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District Heating and Cooling
Chapter Summaries

EXECUTIVE SUMMARY

Chapter 1 - THE HEAT SECTOR

District Heating (DH) is a tiny proportion of total global energy production but it is a large market. TPES (total primary energy supply) in 2014 was XXX EJ. Heat production was XXX EJ or Xx% of TPES and district heat consumption was XXX EJ. District heat consumption amounted to XXX% of all heat production and XXX% of TPES. In 2015 the global production of district heat was XXX PJ and consumption was XXXX PJ, with self-use and losses of XXX%. This includes heat for all purposes, industrial, res…… There was a decline in heat production from 1990 to 2000, due to the demise of the Soviet Union and the almost immediate collapse of the economies and industrial output in the USSR and the Soviet bloc……. In contrast, the Scandinavian systems are smaller but they lead the world in new technology, good practice and investment in District Heating networks…… There are an estimated XXX DH utilities in Europe and XXXXX in the rest of the world, excluding China. The market concentration of district heat production companies is low. In 2015 the largest 24 companies accounted for XX% of total global…….

Chapter 2 - DISTRICT HEAT CONSUMPTION AND NETWORK LENGTH

District Heat consumption by country in TJ, 1990 to 2020 and Trench length of district heating transmission and distribution pipelines in km, 2010 to 2020.

Chapter 3 - DISTRICT HEATING TURNOVER, PRICES AND EXCHANGE RATES

In value, the sales pattern has been quite different. In our view it is rather misleading to consider sales in global terms, because such a high proportion is contributed by Russia and Eastern Europe. Sales value almost doubled between 2000 and 2013, but then fell XXX% in the three years between 2013 and 2016. This has been due to the collapse of the currencies in the CIS. Global revenue increased from $XXX billion in 2000 to $XXX billion in 2013 and then dropped to $XXX billion in 2016 but has regained its position since then, and is forecast to reach $XXX billion in 2020 and $XXX billion in 2021……. There is a huge inequality in heat prices in Western European countries with those in Russia and the CIS republics, and there are large variations within Europe……. The pattern of sales of heat energy in TJ shows a steady growth in most countries outside the CIS, where it has fallen since the collapse of the Soviet Union. Between 1990 and 2000 sales in the CIS fell …… in the rest of the world increased by ……mainly in China……..

Chapter 4 - DISTRICT HEATING CAPEX AND EQUIPMENT SALES

Capital expenditure in 2016 was $XXX billion. Capital expenditure for district heating networks is lumpy; it has been volatile and evinces almost no pattern within many individual countries. For example, in Austria it went……. These encompass network pipelines, internal piping, substations, HIUs in substations and buildings, meters and heat cost allocators……

Chapter 5 - DISTRICT HEATING SYSTEM STRUCTURE - OPEN AND CLOSED, DIRECT AND INDIRECT DH

The differences between direct and indirect, open and closed, technologies of District Heating networks are fundamental to their operation and understanding how they work. A District Heating system is

a……. A dependent scheme of DH connection for DHW system is called an open scheme, and when used for space heating it is called a …….

Chapter 6 - DEFINITIONS AND UNITS

Units of Power and Energy used in District Heating and Cooling…….Power……Energy……Heat…. The equivalent full load hours (EFLH)

Chapter 7 - THE TECHNOLOGY GENERATIONS OF DISTRICT HEATING SYSTEMS - 1GDH TO 4GDH

Three generations of District Heating technologies have successfully been developed globally. The first generation was based on steam pipes, the second used high temperature hot water, and the third and current one uses medium……1GDh……..2GDH……3GDH……..4GDH……. The temperature levels differ…….

Chapter 8 - DISTRICT HEAT NETWORK COMPONENTS

District Heating networks are complex systems designed to cope…… Network pipelines……. A District Heating substation is the connecting link between……. Group substation (GS)……Building level substations (BLS)…… HIU Hydraulic or Heat Interface Unit …… Heat Exchangers.

