Biomass: an important role in District Energy solutions

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Agenda

Chapter 1

District Energy: evolution towards more efficient and sustainable configurations

Chapter 2

Examples of biomass & biofuel in district energy solutions

01

District Energy:
Evolution towards more efficient & sustainable configurations

DHC can help to make energy consumption more "green" with the use of 4th generation district heating systems

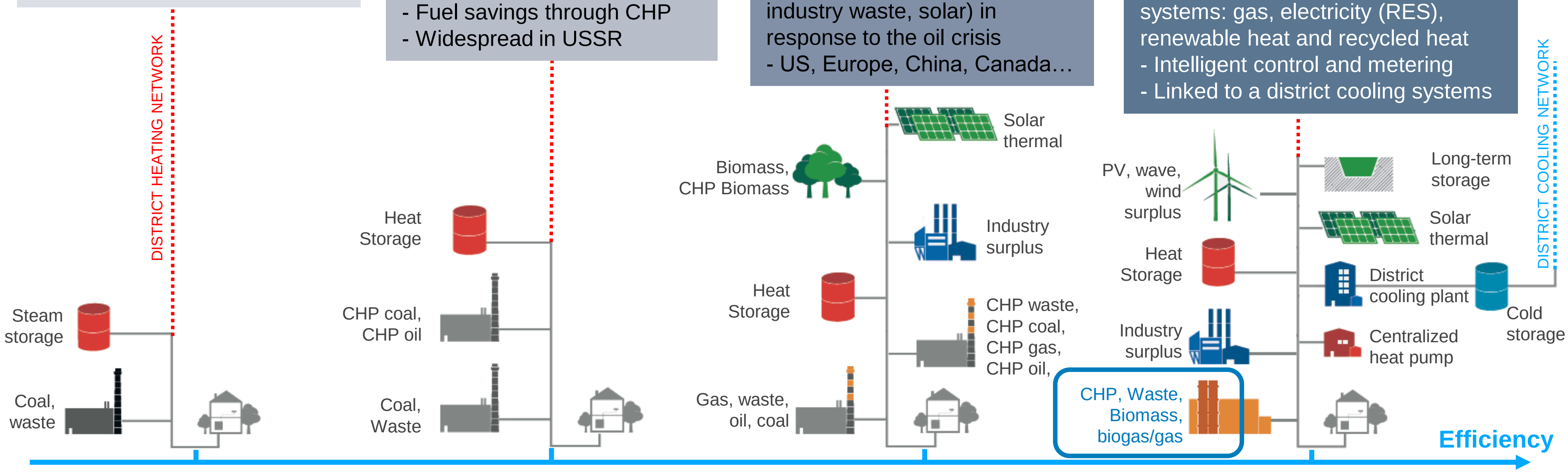
Integrating smart thermal networks into sustainable energy systems for the future

1G: Steam (~200°C)
- Steam pipes in concrete ducts
- Powered by coal plants
- Appeared in US and Europe

2G: Pressurized hot-water (> 100°C)
- Water pipes in concrete ducts
- Fuel savings through CHP
- Widespread in USSR

3G: The Scandinavian model
- Pressurized hot-water but with T° < 100°C
- Use of local fuels (biomass, industry waste, solar) in response to the oil crisis
- US, Europe, China, Canada…

4th GENERATION
- Low-temperature (40-60°C) district heating, low grid losses
- Integrated to smart energy systems: gas, electricity (RES), renewable heat and recycled heat
- Intelligent control and metering
- Linked to a district cooling systems



