & slower system response





# 7. DCN COLD ENERGY RECOVERY FROM LIQUEFIED NATURAL GAS VAPORIZATION

## Conclusions

- **DCS Benefits:**
  - Low-cost cold energy supply with reduced CO<sub>2</sub> emissions
  - Integration with renewables, trigeneration, and thermal storage
  - Efficient waste cold energy recovery (ex, L-CNG refueling stations)
- **Case Study:**
  - System: L-CNG refueling station supplying cooling to a residential neighborhood
  - Best Performance: 60% electricity savings (P3 profile + 60 m<sup>3</sup> TES)
  - General Savings: >50% electricity reduction across all scenarios
- **Considerations & Future Work:**
  - Results depend on assumptions about LNG vaporizer energy availability
  - Further studies needed on DCS sizing and user connection optimization
- **Main conclusions:**
  - LNG vaporization can effectively supply residential DCSs
  - Integrating transport and residential cooling enhances urban sustainability

## 8. DCN STOCKHOLM CITY (STOCKHOLM, SWEDEN)

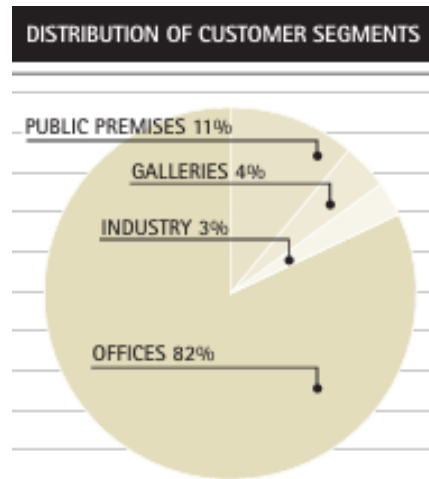


# 8. DCN STOCKHOLM CITY

## Overview

A preliminary study pointed to the possibility of using an existing heating pump plant with seawater as the resource for simultaneous heat and refrigeration production for district cooling in Stockholm City.

Stockholm City consists of various properties serving different purposes, such as offices and commercial centers. The city's cooling demand is high and growing with increased trade, more stringent comfort requirements, and computerization. Stockholm City was the first area to provide environmentally friendly district cooling, produced using heating pumps and free cooling from cold seawater.



	kW/contract	MWh/contract	Number of contracts
Public building	300	300	35
Hospitals	1000	1500	5
Universities and schools	2000	3000	5
Business centers	1500	1500	15
Industry and pharmaceuticals	500	500	10
Offices	500	500	330

