Overview of District Heating and Cooling Markets and Regulatory Frameworks under the Revised Renewable Energy Directive

Annexes 3 to 5
Final version

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District Heating and Cooling in the European Union

Overview of Markets and Regulatory Frameworks under the Revised Renewable Energy Directive

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List of acronyms

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie (French agency for environment and energy management)
AGFW	Energieeffizienzverband für Wärme, Kälte und KWK (German energy efficiency association for heating, cooling and CHP)
APG	Algemene Pensioen Groep (Dutch Pension Fund)
Art	Article
ATES	Aquifer Thermal Energy Storage
AVBFernwärmeV	Verordnung über Allgemeine Bedingungen für die Versorgung mit Fernwärme (Ordinance on General Terms and Conditions for the Supply of District Heating Germany)
BTES	Borehole Thermal Energy Storage
CAPEX	Capital Expenditure
CAPM	Capital Asset Pricing Model
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
COC	Condensable Organic Compounds
COP	Coefficient Of Performance
CoP	European Statistics Code of Practice
COx	Oxides of Carbon
CPC	Compound Parabolic Collector
CSP	Concentrated Solar Power
CTR	Centralkommunernes Transmissionsselskab I/S (Metropolitan Copenhagen Heating Transmission company)
DC	Distrcit Cooling
DCS	District Cooling Systems
DH	District Heating
DHC	District Heating and Cooling
DHW	Domestic Hot Water
DN	Nominal Diameter (in mm)
EC	European Commission
ECJ	European Court of Justice
EED	Energy Efficiency Directive
ELAN	Evolution du logement de l'aménagement et du numérique (Evolution of housing, development and the digital environment)
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Coefficient
EPCC	Engineering, Procurement, Construction and Commissioning
ESIF	European Structural and Investment Funds

ESP	ElectroSubmersible Pump
ESS	European Statistical System
EU	European Union
EWRC	Energy and Water Regulatory Commission (Bulgaria)
GHG	GreenHouse Gases
GW	GigaWatt
GWB	Gesetz gegen Wettbewerbsbeschränkungen (Act against Restraints of Competition in Germany)
GWh	GigaWatt hour
HC	Heating and Cooling
HeizkostenV	Verordnung über Heizkostenabrechnung (Ordinance on the Settlement of Heating Costs)
IHP	Independent Heat Producer
kW	KiloWatt
kWh	KiloWatt hour
L-CNG	Liquid to Compressed Natural Gas
LNG	Liquefied Natural Gas
MID	Measuring Instruments Directive
MS	Member State
MW	MegaWatt
MWe	MegaWatt electric
MWh	MegaWatt hour
MWth	MegaWatt thermal
na; n/a	not available
NCC	National Commission on Energy Prices (Lithuania)
NECP	National Energy and Climate Plan
NERC	National Energy Regulatory Counci (Lithuania)
Nm3	Normal cubic meter
No.	Number
NOx	Oxides of Nitrogen
NRA	National Regulatory Authority
NUP	National Urban Policy
nZEB	nearly Zero Energy Building
OPEX	Operational Expenditure
ORC	Organic Rankine Cycle
P2P	Point-to-Point
PEC	Primary Energy Consumption
PM	Particulates Matter
pp	Percentage Points
RED	Renewable Energy Directive

RES	Renewable Energy Sources
RES-HC	Renewable Heating and Cooling
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SOx	Oxides of Sulphur
TO4	Thematic Objective 4
TPA	Third Party Access
TPS	Third Party Supplier
TSO	Transmission System Operator
UK	United Kingdom
URE	Energy Regulatory Office Electricity (Poland)
URSO	Úrad pre reguláciu sieťových odvetví (Office for Regulation of Network Industries Slovakia)
VAT	Value Added Tax
VEKS	Vestegnens Kraftvarmeselskab I/S (DH Company Copenhagen)
VOC	Volatile Organic Compounds
VST	Vilniaus Šilumos Tinklai (DH Company in Lithuania)
WWTP	WasteWater Treatment Plant

Annex 3: List of statistical sources

Table 1: List of statistical sources

Country	Statistical source	Statistics published by the sources
Austria	• Statistics Austria, https://www.statistik.at/web_en/statistics/index.html	• DH Balance, https://www.statistik.at/wcm/idc/idcplg?IdcService=GET_NATIVE_FILE&RevisionSelectionMethod=LatestReleased&dDocName=036280
Belgium	• Belgian statistical office, https://statbel.fgov.be/en/about-statbel	• Energy DHC, https://www.nsi.bg/en/content/17164/district-heating-and-cooling-systems
Bulgaria	• National statistical institute, https://www.nsi.bg/en	
Croatia	• Croatian Bureau of Statistics, https://www.dzs.hr • Croatian Energy Regulatory Agency (HERA), https://www.hera.hr/en/	• Annual reports with data on DH, https://www.hera.hr/en/html/annual_reports.html
Cyprus	• Statistical Service of Cyprus, https://www.mof.gov.cy/	
Czech Republic	• Czech Statistical Office, https://www.czso.cz/csu/czso/home • Energy Regulatory Office (ERU), https://www.eru.cz/cs/	• Annual reports with data on DH, https://www.eru.cz/en/zpravy-o-provozu-teplarenskych-soustav
Denmark	• Statistics Denmark, https://www.dst.dk/en • Danish Energy Agency, https://ens.dk/en • Danish Board of District Heating, https://dbdh.dk/	• Energy consumption, including DHC, https://www.statbank.dk/ENETYPE • Energy statistics, including DHC, https://ens.dk/en/our-services/statistics-data-key-figures-and-energy-maps/annual-and-monthly-statistics
Estonia	• Statistics Estonia, https://www.stat.ee/en	
Finland	• Statistics Finland, https://www.stat.fi/index_en.html • Finnish Energy, https://energia.fi/en	• Production and consumption of DH, http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehk/statfin_ehk_pxt_012_en.px • DH statistics, https://energia.fi/en/newsroom/publications/district_heating_statistics.html#material-view
France	• Institut national de la statistique et des études économiques, (INSEE), https://www.insee.fr/fr/accueil • French Federation for Energy & Environment Services (FEDENE), http://www.fedene.fr/	• Annual reports with data on DH, https://www.fedene.fr/wp-content/uploads/sites/2/2019/12/SNCU-Rapport-Global-2019-Restitution-enquete-r%C3%A9seaux.pdf
Germany	• Federal Statistical Office (Destatis), https://www.destatis.de/ • Energy efficiency association for heating, cooling and CHP (AGFW), https://www.agfw.de/	• Annual report on CHP and DH, https://www.agfw.de/zahlen-und-statistiken/agfw-hauptbericht/
Greece	• Hellenic Statistical Authority (ELSTAT), https://www.statistics.gr/en/home/	
Hungary	• Hungarian Central Statistical Office (HCSO), https://www.ksh.hu/?lang=en • Association of Hungarian District Heating Suppliers (MaTáSzSz), http://www.tavho.org/	• Annual data of the DH sector, http://tavho.org/tudaskozpont/statisztika
Ireland	• Central Statistics Office (CSO), https://www.cso.ie/en/	

Country	Statistical source	Statistics published by the sources
Italy	• Italian National Institute of Statistics (Istat), https://www.istat.it/en/ • Regulatory Authority for Energy, Networks and Environment (ARERA), https://www.arera.it/it/index.htm	• Annual reports with data on DH, https://www.arera.it/it/inglese/annual_report/relaz_annuale.htm
Latvia	• Central Statistical Bureau of Latvia (CSB), • https://www.csb.gov.lv/en/sakums	• Heat energy balance, https://data1.csb.gov.lv/pxweb/en/vide/vide__energetika__ikgad/ENG160.px
Lithuania	• Lithuanian Department of Statistics (Statistics Lithuania), https://www.stat.gov.lt/ • Lithuanian DH Association, https://lsta.lt/en/	• Energy indicators, including DH, https://osp.stat.gov.lt/statistiniu-rodikliu-analize?indicator=S1R003#/
Luxem-bourg	• National Institute of Statistics and Economic Studies (STATEC), https://statistiques.public.lu/en/	
Malta	• National Statistics Office (NSO), https://nso.gov.mt/en/	
Nether-lands	• Statistics Netherlands (CBS), https://www.cbs.nl/en-gb	
Poland	• Statistics Poland, https://stat.gov.pl/en/ • Energy Regulatory Office, https://www.ure.gov.pl/en	• Annual report with data on DH, https://www.ure.gov.pl/pl/cieplo/energetyka-cieplna-w-l/8386,2018.html
Portugal	• Instituto Nacional de Estatística (INE), https://www.ine.pt/	
Romania	• National Institute of Statistics (NIS), https://insse.ro/cms/en	
Slovakia	• Statistical Office of the Slovak Republic, https://slovak.statistics.sk	
Slovenia	• Statistical Office of the Republic of Slovenia (SURS), https://www.stat.si/StatWeb/en • Energy Agency, https://www.agen-rs.si/web/en	• Annual report with data on DH, https://www.agen-rs.si/web/en/-/annual-report-on-teh-energy-sector-in-slovenia-for-2019
Spain	• Instituto Nacional de Estadística (INE), https://www.ine.es/ • Association of Heat and Cold Network Companies, http://www.adhac.es/	• Data on DHC, http://www.adhac.es/Priv/propio.php?id=8
Sweden	• Statistics Sweden, https://www.scb.se/en/ • Swedisch Energy Agency, http://www.energimyndigheten.se/en/	• Annual statistics with DHC, https://scb.se/en/finding-statistics/statistics-by-subject-area/energy/energy-supply-and-use/annual-energy-statistics-electricity-gas-and-district-heating/ • Energy statistics, including DH, http://www.energimyndigheten.se/en/facts-and-figures/statistics/
UK	• Office for National Statistics, https://www.ons.gov.uk/	
Iceland	• National Statistical Institute of Iceland, https://www.statice.is/ • National Energy Authority, https://nea.is/	• Energy data, including DH, https://nea.is/the-national-energy-authority/energy-data/data-repository/
Norway	• Statistik Sentralbyra (SSB), https://www.ssb.no/en	• DHC, https://www.ssb.no/en/energi-og-industri/statistikker/fjernvarme
Ukraine	• State Statistics Service of Ukraine (Ukrstat), https://ukrstat.org/en	• Indicators DH, https://ukrstat.org/en/operativ/operativ2012/pr/etgv/etgv_e/ok_tm_11e.html

Disclamer: The links were collected in 2020 and beginning of 2021. The completeness of the list cannot be guaranteed, as a full and comprehensive list is impossiible to complie and not long up to date.

Annex 4: Regulatory regimes applied to district heating and cooling

The following applies to the entries in the tables from Annex 4:

- When a country does not present any DH or DC systems, it is excluded from the analysis and marked with "na" for "not applicable" in the table below. For instance, Malta and Cyprus do not present any DHC networks so these countries are excluded from the following analysis.
- When no data was collected from the survey nor found in the literature for a country, the data field is marked with "-".

1.1. Measuring

Table 2: Overview of regulatory requirements for metering of district heat and cold for the purpose of billing in the Member States including UK, Iceland, Norway and Ukraine (Source:Own survey with input from national DHC stakeholders)

Country	Regulation on DHC metering	Regulation on individualised metering	Regulation on remote metering/reading	Ambitious roll out of smart DHC metering	Predominant method for heat metering (a-c)[2)]
Austria	Yes	No	No	No	a
Belgium[1)]	Yes	Yes	Yes	Yes	a
Bulgaria	Yes	Yes	-	No	a
Croatia	-	-	-	-	-
Cyprus	na	na	na	na	na
Czech Republic	Yes	Yes	No	No	a
Denmark	Yes	Yes	No	Yes	a
Estonia	Yes	Yes	Yes	Yes	a
Finland	Yes	No	-	Yes	a
France	Yes	Yes	-	Yes	a
Germany	Yes	Yes	No	No	a
Greece	No	Yes	No	No	b
Hungary	Yes	No	No	No	a
Ireland	Yes	Yes	No	No	-
Italy	No	No	No	No	c
Latvia	Yes	Yes	-	-	-
Lithuania	Yes	No	Yes	Yes	a
Luxembourg	-	-	-	-	-
Malta	na	na	na	na	na
Netherlands	Yes	Yes	No	No	a
Poland	Yes	Yes	No	Yes	a
Portugal	-	-	-	-	-
Romania	Yes	Yes	No	No	a
Slovenia	Yes	Yes	No	No	a
Slovakia	Yes	Yes	No	No	a
Spain	No	No	No	No	a
Sweden	Yes	No	No	No	a
UK	Yes	Yes	No	No	c
Iceland	No	No	No	Yes	c
Norway	No	No	No	No	a
Ukraine	Yes	Yes	-	-	-

1) Answers are only provided for Flanders as there is no legal framework on DHC in place in Brussels and Wallonia.

2) Predominant method for heat metering: (a) Metering the water flow rate and the temperature differential between the inlet and the outlet, (b) Metering the water flow rate and the temperature level of the inlet, (c) Metering the water flow rate only

Table 3: Overview of legal requirements for providing statistical data in the Member States including UK, Iceland, Norway and Ukraine (Source: Own survey with input from national DHC stakeholders)

Country	Legal obligation to collect DHC statistics as defined in EED	Obligation to report renewable sources used for DHC by type	Responsible body for data collection and reporting
Austria	Yes	Yes	Austrian Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology
Belgium[1)]	Yes	Yes	Flemish Energy Agency (VEA)
Bulgaria	Yes	Yes	Ministry of Energy
Croatia	-	-	-
Cyprus	na	na	-
Czech Republic	Yes	Yes	Energy Regulatory Office; Ministry of Industry and Trade
Denmark	Yes	Yes	District heating association; the Danish Energy Agency
Estonia	No[3)]	-	Statistics Estonia
Finland	Yes	Yes	Statistics Finland (reporting); Finnish Energy (data collection from DHC companies)
France	Yes	Yes	SNCU (Syndicat National du Chauffage Urbain et de la Climatisation Urbaine) on behalf of the Ministry for the Environment
Germany	Yes	Yes	State Statistical Offices and Federal Statistical Office
Greece	Yes	Yes	na
Hungary	Yes	Yes	Hungarian Energy Office; Ministry of Innovation and Technology
Ireland	No	-	-
Italy	No	-	-
Latvia	-	-	-
Lithuania	No	Yes	National Commission for Energy Control and Prices of the Republic of Lithuania
Luxembourg	-	-	-
Malta	na	Na	na
Netherlands	No	No[1]	-
Poland	Yes	Yes	Energy Regulatory Office
Portugal	-	-	-
Romania	Yes	Yes	-
Slovenia	Yes	Yes	Energy Agency
Slovakia	Yes	-	Slovak Energy and Innovation Agency
Spain[2)]	No	No	-
Sweden	Yes	Yes	Swedish Energy Agency
UK	Yes	-	Department for Business, Energy & Industrial Strategy
Iceland	No	-	-
Norway	Yes	-	-
Ukraine	-	-	-

[1] Obligation to report on sustainability (CO_2, renewable fraction, primary energy). An Obligation to report detailed data on different renewables is not in place, but improving the data is planned.

