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District heating vs Heat pumps when reducing CO_2 emissions in Sweden

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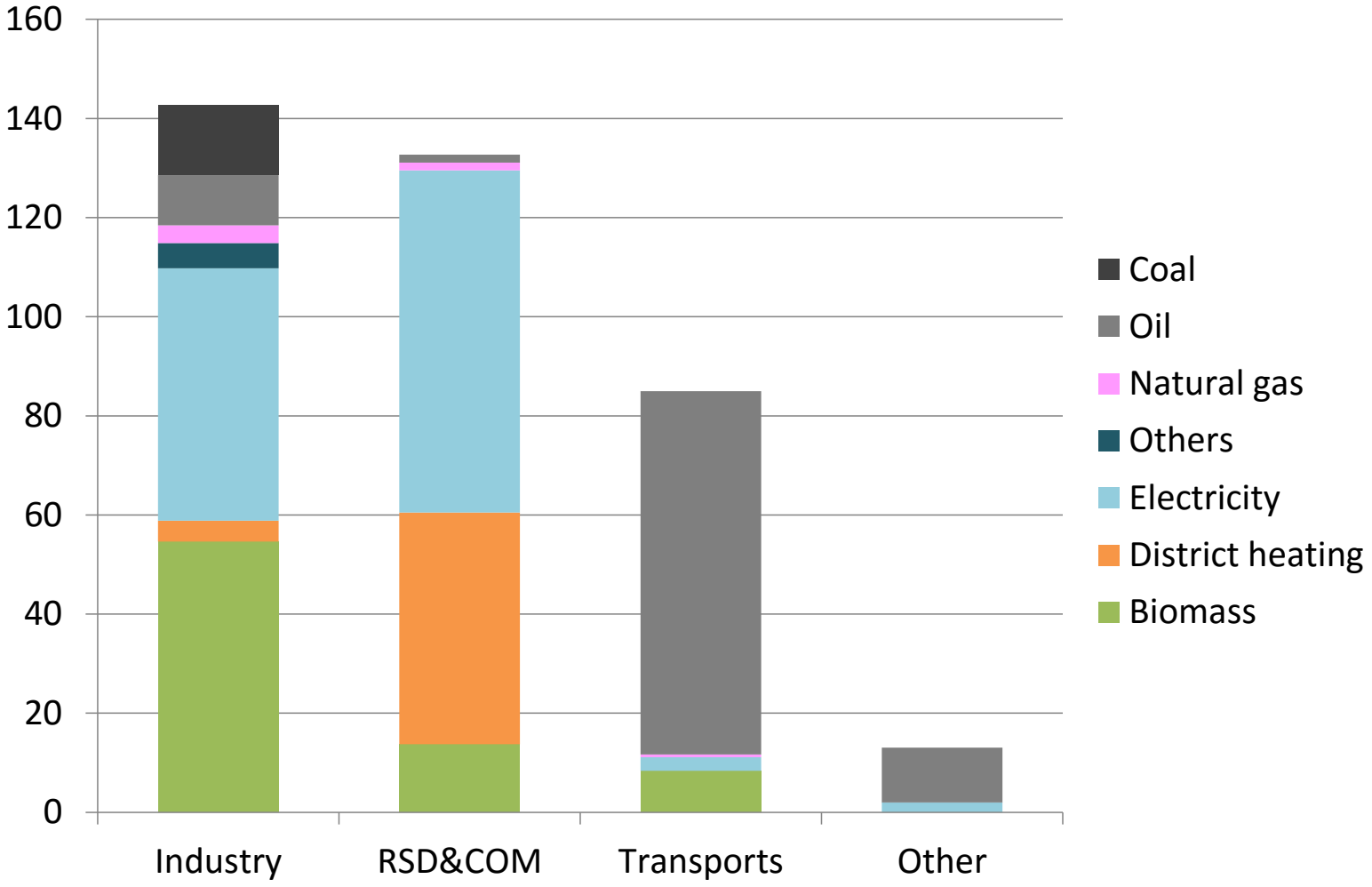
Outline