# 8. DCN STOCKHOLM CITY

## Key facts

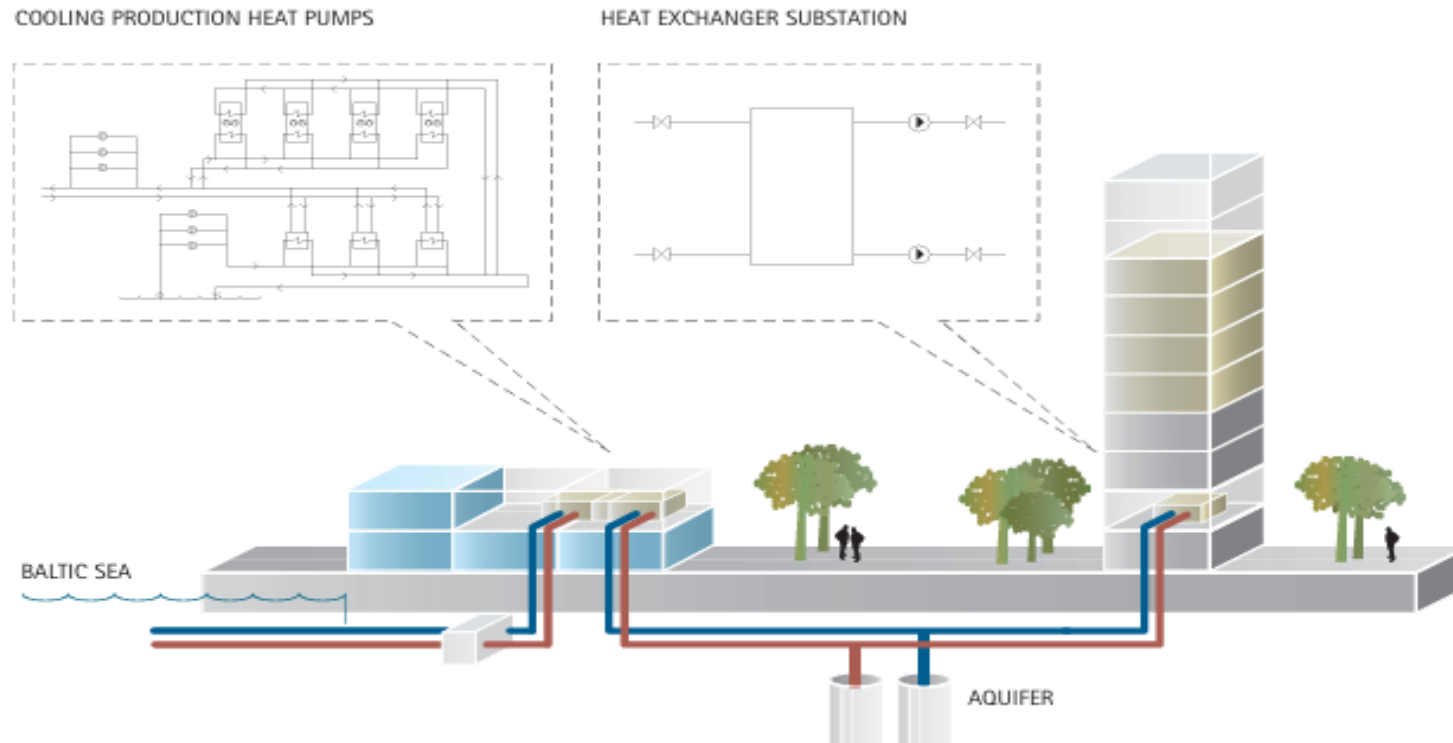
Installed power	170 MW
Energy	240 GWh/annum
Mains	8.6 km
Distribution network	12 km
Operating pressure	10 bar
Feed temperature	+6 °C
Return temperature	+16 °C
Number of customers	300



## 8. DCN STOCKHOLM CITY

### Distribution

District cooling is transferred to the City area in a mains that is 8.6 km long and has a diameter of 800 mm. The mains are installed in existing pipe tunnels and in the ground. In the City area, a distribution network has been established with a total length of 12 km. The distribution network is also installed in tunnels and in the ground.



## 8. DCN STOCKHOLM CITY

### Main conclusions

- Stockholm's district cooling system was launched in 1995 with a 60 MW cooling plant adjacent to an existing heat pump in Värtan.
- The system integrates free cooling and heat recovery, ensuring strong environmental and economic performance.
- In 1998, an aquifer energy storage system was added, primarily charged with cold seawater supplying 25 MW during peak loads.
- By 2000, a new 50 MW excess-power plant with heat recovery was integrated, supporting district heating and peak summer cooling.
- The distribution network was carefully planned to minimize road traffic disruption using specialized construction methods.

