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Combination of energy savings in buildings and renewable energy supply solutions

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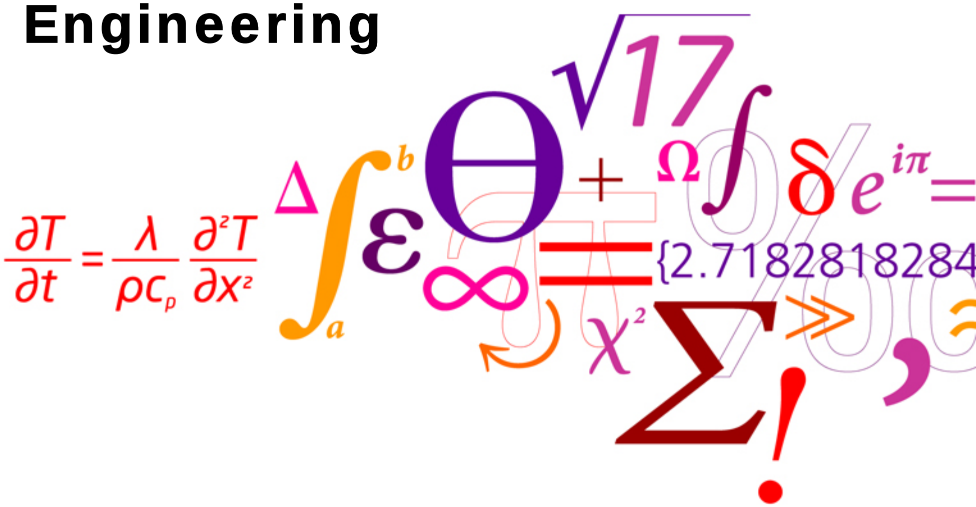


Introduction
Policies on energy and buildings in EU and DK

New buildings:

EPBD recast:

All new buildings in the EU as from December 2020 (2018 for public buildings) will have to be **nearly zero energy buildings**

the ***nearly zero or very low amount of energy required should to*** a very significant level be covered by energy from renewable sources

DK Building Code 2020:

Energy frame of 20-25kWh/m^2

Introduction
Policies on energy and buildings in EU and DK

Existing buildings

Danish Energy Plan *

- **All buildings and electricity fossil fuel free by 2035**
- Transport and industry fossil fuel free by 2050

Based on:

- energy savings and
- renewable energy supply

- * http://www.kemin.dk/Documents/Klima- og Energipolitik/our future energy.pdf

Problems of realizing zero fossil energy buildings

Solutions based on:

- **Energy savings and no energy supply**
- **Energy savings and use of ’on site’ - renewable energy**
- **Renewable energy supply and no energy savings**

Not possible or more costly than necessary

PS: Net zero energy buildings with renewable energy production from PV to the electrical grid shift the problem from buildings to electrical system

Compensating use of fossil fuels by production of RE does not stop global warming

Optimal solutions

No fossil energy by:

- Energy savings in buildings and
- Supply of renewable energy to buildings

Optimization of:

- Energy savings versus renewable energy supply
- Energy retrofitting or new low energy buildings
- Renewable energy supply on site or from energy system
- Integrated renewable energy system for buildings, transport and industrial processes
- Renewable energy system on global level and on long term

Optimal solutions
For zero fossil energy buildings

Low energy buildings and

Renewable energy supplying systems:

In areas with high building density

- **RE-based low temperature district heating from**
  - Solar heating plants with seasonal storage
  - Geothermal heating plant
  - Waste heat from RE-based processes of industry and energy system (power – fuels – storage – power)

In areas with low building density

- **Heat pumps using RE-based electrical energy from**
  - Hydro, Wind, PV

New low energy buildings (2020)
Single family houses
Low temperature district heating