1st Generation: 1880 – 1930

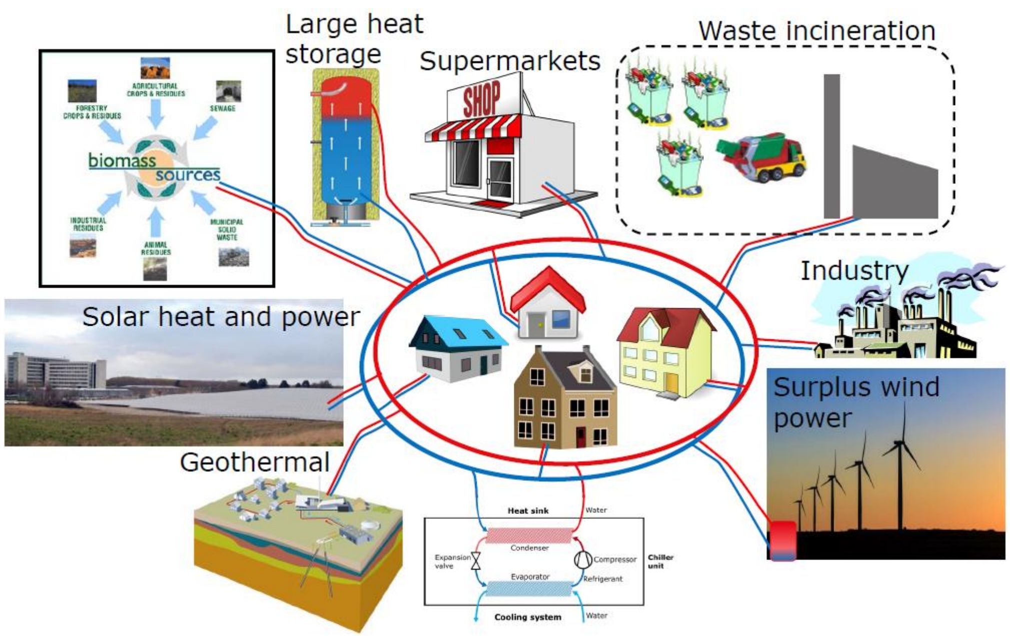
2nd Generation: 1930 – 1980

3rd Generation: 1980 – 2020

4th Generation: 2020 – 2050

Source: Aalborg University and Danfoss District Energy, 2014

Increasing the use of renewables & waste heat in DHC systems



- Existing buildings, which are less energy efficient, will account for 45% of buildings heating & cooling energy demand by 2050
- Decarbonizing existing buildings connected to DHC systems only requires changes on heating & cooling plants
- Only District Heating can valorize a maximum of waste heat
- Maximum impact comes with our ability to combine all the different renewable sources

How DHC can facilitate large-scale integration of renewable energy ?

District Energy systems allow:

- The use of renewables that may not be economical at the building level
- A high diversity of renewable energy sources

DISTRICT HEATING

TECHNOLOGY	BENEFITS	DRAWBACKS	EXAMPLES
GEOTHERMAL	Provide baseload heat, high operation stability, cheap running costs	Not widespread source of energy, potential uncertainty of resource available until wells drilled	**Bordeaux** will be served by a geothermal district heating networks.
HEAT PUMPS	Convert electricity to heat at high efficiencies, utilize heat from: underground, sewage, return water in DHC,…	High costs, efficiency decreases with temperature	**Marseille (Thassalia)**: 500,000 m2 of buildings are supplied with heat pumps
SOLAR THERMAL	Renewable and CO2-free energy source, cheap running costs	Ground-mounted collectors can require significant land, backup/peak load source is required	**St. Paul** (US) developed 2 140 m^2 of solar collectors to incorporate into the DH
WASTE HEAT RECOVERY	Recycling waste energy increases the energy efficiency of a city (as part of a circular economy)	Waste heat may not be able to guarantee supply and may require redundant backup boilers	**Barcelona**: an incineration plant supplies 94% of the heat
BIOMASS BOILER/CHP	Boilers are more flexible, fuel costs cheaper than gas, a CHP provides higher efficiency	CO2-free only if the biomass is sustainably sourced, requires costly filters to avoid pollution	**Chalon-sur-Saône:** 14 000 dwellings supplied with 85% of the heat obtained from biomass

Source: District Energy in Cities, UNEP, 2015

How DHC can facilitate large-scale integration of renewable energy ?

