Heat and the ~~City~~ Community: The institutional roots of Danish energy conversion efficiency

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The two faces of Danish energy efficiency

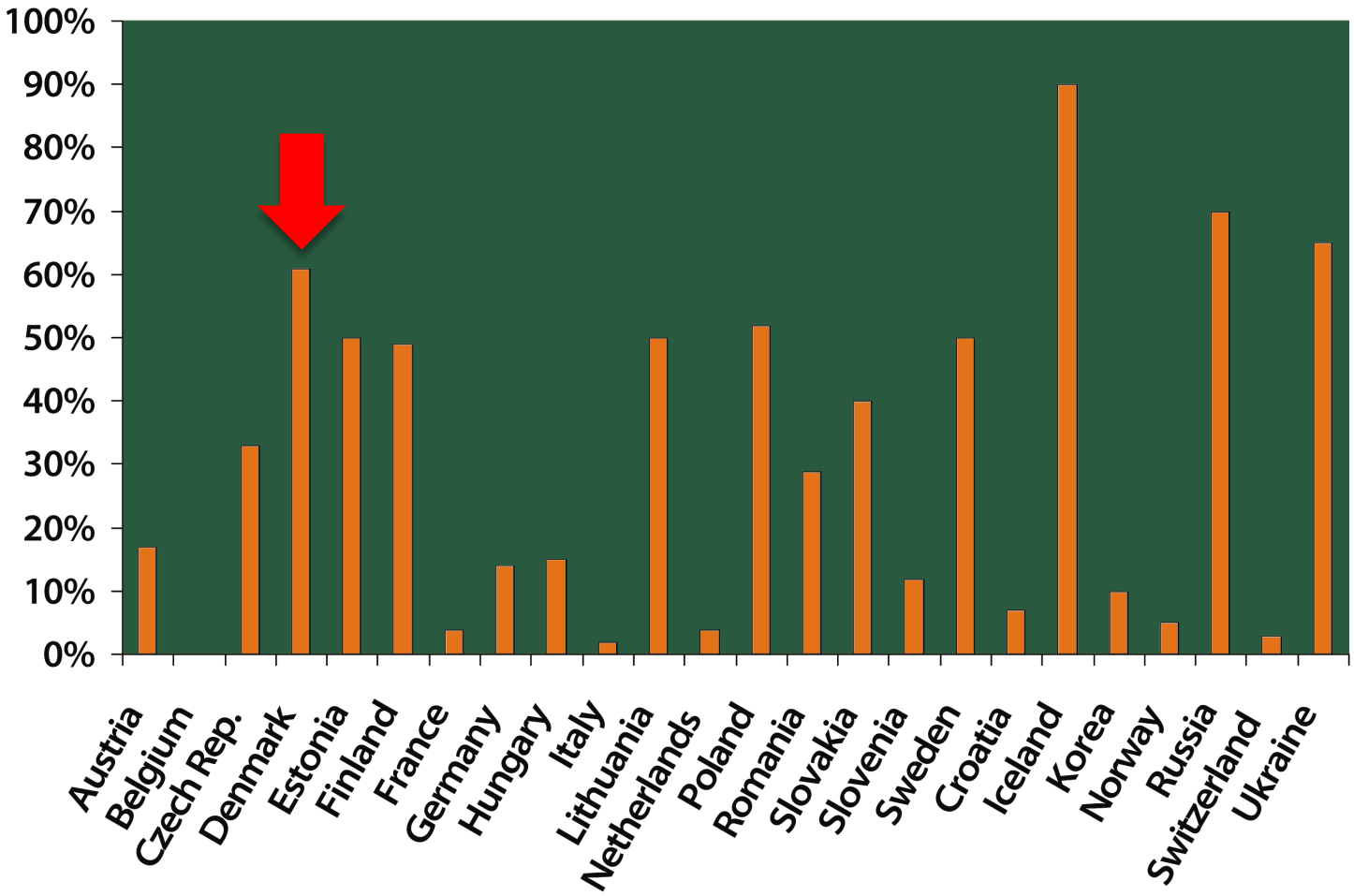
End-use

- CO_2 and energy taxation
- Subsidy programmes
- Building regulations
- Information and labelling
- Obligation on distribution companies

Conversion

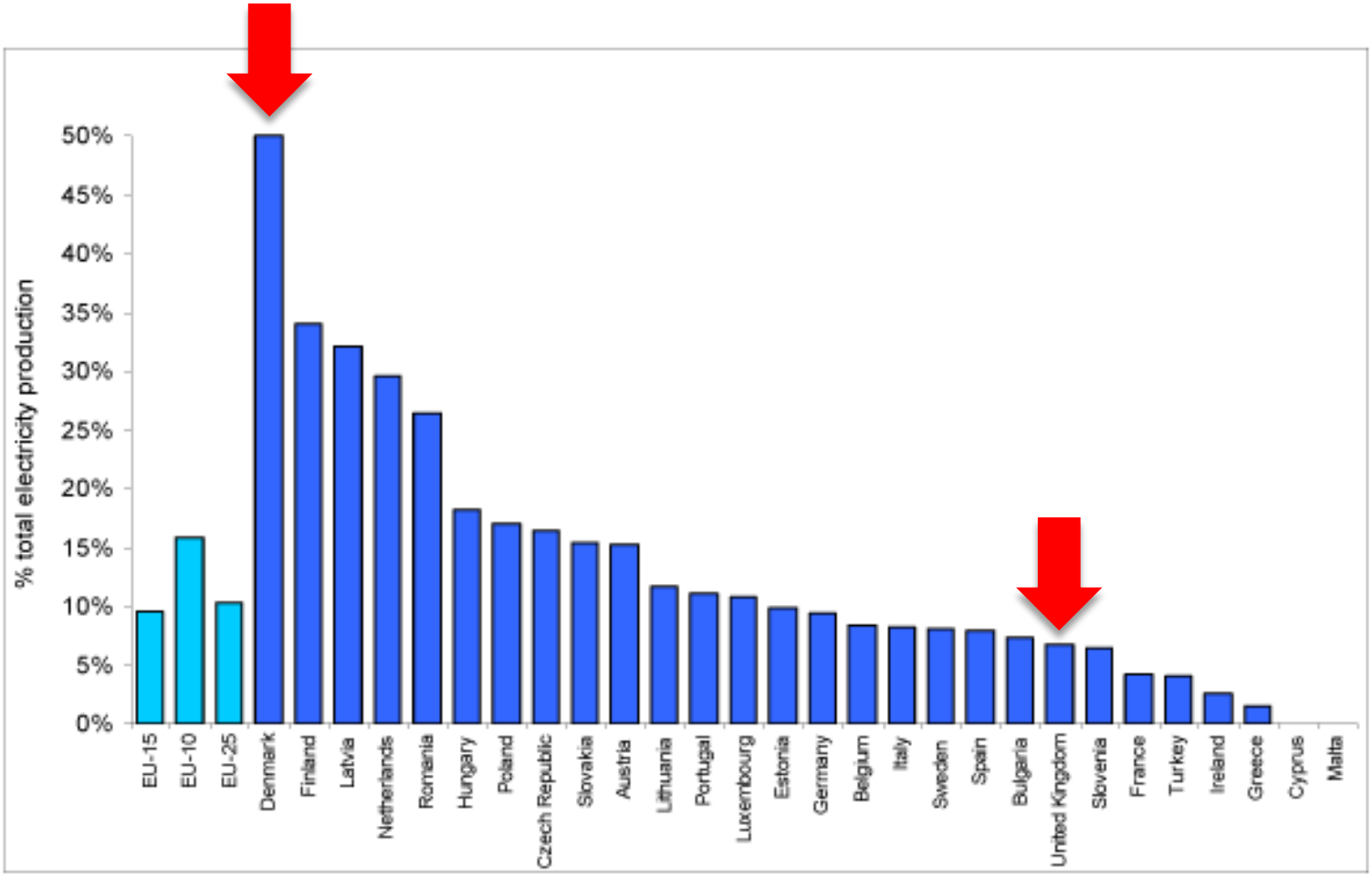
- District heating
- Combined heat and power

