Techno-economic Comparison Between Multiple Forecourt Electrolysers and Central Hydrogen Production

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Introduction

- *Hydrogen can be produced in small units where it is needed, in a manner known as "distributed production."*

- *Distributed production may be the most viable approach for introducing hydrogen in the near term in part because the initial demand for hydrogen will be low.*

- *Two distributed hydrogen production technologies that may offer potential for development are (1) reforming natural gas or liquid fuels, and (2) small-scale water electrolysis.*

- *large central hydrogen production facilities (750,000 kg/day) will be needed in the long term to meet the expected large hydrogen demand.*

Introduction

- *Compared with distributed production, centralised production will require more capital investment as well as a substantial hydrogen transport and delivery infrastructure*

- *Intermediate-size (semi central) hydrogen production facilities (5,000–50,000 kg/day) located in close proximity (25–100 miles) to the point of use may play an important role in the long-term use of hydrogen as an energy carrier.*

- *Intermediate-size can provide not only a level of economy of scale but also minimize hydrogen transport costs and infrastructure.*

Operation summary

- *Flexible operation of electrolysis (DSM) will be tested for both production ways.*

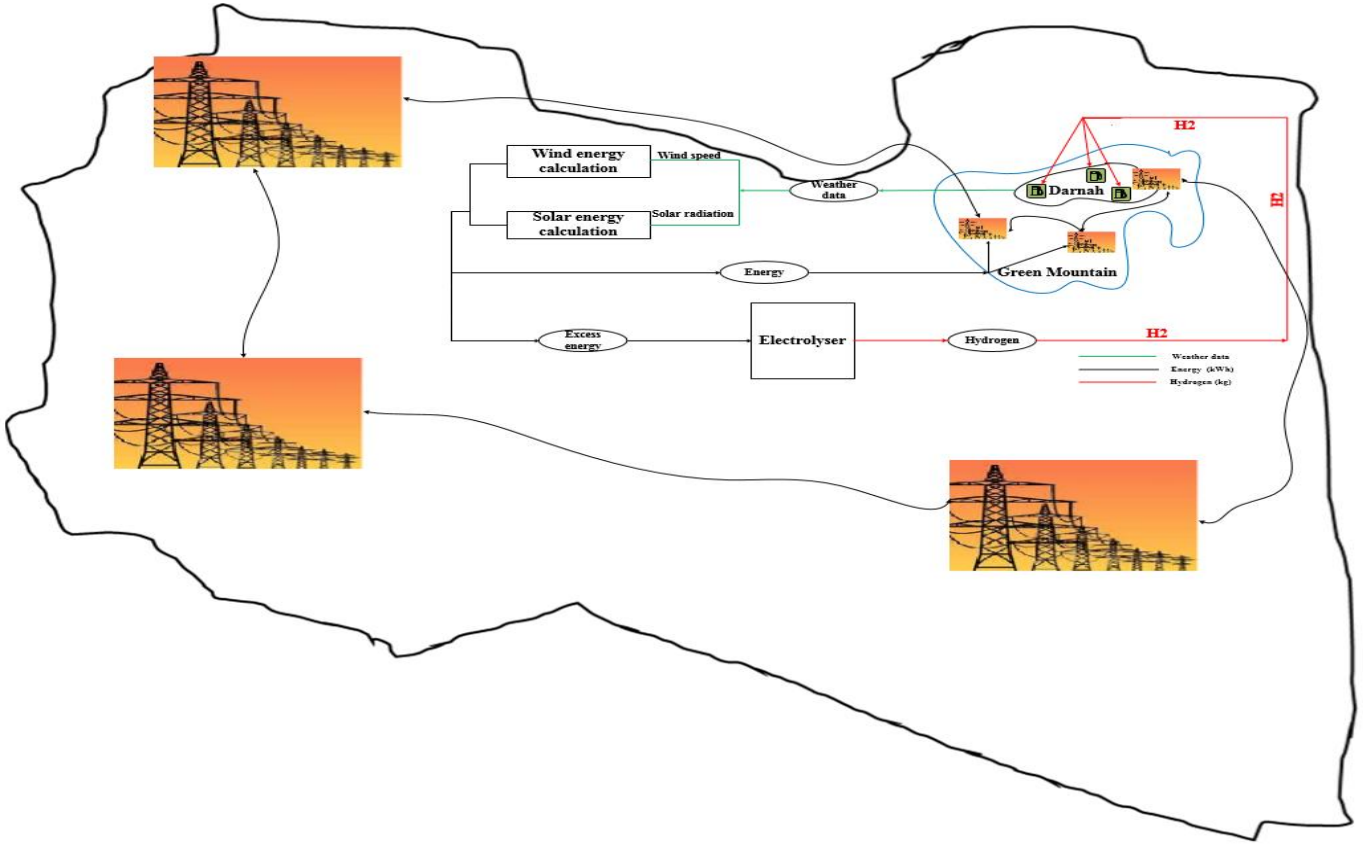
- *The produced hydrogen will be used as a clean fuel to replace fossil fuels*

- *Three main factors needs to be investigated and compared between the two production ways (central and decentral)*
  - *grid balancing based on the excess power absorption.*
  - *Hydrogen fuel demands meet*
  - *The average price of hydrogen*

