HEAT PLAN DENMARK

LOW CARBON URBAN HEATING
ANDERS DYRELUND
MARKET MANAGER RAMBØLL DENMARK

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Heat Plan Denmark
a small study with a significant impact

- Bottom-up R&D study financed by the district heating consumers
- Prepared by an independent team of experts from
  - Rambøll Denmark and
  - Aalborg University
- The first study in Denmark, really to integrate the energy and building sectors – to combine the supply and the demand side
- An eye-opener for the Danish politicians
- Could be a model for other countries

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Heat Plan Denmark by Anders Dyrelund

Energy Tours CTR FRB 2009 2

We focus on the overall energy policy objective in the European Union

- The main objective is to reduce the fossil fuel consumption and the CO_2 emission in a cost effective way

- Important EU directives to implement this objective
  - Strategic environmental assessment
  - Combined Heat and Power (CHP)
  - Energy performance of buildings
  - Renewable energy

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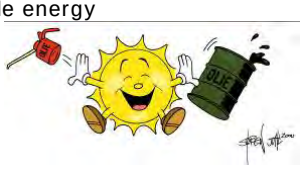
Most important objectives in the energy policy in Denmark since 1976

- Objectives since 1976
  - Develop the most economic heat supply projects for the society of Denmark
  - Reduce the dependency on oil
  - Promote Combined Heat and Power (CHP)
  - Promote renewable energy



- New additional objectives
  - National obligation to reduce CO_2 emissions outside the CO_2 emission trading scheme
  - Reduce CO_2 emissions for the whole society
  - **To be independent of fossil fuels in the long run ! (2050?)**

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Important Danish legislation to implement the policy

- Electricity supply act from 1976
  - all new power capacity since 1976 has been CHP
- Heat supply act from 1979
  - municipal heat supply planning, a new natural gas infrastructure and a substantial increase of district heating
  - optimal zoning of district heating and natural gas networks based on overall economic evaluation for the society of Denmark
  - district heating shifts from fossil fuel boilers to CHP and renewable energy
- This legislation ensures unique least cost integration of power, heat, gas and waste sectors in Denmark
- However, the building sector is not yet fully co-ordinated with the other sectors

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Heat plan Denmark focus on the heating sector

- The plan shows how the Danish heating sector has reduced CO_2 emissions from 25 to 10 kg/m^2 since 1980
- The plan shows that this progressive development can continue
  - to achieve a further **50%** reduction before 2020 and
  - to achieve an **almost CO_2 neutral** society before 2030
- The plan is based on an integrated approach, combining
  - optimal end-user heat demand reductions - additional 25% or more?
  - a lower return temperature from building installations – <35ºC
  - more district heating (DH) - from 46% up to 63-70% of the market
  - energy efficient use of renewable energy in district heating
  - individual heat pumps, solar heating and wood pellets

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How to produce the heat?
CHP and surplus wind energy via heat pumps combined with large heat accumulators

District heating which combines

- Large and small CHP
- Electric boilers
- Heat pumps and
- Heat accumulators

Is a precondition for integration of large share of wind energy in Europe

In Denmark the share of wind is growing from 20% towards 70%

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How to produce the heat?
Waste to energy CHP

Case: Amagerforbrænding

- the first 100% utilization of waste
- tunnel to Zealand

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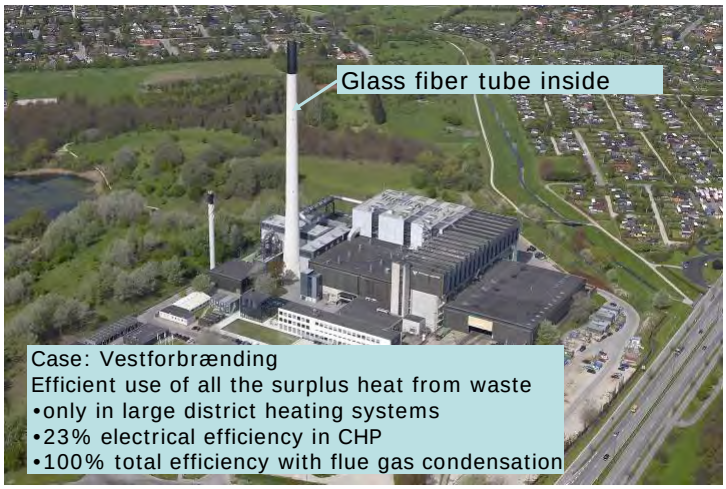
How to produce the heat?
Waste to energy with flue gas condensation



Case: Vestforbrænding
Efficient use of all the surplus heat from waste
- only in large district heating systems
- 23% electrical efficiency in CHP
- 100% total efficiency with flue gas condensation

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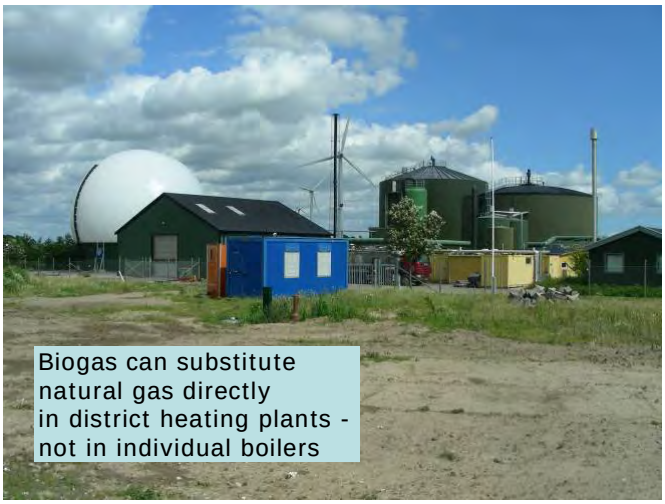
How to produce the heat?
Biogas CHP



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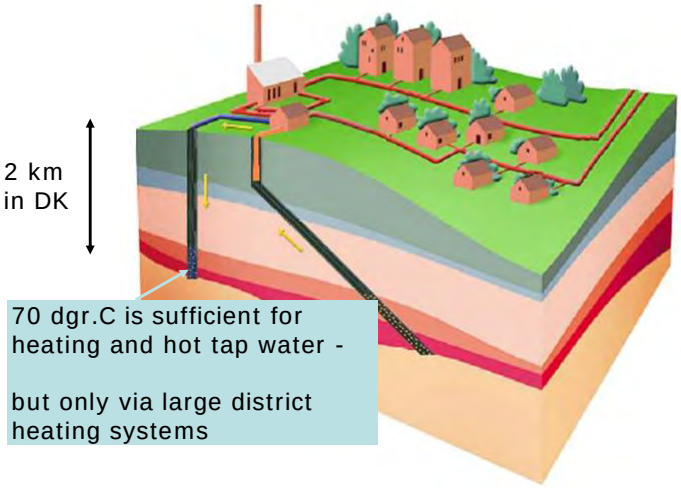
How to produce the heat?
Geothermal energy boosted by biomass



70 dgr.C is sufficient for heating and hot tap water -

but only via large district heating systems

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How to produce the heat?
Large scale solar thermal plants

6 times more cost effective than individual solar heating

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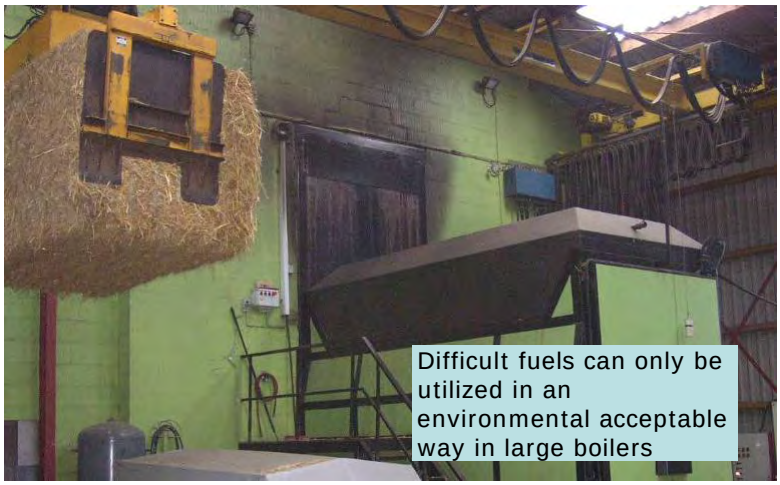
How to produce the heat?
Straw



Difficult fuels can only be utilized in an environmental acceptable way in large boilers

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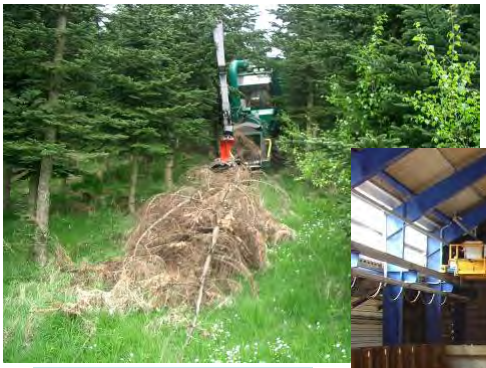
How to produce the heat?
Surplus wood chip with flue gas condensation



1000 times more environmental friendly than wood stoves – and twice as efficient

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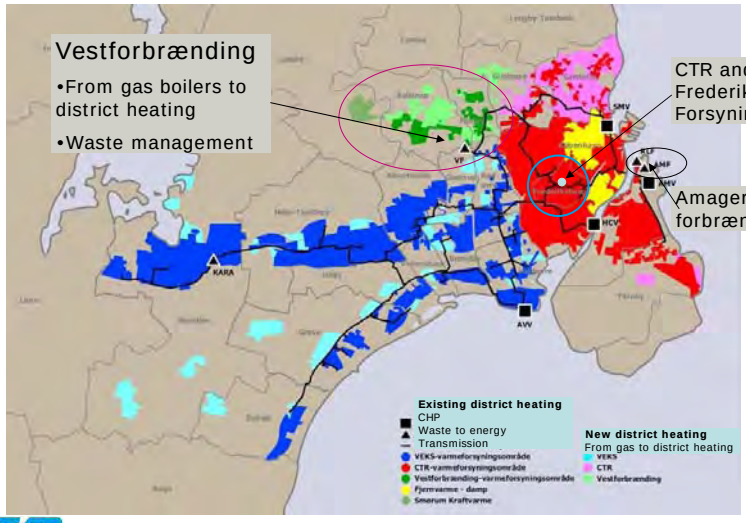
Integrated district heating systems
Case: Greater Copenhagen, 2009