DH shares in residential heating



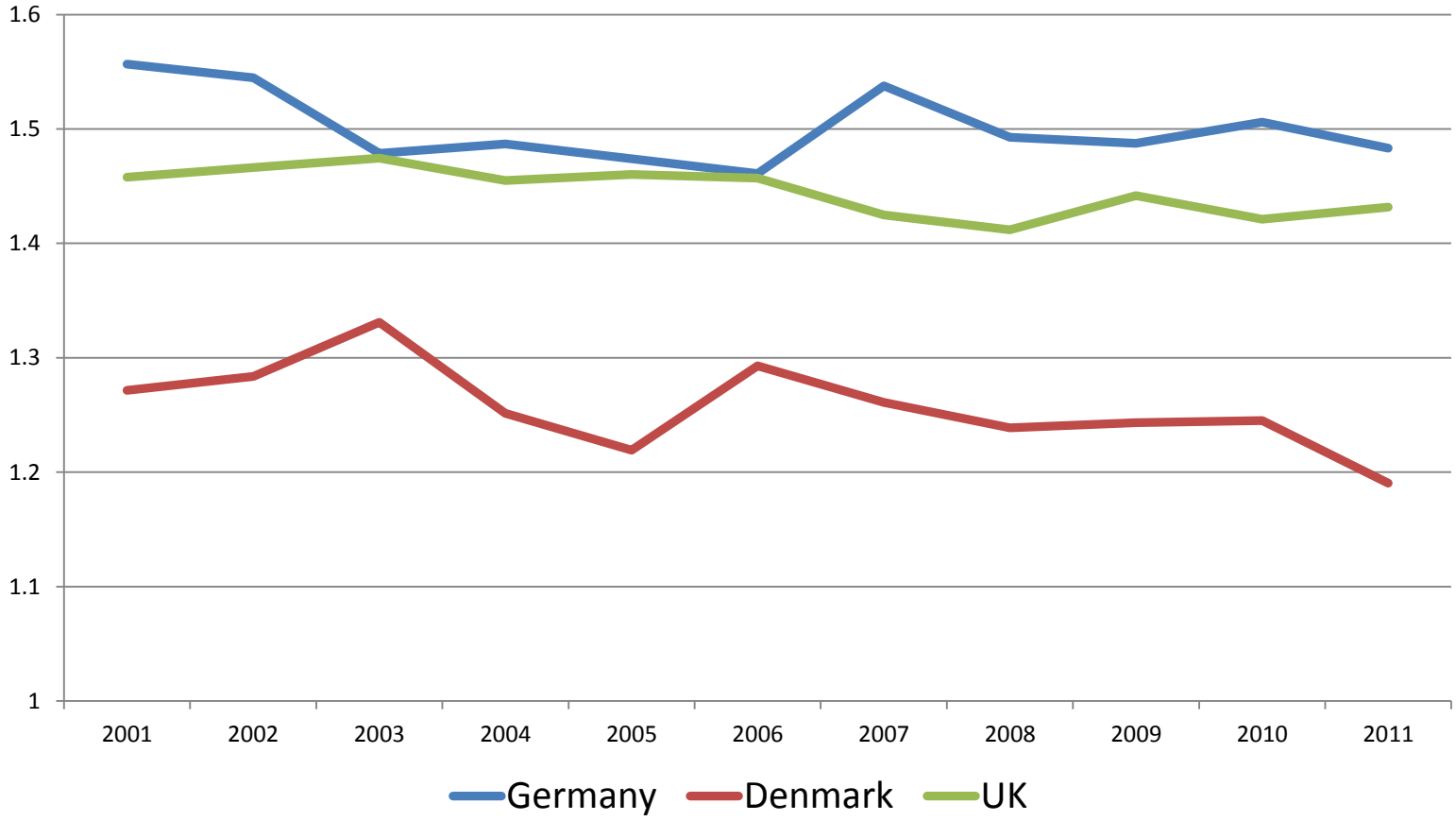
Source: DDHA

Share of CHP in electricity generation



Source: DDHA

Ratio of TPES to energy consumption



Source: OECD

Conventional story - the 1970s oil crisis as trigger

- International Energy Agency (2008) *CHP/DHC Country Scorecard* "Since 1979, strong incentive policies have strongly encouraged the growth of CHP and DH. This support was triggered by the oil crises in 1973-74 and the late 1970s…"
- Sovacool (2013) 'Energy policy making in Denmark', *Energy Policy* : "The Danish Energy Policy of 1976…articulated the short-term goal of reducing oil dependence,…and meeting two-thirds of total heat consumption with 'collective heat supply' by 2002."
- Danish Energy Agency (2012), *Energy Policy in Denmark*: "It began with the oil crises of the 1970s",
- Danish Energy Agency (2015), *The Danish Energy* Model "Denmark has a long tradition of active energy policy, initiated as a reaction to the first oil crisis in 1973."
- London Economics (2015) *Best practice from Denmark in price setting for heat tariffs "*Kicked off in 1979 with the legal requirement that all local authorities produce heat maps by end-1982 at the latest…"

Historical institutionalism (e.g. Peters 2012)

- Institutions as ‘rules of the game’ (including policies where these ‘stipulate rules that assign normatively backed rights and responsibilities to actors and provide for their…enforcement’ (Streeck and Thelen 2005: 12)
- Institutional arrangements as relatively stable regimes, reflecting distributions of power, with associated driving and legitimising sets of ideas
- Institutional change
  - ‘Punctuated equilibrium’ = stable institutional arrangements interrupted by ‘critical junctures’ caused by external shocks or trends
  - ‘Punctuated evolution’ = periods of gradual change (Mahoney and Thelen 2010) interspersed by critical junctures
- Both types of change shaped by past/pre-existing institutions, interests (material, electoral) and ideas (political, policy)