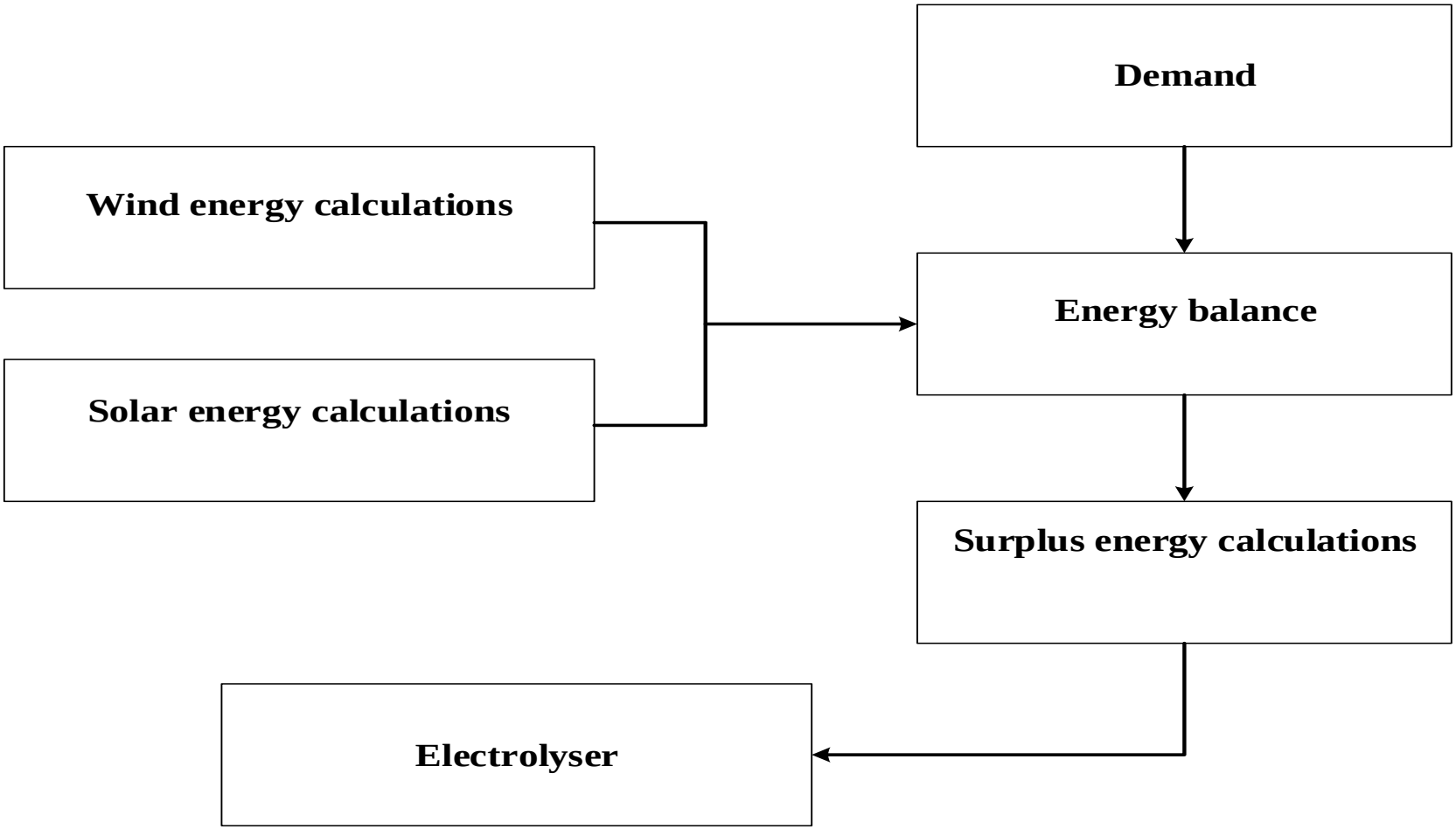
- *The work will focus on focus on Darnah, which is a small coastal city in Libya with a high potential for wind power and solar power.*

Operation summary

- *Solar power and wind power has been calculated and sized based on the green mountain demand , then excess power can be extracted*

