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Energy Security Project

Practice and Recommendations for Cost Allocation between Electricity and Thermal Energy in Co-Generating Facilities

Energy Security Project Goals, Objectives, and Activities

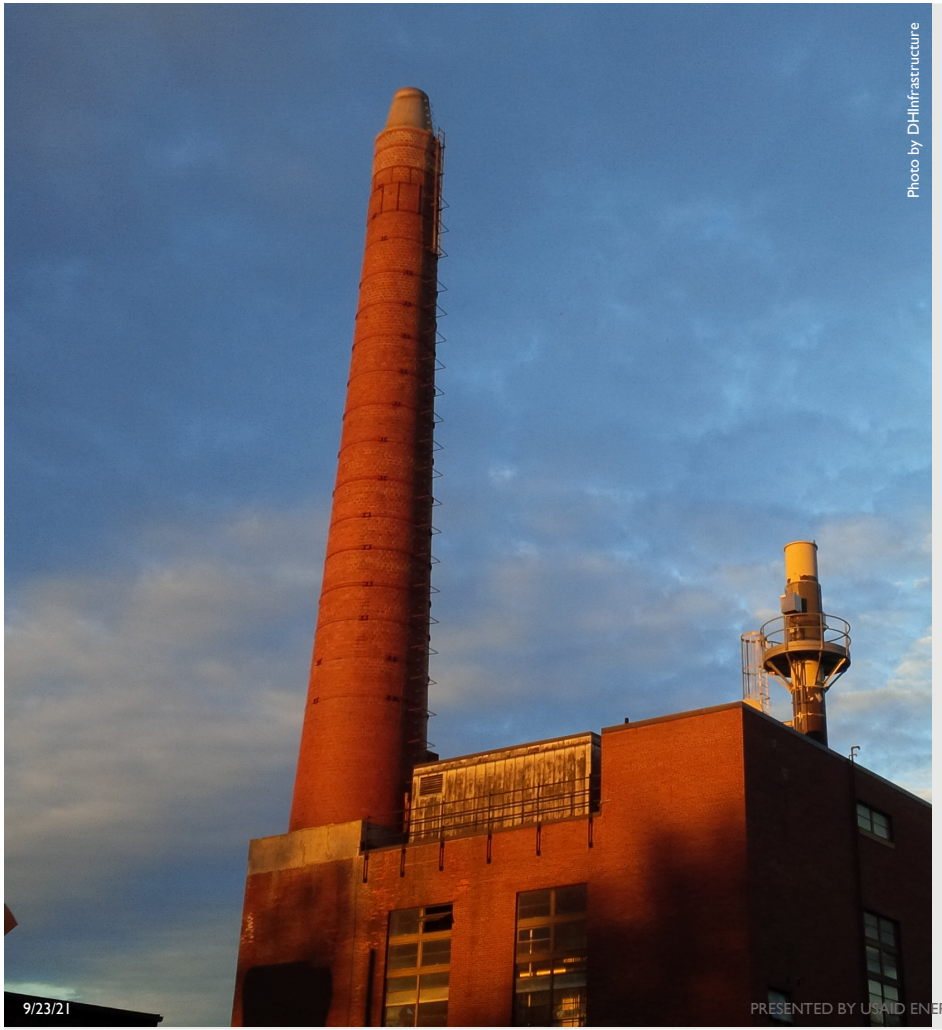
- ESP's Goal: to strengthen Ukraine's energy security: building security of supply and improving the regulatory environment will help USAID support the Government of Ukraine to achieve broad and sustainable economic development, thus strengthening democracy. ESP is assisting the government to:
  - Improve the regulatory environment for the Ukrainian energy sector;
  - Facilitate integration into European energy markets by supporting key government agencies and the national energy regulator to ensure compliance with EU energy legislation;
  - Promote private sector investment in the energy sector and energize competitive market mechanisms in the sectors of electricity, natural gas, and district heating (DH)
  - Facilitate development of efficient, reliable, and sustainable DH systems in Ukraine

Purpose of this Report

- To assist the National Energy and Utilities Regulatory Commission (NEURC) in deciding how best to allocate the costs of combined heat and power plants (CHPs), with the broader objective of improving tariff regulation in the district heating sector.
- To achieve this purpose, the report does the following:
  - Describes international practices of cost allocation between power and thermal energy in CHPs
  - Analyzes cost allocation practices for gas-, coal-, and renewable-fired cogeneration
  - Analyzes the legal and regulatory framework for cogeneration activities in 12 countries
  - Sets out recommendations for Ukraine based on international experience
- The challenges facing CHPs are closely aligned with the challenges facing district heating:
  - Whereas district heating systems can exist without CHPs, CHPs have no purpose in the absence of district heating or some guaranteed offtake of heat
  - Liberalization of electricity and gas markets will change the pricing dynamics of all energy services, district heating included

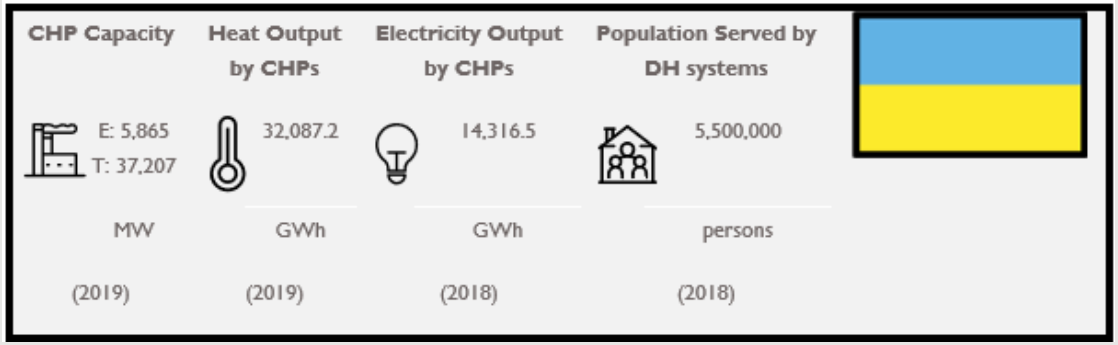
Context for Cost Allocation at Ukraine's CHPs

- Any tariff setting process typically has three steps:
  1. Costs are aggregated into a total 'revenue requirement'
  2. Portions of this total are divided and assigned to each customer class in an 'allocated cost of service study'
  3. Tariffs are designed to recover the portion of costs assigned to each customer class.
- Cost allocation typically involves the following:
  - *Functionalization:* Assigning the revenue requirement components by business segment
  - *Classification*: Assign costs by causation
  - *Allocation to customer class*: Assign costs to customer classes
- The focus of this study is ***functionalization***



