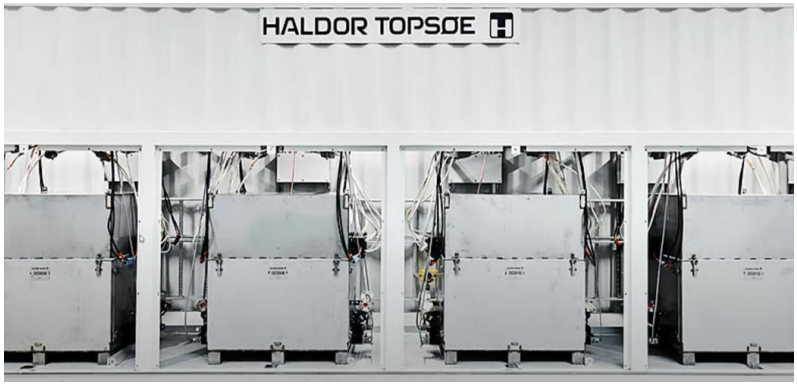
Project NESOI English summary

August 2022. Revised October 2022



1. Economical feasibility and regulation capacity

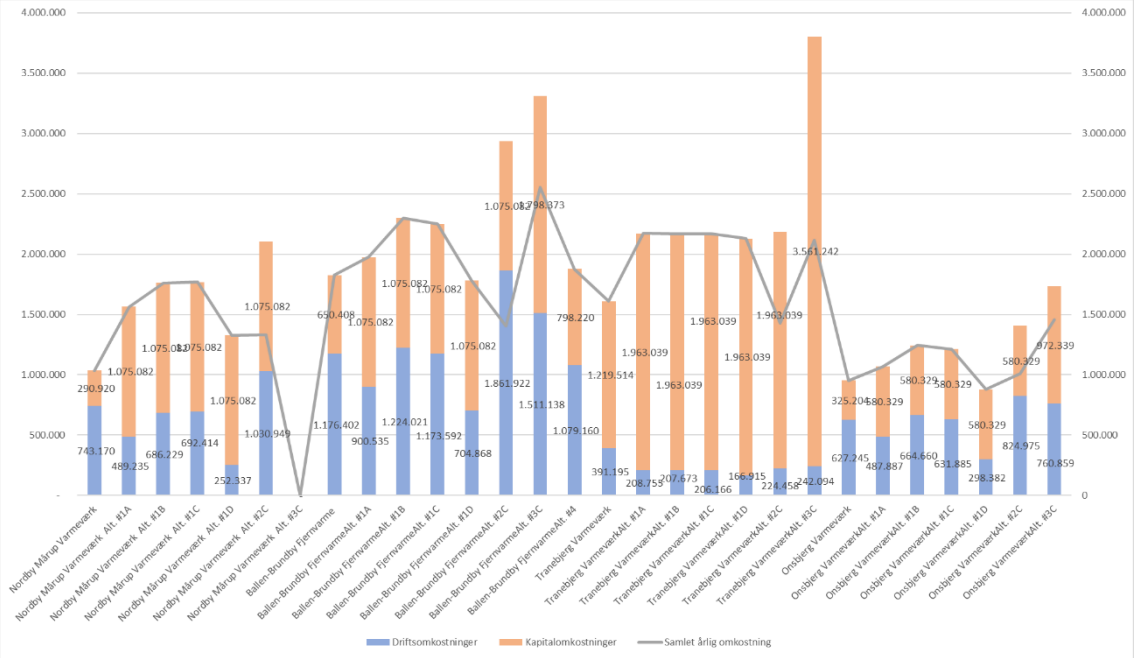
In the English summary expected technical installations, economical feasibility and electrical reegulation capacity is summarised for change of production system in district heating, implementation of biogas production, implementation of hydrogen production and implementation of charging stations for electrical vehicles.

District heating
There are 4 district heating plants on Samsø. The following changes are calculated:
Nordby Mårup (Now 2.500 m^2 solar thermal, 0.9 MW woodchip boiler as main production units)
Installed: 1.4 MW heat pump, 2 MW electric boiler and 1.000 m^3 accumulation tank
Onsbjerg (Now 0.8 MW straw boiler as main production unit)
Installed: 0.7 MW heat pump, 1 MW electric boiler and 1.000 m^3 accumulation tank
Tranebjerg (Now 3 MW straw boiler as main production unit)
Installed: 2.8 MW heat pump, 3 MW electric boiler and 1.000 m^3 accumulation tank
Ballen-Brundby (Now 1.6 MW straw boiler as main production unit)
Installed: 1.4 MW heat pump, 2 MW electric boiler and 1.000 m^3 accumulation tank

