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FEDERAL FACILITIES COUNCIL

ENERGY MASTER PLANNING FOR RESILIENT PUBLIC COMMUNITIES – VIRTUAL TRAINING WORKSHOP

October 13-16, 2020

Energy Technologies Database

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IEA EBC Annex 73 Task C – EUDP Denmark

RAMBOLL Bright ideas. Sustainable change.

PRESENTATION AND BACK GROUND

- Ramboll
  - Independent Multidisciplinary Consulting Eng. Comp. Owned by the Ramboll Foundation
  - 16.000 Employees 300 offices in 35 countries, mainly Northern Europe and US
  - World leading within several energy services
- Anders Dyrelund
  - Civ.Eng. in buildings, Graduate diploma in Economics
  - 1975-81 Ramboll (BHR)
  - 1981-86 Danish Energy Authority
  - 1986- Ramboll
  - 1980 The First Heat Plan in Denmark for Aarhus, PM
  - 1981- Copenhagen Regional DH, task manager/consultant
  - 1990- Consultancy services to more than 20 countries

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ENERGY TECHNOLOGIES DATABASE
CONTENT OF PRESENTATION

- IEA EBC Annex 73 Task C
- Energy Master Planning Guideline
- Chapter 7 Selection of energy system architecture and technologies
- Appendix F. Database of technologies
  - Word file of a snapshot of selected assumptions
  - Excel spreadsheet with the database and dynamic assumptions
  - Data interface to the tool

This presentation is an introduction on how to use the database of energy technologies for energy master planning in local communicites

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THE LEVEL OF PLANNING

The planning can typically be at one of these four levels

- State
- Community
- Campus
- Building

Planing at one level shall always include interacting with the level above

Planning at the campus level includes building and other assets at the campus, but

- Important to identify all real boundary conditions, e.g. city gate prises
- Important to identify opportunities for interacting with other stakeholders, e.g. use energy from a plant outside the campus or deliver energy to buildings outside the campus

THE OBJECTIVES OF THE PLANNING

The objectives for low carbon and resilient energy planning are also expresses at several levels

- International objectives like Paris Agreement and UN Sustainable Development Goals
- National energy policy objectives (CO_2 targets, could affect the CO_2 taxes etc.)
- City (e.g. minimize the costs of energy inluding costs of emissions)
- Campus (e.g. minimize cost of energy and meeting local objectives of resilience)
- Building owner (minimize costs based on actual tariffs)

- Have in mind that todays tariffs and taxes at the level we plan for can be affected by the objectives at the levels above e.g. that energy tax will be introduced and that tariffs may change

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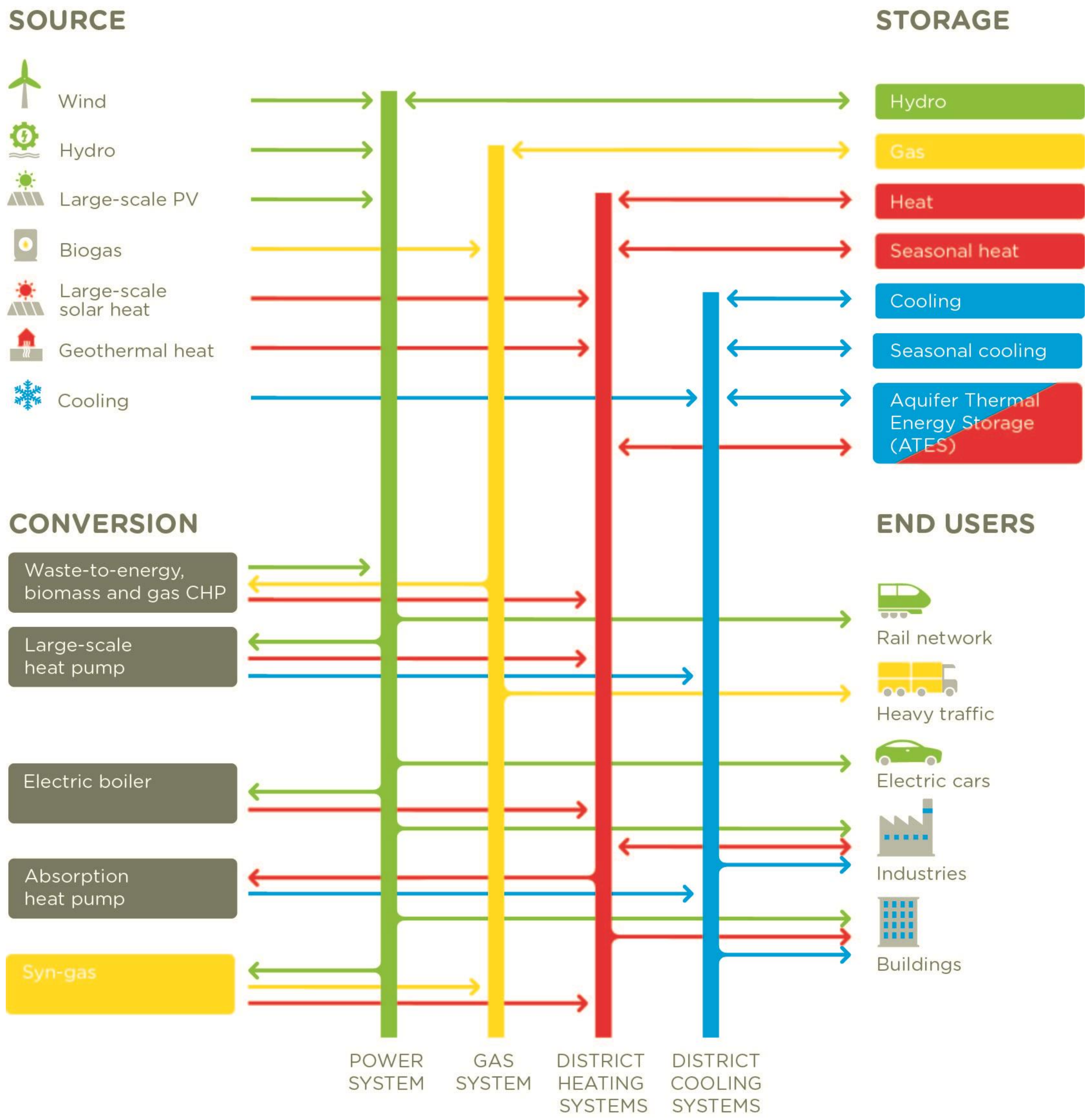
THE ENERGY SYSTEM

- Network technologies most important in the planning
  - Electricity (high – low voltage)
  - District heating (steam, hot water)
  - District cooling (-5 dgr.C -15 dgr,C)
  - Gas (natural gas, biogas)
- Energy conversion technologies
- Energy production technologies
- Energy storage technologies
- End-user or building level technologies
- All technologies are commercial – except (synthetic gas)



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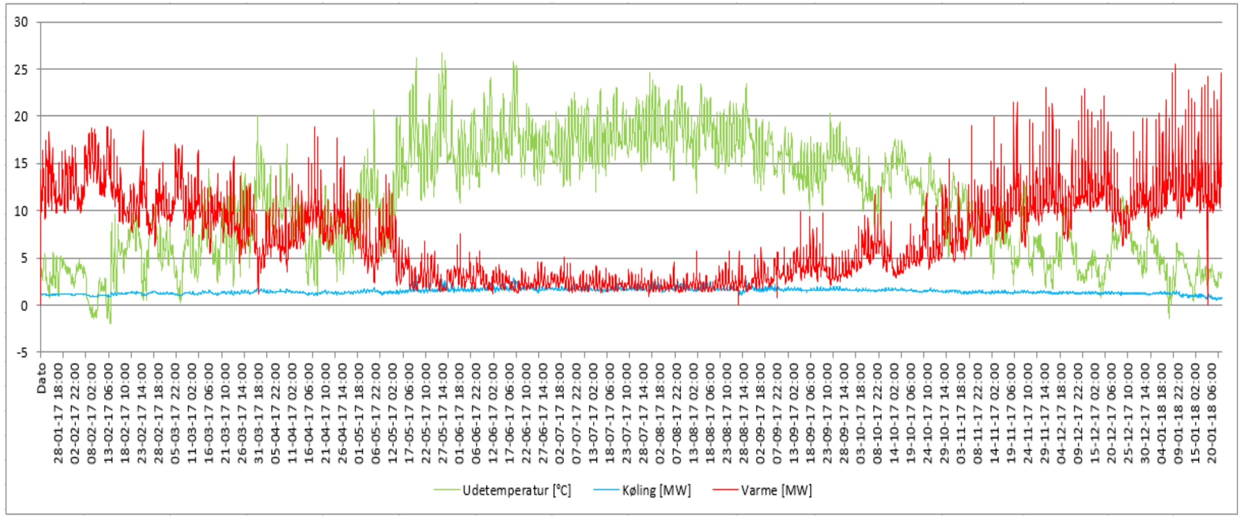
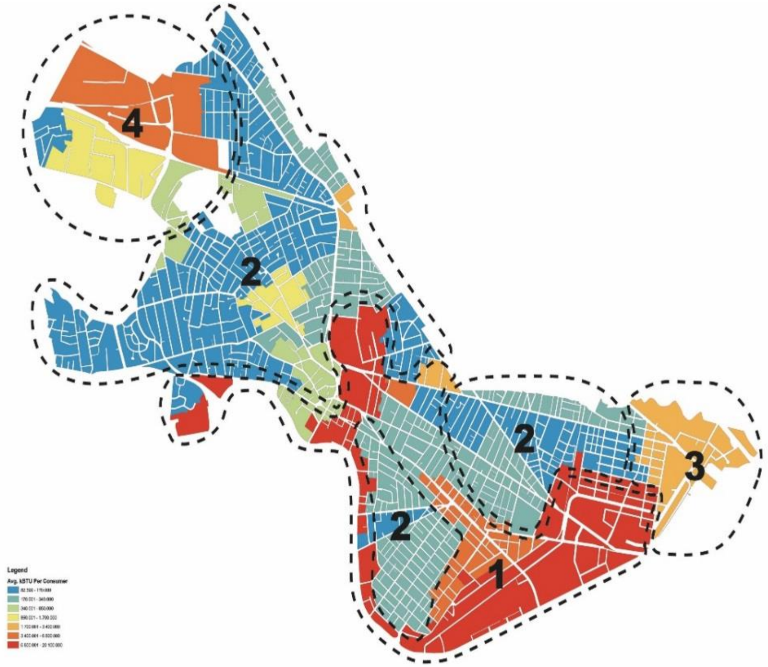
THE INTERACTIVE PLANNING TO-DOWN AND BOTTOM-UP IDENTIFY DEMANDS

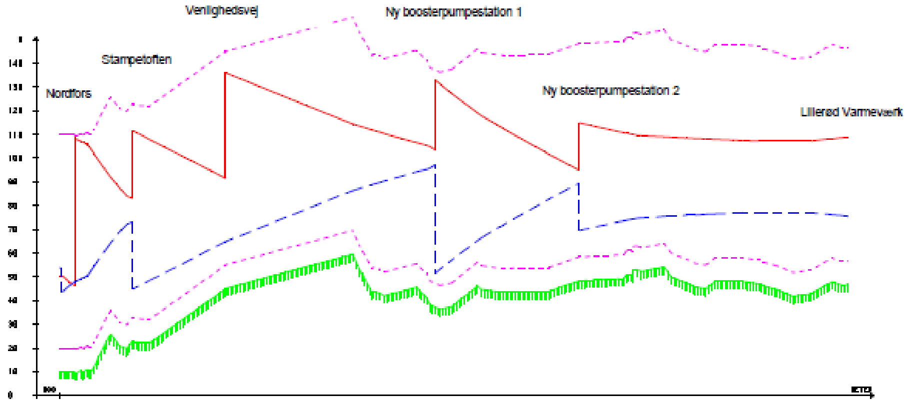
- Present demand based on supply from energy carriers and supply of fuels
- Estimate realistic end-use conversions in case a new energy carrier is planned
- Electricity demand should be split into:
  - Electricity only demand
  - Heat demand supplied by electric heating
  - Cooling demand supplied by electric chillers
  - Crritical demand
- Steam demand should be split into
  - Heat demand < 100 dgr.C
  - Proces steam < 160 drg.C
  - Proces steam > 160 dgr.C
  - Critical demand