Renewable energy sources are also applicable to District Cooling Systems

DISTRICT COOLING

TECHNOLOGY	BENEFITS	DRAWBACKS	EXAMPLES
FREE COOLING	Cost effective solution No use of "environmentally damaging" refrigerants	Requires suitable cooling source. Plant must be close to the buildings where the water is carried.	**Paris**'s DC system extract cooling from the Seine River
ABSORPTION CHILLER WITH RES	Huge diversity of heat sources to run the absorption cycle: waste heat, solar thermal, CHP, NG combustion…	More expensive than electric chillers	**London**'s Olympic Park with a 4 MW absorption chiller in the **tri-generation** plant
ELECTRIC CHILLER WITH RES	Convert electricity to cool at high efficiencies	Use refrigerants with a global warming potential	**Marseille's** DC system is powered by 12 MW of seawater-cooled electric chillers (Thassalia)

Source: District Energy in Cities, UNEP, 2015

02

Examples of biomass & biofuel in district energy solutions

A network linked to the history of the City of Paris

CPCU
Notre réseau renouvelle vos énergies

Starting point

- An « old » steam plant of the end of the 19th century
- A steam distribution network for a few buildings downtown

Mid 20th century

- Connection to the thermoelectric power stations of the suburbs
- Recovery of heat in the incineration plants
- Sustained development in the south and north-west of Paris

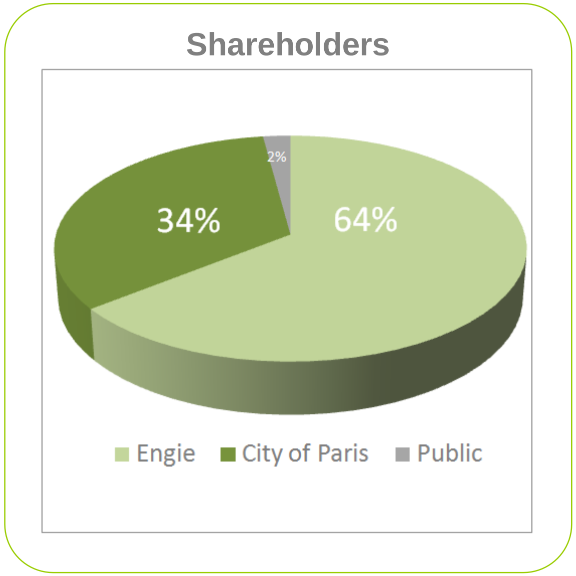
The years 1980 - 2000

- Limited growth
- Diversification of energies

Since 2000

- CHP with Gas Combustion Turbines
- Networks recognized as vectors of renewable energies
- Energy efficiency with new developments

Public Service contract
since 1927



- **First District Heating in France**
- **4 000 MW Thermal production** (including EfW plants)
- **5TWh/y ~ 18 000 TJ/y**
- **1/3** of collective heating in Paris
- **500 000** households equivalent
- **1 à 2%** yearly average growth in the last 10 years

Almost a century of history !

