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Economic viability of small nuclear reactors in future European cogeneration markets

J. Carlsson, D. E. Shropshire, A. van Heek, M. A. Fütterer

Overview

- Market opportunities
- Representative co-generation markets
- Target cost methodology and modelling
- Target costs for nuclear CHP in different Markets
- Target cost sensitivity analysis
- Conclusions

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Market opportunities

- The size of the European heat market is similar in size to the electricity market
- About 30% of heat demand is provided by fossil-fired co-generation units. These would be the easiest to replace by nuclear cogeneration
- Energy intensive industries leave EU due to high energy prices
- Smaller nuclear co-generation units align well with the process heat needs of most industries.
- Examples of industries with suitable needs for nuclear cogeneration are: Chemical industry, Refineries, Biomass drying and torrefaction

Representative co-generation markets

- Purpose of study is to develop target cost for nuclear CHP competing against coal and natural gas CHP
- Target markets are based on costs predicted in 2030 according to Second Strategic EU Energy Review
- CHP entails energy savings in the range 15-30% compared to separate electricity and heat production
- The extra CAPEX of CHP compared to power production was derived from the CASES study
- Estimated cost of carbon emissions were taken into account

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Markets studied

1. Coal IGCC CHP for steel industry
2. Coal IGCC CHP + CCS for steel industry
3. Gas CCGT CHP for chemical industry
4. Gas CCGT CHP + CCS for chemical industry

- The value of heat is assumed to be that of alternative heat production by boiler using either coal or natural gas as fuel. SSER fuel data used for price projections.

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Cost structure and breakdown

- A cost breakdown was created in order to develop target costs
- Cost breakdown of Code of Accounts (COA) of Gen IV economic modelling working group was used
- Method to develop COA was evolutionary and adjusted to take into account smaller reactors

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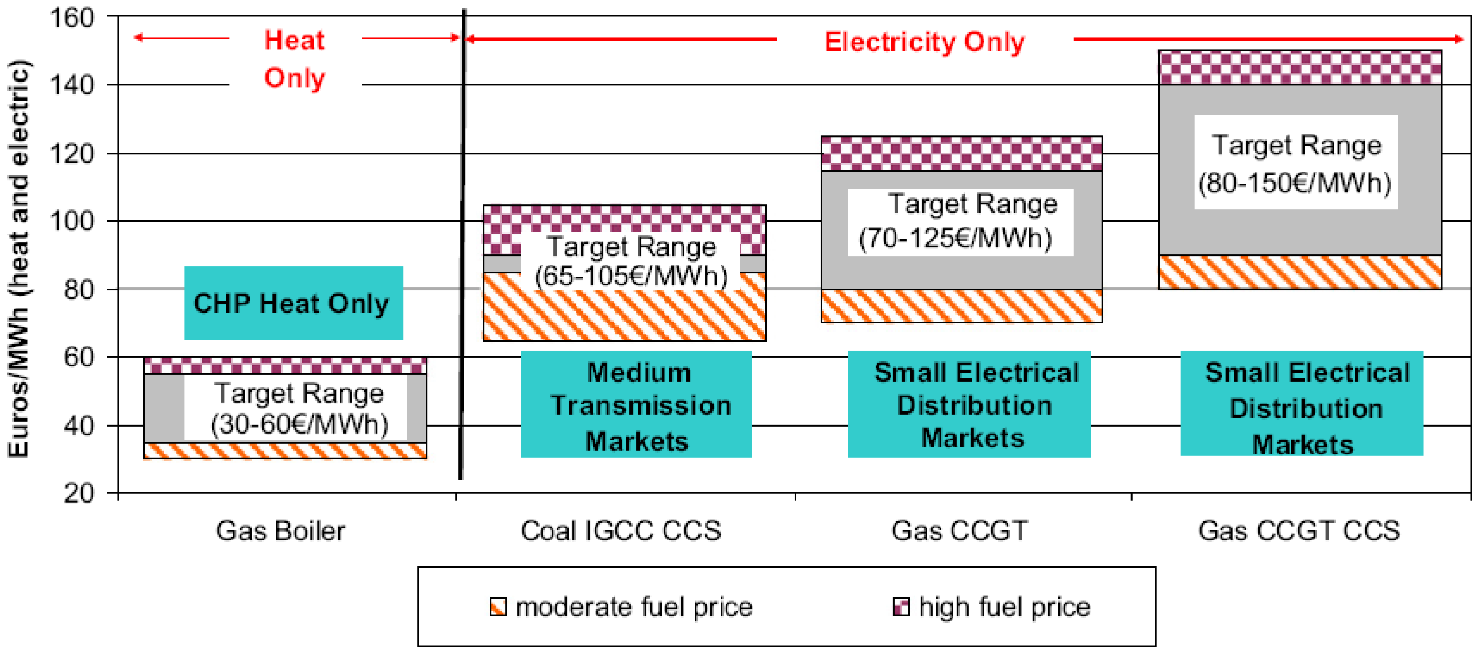
Capital cost composition of small reactor CHP