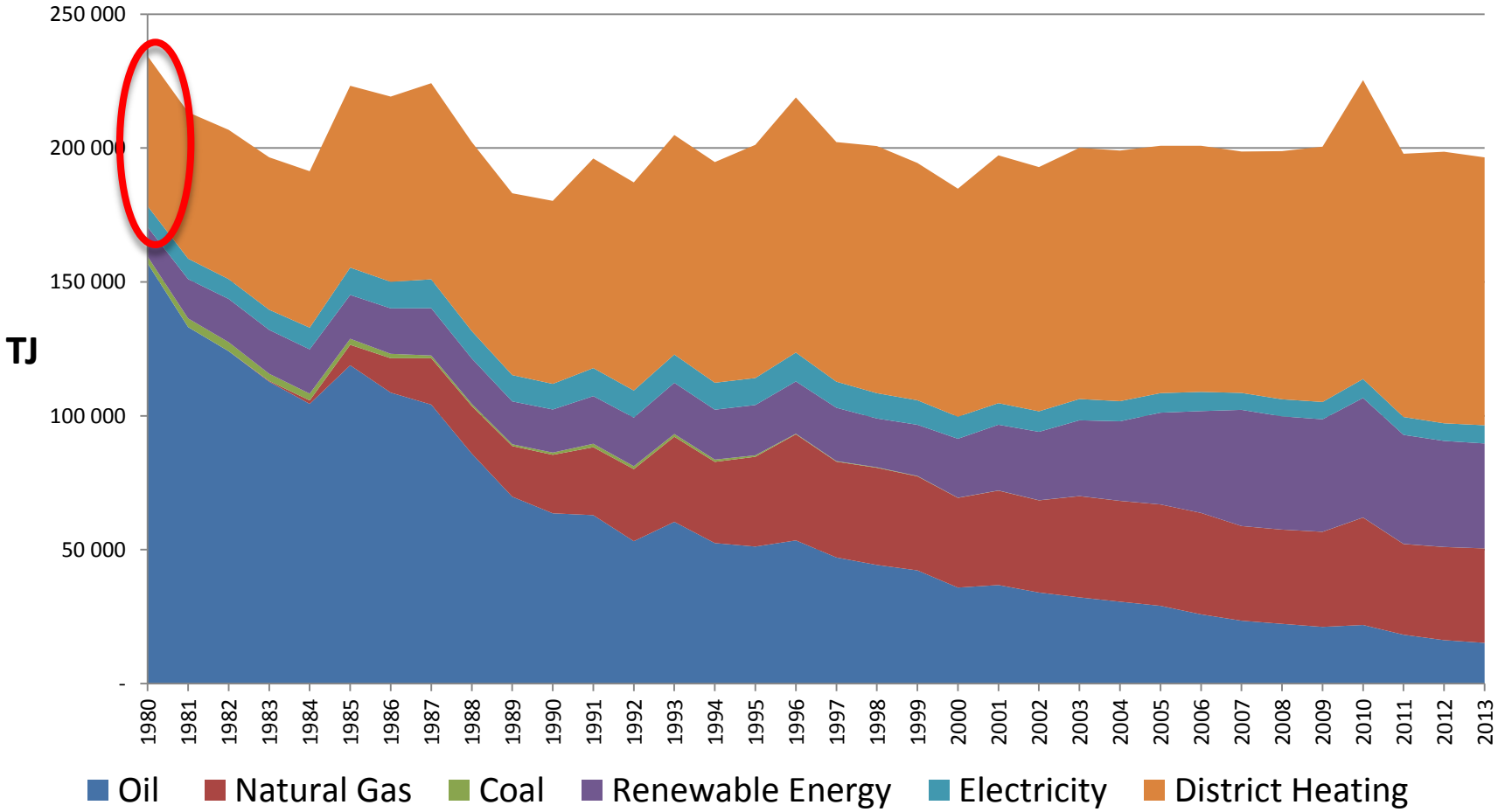
Early evolution

- First Danish system 1903 in Frederiksberg, initially served institutional consumers (hospital, children's home etc.)
- Expansion of schemes in 1920s and 1930s (Manczyk and Leach 2001).
- Between 1955-1973, ~200 DH networks established (ibid, Sovacool 2013), mainly in urban centres (~30% of homes and municipal buildings)
- By mid-1930s, 14 out of 70 power producing urban utilities used CHP; 30 by 1954, including 5 using large-scale power plants (van der Vleuten and Raven 2006)
- Centralisation of electricity system and move to large-scale generation plants in 1950s and 1960s curtailed further growth

Institutional arrangements and history

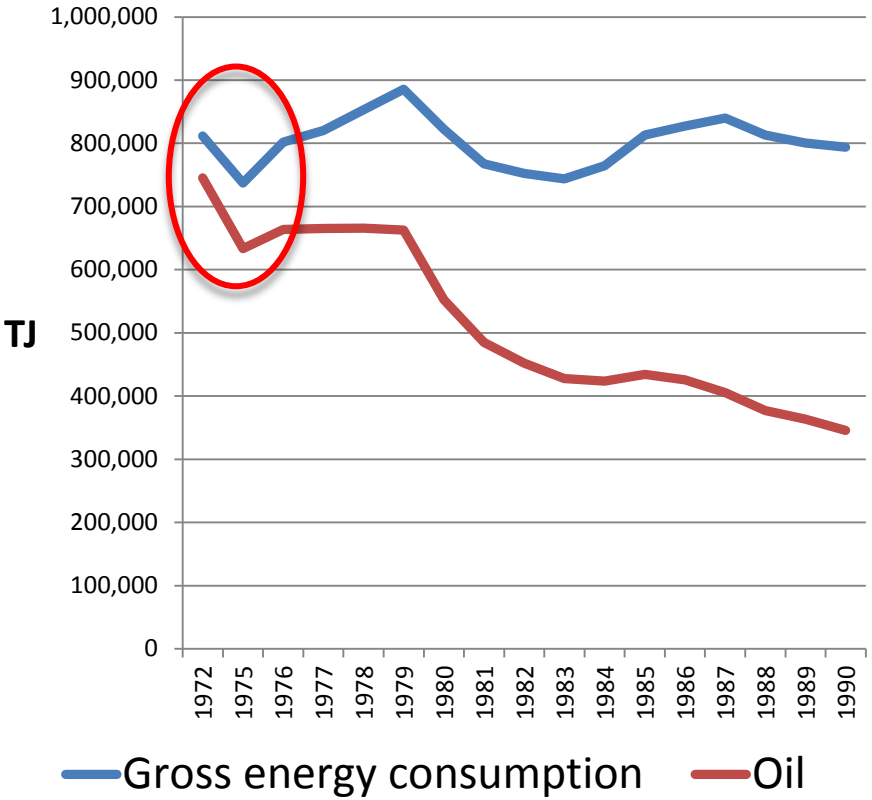
- Municipal government in urban areas
  - Owners and operators of DH/CHP in large towns/urban areas;
  - Highly organised set of actors
  - Delivery of services in Denmark highly decentralised
  - Local government relatively autonomous, including a degree of financial autonomy and ability to borrow for utilities investment (Pedersen 2002)
- Co-operatives in small towns/rural areas
  - Electricity generation and distribution networks
  - Also organised (e.g. Danish Association of Rural Utilities (De danske jævnstrømsværker)),
  - Roots of co-operatives in equitable land ownership and agricultural reconstruction from 1860s (Campbell and Hall 2006)
  - Subsequent spread of co-operative principle and institutional capacities across Danish society
- Centralisation of electricity generation in 1950s and 1960s but <u>not</u> ownership, which remained in hands of municipalities and cooperatives

Total heat demand



The 1970s oil shocks as ‘critical juncture’