Example: Type house improved to 2020 requirements

Area 200m^2 U-values of 0.06- 0.08 W/m^2K

Energy for space heating	11 kWh/m^2
Energy for domestic hot water	13 kWh/m^2
Energy for pumps and fans	3 kWh/m^2
Total - factors of 0.6 and 1.8	20 kWh/m^2

Typical yearly heat supply 5000 kWh

New low energy buildings (2020)
Single family houses
Low temperature district heating

Example: RE district heating

Low temperatures: Supply 50C Return 20C

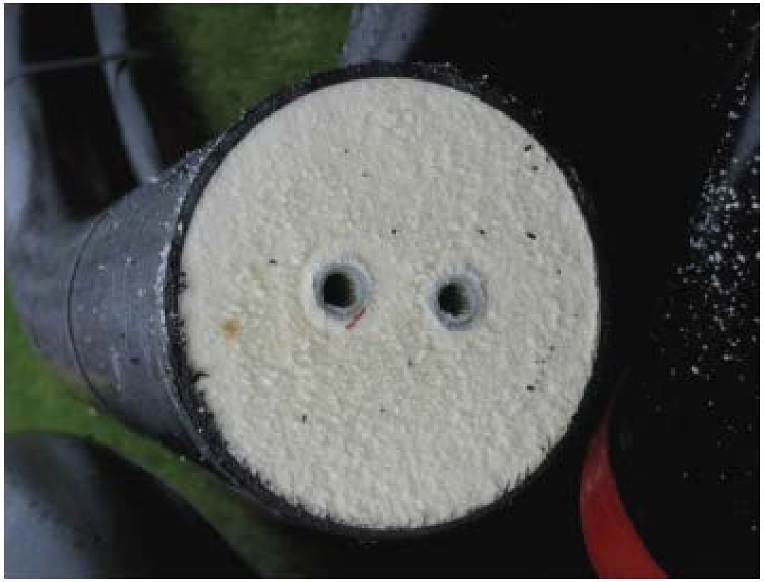
Twinpipes with small diameter pipes (14mm) in service pipes

Heat loss of 15 m service pipe: 3 W/m x 15m = 45W

Heat loss of 10 m street pipe: 6 W/m x 10m = 60W

Yearly heat loss of district heating pipes: 1000 kWh

Heat loss of
district heating grid:
20% of delivered energy



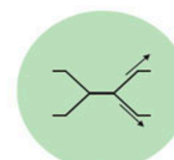
Figur 12 Tværsnit af det fremstillede prototyperør 14/14/110 mm

Demonstration of low temperature district heating in new LE-buildings –Lystrup Aarhus

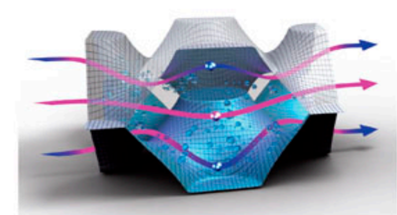
- 40 row-houses 37 kWh/$m^2 \cdot$yr
- DH design parameters: 50/25° C, 10 bar
- District heating network
  - AluFlex Twin pipes (insulation series 2)
  - reduced pipe sizes -> higher pressure drop
  - annual distribution heat loss approx. 15%-20%
- Substations: Domestic hot water heat exchanger
  - no problem with Legionella and comfort
- 2 years of operation , no complaints

Heat exchanger for DHW: 33kW 52/20 -10/45

www.mphe.danfoss.com



Micro Plate Heat Exchangers have a broad, flat brazing surface which adds stability to the construction.



