20/06/2014

Step-up Coaching: Trajectory 1
Dynamic District Developments

Workshop Presentation

SEVENTH FRAMEWORK PROGRAMME

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2. Barriers
3. Coaching Project Oostende
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1. Background

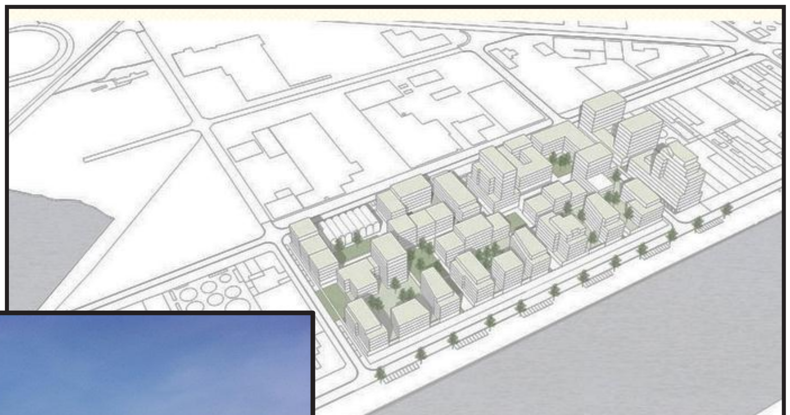
- Heating grid Oostende: feasibility study POM West-Vlaanderen
- New residential development project ‘Oosteroever’

1. Background

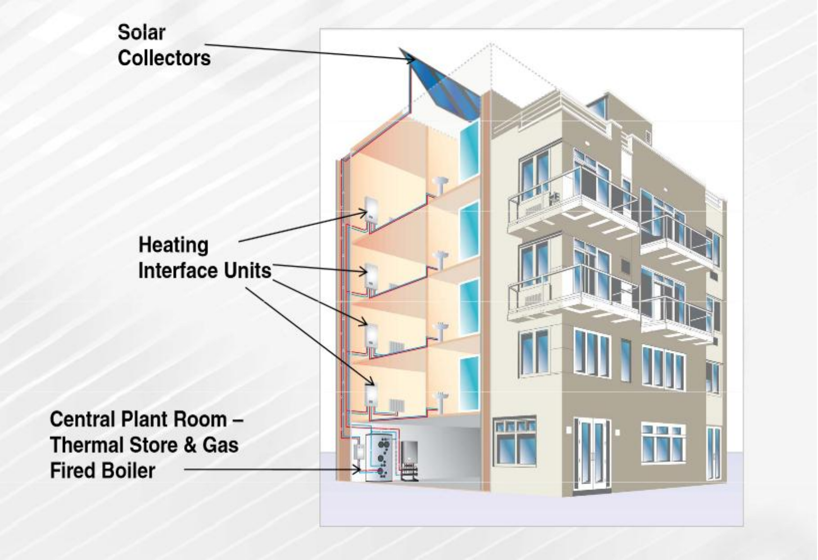
» ‘Oosteroever’

» Residential/commercial project (already submitted, first works started)

- Individual Boilers, No renewables



2. Barriers



- **Common practice in residential buildings = Individual boiler for each home unit**
- **Missing out on opportunities!**
  Communal heating allows for:
  - Easy integration of renewable energy sources, ex:
    - Central biomass fired boiler, CHP
    - Combinations with solar PV and thermal collectors
  - Integration of nearby waste heat streams
  - Connection to future heating grids
  - Reduced Installation capacity (kW) compared to individual boilers
  - Flatter combined load, maximising full load time, minimising start/stop
  - No additional room ventilation and flue gas requirements
  - Higher Thermal production efficiency
  - Minimal maintenance
  - No risk of CO-poisoning

EPB
10 kWh/year/m²
Renewable Energy

2. Barriers

- **Biases counteract Communal (central) heating, for example:**
  - “Individual boiler = cheaper”
  - “Individual boiler = luxury”
  - “High distribution loses”
  - “EPB”
  - “Buyers want independence”
  - …
- **Barrier/bottleneck = collaboration of project investors/developers**
- **Hard for smaller cities to enforce heating grids and/or sustainable energy demands in local policies or master plan.**
- **Need for knowledge to persuade investors and buyers!**
  (Benefits? Economic feasibility? Prestige/Image?)

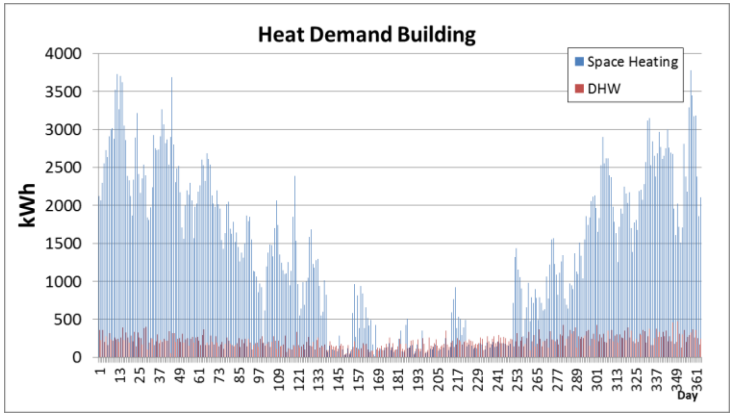
3. Coaching Project Casestudy: Baelskaai

- <u>Building:</u> "Baelskaai 20"
  - 37 apartments, 8 levels ("8 story building")
  - 111 residents (estimate)
  - Roof surface +- 290 m²
  - High level of thermal insulation
  - No Renewables, Individual Boilers

→ Study to evaluate economic feasibility of Communal Heating: in general + applied to Baelskaai

Stad aan Zee OOSTENDE

4. Calculations



» **Detailed evaluation:**

» Hourly energy profiles for Space Heating, DHW and Solar Thermal gains

» Calculations on an hourly basis

- State-of-charge thermal storage, boiler efficiency, loss in piping/buffer/circulation pumps, …

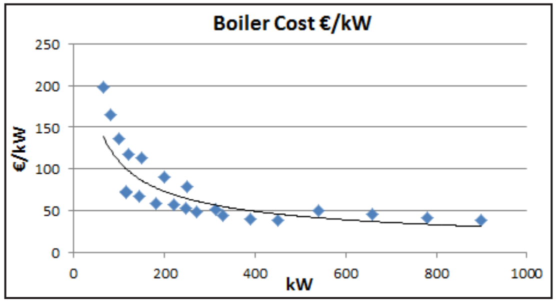
» Economic calculations (detailed costs and/or pricing curves for components, discounting, inflation, NPV)