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New sustainable buildings
interact with the energy infrastructure

Case: New Ramboll office in Kolding:

- Close to public transport
- District heating with
- Waste to energy CHP with flue gas condensation
- "District Cooling" from near by water
- Low temperature floor heating down to 25 dgr. C
- High temperature free cooling through the same floor tupe system

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Heat Plan Denmark
statistics from 1980–forecast to 2050

- Statistics from 1980–2006
  - Danish Energy Authority
  - More specific information from 430 district heating companies
- Forecast 2006-2050 based on bottom-up analysis for all 420 DH companies grouped in 10 clusters, which reflects the average
  - DH from 46% to 63% in 2020
  - DH up to 70% before 2050
  - 25% heat demand reduction
  - return temperature down to 35 ºC in 2030
- State of the art of to-days technologies

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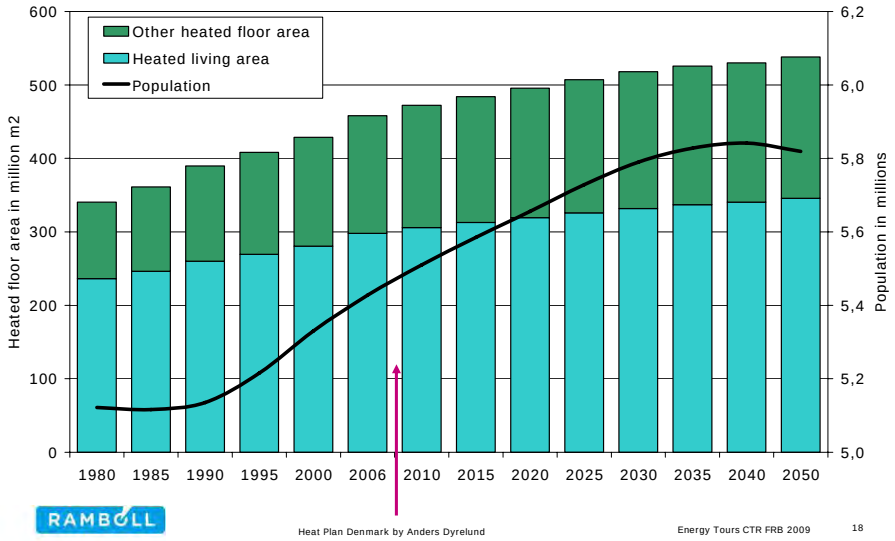
Heated floor area and
population grows