THE INTERACTIVE PLANNING TOP-DOWN AND BOTTOM-UP SELECT ENERGY CARRIERS AND ZONING OF NETWORKS

- Identify all buildings and all energy networks on a digital map
- Divide the area into energy districts based on building and energy supply characteristics
- Select the networks based on the dominating demand
    - e.g. hot water district heating < 100 dgr.C to supply all heat demand
    - e.g. cold water to supply all cooling demand
- Propose new zoning of the network based on information from the map and experience from similar cases
- Model the network capacities, e.g. hydraulic modelling for district heating and cooling
- Network key-figures (network investment)/(sale of energy)





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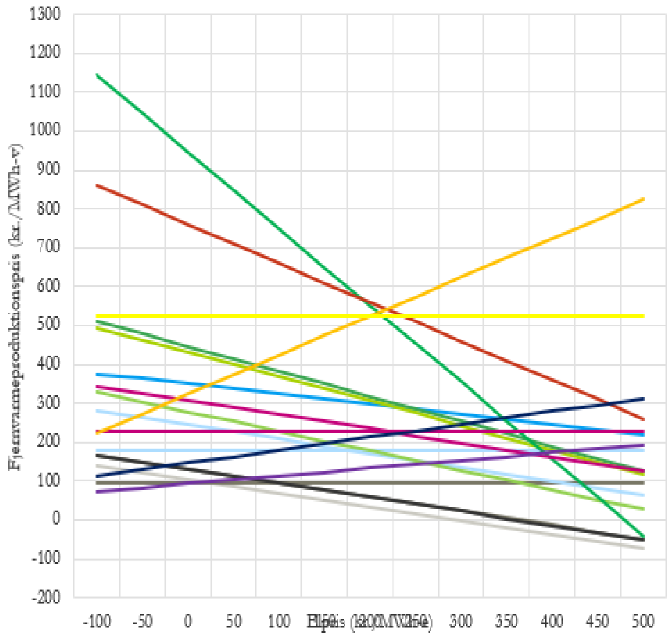
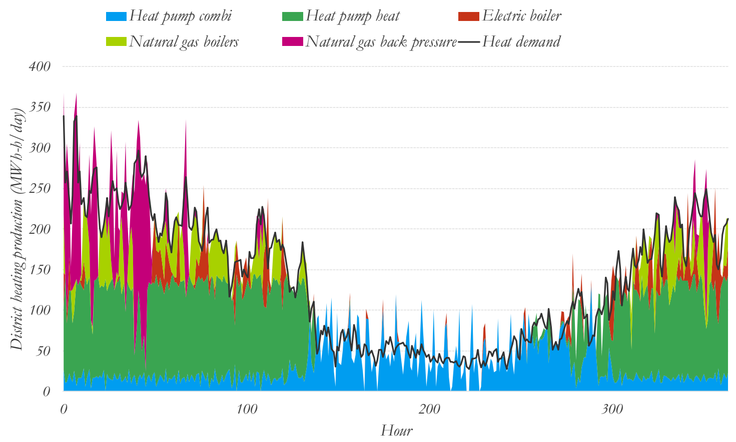
THE INTERACTIVE PLANNING TOP-DOWN AND BOTTOM-UP PRODUCTION, CONVERSION AND STORAGE TECHNOLOGIES

- The network an energy market characterized by the following:
  - Annual energy demand and aximal hourly capacity demand
  - Typical annual load profile for a network of this type, e.g. Energy duration curve
- Propose:
  - Production plants, for base load and peak load
  - Conversion technologies from one energy carrier to another
  - Storages (hot water, cold water, gas, electricity)
- Optimal load dispatch, e.g. with EnergyPro
- Total costs to compare with others solutions – change of plants
- Marginal costs of energy – change of zoning and change of demand, e.g. converting from electricity to hot water





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ENERGY TECHNOLOGIES DATABASE

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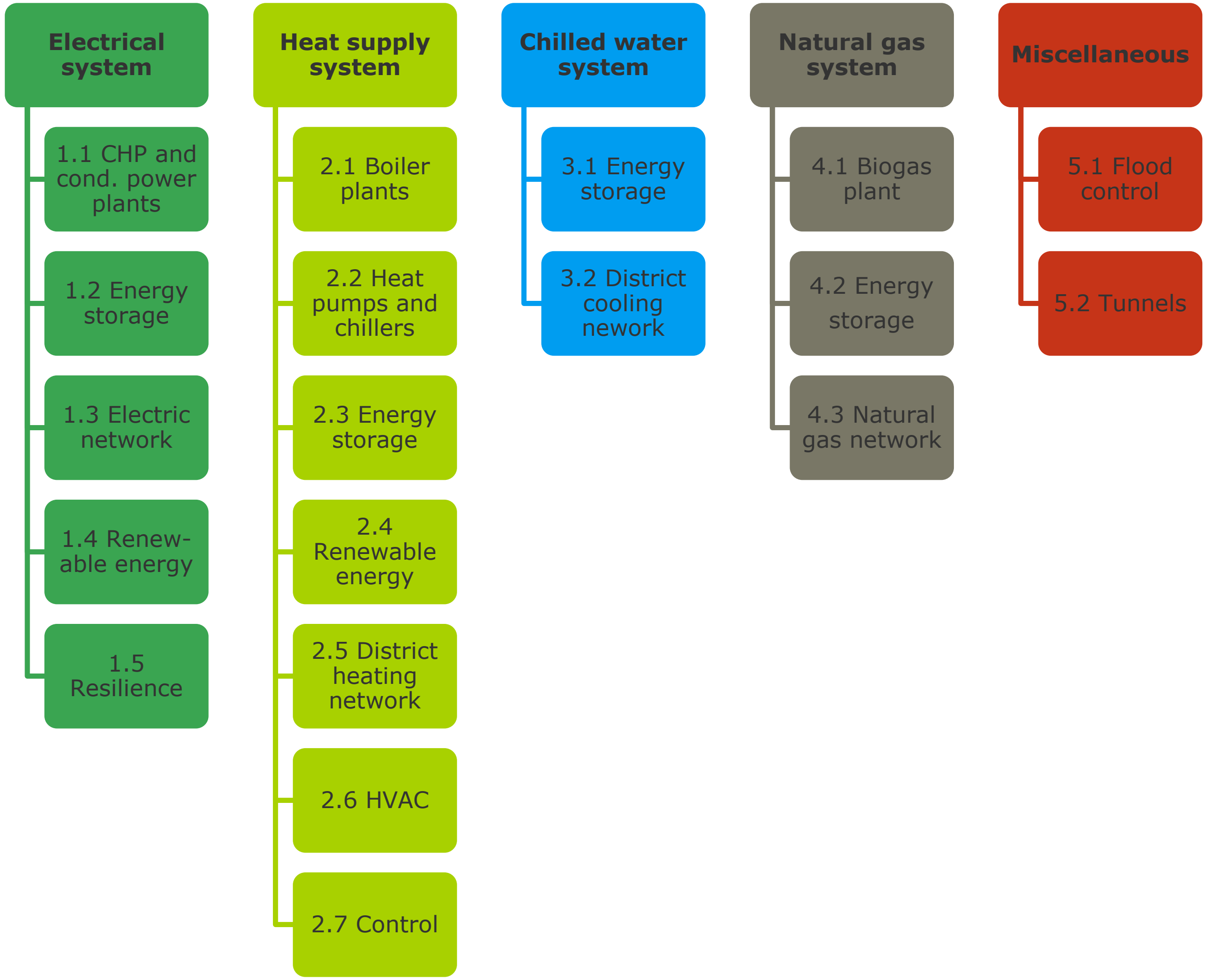
THE TECHNOLOGY DATABASE
A STATIC SNAP-SHOT IN WORD.DOC FORMAT

The structure of the database includes the following categories:

- Electric systems
- Heat supply systems
- Chilled water systems
- Natural gas systems
- Miscellaneous



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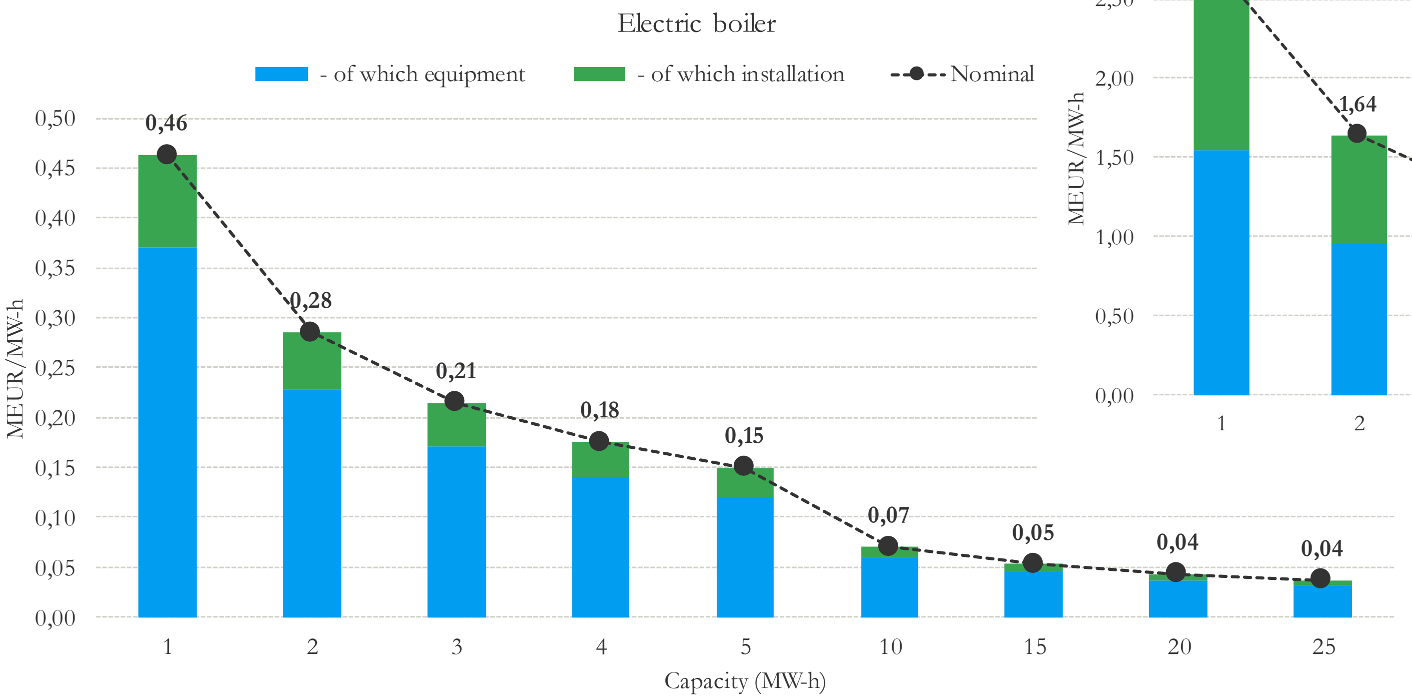
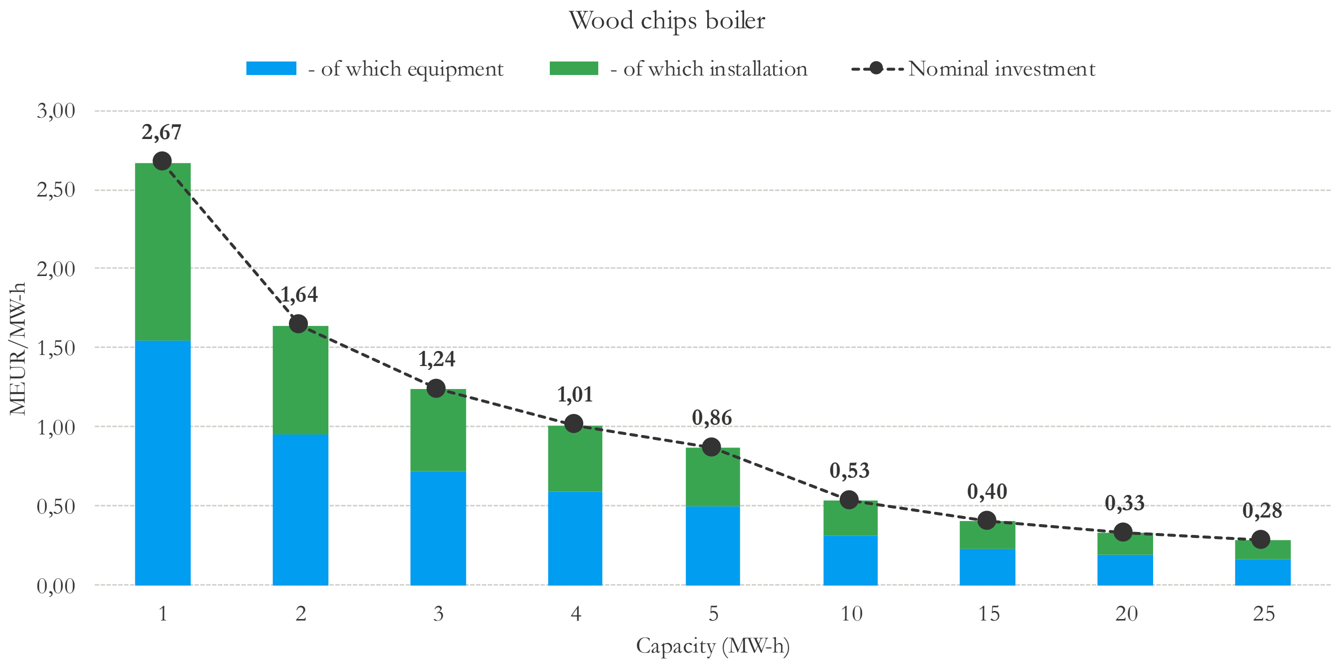
CONVERSION TECHNOLOGIES BOILERS