Summary costs	Small reactor CHP-average (%)	Examples of sub-accounts
10 Capitalized pre-construction	0.18	Land and land rights, site permits
20 Capitalized direct costs	57.0	Structures and improvements, reactor eq.
30 Capitalized support services	17.0	Field indirect costs, construction supervision
40 Capitalized operations costs	8.6	Staff recruitment and training
50 Capitalized supplemental costs	3.2	Shipping and transportation costs, spare parts
10-50 contingency costs	14.0	Escalation, fees

Total target cost with revenue from heat included for Markets 2-4



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Discussion natural gas prices

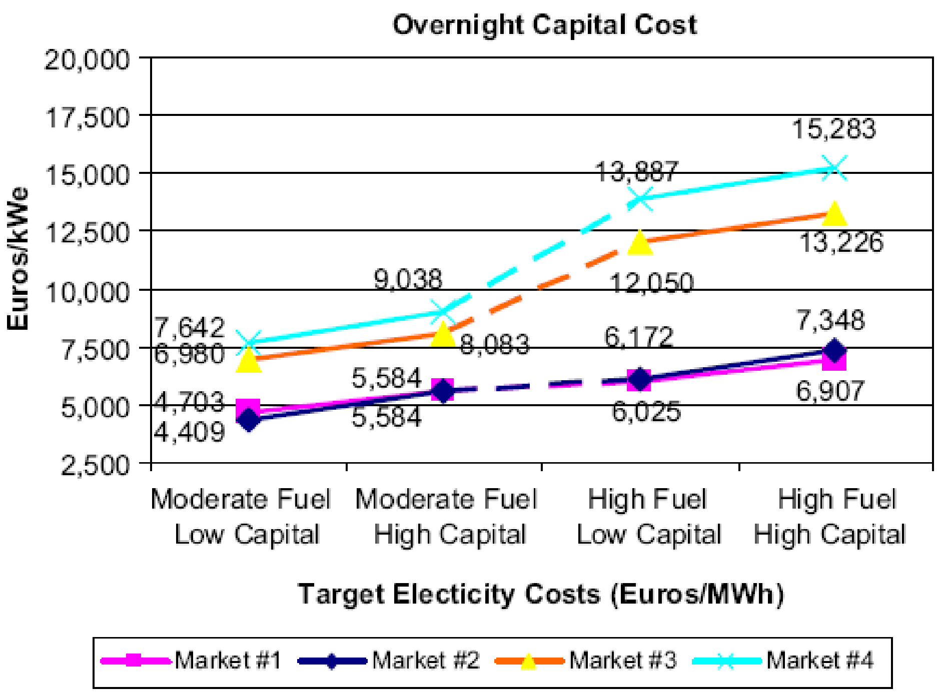
Gas prices in June 2012
Supply of 1.25 GWh/month excl. VAT