1) Answers are only provided for Flanders as there is no legal framework on DHC in place in Brussels and Wallonia.

2) No legal obligation, but Measure 1.6 "Framework for the development of thermal renewable energies" of the PNIEC ensures data collection and reporting

3) According to Estonian Competition Authority there is no obligation. But data is collected, and statistics are provided based on the Official Statistics Act.

Table 4: Overview of legal requirements for providing statistical data in the Member States including UK, Iceland, Norway and Ukraine (Source: Own survey with input from national DHC stakeholders)

Country	Legal obligation for DHC companies to provide data	Scope of obligation for DHC companies
Austria	Yes	Share of CHP, heat delivery to sectors, network length, district cooling
Belgium[1)]	Yes	Heat production, heat supply, losses
Bulgaria	Yes	Heat production, heat supply, losses, sales of combined and non-combined electricity and heat, usage of basic production and reserve fuels, fuel caloric content, production effectiveness coefficients
Croatia	-	-
Cyprus	na	na
Czech Republic	Yes	Heat production, heat supply, losses, price calculation (costs and profit), fuel shares/composition
Denmark	Yes	Heat production, heat supply, losses, prices, fuels shares/composition, share of CHP
Estonia	Yes	Heat production, heat supply, losses
Finland	Yes	Heat production, heat supply by sector, losses, fuel type, price
France	Yes	Energy mix, prices, network length (collected data confidential)
Germany	Yes	Heat production, heat supply, losses, fuel shares/composition, own consumption, generation capacities, heat carrier/ fluid, grid extension or dismantling
Greece	Yes	Heat supply, losses
Hungary	Yes	Heat production, heat supply, losses, fuel type
Ireland	No	-
Italy	No	-
Latvia	-	-
Lithuania	Yes	Heat production, heat supply, losses, fuel type
Luxembourg	-	-
Malta	na	na
Netherlands	Yes	Heat production, heat supply, losses, CO_2-emissions per GJ, fraction of renewable heat
Poland	Yes	Heat production, heat supply, losses
Portugal	-	-
Romania	Yes	Heat production, heat supply, losses, fuel type, price
Slovenia	Yes	Heat production, heat supply, losses
Slovakia	Yes	Heat supply, losses
Spain	Yes[2)]	Depending on concession; fuel consumption, yields, energy generated and sold to end customers, prices and rates applied to each end customer

Country	Legal obligation for DHC companies to provide data	Scope of obligation for DHC companies
Sweden	Yes	Heat production, heat supply, economical/ business statistics on operation
UK	Yes	Heat production, heat supply
Iceland	Yes	Heat production, heat supply, revenues, number of users and connections
Norway	Yes	Heat production, heat supply
Ukraine	-	-

1) Answers are only provided for Flanders as there is no legal framework on DHC in place in Brussels and Wallonia.

2) Only DHC-Systems developed under a concession regime

1.2. Pricing regimes and support schemes

Table 5: Overview of regulations on district heating pricing in the Member States including UK, Iceland, Norway and Ukraine (Source: Own survey with input from national DHC stakeholders)

Country	DHC prices regulated/ liberalised	Price control in place	Price control ex-ante or ex-post	If ex-post, mandatory for all suppliers or only on request
Austria	Liberalised	Yes	Ex-ante/Ex-post[1)]	Both options
Belgium[2)]	Liberalised	No	-	-
Bulgaria	Regulated	Yes	Ex-ante	Mandatory all
Croatia	Regulated	Yes	Ex-ante	Mandatory all
Cyprus	na	na	na	na
Czech Republic	Regulated	Yes	Ex-post	On request
Denmark	Regulated	Yes	Ex-post	Mandatory all
Estonia	Regulated	Yes	Ex-ante	Mandatory all
Finland	Liberalised	Yes	Ex-post	On request
France	Liberalised	Yes	Ex-ante	Mandatory all
Germany	Liberalised	Yes	Ex-post	On request
Greece	Liberalised	No		
Hungary	Regulated	Yes	Ex-ante	Mandatory all
Ireland	Liberalised	No		
Italy	Liberalised	No		
Latvia	Regulated	Yes	Ex-ante	Mandatory all
Lithuania	Regulated	Yes	Ex-ante	Mandatory all
Luxembourg	Liberalised	na	na	na
Malta	na	na	na	na
Netherlands	Regulated	Yes	Ex-post	Mandatory all
Poland	Regulated	Yes	Ex-ante	Mandatory all
Portugal	Liberalised	No		
Romania	Regulated	Yes	Ex-ante	Mandatory all
Slovenia	Regulated	Yes	Ex-ante	Mandatory all
Slovakia	Regulated	Yes	Ex-post	Mandatory all
Spain	Liberalised	No		
Sweden	Liberalised	No		
UK	Liberalised	No		
Iceland	Regulated	Yes	Ex-ante	
Norway	Regulated	Yes	Ex-post	On request
Ukraine	Regulated	Yes	Ex-ante	Mandatory all

1) Depending on the Bundesland
2) Answers are only provided for Flanders as there is no legal framework on DHC in place in Brussels and Wallonia.

1.1. Connection and access to DHC networks (Third Party Access)

Table 6: Overview of third party access (TPA) regulations in the Member States, the UK, Iceland, Norway and Ukraine (Source: Own survey with input from national DHC stakeholders)

	If TPA is allowed (at least in principle)

Country	Regulation on TPA	Restrictions for TPA	Exceptions for TPA	Open retail market (full TPA)	Producer TPA	Regulation of grid access: mandatory vs. voluntary	Regulation of grid access: negotiated vs. regulated
Austria	No			No	Yes	voluntary	negotiated
Belgium[1)]	No			No	Yes	voluntary	negotiated
Bulgaria	Yes	-	a,b,d[3)]	No	Yes	mandatory	regulated
Croatia	No			No	Yes	voluntary	negotiated
Cyprus	na	na	na	na	na	na	na
Czech Republic	Yes	I,II[2)]	a,b,c[3)]	No	Yes	mandatory	negotiated
Denmark	No			No	Yes	voluntary	negotiated
Estonia	Yes	I[2)]	No	No	Yes	mandatory	regulated
Finland	No			No	Yes	voluntary	negotiated
France	No			No	Yes	voluntary	negotiated
Germany	No			No	Yes	voluntary	negotiated
Greece	No			No	No		
Hungary	No			No	Yes	voluntary	negotiated
Ireland	No			No	Yes	voluntary	negotiated
Italy	No			No	Yes	voluntary	negotiated
Latvia	Yes	-	a,b,c[3)]	No	Yes	mandatory	negotiated
Lithuania	Yes	-	a,b,c[3)]	No	Yes	mandatory	regulated
Luxembourg	-	-	-	-	-	-	-
Malta	na	na	na	na	na	na	na
Netherlands	Yes	-	-	No	Yes	voluntary	negotiated
Poland	Yes	-	c[3)]	Yes	Yes	mandatory	negotiated
Portugal	No			No	No		
Romania	Yes	-	-	-	-	-	-
Slovenia	-	-	-	-	-	-	-
Slovakia	Yes	II[2)]	a,b,c[3)]	No	Yes	mandatory	
Spain	No						
Sweden	Yes	II[2)]	c[3)]	No	Yes	mandatory	negotiated
UK	No						
Iceland	-	-	-	-	-	-	-
Norway	Yes	No	a,b,c[3)]	Yes	Yes	mandatory	negotiated
Ukraine	-	-	-	-	-	-	-

[1)] Answers are only provided for Flanders as there is no legal framework on DHC in place in Brussels and Wallonia.

[2)] Occasions at which TPA is required, e.g. (I) TPA required when new demand needs to be covered or existing heat production capacities need to be replaced, (II) TPA for RES-H/excess heat only, (III) TPA restricted to large DHC systems

[3)] (a) Grid lacks the necessary capacity, (b) heat does not meet the required technical parameters, (c) negative impact on costs for customers, (d) other reasons

Table 7: Overview of level of unbundling (obligation) of DHC systems in the Member States including UK, Iceland, Norway and Ukraine (Source:Own survey with input from national DHC stakeholders)

Country	Unbundling requirements	Level of unbundling	Partial unbundling: specification
Austria	No	-	-
Belgium[1)]	No	-	-
Bulgaria	No	-	-
Croatia	-	-	-
Cyprus	na	-	-
Czech Republic	No	-	-
Denmark	No	-	-
Estonia	No	-	-
Finland	No	-	-
France	No	-	-
Germany	No	-	-
Greece	No	-	-
Hungary	No	II[2)]	Unbundling of production and grid operation/retail
Ireland	No	-	-
Italy	No	-	-
Latvia	Yes	III[2)]	Only financial unbundling requirement (full)
Lithuania	Yes	III[2)]	Full financial/ accounting undundling; Independent Heat Producers
Luxembourg	-	-	-
Malta	na	-	-
Netherlands	No	-	-
Poland	No	-	-
Portugal	-	-	-
Romania	Yes	na	-
Slovenia	No	-	-
Slovakia	No	-	-
Spain	No	-	-
Sweden	No	-	-
UK	No	-	-
Iceland	No	-	-
Norway	No	-	-
Ukraine	-	-	-

[1)] *Answers are only provided for Flanders as there is no legal framework on DHC in place in Brussels and Wallonia*

[2)] *Level of unbundling: (I) no unbundling obligation, (II) partial unbundling, (III) full unbundling of all three levels of supply chain*

1.2. Overview on subsidies and financial incentives

DHC grid infrastructure

Table 8: Overview on subsidies and financial incentives targeting DHC grid infrastructure

Subsidies and financial incentives targeting DHC grid infrastructure						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available / spent budget
Austria	Y	AWISTA, KPC, ÖMAG, UFI, federal agencies	DHC suppliers, natural and legal persons	Financing grants	Depending on project	€ 80 millions annually (2017-2021)
Belgium	N	-	-	-	-	-
Bulgaria	Y	Bulgarian Energy Efficiency and Renewable Sources Fund (EERSF)	Municipalities, SMEs, Universities and Hospitals, companies, private persons	Low interest loans	Interest of 4-7 % per year (3.5-5.5 % per year for companies and private persons)	-
Croatia	N	-	-	-	-	-
Cyprus	N	-	-	-	-	-
Czech Republic	Y	Ministry of Industry and Trade (ERDF)	Companies	Financing grants	Around € 9,600 to € 3.8 million for RES projects	Around € 57 million (from 2014 to 2020)
Denmark	N	-	-	-	-	-
Estonia	Y	Environmental Investment Centre	DH opcoators/owners; heat producers, companies	Financing grants	78 applications rounds from 2008 to 2020	Around € 255 millions from 2008 to 2020 (899 grants)
Finland	N	-	-	-	-	-
France	Y	ADEME	Collective houseing, communities and companies	Financing grants and tax exemptions	Grants / tax exemptions if RES and waste heat share >60 % />50	€ 1.6 billion supporting 4.000 projects (2009-2016)

Subsidies and financial incentives targeting DHC grid infrastructure						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available / spent budget
					%	
Germany	Y	Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) and KfW	Municipalities, private companies	Financing grants and low interest loans	Up to 15 million € (max. 50 % of eligible costs)	€ 100 millions (2020)
Greece	N	-	-	-	-	-
Hungary	Y	Environmental and Energy Efficiency Operational Programme (EEEOP)	Civil organisations, church institutions, companies, public institutions	Financing grants	Depending on project	Around € 1.01 billion (from 2014 to 2020)
	Y	Ministry of Innovation and Technology	DH companies	Financing grants	-	-
Ireland	Y	Department of Communications, Climate Change and the Environment (DCCAE)	Heat users not in the Emission Trading System	Financing grants	Up to 50 % of eligible costs	-
Italy	N	-	-	-	-	-
Latvia	N	-	-	-	-	-
Lithuania	Y	Lithuanian Business Support Agency (LVPA)	DH companies	Financing grants	Up to 50 % of eligible costs	€ 101 millions (2014-2020)
Luxembourg	Y	Ministers responsible for Small Enterprises and for the budget	Natural and legal persons running a company	Financing grants	Up to 50 % of eligible costs	-
	Y	Ministry of Environment	Municipalities	Financing grants	Depending on project	-
Malta	N	-	-	-	-	-

Subsidies and financial incentives targeting DHC grid infrastructure						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available / spent budget
Netherlands	Y	Netherlands Enterprise Agency, tax authority	Companies	Tax exemption	Up to 54.5 % of eligible costs (investment max. € 121 million per year)	-
	Y	The Ministry of Economic Affairs and Climate	Large transport networks	Being discussed	-	-
Poland	Y	NFOŚiGW	Companies	Subsidies and low interest loans	Depends on region	-
Portugal	N	-	-	-	-	-
Romania	N	-	-	-	-	-
Slovakia	Y	Slovak Innovation and Energy Agency (SIEA)	DH companies	-	-	-
Slovenia	N	-	-	-	-	-
Spain	Y	Multiregional Operational Program of Spain (POPE)	Investors (in case of investment in RES)	Financing grants	-	-
Sweden	Y	Swedish Environmental Protection Agency	Companies	Financing grants	-	-
United Kingdom	N	-	-	-	-	-

Renewable and efficient DHC energy generation

Table 9: Overview on subsidies and financial incentives targeting renewable and efficient DHC generation