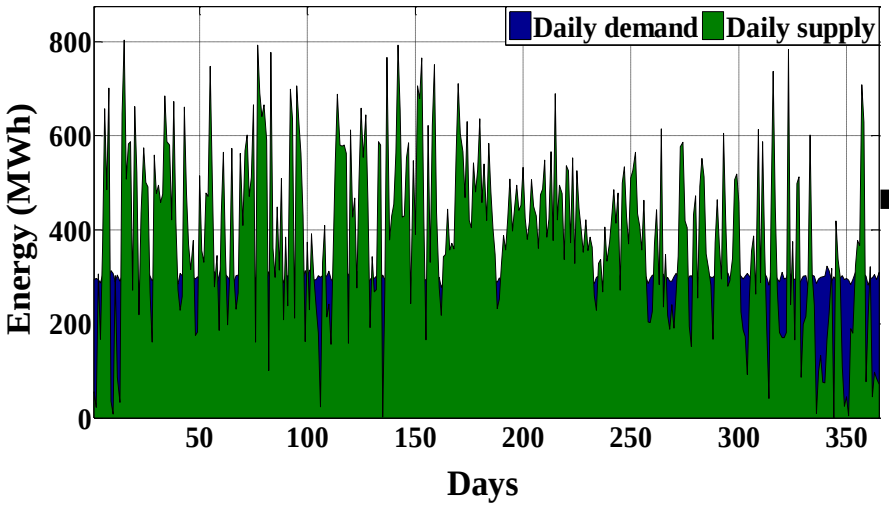


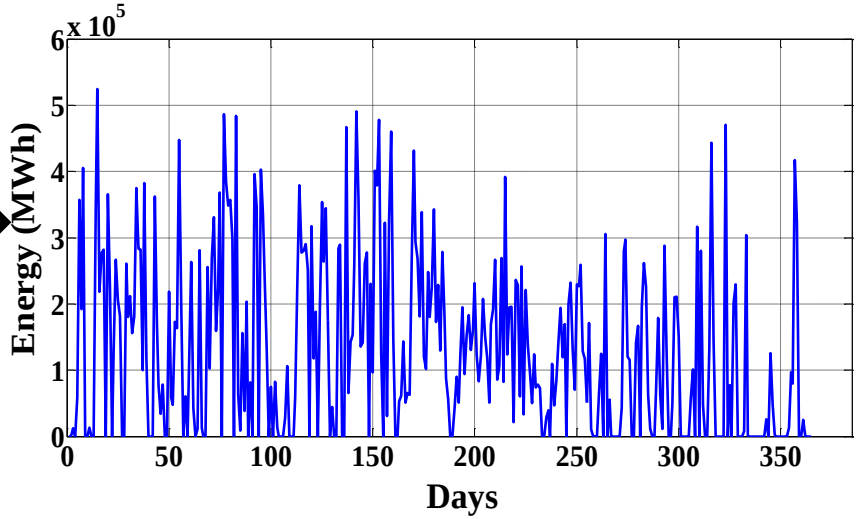
Operation summary



System sizing

- *The total energy produced from the system versus the energy demand in a daily pattern is presented in figures below*





- *Surplus energy can be summarised as*

1- 108 days without surplus energy (0 MWh)

2- 257 days with surplus energy

Hydrogen demand simulation

➢ fuel consumption in Darnah

- There are 6 fuel stations across the city of Darnah with heavy daily consumption.
- The fuel consumption information is obtained from the stations owners' daily records
- Daily average fuel consumption of these stations was 22788 litres/day, 32495 litres/day, 68010 litres/day, 41720 litres/day, 111490 litres/day, and 56485 litres/day for stations 1-6 respectively.

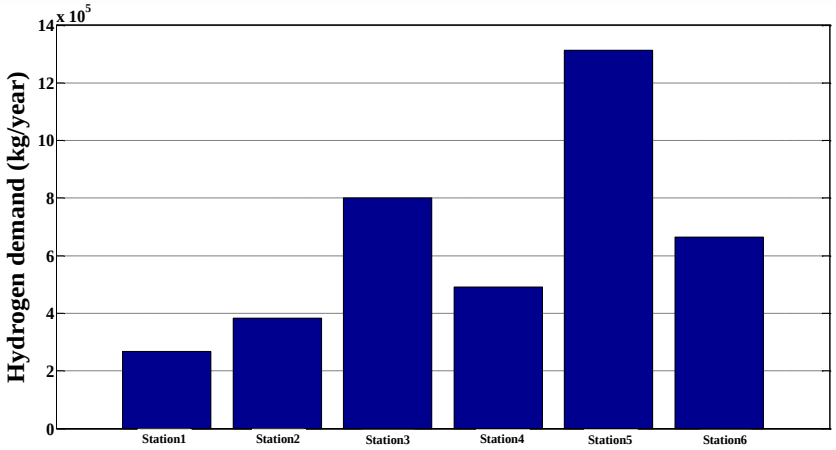
➢ hydrogen consumption simulation

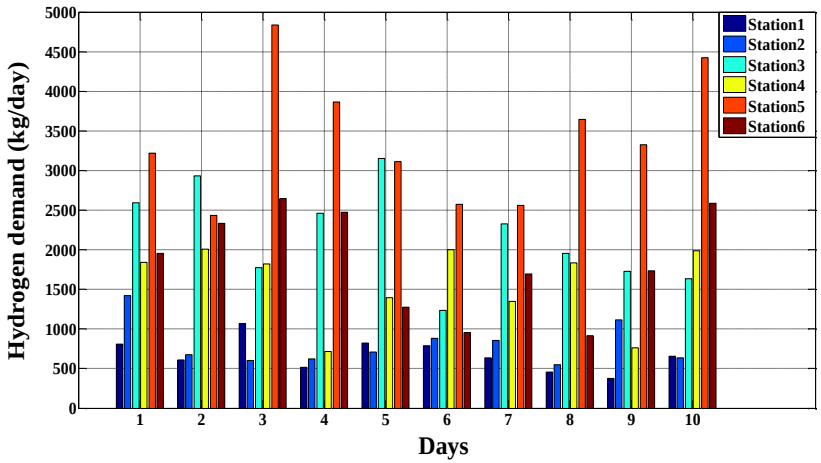
- The estimation of hydrogen refuelling station demand is based on the current petrol stations' data. Our work assumes that 20% of all cars will be fuelled by H2
- 1kg is equal to 1 gallon of fossil fuels, like diesel, or for more clarification the formula below could be applied

$$Q_{H2} = \frac{Q_{ff} \times LHV_{ff} \times \mu_{ff}}{LHV_{H2} \times \mu_{H2}}$$