1) Background - Aim
2) Scenarios defined
3) Model used
4) Results
5) Conclusions

Background: Swedish Energy System

Final Energy Consumption in 2013 (TWh)

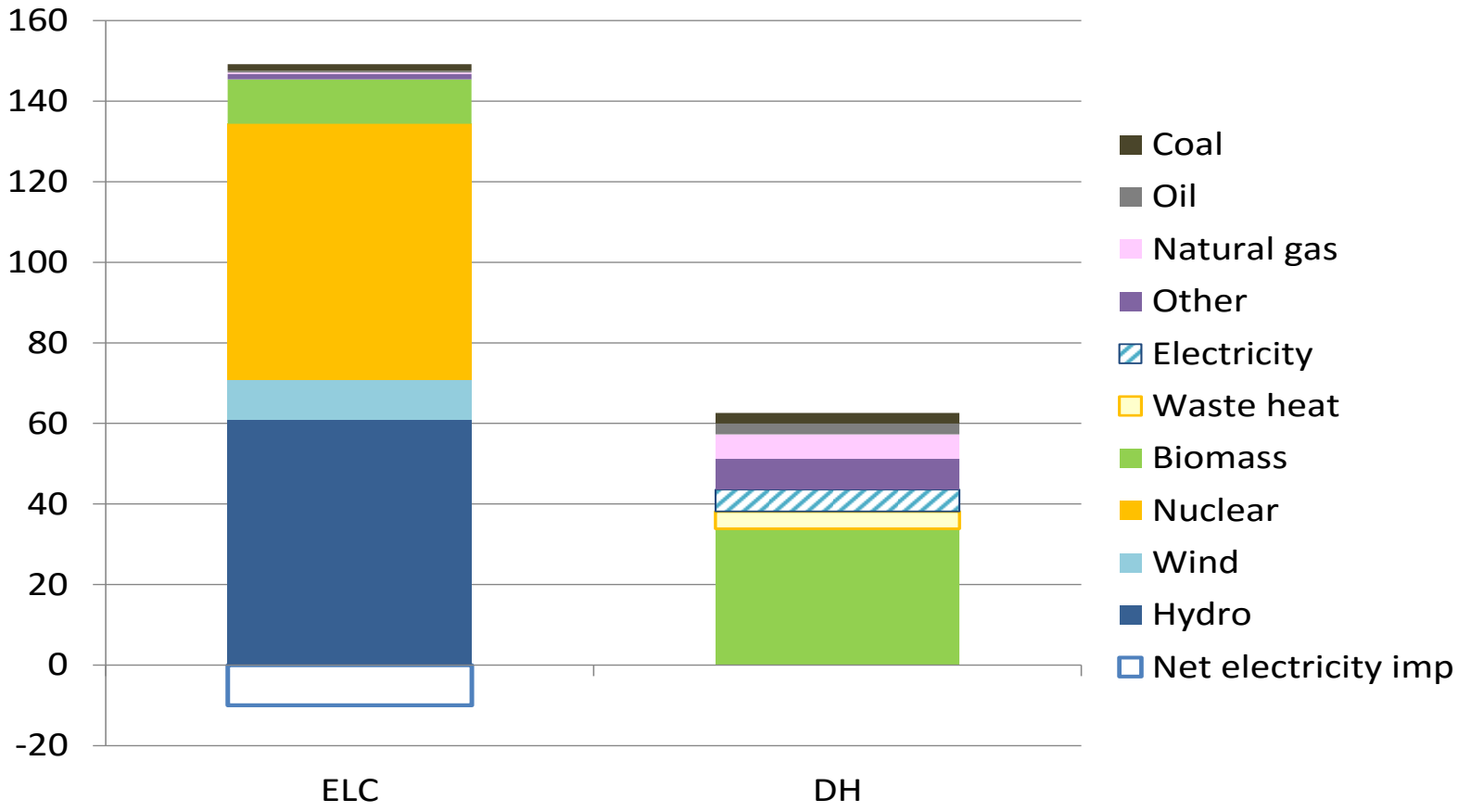
Source: Statistics Sweden/Swedish Energy Agency