- Significant economy of scale factor
- Large boilers can burn solid fuels at minor pollution





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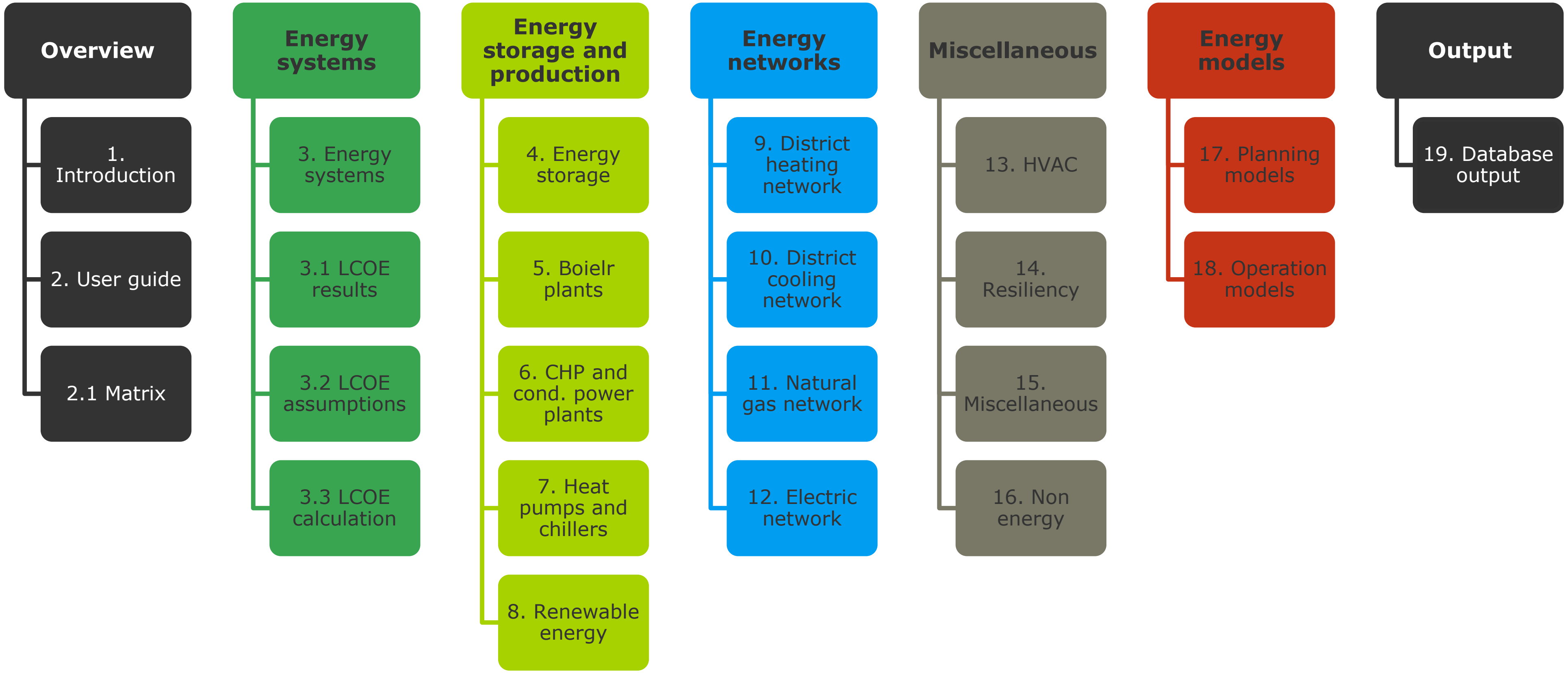
DATABASE
A DYNAMIC EXCEL MODEL



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THE MATRIX – THE ARCHITECTURE DESIGN
DYNAMIC LIST OF CONTENT

	Classification System					Case		District heating				District cooling		Renewable energy				CHP				E2H & E2C				Boiler				Storage			Resiliency		
System design and case number	Type of example	Spatial location	Buildings to be supplied from the outside with ...	No. of example	Indexation	Case number (Task B)	Energy system example (Task C)	Steam system	District heating system (160/70)	District heating stem (110/80/50)	District heating ystem (70/60/40)	High temperature cooling 10/15	District cooling system (5/10)	Solar Heating	Deep geothermal	Solar PV	Wind turbine	Oil CHP	Gas CHP	Biomass CHP	Waste CHP	Electric chiller	Electric heat pump	Absorption heat pump	Electric boiler	Oil boiler	Gas boiler	Biomass boiler	Waste boiler	Thermal tank storage	Cold storage	Thermal pit storage	Security 0 to 10	Fuel 0 to 10	Description, draft to be considered, and explained in detail in section on system design
1	Best practice examples	At community level	Power + heating	Example 1	2.3.1.1	---	Arctic Climate	X	---	---	---	---	---	---	---	---	---	X	---	---	---	---	---	---	---	X	---	---	---	---	---	---	0	1	Risk of break down and fuel shortage
2	Best practice examples	Combination	Power + heating	Example 2	2.4.1.2	---	Mild climate (w/ grid connection)	---	---	---	X	X	---	---	---	---	---	---	X	---	---	X	X	---	X	---	X	---	---	X	X	---	10	10	Reliable heating cooling and power, smart use of electricity
3	Best practice examples	At community level	Power + heating + cooling	Example 3	2.3.4.3	---	Mild climate (wo/ grid connection)	---	---	---	X	X	---	X	---	---	---	X	---	---	---	X	X	---	X	X	---	---	---	X	X	---	10	10	Reliable heating cooling and power, smart use of electricity
4	Best practice examples	At community level	Power + heating + cooling	Example 4	2.3.4.4	---	Mild climate (wo/ grid connection, w/ wind	---	---	---	X	X	---	X	---	---	X	X	---	---	---	X	X	---	X	X	---	---	---	X	X	X	10	10	Reliable heating cooling and power, smart use of electricity
5	Best practice examples	At community level	Power + heating + cooling	Example 5	2.3.4.5	---	Tropic climate	---	---	---	X	X	---	---	---	---	---	---	---	X	X	X	X	X	---	---	X	---	---	X	X	---	10	10	Large city, Reliable heating cooling and power, smart use of electricity

INFORMATION IN THE DATABASES

Technology

- A broad technology description is provided for each technology.

Primarily fuels

- Type of fuel(s) that each technology can use for its operation.

Energy production

- The output of electricity, heating, cooling and any relevant by-products for each technology.

Capacities

- The stated capacities are for a single unit capable of producing energy (e.g. a single wind turbine or a single gas turbine), not a power plant consisting of a multitude of units such as a wind farm. In the case of a modular technology such as PV or solar heating, a typical size of a solar power plant based on the market standard is chosen as a unit.

Space requirement

- The space requirement for renewable energy installations (solar PV, wind, etc.) are available. The value presented only refers to the area occupied by energy produced equipment. The space requirements may for example be used to calculate the rent of land, which is not included in the financial cost, since this cost item depends on the specific location of the plant.

Control ability

- Control abilities are particularly relevant for electricity generating technologies. This includes the part-load characteristics, start-up time and how quickly it can change its production when already online.

Environment

- Environmental characteristics are available including emissions and local pollutants.

Financial

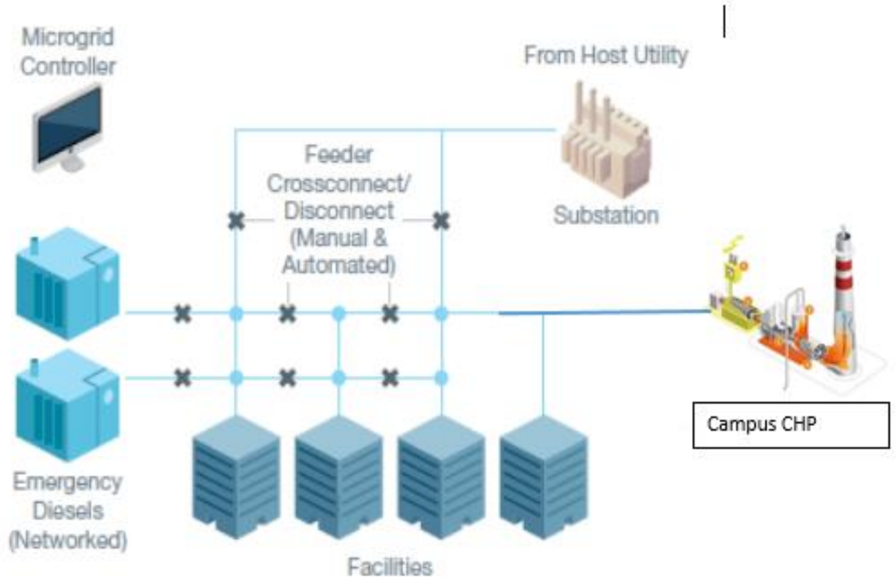
- For each technology the following financial information is provided: investment costs, fixed O&M and variable O&M costs provided. The costs are provided in Euro and US Dollars. In the Excel database the currency can be selected for a broader range of currencies which can be adjusting to the current exchange rates.