(hydrogen consumption estimation) Where: Q_{ff} is the demand at a fossil-fuel forecourt, LHV_{ff} is fossil fuel's lower heating value (kWh/kg), μ_{ff} is the efficiency of a fossil-fuelled engine, LHV_{H2} is hydrogen's lower heating value, μ_{H2} is the efficiency of the H2 engine

Hydrogen demand simulation

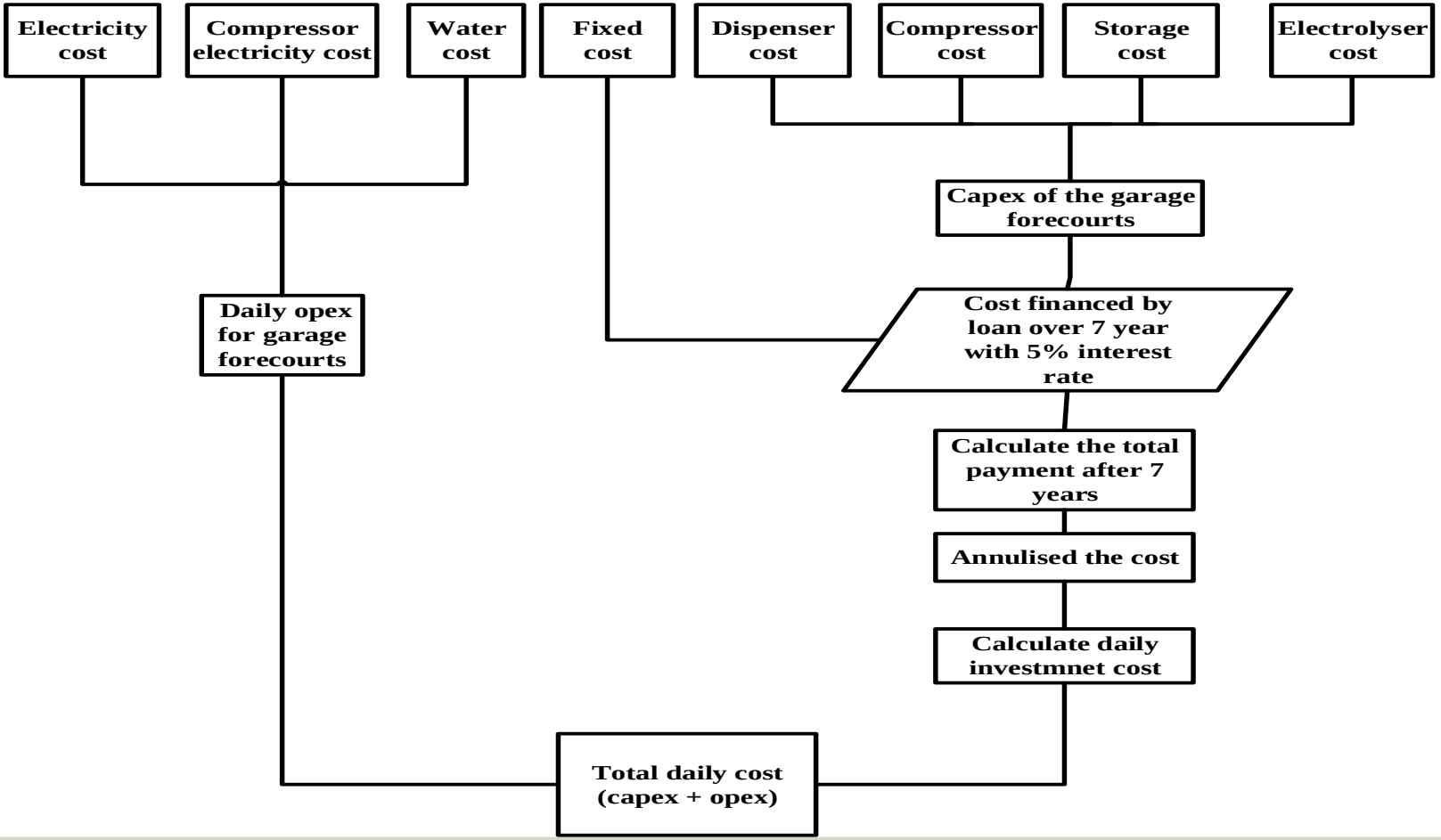




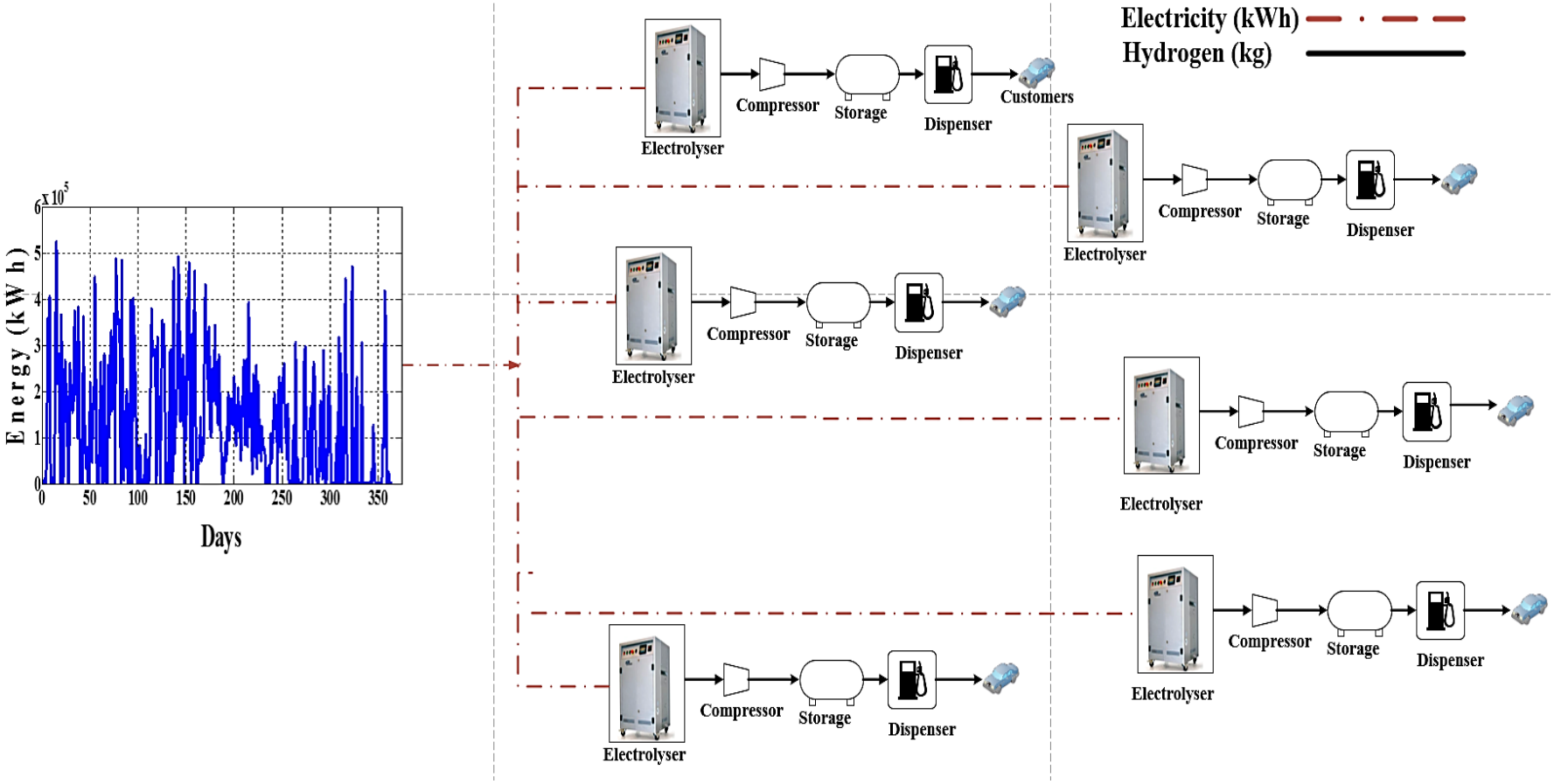
- *Two techniques of hydrogen production will be tested onsite and central electrolyser*
- *Main goals which should satisfied are grid balancing, hydrogen demand meet and average price of hydrogen*
- *alkaline electrolysis will be tested using two different cost scenarios (2015 and 2030).*

Cost calculations

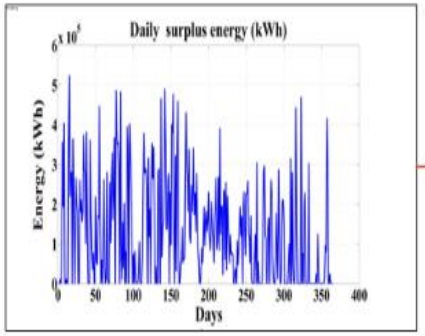
- *The process below summarised the cost calculations*