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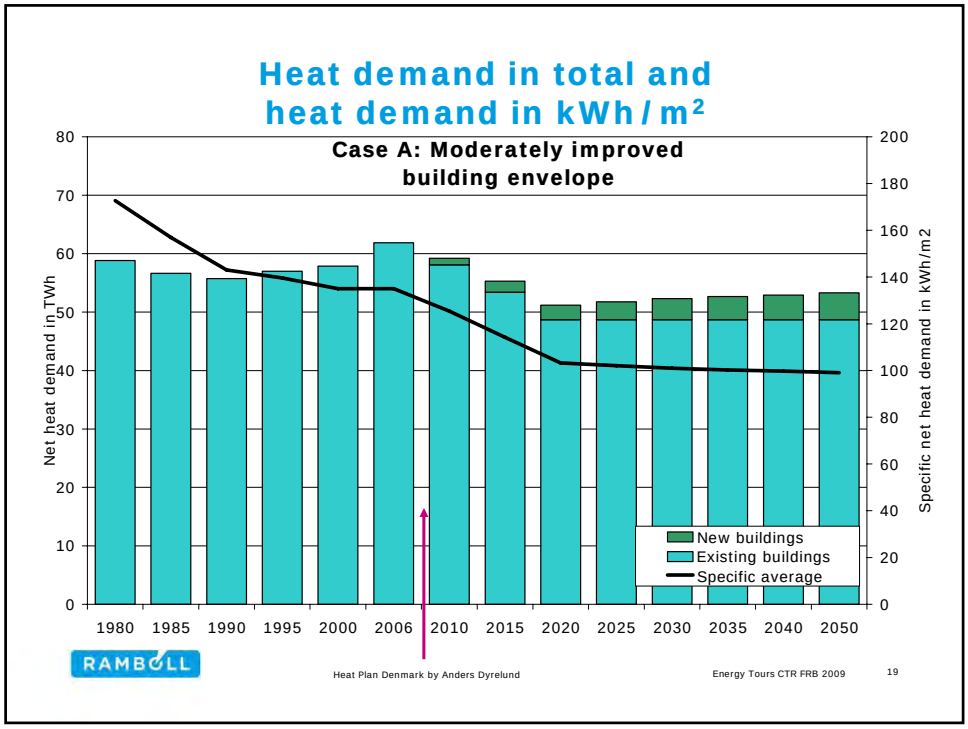
Heat demand in total and heat demand in kWh/m²
Case A: Moderately improved building envelope
Net heat demand in TWh
Specific net heat demand in kWh/m2
New buildings
Existing buildings
Specific average
1980 1985 1990 1995 2000 2006 2010 2015 2020 2025 2030 2035 2040 2050
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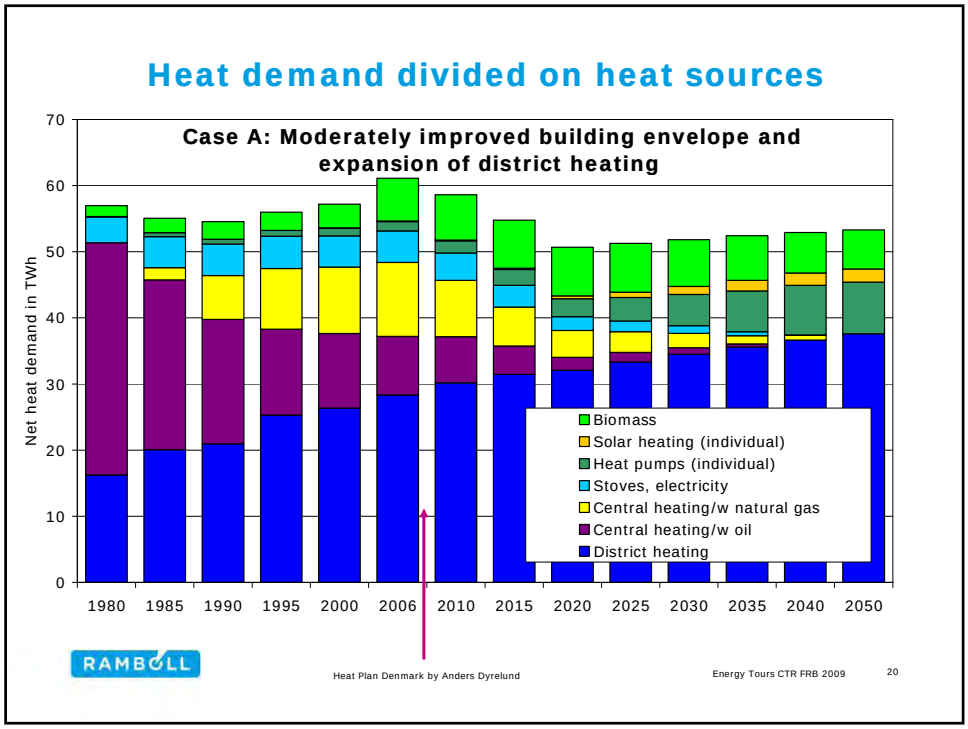
Heat demand divided on heat sources
Case A: Moderately improved building envelope and expansion of district heating
Net heat demand in TWh
Biomass
Solar heating (individual)
Heat pumps (individual)
Stoves, electricity
Central heating/w natural gas
Central heating/w oil
District heating
1980 1985 1990 1995 2000 2006 2010 2015 2020 2025 2030 2035 2040 2050
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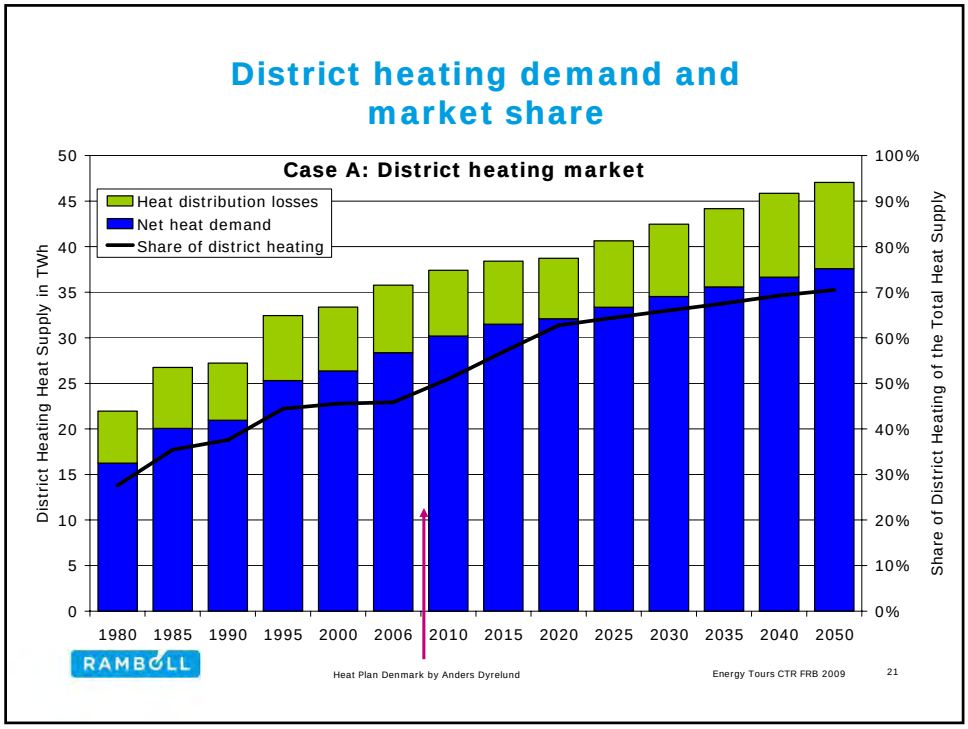
District heating demand and market share
Case A: District heating market
Heat distribution losses
Net heat demand
Share of district heating
District Heating Heat Supply in TWh
Share of District Heating of the Total Heat Supply
0
5
10
15
20
25
30
35
40
45
50
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
1980
1985
1990
1995
2000
2006
2010
2015
2020
2025
2030
2035
2040
2050
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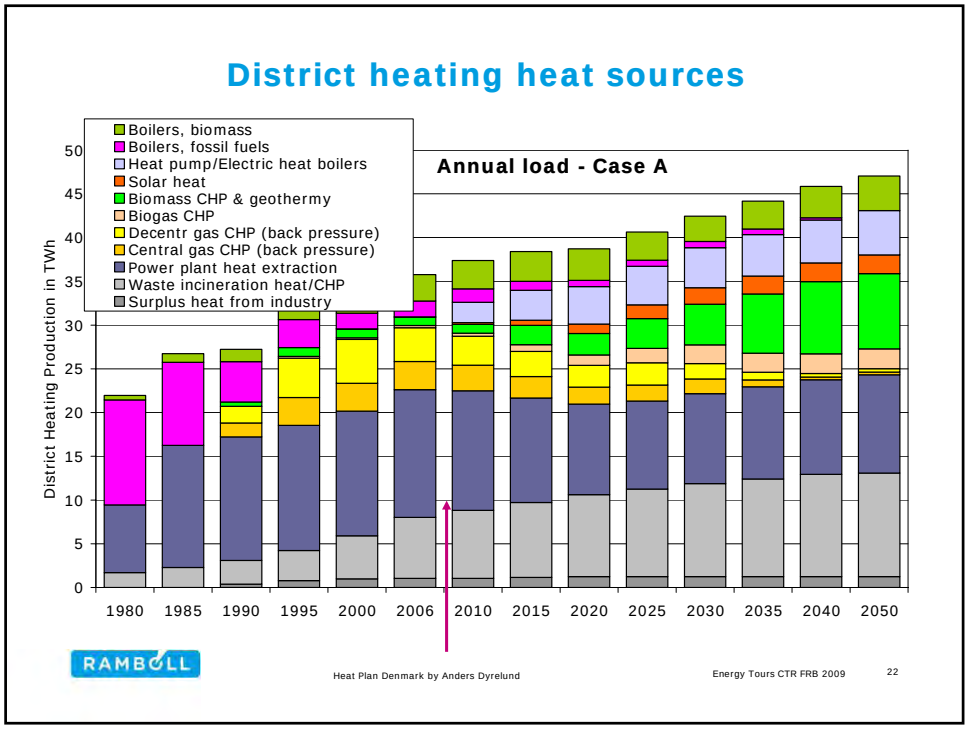
District heating heat sources
Annual load - Case A
Boilers, biomass
Boilers, fossil fuels
Heat pump/Electric heat boilers
Solar heat
Biomass CHP & geothermy
Biogas CHP
Decentr gas CHP (back pressure)
Central gas CHP (back pressure)
Power plant heat extraction
Waste incineration heat/CHP
Surplus heat from industry
District Heating Production in TWh
0
5
10
15
20
25
30
35
40
45
50
1980
1985
1990
1995
2000
2006
2010
2015
2020
2025
2030
2035
2040
2050
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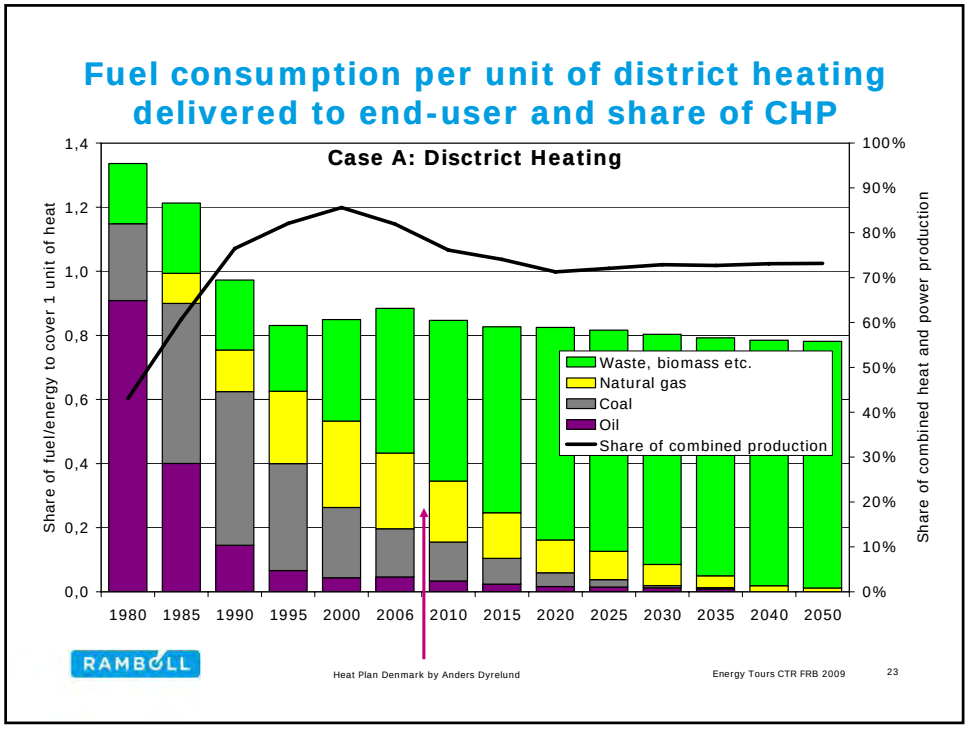
Fuel consumption per unit of district heating delivered to end-user and share of CHP
Case A: Disctrict Heating
Share of fuel/energy to cover 1 unit of heat
Share of combined heat and power production
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1980 1985 1990 1995 2000 2006 2010 2015 2020 2025 2030 2035 2040 2050
Waste, biomass etc.
Natural gas
Coal
Oil
Share of combined production
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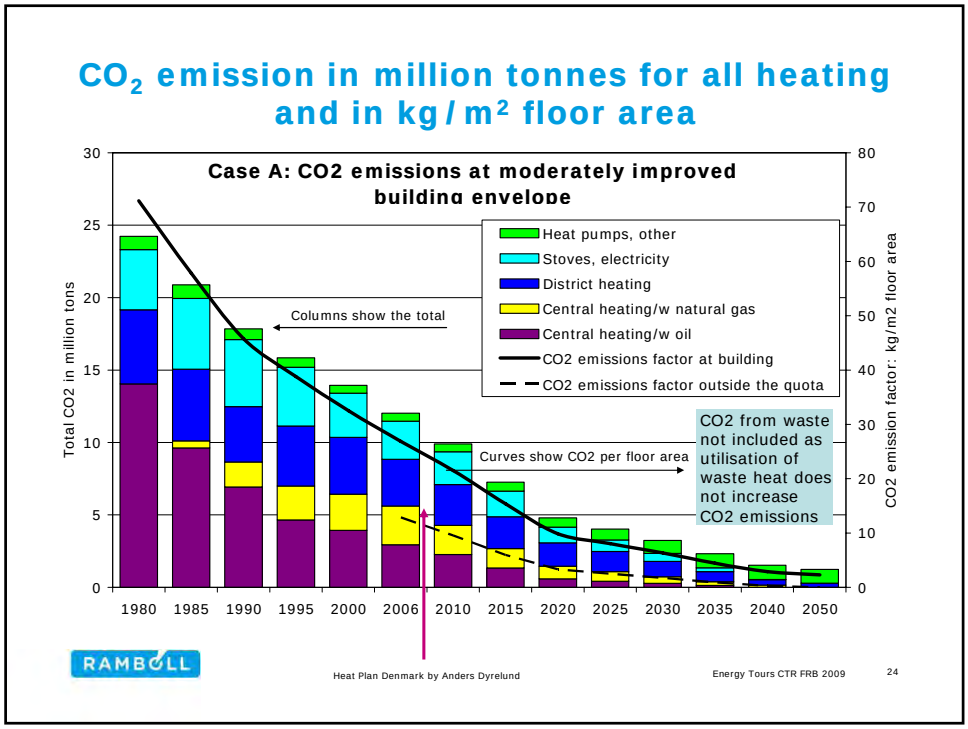
CO_2 emission in million tonnes for all heating and in kg / m² floor area
Case A: CO2 emissions at moderately improved building envelope
Total CO2 in million tons
CO2 emission factor: kg/m2 floor area
30
25
20
15
10
5
0
80
70
60
50
40
30
20
10
0
1980 1985 1990 1995 2000 2006 2010 2015 2020 2025 2030 2035 2040 2050
Heat pumps, other
Stoves, electricity
District heating
Central heating/w natural gas
Central heating/w oil
CO2 emissions factor at building
CO2 emissions factor outside the quota
Columns show the total
Curves show CO2 per floor area
CO2 from waste not included as utilisation of waste heat does not increase CO2 emissions
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Heat plan Denmark - Statements

- It is important to focus on **integrated solutions,** including building envelope, building installations, district heating and power system
- **District heating** is a natural part of the urban infrastructure in modern cities
- District heating is a **precondition** for efficient, flexible and cost-effective use of renewable energy and CHP for urban heating, not least waste-to-energy and wind
- **District cooling** is a natural part of the urban infrastructure in districts with sufficient cooling load
- A stable energy policy since 1976, municipal planning and a tradition for **co-operation in the society** have been important preconditions for CO_2 emission reductions in Denmark

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Heat Plan Denmark
Message to COP 15 in Copenhagen

- Do not worry about signing the Copenhagen Climate Agreement
- It is not a problem to develop a zero carbon heating sector
- You just have to co-operate at all levels in the society
  - a stable and strong national energy policy
  - municipalities take responsibility for the infrastructure
  - well functioning co-operatives in the housing and heating sectors
- Even Danes can do it
- Have a look your self in Copenhagen

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Thank you for your attention!

