hypster
Hydrogen Storage

STORAGE NEED CHARACTERIZATION FOR TARGETED PROJECTS AND STANDARD UTILIZATION

Work package 1 - Deliverable 1.2

Authors : Rostand NGAMENI, Gregoire HEVIN, (Storengy)

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GLOSSARY

ELY : Electrolyser

RE : Renewable Energy

Load rate: ratio between real utilization of electrolyser to produce hydrogen and nominal capacity of the electrolyser

Utilization rate: ratio between real time of electrolyser utilization and nominal available time of electrolyser utilization on one year (taking into accounttime for preventive maintenance)

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01

METHOD TO EVALUATE THE NEEDS OF HYDROGEN STORAGE IN ETREZ

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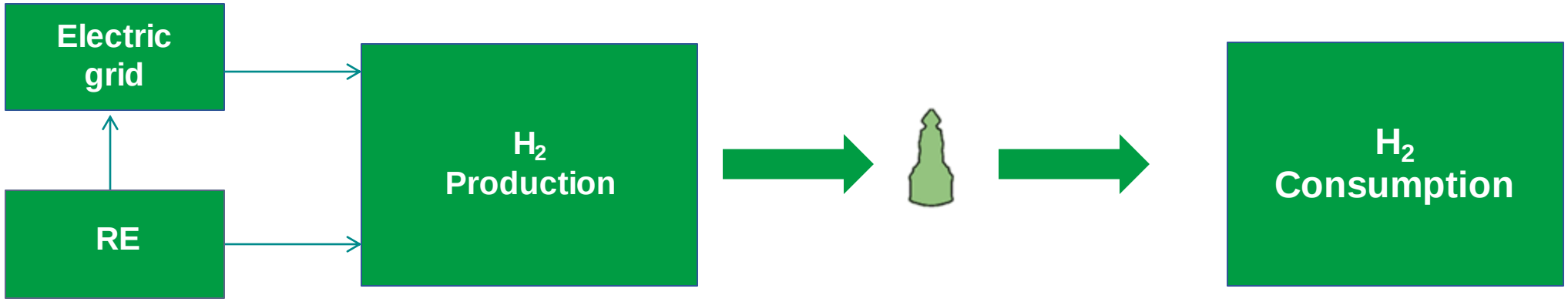
Storage is a system to support the balance between offer and demand, between possible production and consumption needs.



Define hydrogen production and consumption profiles and consequences on the salt cavern design : size, flowrate…

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02

H_2 PRODUCTION

H_2 PRODUCTION PROFILES

The different configurations of the energy landscape where renewable hydrogen production can be variable or continuous (100% load rate)

1st configuration

Connection to electric grid

- The electrolyser is **connected to the electric grid with a RE-PPA** (with origin warranties) to produce renewable hydrogen.
- In this configuration, the electrolyser **load and utilization rates** can be **100%.**

2nd configuration

Connection to electric grid & to RE

- Electrolyser is fed by **RE + a supplement from electric grid** to optimize the loading and utilization rates.
- In this configuration, the electrolyser **load and utilization rates** can be **100%.**

3rd configuration

Connection to RE via electric grid

- The electrolyser is **connected to the electric grid but fed exclusively by RE** via a control system of blockchain type.
- In this configuration, **H_2 production is intermittent**

4th configuration

Direct connection to RE

- The electrolyser is directly connected to RE production field. Two different approach can be considered :
  - priority to the electrolyser
  - Priority to the electric grid
- In this configuration**, H_2 production is intermittent**