# 9. DCN COMBINED WITH HYDROGEN ELECTROLYZERS (BERLIN, GERMANY)

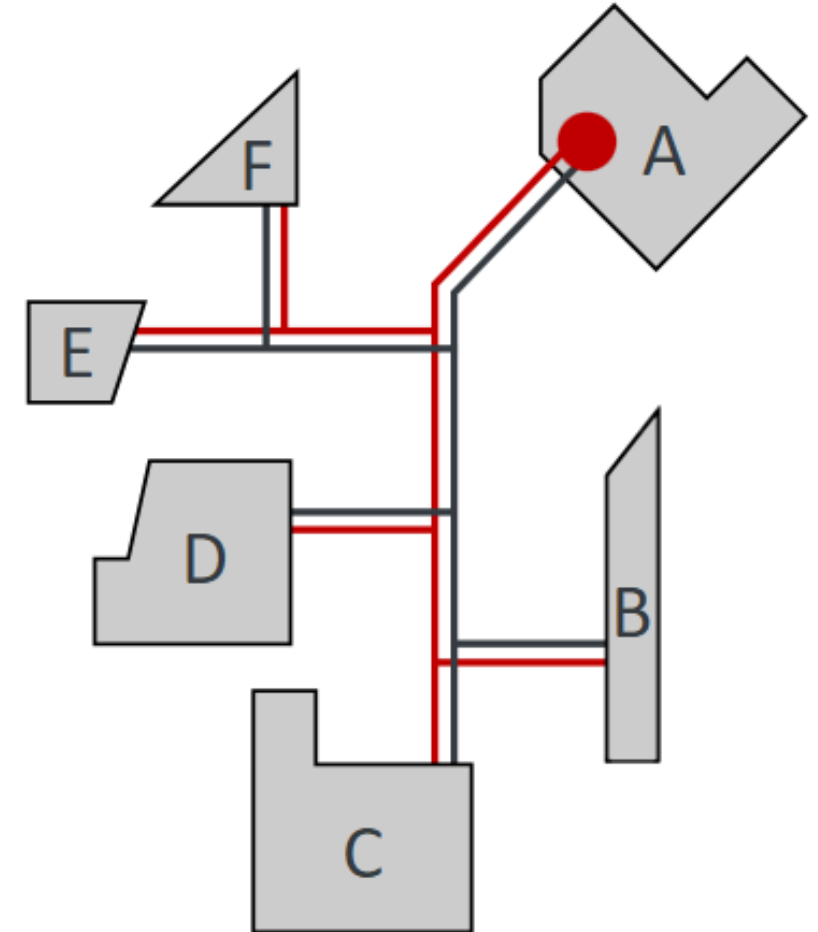


# 9. DCN COMBINED WITH HYDROGEN ELECTROLYZERS

## Overview

In this case study, a district with a district heating and cooling network is partially supplied by hydrogen technologies.

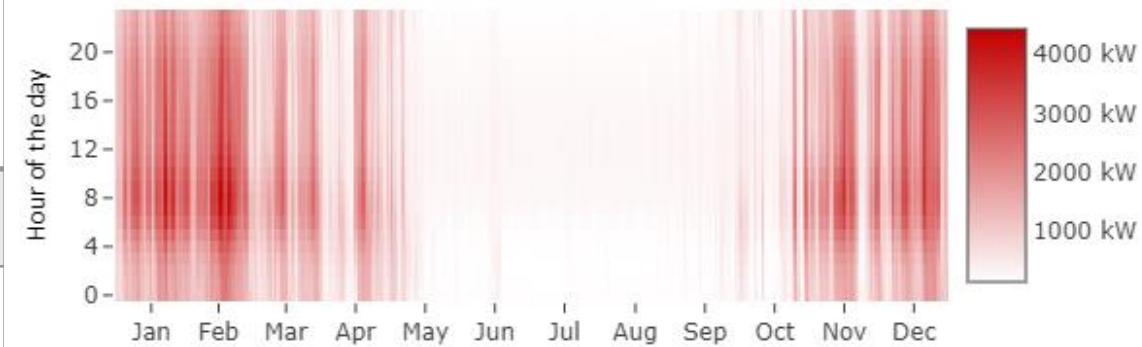
An energy supply for an exemplary district with 6 buildings is planned (the energy center is in building A). The district's location is assumed to be Berlin (Germany).