Background: Swedish Energy System

Net elc & DH production by source in 2013 (TWh)

Source: Statistics Sweden/Swedish Energy agency



Building Regulations (BFS 2014:3 BBR 21

Energy performance in new buildings, measured in to the dwelling delivered energy (kWh per m2 Atemp and year).

	I	II	III
with electrical heating systems	95	75	55
with non-electrical heating systems	130	110	90

-> Less insulation is needed (cheaper to build) if choosing heat-pumps compared with DH -> **Unfair competition**

District heating companies are getting stressed.

Nevertheless:

Above definition could still be reasonable **IF heat-pumps** were identified to have overall benefits compared with other heating technologies, e.g. meet environmental targets to a lower cost.

Aim

Identify potential long-term impacts of district heating in meeting overall energy goals.

A **Competitive**, **Sustainable** and **Secure** energy system as defined in the Lisbon Treaty in 2007.

Competitiveness: System cost and marginal cost of electricity

Sustainable: Climate and resource efficiency

Energy Security: Energy infrastructure (electric grids and district heating grids)

Scenarios Defined

? Which scenario should we evaluate against?

► Define the Alternative scenario as a **counterplan** to the system with DH *(applying Churchman,1968, p.173)*

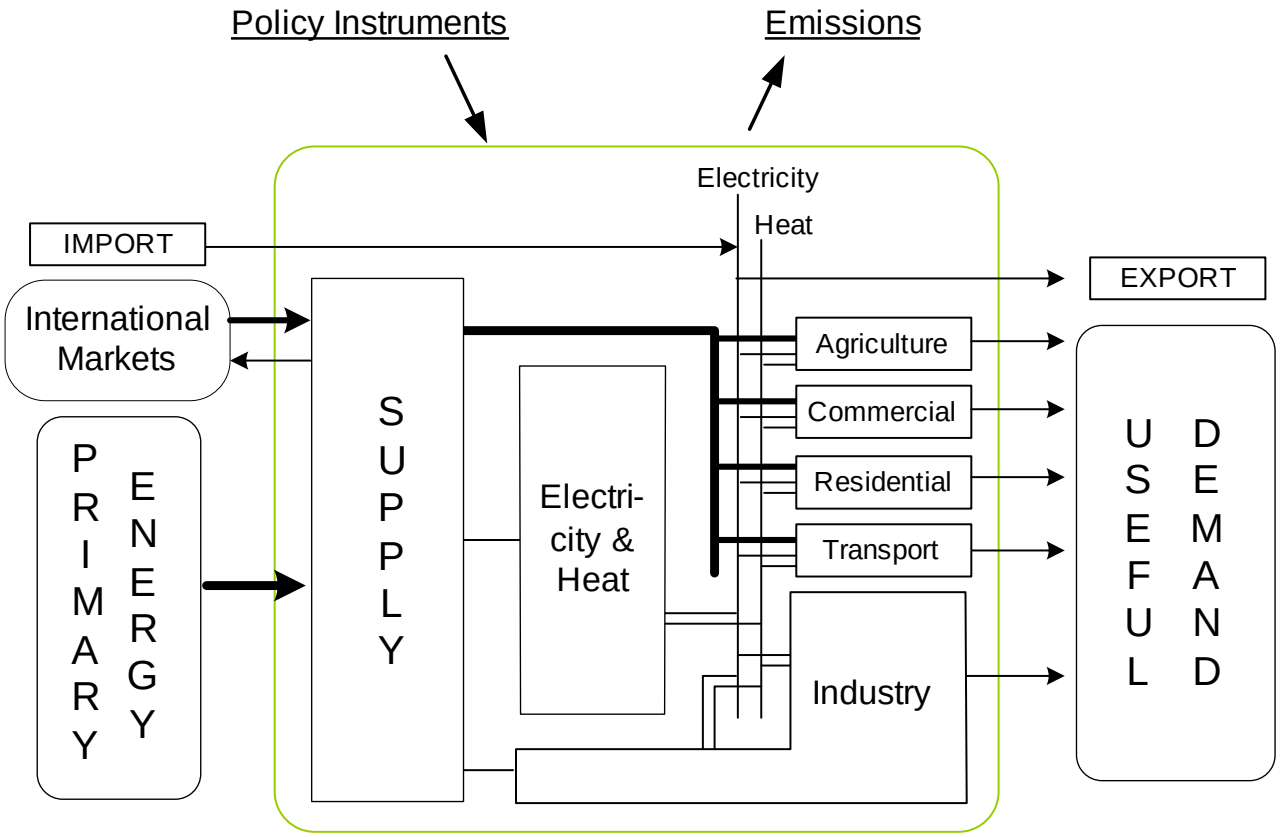
DH Scenario: Business as usual (thus with DH)

