4th International Conference on Smart Energy Systems and 4th Generation District Heating
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CORE

Energy system flexibility and costs by means of electrofuel production for the transport sector

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4th International Conference on Smart Energy Systems and 4th Generation District Heating 2018
#SES4DH2018

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Decarbonizing the transport sector

Small vehicles

Rail

Planes

Ships

Busses

Lorries

Transport demand in Denmark
IDA Energy Vision 2050

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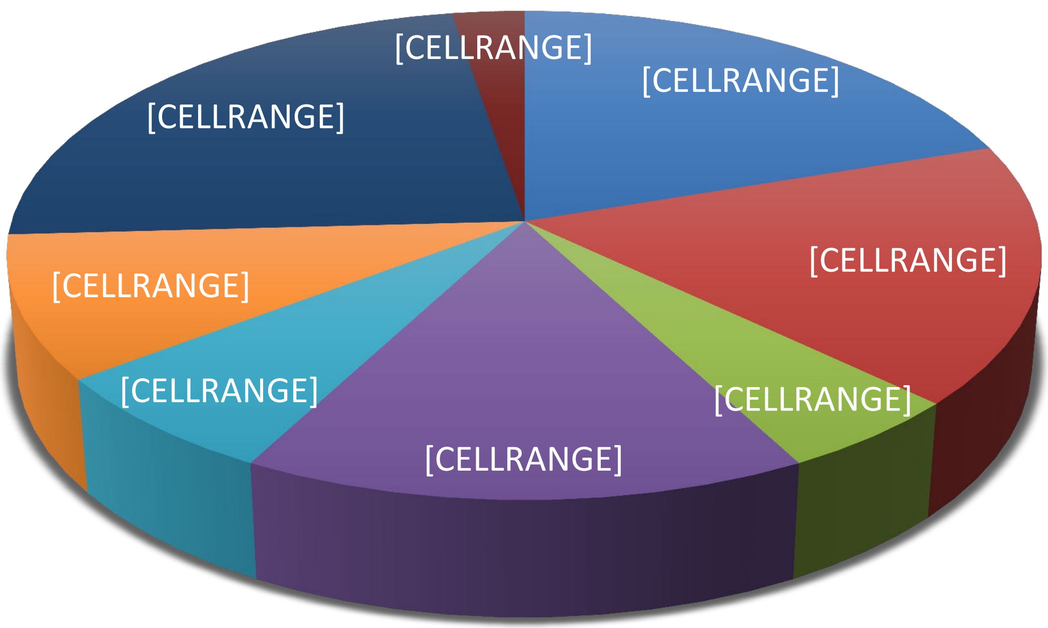

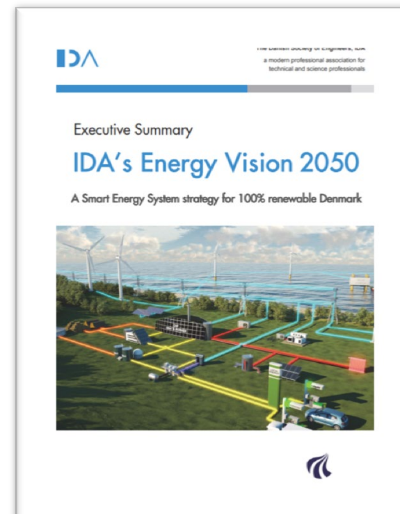

Total demand 32,5 TWh
75% of personal transport electrified
35% of commercial vehicles electrified

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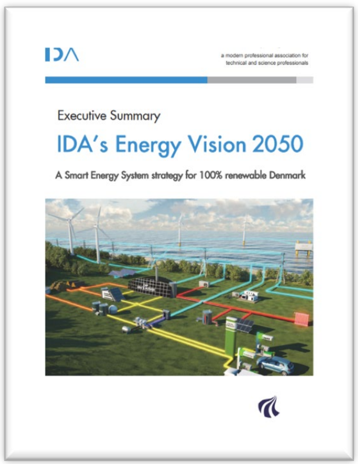
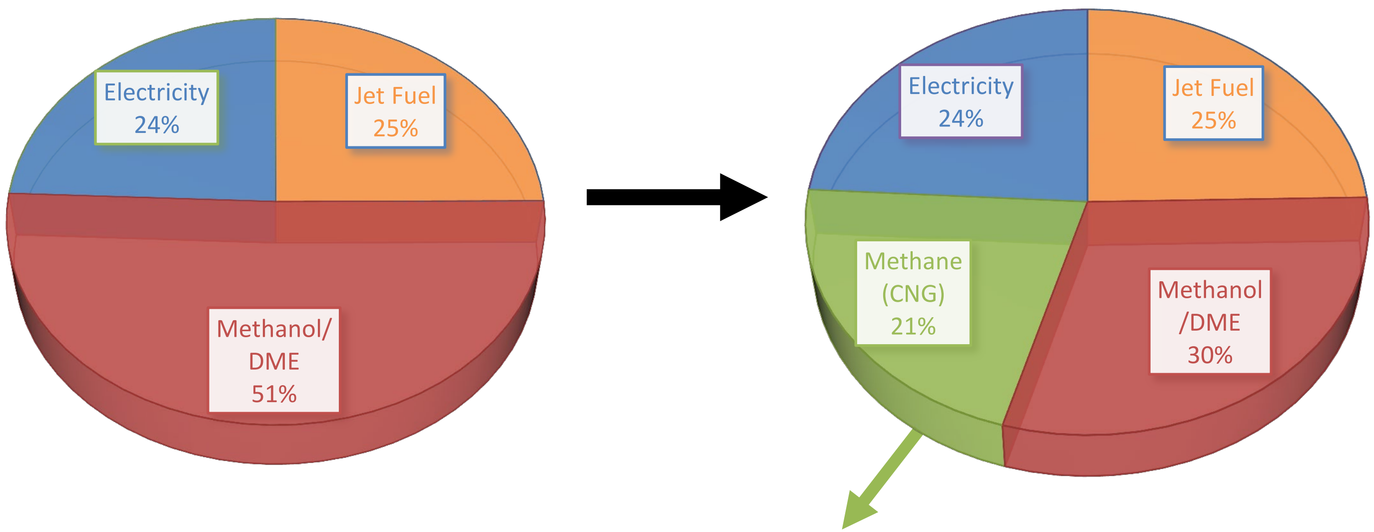
Energistyrelsen