Subsidies and financial incentives targeting renewable and efficient DHC generation						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available / spent budget
Austria	Y	Kommunalkredit Public Consulting (KPC)	Companies	Financing grants	Up to 35 % of eligible costs	€ 20 millions (2020-2021)
Belgium	Y	Flemish Energy Agency (VEA)	Companies	Financing grants and low interest loans	Calls at least once a year (twice in 2020)	€ 3 millions for green heat and € 7 millions for DH
Bulgaria	Y	The Bulgarian state	Building owners	Tax exemption	Additional 3/2 years if RES used in buildings national classes "B/C"	-
Croatia	N	-	-	-	-	-
Cyprus	N	-	-	-	-	-
Czech Republic	Y	Ministry of Industry and Trade, Ministry of the Environment (ERDF)	DH companies, Public institutions	Financing grants	Up to total project´s eligible expenditures by EU (up to 15 % support by the state)	Around € 0.5 billion (from 2014 to 2020)
Denmark	Y	Danish Ministry of Taxation	Companies	Tax exemption	Amount of tax relief is equal to the tax rate of respective persons	-
Estonia	Y	-	-	-	-	-

Subsidies and financial incentives targeting renewable and efficient DHC generation						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available / spent budget
Finland	Y	The Energy Authority (Ministry of Economic Affairs and Employment)	CHP energy producers	Premium tariff	50 €/MWh (biogas) or 20 €/MWh (wood)	-
	Y	Ministry of Economic Affairs and Employment or Finnish Funding Agency for Innovation (Tekes)	Companies, municipalities and communities	Financing grants	Up to 40 % of the project's total cost	-
France	Y	ADEME	Collective houseing, communities and companies	Financing grants and tax exemptions	Grants / tax exemptions if RES and waste heat share >60 % />50 %	€ 1.6 billion supporting 4.000 projects (2009-2016)
Germany	Y	Kreditanstalt für Wiederaufbau (KfW)	SMEs, municipalities, local authorities	Low interest loans with grant payback support	Depending on project	
	Y	Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA)	Private Persons, SMEs, municipalities, local authorities	Financing grants	Depending on project	€ 1.8 billion per year due to KWKG (law)
Greece	N	-	-	-	-	-
Hungary	Y	Ministry of Innovation and Technology	DH companies	Financing grants	-	-
Ireland	Y	Department of Communications, Climate Change and the Environment (DCCAE)	Heat users not in the Emission Trading System	Financing grants	Up to 50 % of eligible costs	-
Italy	Y	Gestore dei Servizi Energetici (GSE)	Public institutions and private individuals or institutions	Financing grants	Depending on project	The cap is set at € 900 million per

Subsidies and financial incentives targeting renewable and efficient DHC generation						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available / spent budget
						year
Latvia	N	-	-	-	-	-
Lithuania	Y	The Lithuanian state	Natural and legal persons	Tax exemption	Amount of tax relief is equal to the tax rate of respective persons	-
	Y	Lithuanian Business Support Agency (LVPA)	DH companies	Financing grants	Depending on project	€ 24 millions
Luxembourg	Y	Ministers responsible for Small Enterprises and for the budget	Natural and legal persons running a company	Financing grants	Up to 50 % of eligible costs	-
	Y	Ministry of Environment	Municipalities	Financing grants	Depending on project	-
Malta	N	-	-	-	-	-
Netherlands	Y	The Ministry of Economic Affairs and Climate Policy	Every energy producer	Premium tariff	Between €ct 3.3 and €ct 10.0 per kWh for up to 15 years	The cap is set at € 12 billion (for applications in 2018)
	Y	Netherlands Enterprise Agency, tax authority	Companies	Tax exemption	Up to 54.5 % of eligible costs (investment max. € 121 million per year)	-
Poland	Y	NFOŚiGW	Companies	Low interest loans	Max. 85 % of eligible costs (for up to 15 years)	€ 132.71 million (from 2015 to 2023)

Subsidies and financial incentives targeting renewable and efficient DHC generation						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available / spent budget
Portugal	N	-	-	-	-	-
Romania	N	-	-	-	-	-
Slovakia	Y	Ministry of Environment of the Slovak Republic	Natural or legal persons authorised to conduct companies	Financing grants	Depending on project	Around € 939 million (from 2014 to 2020)
Slovenia	Y	Environmental Fund (Eko Sklad)	Natural or legal persons	Low interest loans	Depending on project (duration up to 15 years)	Around € 16 million (from three public calls currently open)
	Y	Environmental Fund (Eko Sklad)	Depending on respective calls	Financing grants	Depending on project	€ 44.9 million (for two calls in 2017)
Spain	Y	Pluriregional Operational Program of Spain (POPE)	Investors (in case of investment in RES)	Financing grants	-	-
Sweden	Y	The Swedish Tax Authority, Swedish Environment Protection Agency	Suppliers, importers and producers of heating from RES, Companies	Tax exemption	Amount of tax relief is equal to the tax rate of respective persons	-
United Kingdom	Y	Department of Energy and Climate Change (BEIS)	Every energy producer	Premium tariff	Between €ct 2.42 and €ct 12.5 per kWh for up to 20 years	-

Research, technology development and demonstration of innovative DHC systems

Table 10: Overview on subsidies and financial incentives targeting research, technology development and demonstration of innovative DHC systems

Subsidies and financial incentives directly targeting research, technology development and demonstration of innovative DHC systems						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available/ spent budget
Austria	Y	Österreichische Forschungsförderungs-gesellschaft (FFG)	Companies, municipalities research institutions, private persons	Depending on project	Depending on project	-
Belgium	N	-	-	-	-	-
Bulgaria	N	-	-	-	-	-
Croatia	N	-	-	-	-	-
Cyprus	N	-	-	-	-	-
Czech Republic	Y	Ministry of Industry and Trade	DH companies	Financing grants	-	-
Denmark	Y	EUDP	Research projects	Financing grants	-	-
Estonia	N	-	-	-	-	-
Finland	Y	Ministry of Economic Affairs and Employment or Finnish Funding Agency for Innovation (Tekes)	Companies, municipalities and communities	Financing grants	Up to 40 % of the project's total cost	-
France	N	-	-	-	-	-
Germany	Y	Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA)	Municipalities, private companies	Financing grants	Up to € 600,000 (max. 60 % of eligible costs)	-
Greece	N	-	-	-	-	-
Hungary	N	-	-	-	-	-
Ireland	N	-	-	-	-	-
Italy	N	-	-	-	-	-
Latvia	N	-	-	-	-	-

Subsidies and financial incentives directly targeting research, technology development and demonstration of innovative DHC systems						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity & phasing	Available/ spent budget
Lithuania	N	-	-	-	-	-
Luxembourg	N	-	-	-	-	-
Malta	N	-	-	-	-	-
Netherlands	Y	RVO	Companies	Financing grants	Depending on project	-
Poland	Y	NFOŚiGW	Companies	Subsidies and low interest loans	Depends on region	-
Portugal	N	-	-	-	-	-
Romania	N	-	-	-	-	-
Slovakia	N	-	-	-	-	-
Slovenia	N	-	-	-	-	-
Spain	N	-	-	-	-	-
Sweden	Y	Swedish Energy Agency	Private and public sector, academia, companies	Financing grants and low interest loans	-	SEK 79 millions per year
United Kingdom	N	-	-	-	-	-

Connection of end users to DHC grids

Table 11: Overview on subsidies and financial incentives targeting connection of end-users to DHC grids

Subsidies and financial incentives directly targeting connection of end-users to DHC grids						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity and phasing	Available / spent budget
Austria	Y	KPC, federal states, municipalities	Companies and private persons	Financing grants and loans	Up to 35 % of eligible costs	-
Belgium	N	-	-	-	-	-
Bulgaria	N	-	-	-	-	-
Croatia	N	-	-	-	-	-
Cyprus	N	-	-	-	-	-
Czech Republic	N	-	-	-	-	-
Denmark	N	-	-	-	-	-
Estonia	Y	-	-	-	-	-
Finland	N	-	-	-	-	-
France	N	-	-	-	-	-
Germany	Y	Kreditanstalt für Wiederaufbau (KfW)	SMEs, municipalities, local authorities	Financing grants and loans with grant payback support	Depending on project	
Greece	N	-	-	-	-	-
Hungary	N	-	-	-	-	-
Ireland	N	-	-	-	-	-
Italy	N	-	-	-	-	-
Latvia	N	-	-	-	-	-
Lithuania	Y	Lithuanian Business Support Agency (LVPA)	DH companies	Financing grants	Depending on project	-
	Y	Respective heat suppliers (grid operators)	Independent producers of renewable heat	Purchase obligation for RES heat from independent	-	-

Subsidies and financial incentives directly targeting connection of end-users to DHC grids						
Country	Existence (Y/N)	Responsible funding agency	Addressees	Form of support	Intensity and phasing	Available / spent budget
				producers		
Luxem-bourg	N	-	-	-	-	-
Malta	N	-	-	-	-	-
Netherlands	Y	RVO	Private persons and renting organizations	Financing grants	About 40 % of investment costs	€ 193 millions
	Y	Netherlands Enterprise Agency, tax authority	Companies	Tax exemption	Up to 54.5 % of eligible costs (investment max. € 121 million per year)	-
Poland	Y	NFOŚiGW	Companies	Low interests Loans	Max. 85 % of eligible costs (for up to 15 years)	€ 699 million (from 2015 to 2023)
Portugal	N	-	-	-	-	-
Romania	N	-	-	-	-	-
Slovakia	N	-	-	-	-	-
Slovenia	N	-	-	-	-	-
Spain	N	-	-	-	-	-
Sweden	N	-	-	-	-	-
United Kingdom	N	-	-	-	-	-

Annex 5: Details on national regulation and urban planning

5.1. Impact of national building codes and related standards on DHC systems across the EU

In order to provide a broad overview on the impact of national building codes and related legislative standards and regulations, investigations on ten focus countries were performed. The aim was to provide insight on the national situations concerning energy efficiency in buildings and the impact of respective legislations on DHC. As a result, country case studies for the focus countries of Austria, Denmark, Finland, France, Germany, Lithuania, Netherlands, Poland, Slovak Republic and Sweden are presented in this annex.

Austria

A brief overview

Austria implemented the EPBD through its nine federal provinces and thus strengthened the development of building regulations. The Austrian national building regulation directive "OIB-Guideline 6" aims for high energy efficiency standards in buildings and is revised regularly. The Concerted Action EPBD Country Report of Austria [1] as well as the OIB-Guideline 6 [2] are the basis for the following information.

Building codes and related standards in Austria

In Austria, the legal sovereignty concerning implementation of building regulations lies in hand of federal provinces. In order to harmonise the implementation of the EPBD, the Austrian Institute of Construction Engineering (OIB) was assigned to publish today's OIB Directives.

The OIB Directive 6 defines the requirements for the thermal performance of buildings including protection against summer overheating and harmful condensation resulting from thermal bridges in winter. Domestic hot water and parts of the technical H&C systems are also considered in this Directive. Furthermore, the Directive sets requirements concerning the use of RES in buildings.

Compliance with the requirements of OIB Directive 6 concerning energy and climate efficient building performance can be achieved in two ways. The first approach is by ensuring a tight building envelope in order to achieve space heating demand below the specified maximum permissible final energy demand. The second approach makes use of the so-called total energy efficiency factor, which reflects the type of energy use and production. In case that the second method is applied, a slightly higher space heating demand of buildings is acceptable under the condition of very efficient or RES-based systems. Anyhow, in both cases, maximum values for PEC and CO_2 emissions are defined.

The European Eco Design Directive (2009/125/EC) is implemented in Austrian legislation through the "Ökodesign-Verordnung 2007", which includes specific requirements for heating, ventilation and air conditioning systems to guarantee the implementation of energy-efficient technologies. Furthermore, regular on-site inspections and monitoring of the emissions of such systems are required. Inspection reports or protocols are collected by the provinces and made available for inspectors (e.g. chimney sweepers or heating engineers).

Metering is regulated depending on the energy forms. Space heating and hot water consumption metering are regulated by the heating metering law ("Heizkostenabrechnungsgesetz - HeizKG"). Legal obligations for installing intelligent meters are only given for the electricity sector, but are not present for the metering of gas or DH.

Description of building codes and their relevance for DHC in Austria

The Austrian building code (OIB Directive 6) does not recommend the use of certain energy supply technologies and accordingly, does not promote DHC directly. Nevertheless, the OIB Directive 6 pushes toward efficient and RES-based supply of buildings, which can indirectly and positively influence the utilization of DHC systems. While individual heat supply systems are applicable in low dense regions such as rural areas, grid-bound heat supply can facilitate the implementation of OIB guidelines in larger cities like Vienna. Furthermore, the wide spread availability of DH networks can also facilitate the phase-out of gas boilers and increase of RES-based heat supply. This can potentially result in revising the OIB 6 concerning the decrease of values for PEFs and CO_2 factors for DH.

Denmark

A brief overview

In Denmark, an early introduction of future requirements in building policy and regulation can be considered as a tradition (before they actually become mandatory). As an example, the equivalent to the nZEB definition, namely "Building Class 2020", designated in 2011 as a voluntary measure. This approach gives all stakeholders the opportunity to prepare for, develop and experiment future regulations and push the Danish building industry toward highly efficient and cost-effective buildings. In Denmark, the responsible authority for the implementation of the EPBD is Danish Energy Agency. The Concerted Action EPBD Country Report of Denmark [3] as well as a report on the latest Danish Building Regulations [4] are the basis for the following information.

Building codes and related standards in Denmark

Energy consumption in new buildings has steadily declined since the introduction of the first energy requirements in buildings regulation in 1961. The current Danish energy performance requirements were implemented through the Danish Building Regulation in 2006. In 2016, the previously voluntary "Low-energy Class 2015" became binding and presented as "Danish Building Regulation 2015" (BR2015). Today, an updated version of this regulation exists and is called Danish Building Regulations 2018 (BR18).

BR18 sets energy performance requirements on maximum PEC for all types of new buildings as well as for existing buildings after anyalteration that affects the energy consumption in the building. In addition to the requirements defined by BR18, it also sets additional guidelines for a voluntary "Building Class 2020", which is equivalent to nZEB level. The minimum energy performance sets limits for buildings maximum PEC. To reach this, a certain thermal indoor climate as well as airtightness must be proven. Furthermore, there are requirements for a wide range of technical building equipment systems such as boilers, ventilation units, combined heat and power appliances, heat pumps and circulation pumps.