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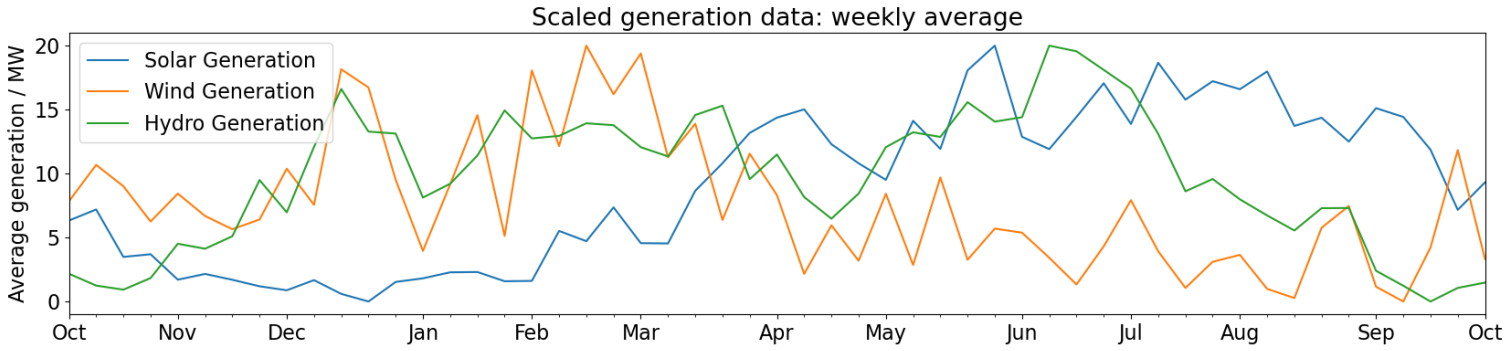
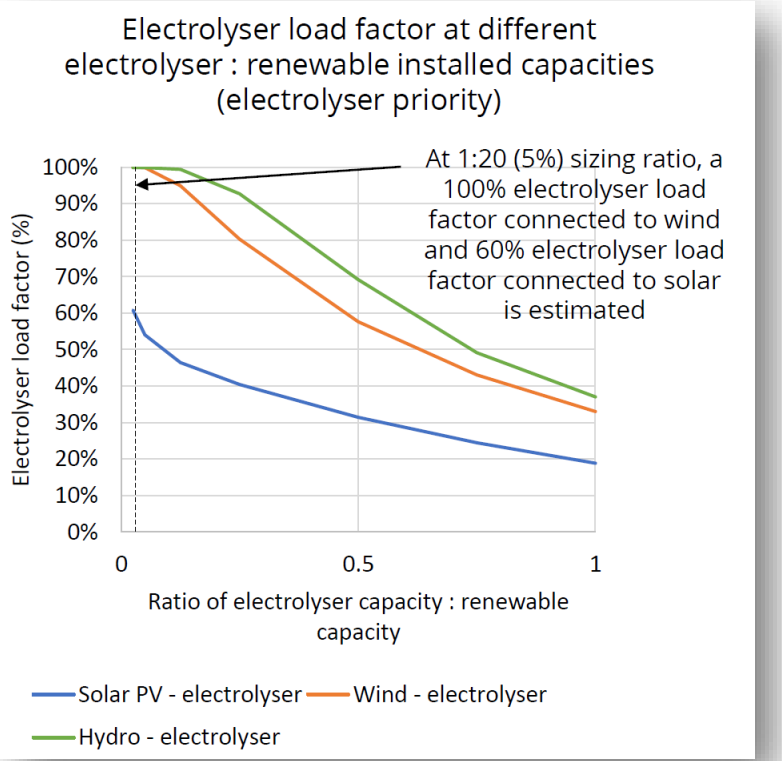
H2 PRODUCTION PROFILES

Hydrogen production will be estimated from a 20 MW RE capacity.
This choice of capacity allows for a significant load rate for a 1 MW electrolyser.

- **RE production profiles:** solar PV and wind in France in 2019-2020 and hydro in the AuRA region (Auvergne-Rhône-Alpes) in 2018-2019.

- For an electrolyser capacity of 1 MW (representing **1/20 or 5%** of the installed RE capacity)
  - **Hydroelectric - wind:** the load rate of the electrolyser is about 100%,
  - **Solar PV:** the load rate of the electrolyser ~ 60%.