- Present environmental and energy policies
- Carbon price in line with IEA's 2 degree target.
- The energy balance for previous years are calibrated based on national energy statistics.

No-DH Scenario: Like DH Scenario except from

- DH removed from the current energy system in year 2005.
- City gas grids are in this scenario allowed to expand.

Model Used: **TIMES-Sweden** an Energy System Optimization Model of the Swedish Energy System



TIMES-Sweden

- **Based on the TIMES platform (The Integrated MARKAL- EFOM System):**
  TIMES-Sweden was initially developed as a part of the Pan European TIMES model (**PET model**), within two EU funded projects (NEEDS and RES2020). In the model each country is represented as one model, and all the country models are then hard-linked into one big model. There are several European models still being used, e.g. the JRC-EU-TIMES model (**JET model**) documented by Simoes et al. (2013).

- **The national models share the same:**
  - RES-structure (Reference Energy System) and naming convention
  - Techno-economic data-base
  - Approaches/Methods to estimate underlying assumptions such as: Base-year calibration, demand projections, potential of biomass, emission-factors etc.

- **TIMES-Sweden has been further developed to better represent Swedish conditions:**
  - **Emissions-factors/Ancillary benefits (Krook-Riekkola et al. 2011),**
  - **Iron- and steel industry (2012)**
  - **District heating (Krook-Riekkola & Söderholm, 2013) and (Pädam et al., 2013)**
  - **Demand through soft-linking with EMEC (Krook-Riekkola et al. 2013a, 2013b)**
  - Space heating and hot water (cooperation with The Swedish National Board of Housing, Building and Planning, 2015)
  - Biomass (2015: Funded by Fjärrsyn)
  - Transportation (2015/2016: Funded by Swedish Energy Agency)

TIMES-Sweden is further described in Chapter 5 in Krook-Riekkola (2015)

Model implications

'Poles apart' scenarios needs different simplifications → Reconsidered boundaries & technology description

DH Scenario:

- Capture local DH conditions: 6 DH-networks
- Separate end-use-DH technologies: grid-connection (new connection) and heat-exchanger (all dwellings)
- Investments grid cost for x increase of DH demand.
- Uses local sources -> Qualitative analysis
- (Building regulations -> Heat demand in dwellings will differ – electric/non-electric. Difficult to include –> assumed demand is similar)

No-DH Scenario:

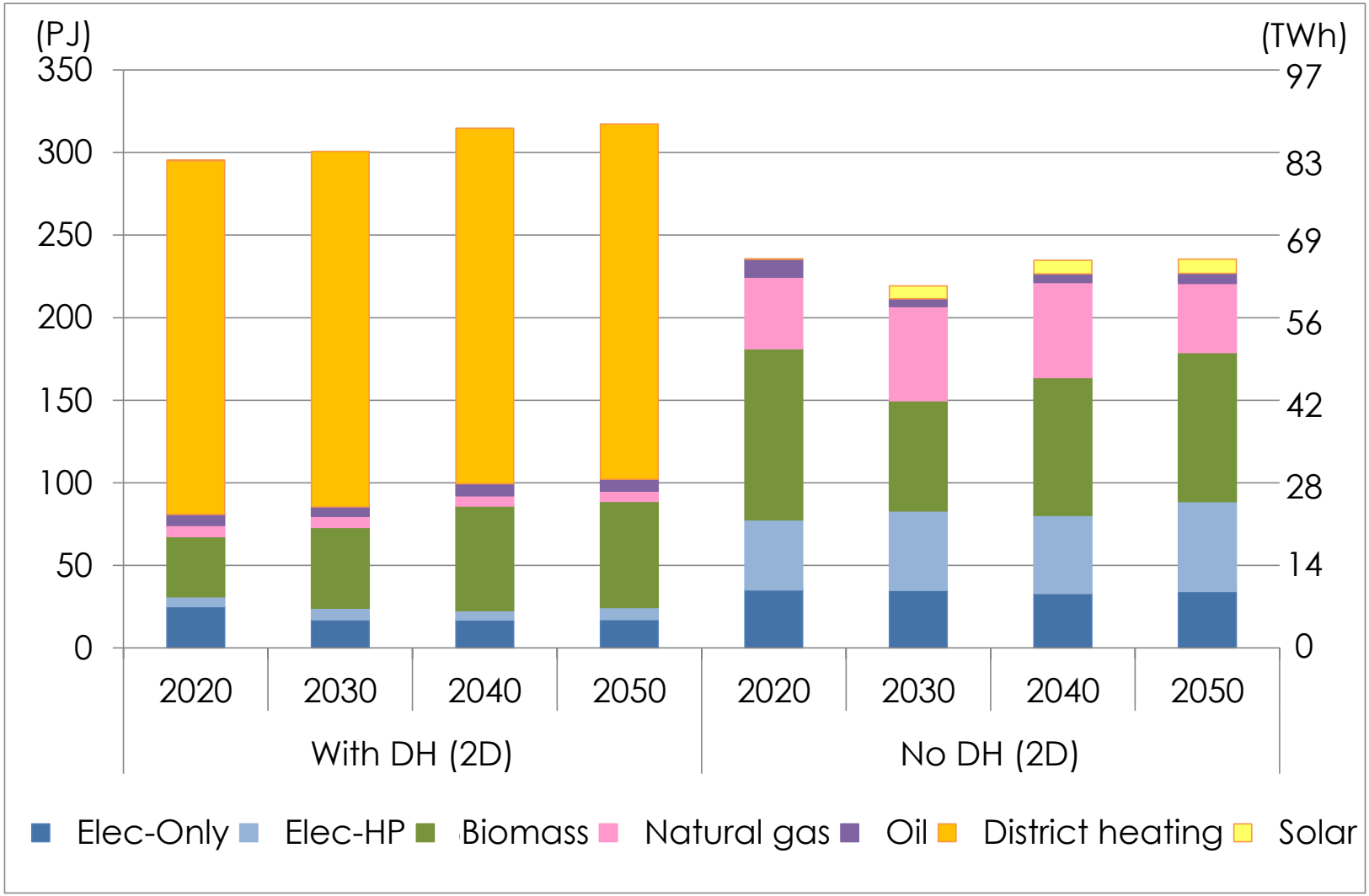
- Remove boundary on city-gas grid expansion
- Result comparison from 2020 and beyond