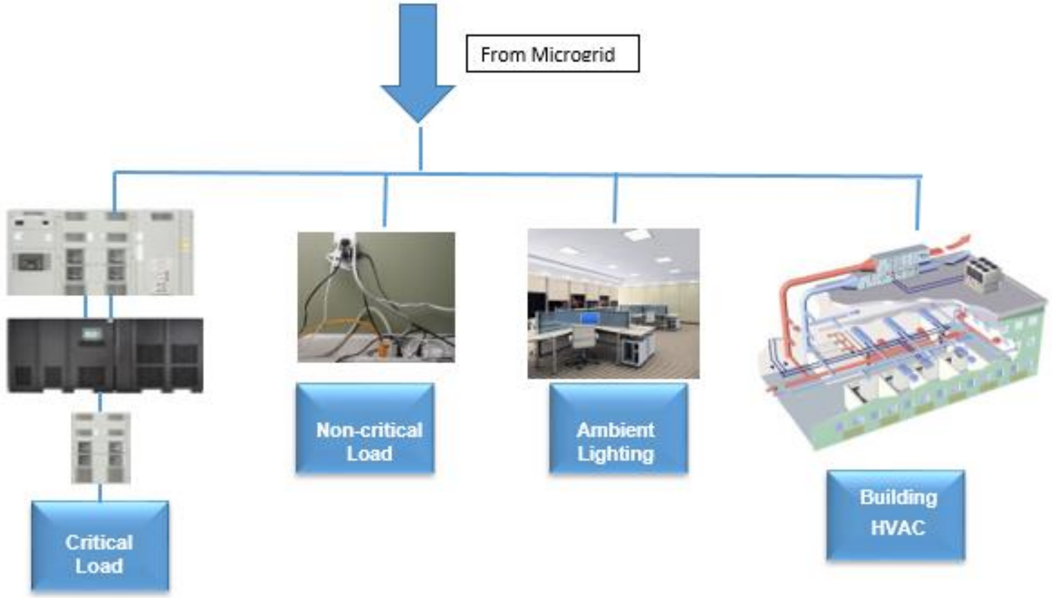
ELECTRICITY NETWORKS

- **No need for zoning in campusses as all buildings are to be connected, but** Identify critical demand

- The electricity market
  - Hourly Energy prices fluctuates
  - Matket for regulation up/down
  - Market for capacity
  - Market for stabilizing the grid

- Consumers, e.g. hot water district heating systems in campusses can offer many of these services
- Local back-up to critical demand





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THERMAL NETWORKS

- **Zoning of low temperature thermal networks is the first priority in local community planning**
- Production to the networks is the second priority
- ‘Utilizing waste heat from power generation for heating/cooling via thermal grids can add to the efficiency and resiliency of the energy system.
- Thus, a decision needs to be made whether the future energy system should include thermal grids (heating grid only, cooling only, heating and cooling, depending on the climate zone and energy density).
- If buildings within a campus or community are spaced too far apart and/or building energy demand is low (e.g. buildings need only domestic hot water and no heating), thermal grid options for these specific buildings can often be excluded from the selection process.

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Table 8.1: Advantages and disadvantages of centralised thermal energy systems

Description	Application, advantages, disadvantages

Centralised systems with heating and/or cooling grids	**Application**: Communities with high energy density (at least in some parts of the community)
	
	• Requires space in the streets for the distributin lines.
	• Requires space for central energy plants.
	• Requires an operator
	
	Advantages:
	
	• Distribution of waste heat to a whole community is possible (e.g. from waste incineration or industrial processes)
	• Higher reliability and security of supply than decentral options
	• Larger equipment offers economies of scale
	• Only one (or a few) generation sites needs to be operated and maintained
	• Switch to larger share of renewables is easier than in decentral options
	• Save space for energy generation plants in buildings and saves investment cost and O&M costs in buildings
	• Eliminate local pollution from emissions and noise
	• Opportunities for sector coupling
	  o On-site CHP and power improve resiliency against outages on the electrical network
	  o Surplus heating from CHP in summer can be utilized to provide cooling via absorption chillers
	  o Electric boilers can convert surplus renewable electricity into heat, heat pumps can convert it to heating and cooling.
	
	Disadvantages:
	
	• Additional capital cost of constructing a network.
	• Additional effort and cost of maintaining the network.

THERMAL NETWORK TEMPERATURES

- Selection of network temperatures depends on temperature levels required by the buildings and the output temperatures that can be produced from the energy sources.
- Modern buildings designed to high energy efficiency standards are often able to operate with low temperatures for their heating systems (and higher temperatures for the cooling systems).
- With networks intended to supply older buildings, the costs and benefits for retrofitting these buildings to a more modern standard can be compared to the option of operating grids on higher temperature levels for heating and lower temperatures for cooling with corresponding higher thermal losses.

Table 8.2: Advantages and disadvantages of high grid temperatures

Description	Application, advantages, disadvantages
District Heating with high supply temperatures (> 90 °C)	**Application**: • High-temperature fuel input, e.g. fossil fuel, biomass, waste incineration, high temperature geothermal energy and high temperature industrial waste heat. • Existing DH network with pipe diameters dimensioned to serve peak load at a defined temperature difference. • Existing building substations are dimensioned to serve peak load at a defined temperature difference. • Building stock with heating and domestic hot water (DHW) installations requiring high temperatures (e.g. 70 °C supply for DHW) and returning high temperatures to the grid (e.g. 65 ° from DHW circulation in summer). **Advantages**: • High temperature difference between supply and return allows lower pipe diameters for the same energy transport capacity (lower diameters usually mean lower cost to build the network). **Disadvantages**: • Higher heat losses. • Integration of low-temperature renewables or excess industrial heat is more difficult and more expensive. • Piping systems with higher absolute specific costs (per meter pipe of the same diameter; this may however be outweighed by other factors (see above)).

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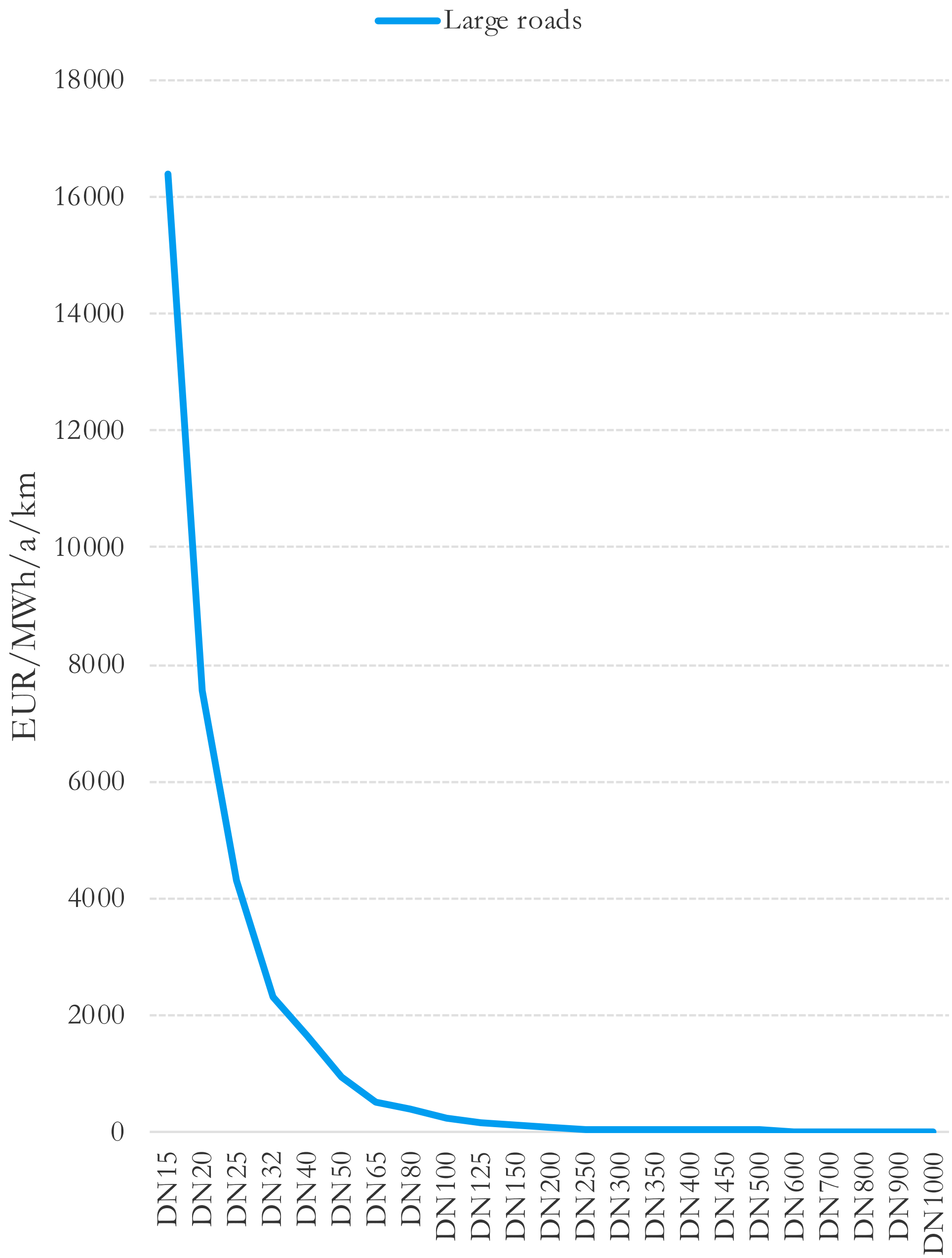
THERMAL NETWORKS
ECONOMY OF SCALE
MINOR LOSSES AND LOWER COSTS



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DISTRICT HEATING FROM 1ST TO 4TH GENERATION

District is heating in a transition

- from steam
- to integrated low temperaure system:

- Lower temperatures to and from buildings (low temperature HVAC
    - More cost effective storages
    - More efficient CHP
    - More efficiient heat pumps
    - Intereraction with district cooling via heat pumps and ATES

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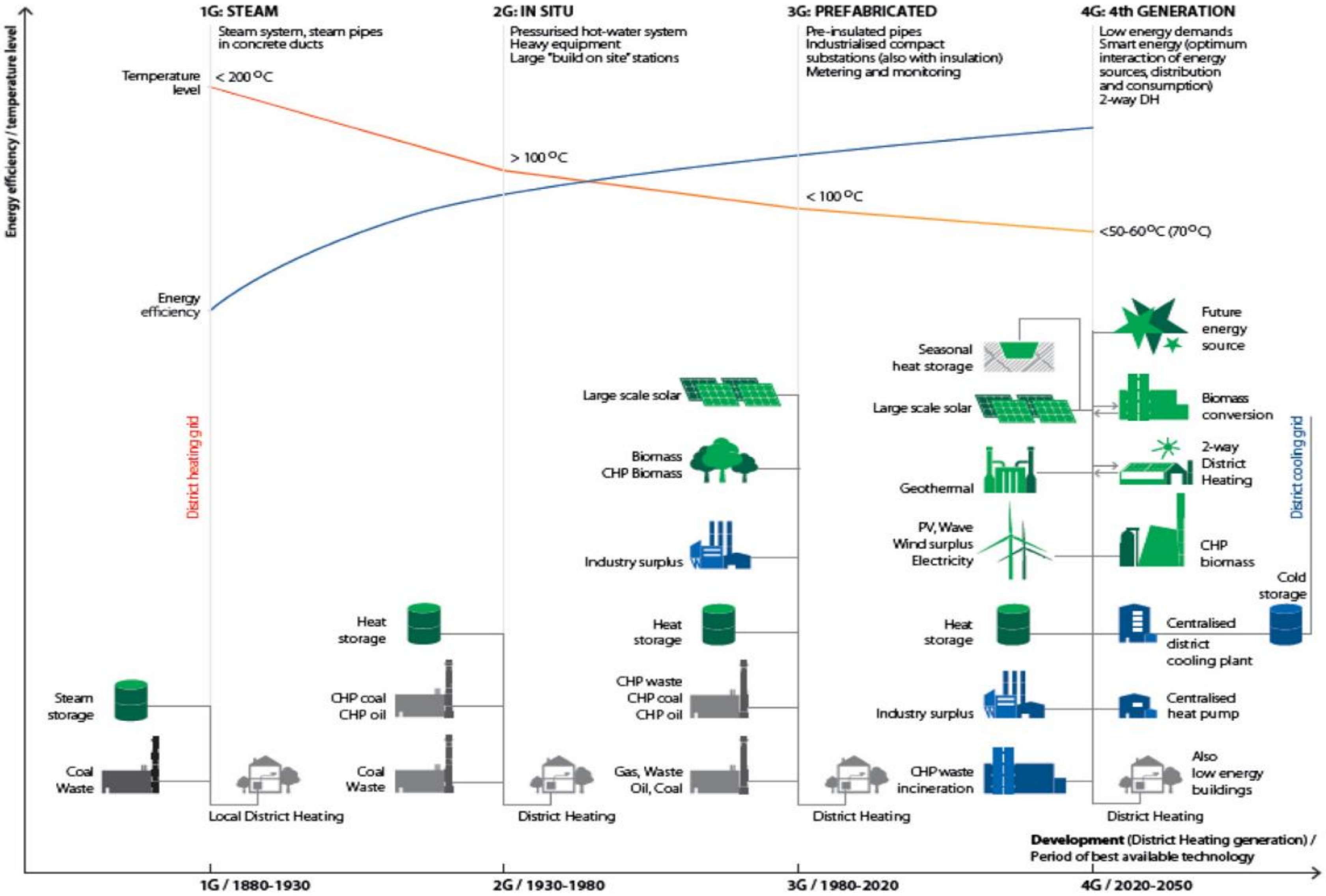