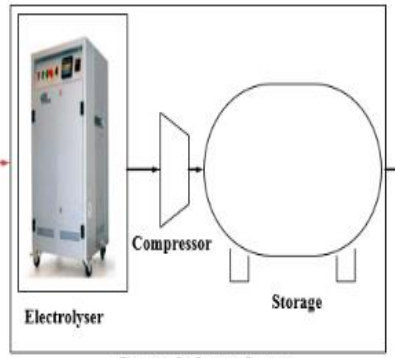


Onsite (decentral) hydrogen production



Central hydrogen production



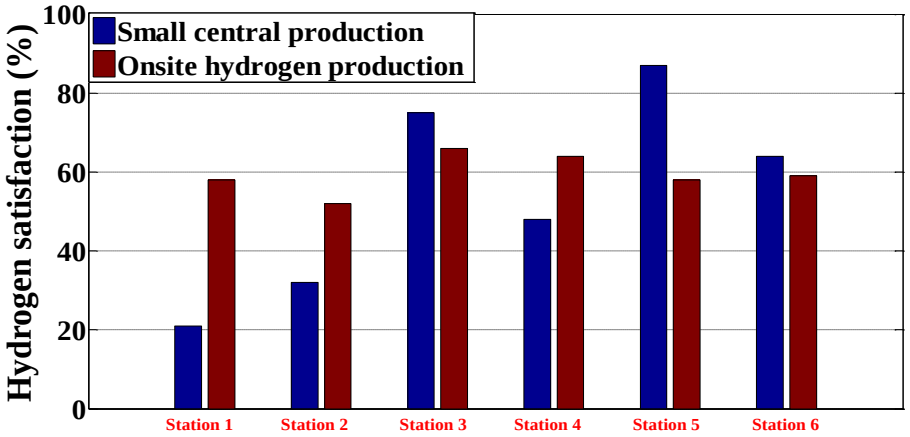


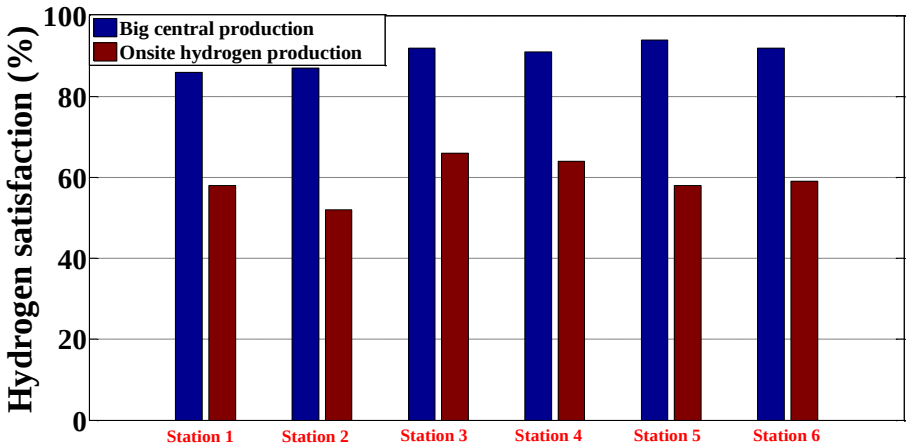
Electricity (kWh)

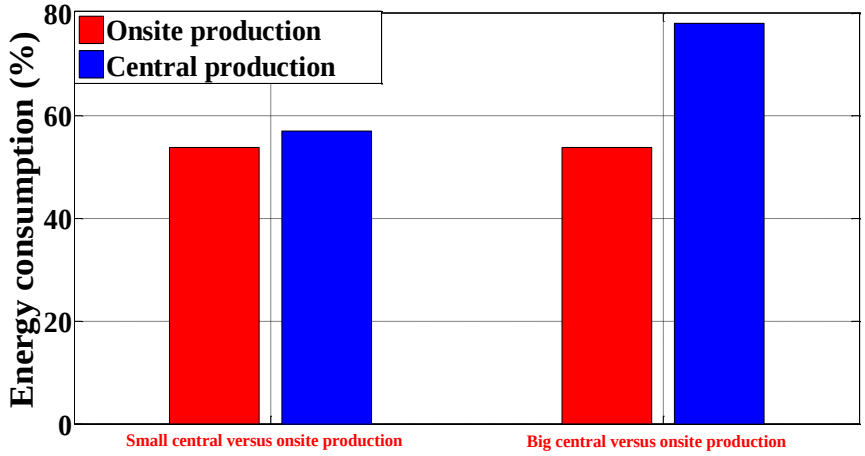
Hydrogen (kg)

2015 cost scenario comparison

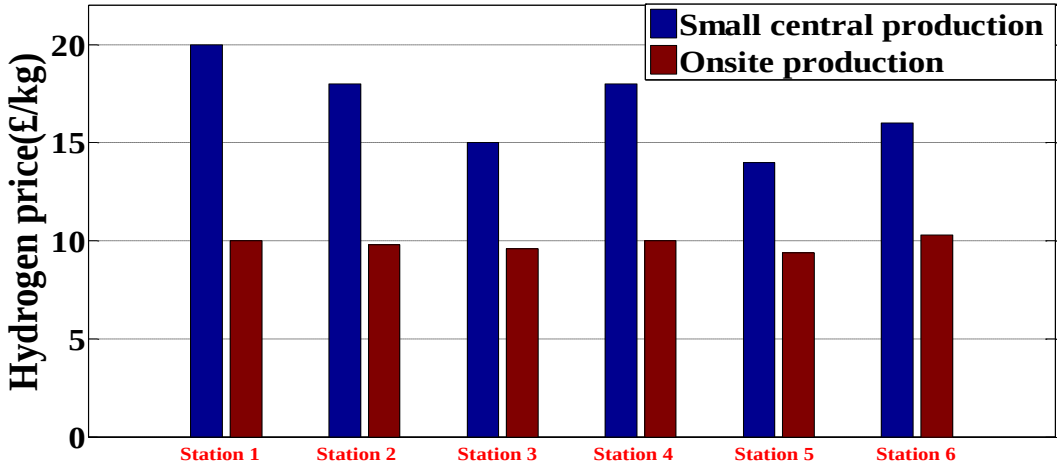
- *Comparison between central production and small onsite electrolyser in each station*

