CHALMERS UNIVERSITY OF TECHNOLOGY

TRA105 Fuel Cell Systems

Energy efficiency and power ability of a hydrogen equipped self-sufficient solar building with grid support

Introduction, scope and methodology

The project investigates two models over an energy system for an apartment building. Data for consumption load and production from solar PV installed today was given from HSB living lab, a building located on the Chalmers premises. The energy system requires to fulfill the electricity demand for the building for an entire year. The project could also include that the system should provide grid support, but this has due to limited time not been in the scope of the project. The system has to be designed in such way that it provides a good energy efficiency and at the same time is reasonable cost wise. The two models was developed using Python. During surplus solar the system converts the energy to hydrogen in model one. In model two the system either convert the excess energy to hydrogen or store it in a battery based on the demand.

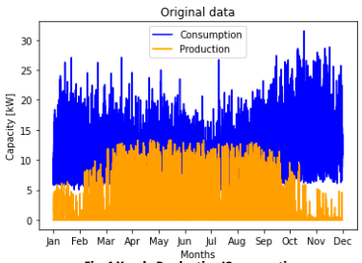


Fig. 1 Yearly Production/Consumption

- **Original installed solar energy is not enough as seen in figure 1.**
- **For the models the production was scaled to meet the demand as in figure 2.**

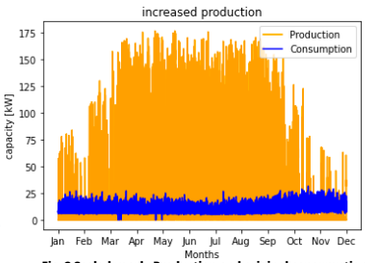


Fig. 2 Scaled yearly Production and original consumption

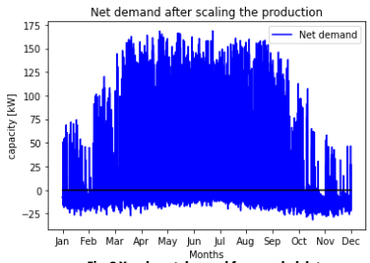
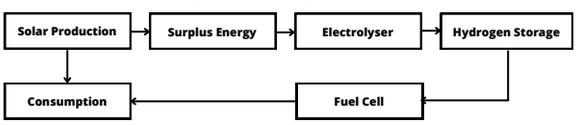


Fig. 3 Yearly net demand from scaled data

Model 1 - Hydrogen storage



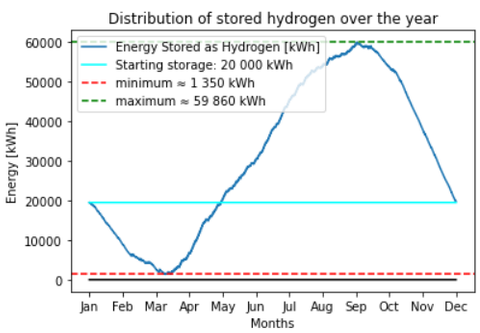
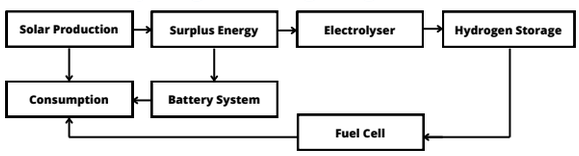


Fig. 4 Hydrogen storage over the year in model 1

Model 2 - Hydrogen storage together with battery



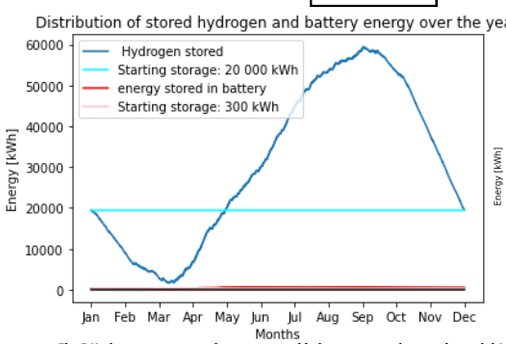


Fig. 5 Hydrogen storage and energy stored in battery over the year in model 2

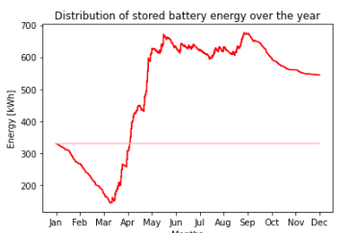


Fig. 6 Energy stored in battery close-up over the year in model 2

Cost comparison

	Input	Output			
Devices	**Efficiency**	**Model 1**	**Cost [USD]**	**Model 2**	**Cost [USD]**
Solar PV panels *	**0.24**	**13.3 times what is installed today**	**4e+05**	**13.2 times what is installed today**	**4e+05**
Battery *	**0.90**	**--**	**--**	**680 KWh**	**5.1465e+05**
Inverters *	**0.95**		**30e+03**		**30e+03**
Fuel Cell	**0.5**	**31.5KW**	**1.1815e+04**	**31.5KW**	**1.1815e+04**
Electrolyzer	**0.75**	**165.8KW**	**1.8238e+05**	**137KW**	**1.507e+05**
Hydrogen Storage **	**1**	**At most 1507 kg**	**9.946e+05**	**At most 1498 kg**	**9.89e+05**
Total			**1.61e+06**		**2.1e+06**

***These are approximate estimations of the actual price of the system, the actual cost depends on several factors that are unique to each individual case. Additionally the cost of PV panels may reduce in the next years due to advancements in technology, government incentives and policies, etc.**

****For the hydrogen storage, we chose storages for compressed hydrogen at 700 bars. It is simple and cost effective however it requires high pressure storage in which the tanks are heavy and take up a lot of space.**

Table 1 - cost comparison between model 1 and 2

Energy comparison

Energy	Model 1	Model 2
Demand	**83 816 kWh yearly**	**83 816 kWh yearly**
Produced	**162 957 kWh yearly**	**161 732 kWh yearly**
Energy lost in conversion	**79 141 kWh**	**77 916 kWh**

Table 2 - Energy comparison between model 1 and 2

Conclusion

- **A system consisting of a combination of battery, fuel cell system and an electrolyser with hydrogen storage can be feasible for the building to be self-sufficient from solar without grid support.**
- **After comparing the two models, a conclusion is made that both systems are operational yet very costly. However model 2 is recommended out of its stability to ensure the equilibrium of the system.**
- **Its high cost is mainly because of the oversized batteries employed to store the surplus energy from solar during the summer.**
- **A rather practical and cost saving option would be to connect the building to the grid and use the electricity from the grid rather than the system consisting of batteries and fuel cell systems.**
- **A future recommendation is the consideration of grid support for ancillary services (FRR) when fluctuations in grid occur.**

Main take-aways

- **To be self-sufficient a lot of energy is needed**
- **It is possible to build a system that is self sufficient and can rely on hydrogen for variation.**
- **An island energy system consisting of solar PVs, electrolyser, fuel cell and battery has a high cost**

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