Chapter 9 - BILLING AND HEAT METERS

Billing for heat is done in different ways from country to country. Most countries calculate heat prices in two parts; a basic charge for the building which covers public areas and heat received by conduction from neighbouring apartments, and a consumption based charge. There are different methods of calculating each of these……. Apartment level meters or heat cost allocators……

Chapter 10 - THE GLOBAL DISTRICT COOLING SECTOR

Current annual district cold deliveries are estimated to be around 300 PJ per year, thereof around XXX PJ in the Middle East, XX PJ in USA, XX PJ in Japan, and XX PJ in Europe. The volumes of district cold deliveries in the world are currently much smaller……..

Chapter 11 - TECHNOLOGY OF A DISTRICT COOLING SYSTEM

A district cooling system can be part of an upstream system, either supplying energy to a cooling plant or…… The plant can be equipped with compressor chillers, heat-driven absorption chillers, or heat exchangers (for free cooling……. Thermal storage for district cooling is often…….

Chapter 12 - DISTRICT HEATING AND COOLING IN THE CIS

Although the Russian technology is backward and inefficient compared with the cutting-edge developments in the Nordic countries and Germany, the sheer volume of the DH networks in Russia, in other CIS republics and in the former Soviet satellite countries of Eastern Europe makes it hugely significant in the global district heating sector……. Within buildings, heating pipes supplying radiators are usually vertically arranged one-pipe systems……. not conventionally used decentralised thermostatic heating

regulators…… constant flow regime……. The decline in heat production after the collapse of the Soviet Union……in Russia there are XXX CHP plants, about XXXX boiler-houses with the capacity more than XXMW, more than XXX small boiler-houses and about XXX autonomous individual heat generators. About XX% of heat energy from all DH system heat loads is produced at CHP plants…… Moskovskaya Ob'edinennaya Energenticheskaya Kompaniya…….. Apartment-level metering in old constructions, and a majority of apartment buildings were built before 1970, is often much more expensive than establishing building-level substations ……Ukraine……Kazakhstan……Belarus……..

Chapter 13 - DISTRICT HEATING AND COOLING IN EUROPE

Total District Heat consumption in Europe was XXX PJ in 2016. There are three large consumers of District Heat in Europe; Germany is the largest, followed by Poland and Sweden. These the countries combined account for XX% of European consumption. A second tier, consisting of Austria, Czech Republic, France, Denmark and Finland account for a further XX%..... District cooling supply in EU-274 is about XX TWh yearly. It covers X% of the total district heating market in EU-27 (XXX TWh), and XX % of the potential district cooling market (about XXX).

Chapter 14 - DISTRICT HEATING AND COOLING IN THE NORDIC COUNTRIES

The heating and cooling demand in Sweden and Finland is much larger than that of Norway and Denmark, and demand in Iceland is very small compared to all the other Nordic countries. Greenland is even smaller……. The DH systems of the Nordic countries and are often cited as the gold standard of district heating……., the district cooling market has grown in the Nordic countries…… Transition to 4th generation district heating……today in Denmark, low temperature district heating is becoming a reality……..New rules on metering of electricity, gas, water, heating and cooling came into effect in……Denmark……Finland……Greenland…….Iceland……Norway…….Sweden…..future…….devel opment of district heating……

Chapter 15 - DISTRICT HEATING NETWORKS IN THE BALTIC STATES

Estonia, Latvia and Lithuania…… District heating dominates heat demand supply, with a XX% of market share. XX% of heat is produced with biomass and XX% with gas, XX% oil shale and Xx% oil shale gas, and 6% oil…….. building-level DH metering covers virtually 100% of all buildings…….

Chapter 16 - DISTRICT HEATING AND COOLING IN EASTERN EUROPE

The former Soviet bloc countries of Central and Eastern Europe inherited district heating networks along the Russian model and are today a mixture of 2nd and 3rd generation systems…….. Cumulative heat losses from production through transportation to end use range between XX% and XX% in Central and Eastern Europe and the former Soviet Union……Poland…….Czech Republic……..Hungary……..Romania……Slovakia…..Bulgaria…… District heating system applications have been started with large scale, city based geothermal district heating systems in Turkey…… houses the geothermal district heating systems (GDHS) Balcova-Narlidere, which supply 11,500 households with a capacity of 72 MW……..