Challenges Facing Ukraine's CHPs

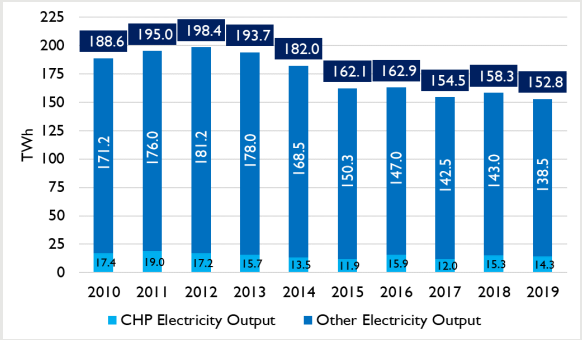
Role of CHPs in Ukraine

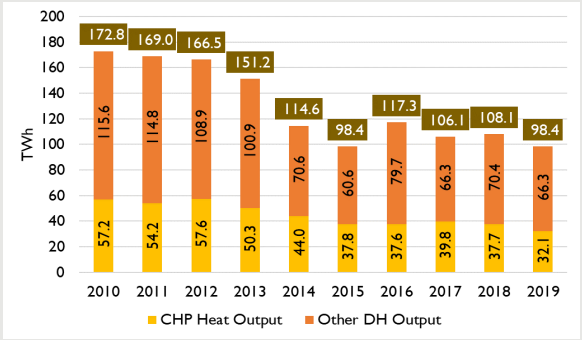


- The district heating market consists of public utilities that generate, transport, and supply thermal energy, in addition to providing residential heating and hot water services. District heating using CHPs is even more efficient.
- Ukraine's CHPs were originally built before the 1990s. CHPs focus on selling heat, with electricity as a byproduct. In many regions of Ukraine, district heating relies on CHPs and cannot function without them.
- CHPs in Ukraine produce approximately 33 percent of total heat for district heating and about 9 percent of total electricity.

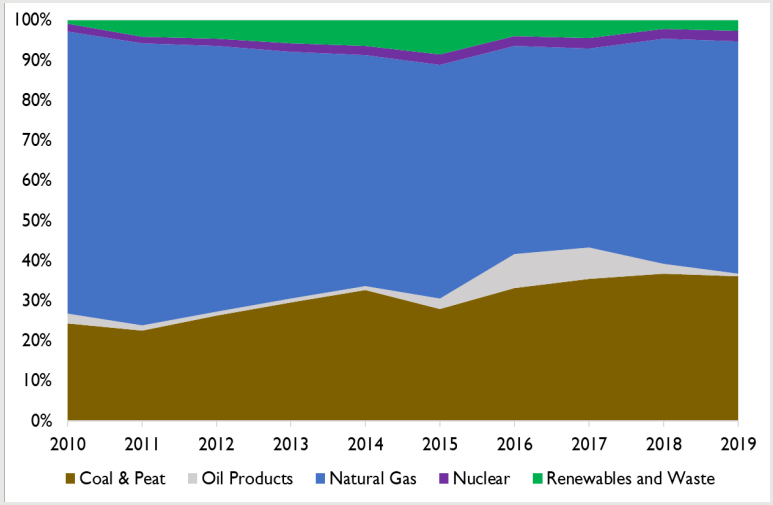
Ukraine CHP Statistics

Electricity and Heat Output





CHP Fuel Mix



- Ukraine's CHP fuel mix is primarily natural gas (58%) followed by coal and peat (36%). Renewables make up just 3%.

Source: State Statistic Service of Ukraine (SSC), *Energy Balance of Ukraine* 2010–2019 editions, (Kyiv: SSC, 2011–2020).

Legal and Regulatory Framework for CHPs

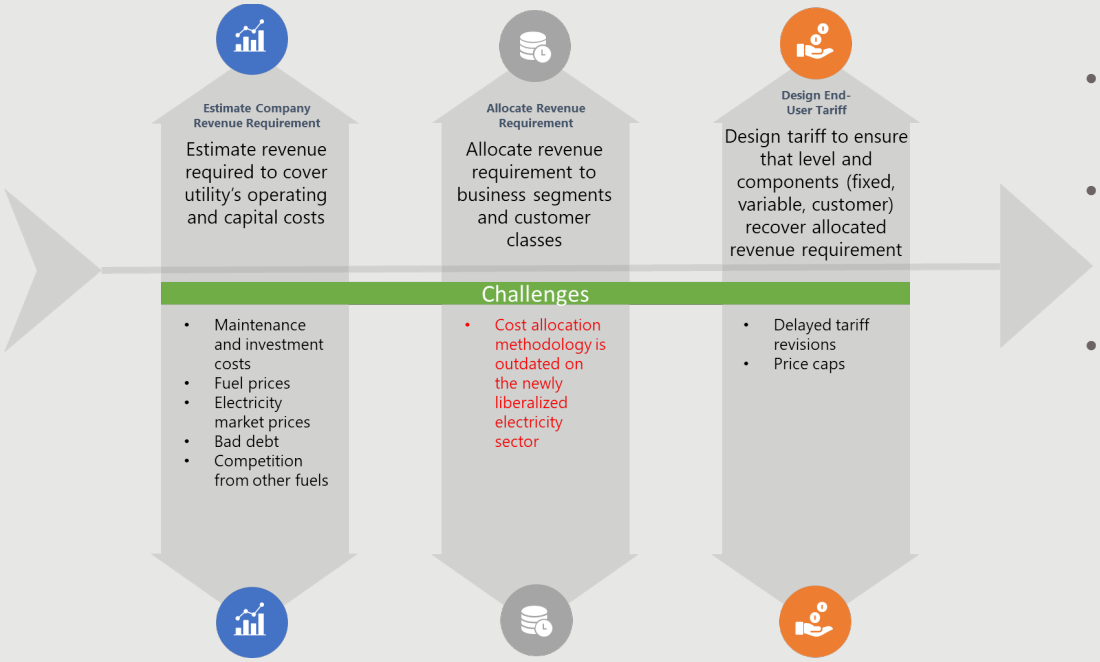
- Ukraine has made strides in reforming energy sector since joining the European Energy Community in 2011
  - Has transposed the majority of the EU Third Energy Package in relation to unbundling, third-party access, and retail market for electricity
  - Has transposed measures related to unbundling, third-party access, the retail market for natural gas, and interconnectivity, but…
  - Has not yet fully transposed measured related to the wholesale market for natural gas

Legal and Regulatory Framework for CHPs

- NEURC establishes tariffs for production of thermal energy for all CHPs.[1]
- Sale of electricity as a commodity on the day-ahead, intra-day, balancing markets and market of ancillary services, as well as sale under bilateral agreements, has been liberalized. NEURC has set price caps on the electricity market in order to prevent substantial changes in prices.
- Cost allocation between electricity and heat production is determined by NEURC based on the fuel required for the planned production of electricity and heat, with cross-subsidies between the two products prohibited.[2]
- CHPs have been unable to recover the costs of electricity production on the market because of an inability to shift costs allocated to electricity production to heat, where they might be recovered under the regulated heating tariff.