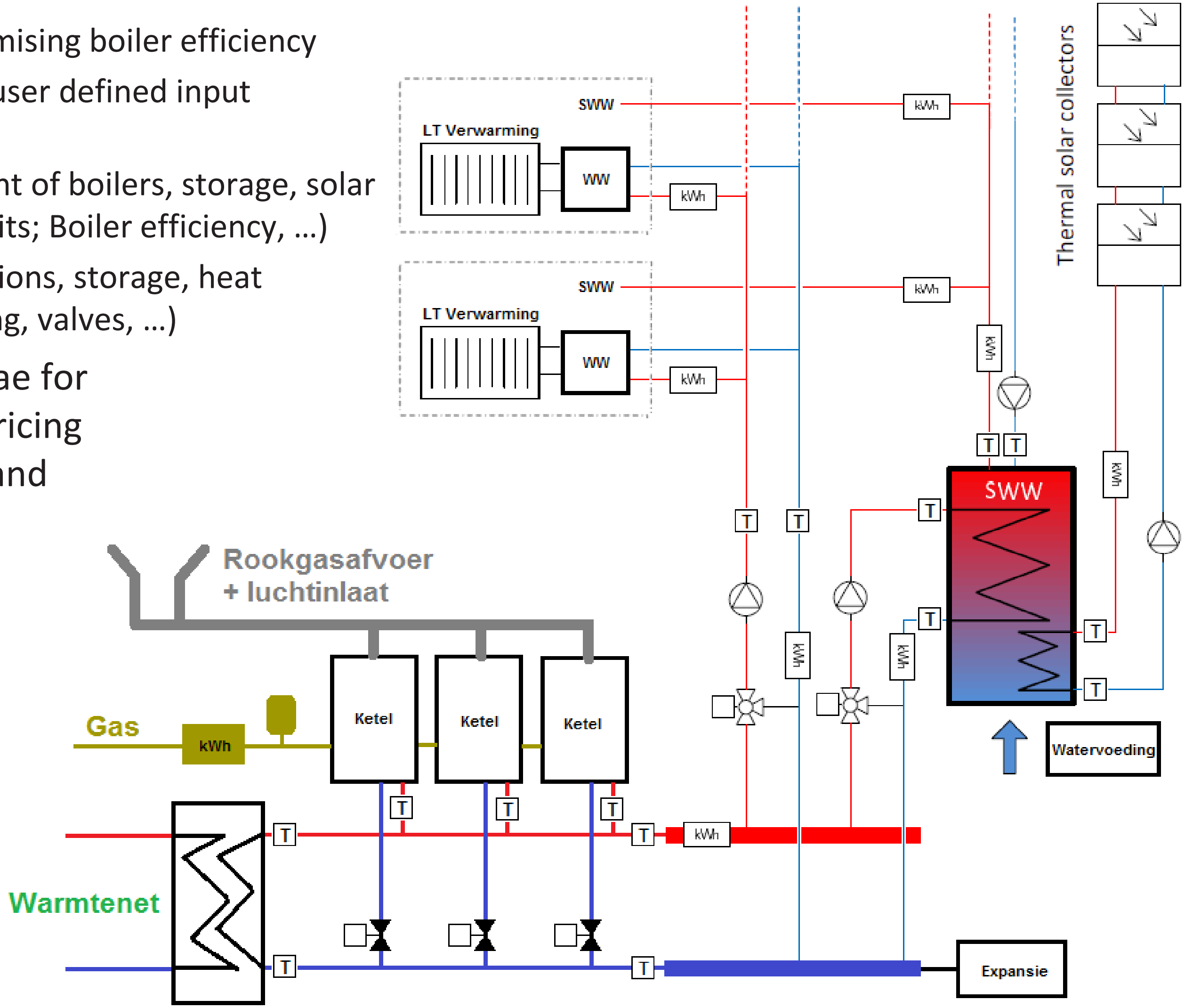
» **Output: Present Value of Total Costs for 5 scenarios:**

1. Individual Boilers (reference case)
2. Central Boilers
3. Heating Grid
4. Central Boilers + Heating Grid Ready (switch to Heating Grid at time ‘x’)
5. Central Boilers + Future switch to Heating Grid (not yet HG ready, switch at time ‘x’)

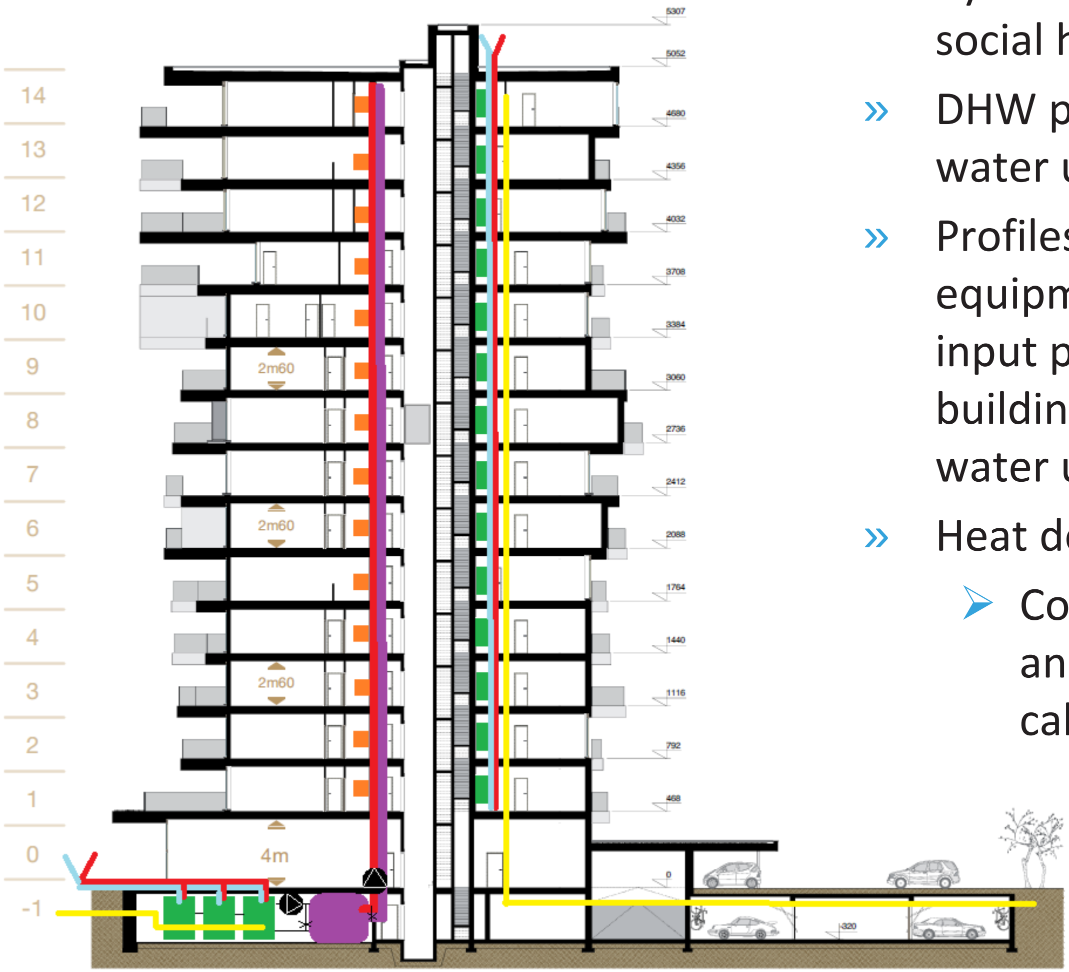
4. Calculations

- **Hydraulic scheme**
- Separation of Space Heating (30/40°C) and DHW network (60/80°C)
  - Minimising Heat loss, maximising boiler efficiency
- Calculation is shaped by several user defined input parameters, influencing:
  - **Technical** (sizing and amount of boilers, storage, solar collectors; temperature limits; Boiler efficiency, …)
  - **Economic** (costs of installations, storage, heat exchangers, piping, metering, valves, …)
- **Costs:** prices and price formulae for every component, based on pricing catalogues, contractor offers and standardized pricing booklets
(excl. VAT; incl. installation cost)