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Actual measured annual consumption (28 June 2010 to 27 June 2011)

- Heat consumption* 6.2 MWh per house
- Heat loss from distribution network: 1.3 MWh per house
- Total district heating consumption**: 7.5 MWh per house

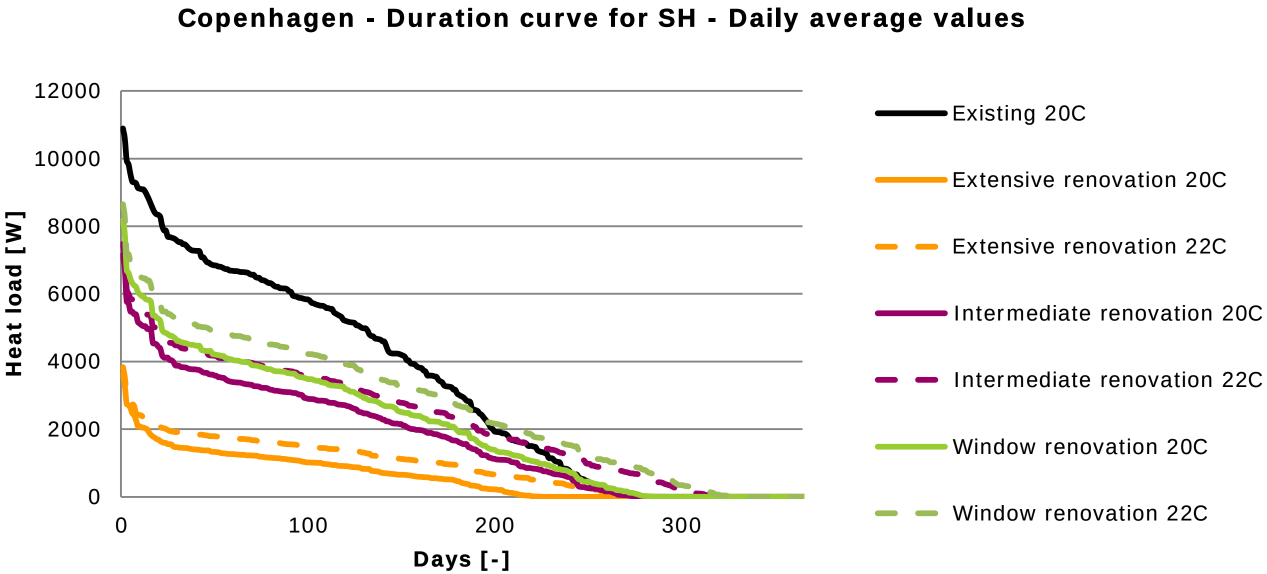
* Based on average consumption of 22 houses

** Based on main meter to the area.

- Measured electricity consumption for booster pump is 2.840 kWh per year or about: 69 kWh per house

Change of
Existing buildings and
existing district heating systems to
RE-based low temperature district heating