Quantitative Results from TIMES-Sweden

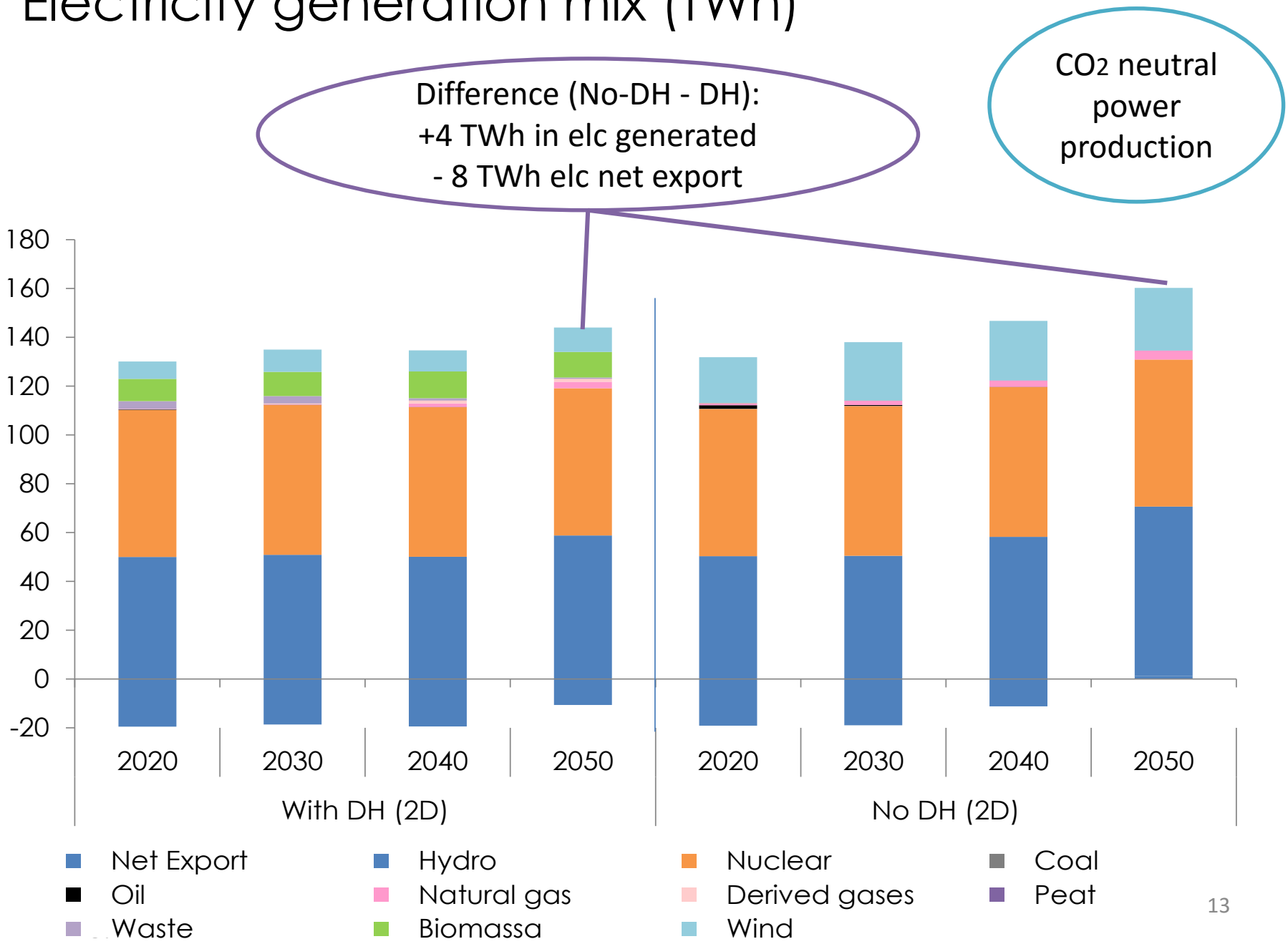
Green electricity scheme:
(RES-e) > (x*electricity demand in RSD&COM sectors)