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See our climate solutions at
www.energymap.dk

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Source: Energi E2

Heat Plan Denmark

Danish Heating Sector can be CO_2 Neutral before 2030

Heat Plan Denmark shows how the Danish heating sector has reduced the CO_2 emissions from 25 kg/m² to 10 kg/m² floor area since 1980, and how the heating sector can be almost CO_2 neutral by 2030 based on well-known technologies. To the surprise for many, district heating based on combined heat and power and renewable energy is the key driver in this development, supplemented by optimal investments on the demand side in building envelope and heating installations.

Many countries are in the beginning of this process and their heating sector is much like the sector was in Denmark before 1980. Therefore Heat Plan Denmark could be a road map for other countries in their efforts to improve their carbon footprint – in fact the plan demonstrates that it is not that difficult. You just have to follow the objectives of the relevant EU directives and co-operate on all levels in the society. Therefore, why not join the Copenhagen Climate Agreement 2009.

Anders Dyrelund (l.), Ramboll Denmark, ***Henrik Lund***, Aalborg University

First waste incineration plant in Denmark

Heat Plan Denmark

Heat Plan Denmark is a Research and Development study financed by the Danish District Heating Association, Kolding/Denmark. It demonstrates that district heating is the key technology for implementing a CO_2 neutral Danish heating sector in a cost effective way.

Heating Sector since 1973

Since the first oil crisis in 1973, improvements in the heating sector have played a crucial role in the Danish energy supply mix. The heat supply act and the gas supply act in 1979 started a target oriented, least-cost planning process and widespread implementation of natural gas and district heating networks.

Since 1980 annual CO_2 emissions have been reduced from approximately 25 kg/m² to 10 kg/m² floor area. This is due to two efforts: firstly, consumers have saved 25 % on heat; secondly, the heat market share of district heating has increased from 30 to 46 % (corresponding to 60 % of the dwellings in Denmark). The district heating expansion has made it possible to implement large scale combined heat and power plants, using low carbon energy. Natural gas has also had an important role.

Danish District Heating Sector in Focus of the Danish Government

The current awareness of climate change and the decision of the Danish Government to base future energy supply in Denmark on renewable sources has once again brought the heating sector and the possibilities of district heating into focus.

Heat Plan Denmark shows that it is possible to continue this progressive development, so that CO_2 emissions from the heating sector can be reduced by another 50 % by 2020 and that an almost CO_2 neutral heating sector is achievable by 2030.

Reducing the CO_2 Emissions by another 50 % by 2020

Heat Plan Denmark shows how these benefits can be achieved by 2020 in a cost effective way through a combination of the following initiatives:

- Consumers save another 25 % on heating and reduce their return

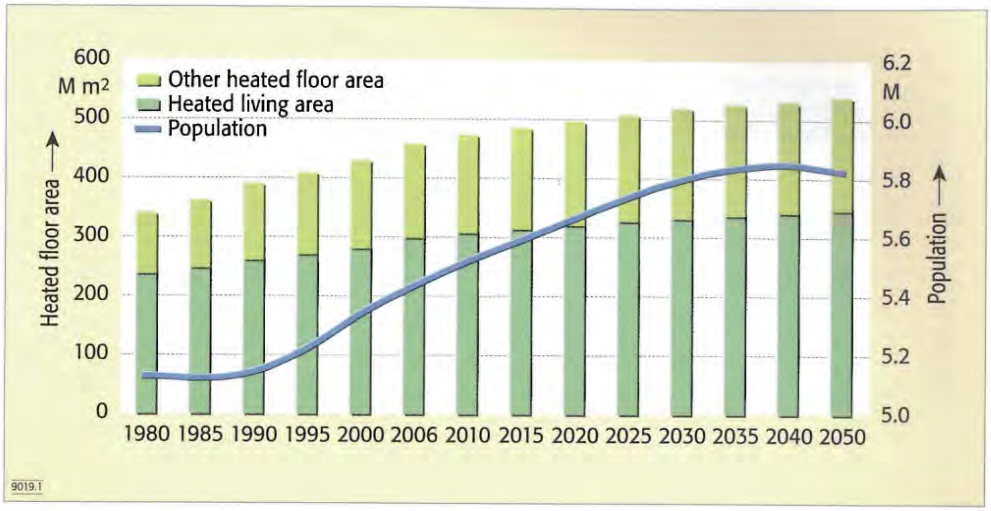

Figure 1. *Increasing population and heated floor area*

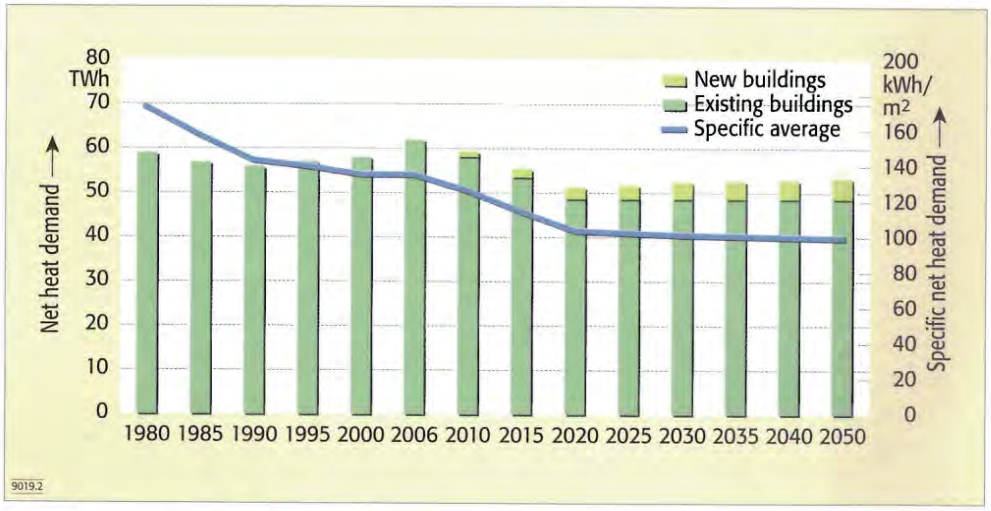

Figure 2. *Heat demand*

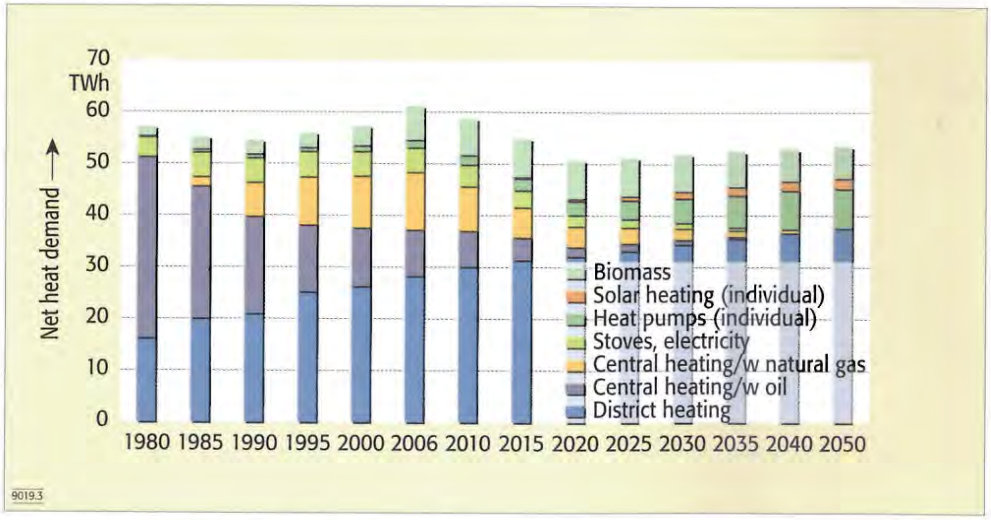

Figure 3. *Consumers save heat and shift to more environmental friendly heat sources*