Example:
Building from 1906

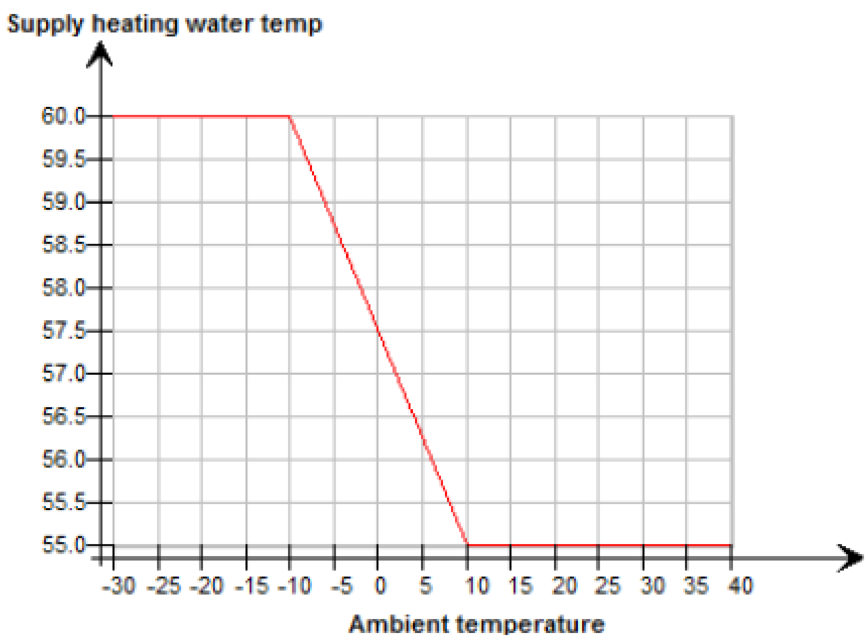


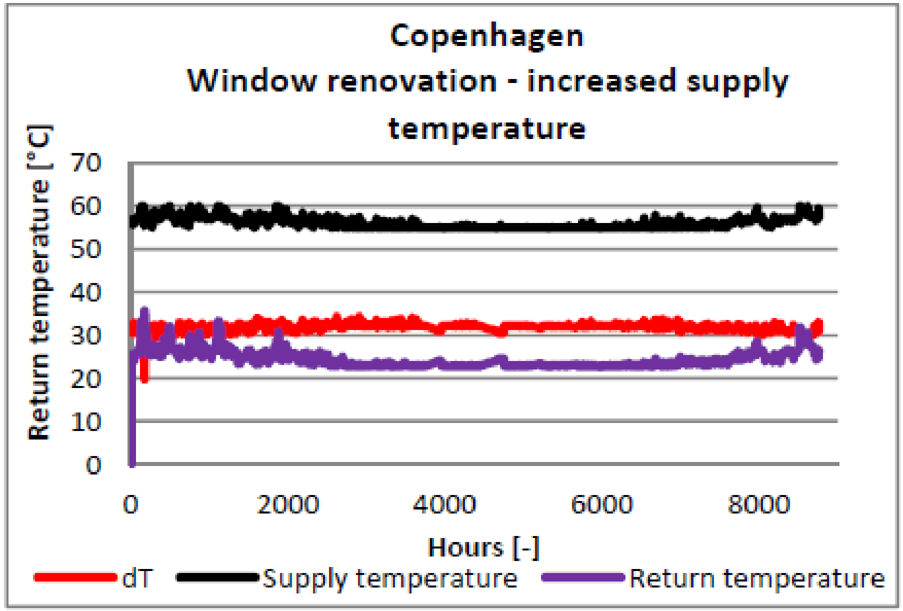
Example

Original size of radiators based on:

- constant temperatures at 20C and -12C
- no heat gain
- water temperatures of 70C-40C

New temperatures: 55C-25C and 60C in cold periods





Hours with insufficient temperature in building with new windows and ventilation with heat recovery

Low temperature district heating can be used without change of radiators without discomfort

	Average of 5 days with highest daily average load	Living room 1	Living room 2	Living room 3	Bedroom 1a	Bedroom 2a	Bedroom 2b	Bedroom 3a	Bedroom 3b
Window renovation 20 °C	Ti_max [°C]	26.9	27.4	27.2	26.9	27.2	27.1	27.1	27.0
	Ti_min [°C]	18.2	18.3	18.1	19.0	19.1	18.8	18.1	18.5
	Ti<20°C	64	42	62	16	29	42	61	47
	Ti<19°C	16	13	15	0	0	5	15	10
	% hours below 20 °C	0.7	0.5	0.7	0.2	0.3	0.5	0.7	0.5
	% hours below 19 °C	0.2	0.2	0.2	0	0	0.1	0.2	0.1
	Ti<20°C with SH $T_{set\ point}$ increased to 22C	0	0	0	0	0	0	0	0

Example: Copenhagen
Energy renovation of buildings and RE-based low temperature district heating
3 Scenarios