Oil prices from IEA (2011) -> high prices

Energy for space heating and domestic hot water – Final energy

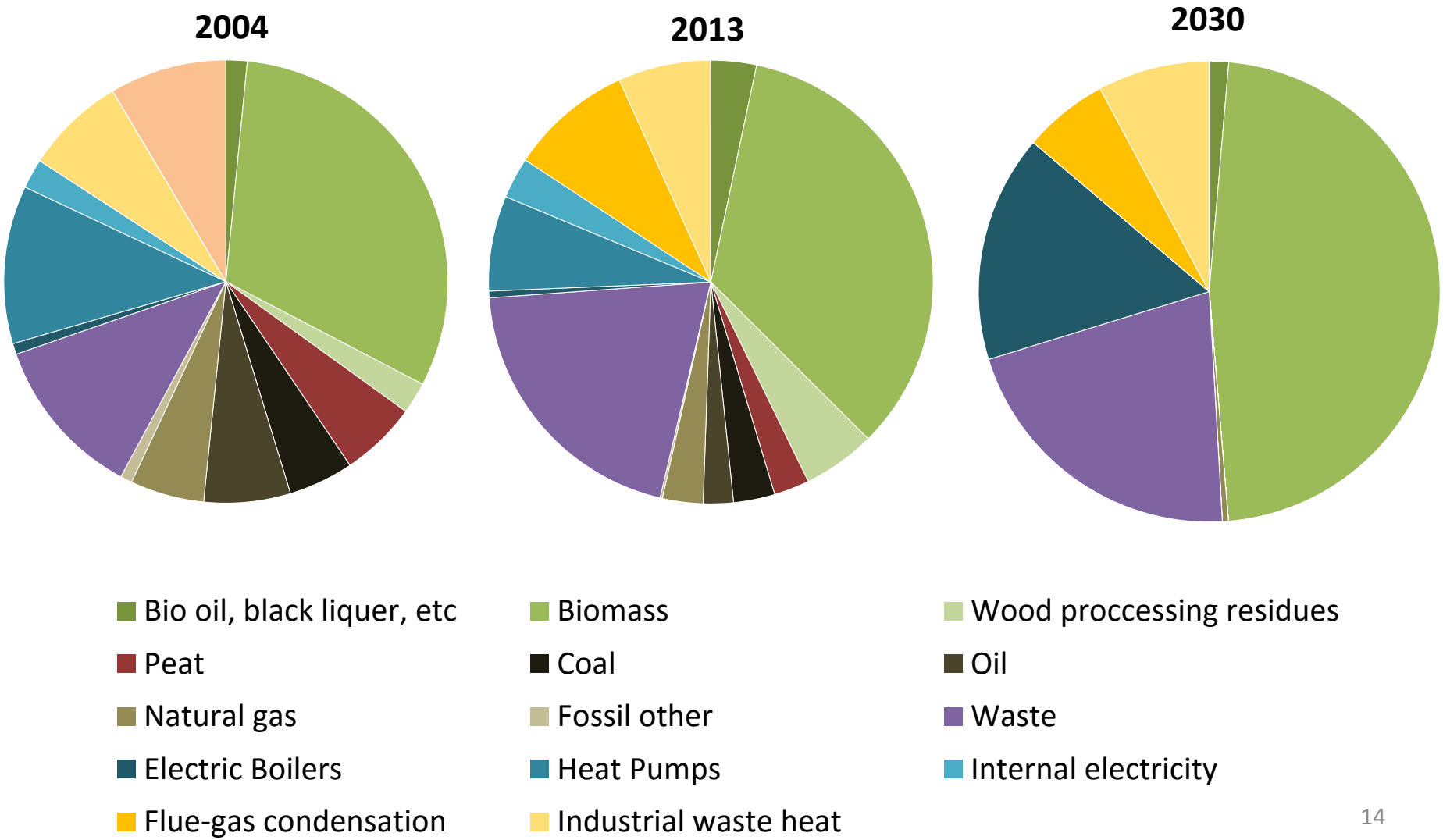


Electricity generation mix (TWh)