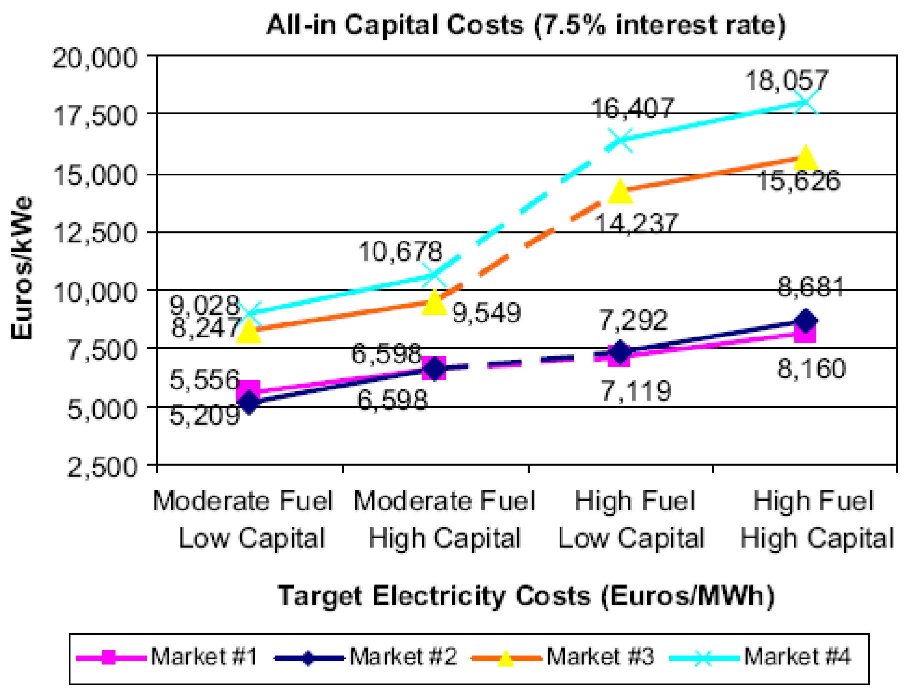
Country	Gas prices €(2012)/kWh
S. Africa	0.057
Germany	0.043
France	0.034
USA	0.015

EC, 2008, Second Strategic Energy Review

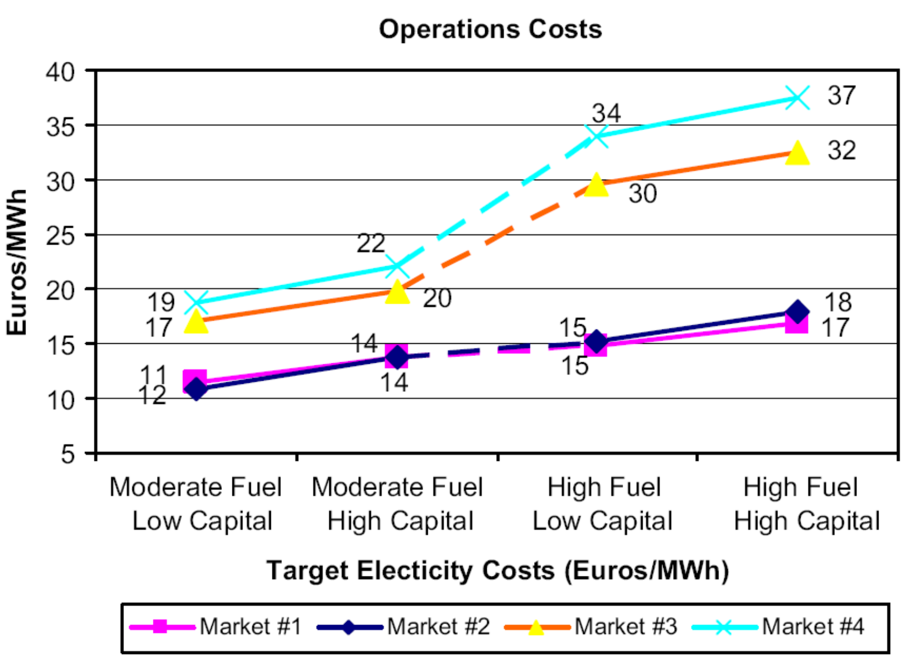
Projected natural gas prices in 2030	
Low €(2012)/kWh	0.033
High €(2012)/kWh	0.061