- 90% reliance on imported oil
- Energy use falls ~10% in 3 years
- Rationing, e.g. Sunday driving ban
- Creates ‘burning platform’ for energy system transformation



Source: DEA

Policy response

- 1976 Energy Supply Law - required govt approval for new plants under Energy Plans, CHP obligatory for new plants
- Energy Plan 1976 goals:
  - 2/3 of heat demand from ‘collective heat supply’ by 2002
  - 25% of heat from CHP by 1995
- 1979 Heat Supply Act - LAs responsible for mapping heat demand, leading up to county and regional heat plans
- Obligation to connect to local DH distribution network 1982
- Ban on electric heating in 1988
- DH legislated as a non-profit activity, with prices and allowable costs regulated at national level and published and ranked
- Schemes owned and operated by municipalities and consumer cooperatives, not private companies
  - Currently 40 public utilities and 350+ consumer cooperatives, each providing about half of DH demand

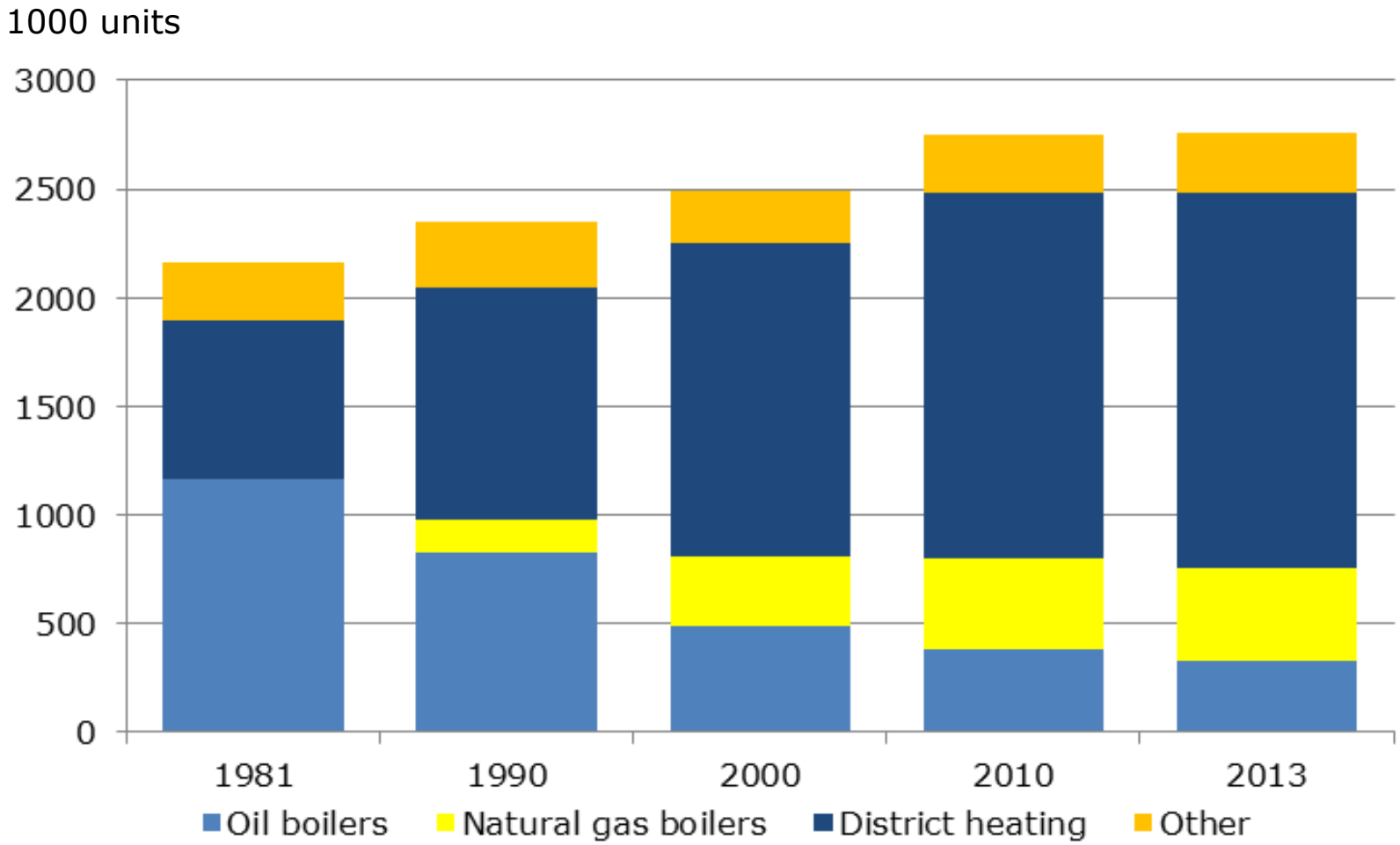
Politics of the 1970s ‘critical juncture’ - ideas

- Crisis of energy security legitimises state intervention
  - Depth of crisis
  - 1970s - ‘In international comparison the form of intervention was not particularly harsh but quite consistent in time’ (van der Vleuten and Raven 2006: 3744)
  - Centre-left government in power in 1973
  - Denmark as a small state (Katzenstein 1985) and the importance of ‘common interest’ (Campbell and Hall 2006, Pedersen 2006)
- Battle of ideas over direction of Energy Plans (Van der Vleuten and Raven 2006, Lund 2010)
  - ‘liberal alliance’ vs. ‘state alliance’ vs ‘green alliance’
  - First Energy Plan in 1976 – compromise vision including state-owned gas network, nuclear power and renewables + CHP
  - Greens alliance published Alternative Plan in 1976; popular opposition to nuclear led to removal from second Energy Plan (1981), and 1985 referendum finally ruled it out