Transport fuels in IDA Energy Vision 2050



<u>Original</u> fuel mix based on
IDA Energy Vision 2050
Reference case

<u>New</u> fuel mix



7.36 TWh (including 5% losses)
85% of buses
>90% of lorries

Renewable fuel pathways

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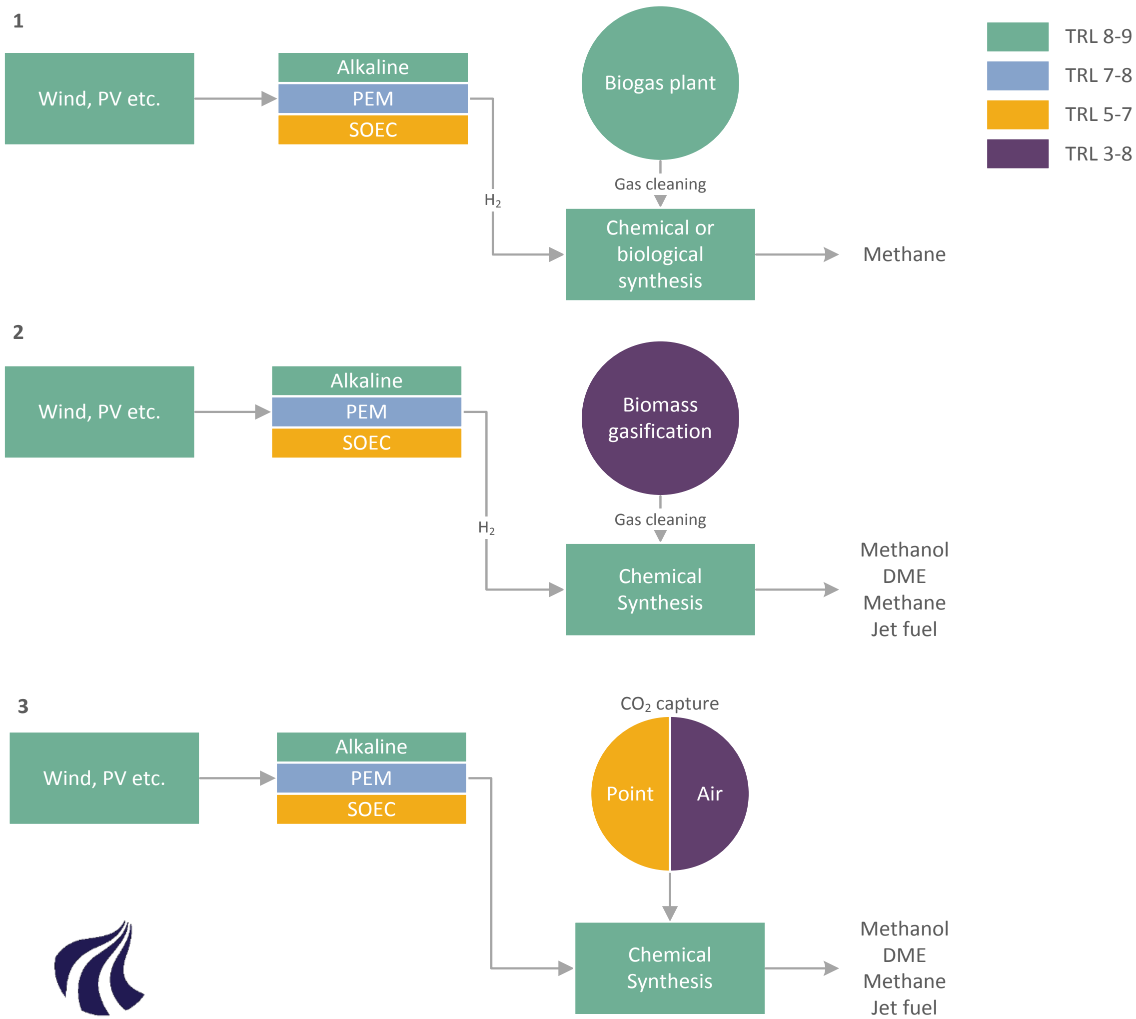