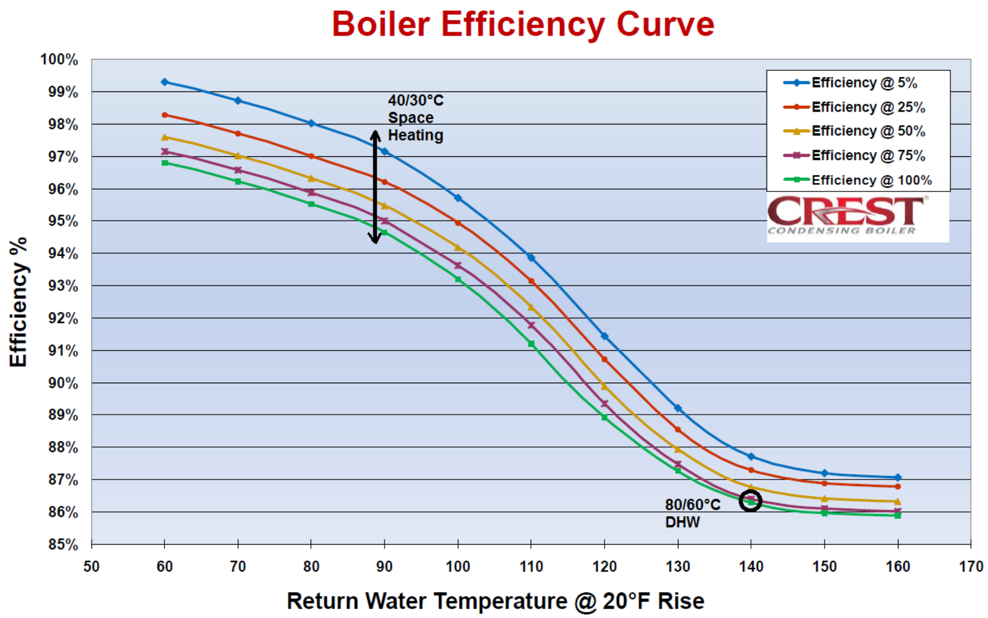
4. Calculations



- **<u>Flexible calculation</u>**, for buildings of all sizes
- Space Heating profiles: rescaled from dynamic simulation of heat demand for social housing project (source VITO)
- DHW profiles: rescaled from measured water usage profile (source VITO)
- Profiles + Lengths of piping, other equipment, … are all rescaled by a set of input parameters (#apartments, height of building, #persons, daily average personal water usage, heat loss)
- Heat delivery system in apartment:
  - Considered equal for both the individual and central boiler cases, no influence on calculations

4. Calculations

- <u>System losses</u>
  - Electricity consumption of variable flow pumps (60% pump efficiency; consumption is calculated according to heat demand and head)
  - Heat loss of DHW buffer (calculated each hour for any given storage size 0,1 – 100 m³, with variable ΔT according to storage temperature, wrt surrounding environment 15°C)
  - Heat loss in piping (fixed ΔT regime for space heating and variable ΔT according to storage temperature for DHW pipes, wrt surrounding environment 15°C)
- <u>Boiler efficiency</u>
  - Boiler curves are included to provide the effects of partial load and temperature regime on the boiler efficiency. The efficiency is calculated each hour.
  - Load dependant curve for space Heating (@30°C return) and fixed full-load efficiency for DHW (@60°C return)



5. Setup
Economic Parameters (general)

» Energy Prices
  - Gas Price single apartment = 60 €/MWh
  - Gas Price building = 48 €/MWh
  - Electricity Price building = 180 €/MWh

» Economic Parameters (yearly)
  - Discount rate = 5%
  - Inflation = 2%
  - Increasing energy prices = 2%
  - Price ratio District Heat/Natural Gas = 1
    - ➢ **Gas Price = Heating Grid Price**

5. Setup
Economic Parameters (specified costs)

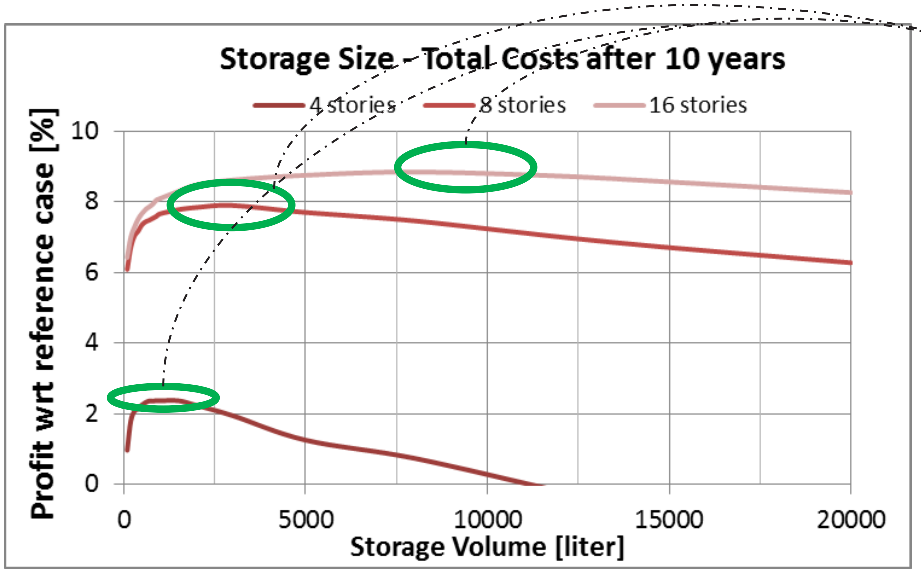
- Maintenance
  - Single apartment = 100 €/year
  - Building = 1400 €/year

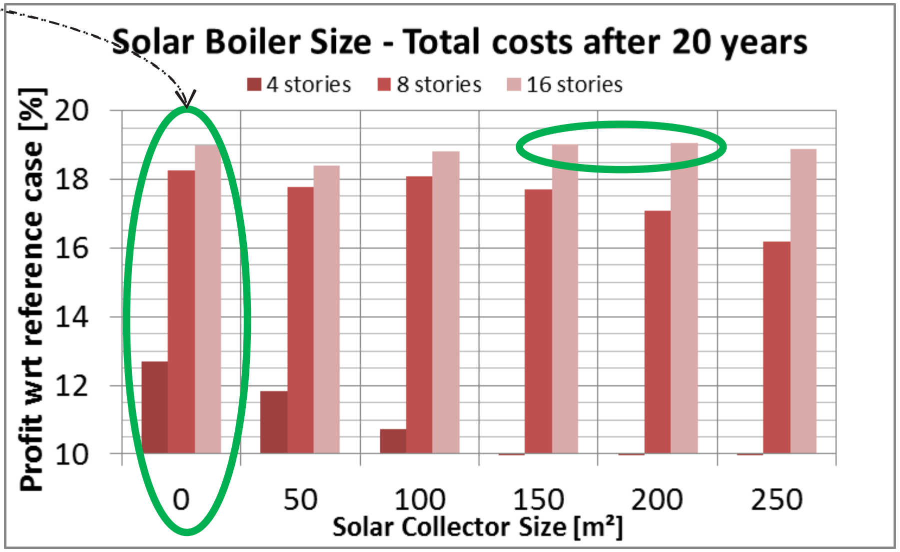
- Grid connection
  - Gas connectivity single apartment = 200 €
  - Gas connectivity general (building) = 1200 €
  - Heating grid connectivity (building) = 1200 €