Politics of the 1970s ‘critical juncture’ – institutions and interests

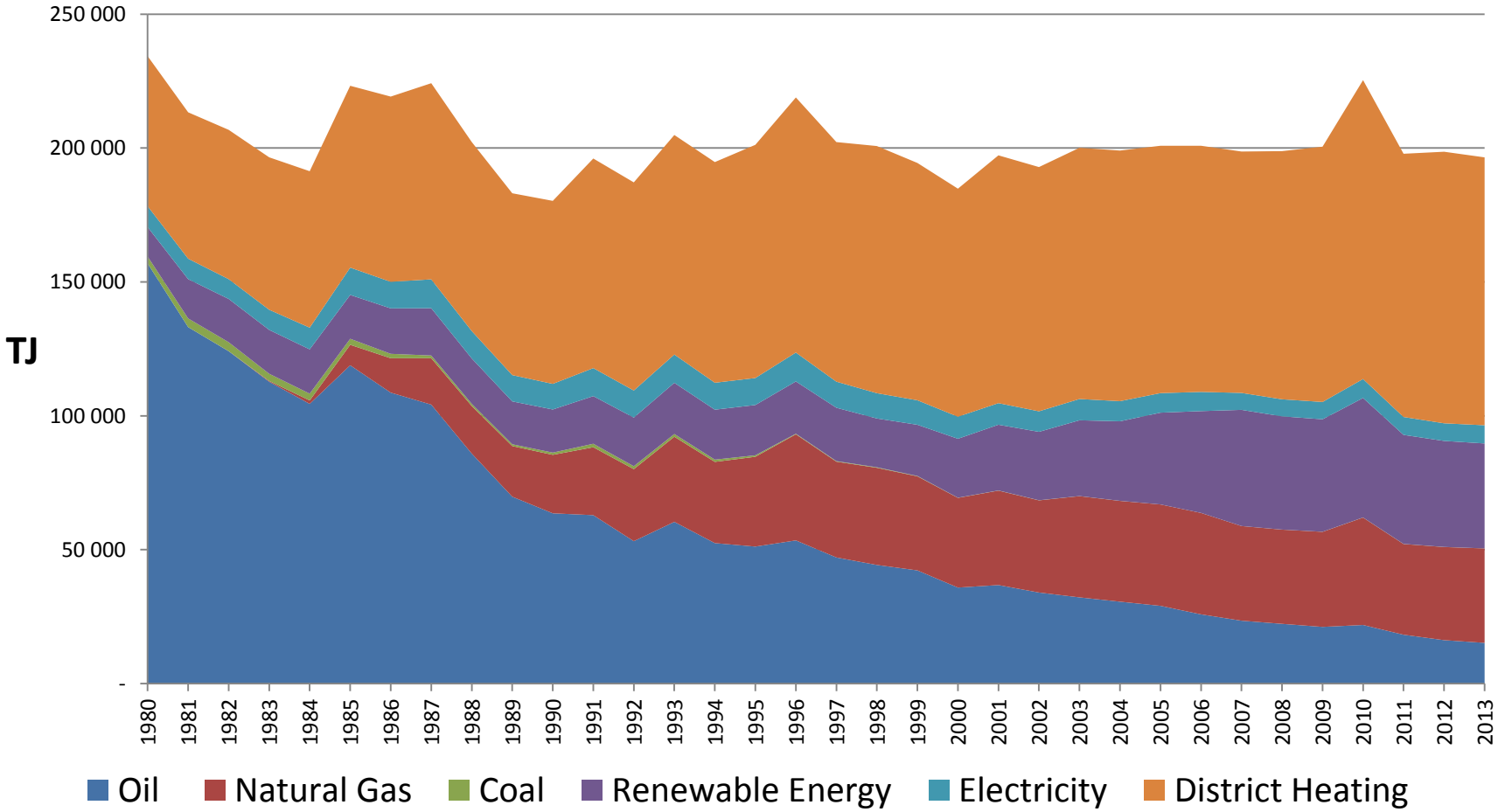
- Central state intervention was implemented via existing local institutions, i.e. municipalities and cooperatives
- Relied on reviving capacities from earlier decentralised regime, including heat planning, management of construction and O&M, plus supporting institutions in finance, supply chain, consultants etc.
- Absence of domestic fossil fuel producer industry lobbies
- Larger utilities
  - ultimate owners were often municipalities
  - Government subsequently required construction of CHP plants alongside conventional plants

Expansion of DH 1981-2013



Source: DEA

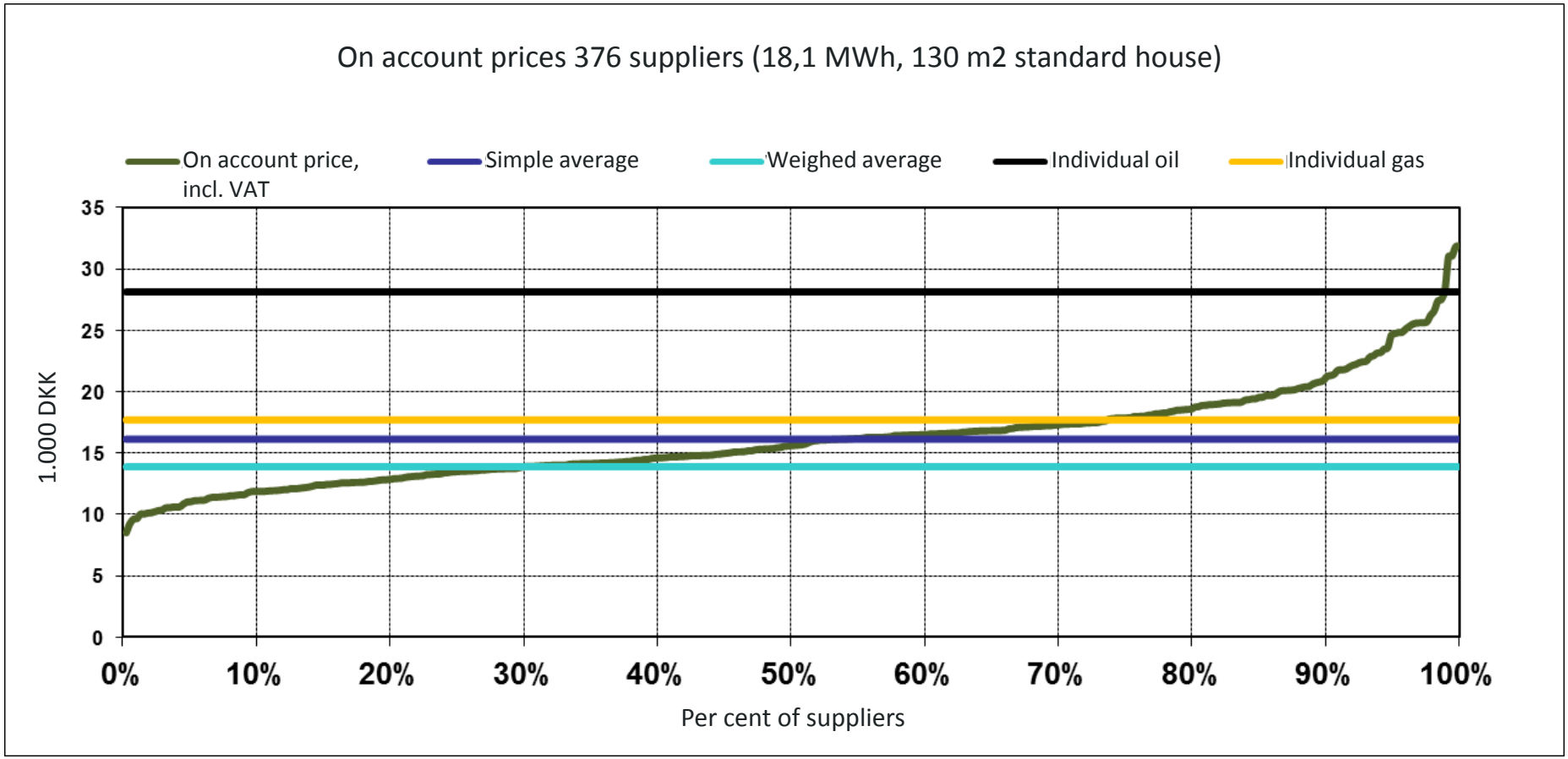
Total heat demand



Institutional stability of DH

- Steady expansion and linking of networks since 1981 but basic institutional arrangements stable
- Increasing returns and network effects have created lock-in
- Combination of cost-plus regulation and municipal or consumer accountability loop also provides incentives for high quality of service and efficiency, while also providing no incentives to change ownership
- View that the sector has pockets of inefficiency but is broadly efficient, technologically innovative and competitive with individual gas heating