A few words on CPCU

CPCU
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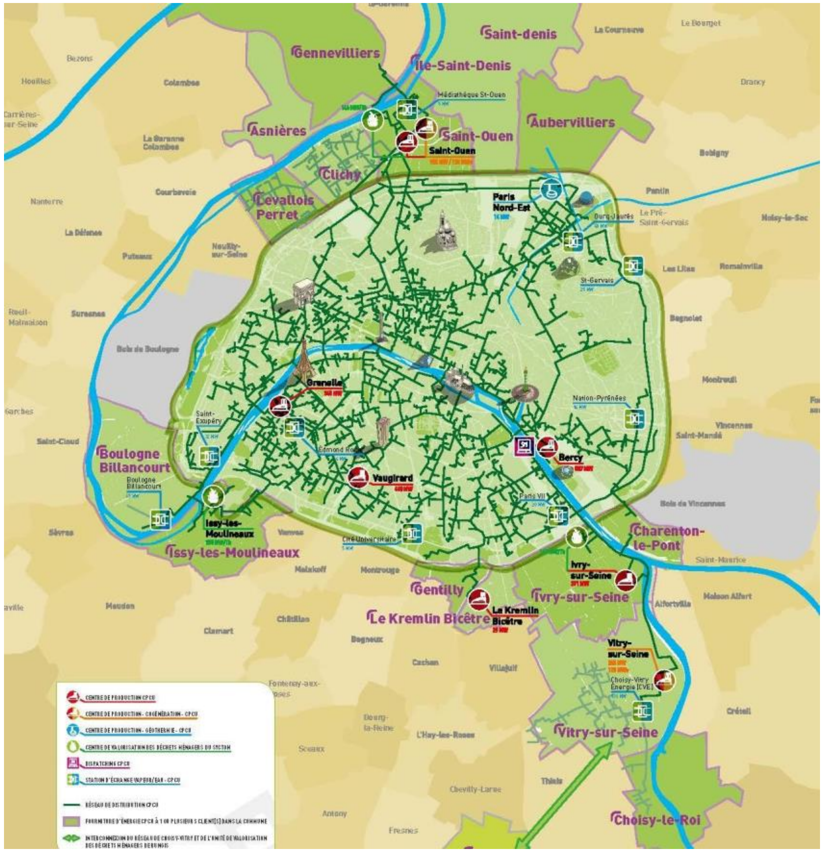
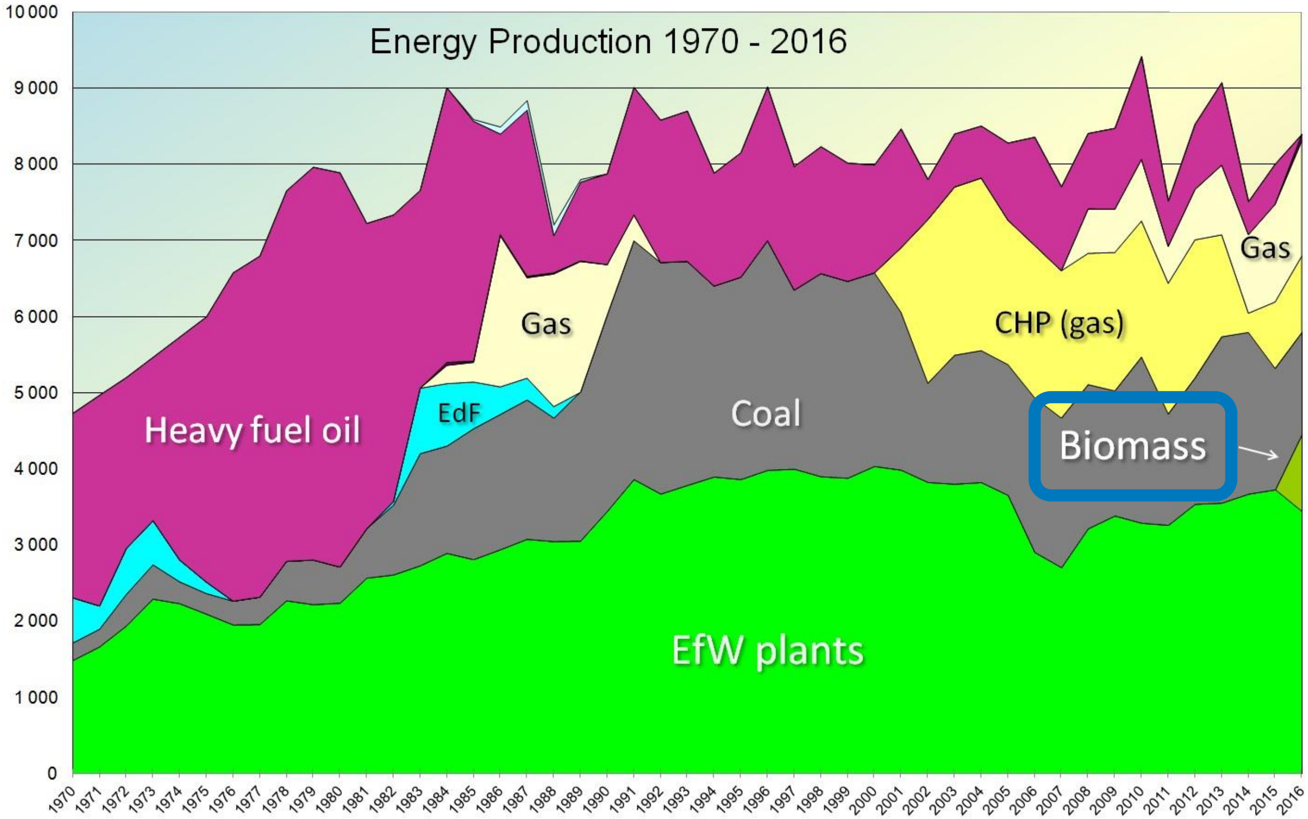
In the city of Paris... and in others nearby