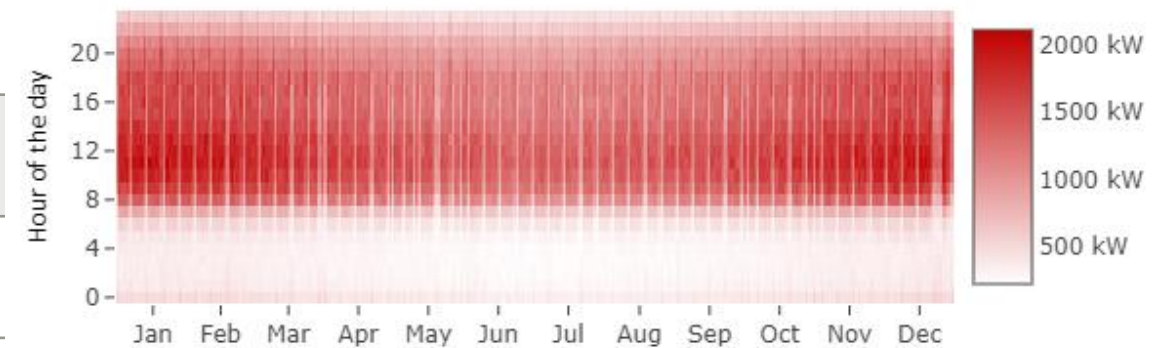
# 9. DCN COMBINED WITH HYDROGEN ELECTROLYZERS

## Demand profile

Building	Usage	Floor area (m <sup>2</sup> )	Space heating (MWh)	Domestic hot water (MWh)	Space cooling (MWh)	Electricity (MWh)
A	Hotel	20,000	1700	640	980	3000
B	Office	18,000	1170	144	1062	936
C	Retail	24,500	1593	74	784	2352
D	Museum	16,500	1073	83	578	859
E	Theater	6,700	503	40	101	563
F	Restaurant	2,500	188	125	50	358