Chapter 17 - DISTRICT HEATING AND COOLING IN WESTERN EUROPE

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In Austria, district heating networks are managed at local level by the individual heat supply companies…….. District Heating currently provides approximately 6% of France's heat demand. Compared with countries in Central and Eastern Europe……the district heating market in France is comprised of nearly 600 different heating and cooling networks which provide an annual output of about XXXX MWh…….. The Parisian region (Île-de-France) uses more than the half the total heat…….. France has 17 District Cooling systems…… In absolute terms, Germany is f the largest markets for district heating in Europe although district heat has relatively low penetration…….. German utilities are leading the way in a number of technical developments towards the 4th generation of DH, notably the use of distributed generation and renewables……..Berlin……Hambburg……..Munich…….. The Italian district heating has developed very recently. Since the 1970s, it has grown, but it only satisfies XX% of residential heat demand. At the end of 2015, more than XXX cities were served by district heating systems. XX% of sales were to the residential sector……. The low penetration of DHC in Italy can be tracked back to the energy…… District heating has been used in Switzerland for more than 50 years but its share of the heat market is less than XX% today. In 2015…….. The district energy market in UK is underdeveloped. Today approximatelyXX% of the buildings are connected to heat networks….. With over 280 heat network projects at varying stages of development across the UK, there are significant investment and supply chain opportunities anticipated over the next 10 years; up to £XX billion…….

<u>Chapter 18</u> - DISTRICT HEATING AND COOLING IN CHINA

Heating is confined to the Northern urban area of China…… Outside the heating zone, heating is not provided by the state and central heating south of the Yangtze river even used to be prohibited in the past ……. No other country in the world can show the same growth of DH during the last 10-15 years……..About XX% of the existing residential building space in Northern China needs to be refurbished and retrofitted with efficient equipment and this includes legacy district heating systems. Chinese buildings are poor quality……half of all the major cities have district heating systems In the rural area of northern China nearly 85% of homes use the traditional Chinese kang as a domestic heating system…… Total pipe length reached XXX km for steam and XXXX km for hot water in 2015…… In China, the substation serves 20–30 buildings through the secondary underground network….. Although heat meters have been installed in new and existing buildings in China, most heat users are still charged with an area-based heat price…… District cooling is a well-known concept in China…… The potential annual increase in demand for district cooling in China has been estimated at XXXTWh…….

<u>Chapter 19</u> - DISTRICT HEATNG AND COOLING IN KOREA

Space heating and domestic hot water supply for buildings is currently one of the largest sectors in energy use. Korean residents prefer DH to individual heating systems because…… According to the latest available data, Korea had XXX GW of installed CHP capacity, mostly supplying DH applications …… The Korea District Heating Corporation (KDHC) is the main CHP/DHC company…… There is a growing focus on District Cooling in the major towns and cities in Korea. The DC market has been rapidly expanding in the last 10 years. DC consumers have increased XXX% and DC capacity has tripled in size between 2005 and 2016…… the numbers of heat supply operators and service districts were XX and XX…… Japan is moving towards 4GDH and these days, the 'microgrid' system has started to attract attention

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Chapter 20 - DISTRICT HEATING AND COOLING IN JAPAN

Most Japanese use air conditioners to live indoors comfortably throughout the year…. . Many local governments, including those in Tokyo and other metropolitan areas, were speeding up the adoption of district heating and cooling systems as an effective measure against air pollution ……..Some cities have district-wide heating and cooling systems, which distribute cold water, hot water, and steam……

Chapter 21 - DISTRICT COOLING IN THE MIDDLE EAST

With increasing urbanisation and improvement in living standards in GCC, cooling has become an integral part of region's basic utility requirements……. With temperatures in the Gulf exceeding 50 °C in summer……. It is estimated that District Cooling load has increased from a XX million RT peak in 2011 to about a XX million RT peak in 2015, a CAGR of XX%. At this growth, load is expected to increase to a XX million RT peak by 2020, an opportunity in excess of $XX billion…….. UAE is the market leader in the GCC, with installed capacity of XX million RT accounting for XX% market share, followed by Saudi Arabia with XX% and Qatar with XX%..... The DC market is split between XX% DC utilities and XX% Government or large single customer owned utilities…….