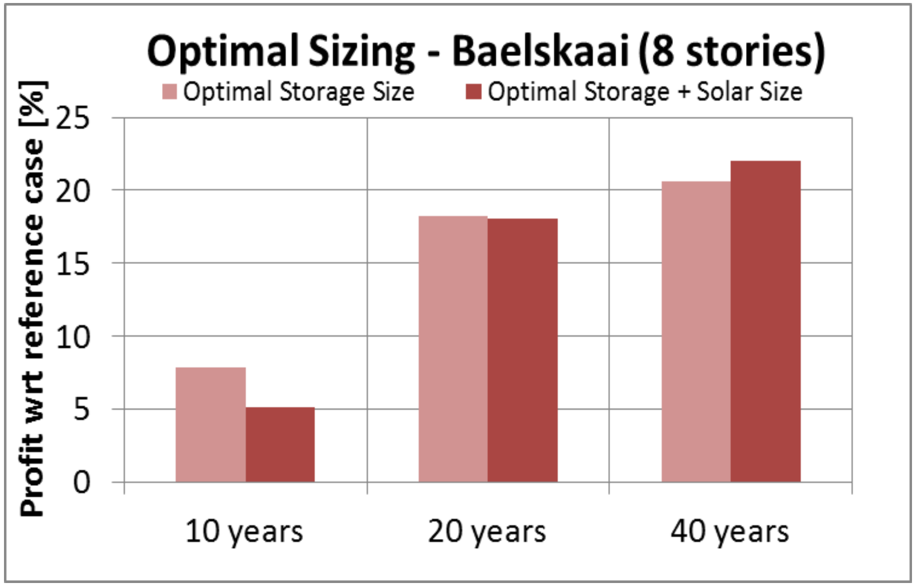
- Fixed distribution grid fee (for building)
  - Natural gas: 350 €/year
  - Heating grid: 350 €/year

5. Setup - Installation Sizing

Results displayed: Present Value of Total Costs with respect to **Reference Case (= Individual Boilers)**



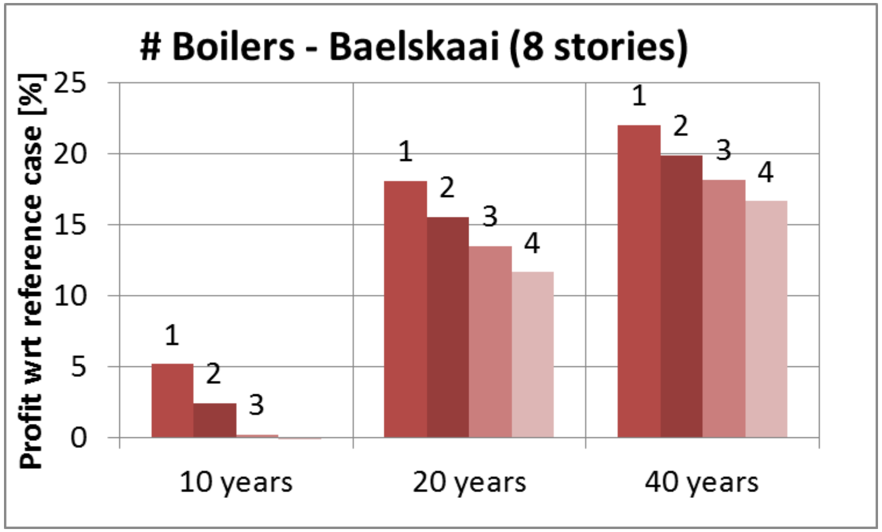


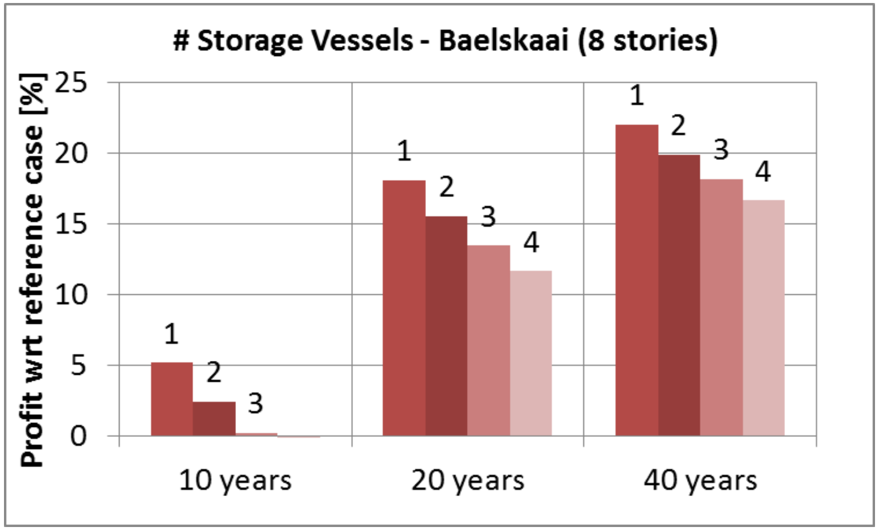


- Optima in Storage and Solar Boiler sizing
- Higher profits wrt reference for **larger buildings**!
- Solar collectors not beneficial when building is too small
- High payback time for solar collectors
- Optimal sizing Baelskaai:
  - 3000 liter storage (no solar)
  - 5000 liter storage, 100 m² solar collectors

5. Setup - Installation Sizing

Results displayed: Present Value of Total Costs with respect to **Reference Case (= Individual Boilers)**





- Calculations above, made with Baelskaai setup: 5000 litres storage, 100 m² solar collectors
- Economy of scale!
- Choosing 1 Boiler/buffer unit is economically optimal
- However:
  - Separating the capacity over several boilers improves system redundancy