1. NEURC Decree No. 991 of August 1, 2017, "On approval of methodology for forming, calculation and establishment of tariffs on electricity and (or) thermal energy, that is produced by thermal stations, heat power plants and cogeneration plants"
2. Cross-subsidies are prohibited by Clause 1.13 of the Methodology

Taxonomy of Challenges



- This figure shows the three stages of tariff setting
- Many of the challenges CHPs face are related to the estimate of the appropriate level of revenue requirement
- One challenge (in the middle column, in red) is specific to cost allocation, stemming from the fact that both heat and electricity tariffs were regulated on similar terms when the methodology was developed.

Challenges Related to Estimating the Revenue Requirement

- **Maintenance and modernization requirements.** Most CHPs in Ukraine require modernization, estimated to require USD 6 billion.[1] Such investments may be difficult to pass-through into heating tariffs and experience has shown that it is difficult to make up the different selling electricity into the competitive wholesale market.
- **High fuel prices.** CHPs pay market prices for natural gas post May 2021. Tariffs for production of heat usually are reviewed on an annual basis, meaning CHPs will experience a substantial lag in recovery of their fuel costs, requiring higher working capital and potentially imposing severe cash constraints.
- **Inflexibility of the cost allocation methodology in the context of the new electricity market.** Electricity prices in the wake of market liberalization became market driven and have been much more competitive compared to the levels seen before electricity sector reforms. CHPs may be recovering less revenue from their electricity sales due to the outdated methodology for allocation of costs for CHPs electricity and thermal energy production.
- **Household heating and hot water debt.** As of Feb. 2021, households owed more than UAH 27 billion to district heating companies. A new draft law (3508-d) allows for restructuring of historic bad debt, but does not recognize in the tariffs provisions for future bad debt.
- **Competitions from other fuels.** Some existing customers are disconnecting from district heating in favor of gas-fired individual heating systems. If demand falls short of presumed demand when the tariff is set, the CHP may fall short of its revenue requirement and suffer losses.

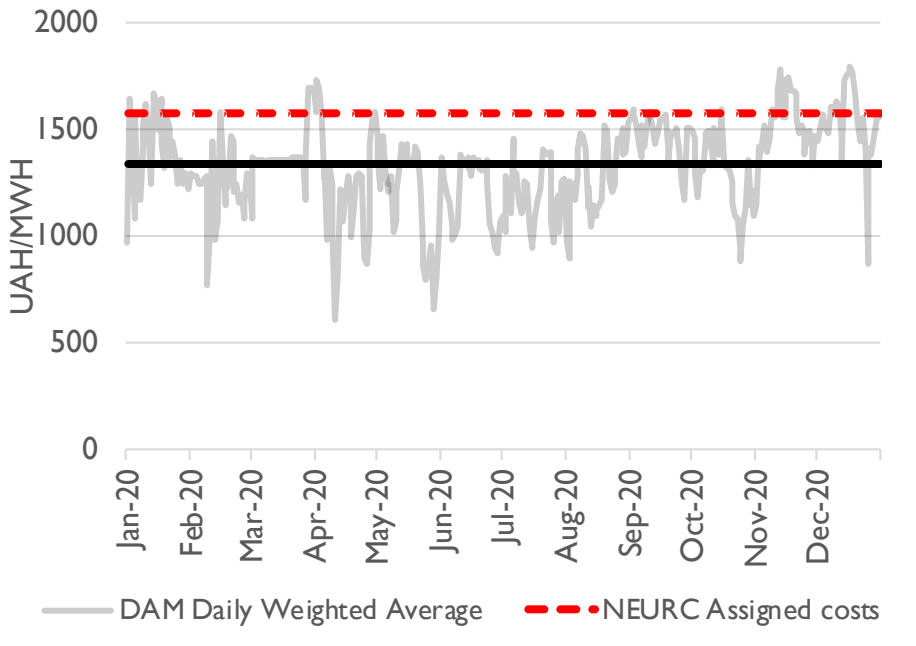
1. USAID, "Outline of Reforms in District Heating Tariff System in Ukraine" (Kyiv: USAID, 2021).

Challenges Related to Tariff Design

- **Delayed heat tariff revisions.** Moratorium on application of the new heating tariffs until the end of the 2020/2021 heating season meant CHPs had to sell heat at prices that did not reflect increases in natural gas distribution prices, higher minimum wage, and increased electricity prices.
- **Price caps.** CHPs are limited in their ability of supplement their revenue with sales of electricity. Because heat tariffs are regulated, it is difficult for CHPs to shift more of the costs to heating customers.

Legal and Regulatory Framework for CHPs

- The challenge faced by CHP operators on the electricity side under current allocation methods is seen by comparing the average day-ahead market price in the IPS zone with the cost per kWh of electricity production assigned to a coal-fired CHP
- In 2020, the CHP operator would have lost on average 230 UAH per MWh sold into the electricity market (gap between red-dotted and solid-black lines).