Chapter 22 - DISTRICT HEATING AND COOLING IN THE UNITED STATES

District heating in the United States is not a new idea. The first District Heating system using a central heat source connected to a steam pipe was constructed over 100 years ago……. Many DH systems lost their sources of inexpensive waste heat and had to rely on far more expensive steam-only plants… The US experience was completely different from that in Europe with district heating, where countries in both Western and Eastern Europe have greatly increased their district heating capacity … The theoretical advantages of European-style hot water systems over American-style steam are increasingly well understood in the US…. Today, over XXX Canadian and XXX US District Heating systems are in operation and serving more than XX% of commercial buildings, downtown districts, campuses, military bases, research facilities and some residential locations…..The large-scale District Heating systems in the US are located in two key market segments: downtown DH systems, and university campus…… The first commercial District Cooling system in North America was established in 1962 in Hartford, Connecticut. Today nearly 400 District Cooling systems serve…… North America has XX GW of installed DC capacity ….

Chapter 23 - DISTRICT HEAT PRODUCERS

The market concentration of district heat production companies is low. In 2015 the largest 24 companies accounted for XXX% of total global production of heat. The highest two shares were XX% and XX% for Gazprom and IES, both Russian companies……. The European companies are the large energy companies involved in electricity, gas and heat and have a Nordic bias, with Fortum, Vattenfall and Dong. China is challenging Russia in the total size of its heat market and will overtake it quite soon, but it has not yet developed a number of large companies to rival Russia.

Chapter 22 - LEADING DHC PLANT SUPPLIERS

A short summary of some of the leading companies providing DHC plant, designs and installations. It does not include DHC operators.

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Tables

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Sample Tables

Table 1: District Heat consumption by country in TJ, 1990 to 2020

TJ	1990	1995	2000	2005	2010	2015	2020
Austria							
Bulgaria							
Croatia							
Czech Republic							
Denmark							
Estonia							
Finland							
France							
Germany							
Hungary							
Iceland							
Italy							
Latvia							
Lithuania							
Netherlands							
Norway							
Poland							
Romania							
Slovakia							
Slovenia							
Sweden							
Switzerland							
United Kingdom							
EUROPE							
Russia							
Ukraine							
Kazakhstan							
Belarus							
Rest of CIS							
Japan							
China							
Korea							
USA							
WORLD							

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Sample Tables

Table 2: Trench length of District Heating transmission and distribution pipelines in km, 2010 to 2020

km	2010	2015	2016	2017	2018	2019	2020
Austria							
Bulgaria							
Croatia							
Czech Rep							
Denmark							
Estonia							
Finland							
France							
Germany							
Hungary							
Iceland							
Italy							
Latvia							
Lithuania							
Netherlands							
Norway							
Poland							
Romania							
Slovakia							
Slovenia							
Sweden							
Switzerland							
United Kingdom							
EUROPE							
Russia							
Ukraine							
Kazakhstan							
Belarus							
Japan							
China							
Korea							
USA							
WORLD							

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Table 3: District heat sales turnover in US$ million, 2000 to 2021

$ million	2000	2003	2013	2016	2020	2021
Europe						
Austria						
Bulgaria						
Croatia						
Czech Republic						
Denmark						
Estonia						
Finland						
France						
Germany						
Hungary						
Iceland						
Italy						
Latvia						
Lithuania						
Netherlands						
Norway						
Poland						
Romania						
Slovakia						
Slovenia						
Sweden						
Switzerland						
United Kingdom						
EU						
CIS						
Russia						
Ukraine						
Kazakhstan						
Belarus						
Asia						
Japan						
China						
Korea						
North America						
USA						
World						

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Table 4: District heat sales turnover in € million, 2000 to 2021