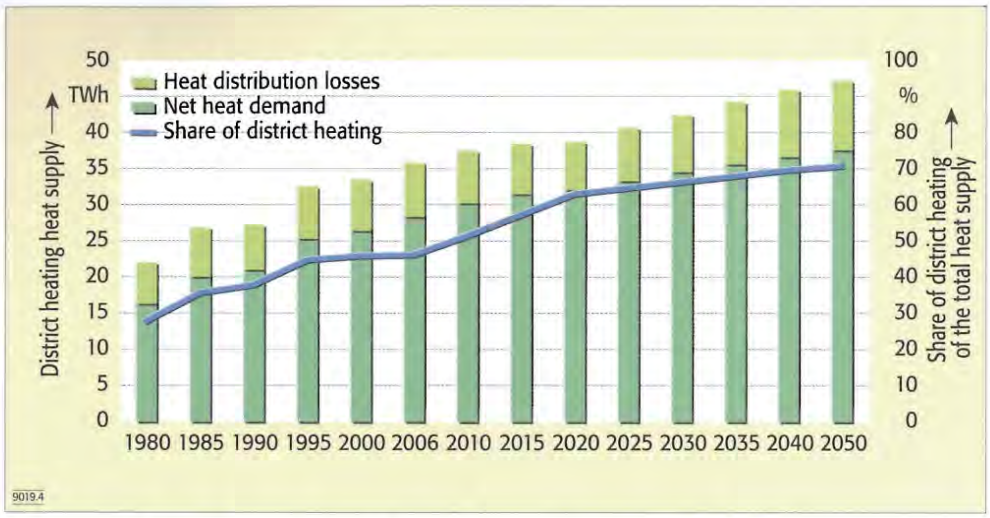

Figure 4. *The district heating demand and market share increases*

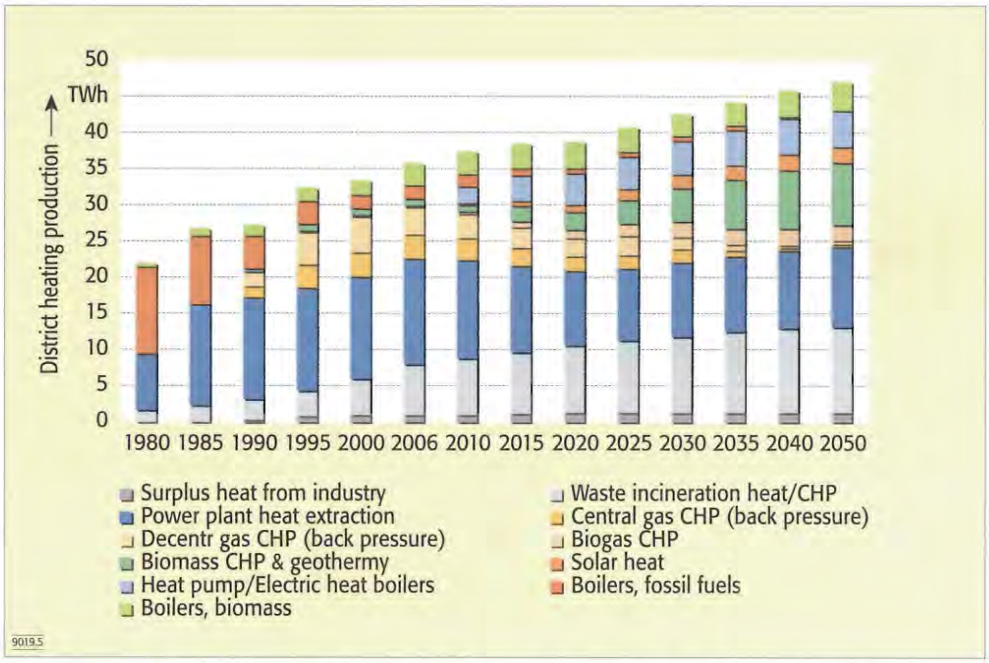

Figure 5. *District heating shifts to more efficient and environment friendly heat sources (Annual load - Case A)*

temperature to the district heating network to around 35 °C, e.g. in connection with renovation of the building envelope.

- District heating is expanded from 46 % to around 63 % of the market share, starting with the very profitable conversion of large gas fuelled boiler plants to district heating based on combined heat and power and renewables.
- The majority (approximately 70 %) of new buildings, for which intelligent urban planning is possible and cost effective, are connected to district heating or block heating, whereas the remaining will be individually supplied low energy houses.
- District heating systems are further interconnected so that utilisation of excess heat in the summer, mainly from waste to energy plants, is improved, and competition between the heat sources is intensified.
- District heating production is expanded with more heat storage tanks, more renewable energy, in particular more efficient waste to energy combined heat and power plants with flue gas condensation, large scale solar heating, biomass boilers and combined heat and power, biogas combined heat and power, geothermal energy and excess wind energy.
- The remaining heat market will be covered by heat pumps and wood pellet boilers in combination with individual solar heating.

Case Studies for the Developement after 2020

Heat Plan Denmark compares 3 cases for the development after 2020.

Case A
A 70 % district heating market share and constant heat demand from 2020, taking into account the effects of electricity savings and increasing comfort, which could be a realistic alternative in case of increasing fuel prices, cost based price signals to the consumers and a strong heat planning.

Case B
A 70 % district heating market share and additional 25 % heat savings after 2020, corresponding to a total 50 % heat savings compared to the 2008 level. This could be an alternative to case A in case of strong enforcement of investments in the building sector.

Case C
A constant 63 % district heating market share and a constant heat demand from 2020, which could be an alternative in case of modest fuel prices and a modest energy policy after 2020.

Comparing the Cases
Comparisons show that the additional heat savings of 25 to 50 % in case B do not contribute to any additional CO_2 reduction – only less consumption of biomass. Moreover, a detailed analysis of numerous heat saving options shows that the cost per saved MWh increase dramatically in case the saving exceeds 25 %. However, further savings may be needed in a long-term perspective in which Denmark is heading for an energy system based 100 % on renewable energy.

Detailed analysis of the heat market, which could shift to district heating (from 46 % up to 70 % mar-

ket share), shows that district heating and heat pumps are the best solutions combining CO_2 emission reductions and costs in a future CO_2 neutral society around 2060. This will be the case even if consumers in these districts reduce the space heating demand by up to 75 %, provided the district heating adjust the networks to lower demand and lower return temperature.

Moreover, compared to individual heat pumps, district heating will further strengthen the reliability and flexibility of the supply of the overall energy system, not least for integrating large amounts of wind energy, (e.g. up to a market share of 70 % wind energy in the electricity market), by combining combined heat and power, large thermal storages, heat pumps and electric boilers, which can absorb excess wind energy and balance the fluctuating wind energy.

With regard to new buildings and new city districts, the analysis shows that district heating combined with combined heat and power and renewable energy is more cost effective than individual solutions based on more investments in the building envelope and/or investments in individual renewable energy solutions. Thus the analysis confirms that it is a very good idea that the EU directive on energy performance of buildings requires that the CO_2 emission shall be reduced in a cost effective way, taking into account local conditions and options for utilizing district heating, block heating and combined heat and power.

Therefore the study presents case A as the preferred option.

Figure 1 to *7* shows the heat market development from 1980 to 2050: heated floor area, heat demand, share of the heat market, district heating demand, district heating production and CO_2 emissions. We note that the CO_2 emission from waste to energy is assumed to be zero, as waste to energy is more environmentally sustainable than landfilling waste and that utilization of the excess heat does not contribute to CO_2 emissions. We consider that the fossil fuel components in the waste are used by industries which produce plastic or utilize plastic in their products, not by those who utilize waste heat from the most environmentally friendly treatment of the waste.

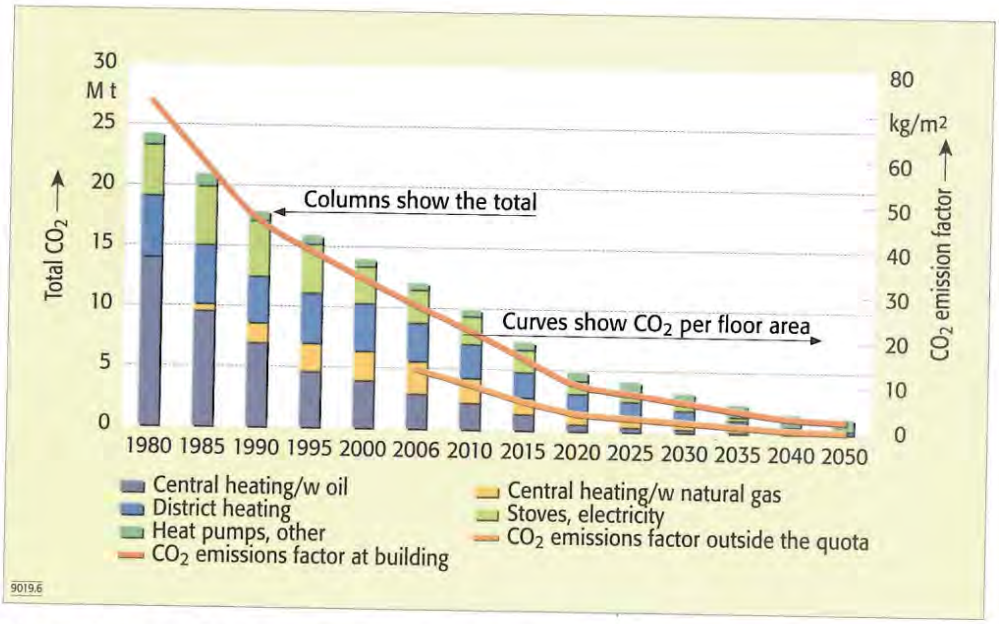

Figure 6. *The total results of end-user savings and development of the district heating is a significant reduction of the CO_2 emission*

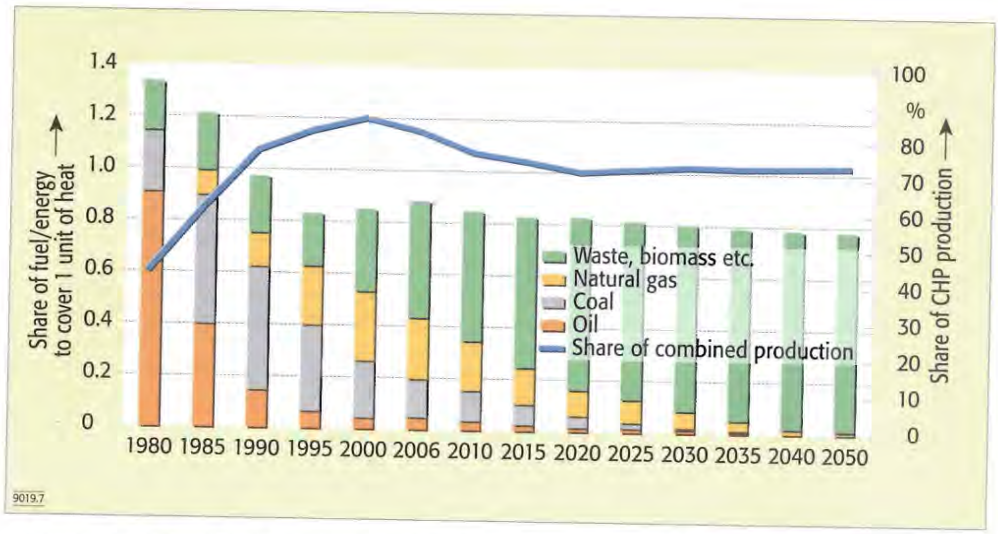

Figure 7. *The fossil fuel consumption to produce the district heating, (in terms of MWh fossil fuel per supplied MWh) is significantly reduced. The market share of CHP will be reduced in order to absorb excess wind energy*

We note that the very dramatic increase in the heat utilization from waste to energy is mainly due to more efficient combined heat and power plants with flue gas condensation and maximal utilization of the summer load.