Source: CHP operator filing; OREE DAM Index data

Challenges Related to Cost Allocation

- Challenges relate, in part, to historical conditions and practices, and in part to the changing shape of the electricity and natural gas industries: industries which both depend on, and compete with district heating for provision of heat supply

- A legacy of below-cost heating tariffs for heating and underinvestment in heat infrastructure

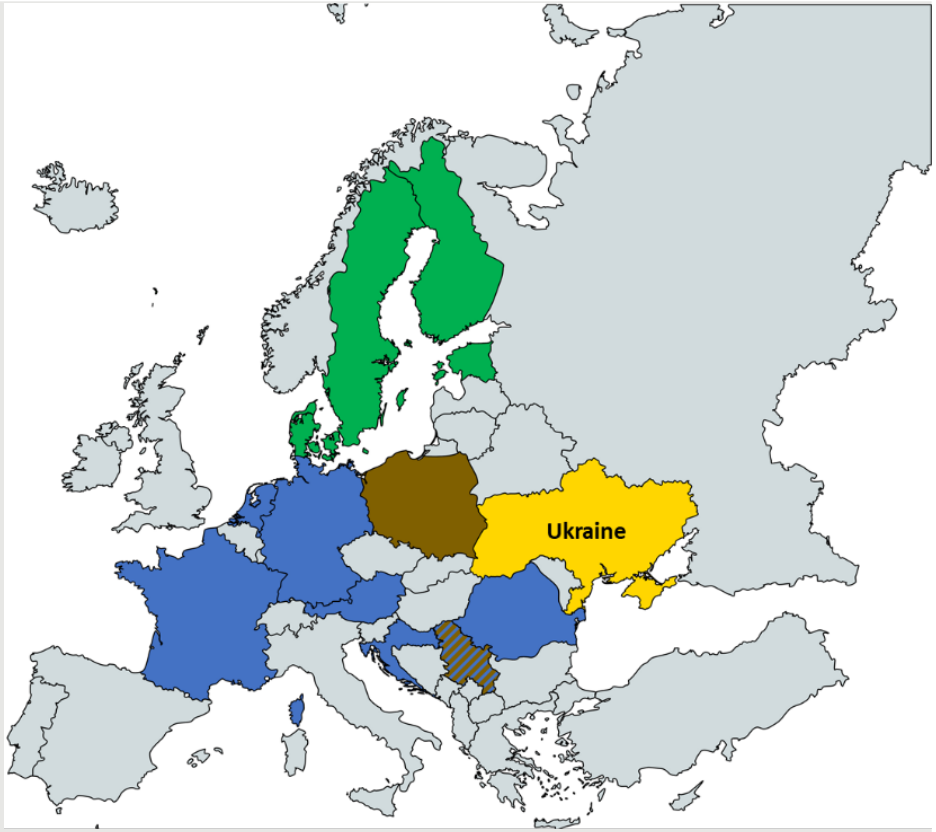
- With move to competition in the electricity wholesale market, CHPs now find it more difficult to cross-subsidize from electricity sales

- NEURC sill uses the outdated methodology to allocate the amount of expenses for a CHP's production of electric energy that must be recovered through electricity sales even though it no longer regulates tariffs for sale of electricity as a commodity.

Lessons from International Experience

International CHP Case Studies

- International case studies examining legal and regulatory framework and allocation methods for CHPs:
  - Six* case studies of countries where CHPs are primarily fueled by natural gas
  - Two* case studies of countries with primarily coal-fueled CHPs
  - Four case studies of countries with primarily renewable CHPs



* Note: Serbia is colored for both coal and gas to reflect its original selection as a coal CHP case study country and its subsequent reclassification as a natural gas CHP case study country

A Variety of Allocation Methods are Used Internationally

- International experience reveals the following possible methods:
    1. *Energy or exergy methods* allocate variable costs according to energy or exergy produced by a plant. *Energy method* typically used in countries where both heat and power operate on saturated, open markets; *exergy method* used where DH challenges dominant individual gas heating.
    2. *Method of alternative heat supply* allocates fixed and variable costs by considering the cost of heat supply using an alternative to CHP. Applicable in cases where heating tariffs are regulated, there is little competition for heat supply, and customers can afford to pay higher DH prices.
    3. *Benefit distribution* method allocates the total costs of CHP in proportion to total costs of alternative supplies. The fuel cost can be then allocated using either energy or exergy method without any impact on total cost (benefit) allocation.

International Experience: Allocation Methods and Incentives

Country	Regulated prices?		CHP cost allocation method(s)	Support schemes for DH and CHPs
	Electricity	Heating		
Countries with primarily natural gas-fueled CHPs				
Austria	No	Partial[1]	Benefit distribution method	Subsidies for biomass CHP construction and emissions reductions; electricity FiTs for biogas CHPs
Croatia	No	Yes	Costs allocated directly where possible; otherwise allocated by share of direct allocation	Electricity market premia, guaranteed offtake, and FiT auctions for eligible highly efficient biogas/biomass CHPs
France	No	No	Benefit distribution method	30% tax credit for connection to DH networks (converted to a bonus); reduced VAT for DH end-users; Heat Fund providing financing for heating networks, renewable energy, and heat recovery; electricity FiT for biogas CHPs; bonus for electricity from biogas CHPs using manure; electricity market premia (under competitive tenders) for biogas/biomass CHPs.
Germany	No	No	Exergy method	Competitive tenders for electricity market premia for new, modernized, or innovative CHPs; coal replacement bonuses for electricity from CHPs

1. In Austria, depending on local regulations, heating prices may be set by DH companies freely or by the municipality

International Experience: Allocation Methods and Incentives

Country	Regulated prices?		CHP cost allocation method(s)	Support schemes for DH and CHPs
	Electricity	Heating		
Countries with primarily natural gas-fueled CHPs				
Netherlands	No	Price Caps[1]	Exergy method	CHPs using natural gas are exempt from energy tax; Government tax scheme supporting investments in energy-saving equipment and sustainable energy; competitive premium FiT auctions for renewable energy to compensate for the difference between the price of the technology and the market price of avoided CO_2
Romania	No	Yes	Method of alternative supply	Bonuses for highly efficient CHPs per MWh delivered to the grid, to cover the differences between the combined revenue a qualifying CHP receives for selling heat at regulated prices and electricity at market prices and its total annual costs, with annual reconciliation process
Serbia	No	Yes	Costs are allocated to electricity and heat equally	Subsidies for high-efficiency CHPs up to 10 MW; electricity FiTs for CHPs up to 500 kW; competitive auctions for electricity market premia to supplement the price obtained on the market for CHPs 500 kW to 10 MW
Countries with primarily coal-fueled CHPs				
Poland	No	Partial[2]	Method of alternative supply	Competitive auctions for electricity market premia covering the difference between generation costs and the electricity market price

1. In the Netherlands, heating tariffs are capped at the price an average household would pay to heat their property with natural gas
2. In Poland, energy companies independently set tariffs based on the cost of heat generation and present them to the regulator for approval