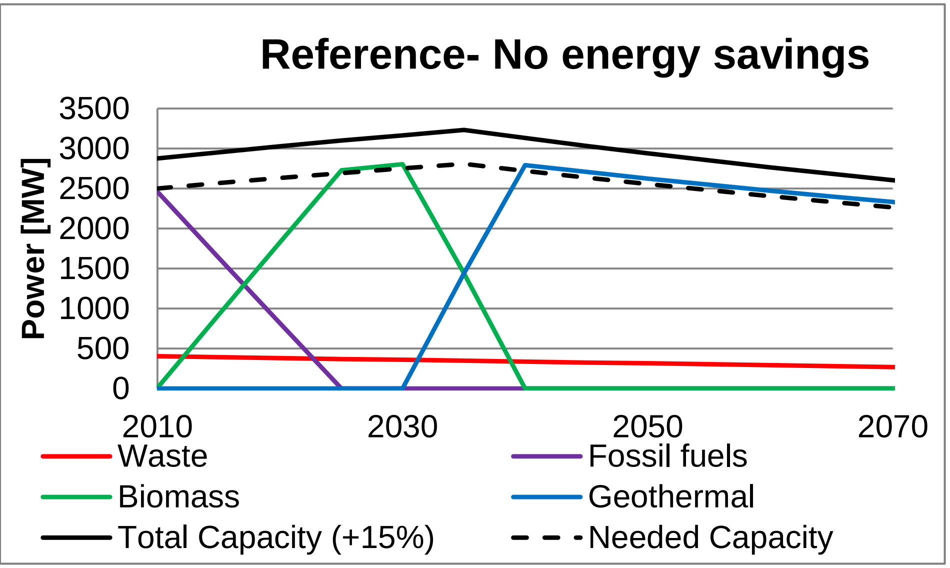
- All scenarios contain a natural replacement on 1% of the existing building mass with newly constructed buildings.

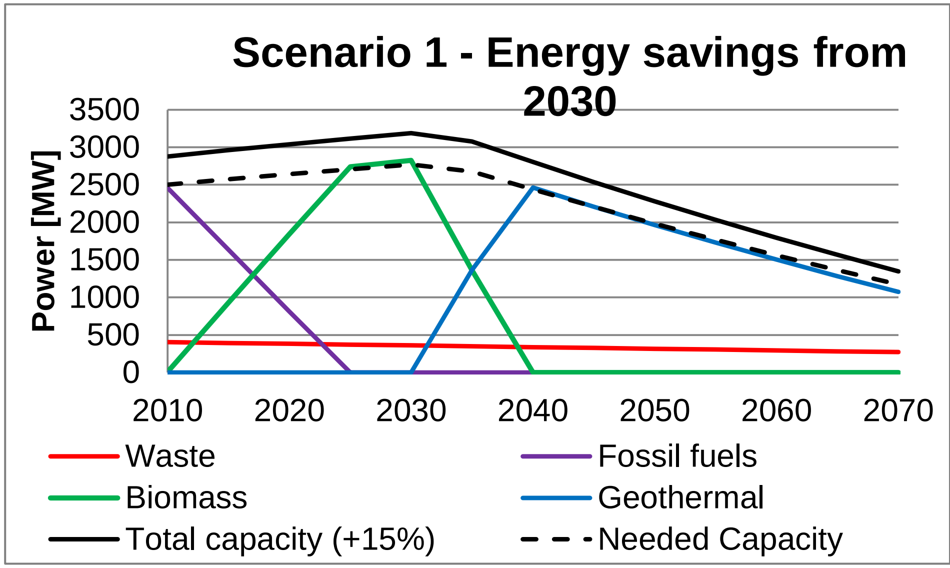
- **Reference scenario - No heat savings**
  - *Represents the extreme case where nothing is done. Supply for the full unchanged heat demand.*