The Danish Standard DS 469 ("Heating and cooling systems in buildings") specifies that H&C systems must be sized, designed, controlled and operated according to defined functional requirements. Use, operation and maintenance are hereby also considered. Ventilation systems in buildings must comply with Danish Standards DS 447 ("Ventilation for buildings – Mechanical, natural and hybrid ventilation systems").

Concerning metering, technical systems must have individual meters installed if energy consumption exceeds certain levels. This depends on the technical equipment applied.

There are minimum annual energy values triggering metering requirements e.g. for heat pumps, ventilation units, heating coils or for preparation of domestic hot water.

Description of building codes and their relevance for DHC in Denmark

The EPBD implementation is achieved through activities such as advisory services, tax benefits and use of RES for heating purposes. The goal is to increase the efficiency and phase out oil and gas in the heating sector. In Denmark, oil and natural gas boilers are no longer allowed in new buildings since 2013. The focus lies on replacement of fossil fuel firing boilers by other efficient or renewable heating sources like heat pumps, solar energy or DH.

According to the Danish Building Regulation (BR18) energy efficiency must always be maintained at a cost-efficient level. From this perspective, DHC can fullfill the BR18 requirements. DH is very strongly developed as well as highly accepted in Denmark and therefore plays a substantial role for the energy supply of the building stock.

Finland

A brief overview

In Finland, building energy efficiency regulations on PEC have been in place since 1976. The Ministry of the Environment is the responsible agency for implementing the EPBD and thus, involved in shaping the national building codes. Minimum requirements on PEC have been developed for new buildings as well as for existing buildings undergoing renovations and retrofitting. Definition and regulation of nZEB have been successfully implemented and the revision of the Land Use and Building Act (132/1999) came into force in 2017. The Concerted Action EPBD Country Report of Finland [5] as well as the Finnish National Building Code [6] are the basis for the following information.

Building codes and related standards in Finland

The Land Use and Building Act sets the basis for the national building code of Finland. The latest version of the Land Use and Building Act was released in 2018. It specifies general conditions concerning buildings, technical requirements, building permit procedures and building supervision by the authorities. The technical requirements are not limited but concerne energy efficiency in buildings. Calculations for the energy performance of buildings include consideration of thermal comfort, indoor-air quality and infiltration, thermal bridges and sun protection devices. Requirements for energy consumption of buildings aim to set a level for nZEB in Finland.

The minimum energy performance requirements of new buildings are based on overall energy consumption. Therefore, calculation has to be performed either by using PEFs for different energy sources (as well as standard user profiles) or by considering defined requirements for building components which, however, may only be applied for single-family houses and apartment buildings. The maximum values depend on the building type and in case of single-family houses, also on the net heated floorarea of the building.

The Finnish strategy on renovation of existing buildings focuses less on determining requirements but rather on initiating energy efficiency improvements through professionally planned and corrective maintenances. This involves communication measures and training building professionals in decision making, services and financial calculations related to renovation projects.

The Building code does not exclude any heating sources nor technologies in particular. Though, it encourages using RES and DH. This is achieved through lower PEFs applied for DH and RES (like solar heating and solar power), resulting in lower calculated primary energy needs of a building.

Description of building codes and their relevance for DHC in Finland

DH contributes substantially to the Finnish heat supply. The Finnish national building code does not directly promote DHC., Although the building code does not exclude the use of any heating sources nor heating technologies in buildings, it encourages using RES and DH. This is indirectly achieved through setting the same PEFs for DH as for RES. In contrast, PEFs of technologies based on fossil fuels or electricity are rated considerably higher. Therefore, it can be stated that DHC is indirectly promoted through low PEFs in the Finnish national building code.

France

A brief overview

In France, the implementation of the EPBD is done by the Ministry for an ecological and solidary transition and the Ministry of territory cohesion. The implementation of the EPBD is achieved through determination of requirements for the energy performance of new and existing buildings, followed by issuing energy performance certificates and inspecting of heating and air conditioning systems. The Concerted Action EPBD Country Report of France [7] is the basis for the following information.

Building codes and related standards in France

The EPBD has been implemented through different laws. The law on the national commitment to the environment (2010/788) has significantly improved the energy performance certification. The Thermal Regulation (RT 2012) brought energy efficiency of new buildings on nZEB level (whereby the term "Low Consumption Energy Building" describes the nZEB standard in France). The Energy Transition for Green Growth Act includes provisions on energy efficiency in the building sector.

The Thermal Regulation (RT 2012) is based on three performance indicators, which aim at the components of new building envelope as well as its energy systems. The first requirement is set for minimum energy efficiency of new buildings by imposing a limitation on energy demand. The second requirement imposes a limitation on PEC for the combined use of heating, cooling domestic hot water, lighting and auxiliaries. The third requirement is on summer comfort, determining a certain reference temperature level, which must not be exceeded in new buildings. Furthermore, new residential buildings have to meet a certain air-tightness quality. Finally, there are requirements for a minimum amount of RES for new buildings, depending on the kind of RES.

For existing buildings, there are two thermal regulations that can be applied, namely the Regulation by Building Component and the Global Thermal Regulation. In case of major renovations, the surface area as well as the year of construction are relevant to determine whether the Regulation by Building Component or the Global Thermal Regulation has to be applied. If minor renovations are realised, the Global Thermal Regulation must not be used. At the moment, renovated buildings do not systematically reach the nZEB level and therefore, certain quality seals were created by the French Government to encourage building owners to go beyond the defined requirements in the regulations.

In 2013, the National Plan for Housing Thermal Renovation was launched. This National Plan is providing independent advice to private individuals for free, optimising grants based on households' incomes and is raising the skills in the construction sector to better handle costs and the quality of renovations.

Description of building codes and their relevance for DHC in France

The Regulation by Building Component sets specifications on minimum efficiency of boilers, heat pumps, air conditioning and ventilation systems, in case they are not covered by the Ecodesign Directive 2009/125/EC.There are certain loans for financing of building renovations and particularly, improving heating systems. These loans explicitly focus on the building envelope and the installation of high-performing technical building systems as well as RES heating or domestic hot water systems. However, they do not address DHC. This could be due to the reason that DHC systems are not widely used in France. Therefore, there is still potential in better inclusion of the DHC in revisions of the building codes in order to prioritise DHC systems.

Germany

A brief overview

Germany implemented a first holistic approach towards energy efficient buildings in 2002, when the Energy Saving Ordinance ("EnEV") was introduced. EvEV replaced the legislation on thermal insulation of buildings ("WschV") and the legislation on system requirements for central heating ("HeizAnlV"). In order to implement the EPBD in Germany, the calculation standard for overall energy performance of buildings was first published by the German Institute for Standardisation (DIN) in 2005. The energy efficiency requirements were strengthened in 2009 due to the Energy Saving Ordinance.At the same time, a certain percentage of RES use for new buildings was legally anchored through the Renewable Heat Act ("EEWärmeG"), which should later as well include requirements for major renovations of public buildings. The Concerted Action EPBD Country Report of Germany [8] as well as the German Building Energy Act [9] are the basis for the following information.

Building codes and related standards in Germany

Until the beginning of November 2020, requirements on energy performance of buildings as well as on the minimum share of RES in buildings were subject of two regulations. Firstly, the Energy Saving Ordinance, which regulated the energy performance of new and existing buildings concerning PEC. Secondly the Renewable Energies Heat Act, which prescribed the mandatory minimum share of RES to cover the demand for heating, cooling and domestic hot water in buildings. Today, the Building Energy Act ("GEG") comprises all legal requirements concerning energy in buildings. PEFs can be derived from GEG for different energy sources; however, GEG does not provide PEFs for DH systems.

A step towards nZEB was made with the Energy Saving Ordinance, which was introduced to comply with the EPBD. Hereby, the main energy performance requirements for new buildings were defined. This included minimum requirement for new building´s thermal envelopes, a maximum non-renewable primary energy demand (determined individually for each building) as well as a minimum percentage of RES for space heating, cooling and domestic hot water.

In order to reduce the non-renewable primary energy demand of the existing building stock, three instruments are considered to be used at the same time. These instruments are aiming at the three topics of regulatory law, financial incentives and information and advice. When relevant refurbishment of a building is done, minimum requirements from the Energy Saving Ordinance have to be met. Often, those minimum requirements are even surpassed due to existing programs like the program for residential and non-residential buildings (KfW program), the incentive program for energy efficiency (APEE) and the incentives program for heating with RES (MAP), contributing to retrofitting of residential buildings.

Description of building codes and their relevance for DHC in Germany

The former Renewable Energies Heat Act did consider DH with a substantial share of RES as well as waste and/ or CHP as a heat supply option based on RES. Even in case of DH systems not using RES, they were still equally treated as RES (in cases that their energy performance was at least 15% better than required by the building code).

Though, the newly passed GEG (from November 2020) does not provide explicit PEFs for DH anymore and therefore, the status of DHC in terms of building code requirements is unclear. RES-based DH systems could be a key for reaching primary energy requirements set by the GEG, in case that the PEFs for DH would still be applied.

Lithuania

A brief overview

The building sector has become one of the priority areas for Lithuania in order to meet its climate and energy targets. Construction of new buildings as well as increase of renovation activities for existing buildings are targeted by Lithuania. The EPBD and the calculation of cost-optimal levels of building energy performance requirements have been transposed into Lithuanian law, bringing Lithuania on track towards implementing all relevant requirements. The Concerted Action EPBD Country Report of Lithuania [10] is the basis for the following information.

Building codes and related standards in Lithuania

In Lithuania, the Ministry of Environment together with the Ministry of Energy are responsible for the implementation of the EPBD. Hereby, the main requirements are prescribed through the Law on Construction and the Law on Energy. Furthermore, energy efficiency requirements and respective calculation procedures are prescribed through detailed technical regulations such as the Building Technical Regulation STR 2.01.02:2016 ("Design and Certification of Energy Performance of Buildings").

By law, new buildings in Lithuania (including building units) must be certified for achieving building specific energy efficiency objectives after the completion of the construction phase. The STR sets the nZEB requirements for new buildings in Lithuania, which are equivalent to the most ambitious energy efficiency class (A++). Besides requirements for the thermal quality of the building´s envelope (and various other energy relevant parameters), most of the energy consumption in nZEB must be covered by RES.

The Programme for the Modernisation of Multi-family apartment houses; set in Lithuania´s Resolution No 1213 of September 2004; is one fo the main programes that promotes the renovation of existing buildings. This program supports and encourages apartment owners to implement energy efficiency measures through renovation and retrofitting.

Description of building codes and their relevance for DHC in Lithuania

In Lithuania, STR is applied to both new and existing buildings and defines various parameters for determination of the building energy performance class. STR includes two indicators C1 and C2 with regards to the energy supply., C1 refers to the non-renewable primary energy efficiency for heating, ventilation, cooling and lighting. C2 refers to the non-renewable PEF for domestic hot water preparation. Another important parameter in the STR with regards to the RES is the buildings renewable energy consumption.

The STR does not directly address DHC. However, the building energy performance indicators C1 and C2 as well as the indicator of renewable energy consumption in the building promote grid bound heating and cooling supply by taking the DHC PEF in Lithuania into the consideration.

Netherlands

A brief overview

In Netherlands, a national energy agreement ("Energie Akkoord") was signed in 2013 by all relevant market participants and other stakeholders, setting requirements for energy efficiency improvements and the use of RES in buildings as proposed by the EPBD. The signatures of various relevant key organisations evidently highlights a broad, existing support for the market uptake of an energy-efficient and energy-neutral building stock in the near future. The Concerted Action EPBD Country Report of Netherlands [11] is the basis for the following information.

Building codes and related standards in Netherlands

Energy performance requirements for new buildings in Netherlands have been updated on a regular basis since 1995. Ambitious requirements were introduced after so called tightening studies. The tightening studies included an analysis of the market penetration of energy efficient measures, renewable energy technologies and energy efficient H&C. They were carried out by consulting companies supervised by the Dutch Agency for Enterprises on behalf of the Dutch Ministry of the Interior. In 2012, the Energy Performance Standard for Buildings ("EPG") replaced existing standards and since then, is applied to the residential and non-residential sector.

The energy performance calculation methods for new and existing buildings are defined in Standard NEN 7120. This standard provides the calculation methods for the PEC of buildings, methods for calculating the thermal quality of the construction and requirements for technical building equipment (e.g. thermal quality of the building envelope, ventilation and air infiltration, hot water use, lighting and day-shading, efficiency of heating and cooling and renewable energy use).

The main parameter for the energy performance of new buildings is the energy performance coefficient, which is based on the estimated total PEC of a building. It is defined as the quotient of a building´s calculated annual primary energy demand to the allowed primary energy performance. The calculation of the energy performance coefficient is part of the building permit procedure and is mandatory for all new buildings and also is applied to existing buildings in case of major renovations.

Major renovations of existing buildings may only be applied in cases that the calculation of the energy performance coefficient of the renovated building delivers the minimum requirements set by the EPG. Minor renovations only require minimum performance of the building envelope. To reach a high renovation rate in Netherlands, a combination of information-sharing, awareness-raising, and support funding was identified and chosen as the most effective measure. In the end of 2016, the Energy Agenda was presented, listing the long-term requirements on renovation in order to achieve energy effiecient building stocks in 2050.

Description of building codes and their relevance for DHC in Netherlands

In Netherlands, no explicit requirement for energy efficiency measures in building's technical system exists. Instead, buildings have to reach a certain level of efficiency indicated by the energy performance coefficient. This ensures cost-efficient solutions for thermal quality measures in combination with heating, domestic hot water, air conditioning and ventilation systems. As proposed by the Energy Agenda, the strategy is to achieve CO_2 neutrality through low temperature heating by 2050. One of the decisions that was made to reach this goal is the gradual reduction of the use of natural gas. Even though the strategies will most likely vary at regional and local levels, it can be expected that the DH system will also gradually move toward RES and low supply temperature (e.g. 4th generation of DH systems).

