Aadorp case outline

Introduction

Aadorp is a small village a few kilometers outside of Almelo in the east of the Netherlands. The village is surrounded by industry and farms. With 1500 residents and about 550 homes, the village poses an interesting opportunity for industrial symbiosis and sustainable energy transition.

Outline

The following technologies and plans are part of the Hub in Aadorp:
Renewable Energy:

- 1 MW solar panel system

Hydrogen Production:

- 70 kW hydrogen production system
- Electrolyzer and compressor for hydrogen production
- Hydrogen storage capacity of up to 2000 kg

Hydrogen Conversion:

- Conversion of trucks to hydrogen fuel
- Conversion of cars to hydrogen fuel
- Reuse of gas infrastructure for hydrogen
- Replacing gas with hydrogen for one SME

Infrastructure:

- Hydrogen filling station for trucks
- Reuse of gas infrastructure for hydrogen
- Pilot test of heating a small group of houses using hydrogen

Education and Research:

- Lecture hall for 80 students
- Offices and lab

Due to limited size of the hydrogen production facility of 70kW it becomes important to know which industry or goal is going to receive what amount. The current situation contains 4 possible small businesses, crematoria, which could substitute natural gas to hydrogen. It contains one pilot for 10 residential houses and a filling station.
A boiler heating system in a residential building 3 to 4 bedroom requires up to 30kW in the

heating system. Substituting the hydrogen would require a 300kW production system of hydrogen in peak demands. This will be achieved easily on winter nights.

If we assume to be using 1300m3 of natural gas yearly, that will result in an average heating demand of 4 kW over the full year.

Substituting gas for hydrogen would require significant storage in the winter as heating demand will exceed the current production facilities.

One cremation cost 60m3 of natural gas or 633kwh of heat. A cremation oven operates between 200 and 600 kW. Substituting natural gas for hydrogen from a system perspective only makes sense if there is no possibility to move to electrical cremation. Depending on the social preferences there might be a limited use case for hydrogen as substitute for natural gas.
The total energy required for 3 cremations a day for 250 days a year would add up to 45000m3 of natural gas. Resulting in 475MWh of heat requirement. This would require 108kW of average heat input which already exceeds the 70kW of heat requirement provided by the electrolysis system. This system produces about 33.33kWh of usable energy per kg of hydrogen and a maximum of 1.3kg per hour. This results in 11388L or 380MWh of usable energy per year of hydrogen.

Remodeling and reuse of hydrogen trucks wil make the transport 10 to 12% more efficient.

https://h2.live/wp-content/uploads/2022/03/H2M_Overview_HDV_Refuelling_2022.pdf

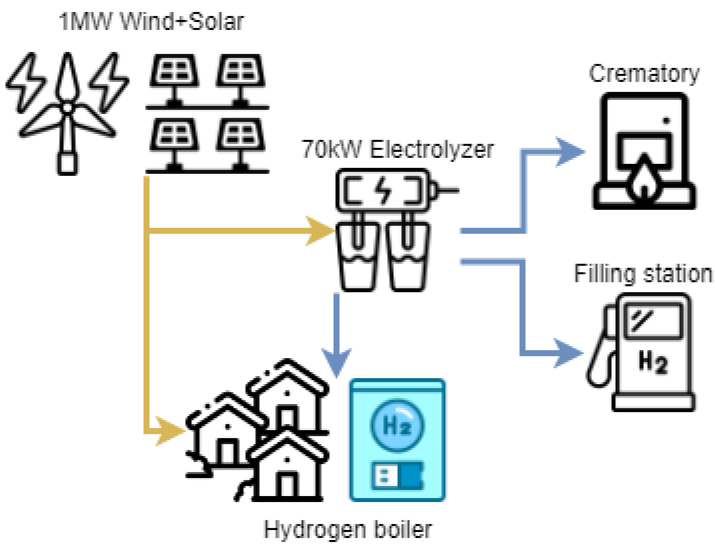
A hydrogen truck would in estimation require 35kg of refueling at a time resulting in a range of 600km. This would require about 1.5MWh of energy.
The closed system as presented is not able to provide the solutions proposed. There is not enough energy within the system to provide for all technologies.

From the perspective of the SEH it would make sense to look for additional heating supply in the form of biogas from wastes, such as bio manure and waste water treatment. Upgrading this gas and adding co2 capture would present a more stable hub which would be able to accommodate more solutions.

1kg hydrogen 57kWh of energy required, roughly. This is for operation at 350 bar in a truck.
The 70kW plant would then produce effectively around 1.3kg compressed hydrogen an hour.
Operating at full speed, the electrolysis compressor combination would produce the capacity of *325 trucks of hydrogen*.

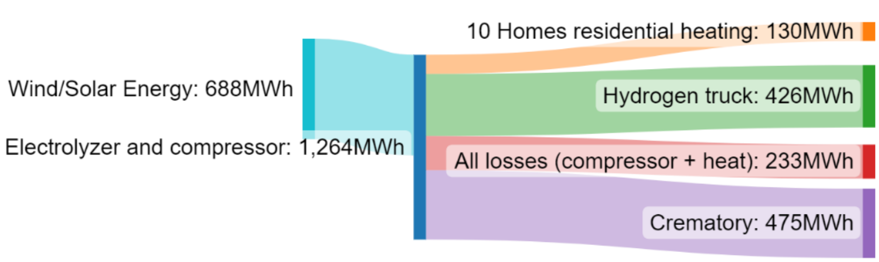
Conclusion

The proposed solutions require more hydrogen to meet the demand. There is still the question on how the boundaries of what is part of the hub need to be considered. Hydrogen uses energy and as part of the larger energy market, it should not be neglected that not all energy is produced green and that by definition the energy used in the total of the system is not green.