CONVERSION TECHNOLOGIES COMBINED HEAT AND POWER

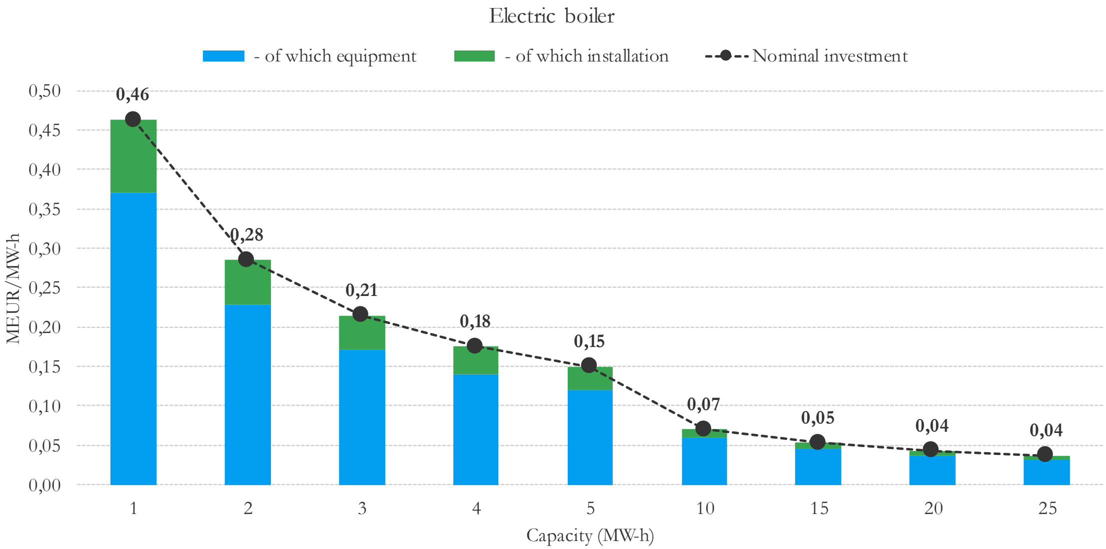
- Important to minimize waste of heat from power generation
- Most district heating systems include some type of CHP equipment.
- Historically, district heating systems often came into existence because operators of large condensation power plants wanted to achieve a more efficient fuel use – and additional income from selling the waste heat.
- Many of the smaller, more recent DH systems serving specialised communities like airports, hospitals, universities or military installations operate their own CHP equipment to reduce the share of electrical power purchased from the grid.

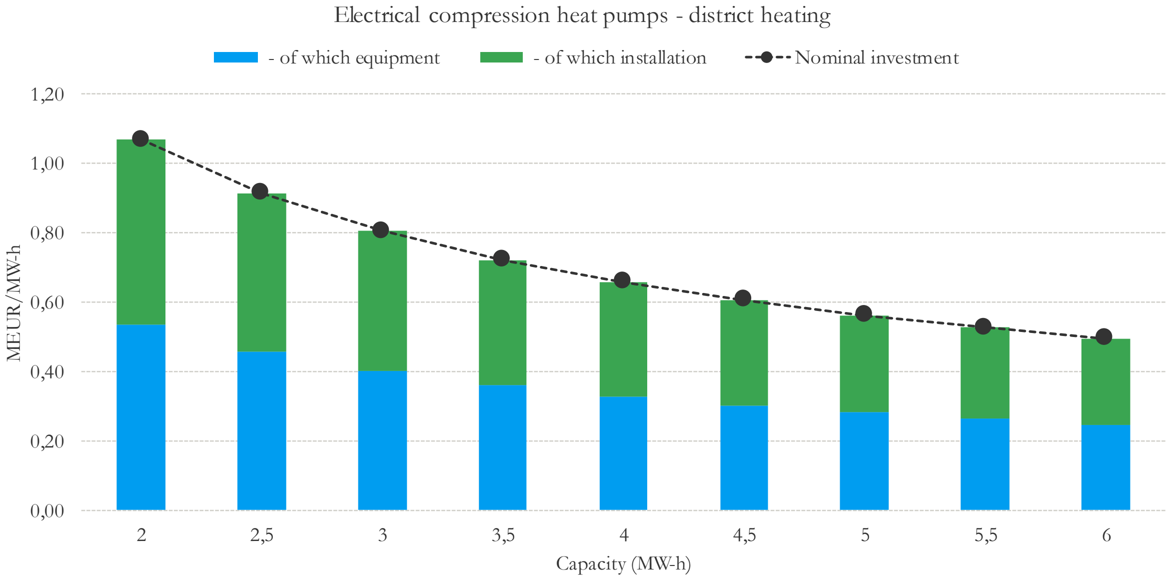
Table 8.3: Advantages and disadvantages of combined heat and power generation

Description	Application, advantages, disadvantages
Combined Heat and Power (CHP) generation	**Application**: Communities with high electricity demand and sufficient heat demand – when on-site power generation is an option with regard to economic and/or resiliency considerations. **Advantages**: • More efficient fuel use compared to condensation power generation in combination with decentralized heating/cooling. • Can be more cost efficient than separate generation of heat and power. • (Higher degree of) independence from electrical mains network. • Can offer services to the power grid and generate to the grid, in particular for generating hot water to the district heating in combination with heat storage tanks. (whereas steam based CHP is expensive and unable to respond on power prices as the steam is expensive to store) • Using CHP in combination with electric and absorption chillers can be a more cost efficient/reliable than relying on outside electricity supply for (decentralized) electric chillers. **Disadvantages**: • Additional system complexity (load curves of power, heating/cooling need to be considered). • Higher capital cost compared to a "boiler-only" generation. • Higher maintenance cost compared to fossil boilers.

CONVERSION TECHNOLOGIES
HEAT PUMPS AND ELECTRICAL BOILERS

- Important for integrating fluctuating renewable energy from wind and solar
- Electric boilers can eliminate zero prices and stabilize the frequency





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RENEWABLE ENERGY SOURCES

- Constraints that need to be considered when designing a district heating and cooling system architecture are the limited quantities of renewable energy resources available, the fluctuating nature of renewables and the constraints of some renewables/excess heat sources regarding output temperature.
- The table gives an indication on how to select a renewable energy source to fit an existing (or new) district heating system.
- Green boxes in the table indicate that the equipment is suitable for the intended purpose, red boxes show that the option is not suitable.
- Biomass options can usually replace fossil generation without many complications, while more thought will go into the consideration of low-temperature and fluctuating renewables.

Integration of renewable energy into district heating

- ✓ available
- not available/does not make ser
- not applicable

Parameter/category characteristic	woody biomass			biogas			bio methane		hydrothermal deep geothermal		solar thermal		heat pump (ambient heat sources, sewage, etc.)	electric boiler
sufficient availability of renewable energy	Amount of biomass procurable? Problems with fine dust pollution at the location?			Amount of biogas available?			Amount of bio synthetic natural gas available?		Geothermal energy locally available?		Solar thermal installation area 1500 m² or more		Amount of ambient heat available	amount of renewable electricity available?
Generator type	boiler	CHP steam power process	CHP ORC/KC	boiler	CHP CHP engine	CHP micro gas turbine	boiler	CHP all natural gas CHP plants possible	heat only	CHP ORC/KC	flat plate collector	vacuum tube collector	heating, cooling or both	boiler
therm. capacity														
up to 1 MW	✓		✓	(✓) 1)	✓	✓	✓	✓			(✓) fluct.	(✓) fluct.	✓ 7)	✓
1 to 5 MW	✓		✓	(✓) 1)	✓	✓	✓	✓	capacity site specific (depending on temperature level, geothermal production rate)		(✓) fluct.	(✓) fluct.	✓ 7)	✓
5 to 10 MW	✓		✓	(✓) 1)	✓	1)	✓	✓			(✓) fluct.	(✓) fluct.	✓ 7)	✓
10 to 20 MW	✓	✓	✓	(✓) 1)	1)	1)	✓	✓					✓ 7)	✓
> 20 MW	✓	✓		(✓) 1)	1)	1)	✓	✓					✓ 7)	✓
electr. capacity														
up to 1 MW			✓		✓	✓		✓		✓ 5)				
1 to 5 MW			✓		✓	✓		✓		✓ 5)				
5 to 10 MW		✓			✓			✓		✓ 5)				
10 to 20 MW		✓						✓		✓ 5)				
> 20 MW		✓						✓		✓ 5)				
load type														
thermal peak load (in winter)	(✓) 3)	3)	3)	(✓) 3)	3)	3)	✓	3)	4)	3)			4)	
thermal base load	✓	✓	✓	(✓) 1)	✓	✓	✓	✓	✓	✓			✓	
thermal (daytime) summer load											✓	✓		
renewable electricity surplus (wind, PV)														✓
temperature level														
steam grid	✓	✓		(✓) 1)		✓	✓	✓						✓
high temperature grid (T_{VL} > 140 °C)	✓	✓		(✓) 1)		✓	✓	✓						✓
hot water grid (140 °C > T_{VL} > 110 °C)	✓	✓		(✓) 1)	✓ 2)	✓	✓	✓	site specific			✓ 6)		✓
110 °C > T_{VL} > 90 °C	✓	✓		(✓) 1)	✓ 2)	✓	✓	✓			✓ 6)	✓ 6)		✓
LowEx grid	✓	✓	✓	(✓) 1)	✓	✓	✓	✓			✓ 6)	✓ 6)	✓ 7)	✓