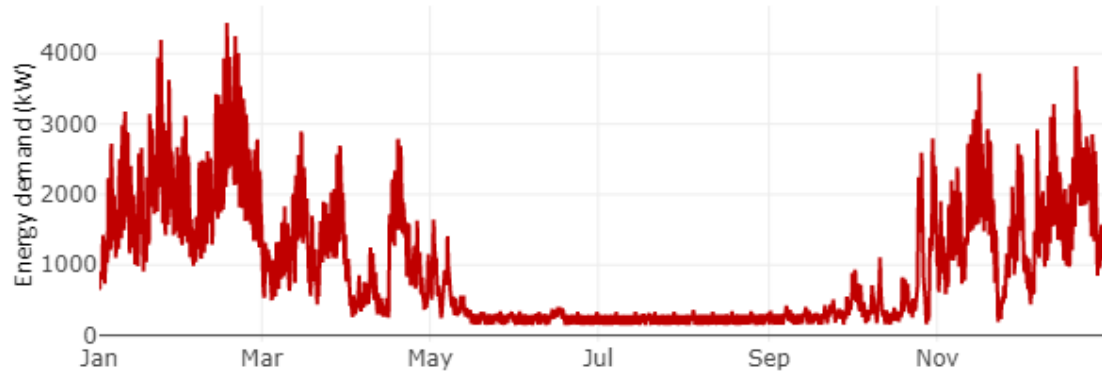
Heat demand



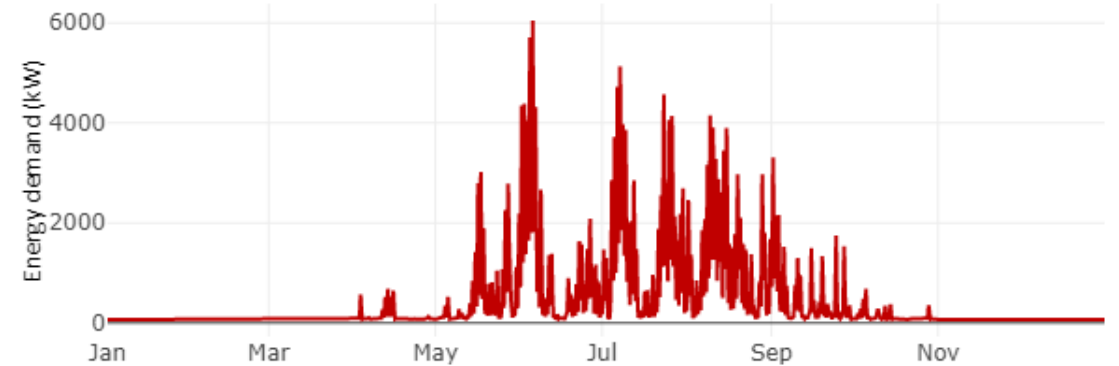
Electricity demand

# 9. DCN COMBINED WITH HYDROGEN ELECTROLYZERS

## Demand profile



Heat demand

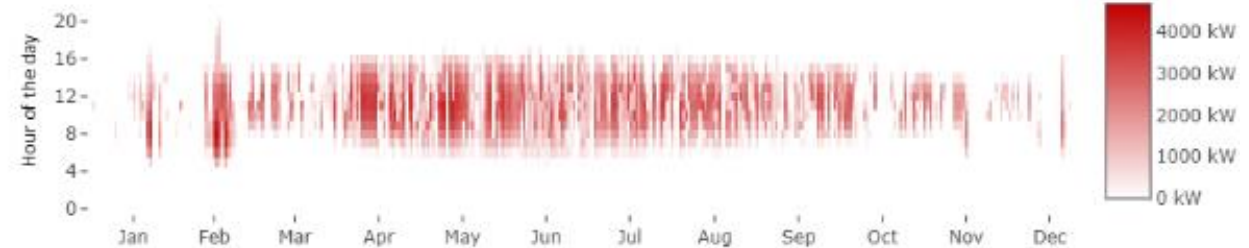


Cooling demand

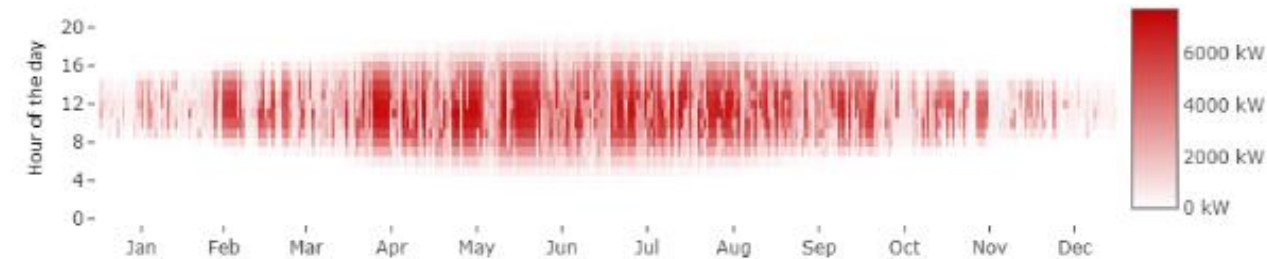
# 9. DCN COMBINED WITH HYDROGEN ELECTROLYZERS

## Design of the energy center

1. Hydrogen technologies support heating and cooling in the district, with a 3 MW connection to an existing district heating network.
2. An electrolyzer uses surplus PV electricity to produce hydrogen, which is fed into the natural gas grid, with waste heat recovered for district heating.
3. Compression chillers provide cooling, and the optimal PV system capacity is 58,800 m<sup>2</sup>, covering 62% of the district's electricity needs.
4. 92.1% of the heat supply comes from the district heating network, while 7.9% is covered by waste heat from electrolysis.
5. The district's CO<sub>2</sub> emissions total 4,370 metric tons per year.