District heating prices 2013

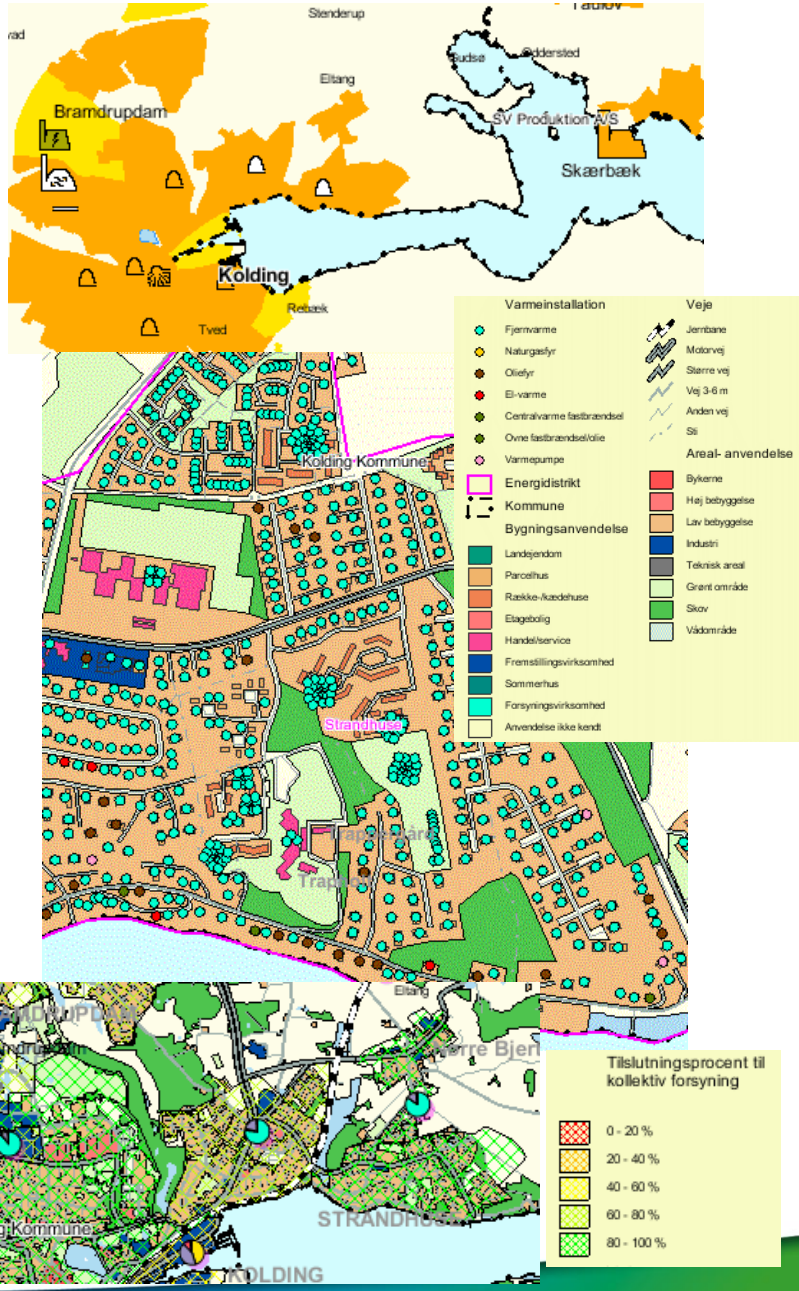


House size: 130 m^3 – 18,1 MWh/y.
Oil price avarage 2012 until and including september
Gas prise first half year 2012
Degrees of efficiency: Oil85 %, N-gas 95 %, no depreciation

Source: DDHA

Institutional stability of DH

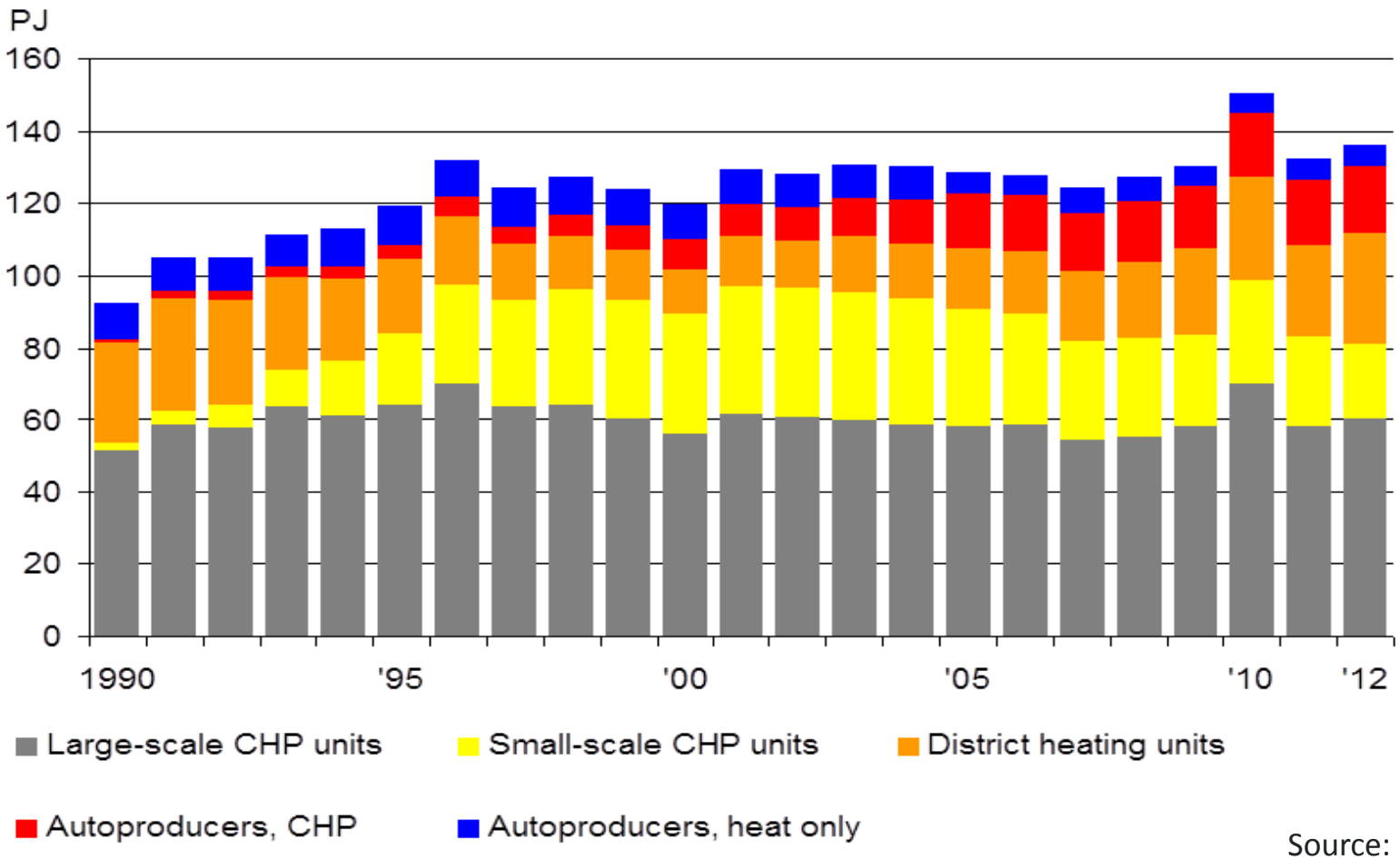
- Institutional interests
- Heat planning consultancy industry
- DH/CHP managers
- Supporting institutions in finance
- Supply chain interests (Danfoss, Logstor, Grundfos etc)
  - Sector turnover of >£1.5 billion/year
  - Employment ~9,000 in 2008
  - Export potential, esp. China (£560m/year in 2013)