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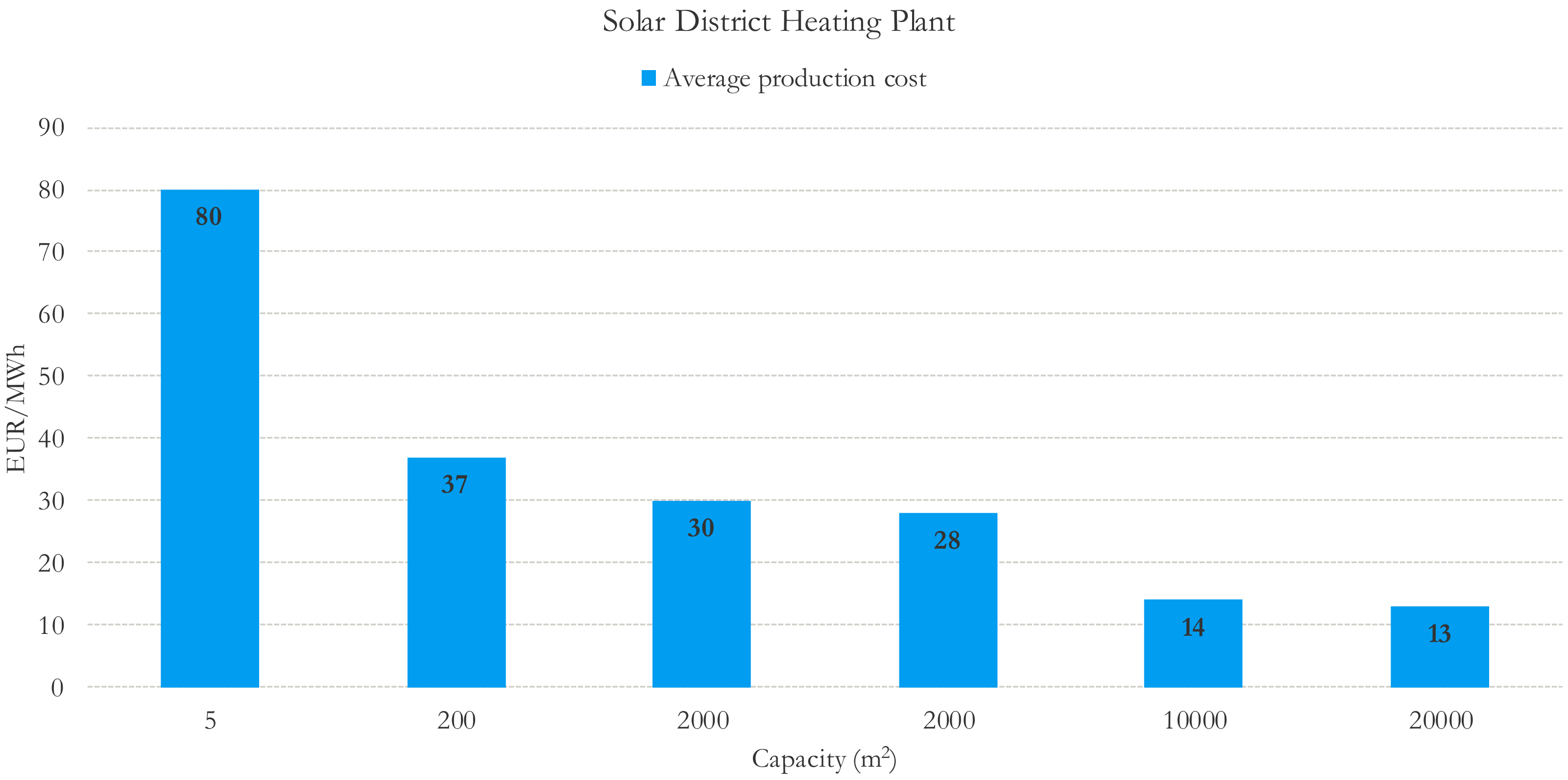
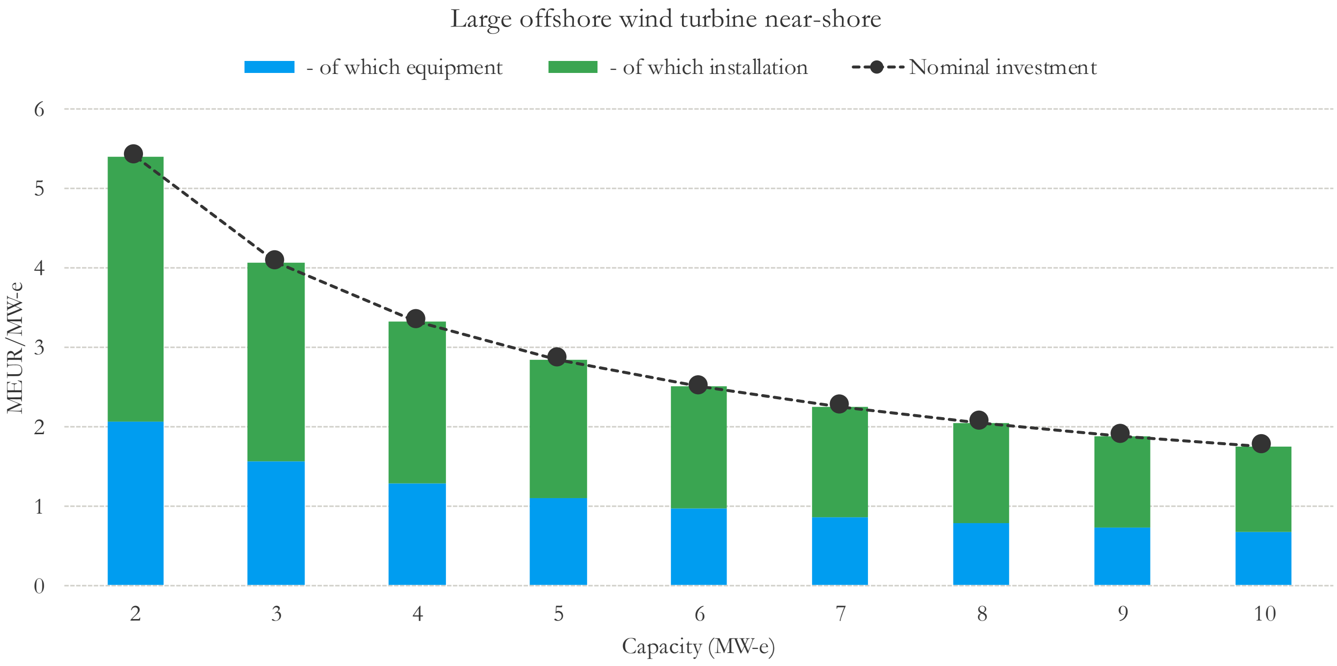
RENEWABLE ENERGY SOURCES
SOLAR WATER HEATING

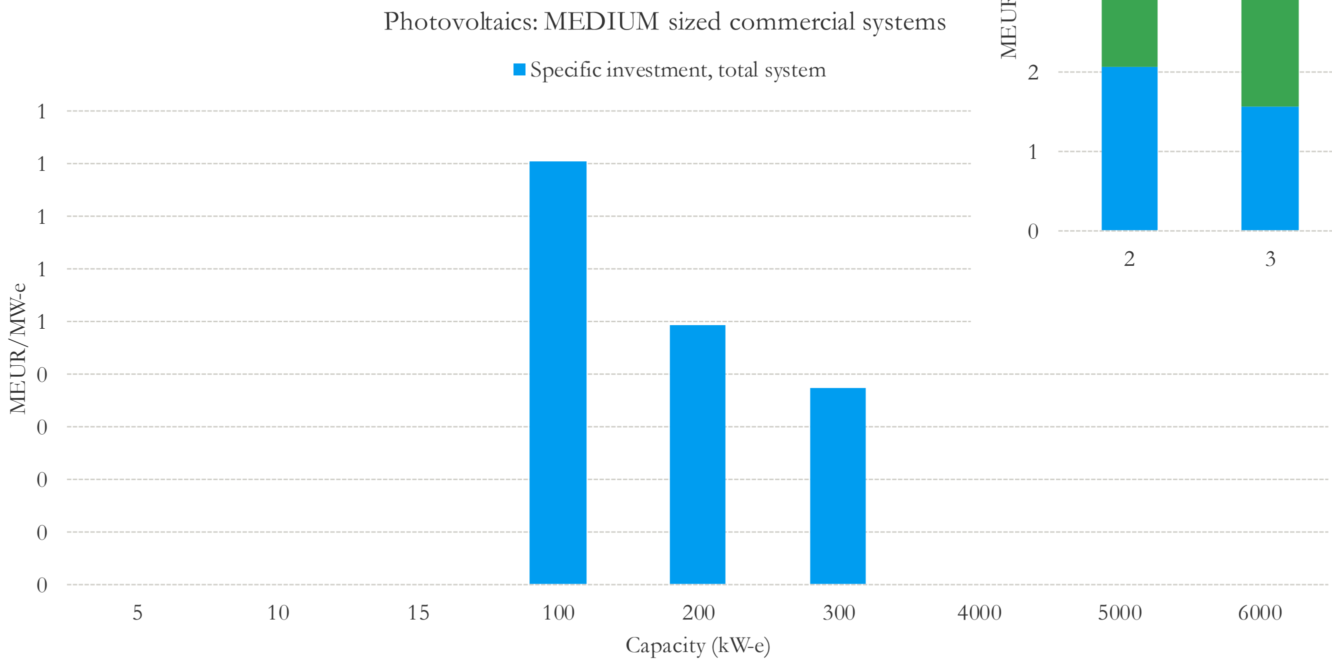
- Significant economy of scale factor.



FLUCTUATING RENEWABLE ENERGY SOURCES WIND AND SOLAR PV

- Some economy of scale factor.



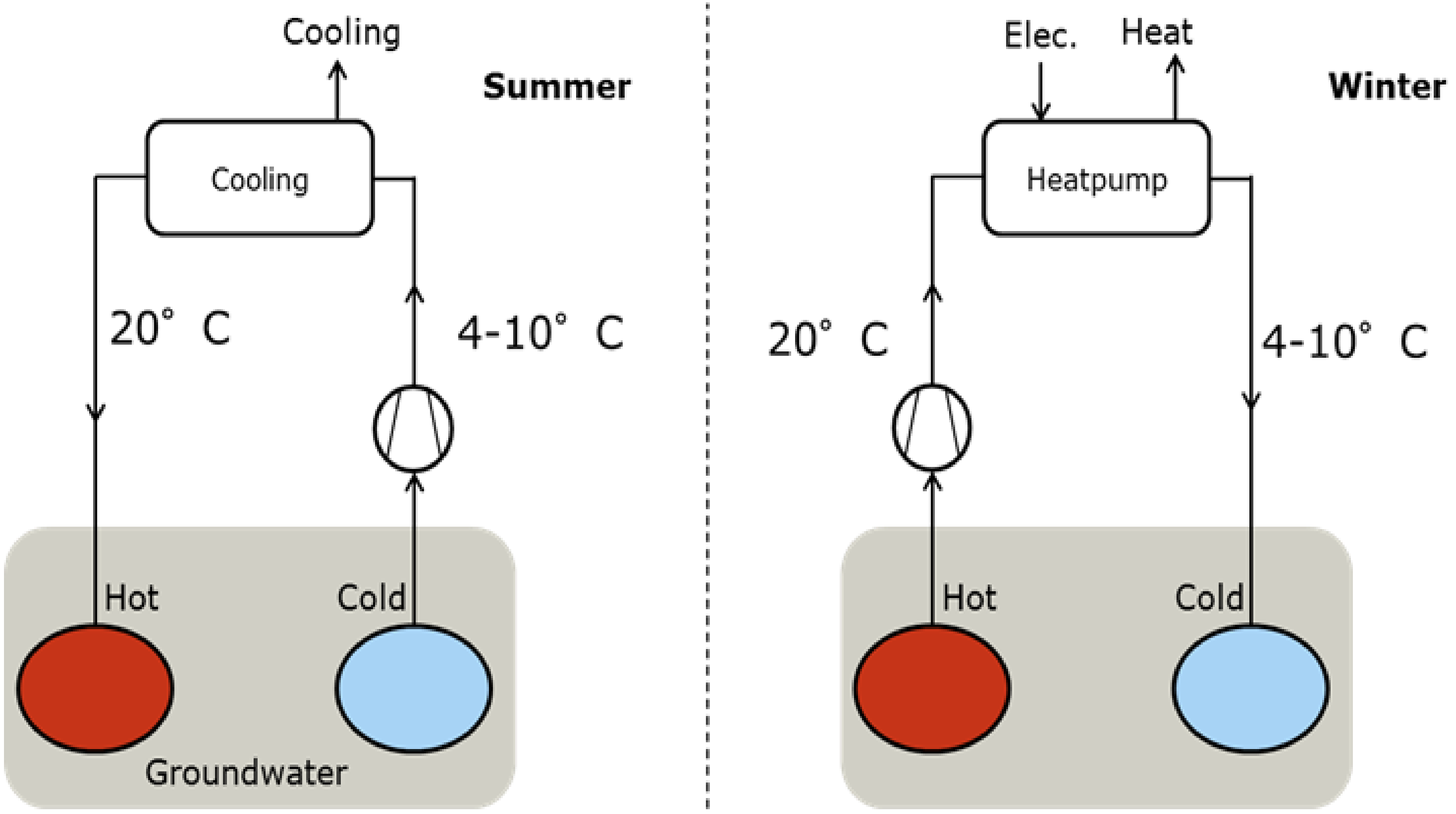


ENERGY STORAGE FACILITIES
THERMAL STORAGES

Thermal energy storages can be integrated into energy systems for different purposes like:

- CHP plants with focus on power generation while providing reliable heating and cooling supply.
- Store energy from fluctuating renewables to match supply and demand.
- Improve resiliency by temporarily supplying loads in case of generation shut-down.
- Improve the operation and optimization
- Offer peak capacity for a certain time in case the maximal load has daily fluctuations
- Store make-up water and maintain the pressure in the network

ENERGY STORAGES FACILITIES
AQUIFER THERMAL ENERGY STORAGE (ATES)



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ENERGY STORAGE FACILITIES
GAS AND ELECTRICITY

- Gas storage in the national gas grid, storage is included in the market prices
  - Salt caverns
  - Aquifer

- Electricity storage in the national power grid, storage is included in the market price
  - Hydro power dam
  - Pump hydro

- Batteries for mobility could be available with access capacity

MISCELLANEOUS MEASURES TO PROTECT ENERGY SYSTEMS AND IMPROVE THEIR RESILIENCY

- Utility tunnels or utilidors for mechanical and electrical services are installed by drilling and/or tunneling to carry utility lines such as electricity, steam, district heating and cooling pipes, water supply pipes, and sewer pipes, communications utilities like fiber optics, cable television, and telephone cables. They are common for very cold climates where direct burial below the frost line is not feasible.
- Another option used in the Artic climate with a permafrost requires is to locate district heating systems and other utilities above the ground in ducts. The relatively low (15%) heat loss from the district heating distribution system provides frost protection service to other infrastructure, wastewater pipes, and fresh water pipes. The ducts and the heat loss further contribute to serve as walking paths within the community.