6. Results

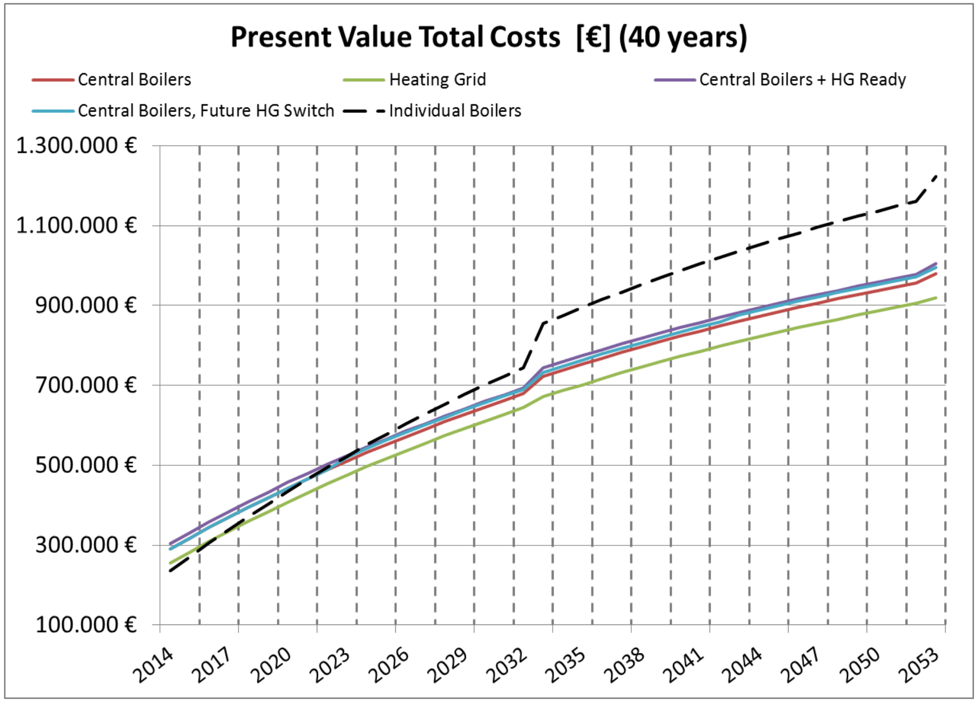
Final setup and calculation results for Building Baelskaai (= Base Case)

- 8 story building, 37 apartments, 111 residents
- Yearly heat demand incl. losses: 90 MWh (DHW) + 502 MWh (Space Heating)
- 2 x 300 kW Boilers (improved system redundancy)
- 5000 liter DHW Storage Vessel
- 100 m² Solar Collectors (potential production 55 MWh)
  - **Covering 52% of DHW demand** (47 MWh is used efficiently; 8 MWh overproduction) = 8% of total heat demand (space heating + DHW)

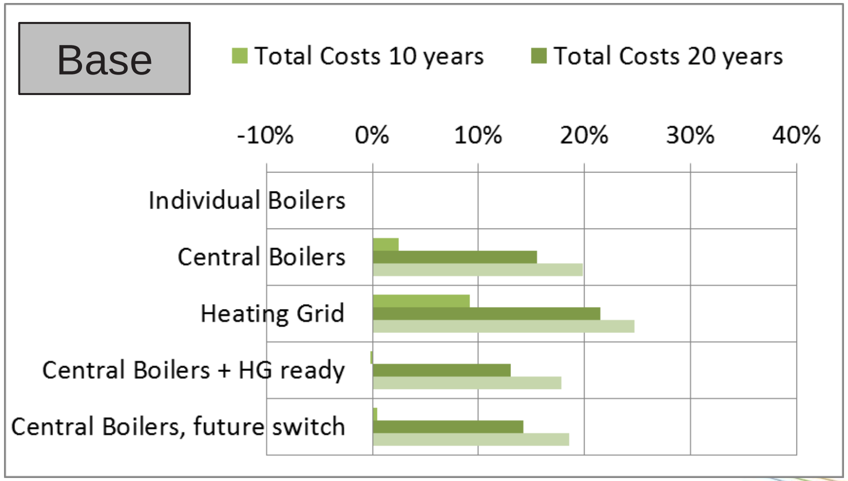
- **After 20 years reinvestment** of crucial components
  - Gas Boilers
  - Heat exchangers (solar collectors, heating grid)
  - Control Software and utilities
- **Switch to Heating Grid after 10 years**

Base

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		Individual Boilers	Central Boilers	Heating Grid	Central Boilers + HG ready	Central Boilers, future switch
Investment	Payback Time [years]		8	3	10	8
Exploitation costs	Yearly cost Single apartment [€]	997	761	761		
	Difference wrt scenario 1 [€]		236	236		
	Difference wrt scenario 1 [%]		**24%**	**24%**		
Total Costs 10 years	Total Cost [€]	522.992	510.200	475.167	524.098	520.907
	Difference wrt scenario 1 [€]		12.792	47.825	-1.106	2.085
	Difference wrt scenario 1 [%]		**2%**	**9%**	**0%**	**0%**
Total Costs 20 years	Total Cost [€]	854.754	721.987	671.163	743.206	732.694
	Difference wrt scenario 1 [€]		132.767	183.591	111.548	122.060
	Difference wrt scenario 1 [%]		**16%**	**21%**	**13%**	**14%**
Total Costs 40 years	Total Cost [€]	1.222.424	979.428	919.759	1.004.747	995.613
	Difference wrt scenario 1 [€]		242.996	302.664	217.677	226.810
	Difference wrt scenario 1 [%]		**20%**	**25%**	**18%**	**19%**



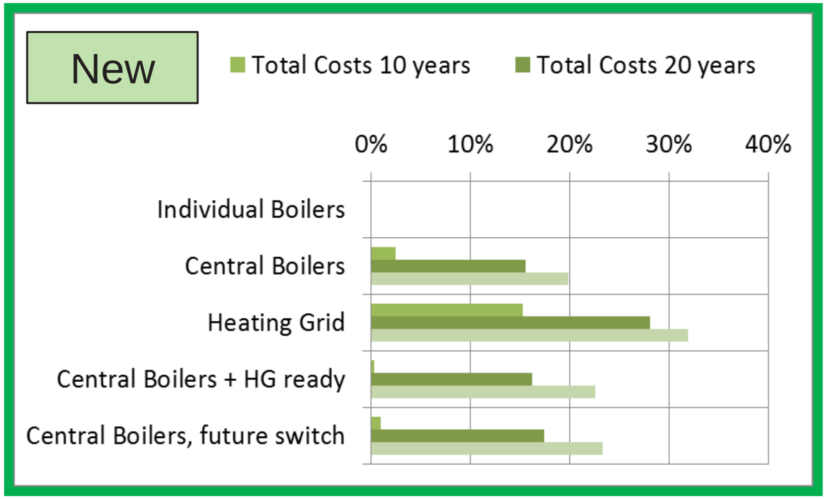
Payback Time = 3 - 8 years
Yearly savings/apartm. = 236 €