International Experience: Allocation Methods and Incentives

Country	Regulated prices?		CHP cost allocation method(s)	Support schemes for DH and CHPs
	Electricity	Heating		
Countries with primarily renewable-fueled CHPs				
Denmark	No	Partial[4]	Heating required to be non-profit	Electricity market premia for biomass CHPs for the additional costs incurred compared to using coal
Estonia	No[5]	Yes[5]	Method of alternative supply; Physical method; and Mechanical utility work method	Subsidies for electricity from (1) biomass CHPs; (2) efficient CHPs fueled by waste, peat, or oil shale gas; and (3) efficient CHPs with generating capacity less than 10 MW
Finland	No	No	Benefit distribution method	Electricity FiT for biogas and biomass CHPs equal to the difference between EUR 83.5 per MWh and actual market price of electricity in NordPool; subsidies for biogas heating
Sweden	No	No	Alternative boiler house method; Energy method	Heat production covered by EU emissions trading scheme is exempt from CO2 tax; green certificate system for electricity produced by renewable or peat-fueled CHPs, with certificates then sold on open market to consumers to generate additional revenue for electricity production

4. In Denmark, district heating companies establish heating prices, but are required to be non-profit.
5. In Estonia, heat undertakings must agree heating prices with the Competition Authority, who ensures costs are justified; electricity distributors must coordinate prices with the Competition Authority but can sell electricity on the open market. The Authority ensures distributors do not earn unjustifiably large profits.

Conclusions and Recommendations

Conclusions from Case Studies

- There is considerable variation in the cost allocation methodologies used across the case study countries.
- Regardless of the cost allocation methodology, all the case study countries offer some sort of financial incentive to CHPs (e.g., subsidies, bonuses, tax credits) on electricity produced by the CHPs
- The variety of methodologies and presence of support schemes suggest that the cost allocation methodology may be less important to a CHP's financial viability than other factors.
- If sustainability of the DH sector is a policy priority in Ukraine, other regulatory approaches are needed. Concern over cost allocation is linked to concerns about CHP financial viability.
- There are no discernable relationships between the cost allocation methodology used and the nature of support schemes used.
- Nevertheless, cost allocation methodologies may still tip the scales in favor or against the financial viability of CHPs.
- Other policies or regulations may be needed to prevent cannibalization of heating sector by competing fuels (e.g., moratorium on new gas connections in certain areas or planning criteria which requires cost-benefit analysis of heating options in each municipality).

Suggested Criteria for Selecting an Option

- Widespread use internationally in systems with similar characteristics
  - Competitive electricity market; regulated heating sector
  - Competition for heating from other fuels (gas and electricity)
- Avoid promoting long-term inefficiencies. Any incentives or any allocation methodology should be dynamic in the sense that it recognizes when district heating may no longer be the most economic option. (But… once the choice is made, it's made).
- Avoid the "problem of the second best" (potential for unintended consequences before other sector challenges are addressed such as the fact that coal CHPs are now favored over gas)
- Ease of implementation

Options

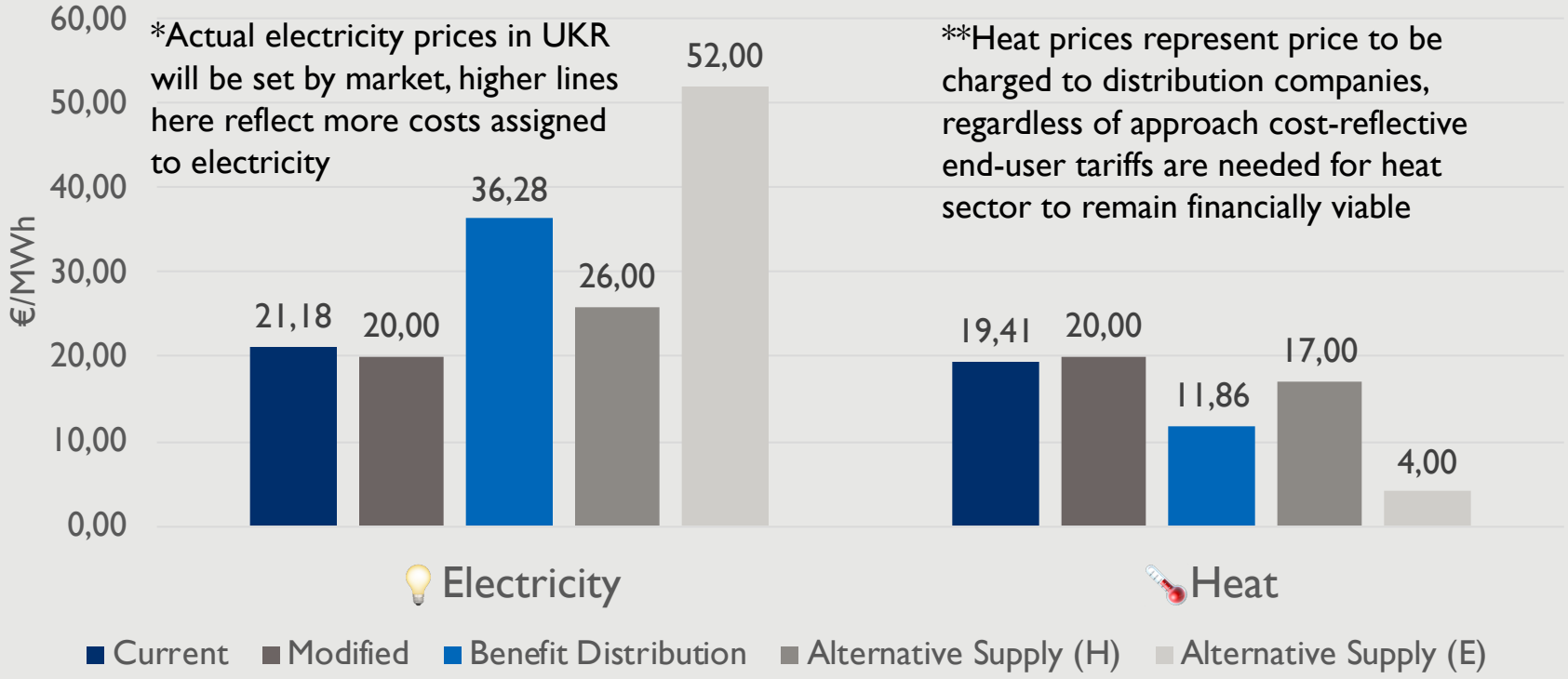
1. Major change in methodology to international standard. CHPs straddle both fully competitive and fully regulated sectors, creating a tension that the ***exergy method*** or ***the method of alternative supply*** seem well suited to resolve:
   - Power from the CHP can be valued equally to a similar power-only plant
   - Would require some sort of market electricity price premium or guaranteed tariff
   - Ties the cost of CHPs to the cost of alternatives, thereby reflecting the market prices of alternative fuels and keeping at least some competitive pressure of CHPs
2. Minor adjustments to Ukraine's existing methodology could improve financial viability without a major shift
   - Existing method uses fuel inputs as indicator of cost, but outputs (MWh_e and MWh_t) are better indicators
   - Focus instead on the sector challenges related to the level of the revenue requirement and tariff design before undertaking a major reform to the cost allocation methodologies