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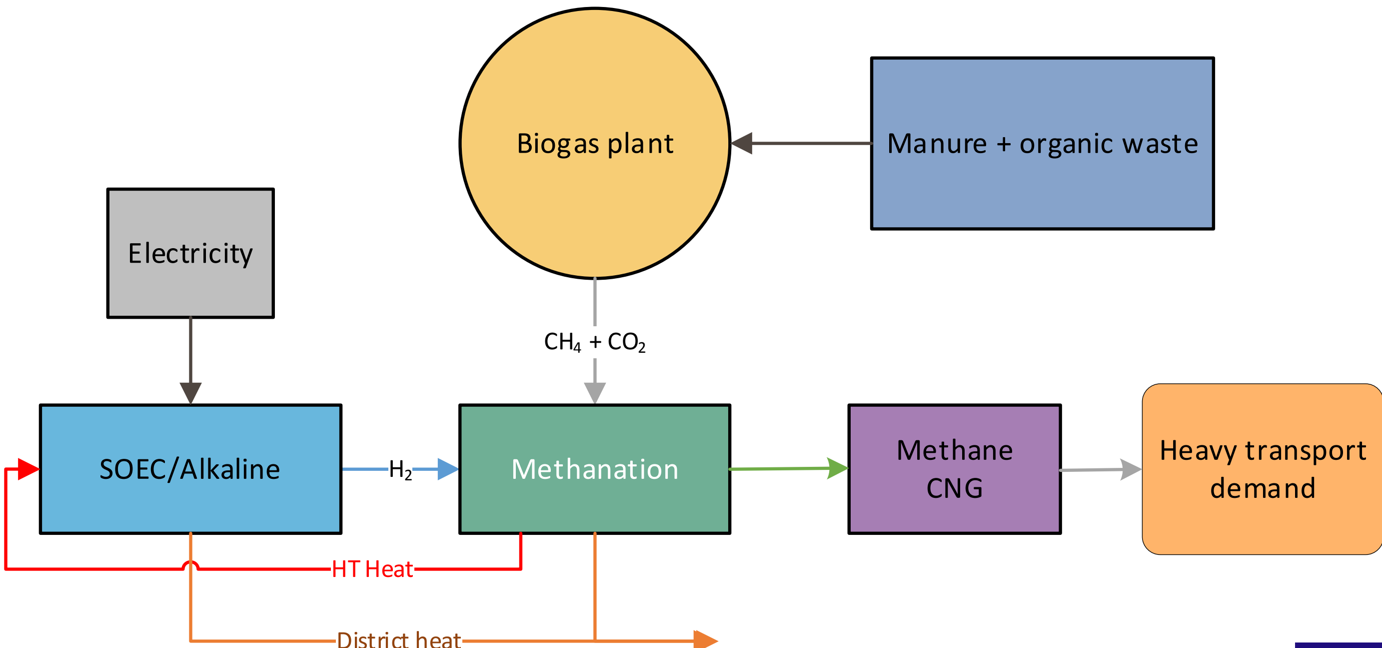
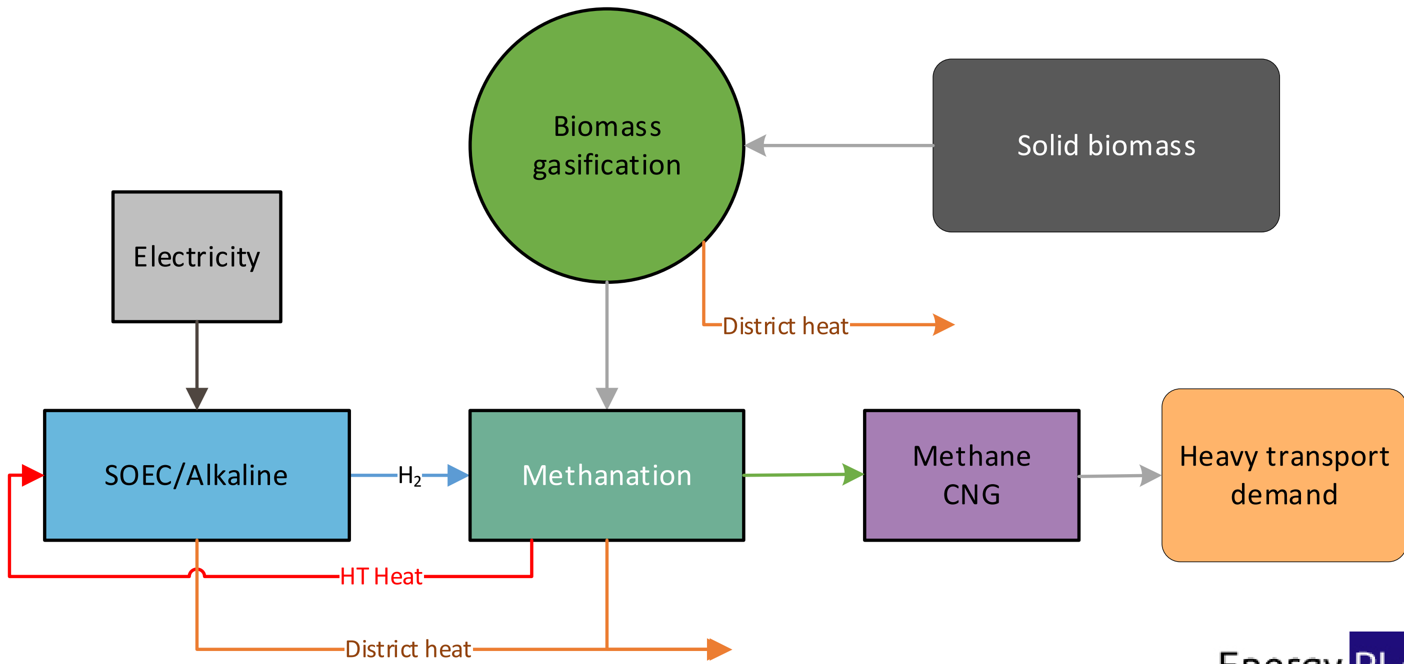
Case A. Total demand: 7.36 TWh
60% Biogas hydrogenation: 4.42 TWh