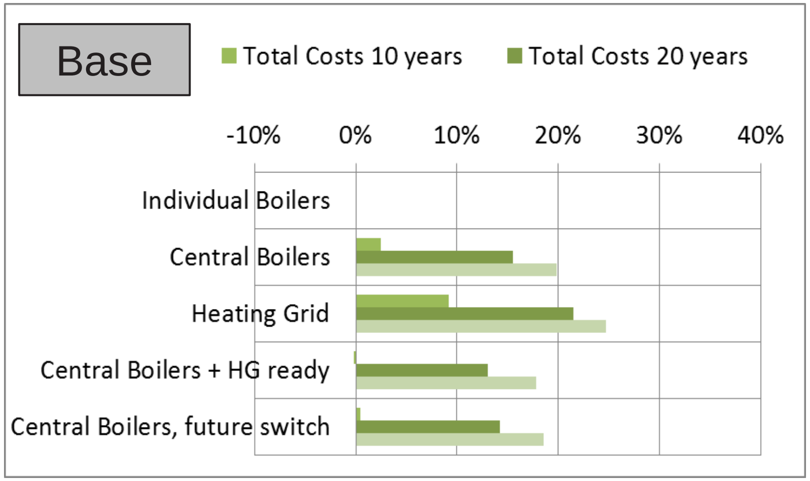


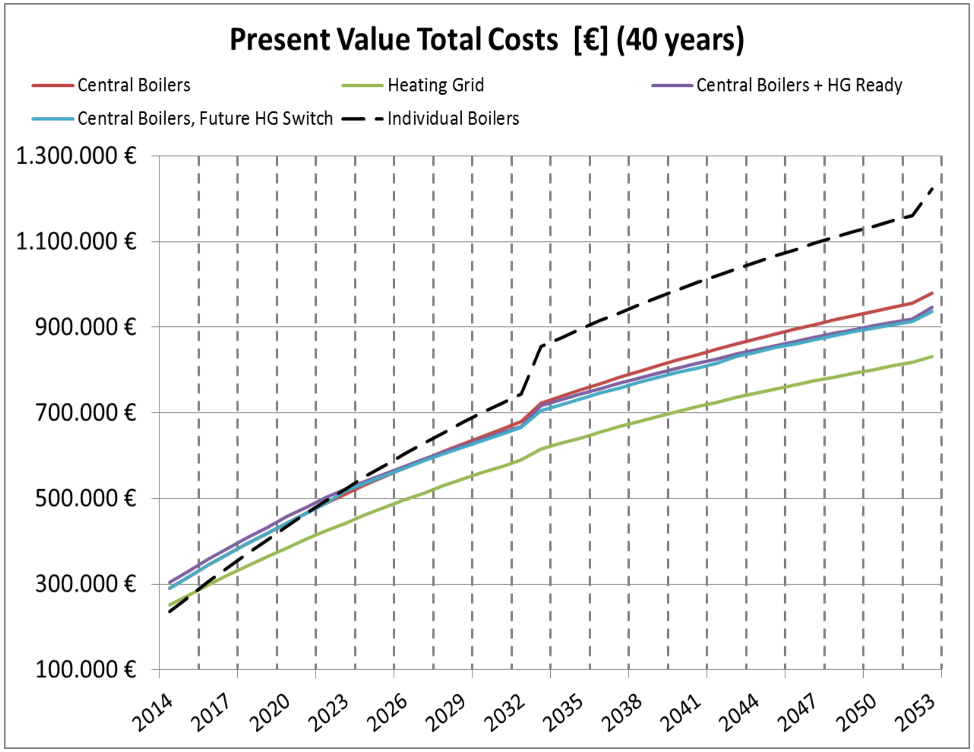
6. Results

Impact: Heating Grid Price Benefit? (stimulation, subsidising)