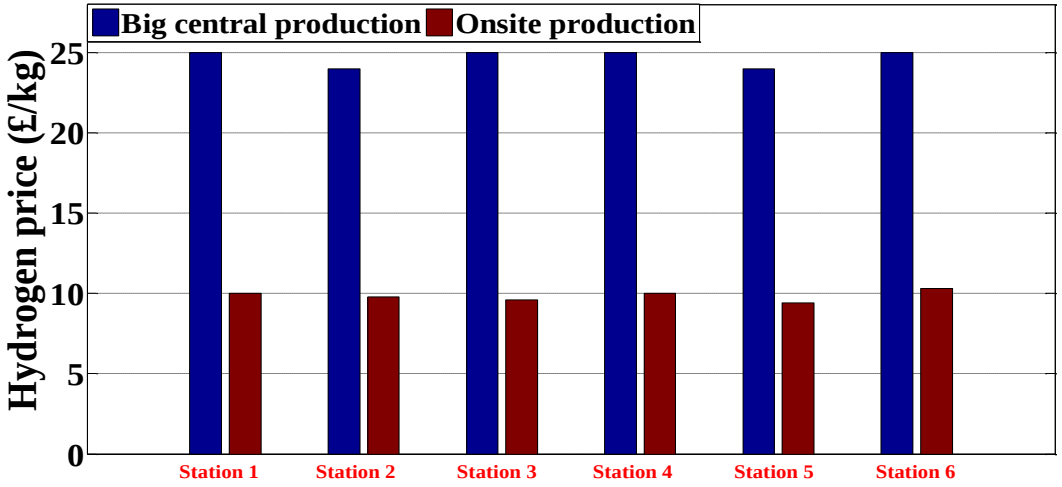






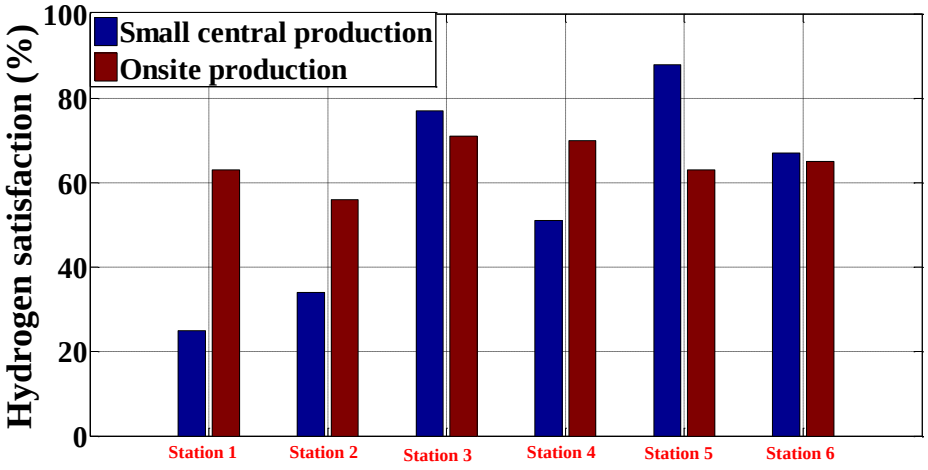
2015 cost scenario comparison

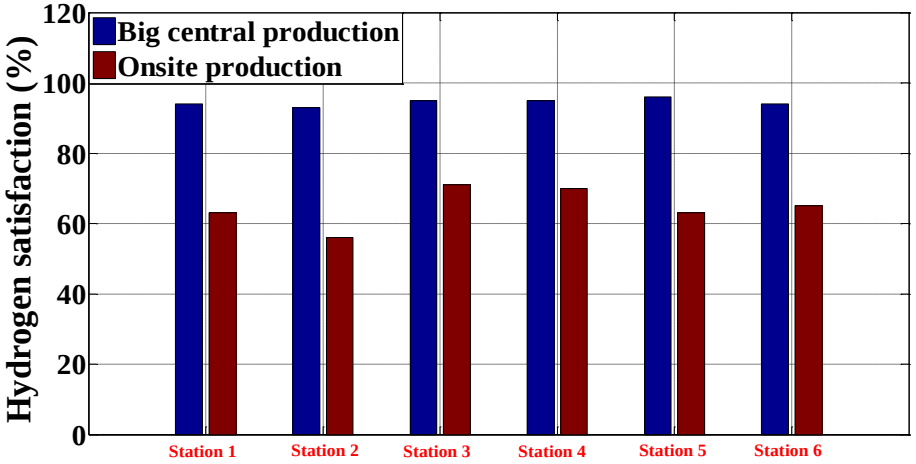


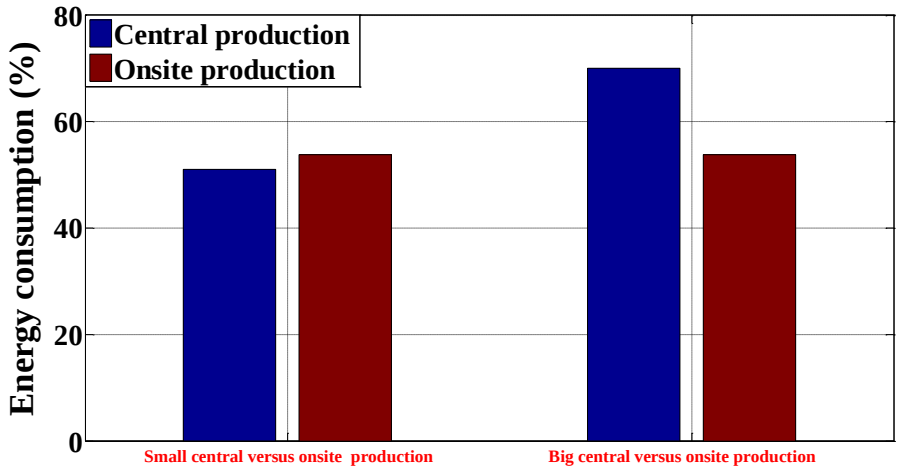


2030 cost scenario comparison

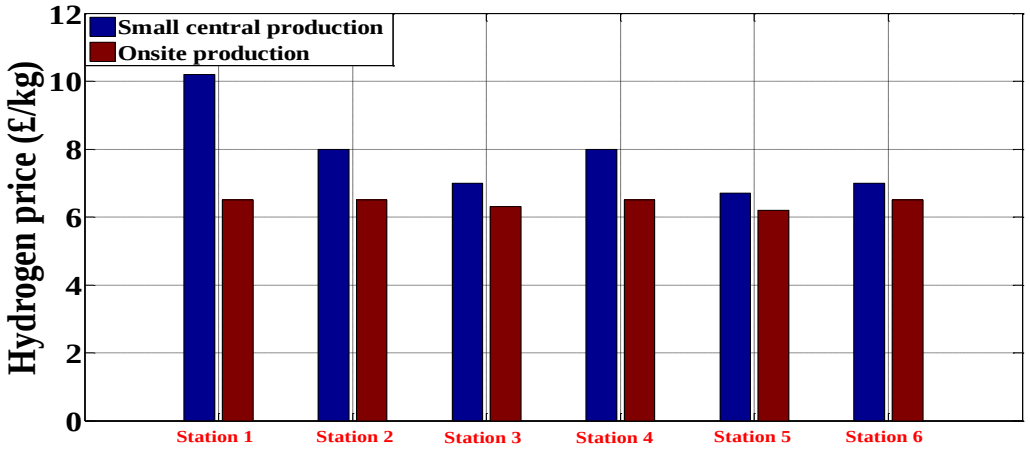
- *Comparison between central production and small onsite electrolyser in each station*

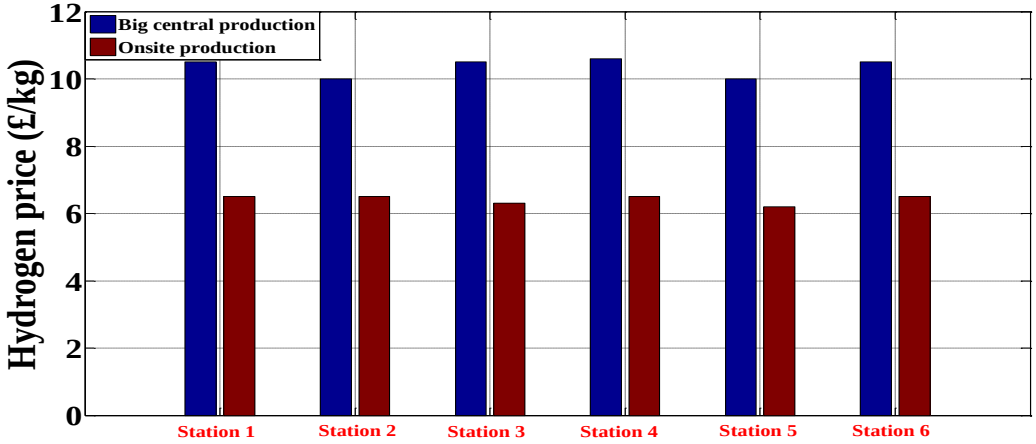






2030 cost scenario comparison





Conclusion

- *"Off-peak electricity was used to produce hydrogen as a way of increasing the penetration of renewable energy sources and to reduce the emissions by using hydrogen fuel instead of fossil fuels*

- *Comparison based on three main goals has been investigated between central and decentral production*

- *The small central and decentral electrolysers can consume nearly same amount of energy. However big central consumption is higher than decentral.*

- *The hydrogen demand meet is higher in big central production method. In small central comparison with decentral case, the hydrogen meet differs between stations.*

Conclusion

- *The average hydrogen price is quite expensive in central case especially in 2015 cost scenario*

- *In 2030 cost scenario the central hydrogen prices has been dropped but still expensive in contrast with decentral production*

- *General speaking , without government support , new policy and regulation, flexible operation of electrolysis seems to be difficult to diffuse and be competitive with the other storage methods and with conventional fuels.*