Evolution - the return of decentralised CHP

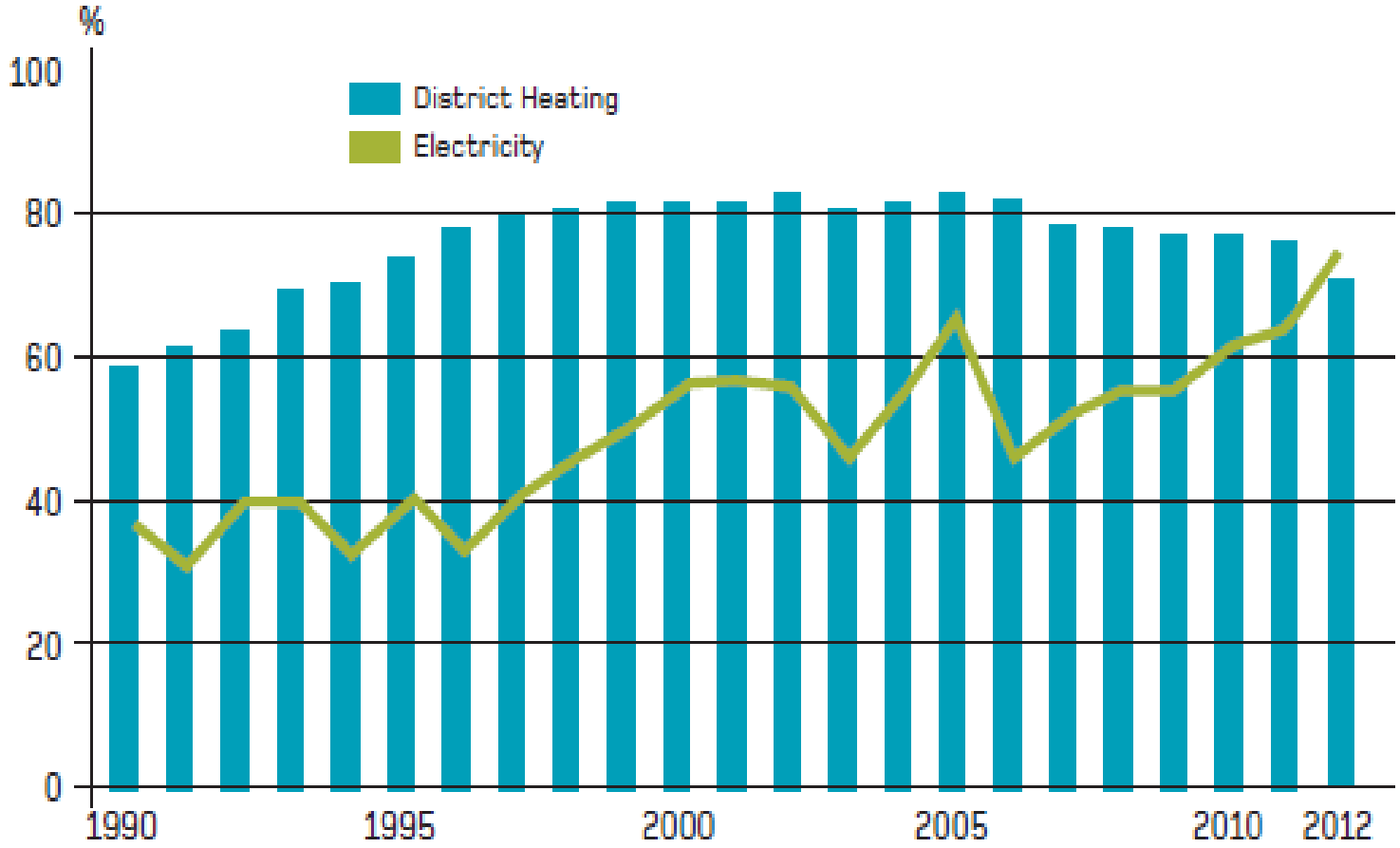
- Large-scale CHP already present in 1970s, expanded in 1980s as 1976 Energy Supply Act required all new generation plant to be CHP
- 1990 Energy Plan
  - DH plants in range of the natural gas network were obliged to convert to gas-fired CHP; by 1999 those outside the network should convert to biomass CHP if technically and economically feasible
  - Tax of fuels for heat but not for electricity production
  - Triple-tariff system guaranteed electricity price
  - Obligation on local electricity suppliers to purchase (until 2005)
- Big shift in small DH schemes from oil- and coal-fired boilers to gas-fired CHP (0.5-10 MWe) over 1990s
- Revival relied on experience with CHP from earlier regimes (van der Vleuten and Raven 2006)
- Why? Driven from above by state seeking use for gas and from below by coops/municipalities seeking additional revenue and following German examples

Heat production by type of unit



Source: DEA

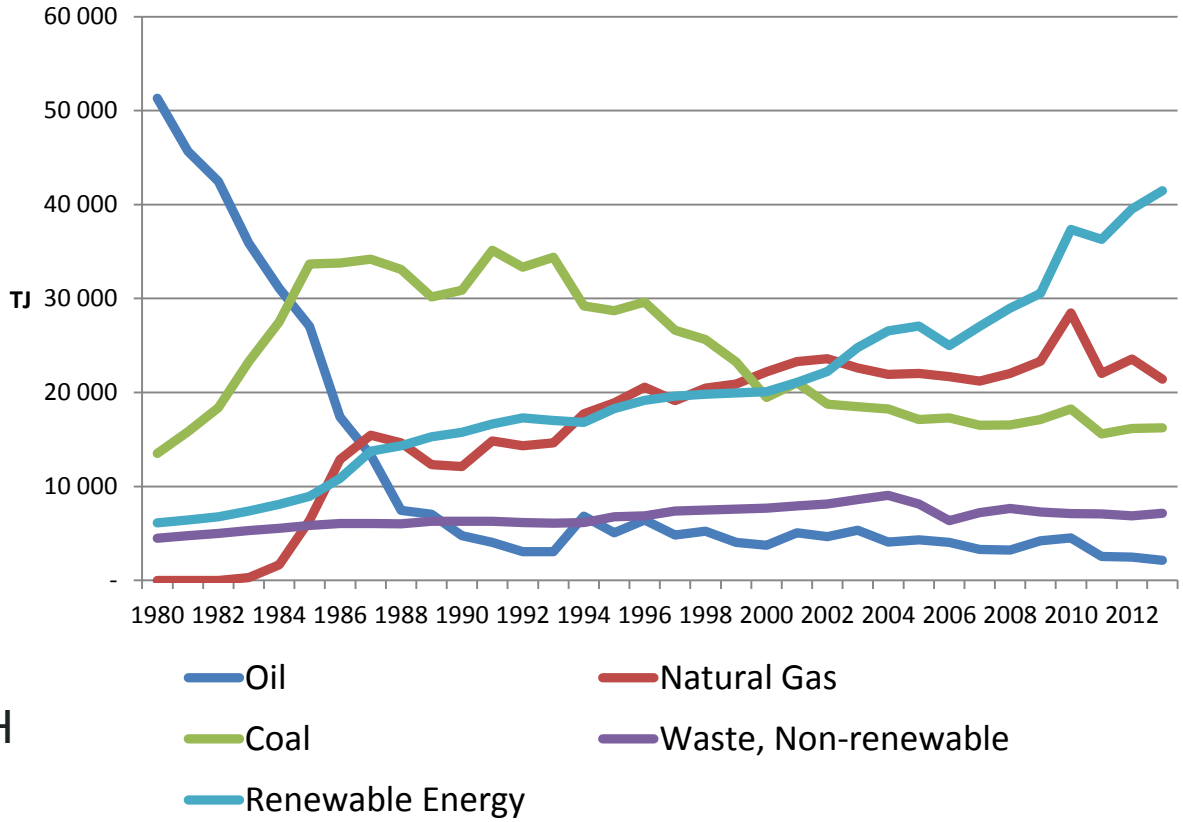
Share of CHP in DH and electricity generation