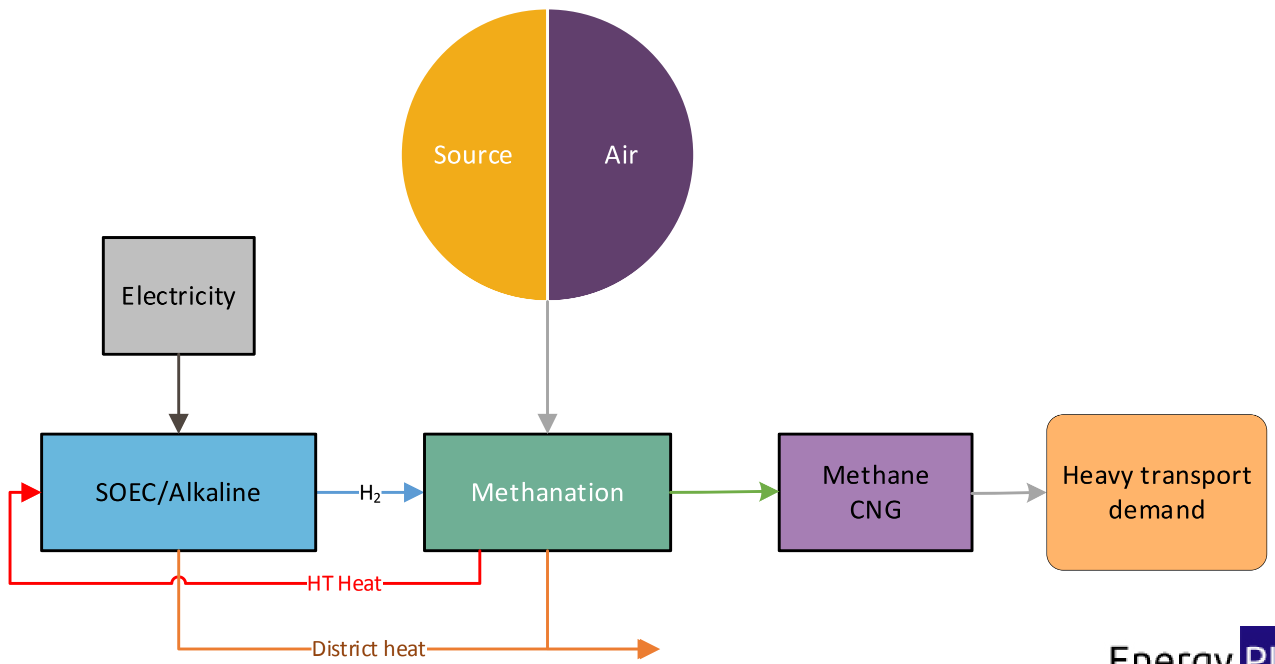
20% biomass hydrogenation: 1.47 TWh
20% CO_2 hydrogenation: 1.47 TWh



Case B. Total demand: 7.36 TWh
60% biomass hydrogenation: 4.42 TWh
20% biogas hydrogenation: 1.47 TWh
20% CO_2 hydrogenation: 1.47 TWh



Case C. Total demand: 7.36 TWh
60% CO_2 hydrogenation: 4.42 TWh
20% biogas hydrogenation: 1.47 TWh
20% biomass hydrogenation: 1.47 TWh



Energy PLAN
Advanced energy system analysis computer model

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Scenarios to test energy system flexibility

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1. **Smart Energy System** (100% buffer capacity SOEC and one week H2 storage)
2. **High Temperature synergies** (100% buffer capacity SOEC with increased efficiency. Same storage)
3. **Alkaline** (100% buffer capacity. Same storage)
4. **Reduced electrolyser** (50% buffer capacity. Same storage)
5. **Base electrolyser** (Minimum capacity with no storage)

EnergyPLAN
Advanced energy system analysis computer model

Across all scenarios:
- similar capacities of power plants an wind
- Excess el. production: 5% of total el. demand