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Figure 8.5a Underground steam lines are have been replaced by steam lines installed under skyways to research buildings (The University of Texas Medical Branch at Galveston)

Figure 8.5b Above ground supply infrastructure in Quaanaaq, Thule [Oddgier, et al 2020]

Figure 8.5c. RICE University undegraound tunnel

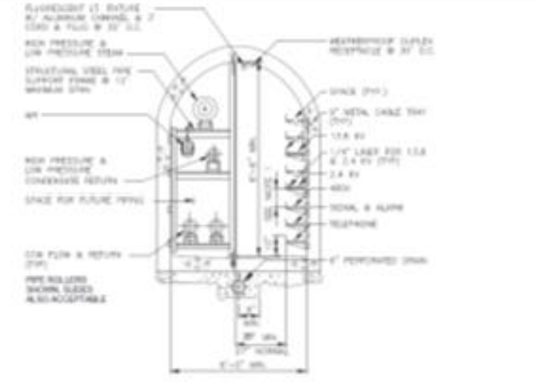

Figure 8.5d Utility Tunnel Section (University of Washington, 2017]

Figure 8.5e Equipment at a power plant is protected by a flood wall ((The University of Texas Medical Branch at Galveston)

Figure 8.5f Elevated Boilers and Chillers (The University of Texas Medical Branch at Galveston)

ENERGY SUPPLY ALTERNATIVES FOR MISSION CRITICAL FACILITIES

- Emergency generators serving individual mission critical building or its part
- Banks of emergency generators serving a cluster of mission critical facilities
- Peaking generators serving a cluster of mission critical facilities
- UPS battery package that can deliver capacity instantaneous in case of breakdown of the power supply and maintain the supply until the emergency generator gets started
- CHP capacity that can be installed at the building, providing a critical power to this and adjacent buildings and replace an ordinary emergency generators
- PV panel connected to a battery package installed at the building, providing a critical power

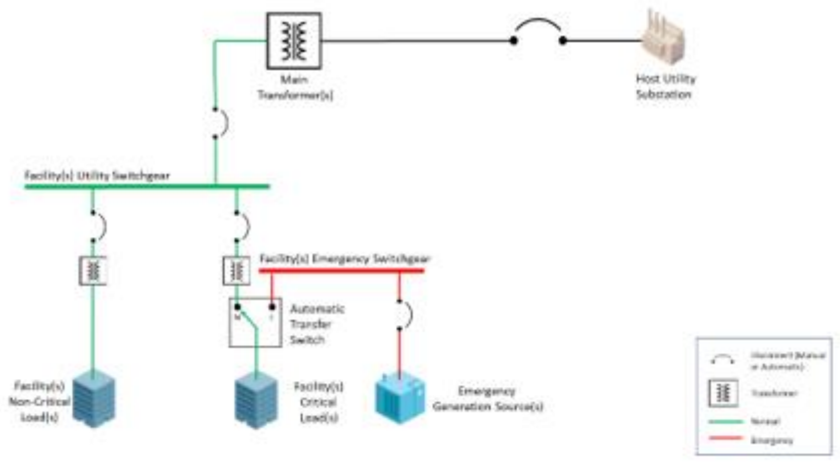

Figure 8.8. Emergency generator serving mission critical facility load.

Figure 8.9. Emergency power generation using a PV panel field connected to a battery pack.

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ELECTRICITY PRICES
ENERGY, DISTRIBUTION, TRANSMISSION

3.2.2.1 Electricity prices and taxes

	Electricity price	Black	Blue	Green	Distribution tarif		Transport tarif	Total	
Reference	[6]	[9]	[9]	[9]	Ramboll	Ramboll	Ramboll		
					Low voltage level	High voltage level		Low voltage level	High voltage level
	EUR/MWh-e	EUR/MWh-e	EUR/MWh-e						EUR/MWh-e
2018	46	46	46						13
2019		47	47						13
2020		47	48						13
2021		48	49						13
2022		49	50						13
2023		49	51						13

3.2.2.3 Electricity price factors

Operation time (% of avail. time)		Electricity consuming units	Electricity producing units
Reference		[6]	
From	To	Factor to be multiplied electricity price	Factor to be multiplied electricity price
0	5	0,06	2,03
5	10	0,27	1,81
10	15	0,40	1,68
15	20	0,47	1,58
20	25	0,53	1,51

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FUEL PRICES

	Natural gas price	Current policies scenario	New policies scenario	Sustainable development scenario
Reference	[6]	[7]	[7]	[7]
	EUR/MWh-f	EUR/MWh-f	EUR/MWh-f	EUR/MWh-f
2019	27,5	27,5	27,5	27,5
2020		27,1	26,9	26,3

	Coal price	Current policies scenario	New policies scenario	Sustainable development scenario
Reference	[6]	[7]	[7]	[7]
	EUR/MWh-f	EUR/MWh-f	EUR/MWh-f	EUR/MWh-f
2019	11,8	11,8	11,8	11,8
[illegible]	[illegible]	[illegible]	[illegible]	,2
[illegible]	[illegible]	[illegible]	[illegible]	,6

	Oil price	Current policies scenario	New policies scenario	Sustainable development scenario
Reference	[6]	[7]	[7]	[7]
	EUR/MWh-f	EUR/MWh-f	EUR/MWh-f	EUR/MWh-f
2019	45,9	45,9	45,9	45,9
2020		47,6	46,0	44,8
2021		49,2	46,1	43,6

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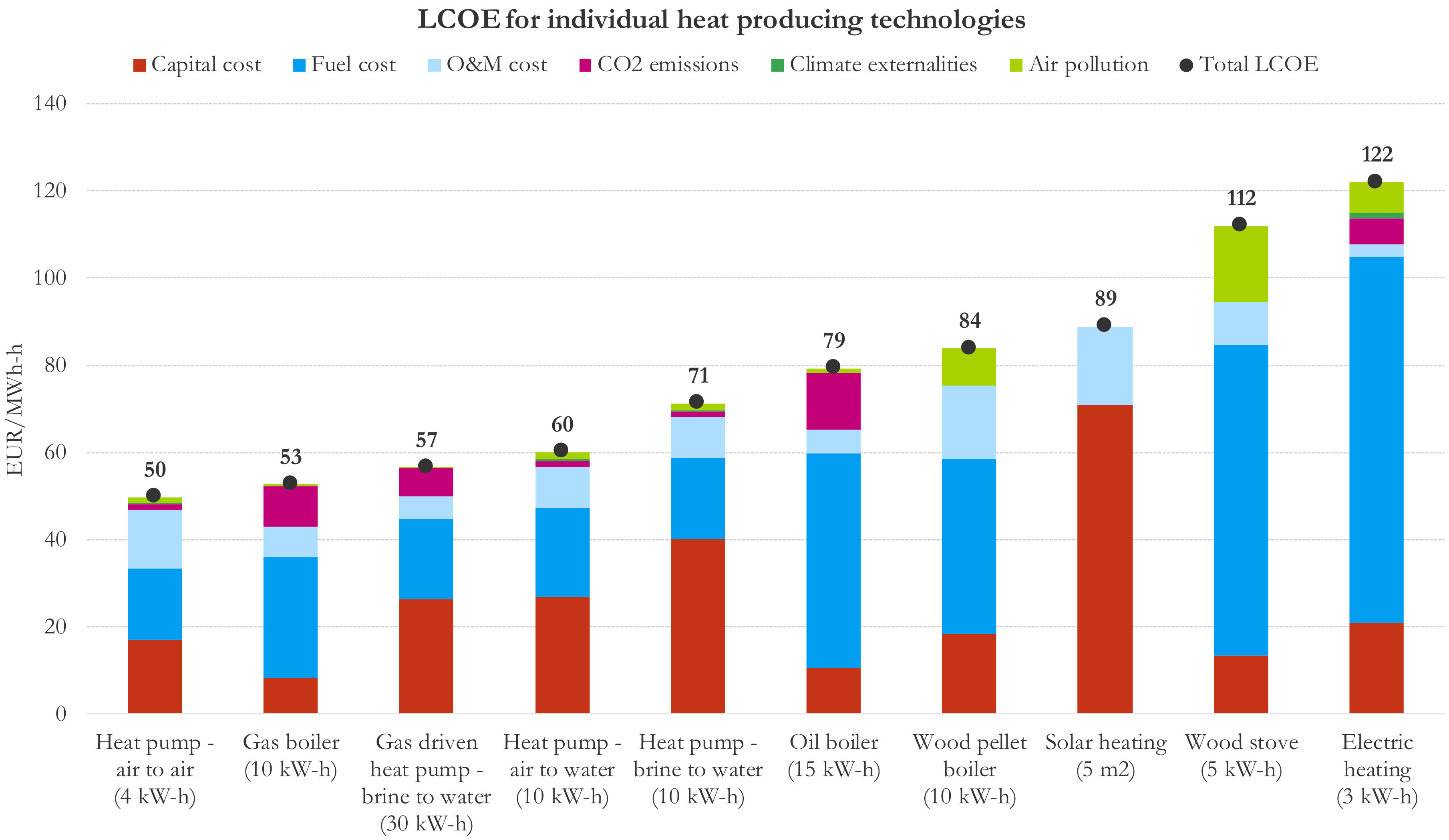
FOR A SPECIFIC SET OF ASSUMPTION THE DATA BASE SHOWS: LEVELIZED COST FOR INDIVIDUAL HEAT PRODUCTION

- Electric heat pumps are only cost effective in case of:
- Low electricity prices
- Low temperature heating system



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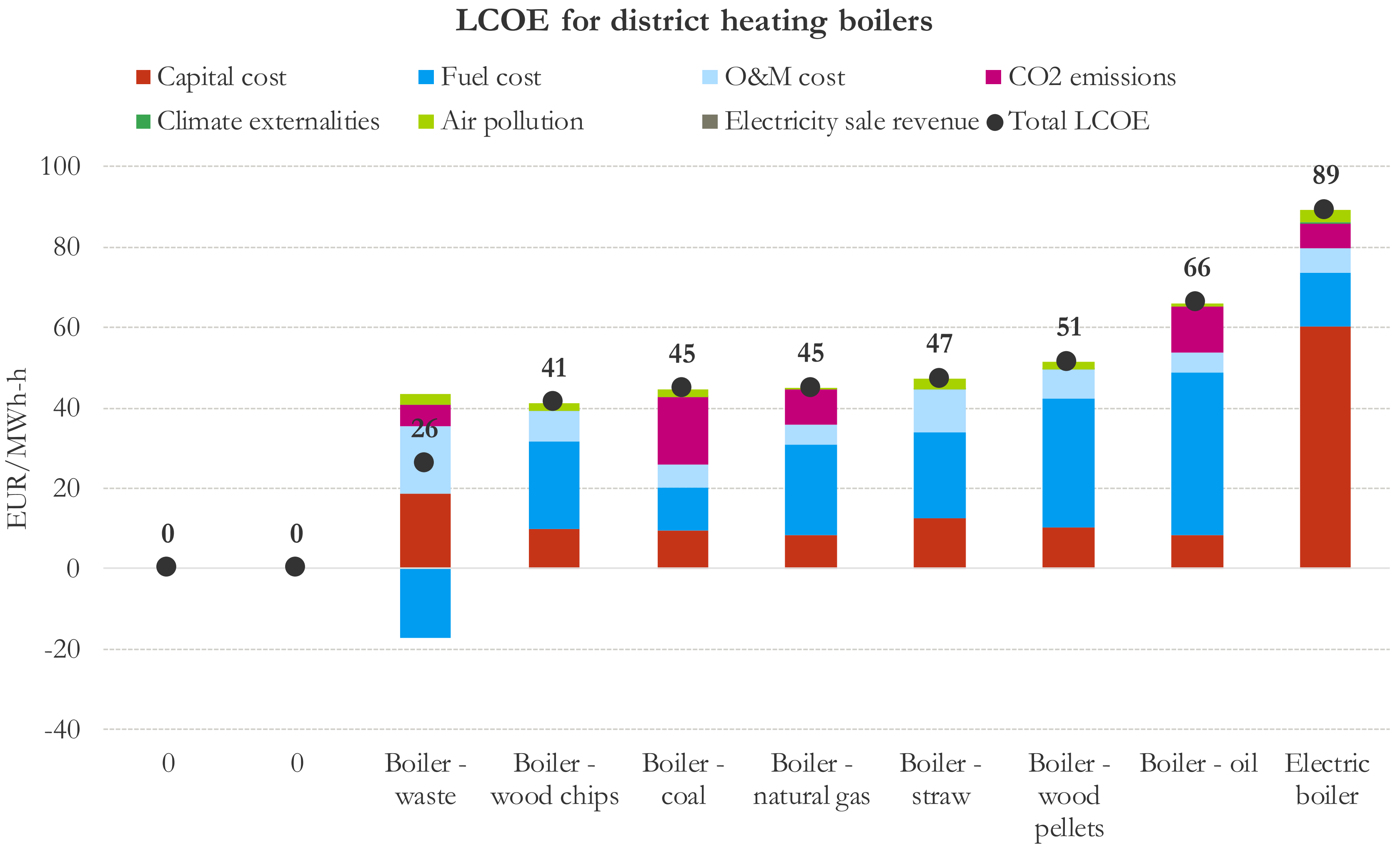
FOR A SPECIFIC SET OF ASSUMPTION THE DATA BASE SHOWS: LEVELIZED COST FOR DISTRICT HEATING BOILERS