Source : Element Energy, D1.1 Hypster Project

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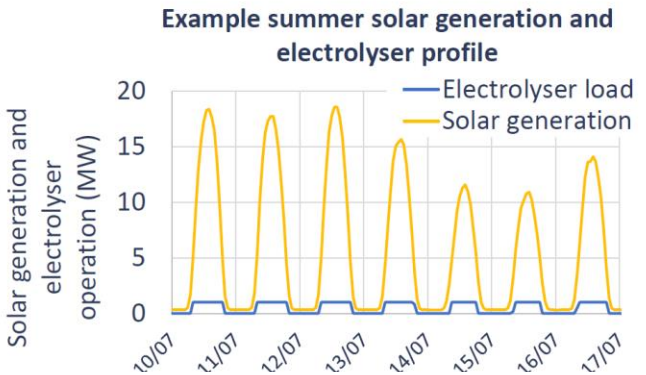
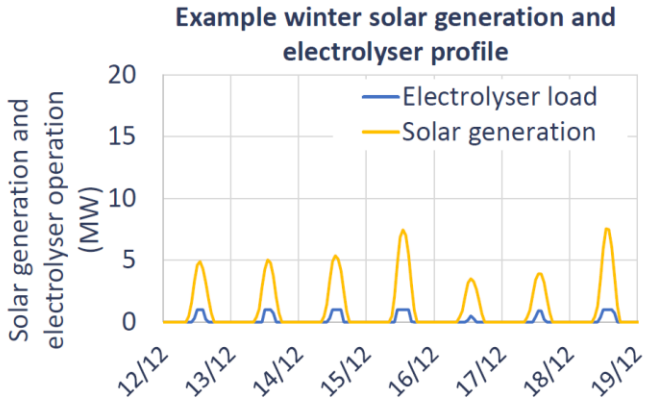
H2 PRODUCTION PROFILS

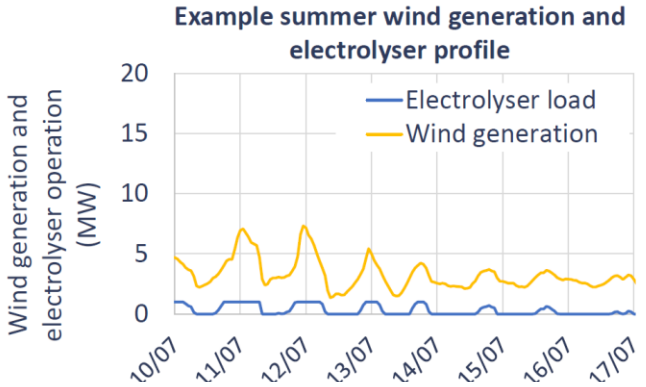
Different electrical profiles (PV, wind, AURA hydro) and electrolyser load rates