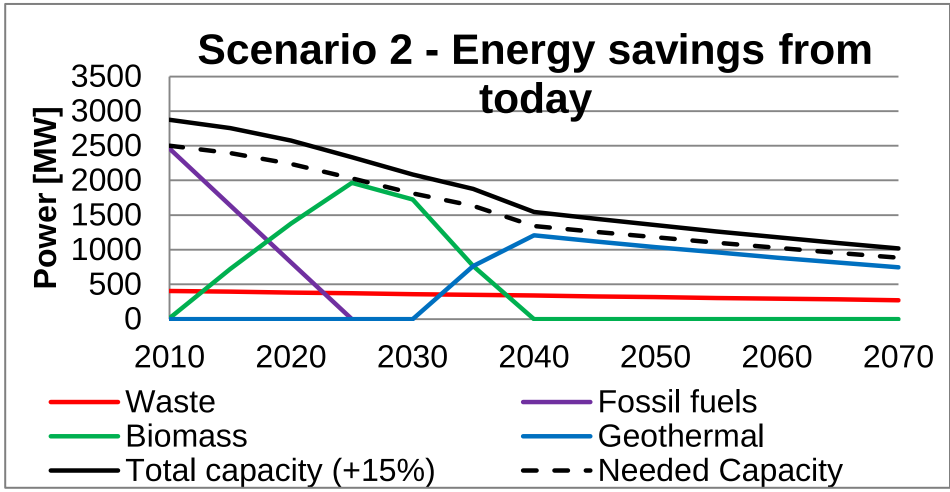
- **Scenario 1 - Accelerated energy renovation from 2030-2070 (65 %)**
  - *Nothing is done in the near future due to low DH-supply prices. Investment in new capacity will increase the supply price and as a consequence heat savings are carried out.*

- **Scenario 2 - Accelerating energy renovations from today (65%)**
  - *Heat savings are implemented from today, resulting in decreased heat demand before investment in new capacity.*