Price ratio HG/gas 1 --> 0,85



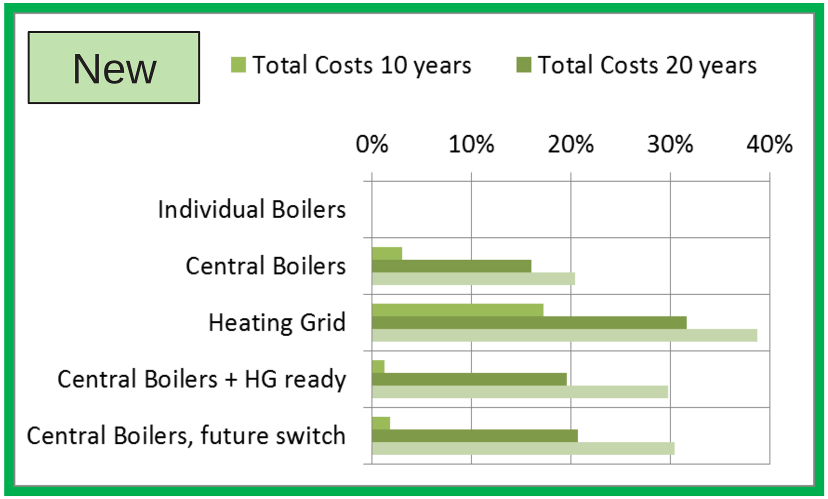


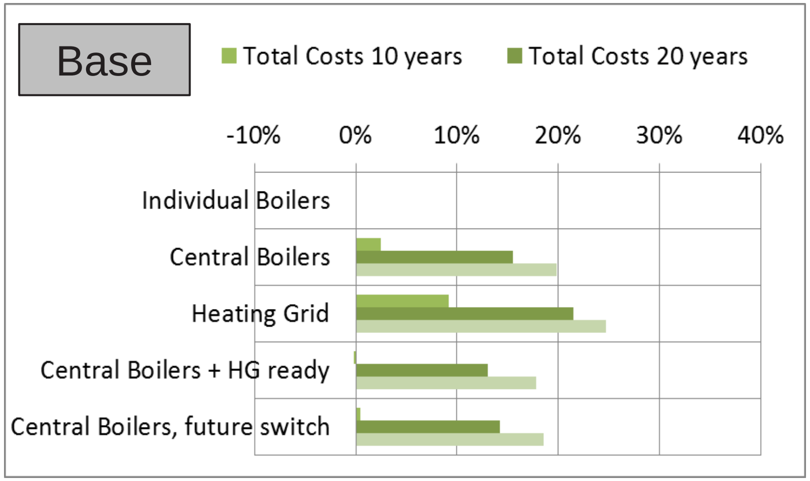


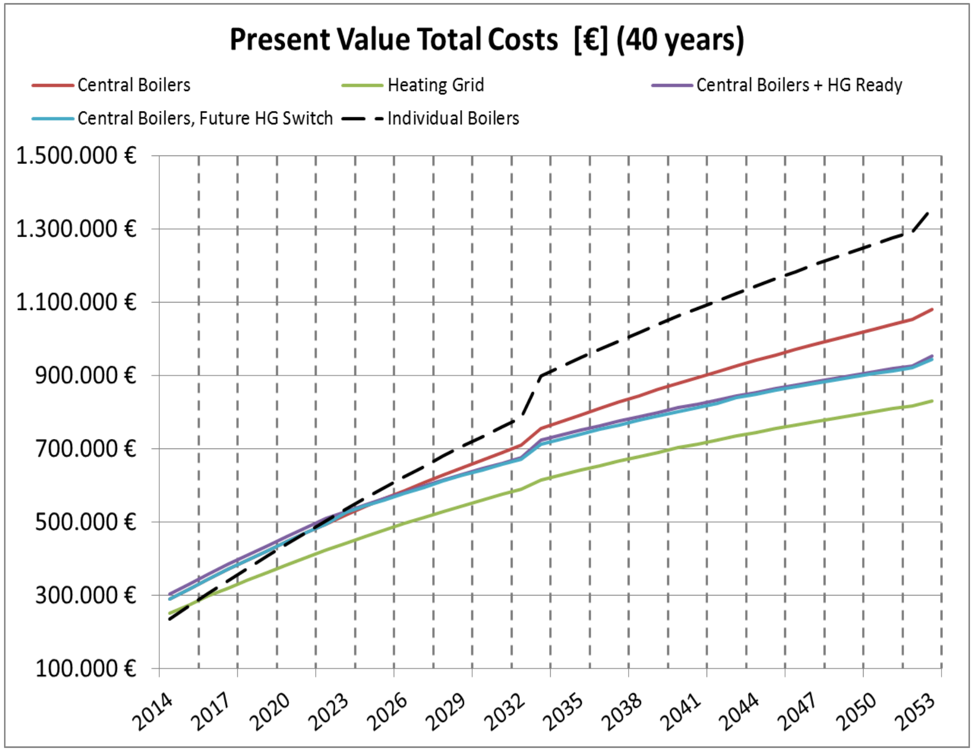
6. Results

Impact: gasprice + price benefit?

Yearly Increase gasprice 2% --> 3%; Price ratio HG/gas 1 --> 0,85





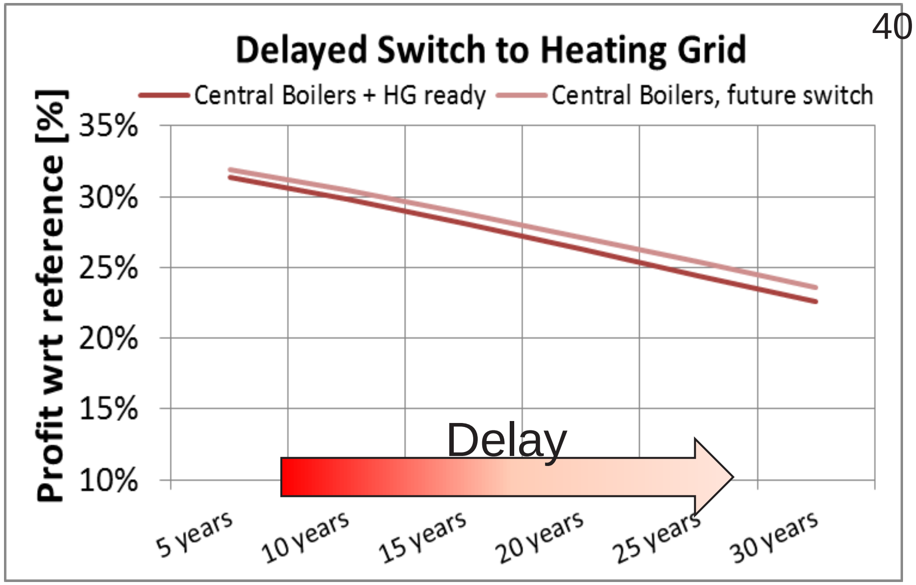


6. Results

Impact: time of switching to Heating Grid?

(following the economic setup of previous slide)

NPV total costs
40 years

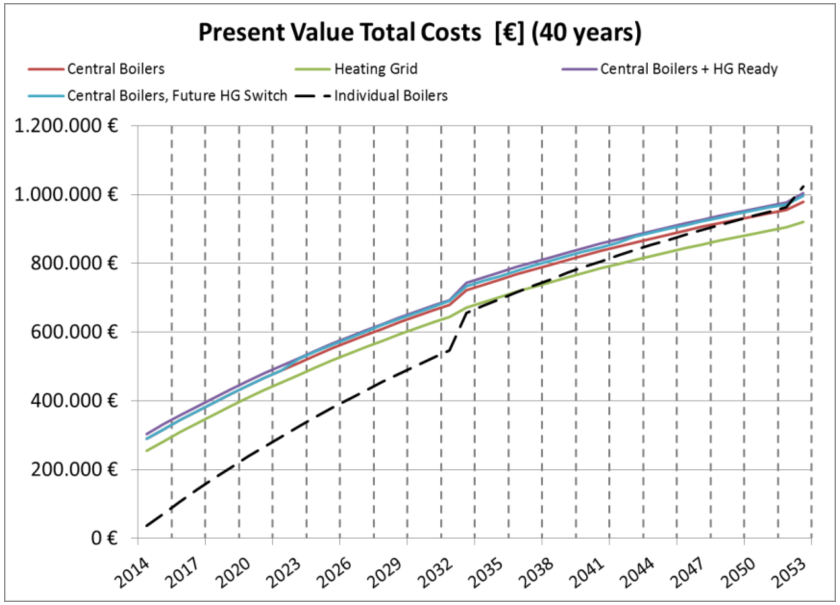


- <u>**In both cases scenario 4 + 5, postponing the switch to future heating grids = losing money**</u>
- <u>Slight advantage for scenario 5:</u> Installing the Heating Grid equipment at year 1 (scenario 4, heat exchanger alongside the central gas fired boilers), without connection it to a heating grid, is economically less beneficial than postponing the investment needed for conversion, till the time of switching in the future (scenario 5)
  - Installation cost will be relatively lower after a period of time (due to inflation and benefits from other investment opportunities that can be made in the meantime)

6. Results

Is it feasible to convert existing buildings to Communal Heating?
(at a time when individual boilers are NOT in need for replacement)

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		Individual Boilers	Central Boilers	Heating Grid	Central Boilers + HG ready	Central Boilers, future switch
Investment	Payback Time [years]		36	23	39	39
Exploitation costs	Yearly cost Single apartment [€]	997	761	761		
	Difference wrt scenario 1 [€]		236	236		
	Difference wrt scenario 1 [%]		**24%**	**24%**		
Total Costs 10 years	Total Cost [€]	324.746	510.200	475.167	524.098	520.907
	Difference wrt scenario 1 [€]		-185.454	-150.421	-199.352	-196.161
	Difference wrt scenario 1 [%]		**-57%**	**-46%**	**-61%**	**-60%**
Total Costs 20 years	Total Cost [€]	656.508	721.987	671.163	743.206	732.694
	Difference wrt scenario 1 [€]		-65.479	-14.655	-86.698	-76.186
	Difference wrt scenario 1 [%]		**-10%**	**-2%**	**-13%**	**-12%**
Total Costs 40 years	Total Cost [€]	1.024.178	979.428	919.759	1.004.747	995.613
	Difference wrt scenario 1 [€]		44.750	104.418	19.431	28.564
	Difference wrt scenario 1 [%]		**4%**	**10%**	**2%**	**3%**