The Heat Plan Denmark has been prepared by experts from Ramboll Denmark, The Energy Division and Aalborg University, The Department for Development and Planning. The work has been commissioned by the Danish District Heating Association, the R&D fund, which is financed by contributions from the district heating consumers. The report can be downloaded from www.danskfjernvarme.dk. ■

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Fuel Flexibility Outflanks the Energy Crisis

District Heating is Tomorrow's Heat Market

Heat consumers demand comfort, simplicity, stable prices, supply safety and conservation of the environment. The solution that meets those requirements is district heating. However, the implementation of this brilliant solution requires considerable planning with participation of many parties from the community. The critical factor is therefore political strength. It is needed at municipality level, at national level, and especially at European level.

The last decades and the world outlook tell a story of rising energy prices and increasing strain on the environment. At the same time heat consumers demand comfort, simplicity, stable prices, supply safety and conservation of the environment. The solution that meets all those requirements is now ready, and it has been thoroughly tested with great success. The solution is district heating.

The district heating system has unique flexibility for heat consumers as it can utilize most kinds of waste heat and primary energy sources. This is important in case of fuel shortages, or for the purpose of reducing fuel costs or for gradually reducing environmental impact in the future. Also, all modifications and fuel replacements can take place without disturbing the district heating consumers at all!

However, the implementation of this brilliant technology requires considerable planning with the immediate participation of many parties from the community, which will be rewarded later. The critical factor is therefore political strength. It is needed at municipality level, at national level, and especially at European level.

Wide Choice of Primary Energy Sources

The district heating system has a wide choice of primary energy sources (*figure 1*). It can be fossil fuels like oil, gas, and coal. However, in Denmark, the majority of the district heating production with fossil fuels takes place with an efficiency as high as 200 to 300 %. The reason is the benefit of the coproduction of heat and power in combined heat and power plants, compared to pure power production with the same power rate. The amount of extra fuel needed to make the heat recoverable is much less than the amount of heat recovered.

Other primary heat sources suitable for district heating include

- waste heat from industrial processes, household or industry waste incineration,
- biomass (including wood, straw and vegetable oils),
- biogas from farming and waste,
- geothermal heat, solar heat, wind surplus electricity,
- or it might even be waste heat from nuclear combined heat and power plants.

The potential of the district heating system can be illustrated using the concept of a town food market (*figure 2*). Several kinds of primary energy available for a particular district heating system correspond to the range of goods available. The range of goods and prices vary depending on the season, the harvesting weather etc. There may be short and long-term variations, predictable or not predictable. But the consumer can choose between the goods and optimize costs and preferences each time. The purchased collection of goods will probably differ from time to time.

The time horizon of energy system planning is, though, much longer than the time horizon of the town food market. It is, or should be, several decades, which might be too long for some decision-makers. It must take into account future de-

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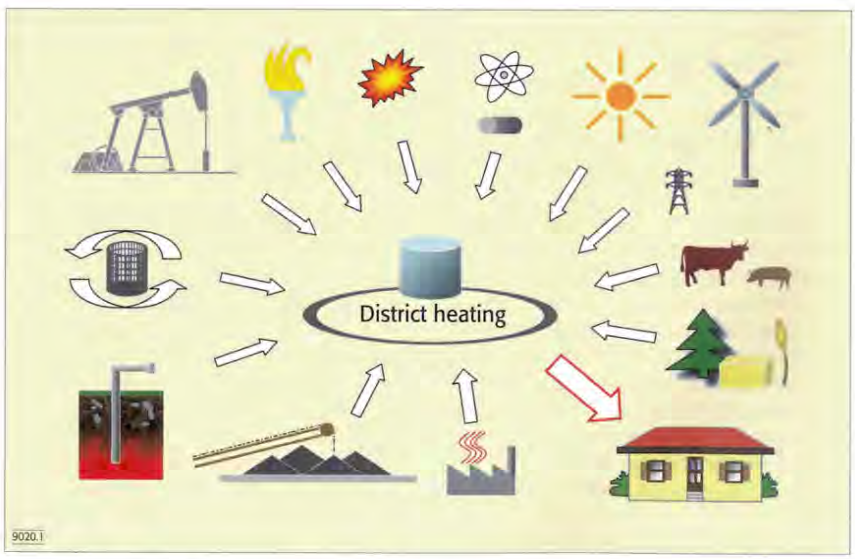

Figure 1. *District heating can utilize most heat sources*

velopment within, for example, fuel supply safety, fuel prices, and the impact on the environment. Generally, all three are expected to become far more critical during the next few decades.

Security of Supply

In case of a crisis, it is easy to change fuel (*figure 3*) within a few days, if the alternative heat production units have already been built, or within a few years if construction of a new production unit is involved. The alternative – replacing thousands of individual boilers and other consumer installations – is not practically possible under these (crisis-)circumstances. It is easy to store coal as a back-up fuel for bigger units. In the future, fuel independence might even have a healthy influence on the long-term fuel prices! If a large region – such as Europe – was supplied with district heating in most of its cities, the entire region would likely benefit from lower and more stable fuel prices in the long run.

In Denmark, it is normal to connect several kinds of primary energy sources to the city district heating network. The most important feature of the district heating systems in the future might be the way in which new kinds of primary energy sources can be connected to the district heating network later

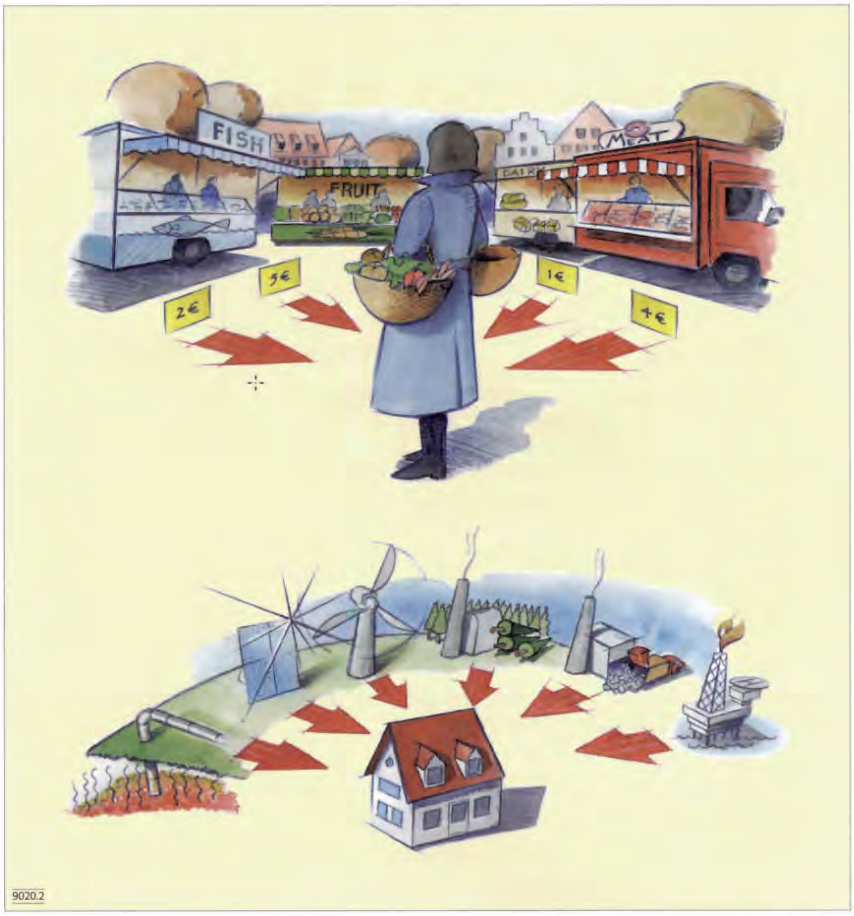

Figure 2. *The flexibility of district heating. The market principle facilitates comparison between price and quality (of sustainability, for example). These two cases are quite similar actually; it is only the time horizons of planning that are different: several days, and several years*