Energy mix for district heating

2004 and 2013 (statistics/Svensk Fjärrvärme)
2030 (results form TIMES-Sweden)



Biomass use by sector (PJ)

Year:	**2020**	**2020**	**2030**	**2030**	**2040**	**2040**
Scenario:	DH	No-DH	DH	No-DH	DH	No-DH
Sector use:						
Agriculture	19	19	19	19	19	19
Electricity and DH	112	0.6	118	0.1	143	0.0
Industry	4	29	4	30	4	44
Residential and Commercial	37	104	49	67	63	84
Transports	143	146	211	202	223	216
Total:	**314**	**298**	**402**	**317**	**453**	**363**
Source:						
Biomass from forestry or crops	363	350	507	414	569	474
Resource eff:	**87%**	**85%**	**79%**	**77%**	**80%**	**77%**

Biomass by source (PJ)

Year:	2020	2020	2030	2030	2040	2040
Scenario:	DH	No-DH	DH	No-DH	DH	No-DH
Source:						
Biogas	5	5	5	5	5	5
Biofuel	17	17	17	17	17	17
Crop	68	62	115	115	117	114
IPP	55	55	55	55	55	55
Forestry waste and by-products	112	25	118	25	141	39
Wood processing residues	177	255	267	267	305	312
Total:	**433**	**419**	**576**	**483**	**639**	**542**

Annual CO_2 emissions (Mton)
Two scenarios: With and without DH

Statistics from the Swedish Energy System
Modeling results form TIMES-Sweden

Year		2012	2020	2020	2030	2030	2040	2040
Scenario		Statistics *	With DH	No DH	With DH	No DH	With DH	No DH
ETS	Elc & Heat	**5.4**	3.2	1.3	**2.3**	**1.1**	2.1	1.2
	Industry	**10.0**	9.0	9.1	**8.6**	**9.5**	9.1	9.4
	Total	**15.4**	12.2	10.4	**10.9**	**10.7**	11.2	10.6
non-ETS	Industry	**5.6**	6.9	6.3	**8.6**	**7.9**	11.6	9.3
	Transports	**18.8**	12.5	12.2	**6.7**	**7.5**	5.7	6.2
	Residential, Service, etc.	**3.2**	1.7	4.1	**1.6**	**4.4**	1.7	4.5
	Total	**27.6**	21.0	22.6	**17.0**	**19.8**	19.1	20.0
TOTAL (conversion)		**44.6**	33.2	33.0	**27.8**	**30.5**	30.2	30.7

Annual system costs in billion Euro(2005)
Two scenarios: With and without DH
Modeling results form TIMES-Sweden

Year:	2020	2020	2030	2030	2040	2040
Scenario:	DH	No-DH	DH	No-DH	DH	No-DH
Activity costs	1.8	1.6	2.5	2.1	2.6	2.2
Fixed operating and maintenance costs	21.3	20.0	21.8	21.8	22.8	22.8
Flow costs (incl. import/export)	15.5	16.5	15.8	16.5	16.7	17.8
Investment costs	151	153	162	164	170	172
Annual taxes/subsidies (incl EU ETS permits)	7.4	8.2	6.3	7.6	6.8	7.8
Total (incl taxes/subs)	197	199	208	212	219	223
Total (excl taxes/subs)	190	191	202	204	212	215

Some conclusions

CO_2

- With **district heating (DH)**, Swedish CO_2 emissions can be reduced without increased power production
- Even if the power sector is decarbonized, a system with a large share of **HP** for space heating is identified to have higher CO_2 emission compared with a system with district heating.

BIOMASS

- Scenarios with **DH** uses significant more biomass, however the difference is mainly in forestry waste and forestry by-products that have few alternative uses.
- The production of biofuels is higher with **DH**, when seen more cost-efficient if co-generated with DH.

-> HP in dwellings has no superior benefits in decreasing CO_2 emissions compared with DH, even if the power sector is decarbonized.

Thanks for the attention

QUESTIONS?

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