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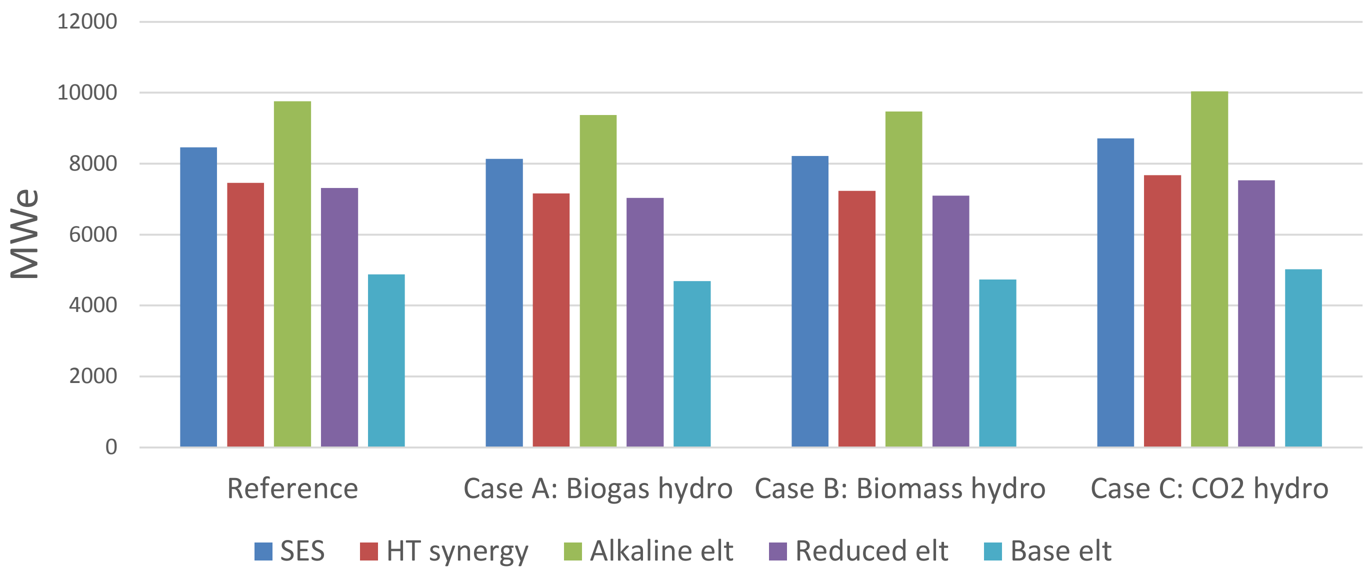
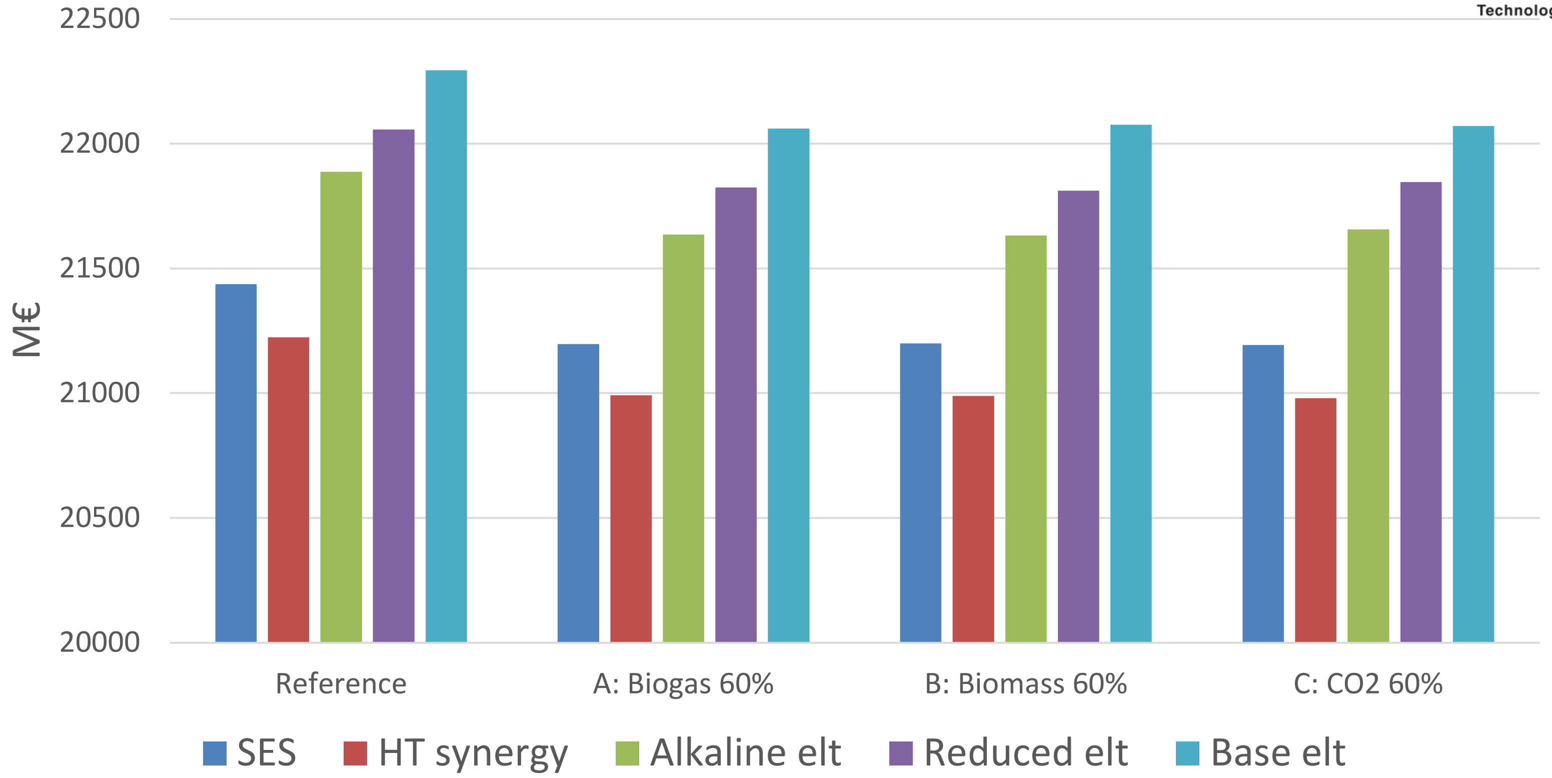
Electrolyser capacities