Source: DBDH 2013

Evolution - Introduction of renewable fuels

- From 1980s, shift from coal to bio-energy, including straw, wood chips and biogas
  - Premium tariff for electricity produced from renewables in centralised CHP in 2004
  - New coal investments banned 1997
- By 2011, 50% of fuel in DH from renewables
- Why?
  - Energy security?
  - Climate change

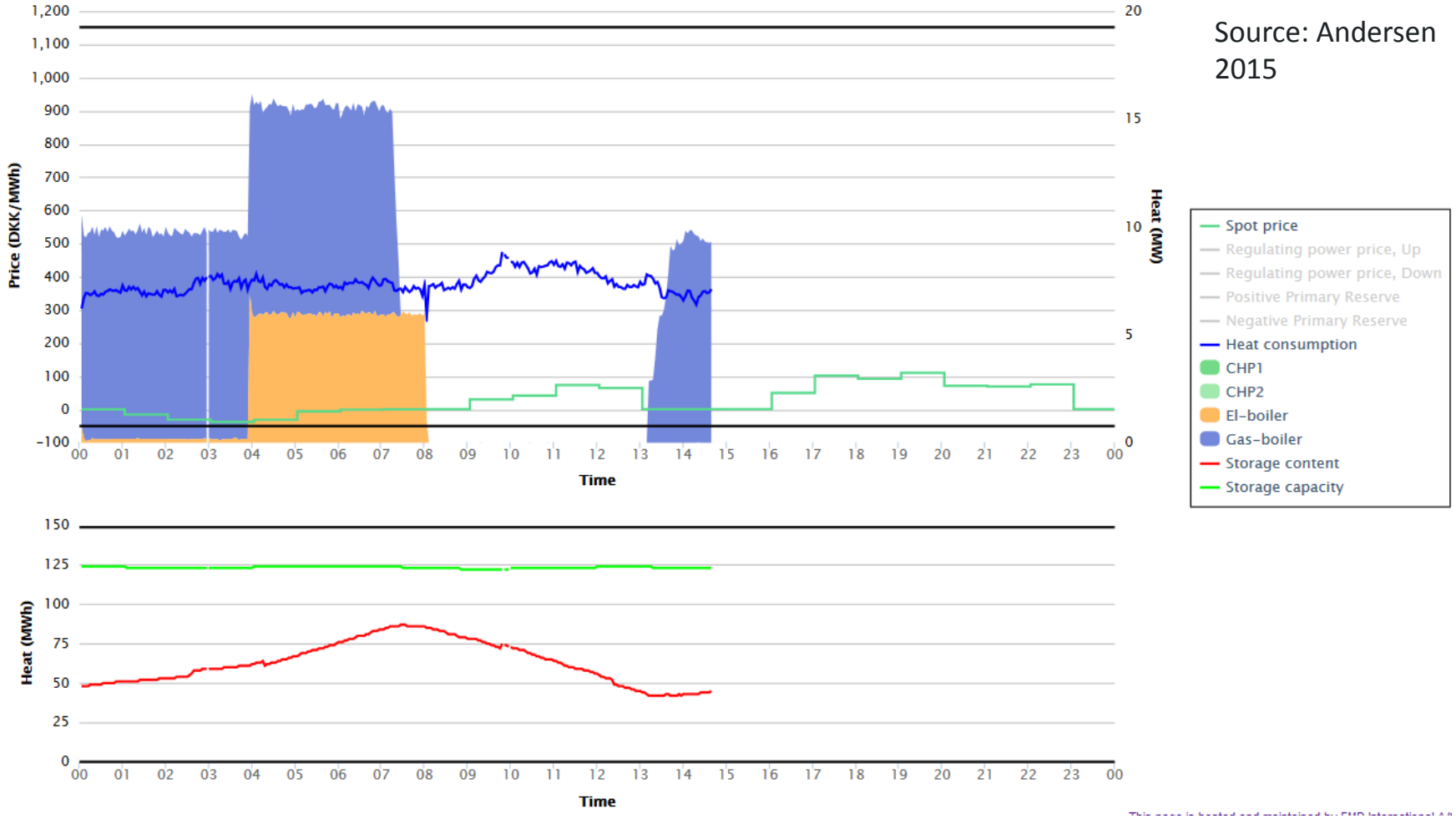


Composition of fuels in District Heating

Evolution - New opportunities in electricity balancing

- Denmark joins Nordpool wholesale electricity market 2002
- 2005 retail market liberalisation under EU Third Package means CHP no longer guaranteed market with local suppliers and is required to sell into Nordpool
- Market structure allows participation by small actors through ‘balancing responsible parties’ (aggregator/traders)
- High value of flexibility because of wind intermittency
- Optimising CHP operation to generate when wind low/prices high and switch to electric boilers when wind high/prices low
- Non-CHP DH schemes also using electric boilers to take advantage of high wind/low prices

New opportunities in electricity balancing



Source: Andersen 2015

Hvide Sande District Heating Sunday 11 January 2015

Summing up

- Policy response to 1970s oil shock, especially requirement to connect, is key element of Danish experience, but…
- Policy response rested on existing history of DH/CHP
- Policy response itself shaped by institutional history (role of municipalities and cooperatives)
- Resulting design of regime (non-profit, local accountability, national regulation) has helped institutional stability, efficiency and innovation

Implications for UK?

- Focus on 1970s not that helpful:
  - We don’t and won’t have a heat law,
  - We didn’t have a 1970s supply shock of the same nature; instead our critical juncture was liberalisation in the 1980s and we now have an institutional set up reflecting that
- Large supplier/generators generally not interested, so municipalities (and co-ops?) obvious actors to fill the gap
- BUT
- UK much more centralised
- Municipalities legally able to do it all, but capacity and finance are issues – Danes (and others) can help
- Regulation (and regulated price transparency) as the missing piece?
  - Exit not possible from heat networks so voice is key, and price transparency makes voice more informed

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