- **8** production plants CPCU
  - **2** Gas turbine CHP
  - **2** Geothermal pits
- **3** Energy from waste plants
  (from neighbouring cities)
- **500 km** network
- **19** Hot water loops
- **6 000** substations
- **17** cities

Primary energy use

A positive evolution



Recent evolutions : cleaner fuels (air quality), renewables…

Upgrade of production plants

2016

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- ✓ Five steam plants switched from HFO to gas or biofuels
- ✓ New environment permits = strong regulatory compliance

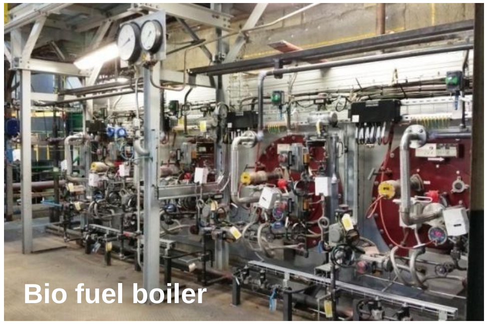
Major decrease in environmental footprint
& better control of industrial risks

DH goes Green in Paris

Recent achievements

1. Geothermal pits (6 to 10 MW_{th} each)
   - Paris-Nord-Est 2009
   - Clichy-Batignolles 2016
   - Ivry-sur-Seine, 2016
2. Co-firing in Saint-Ouen (225 MW_{th})
   - Solid biomass replaces coal
3. Liquid bio fuel (420 MW_{th})
   - Complement / back up EnR

Goal : 50% renewables, up to 60% …



Going Green in Saint-Ouen

30% to 37% of total network input

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3 boilers of different vintage, for a total of 1 180 MW

- Saint-Ouen 1 : two gas boilers, 170 t/h
- Saint-Ouen 2 : two coal & **wood pellets** boilers, 340 t/h
- Saint-Ouen 3 : a gas combustion turbine, 128 MW electrical + boiler 400 t/h

✓ Co-firing of biomass in Saint-Ouen allows to be over 50% in green energy

✓ Better integration of the facilities in the changing urban environment

Reducing the use of coal versus biomass
Lower environmental impact

Wood pellets
at the Saint-Ouen plant

Logistic center (first operated January 2016):

On the railway site : up to two trains a day (~ 2 200 tons) and storage of 6 500 m³ (five silos)
On the steam plant : two silos for daily storage 2 x 2 400 m³.

Boiler operations (October to May):

Feed in of ~ 1000 tons a day, for 50% co-firing
Different types of pellets have been tested

Biomass volume:

2016 : 84 000 tons
2017 : > 100 000 tons

Ratio of co-firing in the boilers :

1. Designed for 50%
2. Working over 70% (peaks)
3. To be tested over 80%, up to 100%

Thermal energy solutions

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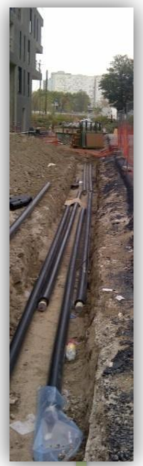
Four levels of action ➔ Green solutions for every level