Poland

A brief overview

In Poland, the introduction of energy efficiency regulations, which are in line with the EPBD, increased the number of energy efficient buildings and helped raising public awareness. An array of legislations (e.g. on inspections of heating and air conditioning systems, energy assessment of buildings components and Energy Performance Certificates) as well as building codes are used for the implementation of EPBD. The Concerted Action EPBD Country Report of Poland [12] is the basis for the following information.

Building codes and related standards in Poland

The Polish Ministry of Infrastructure and Construction published the "Guide to Improve the Energy Performance of Buildings" in 2016, offering significant support and advice in energy efficient construction. This guideline provides instruction for improving the energy performance of new and existing buildings and also provides information about national and regional incentives for actions supporting energy performance increase.

Energy performance requirements for new buildings apply for both the building components and the building's technical equipment. In addition, in case of non-residential buildings minimum energy performance requirements on lighting systems are defined as well. Hereby, the maximum energy performance index specifies the amount of annual non-renewable energy that may be used for space heating, ventilation, cooling and domestic hot water (as well as lighting for non-residential buildings). The energy performance index should be calculated according to the formula provided by the regulation on the energy performance of buildings (§329 p.1 or 3).

The national nZEB plan of Poland sets actions for promoting the use of RES in new and existing buildings. It furthermore states the characteristics of buildings with low energy consumption and sets a timeline for achieving the goals corresponding to the EPBD.

The "Regulation on the methodology for the energy assessment of buildings and their parts, as well as for EPCs" determines the minimum shares of RES from final energy demand of buildings as well as PEFs for certain energy sources, inter alia for non-renewable HD supplied by thermal power plants as well as renewable and non-renewable DH supplied by cogeneration plants.

The energy performance requirements, recommendations on air-tightness for building envelopes and minimum thermal insulation of pipes and components in heating, cooling and domestic hot water are all defined in the "Regulation of the Minister of Infrastructure of 12 April 2002 on the technical conditions that buildings and their locations must meet".

Description of building codes and their relevance for DHC in Poland

The Polish building code provides values on maximum PEC in buildings. The PEC in combination with the PEFs given for various energy carriers, can be seen as an opportunity for the DHC sector. Anyhow, DHC systems are not implicitly supported by the Polish building code.

Slovakia

A brief overview

Since the first introcution of the EPBD in Slovakia, minimum requirements for the energy performance of buildings has been continuously improved. Strong interlinkage of different policies and steady improvement led to a successful implementation of the EPBD, where thermal protection standards and regulations on the energy use of technical systems initiated a decrease in energy demand. The Concerted Action EPBD Country Report of the Slovak Republic [13] is the basis for the following information.

Building codes and related standards in the Slovak Republic

The regulations on energy performance of buildings in Slovakia is defined by the Ministry of Transport, Construction and Regional Development. On the other hand, regular inspection of buildings' technical equipments is the responsibility of the Ministry of Economy. The EPBD has been implemented by Act 300/2012 on the energy performance of buildings. The definition of nZEB was introduced by Decree 364/2012, replacing the former indicator for total energy use in buildings by the primary energy use. Requirements on buildings envelopes and the energy needed for heating are set in the national standard for thermal protection STN 73 0540-2:2012, which also provides the gradual improvement of requirements.

New buildings in Slovakia should fulfil the requirements for ultra-low energy construction (Class A1), where requirements for PEC are set depending on the building class. Requirements on building components are the same for residential and non-residential buildings. For the thermal protection of the envelope, requirements are presented in the national standard STN 73 0540-2:2012/Z1:2016. The use of RES and heat recovery is mandatory in new buildings, whereas the calculated primary energy is based on delivered energy and respective PEFs (stated in the Ministerial Decree 324/2016; calculation of primary energy factors for district heating is subject to Ministerial Decree 308/2016). Minimum efficiency requirements are set for heating, cooling and ventilation as well as for domestic hot water, but there are no regulations defining the minimum efficiency of any building's technical system as a whole. However, building designers must always assess the possibility of alternative renewable energy systems, CHP and DHC before the construction works start.

Major renovations have to meet the requirements of ultra-low energy construction, if feasible. The "Strategy for the rehabilitation of the residential and non-residential building stock" was approved by Government Resolution 347/2014. In order to meet the primary energy requirements of a building, renovation of the building's technical system is needed. In case of no potential for efficiency improvement in the heating system (e.g. it is not possible to influence the PEF), the building must meet the requirements of energy class A for its total energy use.

Description of building codes and their relevance for DHC in the Slovak Republic

An efficient, RES-based DHC system can be a serious rival for other heating technologies as building codes and regulations oblige building designers to assess the possibility of utilizing renewable energy systems, CHP or DHC systems in a building during the planning phase.

Sweden

A brief overview

Energy performance assessment of buildings has been important for achieving higher energy efficiency in buildings. Higher construction quality, efficient building management and efficient operation of building's technical equipment could be achieved in Sweden in the recent years. Through awareness raising and knowledge transfer, the actual energy use has been further decreased. In order to perform building energy performance assessment, the actual energy consumption has been used and is strongly supported by the construction and real estate sectors. The Concerted Action EPBD Country Report of Sweden [14] is the basis for the following information.

Building codes and related standards in Sweden

In Sweden, the Planning and Building Act (2010:900) as well as the Planning and Building Ordinance (2011:338) are the primary pieces of legislation applied to buildings from a construction and planning perspectives. The Planning and Building Act was amended in 2018 (SFS 2018:1370) and the same applies for the Planning and Building Ordinance (SFS 2018:1390). The latest version of the building regulation for determining energy performance of buildings are in place since the end of 2016 (BFS 2016:13 and BFS 2016:12).

Energy performance regulations for new buildings are based on measured delivered energy, including heating, cooling, domestic hot water and other energy consumptions such as lighting. New buildings must comply with the building´s specific energy performance requirements, with the installed maximum electric power rating for heating devices and with the average thermal transmittance of the building envelope. In order to heat a building in accordance with the regulations, compliance with certain maximum allowable values for electrical as well as non-electrical heating is mandatory. The primary energy ratio (PE-ratio) hereby limits the maximum total PE factor applicable by setting a primary energy limit for the mixed use of electrical and non-electrical heating.

Concerning the building's technical equipment of new buildings, Sweden uses functional measures instead of detailed requirements. In this sense, no detailed requirements are set on any specific aspects of the building's technical system; but rather on the system as a whole. Therefore, a building is regarded as compliant if the total measured energy consumption value is in lign with the requirements.

Requirements for existing buildings only come into force when the building is altered. In case of renovation or refurbishmend, the altered parts of the building are treated as new buildings and therefore, have to comply with the regulations set for new buildings. For existing buildings, U-value requirements apply when the building envelope is altered. Alteration of the technical building system in existing buildings also comes with requirements for the new system components.

There is no inspection requirement in place for heating and air conditioning systems. Sweden rather decided to tackle the issue of inefficient heating and cooling components by providing energy and climate advisors and other professionals to develop and customise information activities on energy efficiency measures for the important target groups. This is mainly due to the fact that 95% of the energy used for space heating is covered by DH and electricity.

Description of building codes and their relevance for DHC in Sweden

The application of maximum values for electrical and non-electrical heating is an important factor that can affect DHC in Sweden. Due to the PE-ratio which can be derived from these values, Sweden has developed a useful tool to promote district energy usage for buildings. The PEF applied to DHC systems makes DH a relevant energy source to fulfil primary energy requirements of buildings.

5.2. Urban planning and urban regulations affecting the use of DHC – Case studies on selected cities across the EU

Urban planning and other urban regulations can have crucial impact on the use of DHC system. Examples from Denmark and more recently from Switzerland or Netherlands show that spatial planning, in particular zoning of DH priority zones may be an important trigger for DH.

The profitiblity of DH grid investments strongly depends on the degree of utilization of this infrastructure. Zoning and spatial planning has the potential to strongly increase the share of connected buildings within the supply area and thus, lowering the distribution costs for consumers.

Urban planning and regulations by nature have a local character. They often differ substantially among regions and cities within a country or even within the same region. However, urban planning can also be triggered by national legal provisions and policies.

In order to provide insight to the H&Cplanning and regulations as well as in DHC conditions in European cities, 13 case studies from European cities were selected. This includes Bolzano, Copenhagen, Frankfurt, Graz, Helsinki, Ljubljana, Miskolc, Oradea, Plovdiv, Stockholm, Vienna, Vilnius and Warsaw. Concretely, the following main aspects will be covered in the case studies, as long as relevant information could be extracted:

- Heating and cooling planning in urban development plans
- DH zoning the municipality
- Local RES & waste heat in supply side
- Ownership by municipality
- Municipality influence on the DH company business plan

The information provided in this section are obtained mainly by desktop research. For the case studies of Copenhagen, Graz, Helsinki and Vilnius, expert interviews were conducted additionally to provide comprehensive insight and detailed information on the respective cities. and show the distribution of the city case studies on the map and their corresponding key data, respectively.

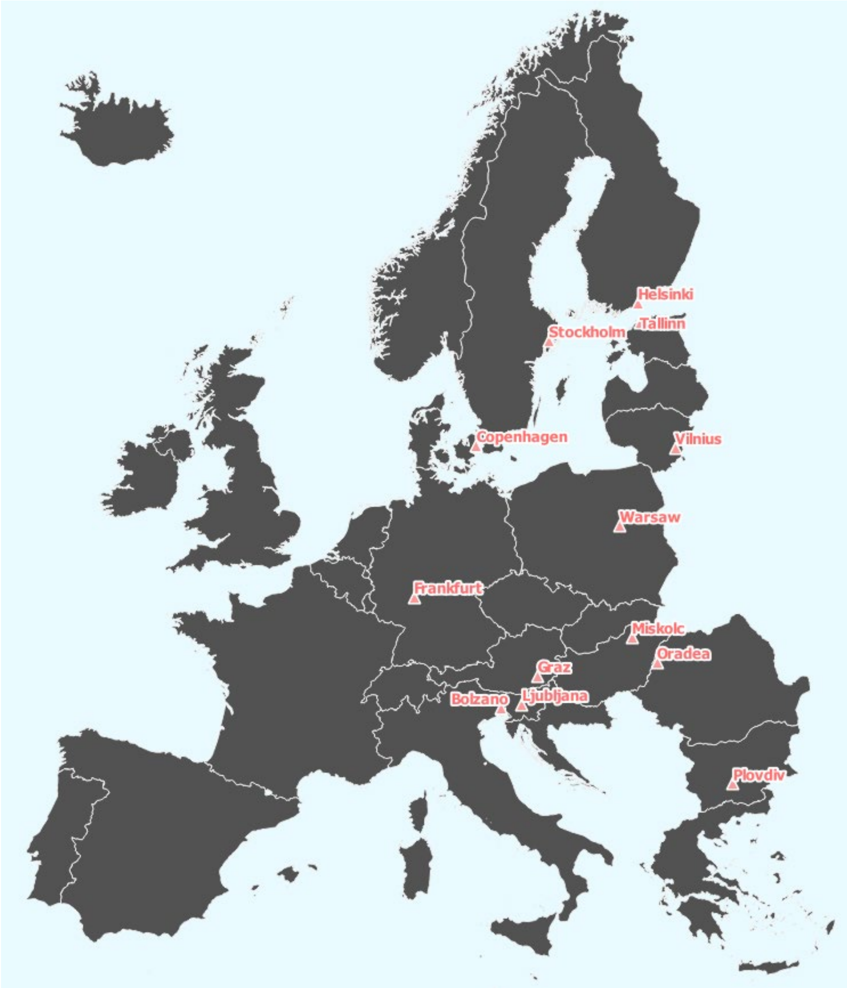

Figure 1: The 13 cities chosen for the city case studies

	DH market share	RES Share	Heat planning regulation	Zonning regulation	Price regulation	Municipality involvement	Public ownership
Copenhagen, Denmark	98%	35%	✓	✓	✓	✓	100%
Graz, Austria	40%	23%	✓	✓	✓	✓	2%
Helsinki, Finland	92%	11%	X	X	X	X	100%
Vilnius, Lithuania	80%	54.5%	✓	✓	✓	✓	99.4%
Bolzano, Italy	16%	90%	-	-	✓	✓	88%
Miskolc, Hungary	32%	51%	-	-	✓	✓	100% Gen.
Stockholm, Sweden	90%	90%	✓	X	X	✓	50%
Frankfurt am Main, Germany	75%	1.3%	✓	-	X	✓	75%
Ljubljana, Slovenia	75%	14%	✓	X	✓	✓	87%
Plovdiv, Bulgaria	75%	0%	✓	X	✓	✓	0%
Oradea, Romania	70%	6.8%	-	-	✓	✓	100%
Tallinn, Estonia	70%	63%	✓	✓	✓	✓	0%
Warsaw, Poland	80%	0%	✓	-	X	✓	0%

(✓) Existing; (-) under specific conditions; (x) Non-existent

Figure 2: Key data for the city case studies

Copenhagen

Denmark´s capital city, Copenhagen, is located on the coastal islands of Zealand and Amager. Copenhagen has around 630,000 inhabitants and a population density of about 7,300 inh/km2. The city provides a major part of the heat needed through an interconnected DH system, which connects the two main networks as well as two smaller networks. The distribution network in Copenhagen Municipality is owned and operated by HOFOR while the transmission companies CTR and VEKS sell heat to HOFOR and local DH companies in the municipalities around Copenhagen, who then re-sell it to consumers. The daily heat plans and load dispatching in the DH system of CTR, HOFOR, and VEKS are planned and operated in cooperation with their shared company "Varmelast".

The information for the case study of Copenhagen was obtained through literature research making use of [15]as well as through an interview conducted with an expert on DHC from Copenhagen [16]. Detailed information can be found in and in the text below.