We have calculated
Alt 0: Reference system
Alt 1A: New installations and electricity spot price 2019
Alt 1B: New installations and electricity standard price 415 (415 DKK/MWh as average)
Alt 1C: New installations and electricity variable price 415 (415 DKK/MWh as average but with larger variations)
Alt 1D: New installations and electricity standard price 415 including markets for down regulation and special regulation
Alt 2C: New installations, electricity variable price 415 and connection of all consumers in the existing district heating area
Alt 3C: New installations, electricity variable price 415 and connection of consumers in neighbor villages
Alt 4C: Only for Ballen-Brundby. Reduction of heat pump to 1.1 MW and use of existing straw boiler as winter backup, electricity variable price 415

The results are shown in the figure below.
The grey line illustrates the total costs for the scenarios
1D and 2C has lower costumer costs than the reference in Tranebjerg and Ballen-Brundby. 4C shows also lower costs as the reference. The conclusion is, that change from biomass to heat pumps is possible if regulation incomes are included and gets better with all costumers connected and/or smaller heat pumps and backup from existing boilers.

Total regulation capacity:
Heat pumps 6.3 MW, COP 3: 2.1 MW
Electric boilers: 8.0 MW



Biogas

Calculations are made for a biogas plant with a total production of 4.76 mio m^3 biometan/year. App. 3 mio m^3 is produced using straw as raw material. Therefore a precondition for the calculations is, that straw is replaced by heat pumps at the district heating plants. If this is not the case, a smaller biogas plant might still be possible to implement.

A change from earlier studies is, that there is now market prices for liquid biometan and for liquified CO_2. For liquid biometan prices at 1.2 DKK/kWh has been seen in Germany for longer contracts. We have calculated with 0.9 DKK/kWh. For liquified CO_2 is a price of 400 DKK/ton used.
2/3 of the gas can cover the needs for Samsø Rederi and the rest could be sold to Germany.

The power needed for liquification of biogas is more than 2 MW.
Excess heat can be delivered to district heating.

Hydrogen

Hydrogen can be utilized for transport, upgrading of biogas or sold. A hydrogen production plant producing hydrogen for upgrading of biogas is calculated to need 8 MW electricity connected when running constantly. If the electricity price is 0.50 DKK/kWh without taxes and transportation costs, the hydrogen production price is calculated to be 0.92 DKK/kWh or 4-5 US $/kg. this is too expensive for upgrading biogas by metanation. The electricity price must be 0.2 DKK/kWh or less if hydrogen shall be used in a metanation process.

Total regulation capacity in case: 8 MW

Charging of electrical vehicles
The charging needs for estimated 692 electrical vehicles is calculated. If charging is made flexible, there will be more than 2 MW regulation capacity.

Altogether the calculated changes represent a regulation capacity of more than 20 MW.

2. Environmental consequences

Environmental consequences is calculated as reduction in emissions calculated as CO_2-eqvivalents. The environmental consequences are calculated for each of the four areas mentioned above.

District heating
Emissions are calculated according to the rules from Danish Energy Agency for calculation of socio- economic consequences for energy projects. The result is for 20 years:

Emissioner[1,2]	Enhed	Alt. # 0	Alt. # 1	Alt. # 2	Alt. # 3	Alt. # 4	Alt. # 5	Alt. # 6	Alt. # 7
CO_2	ton	68	524	0	924	0	2.037	0	496
CH_4 (metan)	ton	2	1	12	3	27	6	6	1
N_2O (lattergas)	ton	1	0	2	0	4	0	1	0
CO_2-ækvivalenter	**ton**	**365**	**573**	**769**	**1.011**	**1.682**	**2.228**	**410**	**542**
SO_2	ton	2	0	47	0	102	1	25	0
NO_x	ton	20	3	36	6	80	12	19	3
$PM_{2,5}$	ton	2	0	5	0	11	0	3	0

Alt 0 and 1 is Nordby Mårup. In the reference system emissions are 365 tons CO_2-eqvivalents and in the alternative 573 tons CO_2-eqvivalents.
Alt 2 and 3 is Ballen-Brundby
Alt 4 and 5 is Tranebjerg and
Alt 6 and 7 is Onsbjerg

The calculation starts in 2022. It is more realistic that the start will be in 2023 or later. Most of the emission in the alternatives come from electricity consumption, and the average CO_2-content in Danish electricity will be reduced and reach close to Zero from 2035. That means that a later start will reduce the 20-years emission. If the DH-transistion to heat pumps starts in 2024, the 20-years emission will be only 73% of the 2022 calculation resulting in a CO_2-neutral transition.

Biogas
Produced biogas will replace natural gas. The emission from biogas is 0 and the emission from natural gas is 203,4 kg/MWh.
The yearly biogas production is calculated to 47.600 MWh. Energy consumption is expected to be 20% of the production. Thus, the reduction of CO_2-emission is expected to be:
47.600 MWh/year x 203,4 kg CO_2/MWh x 0,8 = 7.745 tons CO_2/year.
Biogas consist of CO_2 and CH_4 (methane). The CO_2 content is 7.632 tons/year. CO_2 is expected to be sold, but it can also be converted to methane in an methanation process using hydrogen or converted to for instance methanol.