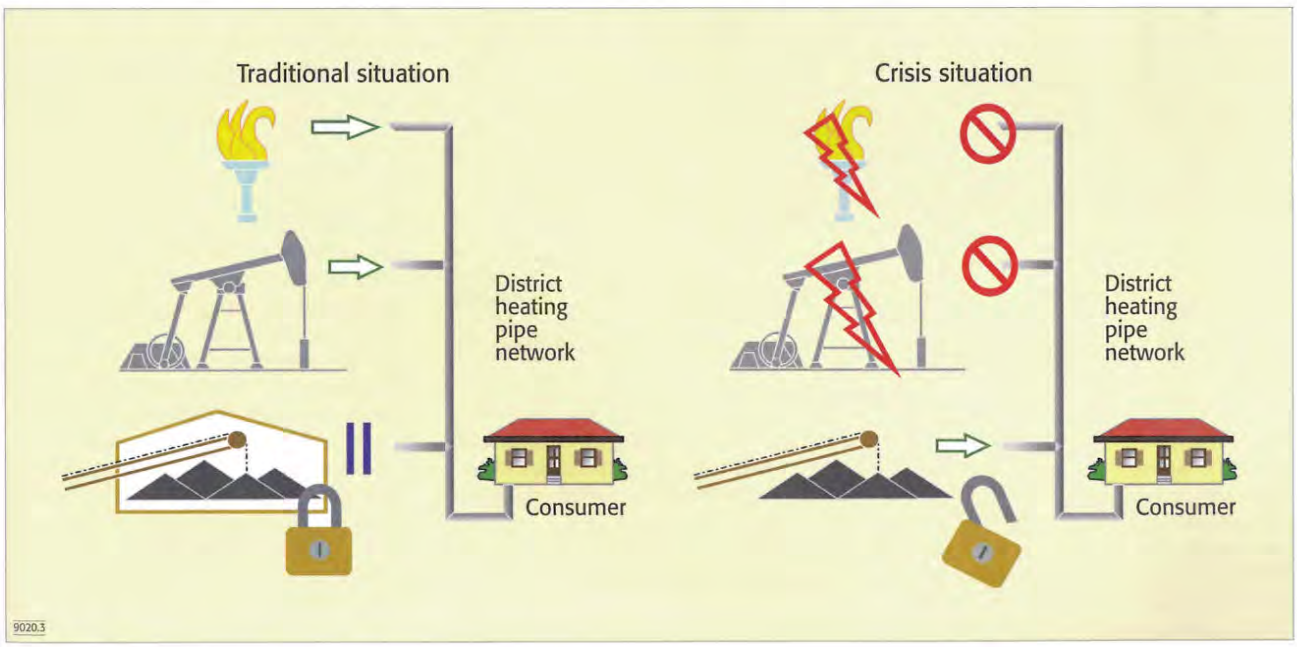

Figure 3. *District heating provides supply safety*

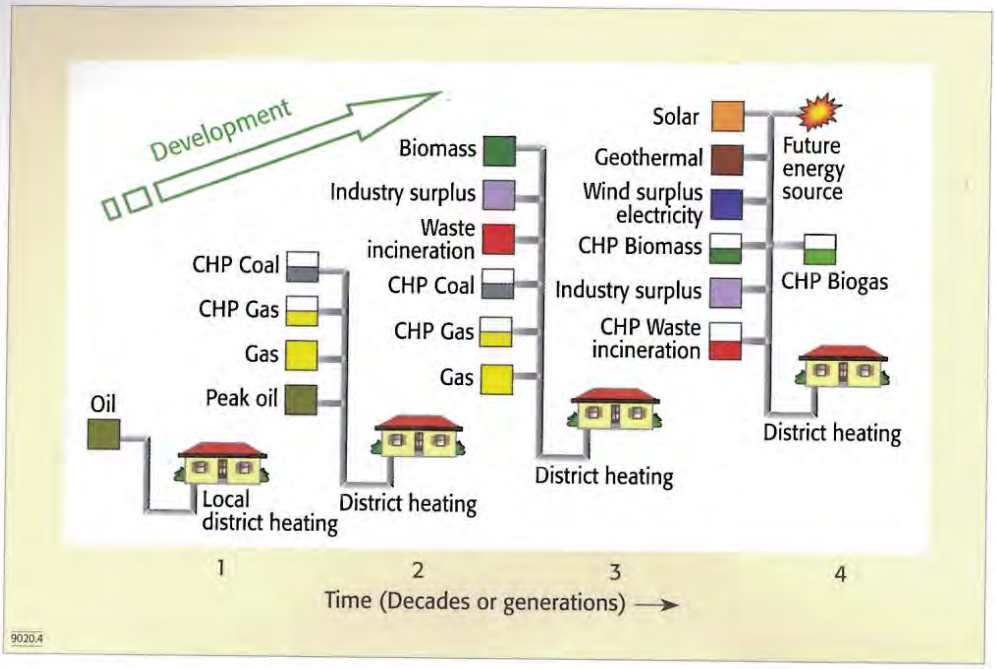

Figure 4. *Safe development towards greener technologies without modifications of consumer installations*

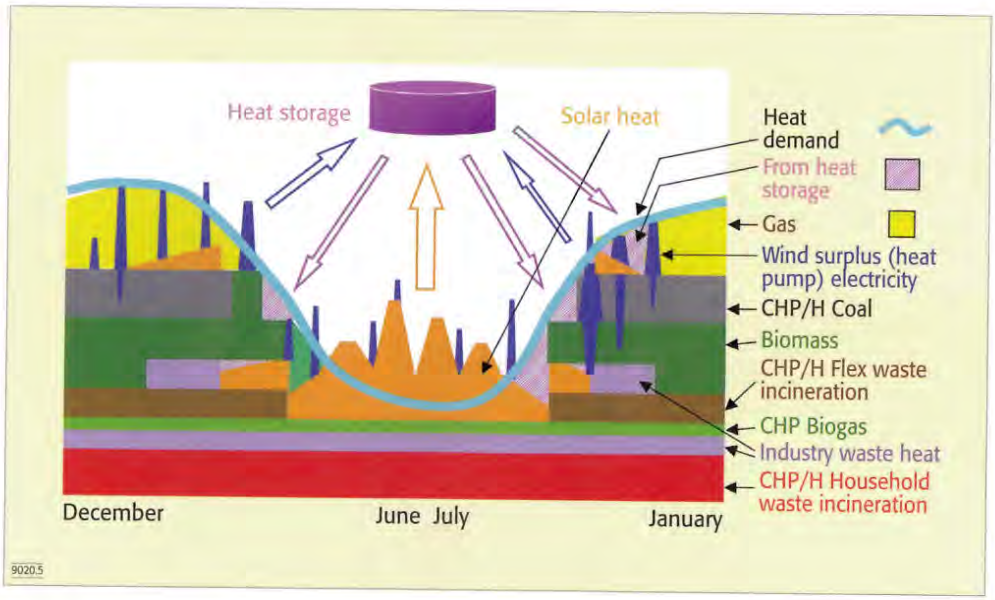

Figure 5. *The patchwork of heat production in a modern district heating system*

on and without disturbing the consumers! No one knows exactly what the future will bring, and the district heating principle provides the necessary flexibility to change the fuel mix at a later date, according to energy-political development. It is both easier and more economical to build a new central district heating production unit than to change thousands of individual boilers, or other heating equipment in factories, institutions and private homes.

Towards Greener Energy

As the financial, environmental and political costs of fossil fuels increase, district heating allows smooth development towards greener energy (*figure 4*), without the need to change consumer installations. This development is already taking place in a few countries. For each MWh district heat supplied to the Danish individual consumer, only about half a MWh of fossils are combusted for district heating.

Windmills produce about 20 % of Denmark's electricity, and a planned large extension of windmill capacity in Denmark will increasingly result in excess power in windy periods. The situation is signalled by extremely low electricity prices temporarily on the pool market, and this is a good opportunity for district heating systems. District heating water can be heated up by means of electrical coil, which is a very cheap investment, or by means of a heat pump, which multiplies the heat output relative to electricity input. In some cases, this heat is stored in a heat accumulator. The same principle applies to solar energy. It is already increasing its share in district heating.

Patchwork of District Heat Production

The primary heat source dispersion of a modern, large district heating system has a patchwork look (*figure 5*). The lowest part of the *figure 5* includes the highest prioritized production which is normally the household waste (or unclassified waste) incineration, as this kind of waste has to be incinerated immediately. The upper part of *figure 5* includes lower prioritized production, like the fossil fuel gas. The priorities partly depend on how storable the fuel is. In addition, the priorities may change for the same district heating system. The situation on the electricity market may affect the priorities of the heat and power plants, among other things. *Figure 5* is designed to illustrate principles; it includes simplifications of both priorities and heat supply peaks.

The opportunity for heat storage has now become a major advantage of district heating. Excess green energy / cheap energy is stored in the traditional aerial district heating accumulators as short-term storage for a day or a week, or it is stored in much bigger underground basins as a long-term or seasonal storage.

District Heating Network for Local Heat Sharing

A future potential of the district heating network, which is associated with flexibility, is local heat sharing (*figure 6*). Future renovations of buildings may involve conversion of the whole roof into a solar heating panel. Some of the houses in the local community will be renovated, whereas others will not. Then, according to economists, the district heating network can be a local market for the surplus solar heat, or, according to technicians, a local heat accumulator for the surplus solar heat. Surplus solar heat from those particular houses is put back into the district heating network. This is probably much more economical than storing heat inside the houses. Heat accumulators in private houses consume space in the region of 1 000 €/m^2. Furthermore, they involve extra investment, maintenance, and heat losses.

The surplus heat may either be transferred to the return pipe or put back into the supply pipe. The first option involves the lowest investment. The second option is usually more energy-saving, but it includes an extra pump in the consumer unit. The latter case also requires a system design with low temperature and low differential pressure in a local / secondary pipe network. Secondary pipe networks with heat sharing should probably be designed with co-insulated PEX pipes to cope with frequent temperature variations mainly caused by local green energy.