€ million	2000	2003	2013	2016	2020	2021
Europe						
Austria						
Bulgaria						
Croatia						
Czech Republic						
Denmark						
Estonia						
Finland						
France						
Germany						
Hungary						
Iceland						
Italy						
Latvia						
Lithuania						
Netherlands						
Norway						
Poland						
Romania						
Slovakia						
Slovenia						
Sweden						
Switzerland						
United Kingdom						
EU						
CIS						
Russia						
Ukraine						
Kazakhstan						
Belarus						
Asia						
Japan						
China						
Korea						
North America						
USA						
World						

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Table 5: Global sales of equipment for District Heating, $ million

$ million	2016	2017	2018	2019	2020	2021
Network						
Substations						
Dwelling HIUs						
Internal pipework						
Building meters						
Dwelling meters						
Dwelling HCAs						
Total						

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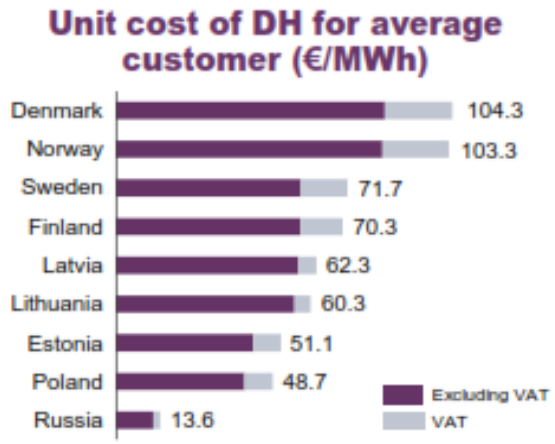
Because of the localised nature of District Heating networks markets must be assessed in their regional units. The District Heating market is unusual because it was dominated by the Soviet Union. Most markets are led by western technology, investment and marketing and the CIS countries have a small share of the global pie. With District Heating, although the technology is primitive and far behind that of Europe, the legacy markets of the CIS and China still have an 82 % share of the global market, although the CIS share has declined from 71% to 53%.

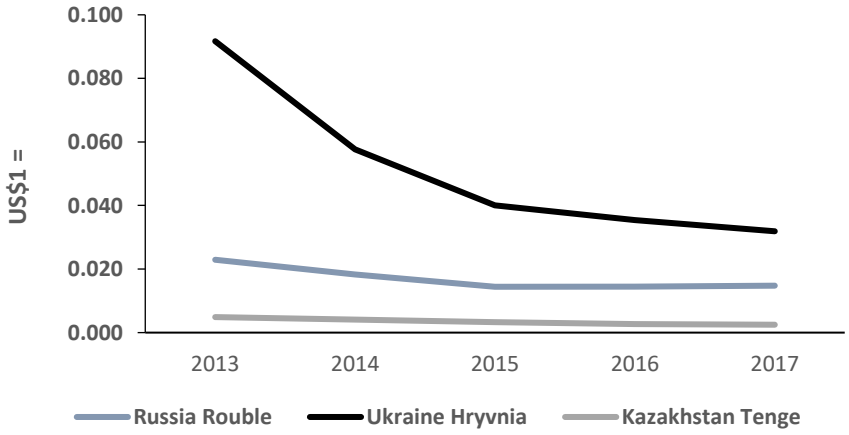
Figure : Russia DH prices compared with Western European countries



There is a huge inequality when comparing heat prices in Western European countries with those in Russia and the CIS republics, and there are large variations within Europe. This inequality is exacerbated by the falls in value of the CIS currencies between 2013 and 2017. Currency losses in the CIS republics in this period have been huge; 36% for the Russian rouble, 65% down for the Ukrainian hryvnia and 50% for the Kazakh tenge.