- Electric boiler: . Large capital costs due to low max load hours, but revenues for regulation services is not included
- Electric boiler can be a very cost-effective alternative to curtailment of wind energy



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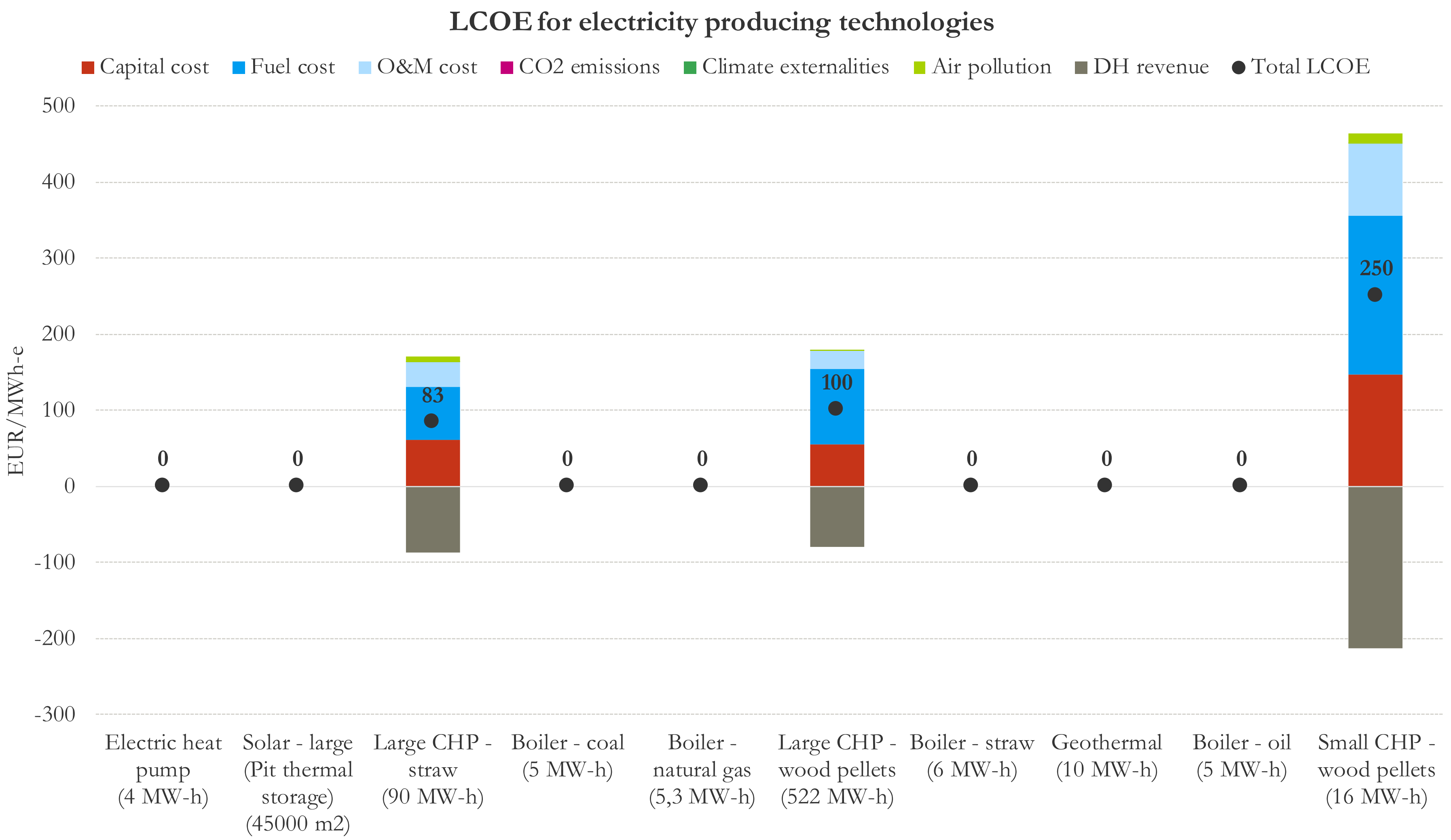
FOR A SPECIFIC SET OF ASSUMPTION THE DATA BASE SHOWS: LEVELIZED COST FOR ELECTRICITY PRODUCTION

- Cost of electricity is:
- Total costs Minus Revenues from sale of heat



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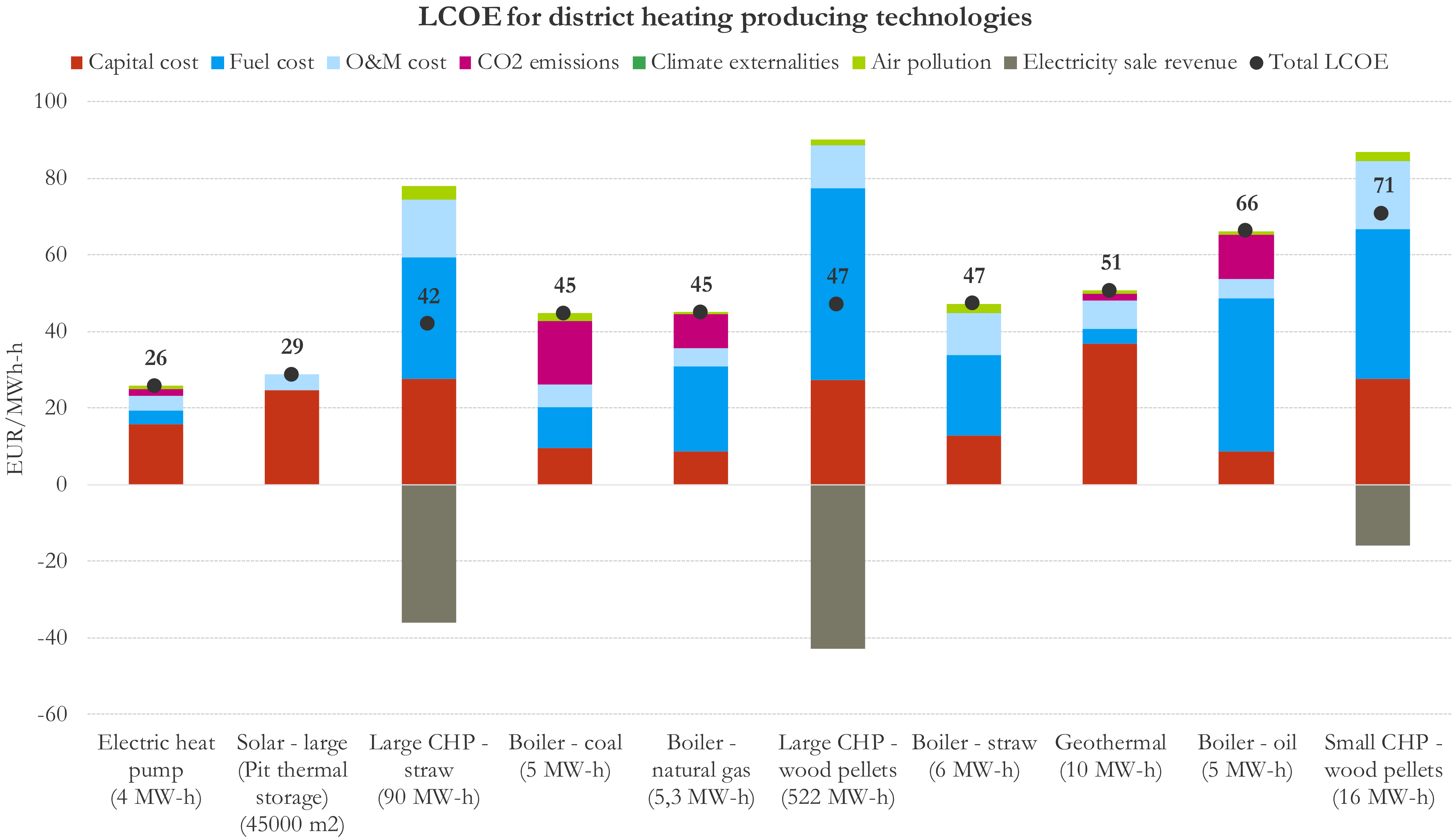
FOR A SPECIFIC SET OF ASSUMPTION THE DATA BASE SHOWS: LEVELIZED COST OF HEAT FOR DISTRICT HEATING SOURCES

- Cost of heat is:
- Total cost minus revenues from sale of electricity



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ENERGY TECHNOLOGIES DATABASE

- **IEA EBC Annex 73 Task C**
- **Energy Master Planning Guideline**
- **Chapter 7 Selection of energy system architecture and technologies**
- **Appendix F. Database of technologies**
  - **Word file of a snapshot of selected assumptions**
  - **Excel spreadsheet with the database and dynamic assumptions**
  - **Data interface to the tool**

This presentation is an introduction on how to use the database of energy technologies for energy master planning in local communicites

DATA TO THE TOOL

Index	Name	Type	Size	(Units)	Capacity/Output	(Units)	Eff. 11	Eff. 12	Eff. 13	Eff. 14	Min load	(Units)	Gradient	(Units)	Input 1	Install Cost	(Units)	Lifetime		Annual O&M Cost	(Units)	Output 1	Output 2	Output 3	Output 4
3	Solar PV 10 kW system	Solar PV			100000	kW	1	0	0	0					Elec. from 10 kW PV system	34630	USD	33	Years	190	USD	Electricity to the grid			
4	Solar PV 100 kW system	Solar PV			100000	kW	1	0	0	0					Elec. from 100 kW PV system	249300	USD	33	Years	1900	USD	Electricity to the grid			
5	Solar PV 1000 kW system	Solar PV			100000	kW	1	0	0	0					Elec. from 1000 kW PV system	2E+06	USD	33	Years	16000	USD	Electricity to the grid			
7	Central plant boiler	Boiler			100	kW	0.84	0	0	0					Natural gas	85250	USD	40	Years	2800	USD	350-375F ~120 PSI heat			
8	Central plant boiler	Boiler			1000	kW	0.84	0	0	0					Natural gas	812500	USD	40	Years	24375	USD	350-375F ~120 PSI heat			
9	Central plant boiler	Boiler			2500	kW	0.86	0	0	0					Natural gas	2031249	USD	40	Years	60937.5	USD	350-375F ~120 PSI heat			
10	Central plant boiler	Boiler			10000	kW	0.88	0	0	0					Natural gas	8124999	USD	40	Years	243750	USD	350-375F ~120 PSI heat			
11	Reciprocating engine (natural gas)	Recip. Engine			300	kW	0.31	0	0	0					Natural gas	289230	USD	20	Years	36977	USD	Electricity to the grid			

Thank you for your attention

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