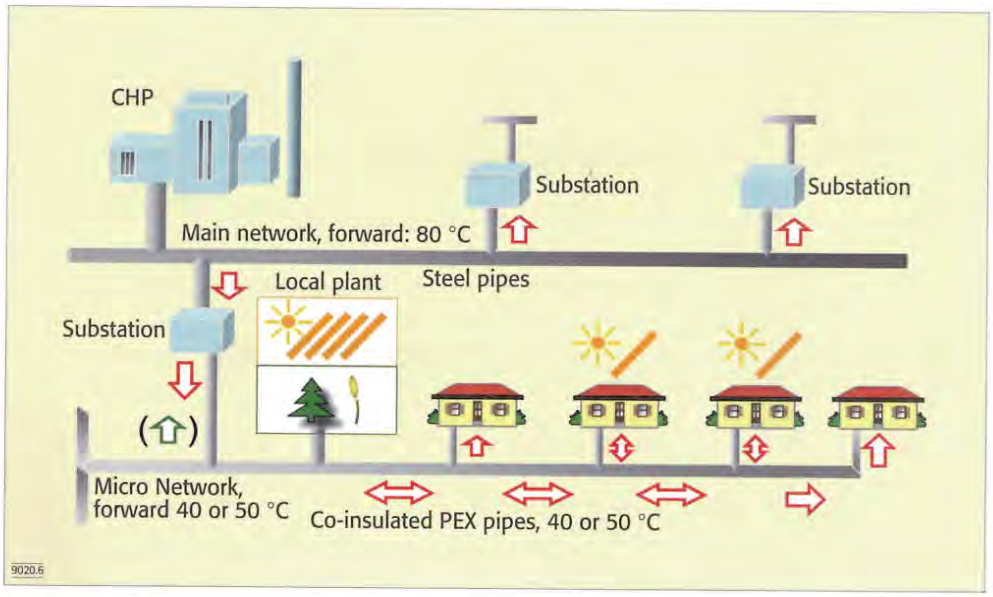

Figure 6. *The micro network utilizing local green energy*

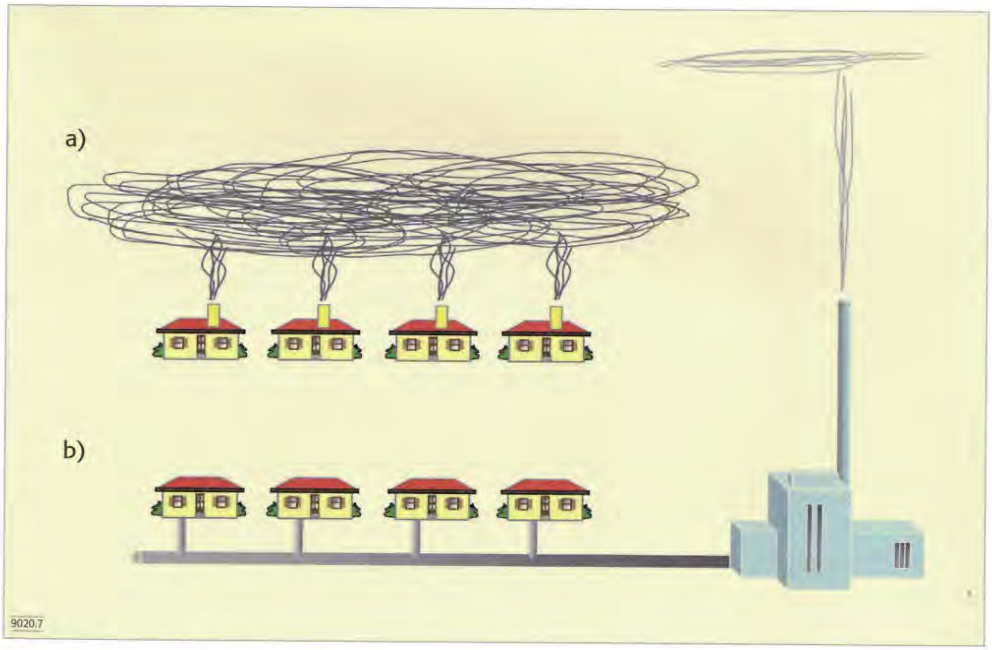

Figure 7. *District heating reduces pollution*
a) heat supply with individual boilers
b) district heat supply with a central heat production unit

Towards Low-Temperature Networks

In the future, the trend is likely to involve reduced temperatures in local district heating networks, since low temperatures facilitate a more efficient utilization of green energy. Most new houses in Denmark are heated using floor heating which only requires 40 °C, so, it is the hot tap water that is critical for the district heating supply temperature. Due to health conditions, the hot tap water temperature must be at least 55 or 60 °C, if stored in a tank. However, if the hot tap water is prepared in a heat exchanger, immediately before consumption, then 45 °C is normally sufficient. Thus new low-temperature networks will involve hot tap water heat exchangers. They can operate directly at 50 °C district heating supply temperature, or they can operate at 40 °C district heating supply temperature, if provided with a temperature boosting device. This design ensures that the pipe heat losses are very low, and is relevant in the case of low-energy houses.

Reducing Air Pollution

Conversion to district heating normally reduces air pollution (*figure 7*). Even in the case of fossil fuels, one large heat production unit in a district heating system pollutes less, compared to thousands of small individual house boilers of different qualities and conditions. Cleaning technologies for large pro-

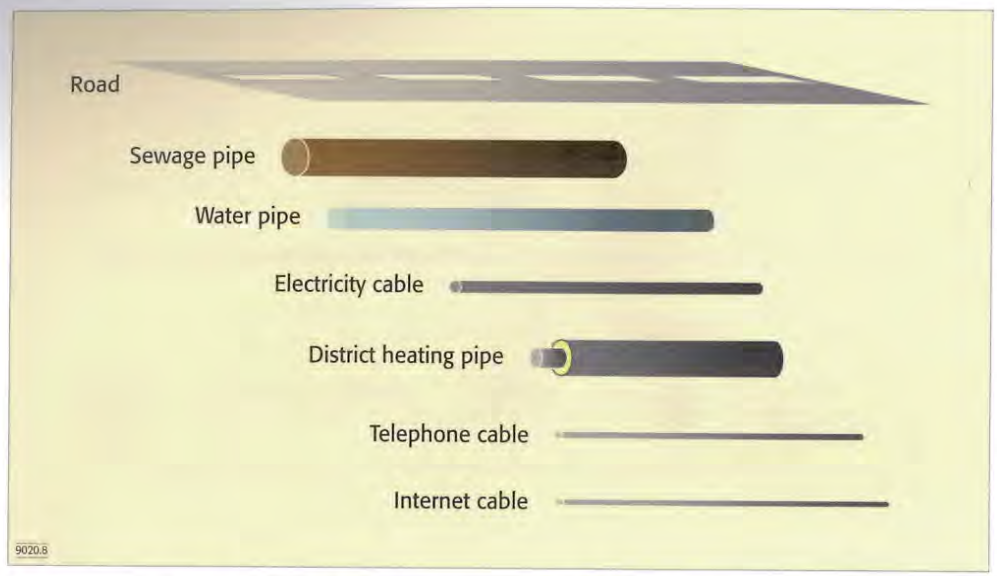

Figure 8. *District heating is just another kind of infrastructure, a well known main characteristic of the modern society*

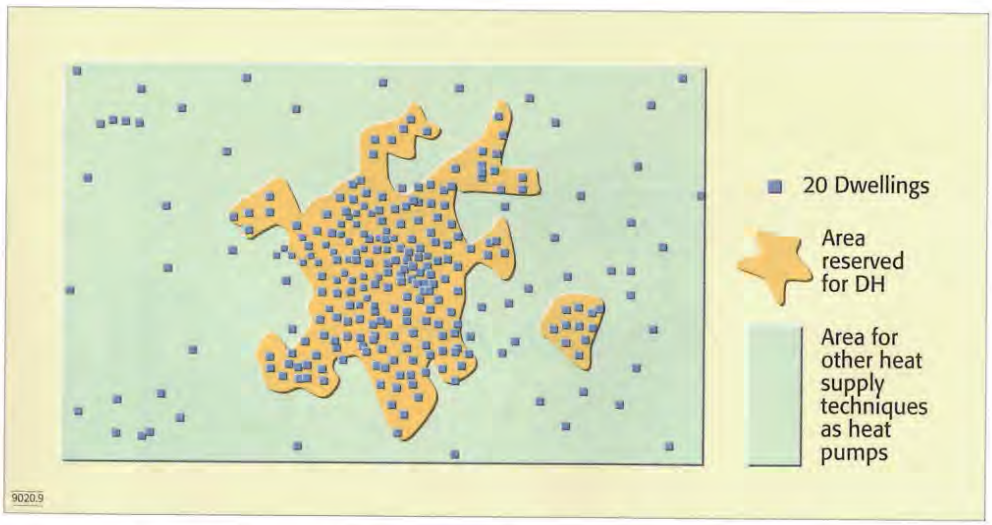

Figure 9. *Reserving dense populated areas to district heating, requires good planning recourses*

duction units are more advanced, and subsequent maintenance and improvements are both more economical and more flexible, because private consumer installations are not involved at all.

Reliable and Well Proven Technology

It can be concluded that the flexibility of the district heating system provides fantastic opportunities for the future. It has a unique ability to utilise the potential of both green energy sources and cheap energy sources. Its robustness against fuel crisis is also unique. It is now a reliable and a well proven technology. Yet still, it is just another kind of infrastructure – one of the main characteristics of modern society (*figure 8*).

A Well Developed Authority System is Necessary

But why is district heating not everywhere already? There are several reasons. The initial investment in a complete district heating system is major – the benefits come later, which is too late for some decision-makers. The investment in district heating technology is in many ways the opposite of investing in bonfire technology. District heating requires more start-up resources, and the reward is bigger. Conversion to district heating involves planning and the cooperation of many organisations, which again requires a well developed authority system. One simple example: Investment expenses are reduced if the installation of new district heating pipes and renovation of existing sewage and water pipes takes place at the same time.

Planning authorities should reserve the more densely populated areas for district heating, including all cities, where it must be agreed that most or all heat consumers are connected to the district heating network (*figure 9*). This is, by the way, already the norm for water networks, sewage networks, electricity networks and the road system. Connecting most or all consumers, drastically reduces the investment per consumer. Due to reasonable planning in Denmark, new district heating networks have already replaced existing gas networks; even if the gas networks still run on 100 % domestic gas which is not likely in Europe, especially not in the future.

Green and supply-safe district heating should play a central role in energy planning in Europe. Implementation of district heating requires a large amount of political strength from the very beginning; at a national or European level. The reward is huge savings of CO_2 and fossil fuels, pretty much immunity against fuel crisis, and low and stable energy costs for the population. Implementation of district heating takes time. Make history and take action now! Tomorrow might be too late. ■

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