Additionally, the hub requires 9l of water for 1kg of hydrogen adding towards a less circular hub.

If we look at the total of the energy flows for the hydrogen between these components it results in the following:



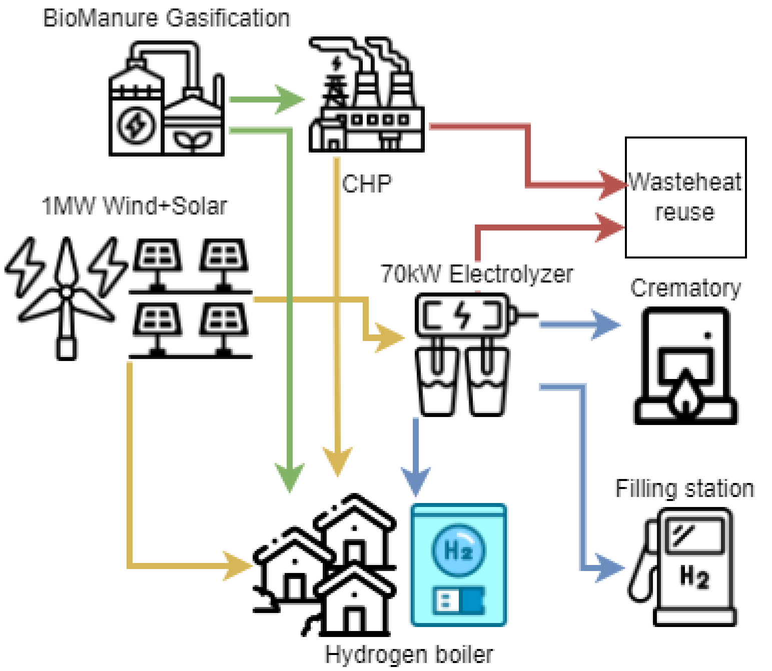
Energy use of the Aadorp H4C of a typical year based on first assumptions.

Proposed solution:

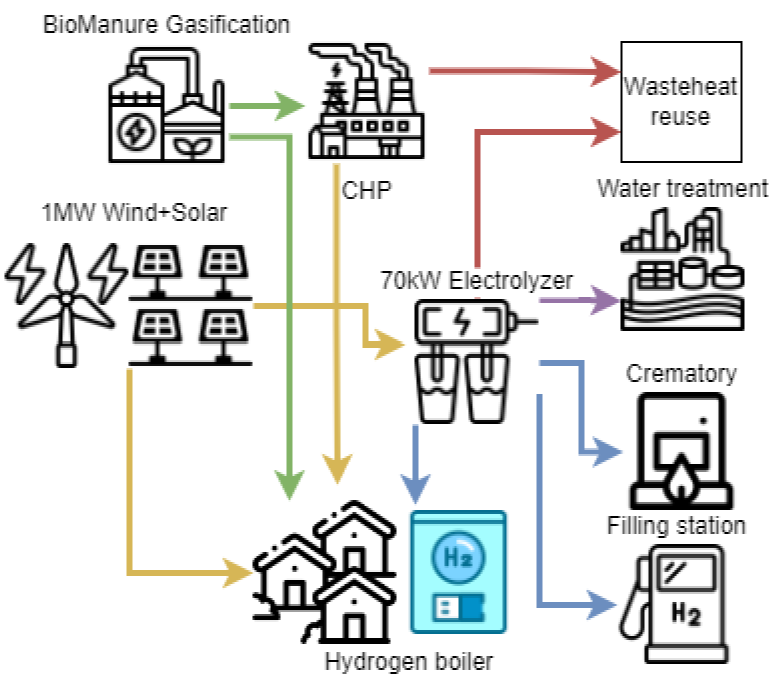
The system requires more sustainable energy to meet the demand. There are plans to inject biogas in large quantities from a covergister at business park Twente in the natural gas pipelines. This will be the equivalent of 10.000 homes of heating demand. Combining this with the existing Hydrogen hub would produce a more stable and circular design. Also managing waste heat from the electrolysis system is required to minimize waste. Lastly the use of hydrogen should be justified. Using hydrogen as energy carrier in a system where fosil fuel is still in the mix and gas is stil being used has a net NEGATIVE impact. Quantifying this impact relative to replacing natural gas is misleading as the use of hydrogen increases the energy demand. If the hydrogen is produced at peak ours one could claim there is a net positive impact but otherwise there is no reason to convert to hydrogen.

In the light of the covergister I would propose using biogas to fulfill the heat demand of the houses, upgraded by hydrogen from peak production hours.
Providing electrical cremation substitution reduces the energy usage of the crematoria even more.

Introducing waste heat management and biomass covergister



Introducing oxigen symbiosis with waste water treatment plant



Integration with wastewater is extremely important!
https://link.springer.com/chapter/10.1007/978-3-030-94191-8_54

Crematorium Enschede
1 huis stap twee meerdere stap 3 heel netwerk