District Heating in Denmark

- 2 questions and 5 answers on how to promote cost-effective DH nationwide

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Delegation from France - 13 September 2016
Facts on Danish District Heating

- 5.6 million inhabitants
- 33,000 km. district heating pipes (trench) all over Denmark.
- 64% of all houses DH-heated
- Average heat consumption: 8.3 MWh per person per year.
- District Heating = 17% of DK’s final energy demand.
- Annual heat sale: 2⅓ Billion Euro (= 2/3 % of GDP).
- Direct Employment = 2,000 persons. 10,900 persons incl. suppliers.
Nationwide District Heating

- Till the 1980’s most DH located around the cities.
- In the 1980’s-90’s new DH established in rural towns. The share of DH doubled in 30 years.
- Future: Development of electricity-based DH.
- Q1: How? By which means and policies?
Low Consumer Prices for DH

- 99.9% of all district heating consumers pay less for their heat compared to heat from household-based oil stoves (year 2015)
- Compared to the cost of heat from an individual natural gas boiler, 66.7% of DH customers pay less (year 2015).
- DH consumer price averages 1,745 Euro in 2015 = 2.6% of a household income.

Q2: How? What kind of regulation ensures low heat prices?

Statistics from Danish District Heating Association
Answer 1: Heat Supply Zones

- First Heat Supply Act on District Heating (1979) introduces a national heat plan. Municipalities assigned a key role.
- This Act also introduces supply zones all over Denmark. Secures economy of scale and optimal use of capacity.
- Heat zones after 1990: New decentralised CHP + conversion of existing decentralised DH units by administrative orders in 1990-98:
  - From oil and coal → natural gas and biomass
  - From DH-plants → CHP, whenever possible
- Contributed $\frac{3}{4}$ of new power capacity from 1990-97.
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… Supply Zones Established in 1980-90’s
Administrative Means to Expand DH-CHP

- Municipalities have the right to impose compulsory connection and continuance to DH networks (1982).

- Existing buildings have a grace period of 9 years.
**Answer 2: New Local Ownership of DH**

Large cities (originally power plants):
- Owned by large energy companies.
- Centralized CHP (production only).
- Transmission usually unbundled.

Smaller centres (originally DH plants/CHP) during the 1980s and 90s:
- Usually joint production and distribution.
- Owned by municipalities or local consumers.

Transmission:
- Typically owned by municipalities.
District Heating Production: 1980 onwards

- Local ownership
- Industry heat
- Industry CHP
- Heat-only boilers
- Small-scale CHP
- Large-scale CHP

Graph showing the production of district heating from 1980 onwards.
CHP: From Cities to Nationwide Coverage

Changes in the generation layout during the last 25 years

CHP-efficiency has lowered DK’s Gross Energy Demand by 11% and reduced the CO$_2$ emission by 4.5 mill. ton annually
Answer 3: DH/CHP must be least costs option

- 1990: Municipalities obliged to carry out a feasibility study of DH/CHP. Only approval if:
  1) Beneficial consumer prices
  2) Sound economy of DH company
  3) Positive cost-benefit calculation (incl. costs of CO₂, Noₓ, SO₂ etc.)

- Feasibility study must use fixed method and prices set by the central government (fuel prices of IEA, interest rate 4% for socio-economic calculation, depreciation period of 20 years, technology catalogue available with DH/CHP data etc.)
Answer 4: Incentives for decentralised DH/CHP

- Investment grants for biomass DH and CHP (1981)
- Financial support to establish or enlarge DH based on bio fuels or CHP on natural gas (1994).
- High energy tax (1977) and CO$_2$ tax on fossil fuels for DH (1992) = Incentive to energy-efficient DH and co-production + conversion to environmentally friendly fuels.

- All subsidies via state budget. The subsidies can be cost-neutral for the state due to energy/CO$_2$-taxes.
- After 1999: Subsidies provided via consumer bill. New debate on energy prices … via state budget
Revenues from Energy and CO$_2$-Taxes etc. can finance subsidies for DH and CHP

PSO was financed by the state budget until 1999, where the PSO was financed via the electricity bill. The size of the PSO vis-a-vis state revenues is shown in the above figure.

Average PSO for biomass and decentralized CHP = 2.8 bill. DKK = 0.1% of GDP

39 Bill. DKK = 2.0% of GDP
District Heating Production by Fuel

Biomass exempted from energy tax
310 Biomass-Based DH-Plants in Denmark

Wood or straw:
• 200 district heating plants
• 45 CHP plants

Biogas (excl. individual farm plants):
• 32 CHP
• 5 district heating plants

Municipality Solid Waste:
• 22 CHP plants
• 6 district heating plants

13% of the electricity consumption and 21% of space heat consumption from biomass, incl. organic waste.