1. The building	Shallow Geothermal	Heat recovery tepid used waters	Thermal solar	**Back-up & complement**
2. The block	Medium deep geothermal	Data centers heat recovery		**Local distribution Pooling Back-up & complement**
3. The district	Deep Geothermal			**Local distribution Back-up & complement**
4. The city	Biomass & biogas	Non recyclable Waste **Refuse Derived Fuel**		**Vector of renewables**



Biogas will also be used for mobility (transportation)

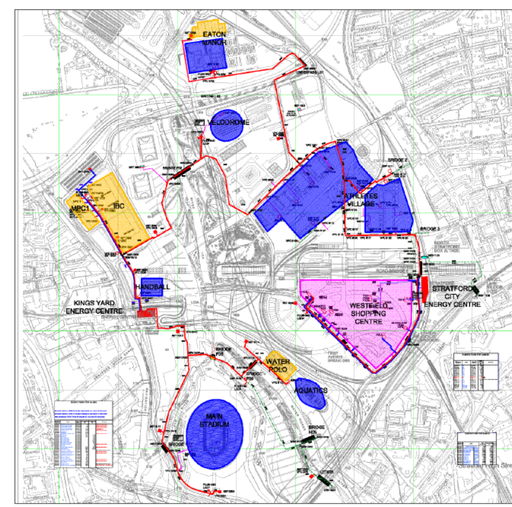
DHC can provide a solution at every scale…

… as a complement & back up, **and a vector of local renewable energy**

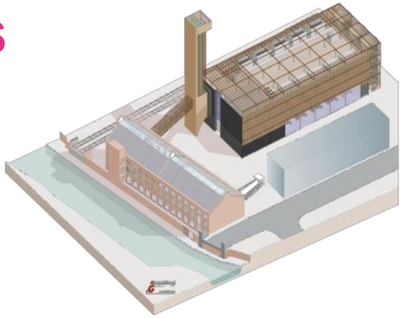
Queen Elizabeth Olympic Park & Stratford City - LONDON
District Energy infrastructure : Tri-generation

- 20 km of piping network installed across the site
- Providing heat & chilled water

+ on-site Power Generation



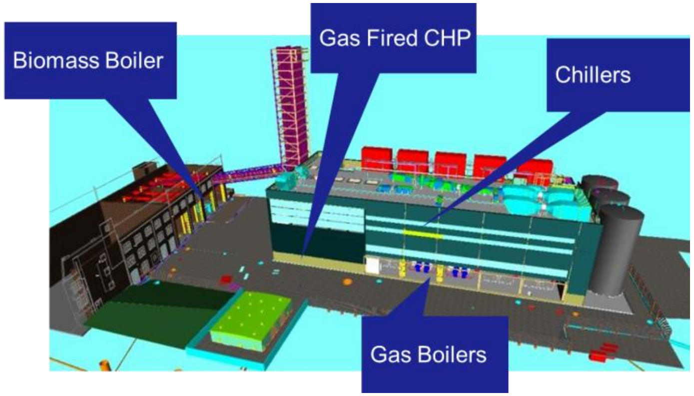
Two Energy Centres



- Energy Centre construction started October 2008
- 2 new purpose built energy centres, Kings Yard for Olympics & Stratford for Westfield Development
- Kings Yard retains the renovated, Grade II listed Edwardian Mill building
- Contains biomass boiler
- All major plant items installed by March 2010
- Combined Heat & Power, chillers, boilers, etc.

Energy centre configuration : Tri-generation

- Energy Centre 1 (Olympic Park - Kings Yard)
  - — 3.1 MWe CHP
  - — **3.5 MW biomass boiler**
  - — 40 MW conventional boilers
  - — 4.0 MW absorption chiller
  - — 14 MW VC chillers



- Energy Centre 2 (Westfield Stratford)
  - — 6.2 MWe CHP
  - — 40 MW conventional boilers
  - — 4.0 MW absorption chiller
  - — 35 MW VC chillers

Biomass – woodchip boiler plant