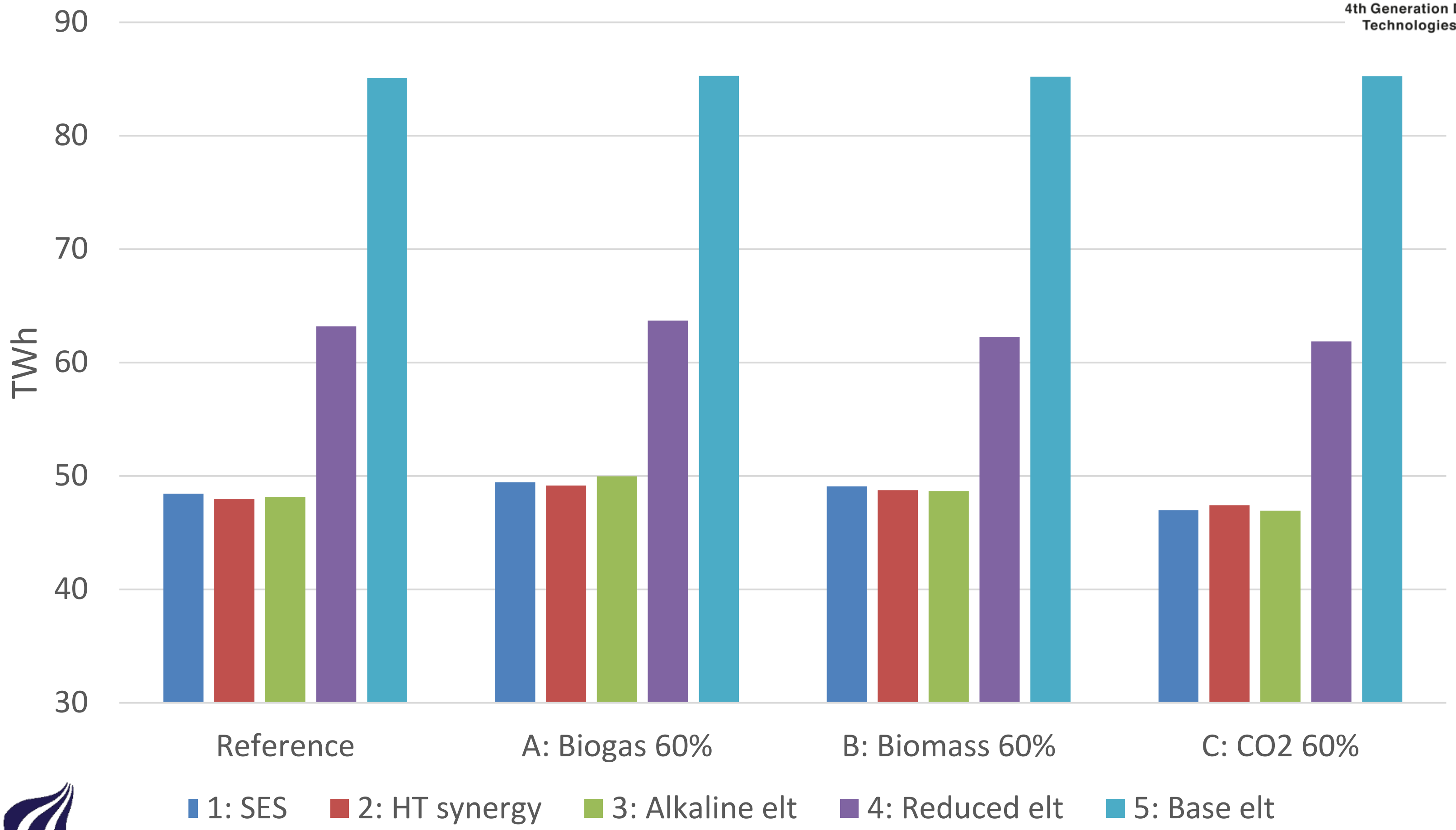
Electrolyser capacity (MWe)	Reference	Case A: Biogas hydro	Case B: Biomass hydro	Case C: CO2 hydro	Efficiency
SES	8464	8132	8216	8710	74%
HT synergy	7456	7164	7238	7672	84%
Alkaline elt	9756	9374	9470	10038	64%
Reduced elt	7317	7031	7103	7529	64%
Base elt	4878	4688	4735	5020	64%



Energy system costs



Biomass consumption



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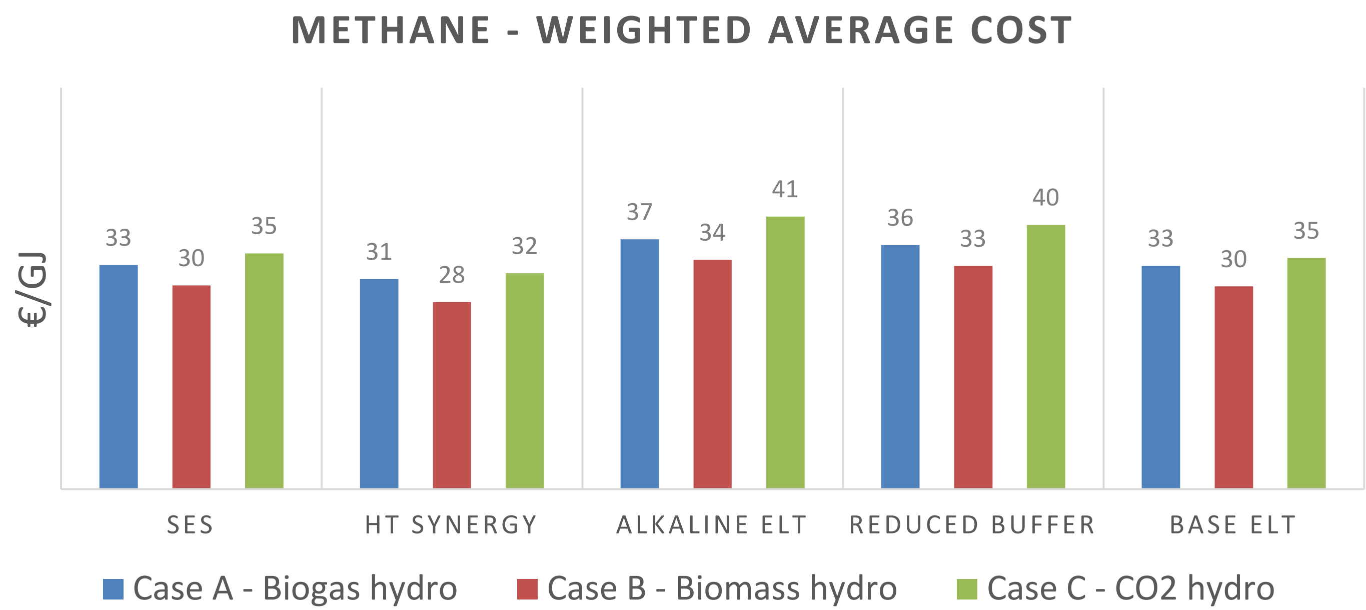
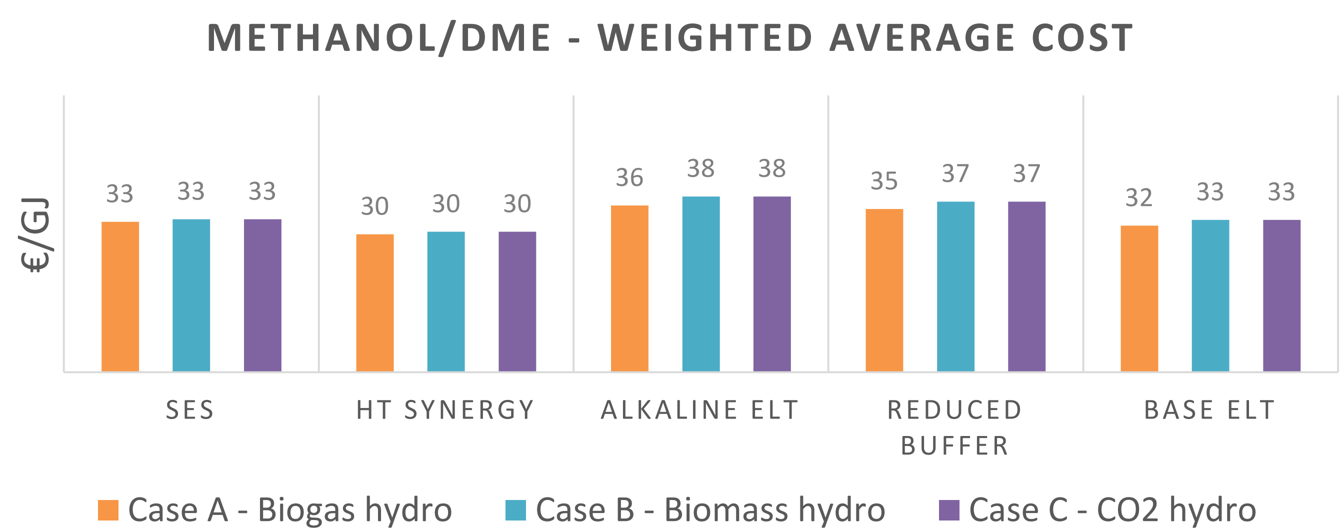
Fuel costs €/GJ