Many large-scale CHP’s around major cities will convert to biomass in next 10 years, as many large cities adopt low carbon or zero carbon climate strategies.
Converting to Renewable Energy in DH

A halt to installation of oil-fired boilers:
- In new buildings from 2013
- In existing buildings where district heating and natural gas is available from 1 July 2016

From coal to biomass in large scale CHP’s. Capital (Copenhagen) decided to base its entire heat consumption on 100% renewables by 2025. All power + heat consumption in DK’s second largest city (Aarhus) will 100% CO₂-neutral by at latest 2035.

New technologies e.g. geothermal energy and large heat pumps at medium and small-scale CHP’s
Answer 5: Company sells DH for True Costs

Consumer price = True costs:

- Guarantees the DH company that all costs will be covered. Ensures a sound economy for the company with predictable and transparent prices.
- Guarantees the consumers against excessive prices
- Each household pays for metered consumption
- Earmark subsidy to vulnerable groups
True Costs Must be Low Costs

- All accounts must be approved by independent auditor.
- All DH prices are publicly available and comparable on the web.
- Benchmarking by branch organization and state regulatory authority → publish economic regression analyses made on nationwide data for each DH plant.
- Branch organizations provide efficiency enhancing courses, tech. advise, recommend new account systems.
Tariffs must reflect de-facto fixed and variable expenses:

- A **fixed** charge per m² covers repayment of capital investment loans (25-30%), while
- The **variable** element for actual DH-consumption (70-75%) covers fuel purchase + other running costs.

The tariff system prevents debt accumulation and lack of maintenance from too low fixed tariff = prevents high prices in future.
Independent administration of subsidies

➢ No local government involvement in price setting and payments:
  o DH plant forward bill directly to the consumers, not via local government
  o All consumers receive an equal allocation of subsidies per GJ
  o Prevents local government subsidies or expropriation of state subsidies

➢ Independent state authority is administrator of subsidies.
Policy Changes ....

The Future

NEXT EXIT
New Strategic Energy Planning

- **Holistic** - all forms of energy demand and energy supply are included (electricity, transport etc.)
- **Medium term and long term planning** (2020, 2035, 2050)
- **Creates overview** with focus on strategic choices and larger efforts - in order to prioritize municipal involvement the coming years
- **Includes local/regional cooperation** between authorities (municipal / regional), supply companies, industry and other stakeholders – essential involvement
- **Voluntary** within their mandatory duties
Wind Power replaces Electricity from Combined Heat and Power Plants

Electricity Production, 2000-2014:

- **Wind turbines:**
  From 12% → 39% of national power supply.

- **Combined Heat and Power Plants:**
  From 41% → 30% of national power supply.
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Denmark’s Electricity Mix in 2020

Latest forecast: 54 pct. **fluctuating** green electricity by 2020
The Danish Toolbox for Efficient Balancing

- Strong transmission grids and interconnectors
- International electricity markets
- Flexible generation system
- Specialized forecasting and operational planning tools
CHP’s and Fluctuating Wind Power Today

- Natural gas turbines = quickest response to market signals (higher el prices)
- Coal fired power units are required to operate down to 35% of rated power. Some are now capable to operate down to 10%
- High el prices: Heat accumulation decouple electricity and heat demand.
- Low el prices: Electric boilers for district heating (2½ % of total DH capacity and increasing).

Legend:
- Decentralized CHP
- Centralized CHP
- Wind mill park
Future District Heating in Denmark

From green fuels to green electricity:
Green electricity will become a main energy carrier, also in the heating sector

50% wind-power by 2020
Flexible Use of Wind Power in Future
Green Fuels and Green Electricity

Production of future District Heating (PJ)

- Solar
- Surplus heat
- Heat pumps/electric boilers
- Boilers
- Combined Heat and Power

Year | 2013 | 2020 | 2025 | 2035 | 2050
--- | --- | --- | --- | --- | ---
Value | 140 | 120 | 110 | 100 | 90

Danish Energy Agency
New policies to Expand Electricity-Based DH

Long term solution:
Smart energy systems and new technologies etc.

Present solutions and suggestions:
- Demonstration programme for use of large heat pumps in CHP plants
- Investment subsidy for heat pumps in CHP plants considered
- Lower energy taxes on electricity for heating considered
Danish Lessons Learned on DH

- DH as CHP increases energy efficiency and CO\(_2\)-reduction
- Mandatory feasibility studies on DH with supply-zones make DH compete with indiv. supply = Cheaper heating
- Only DH if feas. study documents lower consumer prices and economic benefits for DH company and society.
- True costs with fixed and variable tariffs = sound economy
- Independent authority supervise subsidies and prices.
- DH can be cost-neutral for the state by CO\(_2\)/energy-tax.

\[\text{Increased share of renewable energy, increased energy efficiency, and reduced CO}_2\text{-emission.}\]
Energy Statistic
- download data

Heat Supply in Denmark
- download publications