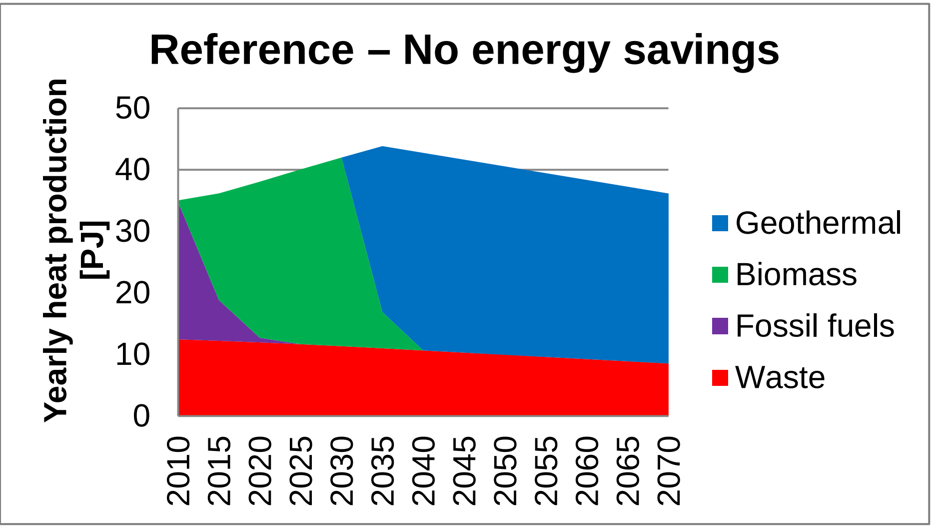
Capacity – Peak loads

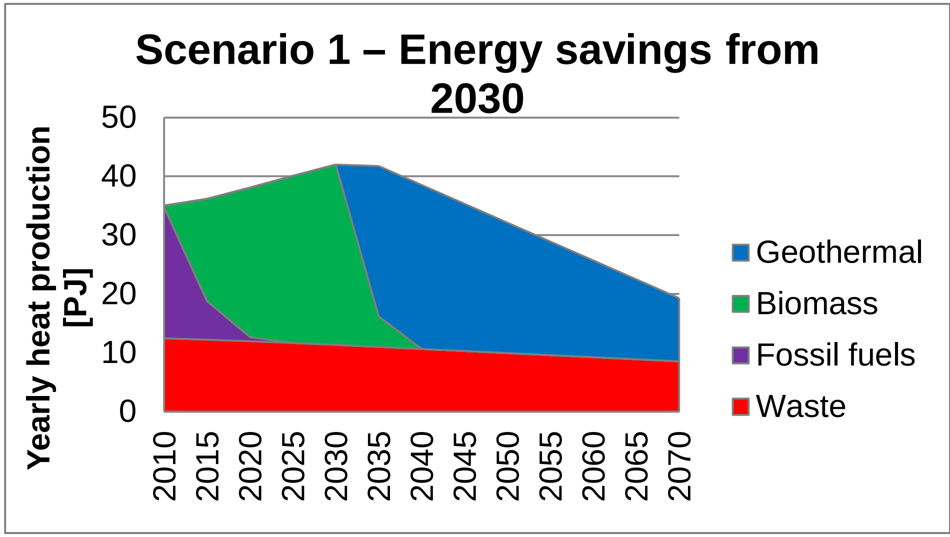


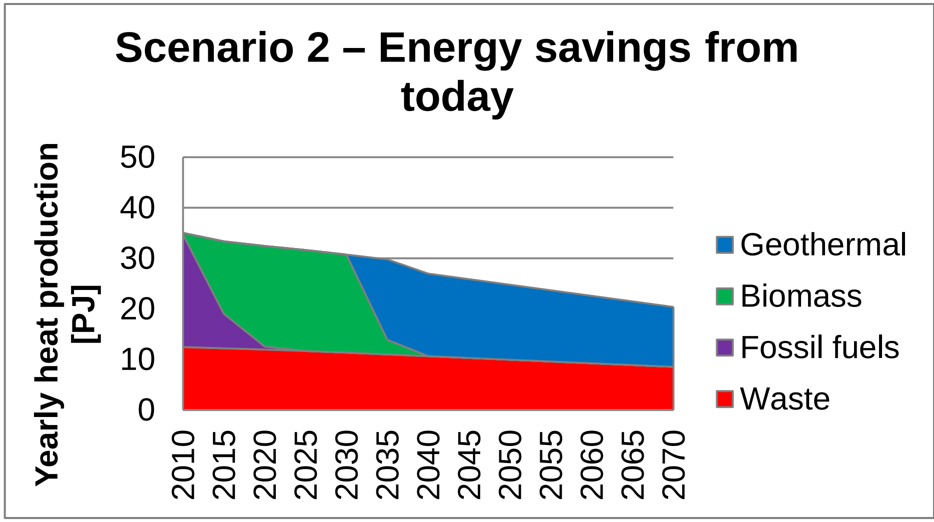




Yearly heat production 2010 - 2070







Economy for society neutral

Economy for district heating company better for scenario 2

NPV 2013-2070	Reference	Scenario 1	Scenario 2
Discount rate 0 %	**[M €]**	**[M €]**	**[M €]**
Investments			
Geothermal plants	8,736	7,644	3,744
DH-net expansion	187	187	187
Renovations	0	7,662	7,662
Salvage value	0	0	0
Geothermal plants	-983	-860	-421
DH-net expansion	-38	-38	-38
Renovations	0	-5,044	-1,877
Fuels	879	874	669
O&M	3,276	2,465	1,622
Total Discount rate 0 %	**12,057**	**12,889**	**11,548**

Economy for consumer

Table 4 Heating bill for a typical 60 m^2 apartment before and after energy renovation.

Heat consumption before renovation	7,980	kWh/year
Heat price 2013	0.094	€/kWh
Yearly heating bill before renovation	**750**	**€/year**
Heat consumption after renovation (65 % reduction)	2,793	kWh/year
Forecasted heat price	0.115	€/kWh
Yearly heating bill after renovation	**318**	**€/year**

Conclusion

Energy savings in buildings first and

renewable energy supply next

replace fossil fuels

the cheapest way