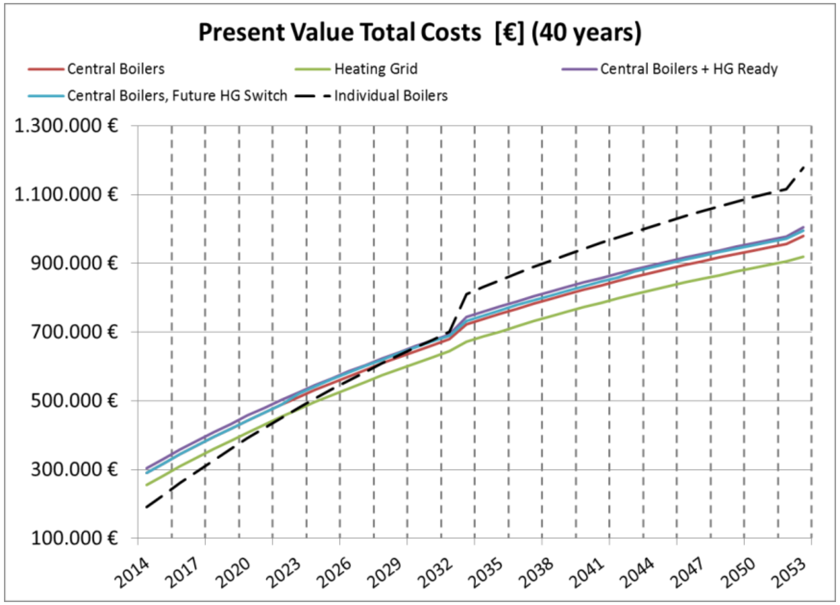


No, very large payback times
Implementing Individual Boilers
= **Lock-In!**

6. Results

Is it feasible to convert existing buildings to Communal Heating?
(at a time when old individual boilers are in need for replacement)

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		Individual Boilers	Central Boilers	Heating Grid	Central Boilers + HG ready	Central Boilers, future switch
Investment	Payback Time [years]		15	9	17	17
Exploitation costs	Yearly cost Single apartment [€]	997	761	761		
	Difference wrt scenario 1 [€]		236	236		
	Difference wrt scenario 1 [%]		24%	24%		
Total Costs 10 years	Total Cost [€]	478.666	510.200	475.167	524.098	520.907
	Difference wrt scenario 1 [€]		-31.534	3.499	-45.432	-42.241
	Difference wrt scenario 1 [%]		-7%	1%	-9%	-9%
Total Costs 20 years	Total Cost [€]	810.428	721.987	671.163	743.206	732.694
	Difference wrt scenario 1 [€]		88.441	139.265	67.222	77.734
	Difference wrt scenario 1 [%]		11%	17%	8%	10%
Total Costs 40 years	Total Cost [€]	1.178.098	979.428	919.759	1.004.747	995.613
	Difference wrt scenario 1 [€]		198.670	258.338	173.351	182.484
	Difference wrt scenario 1 [%]		17%	22%	15%	15%

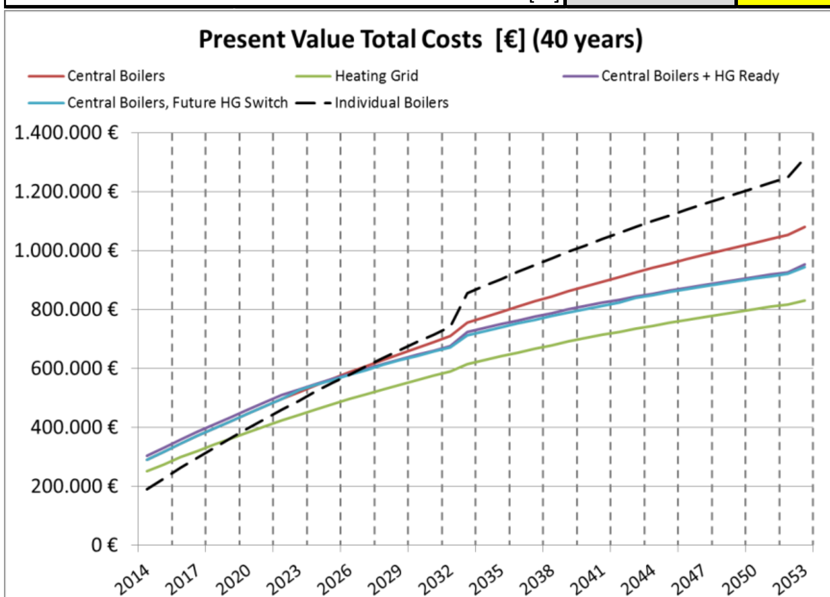


… Large Payback times
Implementing Individual Boilers
= **Lock-In!**

6. Results

Is it feasible to convert existing buildings to Communal Heating?
(at a time when old individual boilers are in need for replacement
…. and in case of economic stimulation Heating Grids + Gas Inflation? Setup according to slide 19)

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		Individual Boilers	Central Boilers	Heating Grid	Central Boilers + HG ready	Central Boilers, future switch
Investment	Payback Time [years]		14	5	13	12
Exploitation costs	Yearly cost Single apartment [€]	997	761	662		
	Difference wrt scenario 1 [€]		236	335		
	Difference wrt scenario 1 [%]		**24%**	**34%**		
Total Costs 10 years	Total Cost [€]	491.055	519.427	442.872	528.772	525.581
	Difference wrt scenario 1 [€]		-28.372	48.183	-37.718	-34.526
	Difference wrt scenario 1 [%]		**-6%**	**10%**	**-8%**	**-7%**
Total Costs 20 years	Total Cost [€]	855.208	755.339	614.699	723.712	713.200
	Difference wrt scenario 1 [€]		99.869	240.509	131.496	142.008
	Difference wrt scenario 1 [%]		**12%**	**28%**	**15%**	**17%**
Total Costs 40 years	Total Cost [€]	1.314.345	1.080.903	831.675	953.631	944.498
	Difference wrt scenario 1 [€]		233.442	482.670	360.714	369.847
	Difference wrt scenario 1 [%]		**18%**	**37%**	**27%**	**28%**



… Yes

- Feasible for connections to heating grids
- Reasonable payback time

7. Conclusions

- Individual Boilers = Lock-in!
- Communal Heating with centralised gas boilers
  - payback time 8 years, apartment owners yearly save 236€ on energy and maintenance costs
  - Preparing for future solutions in heating grids and sustainable energy
  - Combination with Solar Heat or PV = complying with new EPB
- Lessons learned
  - Economy of scale, optimisation opportunities!
  - Best scenario → immediate connection to heating grid
  - Second best → Central Boilers / future switch to heating grid (delayed investment)
  - Third best → future switch to heating grid (immediate investment)
  - Worst scenario → Individual Boilers

7. Conclusions

» Cities should consider enforcing Communal heating in their policies and vision for future project developments
  - Economically profitable
  - Easy integration of renewables (benefit towards EPB)
  - Clear benefits for buyers:
    - Lower energy bill
    - No worries about maintenance
    - No worries about installation reinvestment
    - Same comfort in terms of heat supply
    - No gas-related dangers
    - Green image, Modern building, Connected City

8. Questions? Input?

- Other input parameters? (technical, economical?)
- Other cases to examine?
- Some notes:
  - Temporal occupancy of coastal apartments in Oosteroever may be problematic for communal heating profitability
  - Base scenario equals the price of Heating Grid heat to the Gas Price. Therefore, the profitability of communal heat will only get stronger by:
    - Acquisition of cheaper waste heat from nearby plants
    - Subsidising mechanisms for green Heat
    - Solar PV to cover system electricity consumption
    - Lower gas prices for operator of large Heating Grid

      …