Numerical Demonstration of Options

- Dummy data (not from an actual CHP plant) was used to develop examples of the methodological options for allocating CHP costs
- Methodologies compared include:
  - **Current** - Costs allocated in proportion to fuel consumption by service.
  - **Modified Current** – Use energy production (MWh_e, MWh_h) to allocate costs instead of fuel.
  - **Benefit Distribution** – Costs allocated in proportion to cost of alternative supply plants
  - **Alternative Supply (Heat)** – Heat covers CHP costs up to alternative supply amount and electricity covers the remainder of CHP costs
  - **Alternative Supply (Electricity)** - Electricity covers costs up to alternative supply amount and heat covers the remainder

Reference Plants →	CHP		Power-Only	Heat-Only
Item	Power	Heat	Power	Heat
Capacity (MW)	100	200	100	200
Energy (GWh/year)	500	1000	500	1000
Fuel Consumption Ratio	1.2	1.1	3.0	1.1
Fuel Price (€ / MWh-fuel)	10		10	10
Variable Cost (Million €)	17		15	11
Fixed Cost (Million € /yr)	13		11	6
Total Cost (Million € /yr)	30		26	17

Results of Numerical Demonstration of Options



Thank you for your attention!

Energy Security Project

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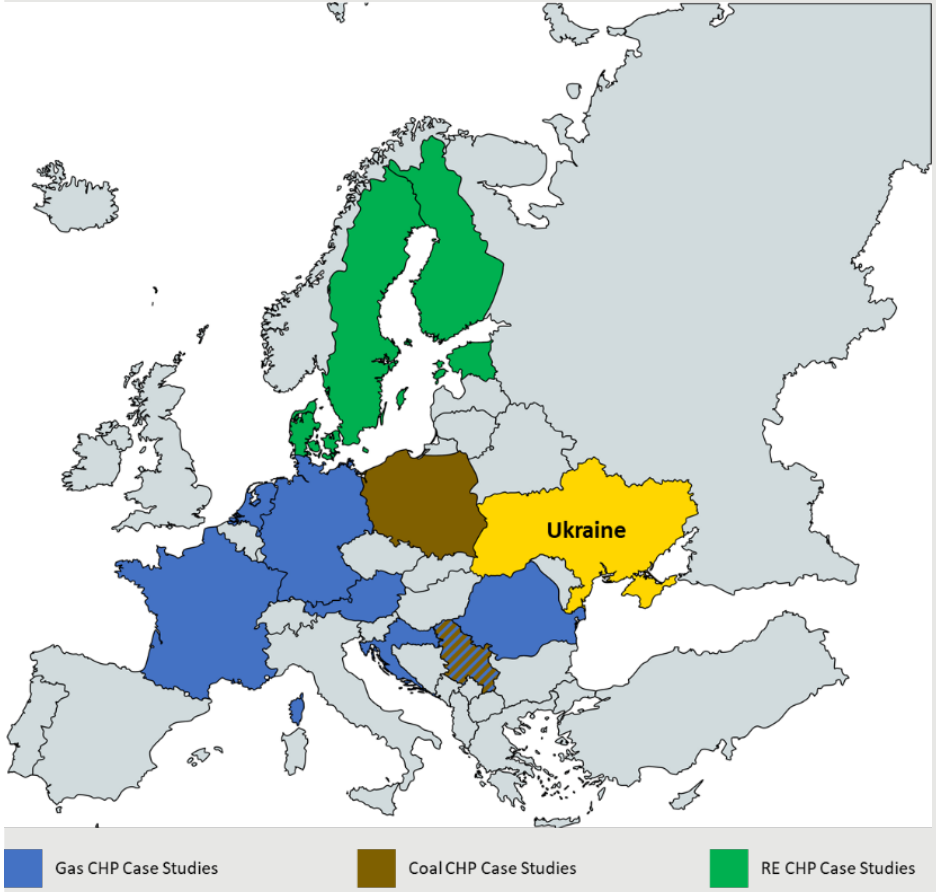
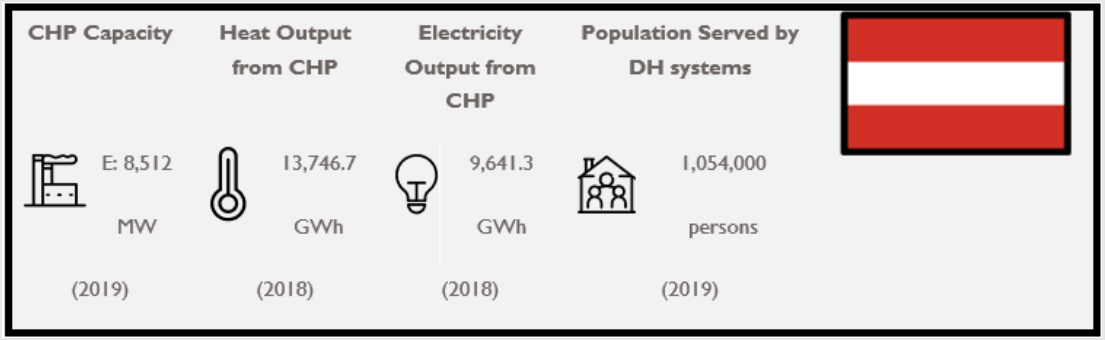


Appendix: Relevant International Experience and Country Summaries

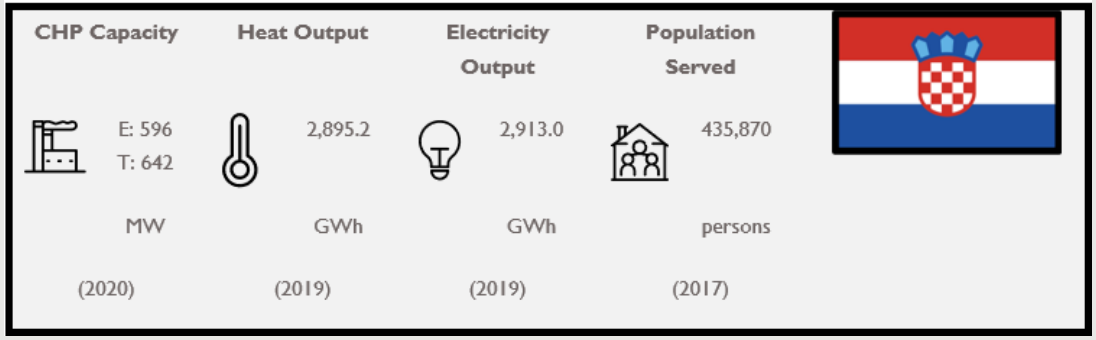
Austria



- 15 CHPs, providing 60% of heat for DH and 48% of electricity
- Primary fuels: Natural Gas (59%), Renewables and waste (33%)

- Liberalized electricity market
- No price regulation for heating; municipalities responsible for heat prices
- No regulations for CHP cost allocation; in practice, *benefit distribution method*.