Table 12: Characteristics of DHC, urban planning and urban regulations in Copenhagen

Characteristics of Copenhagen	
DHC:	
Installed DH capacity	base load capacity about 2.000 MW_{th} peak load capacity about 2.000 MW_{th}
Lenght of network	160 km
Supply mix	25% heat from waste incineration 70% excess heat from power plants 5% heat from boiler plants
Customers	75 million m^2 of heated net floor area
District cooling	at date, 5 DC systems in city centre plans for increasing the number to >20
DHC ownership shares	owned mostly by municipalities
	-
Urban planning and urban regulations:	
Heat planning	local municipalities are responsible
Zoning	local municipalities are responsible
Municipality involvement in DHC	highly given
Heat price regulation	cost based

Introduction to DHC in Copenhagen

In the 1980s, the two main DH grids were connected. Today, the Copenhagen DH grids can be considered as one interconnected system with a shared load dispatching unit. Between the two main grids though, still a bottleneck of about 400 MW_{th} exists, which is not planned to be widened since this would not be economically arguable. Furthermore, the steam system of Copenhagen is planned to be shutdown in the near future. Processes that still require steam will most likely have to change to on-site steam production. From the present point of view, further development for DHC systems are considered rather for small local grids than for the large distribution systems. As DHC systems mostly have been historically grown, exact replicability is never fully possible. Though, many good examples can be taken from the Copenhagen DHC systems in order to build, expand and improve other DHC systems elsewhere in the world.

Renewable energy for DHC in Copenhagen

The municipality of Copenhagen has the target of being CO_2-neutral until 2025 and so does the owner of the DH distribution network (HOFOR). The pathway towards Copenhagen´s climate neutrality started during the oil crisis in 1973, when many power plants were switched to coal and gas all over Denmark. The increasing focus on RES in Copenhagen started by exchanging large coal- and gas-fired production units by biomass plants. The next step towards sustainable energy supply will be to find solutions for the use of biomass in many places. Today, Denmark has to import a large share of the biomass needed. It is expected that in the future, heat pumps and geothermal energy sources will become more revalent. Even though there are no priorities given for the feed-in of RES to the grids, energy from waste is being preferred. However, the main challenge for CO_2-neutrality is the significant share of plastic in the waste that is burned in the waste incineration plants (considered roughly as 60% renewable and 40% fossil). Even though the price for waste energy is relatively high due to the fact that the taxation does not differ between a renewable and a non-renewable share, it will still be very complicated to completely remove waste energy from the energy mix. This is due to the fact that there will be some fossil production capacities left that might be rather expensive to be replaced by RES. From today´s perspective, a realistic approach to reach CO_2-neutrality would not only be phasing out fossil fuels; but also using carbon capture and storage (CCS) methods, which are already being tested in Denmark.

To reduce the CO_2-emissions in the building stock, DHC is incentivised and buildings have to be connected to the heating grid. In case that the demand is lower than 250 kW, an individual heating solution may be applied if at the same time the connection fee for the DHC system is still being paid. If the demand is above 250 kW, all the heat has to be taken from the grid. There are ongoing discussions in the city that may lead to more autonomy for building owners for choosing individual renewable H&C systems (under the condition that positive environmental impact can be demonstrated). Buildings supplied by natural gas are mainly incentivised to switch to DHC due to the price situation since DHC prices are moderate while natural gas prices are rather high due to taxes applied on energy and CO_2-emissions. H&C prices can also be influenced by negotiation between conventional heat suppliers and third parties in case that it comes to distribution of heat to the grid by TPA (no TPA to DC networks possible). All in all, the targets for CO_2 reduction mainly address the use of RES, while the focus on energy efficiency measures is smaller. This may over time result in reduced utilisation factors for the heat production units due to higher building performance. Anyway, grid operators seem to not see this as a critical issue since the reduced heat demand could be compensated by expansion of the grids. Another future development will be reaching lower grid temperature levels, which results in lower losses as well as the opportunity to integrate low temperature, local renewables.

Heat planning and zoning in Copenhagen

The heat planning that was practiced in the 1980s divided Denmark in different supply zones. This can be traced even today in Greater Copenhagen, where heat is supplied either from DH or from natural gas. One serious barrier for the expansion of DH is the financial issue of transforming natural gas areas to DH areas since such development would be highly costly. Danish legislations on heating make the municipalities responsible for heat planning, but do not define how often the plans shall be revised. For a while now, various Danish municipalities have been developing their own climate plans including heat planning and zoning, since H&C is the most feasible issue, which can be tackled by the municipalities. As a result, many heat plans have been updated during the last five to ten years. Today, DH zoning is applied in Copenhagen (this does not count for DC since it is more or less regulated as a free market). Detailed zoning for DH can be seen as a strong policy support, which is sometimes considered as discriminative by natural gas companies. Complains have been raised by natural gas companies about socioeconomic inequality in the past. Still, associations representing other technologies than DHC (e.g. heat pumps, wood pellet boilers etc.) are poorly represented all over Denmark, which again strengthens the role of DH for the Danish heat supply.

Municipal impact on DHC in Copenhagen

In Copenhagen, the municipality is intensively involved in DHC related topics. For example, the Heat Supply Act states that all new projects have to be evaluated according to their socioeconomic impact as well as to their economic impact for the consumers and then must be accepted by the municipality. Due to the fact that the municipality is the sole owner of the DH distribution company HOFOR, the municipal impact is once more directly given. The question whether DHC systems shall be publicly or privately owned is being discussed in Denmark and also in Copenhagen, since the consequences are ambivalent. For example, on the one hand, it is often considered positive that the municipality can more easily set climate relevant actions in the fields of DHC. On the other hand, it is possible that private ownership could lead to taking measures in direction of cost reduction (e.g. due to less bureaucracy and more efficient operation). All in all, the city of Copenhagen since decades demonstrates a successful performance on district energy even though the actual influence of the municipality cannot be fully measured.

Heat price regulation in Copenhagen

The heat price in Copenhagen is determined based on the system costs as expected by the Danish Heat Supply Act (with a few exceptions, where prices can be negotiated more freely, as for example renewable energy supply and conversion of coal plants to biomass). All transmission companies sell heat at the same price to various smaller distribution companies. Here, the heat price has to be presented by the heat companies and in a next step accepted by the national regulation authority. Local grids on the other hand may apply different costs leading to differences in pricing of about 10% to 20% for the consumer and even special price agreements for heat consumers are possible (as long as it is cost-based). The municipality itself does not have direct impact on the heat price, but has influence on the investments that are taken and therefore, influence the heat price.

For the heat consumer, investment costs are an important factor. According to the Heat Supply Act, the consumer has to pay the minimum costs possible for heat supply. Furthermore, it is possible that grid operators grant discount or incentives for the new connections to DHC grid. This ensures higher connection rate for the operators, as well.

Ownership shares in Copenhagen

Heat transmission and waste management companies are owned by the municipalities they serve. Heat distribution companies are owned either by municipalities or consumers while large production units in Copenhagen are owned by municipalities (HOFOR) or by a private company (Ørsted). Though, there have also been ownership changes in the past, as for example when the CHP plant Amagerværket was sold by Vattenfall to HOFOR. Vattenfall tried to make profit out of the CHP plant, but did not succeed. After HOFOR had taken over the plant, different objectives where achieved, namely not making maximum profit but delivering heat at low prices to consumers. This can be taken as an example where ownership change led to the aim of running the production unit more efficiently and using cost effective energy carriers like (in this case) biomass with the aim of lowering energy costs. At this point, also other relevant stakeholders concerning DHC in Copenhagen can be mentioned, as for example the state (e.g. Energy Agency, the regulator, etc.), national and local politicians, municipalities, heat production companies, network owners and distribution companies as well as heat consumers and NGO´s.

Graz

Graz is located in the southeast of Austria. It is the second largest city in Austria and is the capital of the federal state Styria. Graz has approximately 300,000 inhabitants (main residence) and a population density of about 2,300 inh/km^2. DH supply in Graz is operated by Energie Graz GmbH. The company also owns the DH grids. The main part of the DH supply to the grid is managed by Energie Steiermark Wärme GmbH (except for decentral industrial waste heat and solar thermal heat production).

The information for the case study of Graz was obtained through literature research making use of [17] and [18] as well as through an interview conducted with two experts on DHC from Graz [19]. Detailed information can be found in and in the text below.

Table 13: Characteristics of DHC, urban planning and urban regulations in Graz

Characteristics of Graz	
DHC:	
Installed DH capacity	712 MW_{th}
Lenght of network	412 km
Supply mix	23% RES (biomass, solar thermal, waste heat) 60% CHP (mainly natural gas)
Customers	11.000 buildings (around 71.000 accommodation units)
District cooling	1 DC system owned and operated by the hospital "LKH-Universitätsklinikum Graz" (plans for several other small-scale projects)
DHC ownership shares	mainly private, but also public
	-
Urban planning and urban regulations:	
Heat planning	by Styrian law and private initiatives
Zoning	by Styrian law and private initiatives
Municipality involvement in DHC	through a three-step process
Heat price regulation	public authority may determine prices

Introduction to DHC in Graz

As with most DHC systems, the heat supply system in Graz grew from the historical local context. Today, the city benefits from a well-developed network. The progress towards renewable energy supply did not just happen incidently; but was a consequence of well-planning. As an example, a call for contribution and discussion has been practiced in the past. As a result of this call, more than 80 experts discussed about different opportunities for heat supply in Graz and 38 proposals on how to further develop Graz heat supply system were submitted. This call for contribution is still valid today, especially for reaching climate neutrality in the city. Therefore, practicable ideas are always being considered, discussed and if possible implemented. Another interesting example of Graz is the so-called Working Group "Heat Supply Graz 2020/2030" (in german "Wärmearbeitsgruppe"), which consists of local stakeholders and is led by the Environmental Department of the City of Graz. The working group is administrated by the Energy Agency of Graz. Hereby, the stakeholders meet regularly on a six-week basis in order to discuss current issues and to strengthen their cooperation.

Renewable energy for DHC in Graz

In Graz, financial grants are provided for studies aiming at supporting renewable DHC. Furthermore, the connection of private buildings to DHC is being financially subsidised. Specific targets on the RES share in DHC have officially be written down in the "Wärmeversorgung Graz 2020/2030" report; however, it is not legally binding. The city follows certain targets in increasing the RES share in DH: at least 50% RES share until 2028 (aiming for even higher share) and an estimation, described as realistic, of the achievement of 100% RES until 2050. Priorities are already given to the feed-in by RES. In this context, TPA has been discussed regularly; but no success has been achieved so far due to the long-term contractors that have to waive a supply share in order to enable other suppliers to feed in the grid.

Heat planning and zoning in Graz

The Styrian Spatial Planning federal law ("Steirisches Raumordnungskonzept") requires deep investigation of DH potential as well as implementation of heat supply solutions if feasible. Furthermore, there are also private sector initiatives focussing on H&C supply ("FFG Vorzeigeregion Energie"). Together with all relevant stakeholders, the city of Graz introduced a local energy concept ("Kommunales Energiekonzept"), which determines the target for possible market share of DH in the city. The concept is revised every 5-8 years. In addition, Graz is involved in research projects that aim to intensify spatial energy planning. In order to start a step-by-step conversion towards heat supply by DH systems, the connection of two districts (about 250 apartments) was decreed in 2012. In 2013, further eleven districts were added to the plan. In 2017, the local energy concept was once more sharpened and another 41 new districts added to the decree. In total, 54 districts are defined as DH zones. All the buildings in DH zones must be addressed in decree and for all of the DH connections, official legal notices must be issued. Subsequently, existing heat supply systems must be replaced by DH at the end of their lifetime. Graz also plans for greener heat supply. As an example, renewable alternatives replaced one of the major (fossil) CHP power plants in the city, with which heat supply could not be ensured after 2020. Graz approach in heat planning and DH zoning has been demanding, however, very effective.

Municipal impact on DHC in Graz

The Graz municipality is significantly involved in DHC related topics through a three-step process defined by law. In the first step, DH expansion areas are defined in the municipal energy plan according to regional planning law. The second step leads to determination of obligatory DH areas (again according to regulation in regional planning law). Finally, in the third step, obligations are being made to connect to DHC according to the Styrian building law. Any DHC plan has to be first enacted by the municipality of Graz.

Heat price regulation in Graz

The DH price for consumers is subject to official price regulation, which is done by a price commission (formed by federal energy supplier, federal government, the Chamber of Labour, etc.). The public authority may determine justified prices for the supply of DH and the associated services. In Graz, by means of official legal notice of the Styrian federal government, the DH prices were revised (valid from August 2018 onwards). The price for measurement is also integrated. Hereby, the prices quoted are maximum sale prices. Furthermore, there are certain incentives being provided for the development and expansion of DHC grids. There are also incentives for thermal renovation which both influence the local heat market and therefore, the heat price.

Ownership shares in Graz

The DHC system in Graz is owned by Enegie Graz GmbH & Co KG. The company itself is partly owned by the municipality of Graz and Energie Steiermark AG.

Helsinki, Finland

The Helsinki Metropolitan Area consists of the cities of Helsinki capital region and ten surrounding municipalities. The Helsinki metropolitan area is the world's northernmost urban area among those with a population of over one million people, and is the northernmost capital of an EU member state. The Metropolitan Area covers 3,697 square kilometers. Population density in certain parts of Helsinki's inner-city area is very high, reaching 16,494 inh/km2, whereas a whole Helsinki's population density is 3,050 inh/km2.

Detailed information about Helsinki can be found in [20], [21]

Table 14: Characteristics of DHC, urban planning and urban regulations in Helsinki

Characteristics of Helsinki	
DHC:	
Installed DH capacity	3,630 MW_{th}
Lenght of network	DH network: 1,350 km DC network: 46 km
Supply mix	90% of the heat generated by CHP 53% Coal 35% Natural gas 8% Heat pumps 3% Biomass 1% Fuel oil
Customers	DH available in >90% of the city DH customers: 15,000 buildings DC customers: >200
District cooling	5 heat pumps and 10 absorpion units (95 MW_{th})
DHC ownership shares	Helen Ltd is fully owned by the city of Helsinki
Urban planning and urban regulations:	
Heat planning	No specific regulation
Zoning	No specific regulation
Municipality involvement in DHC	No specific regulation
Heat price regulation	No specific regulation

Introduction to DHC in Helsinki

Water-based district heating in Helsinki was first launched in 1957. Since then, the DH network has been widely developed and today has one of the highest DH connection rates with more than 90% of the city buildings being connected to the network. Similar to other countries, the oil crises in the 70s increased the interest in domestic fuels such as peat and wood and since 1991 natural gas as well. Currently, coal and natural gas supply ca. 88% of the DH needs whereas fuel oil is used only in peak boilers. In 1995 the DH network as part of the Helsinki Energy Board became a municipal public utility and changed its name to Helsingin Energiea. In 2015, the Helsingin Energia Concern changed its form and name to Helen Ltd. The district cooling network began its operation in the year 2000.