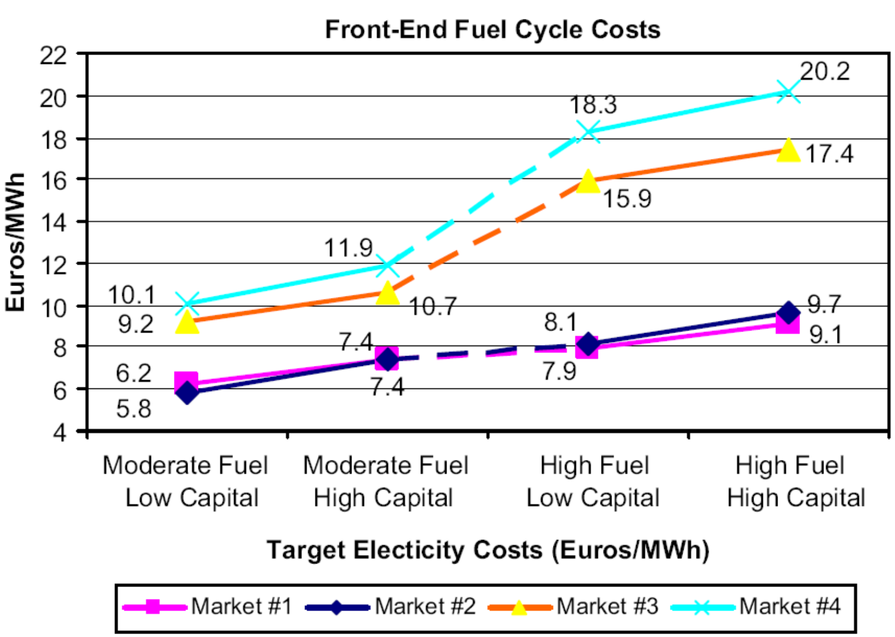
Target capital costs for Markets 1-4





Target operations costs and front-end fuel cycle costs for Markets 1-4





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Target cost sensitivity analysis