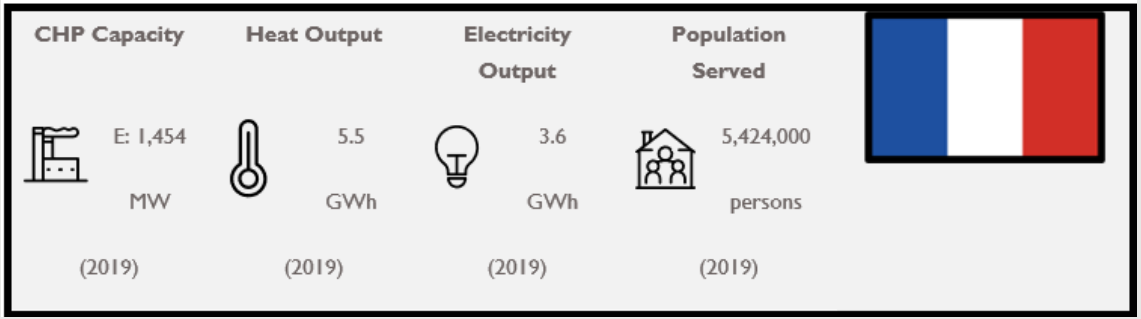
Croatia



- 4 large CHPs, providing 87% of heat for DH and 3% of electricity
- Primary fuels: natural Gas (77%), renewables (11%)

- Electricity market liberalized with no regulated prices except for supply of last resort
- Heat prices determined on the free market with tariffs for thermal energy production
- No regulated method of CHP cost allocation; in practice, costs that cannot be direct allocated are allocated to the share of direct expenses of each product

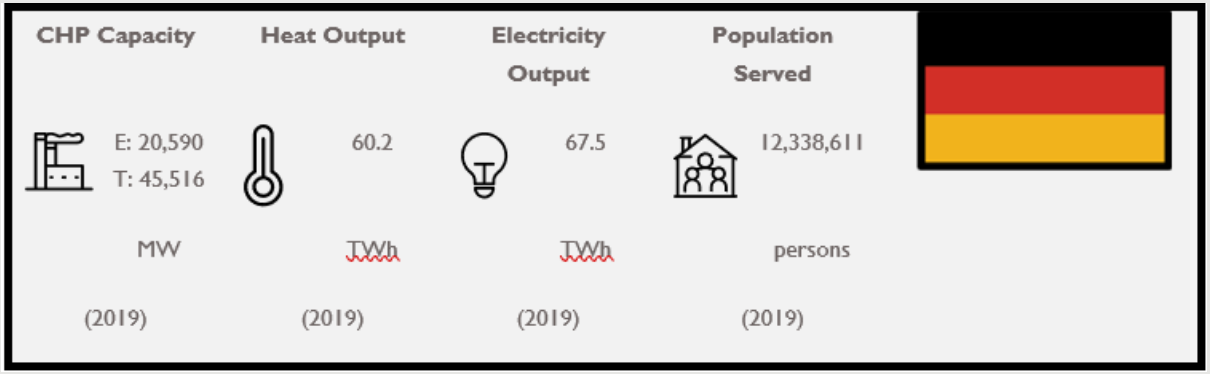
France



- 253 CHPs, providing 18% of heat for DH and 1% of electricity
- Primary fuels: natural gas (74%), renewables and waste (25%)

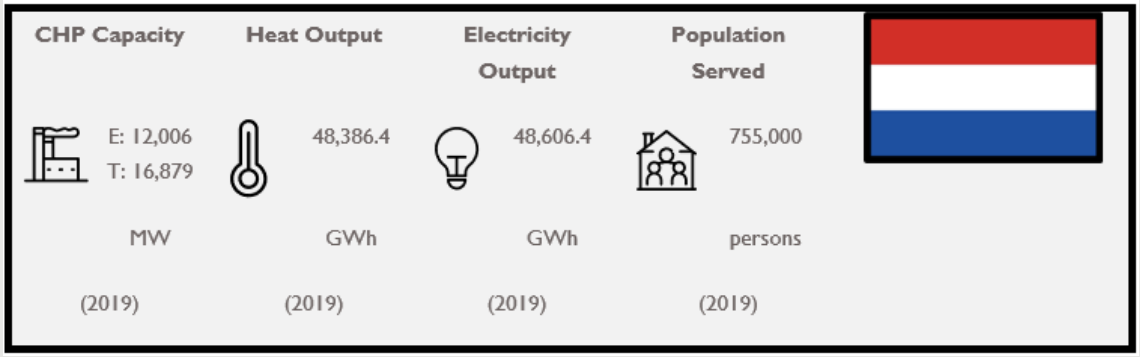
- Both electricity and heat are fully liberalized
- District heating end-users benefit from a reduced VAT rate of 5.5 if at least 50% renewable energy sources are used
- No regulation for CHP cost allocation; in practice, *benefit distribution method* is used

Germany



- 482 CHPs, providing 83% of heat for DH and 12% of electricity
- Primary fuels: natural gas (36%), renewables and waste (32%), coal (31%)
- Prices for electricity and heat not regulated
- No regulation on CHP cost allocation; most operators used the exergy method to allocate variable costs