Renewable energy for DHC in Helsinki

The city of Helsinki has a goal to become carbon-neutral by the year 2035. Since 53% of the district heat produced in 2018 came from coal-fired power plants, which are to be shutdown until 2029 at the latests, the DH company heat production must undergo a profound transformation in a relatively short period of time. The initial plan is to replace much of the coal consumption with biomass. Furthermore, the city plans to increase its industrial waste heat recovery and heat pump capacity. The planned changes of the electricity tax reform, which will transfer heat pumps and data centers generating heat for DH networks to category II of the electricity tax [22], will further improve their business case. After the tax change, the DH company announced that it will initialize certain heat pumps projects that were under review such as the waste heat recovery from Telia data center [23] and the new heat pump in the Katri Vala heating and cooling plant [24].

Heat planning and zoning in Helsinki

The finnish heating market is unregulated and functions on competitive principles. Since there is no separate district heating act, the Competition Authority supervises the work of the DH networks and prohibits the abuse of its dominant position to their customers. As the market is unregulated the heat customers can freely choose their heating method. However, in some cases the municipalities can impose district heating connection in the city plans. Nevertheless, the district heating customers have the right to disconnect from the DH network without any extra fees.

Municipal impact on DHC in Helsinki

There is no specific legislation concerning the municipality involvement in the DHC development plan. Although Helen Ltd. performs its own development and action plan, it complements the municipality climate action plan, and it takes an active part in the work group responsible for the creation of the city carbon neutral action plan. The municipality action plan deals with improvement of energy efficiency and use of renewable energy at the customer end, whereas the Helen’s development program focuses mostly on the centralised energy production (ref climate action plan).

Heat price regulation in Helsinki

In Finland, there is no specific legislation concerning the pricing of heating services. Nevertheless, political decisions on taxes, subsidies and emissions control can have an impact on the economic feasibility of different heat supply solutions. The government uses energy taxation such as energy and CO_2 taxes of fossil heating fuels to promote the use of renewable energies, which are generally tax-free. Another example is the previously mentioned electricity tax reform, which has a goal of reducing the electricity tax for heat pumps from the current 22.53 €/MWh to 7.03 €/MWh to improve their economic attractiveness.

Ownership shares in Helsinki

The energy company Helen which is owned by the city of Helsinki, oversees the production, distribution, and sales of district heat.

Vilnius, Lithuania

The lithuania's capital city Vilnius is one of the largest and oldest citis in the country. With a population of 539,000 residents and area of 401 km², it has a population density of 1,538 inh/km². The Vilnius district heating network is managed and owned by the municipality.

Detailed information about Vilnius can be found in [25]–[27]

Table 15: Characteristics of DHC, urban planning and urban regulations in Vilnius

Characteristics of Tallinn	
DHC:	
Installed DH capacity	1,887 MW_{th}
Lenght of network	DH network: 741 km DC network:n/a
Supply mix	54.5% Biomass 45.1% Natural Gas 0.4% Fuel oil and disel
Customers	80% of the households are using DH DH customers:>7,200 buildings with 212,781 customers DC customers: n/a
District cooling	n/a
DHC ownership shares	99.4% owned by the municipality
Urban planning and urban regulations:	
Heat planning	The municipality formulates long-term developments of the heat sector under the Special Heat Supply Plan
Zoning	Practiced by the municipality
Municipality involvement in DHC	It can approve or reject the DH investment plan
Heat price regulation	Regulated by the national authority

Introduction to DHC in Vilnius

Developed in the 1950s, the DH network in Vilnius has a long tradition and currently has a market share of ca. 80%. The DH networks comprises of one large network with a demand of more than 1,000 MW as well as several smaller networks and 32 very small DH systems. The DH network is supplied by both public and private heat producers, which compete monthly through auction schemes on the open heat supply market. After a 15-year concession period of operation by a private entity, the municipality did not extended the contract and ended the concession in 2017. Since then, the municipality operates the DH network.

Renewable energy for DHC in Vilnius

Based on the Lithuanian National Energy Strategy adopted in 2018, the RES supply share in the DH sector should reach the 90% level by 2030 and the 100% level by 2050. The Vilnius DH network is on the right track of achieving these goals. The current RES share is ca. 54%, which mostly consists of biofuels. The share of biofuels is expected to rise in the coming years above 90% with the commissioning of the new biomass and waste incineration plants. Additionally, the DH utility plans to invest in large-scale heat pumps that use wastewater from the local wastewater treatment plant as a heat source.

Heat planning and zoning in Vilnius
The municipality oversees the heat planning activities and zoning. Within the Spatial Heat Supply Plan (SHSP), it can divide the city into three zones: DH zone, natural gas, and competition zone. Despite the zones assignment the customers still have the right to choose an individual supply solution over a centralized one as long as it uses clean heat sources such as geothermal energy.

Municipal impact on DHC in Vilnius

The municipality can directly impact the development of the DH network. The DH company prepares a network investment plan for a period of 3 to 5 years. The plan can be assessed, revised or rejected by the municipality if it is not in line with the SHSP. The municipality develops the SHSP every 7 year which hast to be in line with the national heat sector development program which is approved by the government. The main objectives of the SHSP is to define long-term strategy for the modernization and development of the municipal heat sector which is in line with the countries environmental targets.

Heat price regulation in Vilnius

The heat prices are strongly regulated by the National Commission for Prices and Energy Control. The regulator retains the right to revise and rejects the investment plan developed by the DH company and approved by the municipality. Based on the Methodology on Heat pricing and the approved investment plan, the basic price is set for three to five years in advance. Nevertheless, the variable components of the heat price such as the fuel costs are revised on a monthly basis according to the regulator’s methodology.

Ownership shares in Vilnius

The energy company Vilnius Šilumos Tinklai (VST), which operates the DH network, is owned by the municipality. There are heat production units that are owned by VST while there are other production units that are owned by private companies.

Bolzano

Bolzano is located in Northeast Italy (South Tyrol). With a number of inhabitants at some 107.000, its population density is approximately 2,050 inh/km^2. Bolzano has a high heating demand during the heating season as well as a significant cooling demand on hot summer days. DHC is provided by ALPERIA ECOPLUS, which is the sole owner and operator of Bolzano´s DHC systems consisting of two generation units (Bolzano South thermal plant including 2 natural gas CHP combustion engines and 5 natural gas and diesel boilers as well as a waste to energy CHP plant).

The information about the status DHC systems in Bolzano can be found in [28] [29]

Table 16: Characteristics of DHC, urban planning and urban regulations in Bolzano

Characteristics of Bolzano	
DHC:	
Installed DH capacity	39 MW_{th}
Lenght of network	788 km
Supply mix	90% biomass & biogas
	10% fossil fuels
Customers	15.000 users connected
District cooling	-
DHC ownership shares	ALPERIA SPA (100%)
Urban planning and urban regulations:	
Heat planning	No specific regulation
Zoning	No specific regulation
Municipality involvement in DHC	In expansion and extention plans
Heat price regulation	Price composed of fix and variable parts. The variable parts is regulated. The suggestion for the fix share can be declied by DH provider.

Miskolc

Miskolc is located in the north-east of Hungary and is the fourth largest city in Hungary. It has around 168,000 inhabitants and a population density of approximately 2,000 inh/km^2. The DH companies are members of the PannErgy Group (Miskolc Geothermia Plc. and KUALA Ltd.) and provide heat with a RES share of above 50% to their customers. A significant total share of 48% of the heat comes from geothermal energy sources.

Detailed information can be found in [30] [31].

Table 17: Characteristics of DHC, urban planning and urban regulations in Miskolc

Characteristics of Miskolc	
DHC:	
Installed DH capacity	60 MW_{th}
Lenght of network	24.6 km
Supply mix	48,81% fossil 48,06% geothermal 2,84% biomass 0,29% landfill gas
Customers	32.000 houses (and 1.000 other consumers)
District cooling	-
DHC ownership shares	Miskolc Geotermia Plc. (90% PannErgy Plc., 10% MIHŐ Ltd. KUALA Ltd. (90% PannErgy Plc., 10% MIHŐ Ltd.)
Urban planning and urban regulations:	
Heat planning	-
Zoning	-
Municipality involvement in DHC	in generation of heat
Heat price regulation	max. heat price: 7.7 €/GJ (8.4 €/GJ for end-consumers)

Stockholm

Stockholm is located in eastern side of Sweden and comprises an archipelago with 14 islands in the Baltic Sea. It has 975,000 inhabitants and a population density of about 5,200 inh/km^2. Stockholm´s DHC system consists of more than 30 production facilities and is operated by Stockholm Exergi. The concept of open district heating in Stockholm allows TPA to the DHC systems.

Detailed information about Stockholm can be found in [32].

Table 18: Characteristics of DHC, urban planning and urban regulations in Stockholm

Characteristics of Stockholm	
DHC:	
Installed DH capacity	3.900 MW_{th}
Lenght of network	DH network: 2.800 km DC network: 250 km
Supply mix	90% RES share in DH (29% waste, 20% electricity, 19% wastewater and seawater, 16% fossil, 14% biofuels and 2% waste heat from DC) 100% RES share in DC
Customers	DH customers: >10.000 DC customers: ~300
District cooling	seawater based cooling facility (350 MW_{th})
DHC ownership shares	50% City of Stockholm 50% Fortum Power and Heat AB
Urban planning and urban regulations:	
Heat planning	No specific regulation
Zoning	No specific regulation
Municipality involvement in DHC	Via ownership
Heat price regulation	No specific regulation

Frankfurt am Main, Germany

The city of Frankfurt am Main is located in the western part of Germany in the federal state of Hesse. The city is part of the metropolitan region Frankfurt/Rhine-Main, with a population size of 5.6 million people. The Frankfurt metropolitan area has population size exceeding 1.9 million inhabitants with a population density of ca 3,000 inh/km^2. Mainova AG is the DH network operator and operates 7 plants with a total heat capacity of 1,002 MW_{th}.

Detailed information about Frankfurt am Main can be found in the [33].

Table 19: Characteristics of DHC, urban planning and urban regulations in Frankfurt am Main

Characteristics of Frankfurt am Main	
DHC:	
Installed DH capacity	1,022 MW_{th}
Lenght of network	DH network: 306 km DC network: supplying Frankfurt airport
Supply mix	87% of the heat generated by CHP 46% Coal 31% Natural gas 21% Municipal waste 1.3% Biomass
Customers	DH available in 75% of the city DH customers: 4,202 buildings DC customers: 1
District cooling	Trigeneration plant (67 MW_{th})
DHC ownership shares	The city of Frankfurt am Main is the largest shareholder with ca 75%
Urban planning and urban regulations:	
Heat planning	With active involvement from the city energy department
Zoning	Compolsury connection under specific conditions
Municipality involvement in DHC	Involved in the strategic energy planning
Heat price regulation	The price is determined by the company

Ljubljana, Slovenia

Ljubljana is the capital of Slovenia and the largest city with a population density of 1,712 inh/km^2. Energetika Ljubljana manages both the district heating and gas networks in the city, as well as the two district heating plants with a total capacity of 1,188 MWth.

Detailed information about Ljubljana can be found in [34], [35]

Table 20: Characteristics of DHC, urban planning and urban regulations in Ljubljana

Characteristics of Ljubljana	
DHC:	
Installed DH capacity	1,188 MW_{th}
Lenght of network	DH network: 263 km DC network: n/a
Supply mix	97% of the heat generated by CHP 78% Coal 8% Natural gas 14% Biomas
Customers	DH available in 75% of the city DH customers: 58,900 residential and 5,700 comercial DC customers: n/a
District cooling	n/a
DHC ownership shares	The city of Ljubljana is the major shareholder with ca. 87% of the shares
Urban planning and urban regulations:	
Heat planning	Energy planning at municipal level
Zoning	No specific regulation
Municipality involvement in DHC	The municipality has a decision-making power
Heat price regulation	Regulated by public authorities

Plovdiv, Bulgaria

Plovdiv is located 140 km southeast of Bulgaria's capital Sofia. It Is the second largest city in Bulgaria and one of the oldest cities in Europe. With a population of 371,686 residents and area of 101.98 km² has a population density of 3,644, inh/km². Since 2007 the district heating network is operated by the Austrian company EVN, which also offers non-residential DH customers the possibility to connect an absorption chiller for the coverage of the space cooling demand.

Detailed information about Plovdiv can be found in [26], [36]

Table 21: Characteristics of DHC, urban planning and urban regulations in Plovdiv

Characteristics of Plovdiv	
DHC:	
Installed DH capacity	543 MW_{th}
Lenght of network	DH network: 175 km DC network: n/a
Supply mix	100% of the heat generated by CHP 100% Natural gas
Customers	DH available in 75% of the city DH customers: 30,000 household DC customers: 3 Buildings
District cooling	Absorption chillers at the premises of the customers supplied by DH
DHC ownership shares	100% privately ownded by EVN
Urban planning and urban regulations:	
Heat planning	Article 6 of the Energy Act requires a coordination between the municipal urban development plan and the DH business plan
Zoning	
Municipality involvement in DHC	The Municipality is involved in the DH 5-year business plan which needs to be approved by the reglatory agency
Heat price regulation	Article 31 of the Energy Act determinates the criteria in which the prices are defined, and which costs shall include.

Oradea, Romania

Oradea is in the northwestern corner of Romania. It is the capital of Bihor County and one of the most important economic, social, and cultural centers of Northwest Romania. With a population of 196,367 residents and area of 115.2 km² it has a population density of 1,700 inh/km². The district heating utility (Termoficare SA) is owned by the municipality.