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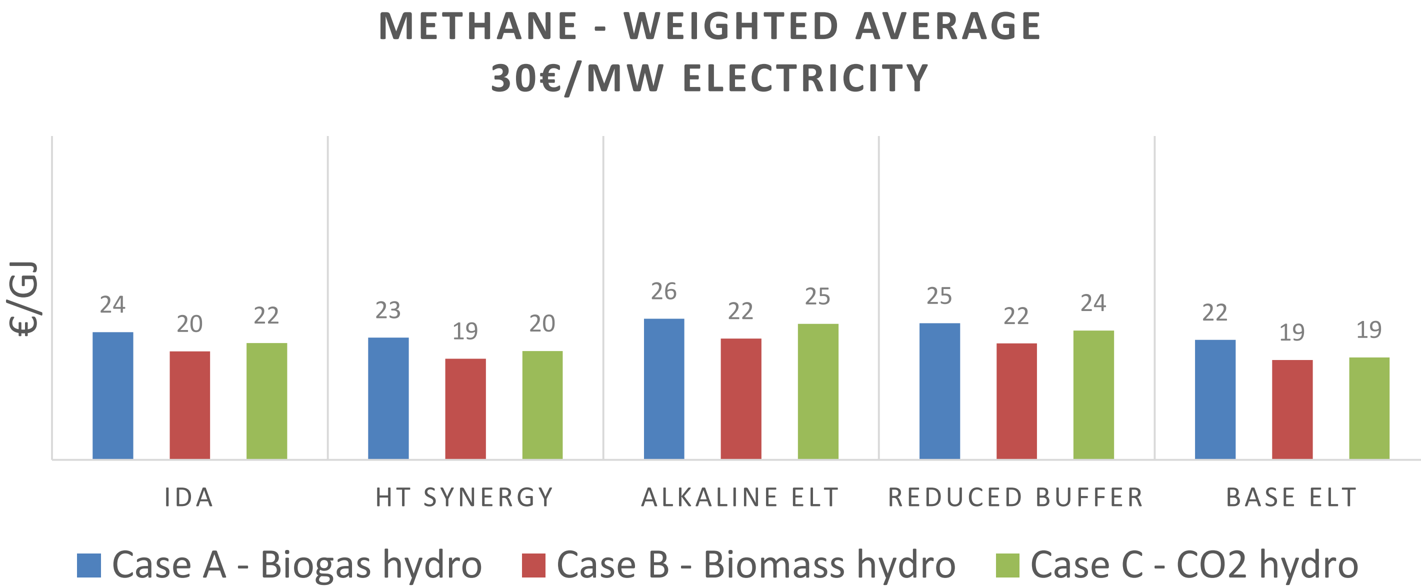
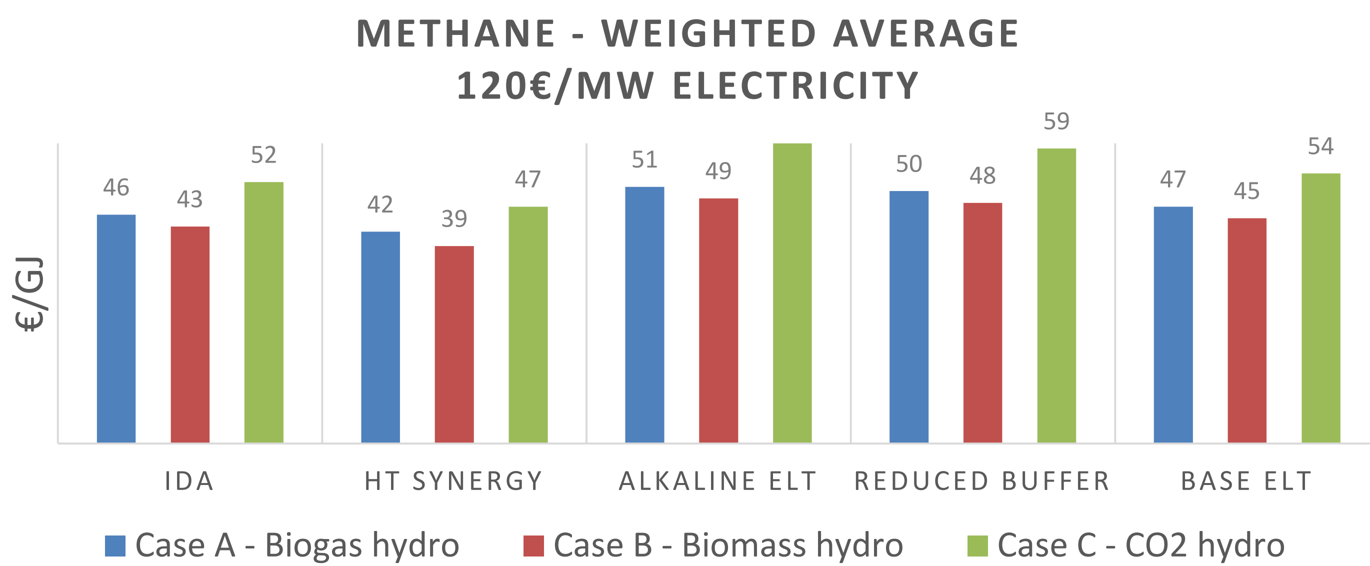
Fuel costs €/GJ – sensitivity analysis