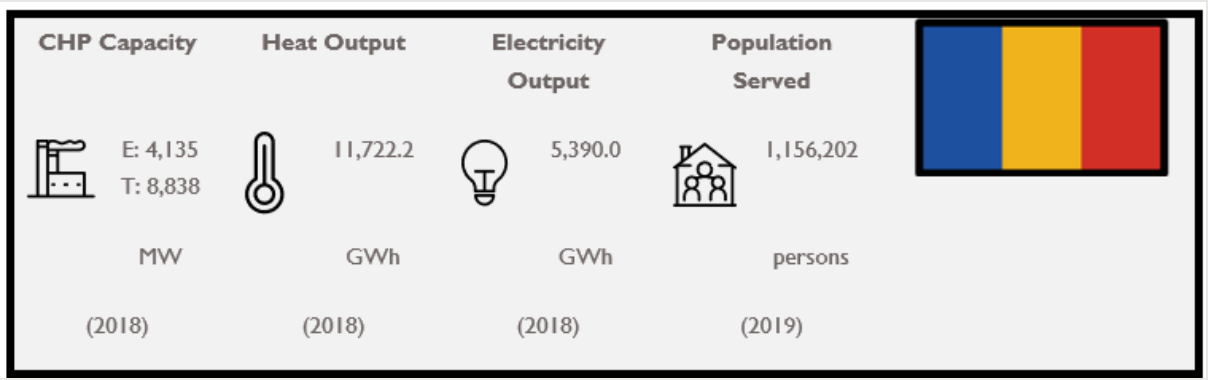
Netherlands



- 2,724 CHP instillations producing 29% of heat for DH and 40% of electricity
- Primary fuel: natural gas (73%)

- Electricity prices are not regulated but are reviewed by Authority for Consumers and Markets (ACM)
- ACM sets tariffs caps on heat to ensure DH users do not pay more than natural gas users
- No CHP cost allocation regulation; *exergy method* commonly used

Romania



- 15 CHPs producing 78% of heat for DH and 8.5% of electricity
- Primary fuels: natural gas (67%), solid fossil fuels (23%)

- Electricity and gas market prices are liberalized
- Prices of thermal energy are regulated
- Regulated cost allocation approach is the *methods of alternative supply approach*

Serbia

CHP Capacity	Heat Output	Electricity Output	Population Served
E: 330 T: 510	3.1	337	630,000
MW	GWh	GWh	persons
(2019)	(2018)	(2019)	(2020)

- 9 CHPs are licensed by the Energy Agency, providing only a small proportion of DH production
- Primary fuel: natural gas

- Electricity prices liberalized; competitive wholesale market since 2017
- Established heating tariff methodology for determining the maximum revenue amount for heat generation, distribution, and supply
- No formal CHP cost allocation method; in practice costs are allocated equally

Poland

CHP Capacity	Heat Output	Electricity Output	Population Served
E: 10,085 T: 25,116	68,635.2	28,838.0	16,500,000
MW	GWh	GWh	persons
(2018)	(2018)	(2018)	(2019)

- 412 DH systems with CHPs producing 55% of heat for DH and 17% of electricity
- Primary fuels: coal (66%); renewables (12%), natural gas (12%)
- Tariffs set by local branches of regulator (URE), in close coordination with local authorities

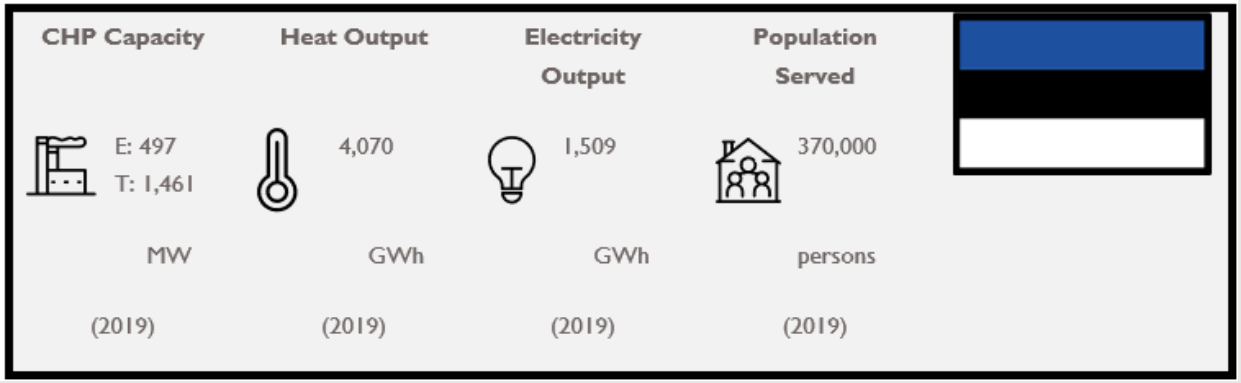
- Two methods for calculating heat tariffs
  - Cost method: based on planned income and costs
  - Benchmark method: heat price has to adhere to regulator's benchmark
- *Alternative boiler house method* used for CHP cost allocation

Denmark

CHP Capacity	Heat Output	Electricity Output	Population Served
E: 4,721 MW	24,571.7 GWh	12,375.1 GWh	3,647,000 persons
(2019)	(2019)	(2019)	(2019)

- CHPs produce 60% of heat in DH and 42% of electricity
- Primary fuels: renewables (58%), coal (28%), natural gas (13%)
- Heat prices are set by DH companies, which are required to be non-profit
- The DH non-profit requirement impacts the CHP cost allocation method

Estonia



- 54 CHP turbines producing 90% of heat for DH and 20% of electricity
- Primary fuel: renewables and waste (74%), oil (14%), natural gas (12%)
- Electricity is sold on the open market
- Estonian Competition Authority responsible for coordination of DH prices
- Competition Authority has approved three CHP cost allocation methods: *alternative boiler house method*, *physical method*, and *mechanical utility work method*

Finland

CHP Capacity	Heat Output	Electricity Output	Population Served
E: 5,301 T: 8,500	24,356.3	10,954.4	2,839,100
MW	GWh	GWh	persons
(2019)	(2019)	(2019)	(2019)

- 106 CHPs producing 74% of heat for DH and 17% of electricity
- Primary fuel: biomass (40%), coal (22%), peat (17%)

- Both electricity and heating markets are fully liberalized
- No specific CHP cost allocation method is required; since both products must benefit for the CHP to be competitive, the *benefit distribution method* is assumed to be used

Sweden

CHP Capacity	Heat Output	Electricity Output	Population Served
E: 3,974 T: 7,821	26,497.0	16,206.0	396,300
MW	GWh	GWh	persons
(2018)	(2019)	(2019)	(2019)

- 135 CHPs producing 50% of heat for DH and 9% of electricity
- Primary fuel: renewables (70%)

- Electricity market and heating prices are both deregulated
- No specific CHP cost allocation method, but several methods are used in practice: the *alternative boiler house method* and the *energy method*