Detailed information about Oradea can be found in [37], [38]

Table 22: Characteristics of DHC, urban planning and urban regulations in Oradea

Characteristics of Oradea	
DHC:	
Installed DH capacity	409MW$_{th}$ CHP Natural Gas and 15 MW$_{th}$ Geothermal
Lenght of network	DH network: 220 km DC network: n/a
Supply mix	93% of the heat generated by CHP 93.2% Natural gas 6.8% Geothermal
Customers	DH available in 70% of the city DH customers: 64,730 apartments and 2,690 non-residential cusotmers DC customers: n/a
District cooling	n/a
DHC ownership shares	100% ownded by the municipality
Urban planning and urban regulations:	
Heat planning	No specific regulation
Zoning	No specific regulation
Municipality involvement in DHC	The DH utility is administratively subordinated to the municipality
Heat price regulation	Regulated by the authorities

Tallinn, Estonia

Tallinn is the capital and the largest city of Estonia. Tallinn's land area measures 159.3 square kilometers with an estimated population of 434,562 and a population density of 2,733 inh/km². The district heating network is operated by the Estonian energy group Utilitas, which supplies heat and electricity to 8 estonian cities.

Detailed information about Tallinn can be found in [26], [39], [40]

Table 23: Characteristics of DHC, urban planning and urban regulations in Tallinn

Characteristics of Tallinn	
DHC:	
Installed DH capacity	683 MW_{th}
Lenght of network	DH network: 445 km DC network:
Supply mix	70% of the heat generated by CHP 63% Biomass 17% Waste 20% Natural Gas
Customers	70% of the households are using DH DH customers:>5,500 builidngs DC customers: 2 buildings
District cooling	Heat pumps (unknow capacity)
DHC ownership shares	100% private company
Urban planning and urban regulations:	
Heat planning	As part of a comprehensive municipal development plan
Zoning	Municipality may determine DH regions
Municipality involvement in DHC	Activly involved in the DH development plan
Heat price regulation	The maximum price of heat is regulated by the authorities

Warsaw, Poland

Warsaw is the capital and largest city of Poland. With a population of ca. 1.8 million residents it has population density of 3,460 inh/km². The city has the largest DH network in Europe, which is is owned and operated by Veolia Warsaw, whereas the heat generation units are owned and operated by PGNiG Termika.

Detailed information about Warsaw can be found in [26], [41]–[43]

Table 24: Characteristics of DHC, urban planning and urban regulations in Warsaw

Characteristics of Warsaw	
DHC:	
Installed DH capacity	4,345 MW_{th}
Lenght of network	DH network: 1,735 km DC network: n/a
Supply mix	89% Coal 1% Natural Gas 10% Municipal waste
Customers	80% of the households are using DH DH customers:>18,600 buildings DC customers: n/a
District cooling	n/a
DHC ownership shares	100% owned by Veolia
Urban planning and urban regulations:	
Heat planning	The municipality prepares local spatial development plan and develops assumption considering the heat supply
Zoning	Practiced under specific conditions
Municipality involvement in DHC	The municipality can change the DH development plan
Heat price regulation	Regulated by the national authority

5.3. National targets and estimated trajectories regarding annual increase of renewable energy in the heating and cooling sector

Here, the national targets and estimated trajectories in H&C and DHC sector in relation with requirements from Article 23 and Article 24 of the Renewable Energy Directive (RED) 2018/2001/EU (European Union, 2018) are brought together. The Article 23 of the RED states that in the period of 2021 to 2030, Member States should annually increase the RES share in the H&C sector by at least 1.1 percentage points (pp) or by 1.3 pp if waste heat and cold are considered. The Article 24 of the RED, on the other hand, asks Member States inter alia to ensure the increase of RES share in the DHC sector. Therefore, the following section provides an insight to the national targets for increasing the share of RES in H&C and DHC sectors besides the overall targets.

In this table, only the 1.1 pp related targets (for MS not using waste heat and cold) are addressed. This is due to the fact that in order to correctly differentiate between the 1.1 pp and 1.3 pp targets, it is required to include information about national history and future plans for the expansion of heat and cold power plants and the use of industrial waste heat. Moreover, further information from NECPs of some Member States are provided below this table in case that a deeper insight on national circumstances is required. From investigation of NECPs, it can be stated that Member States often present estimated trajectories of the annual increase of RES rather than precise targets.

Table 25: National targets and estimated trajectories regarding annual increase of renewable energy in the heating and cooling sector (extended table)

Member State	Annual increase of RES (gross final energy consumption)		Target from RED Art. 23 fulfilled? (RES share in H&C)?	Target from RED Art. 24 fulfilled? (RES share in DHC)?
	All Sectors	H&C Sector		
Austria	37 % in 2021 → 46 % in 2030 (estimated trajectory)	H&C makes 17 % of the total 37 % in 2021 and 20% of the total 46 % in 2030. (estimated trajectory)	-	No
Belgium	11.68 % in 2020 → 17.53 % in 2030 (target)	Flanders: 8,589 GWh in 2020 → 9,688 GWh in 2030 Wallonia: 8,900 GWh in 2020 → 14,233 GWh in 2030 Brussels: no information found (estimated trajectory)	-	No
Bulgaria	20.20 % in 2020 → 27.09 % in 2030 (estimated trajectory)	31.07 % in 2020 → 42.60 % in 2030 (estimated trajectory)	Yes, around 1.1 pp	No
Croatia	28.6 % in 2020 → 36.4 % in 2030 (target)	33.3 % in 2020 → 36.6 % in 2030 (target)	No, below 1.1 pp	Yes, 1 pp per year
Cyprus	14.8 % in 2021 → 22.9 % in 2030 (scenario: PPM) or 29.7 % in 2030 (scenario: PPM with interconnector) (estimated trajectory)	32.6 % in 2021 → 39.4 % in 2030 (in both scenarios) (estimated trajectory)	No, below 1.1 pp	No, no DHC systems
Czech Republic	15.6 % in 2020 → 22.0 % in 2030	20.7 % in 2020 → 30.7 % in 2030	No, below 1.1	No

Member State	Annual increase of RES (gross final energy consumption)		Target from RED Art. 23 fulfilled? (RES share in H&C)?	Target from RED Art. 24 fulfilled? (RES share in DHC)?
	All Sectors	H&C Sector		
	(estimated trajectory)	(estimated trajectory)	pp	
Denmark	41 % in 2020 → 55 % in 2030 (estimated trajectory)	53.5 % in 2020 → 59.9 % in 2030 (estimated trajectory)	Yes, half of 1.1 pp	No, 0.88% per year expected
Estonia	34 % in 2020 → 42 % in 2030 (target)	55 % in 2020 → 63 % in 2030 (target)	Yes, half of 1.1 pp	Yes, 51.64 % in 2020 → 80 % in 2030
Finland	41 % in 2022 → 51 % in 2030 (target)	54 % in 2020 → 61 % in 2030 (estimated trajectory)	Yes, half of 1.1 pp	No
France	23 % in 2020 → 33 % in 2030 (target)	24 % in 2020 → 38 % in 2030 (target)	Yes, above 1.1 pp	Yes, around triple the amount
Germany	19.2 % in 2021 → 30 % in 2030 (estimated trajectory)	14 % in 2020 → 27 % in 2030 (estimated trajectory)	Yes, above 1.1 pp	No, 1.0 % per year expected
Greece	19.7 % in 2020 → 35 % in 2030 (target)	30.6 % in 2020 → 42.5 % in 2030 (target)	Yes, around 1.1 pp	Yes, 30-40 MW installed
Hungary	13 % in 2020 → 21 % in 2030 (target)	18.2 % in 2020 → 28.7 % in 2030 (estimated trajectory)	No, below 1.1 pp	Yes, expand DH from RES
Ireland	12.9/12.8% in 2020→ 21.5/34.1 % in 2030 (estimated trajectory for WEM/WAM scenario)	7.6/7.8 % in 2020 → 14.0/24.0 % in 2030 (estimated trajectory for WEM/WAM scenario)	Depending on scenario (WEM: No / WAM; Yes)	No
Italy	19.0 % in 2020 → 30 % in 2030 (target)	20.9 % in 2020 → 33.9 % in 2030 (target)	Yes, above 1.1 pp	No
Latvia	40 % in 2020 → 50 % in 2030 (target)	53.4 % in 2020 → 57.59 % in 2030 (target)	Yes, half of 1.1 pp	Yes, increase use of biomass
Lithuania	30 % in 2020 → 45 % in 2030 (target)	50.9 % in 2020 → 67.2 % in 2030 (target)	Yes, above 1.1 pp	No
Luxembourg	11 % in 2020 → 25 % in 2030 (target)	13.7 % in 2020 → 30.5 % in 2030 (target; heat sector)	Yes, above 1.1 pp	No
Malta	9.7 % in 2021 → 11.5 % in 2030 (estimated trajectory)	23 % in 2021 → 33.06 % in 2030 (target)	No, difficult to reach the goal	No, no DHC systems
Netherlands	11.4 % in 2022 → 27 % in 2030 (target)	No information given in NECP	No	No
Poland	15 % in 2020 → 23 % in 2030 (target)	9 % in 2020 → 13 % in 2030 (estimated trajectory)	No, below 1.1 pp	No
Portugal	31 % in 2020 → 47 % in 2030 (target)	34 % in 2020 → 38 % in 2030 (target)	No, below 1.1 pp	No
Romania	24.4 % in 2020 → 30.7 % in 2030	25.2 % in 2020 → 33 % in 2030	No, below 1.1	No

Member State	Annual increase of RES (gross final energy consumption)		Target from RED Art. 23 fulfilled? (RES share in H&C)?	Target from RED Art. 24 fulfilled? (RES share in DHC)?
	All Sectors	H&C Sector		
	(target)	(estimated trajectory)	pp	
Slovakia	14 % in 2021 → 19.2 % in 2030 (estimated trajectory)	13 % in 2021 → 19 % in 2030 (estimated trajectory).	No, below 1.1 pp	Yes, 1 % per year
Slovenia	25 % in 2020 → 27 % in 2030 (estimated trajectory)	36.4 % in 2020 → 41.4 % in 2030 (estimated trajectory)	No, below 1.1 pp	Yes, invest € 80 million by 2030
Spain	20 % in 2020 → 42 % in 2030 (target)	20 % in 2020 → 42 % in 2030 (target)	Yes, Above 1.1 pp	No
Sweden	49 % in 2020 → 65 % in 2030 (estimated trajectory)	69.2 % in 2020 → 72.2 % in 2030 (estimated trajectory)	Yes, due to Art. 23 RED – point 2	No, due to Art 24 RED – point 4
United Kingdom (draft)	10.2 % in 2017 (no target or estimated trajectory)	7.7 % in 2017 → (no target or estimated trajectory)	No	Yes, increase of DHC

Additional Information to Annex B.2.2.1

Austria: The Austrian NECP states that in the H&C sector, further in-depth work must be undertaken, in particular the development of a "heating strategy" in collaboration with the federal states. This is expected to be completed in 2020.

Belgium: In Belgium, energy is a matter of regional competence. Therefore, attention shall be paid to Brussels, Flanders and Wallonia separately.

Cyprus: In general, Cyprus complies with the target (set by Art. 23 RED) of increasing RES in H&C by 1.1 % per year, but might for some years be below the target. This is due to the size of the country and the resulting size of projects in the fields of DHC. Even though projects in the H&C sector are relatively small compared to other European countries, they play an important role for a country the size of Cyprus.

Czech Republic: Czech Republic's NECP mentions that meeting the indicative target of 1.1% (set by Art. 23 RED) will not be possible for Czech Republic. It is said that this is due to relatively high current RES share in the H&C sector (19.9 % in 2016).

Finland: The development of DH in Finland´s NECP is not given in numerical numbers but only a figure can be used to roughly estimate the actual values. This figure shows the share of RES in 2030 at around 51 % plus another 23 % of waste heat leaving the share of non-renewables at about 26 % (the shares in 2020 are pictured at about 42 % RES, 9 % waste heat and 49 % non-renewables).

Germany: The final NECP of Germany is not available at the time of writing this report. Therefore, the available draft version was used. The estimated trajectory of RES in DHC shows an annual increase of 1.0 pp (from 21 % in 2021 to 30 % in 2030).

Greece: The objective of Greece is to deploy RES-based DH networks using solid biomass and geothermal energy with a total capacity of 30-40 MW over the 2021-2030 period.

Ireland: The final NECP for Ireland is not available at the time of writing this report. Therefore, the available draft version was used. It shows the estimated trajectory for the overall share of renewable energy. This is done for four scenarios (NECP 1: With existing measures, high oil price; NECP 2: With additional measures, high oil price; NECP 3: With existing measures, low oil price; NECP 4: With additional measures, low oil price).

Malta: In the H&C sector, the use of RES is estimated to increase from 23 % in 2021 to 26 % in 2030. Though, in order to reach the 1.1 pp target (set by Art. 23 RED), Malta must increase the share of RES to at least 33 %. It is stated that the possibility to reach the 1.1 pp target is highly challenging (e.g. biogas cannot be used due to missing gas distribution system or sources of indigenous biomass are missing).

Poland: The development of RES share in total gross final energy (including the losses of the heating systems) consumption in Poland is drawn in the NECP, showing an increase from around 15 % in 2020 to around 23 % in 2030. In the H&C sector, the share of RES is presented to grow from around 9 % in 2020 to around 13 % in 2030.

Sweden: Sweden´s NECP states that there is no national target for the increase of renewable energy share in 2030 for any sector. This is due to the fact that the share of RES in Sweden´s H&C sector to date is above 60 % and therefore already high enough to not require targets according to Art 24 RED – point 4.

5.4. References for the allocation of Member States to certain categories describing the share of RES in nZEB

Table 26: Categorizing countries on national implementation of share of RES in nZEB

Category	Country	References
Category 1: Numerical values for minimum share of RES	Austria	[2]
	Bulgaria	[44]
	Croatia	[45]
	Cyprus	[46]
	France	[47]
	Germany	[48]
	Greece	[49]
	Hungary	[50]
	Ireland	[51]
	Italy	[52]
	Lithuania	[53]
	Slovenia	[54]
Category 2: Qualitative statements for minimum share of RES	Estonia	[55]
	Latvia	[56]
	Luxembourg	[57]
	Malta	[58]
	Netherlands	[59]
	Sweden	[60]
Category 3: No definition provided for minimum share of RES	Belgium-Brussels	[61]
	Belgium-Flanders	[61]
	Belgium-Wallonia	[61]
	Czech Republic	[62]
	Denmark	[63]
	Finland	[64]
	Poland	[65]
	Portugal	[66]
	Romania	[67]
	Slovakia	[68]
	Spain	[69]
	United Kingdom	[70]

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