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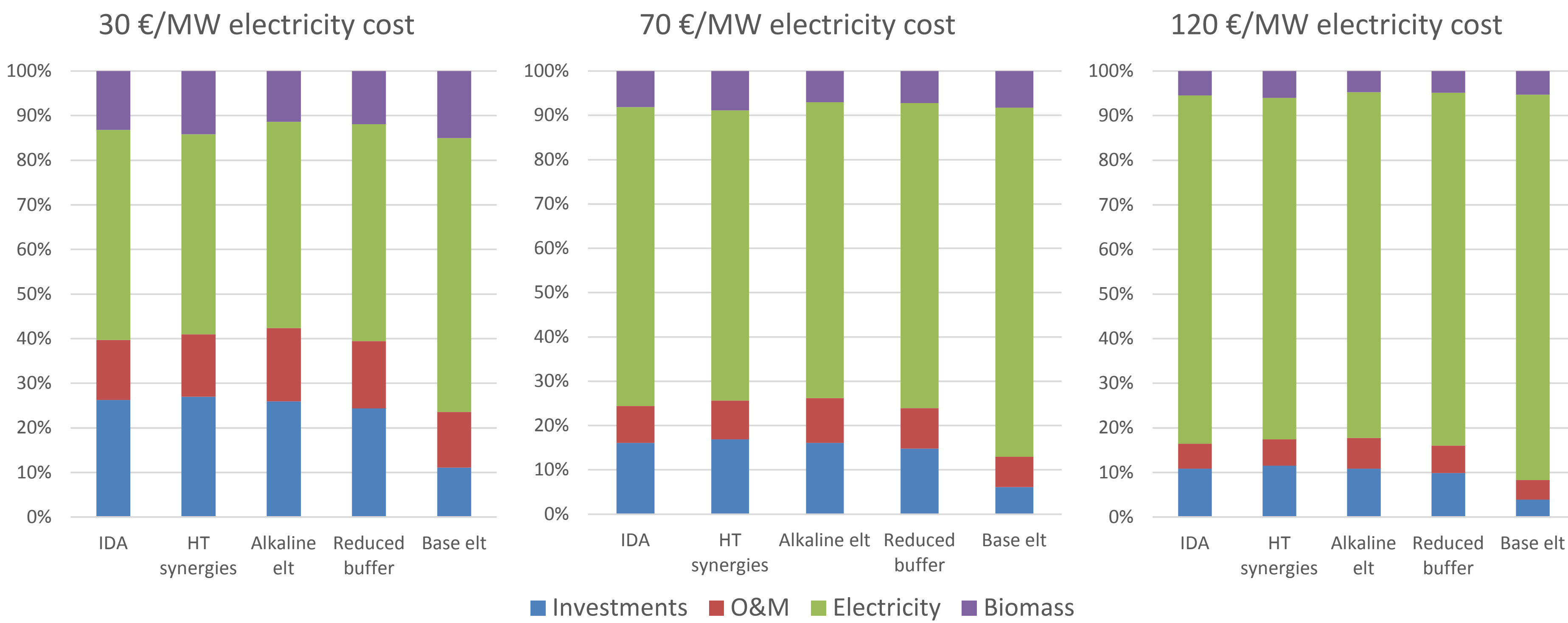
Methane price structure
Case C – CO_2 hydrogenation



Similar trend in all scenarios!

Three main findings

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- Capacity and type of electrolysers has a high impact on energy system costs, fuel costs and biomass consumption

- Electricity costs can take between 30-90% of the fuel price depending on system design and electricity cost

- Smart Energy System operation could have similar energy system and fuel cost to continuous operation

Thank you!

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