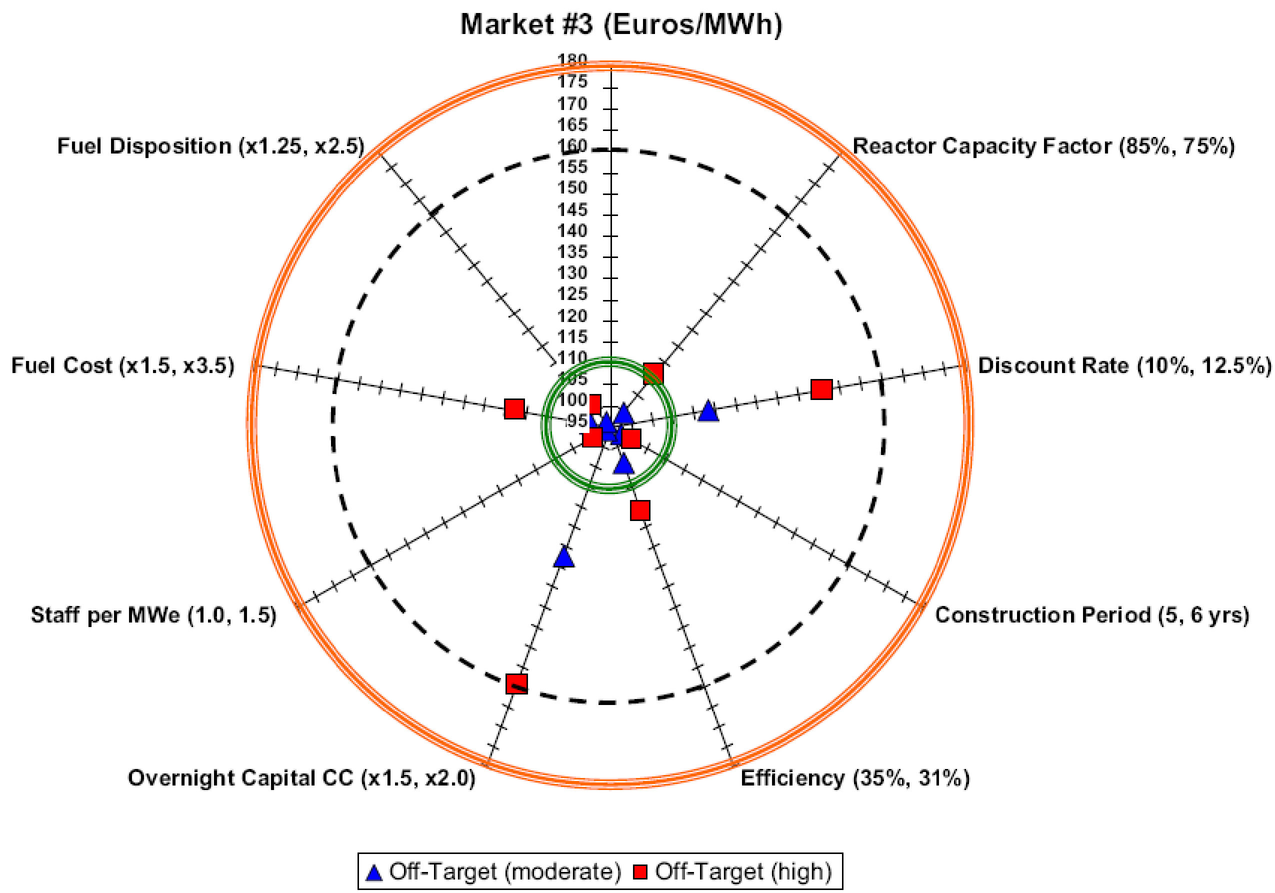
- Higher costs in one area can be compensated by lower costs in another

- To better understand relative importance of the cost parameters a sensitivity analysis was made on
  - Reactor capacity factor (90% / 85% / 75%)
  - Discount rate (7.5% / 10% / 12.5%)
  - Construction period (4 yrs / 5 yrs / 6 yrs)
  - Efficiency (38.7% / 35% / 31%)

Cost input parameters for baseline and off-target conditions

Cost parameters	Target market	Off-target (moderate)	Off-target (high)
Overnight capital costs, €/kW$_e$	As calculated	X 1.5	X 2.0
Staff per MW$_e$	As calculated	Increased to 0.9	Increased to 1.0
Fuel cost, €/MWh	As calculated	X 1.5	X 3.5
Disposition cost, €/MWh	As calculated	X 1.25	X 2.5

Results from sensitivity analysis on performance and cost parameters - Market 3



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Competitiveness of SMRs and nuclear CHP

Competitiveness of SMRs and are based on how well:

1. They are matched to their market niche
2. Financial risks are managed
3. Innovation is applied to the reactor and fuel design
4. How economy of replication can reduce costs
5. Lower capital investment cost compared to large nuclear reactors makes it more affordable for utilities

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Competiveness of nuclear CHP

6. Low fossil fuel prices reduce incentive to switch to alternatives

7. Nuclear CHP needs to be able to compete against alternatives with separate heat and electricity production

8. Policy environment ensuring long-term investments needed

9. Technology readiness (temperature limitation of 550°C for steam today). Demonstrators needed.

10. Safety requirements need to be established

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Conclusions

- Study on competitiveness of nuclear cogeneration was performed
- Nuclear CHP can be competitive against gas and coal CHP, particularly if carbon constraints and fuel prices drive up costs in these markets
- Nuclear CHP has the added value of very limited CO_2 emissions
- Risks exist for example in: variable policy environment, public attitudes

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More information can be found in full paper

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