Hydrogen feed-in



Generation of PV electricity

# 10. DCN FOR HOTEL RESORTS (PUNTA CANA, DOMINICAN REPUBLIC)





# 10. DCN FOR HOTEL RESORTS

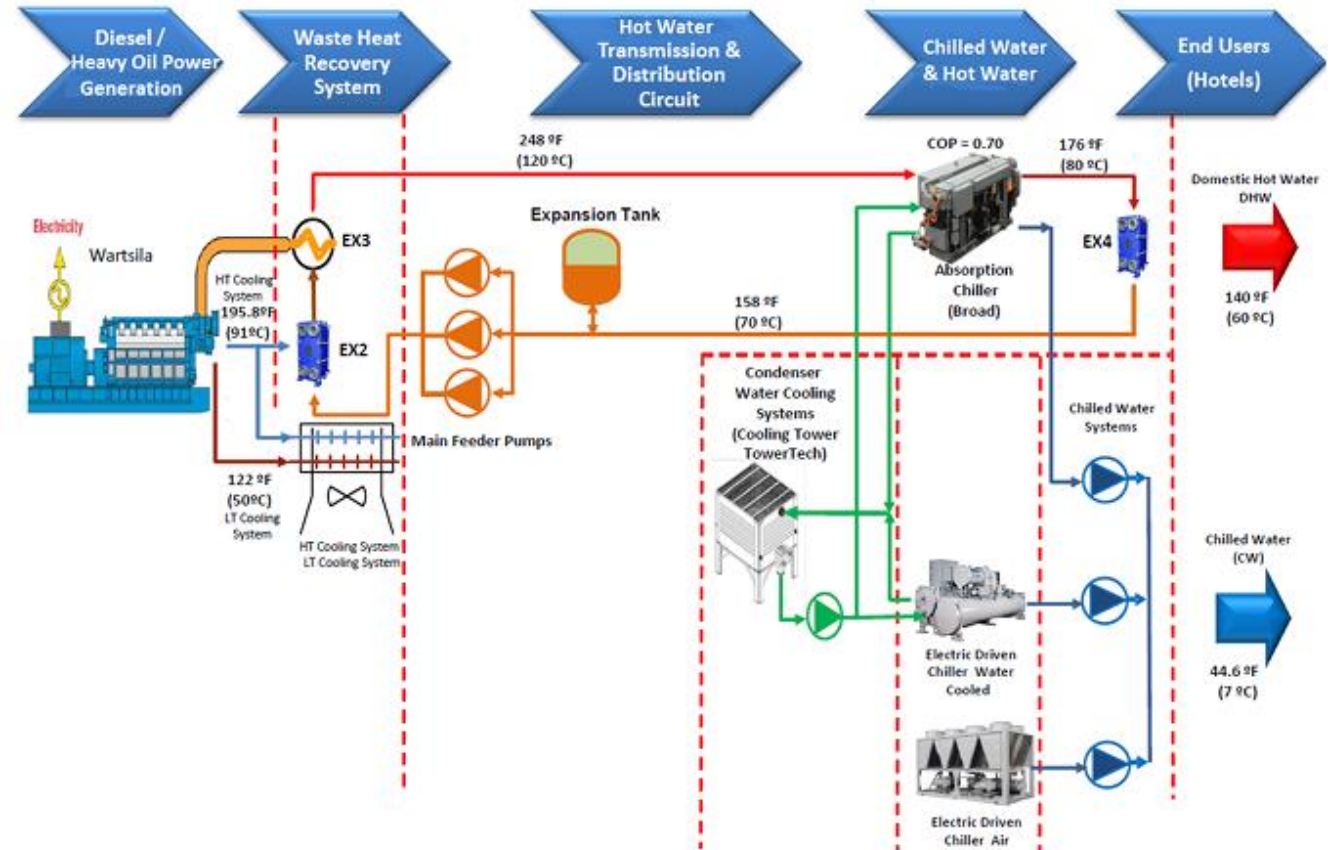
## Background

- This district energy project in Punta Cana, Dominican Republic, is widely recognized, especially in the eastern tourist area.
- BROAD supplied eight single-stage hot water chillers, utilizing waste heat from a heavy oil power plant's Wartsila generators.
- The system provides 19 MW of cooling by transferring 120°C pressurized hot water 4 km to air conditioning units in five hotels.
- Continuous cooling is required due to the tropical climate, with strict performance and stability requirements.
- The project's success led to recognition from CEPM and interest from U.S. and Latin American energy companies, creating new collaboration opportunities.

