International Conference on Smart Energy Systems and 4th Generation District Heating Copenhagen, 25-26 August 2015



A methodology for designing flexible multi-generation plants

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Agenda and purpose



- 1. Introduction
- 2. Design methodology
- 3. Summary

Main point: Synergies from process integration ought to be considered in energy system models!



1. Introduction



What are flexible multi-generation plants?

Definition: 'A flexible multi-generation plant (FMG) is an integrated, flexibly operated facility that provides multiple links between layers of the energy system'



1. Introduction





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1. Introduction



Why should we be interested in FMGs?

Hypothesis: If carefully designed, FMGs may

- achieve high aggregated energy conversion efficiencies through process integration and connection to district energy systems (*synergies*)
- balance production from intermittent renewable energy resources in a cost-efficient way (*energy system valves*)







What must be considered when designing FMGs?

- Synthesis of processes from many technological alternatives
- Design with respect to process dimensioning and integration
- Operation optimization with respect to hourly demand and price fluctuations and long-term energy system development
- Local resource availability
- Investment planning

o ...





Methodology overview





Case study – input data Flexible multi-generation plant superstructure Energy system data Power Natural gas Steam Local resource data Gas turbine Heat pump Rankine cycle Life cycle inventory Gas boiler data Heat exchanger network district heating Biomass boiler Straw Anaerobic Biogas **IBUS** facility -ligninupgrading digester Manure, waste fertilizerligni ethano -International Conference on Smart Energy Systems and AALBORG UNIVERSITY

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Case study – input data

Scatter plot from [Lythcke-Jørgensen et al. 2015]









Surrogate modelling

Case study – structuring phase

Figures from [Lythcke-Jørgensen et al. 2015]



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Case study – optimization phase













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So, why should we care on the energy system level?



3. Summary and perspective



Main point: Synergies from process integration ought to be considered in energy system models!

- FMGs may provide efficient links between the layers of the energy systems (*energy system valves*)
- Future work: Various FMG case studies using long term energy system data to assess energy system impact





Thank you for your attention



Questions & comments?



References

[Lythcke-Jørgensen 2015]: C. Lythcke-Jørgensen, M. Münster, A. V. Ensinas, F. Haglind, "A method for aggregating external operating conditions in multi-generation plant optimization models", *Applied Energy* (under review).





Case study – input data









Case study – input data









Case study – optimization phase