Hydrogen
In the hydrogen example it is expected that 1379 tons of hydrogen will be produced. If hydrogen is replacing gasoline or diesel in the transport sector it is expected that 1 kg of hydrogen can replace 5 liters of gasoline or diesel or app. 50 kWh. Emission from gasoline is 0,263 kg CO_2/kWh. That means that 1379 tons of hydrogen can reduce CO_2-emission with:
1379 tons/year x 50 MWh/ton x 263 kg CO_2/MWh = 18.100 tons CO_2/year.

Electric vehicles
It is expected that 1884 MWh of electricity will be used in electrical vehicles in 2030. Electricity is 3 times more efficient as transport fuel compared to gasoline. Emission from gasoline is 0,263 kg CO_2/kWh. That means that emissions can be reduced with 1884 MWh x 263 kg CO_2/MWh x 3 = 1486 tons CO_2/year in 2030

3. Social consequences

Samsø writes. Be aware that particles from fluegas and vehicles are not mentioned above

4. Comments and answers

The reports have been read by the NESOI supervisers and comments has been given from Lain MCLeod. Comments and answers can be seen below

District heating
The average energy use per household is high compared to the latest Danish standards for heating and hot water, but energy demand figures withing the report look sensible for older housing stock. It is proposed to replace biomass heat generation plant with heat pumps and electric boilers at a central location, and increase the amount of storage. However it may be beneficial to look at other measures before converting the energy centres:
Are there any plans to upgrade the energy efficiency of housing in district heating areas. This has been ongoing since 1996 and is still ongoing
Are their any sources of waste heat that can be incorporated into district heating schemes e.g. sewage treatment and waste incineration. Waste incineration does not take place on the iland, but sewage water might be a resource for Ballen-Brundby
Can the district heating network temperature be reduced in order to lower network losses and to work more effectively with heat pumps. Temperature reduction is part of the daily operation agenda
Has local storage (at properties) been considered as well as including local electric heating temperature boost (primarily for hot water if heating can use low temperatures). This would aid with lowering the network temperature and reduce the increase in electrical connection requirements at the energy centre. If properties have sufficient space then there are larger heat stores available that can provide backup for heating and hot water. This option has not been calculated in the present project but in other DH-systems and it is not economically feasible.

Biogas

Page1: “The island is 100% self-sufficient in electricity”. Do the citizens of Samso have an agreement with the local wind farm to purchase electricity, if not then generation from biogas may be an option. If farming is to continue on the island then biomass resource may be available for the foreseeable future. It is much cheaper to install wind and PV. Biogas can not produce electricity to 15-30 øre/kWh.

Page 2: Provide energy consumption and production figures in a consistent way. Potential gas production is in tonnes of oil equivalent (toe) rather than kWh. 1 toe is 11600 kwh. Toe is not used in DK for biogas or natural gas.

Page 4: High temperature thermal pre-treatment of organic waste can provide sterilisation and improve the yield of biogas. But it is not feasible. Only waste, that must be treated according to appendix 4 from Red2 will be sanitized.

Page 5: Should the term ‘metal loss’ be methane loss. Cant find the word metal. Must come from wrong translation.

Page5: At each processing step to convert biomethane to methane and then to LGN there are increased risks. The level of engineering expertise required to operate and maintain the plant will also increase. Bioomethane and methane is the same product. The risk is from methane to liquid. The risk is typically met by making service contracts with the technology supplier.

Page5:. High temperature thermal pre-treatment of organic waste can destroy potentially harmful pathogens that may otherwise still be present in the digestate, which would limit the digestate end use. In DK weu se thermophilic biogas processes that reduce harmful patogenes. This is controlled yearly. End use on farmland.

Page 16: If the LBG plant is co-located with the biogas plant then the heat generated by cooling the gas may be used in for the biogas plant. Waste heat could potentially fed into a district heating network if the plant can be safely located near a populated area. Yes, but probably a heat pump will be needed.

Hydrogen

The report does reiterate that Samso is 100% self sufficient in electricity. If you refer back to the island’s energy use figures then there is an import of electricity. Although the island generates more than it uses, local generation is not sufficient in all instances. Hydrogen is expected to come from new installations

Electric vehicles

Page2: State the Regulation effect/potential at 2030 as well as 2050 rather than repeating the potential and effect numbers (which are the same value). Values for 2050 will be added

Page 2: EV chargers communication interfaces should have an open protocol that will allow a range of Digital Platforms interface with them. Text will be added

Page 2: EV owners should also be mindful of the additional battery cycling from operating in V2G mode. Text will be added

Page7: “Cars charging on average 50 hours per year”. Average charging hours would relate to the average distance travelled and average size of charger, rather than the battery capacity. Yes, but distances are also mentioned at page 7

Page7: Provide a further estimate of day trippers to stay over and revise the power requirements for the tourists that stay over with electric vehicles. We will not change the figures given from Samsø
Page8: Reduce the regulatory potential of tourist vehicles to those that will stay over and revise figures. Same answer as above