# 10. DCN FOR HOTEL RESORTS

## System design concept

1. The system provides 17.58 MW of chilled water and domestic hot water (DHW) to nearby hotels.
2. Waste heat from diesel engine exhaust and cooling water (6 MWe each) is used for heating and cooling.
3. 248°F (120°C) HTHW is produced at the power plant and sent to hotels to drive single-stage absorption chillers.
4. After cooling, the HTHW at 158°F (70°C) is further used to generate DHW before returning to the power plant.
5. A 50°C temperature drop optimizes heat utilization, allowing a single loop to serve both cooling and DHW needs.



# 10. DCN FOR HOTEL RESORTS

## Economic and environmental aspects

1. 25% reduction in electrical energy consumption at resorts compared to traditional cooling methods.
2. Previously, 34% of the resorts' electricity bill was for cooling, but cogeneration reduced reliance on the grid.
3. The project eliminated the need for domestic hot water boilers, cutting fuel consumption to zero.
4. Waste energy was efficiently reused, covering both cooling and DHW needs, benefiting both resorts and utilities.
5. 25% of thermal energy was recovered, reducing fuel use by 35,740 barrels of HFO and 32,881 barrels of LPG annually.
6. CO<sub>2</sub> emissions were reduced by over 28,872 metric tons annually, showcasing significant environmental benefits.



# 10. DCN FOR HOTEL RESORTS

## Conclusions

- This project is the most innovative energy arrangement in the Caribbean, utilizing residual thermal energy and cascade energy use.
- Hotels benefit from lower operating costs, improved competitiveness, and more sustainable energy consumption.
- Optimizing thermal energy use frees up electrical capacity for future developments and new facilities.
- The project supports regional economic growth while promoting long-term sustainability.



# CONCLUSIONS

<b>Key success factors (external)</b>	<b>Description</b>
<b>Adequate national policy and regulatory environment</b>	The national energy policy and regulatory environment provide adequate ground and incentives for the development of DHC systems
<b>Direct/indirect financial support</b>	DHC projects benefit from existing direct/indirect subsidies
<b>Focused local policy and coherence with urban planning</b>	Local authorities promote DHC as part of their energy supply and climate strategy and integrate heat planning in their urban development projects
<b>Alignment of interests / Cooperation maturity</b>	Public authorities at national and local level, regulating bodies, end users, the DHC company and other local actors cooperate in an efficient manner to achieve a good quality service and a sustainable and cost-efficient heat and cold supply

# CONCLUSIONS

<b>Key success factors (internal)</b>	<b>Description</b>
<b>Availability and relevance of local resources</b>	The DHC system relies to a large extent on available local resources such as renewable energy sources
<b>Comprehensive project development</b>	The DHC system was conceived, developed and implemented following a comprehensive, seamless approach aimed at achieving a high quality, cost-efficient and sustainable heat/cold supply.
<b>Price competitiveness against alternative energy solutions</b>	DHC prices are competitive against alternative energy solutions available in the market. This price competitiveness can be enhanced through an optimized system design, through competitive procedures for the market or by allowing competition between different heat/cold supply solutions.
<b>Flexible heat and cold production</b>	A flexible production allows better cost-efficiencies, mainly through a dynamic optimization of the supply. This can be achieved through a diversified and complementary energy mix, the use of CHP and enhanced ramp-up/cycling practices, connecting the electricity and heating markets, etc.
<b>Combining technical and non-technical innovation</b>	The DHC system embraces and cross-fertilizes innovation at all levels: from the use of state-of-the-art technologies to new governance modes, keeping a long-term approach when making strategic decisions.



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Thank you!

Module 4 - District Cooling  
SHaKE – Sharing Heat and Knowledge on Energy Communities

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Developed by BME

Dr. Adrián Mota-Babiloni | [mota@uji.es](mailto:mota@uji.es)  
Ghad Alarnaot-Alarnaout | [alarnaot@uji.es](mailto:alarnaot@uji.es)



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