1

Figure : Exchange rates for the Russian rouble, the Ukrainian hryvnia and the Kazakh tenge, to the US $, 2013 to 2017



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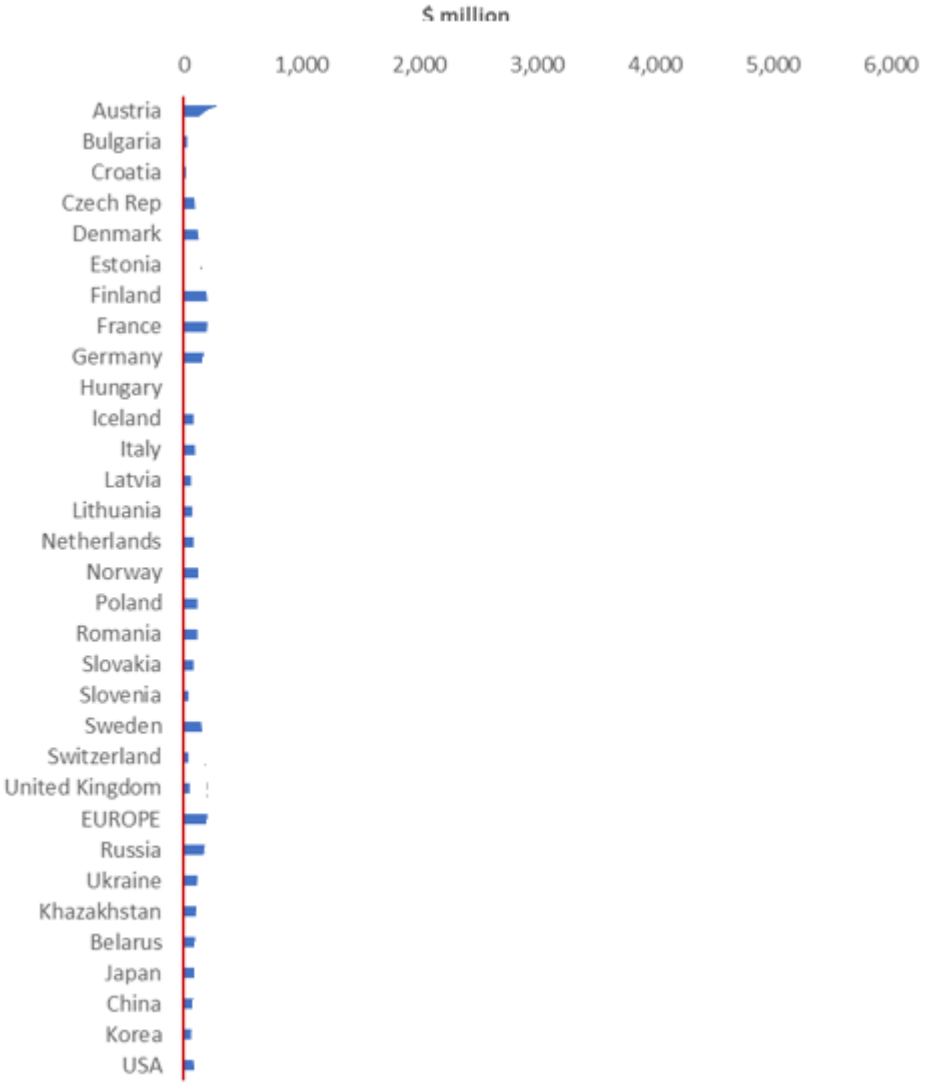
DISTRICT HEATING CAPEX AND EQUIPMENT SALES

Capital expenditure in 2016 was $XXX billion.

Capital expenditure for District Heating networks is lumpy; it has been volatile and evinces almost no pattern within many individual countries. For example, in Austria it went from $XXX million in 2009 down to $XXX million in 2011 and $XXX6 million in 2013. In the neighbouring Czech Republic, it dropped marginally from $XXX to $XXX between 2009 and 2011, but then rose to $XXX million in 2013. Part of the reason for this is that capex is relatively small for many countries and a few largish components in the work for the year can constitute a large chunk of the total capex.

Figure 2: District heating capex in 2016, in $ million.



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District Cooling

District cooling supply in EU-27 is about XX TWh yearly. It covers XX% of the total District Heating market in EU-27 (XXX TWh), and XX % of the potential district cooling market (about XXX TWh).

Figure: District Cooling Supply in Europe, GWh, 2014