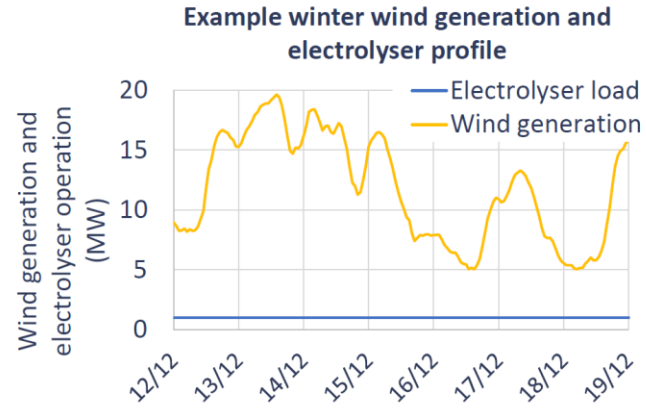
PV



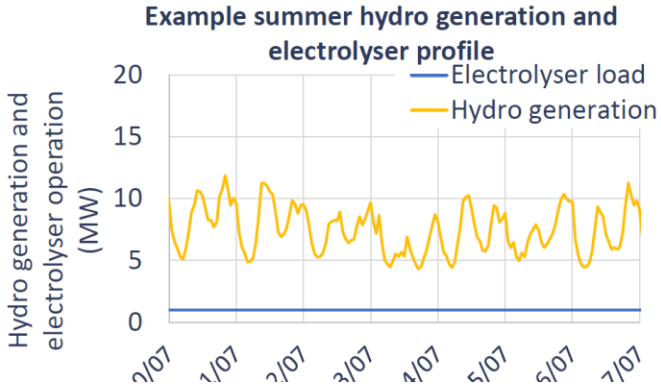


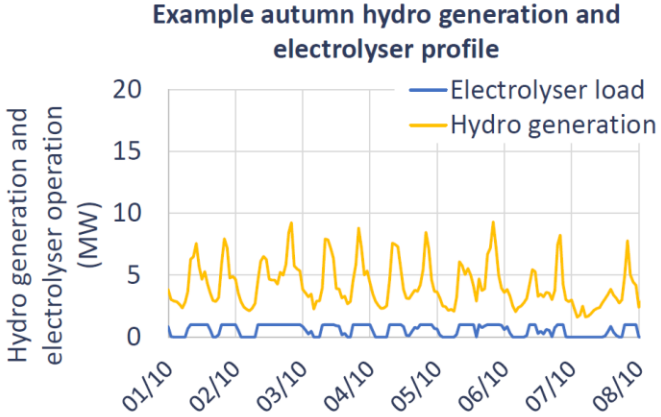
Wind





Hydropower





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03

H_2 NEEDS IN ETREZ AREA

H_2 USES : NEEDS (HORIZON 2025)

H_2 projects list in an area of 150 km around Etrez site

Mobility project	Owner	Distance (km)	Status	Production Capacity (kg/day)	Consumption (t/year)	Estimation Back-up needs (t/year)
Bourg-en-Bresse	Hympulsion (ZEV)	18	In project development	40		0,6
Dijon (ELY)	DMSE	149	Under construction	440		8,8
Lyon (quai des énergies)	CNR/ENGIE	110	Under construction	80		1,2
Lyon (Port Edouard Herriot)	ENGIE	105	In operation	20		0,3
Meyzieu (ELY)	Hympulsion (ZEV)	95	In project development	200		3,0
Macôn	MBA / ENGIE ou ZEV		In project development	40 - 200		1,5
Roussillon (38550)	ZEV	147	In project development	40		0,6
Trévoux – 11 BHNS	ZEV	70	In project development	327	108	4,9
Villefranche-sur-Saône	Hympulsion (ZEV)	75	In project development	40		0,6

Source : https://vighy.france-hydrogene.org//

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ESTIMATION OF STORAGE NEEDS

Two types of services are considered:

- **Projects with H_2 production (electrolysis) on site:**

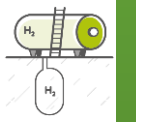
Supply hydrogen back-up to compensate for scheduled or unscheduled unavailability of production facility (preventive or corrective maintenance),

- **Projects without H_2 production on site:**

Provide H_2 in function of their needs from the production or from the storage

Assumptions

projects with on-site electrolysers will be counted as back-up needs



- **Hydrogen back-up: 15 days/year distributed as follows**
  - 5 days × 2: 5 consecutive days per semester for preventive maintenance,
  - 5 days randomly distributed throughout the year (curative maintenance)

projects without electrolyser will be counted as potentially hydrogen needs

- **Hydrogen supply**: supply to cover the hydrogen needs of ~ 300 days a year (excluding Sundays)

Real Expression of Needs

- Today, only two project owners express their needs for back-up: Hympulsion and DMSE
- Only one potential need of H_2 supply for a local industry

Estimation of needs

Back-up hydrogen

DMSE: on short term with 1MW electrolysis needs estimation of **8.8 tons/year** (1st year), then electrolysis will pass to 11MW, on long term needs estimation of **6.6 tons/year**

Hympulsion (ZEV) : 3 electrolysers with 8 MW of total capacity are planned in this project. Needs estimation of **48 tons/year**

Total estimation of back-up service:

55 tons/year

Hydrogen Supply :

One local industry with a potential need estimated to about :

100 tons/year

(eq. 300 kg/d)

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A SIMULATION TO DETERMINE THE LEVEL OF STOCK AND THE CYCLING OPERATION IN THE CAVERN

The simulation model calculates the level of storage in the cavern on a daily basis, taking into account the H_2 production by the electrolysis and the consumption for back-up and supplies.

Prod - Cons

< 0 → **Stock + Prod - Cons**

- < 0 → →
- > 0 → Stock(d+1) = stock(d) + Prod(d+1) - cons(d+1)

> 0 → **Stock + Prod - cons**

- < C_{max} → Stock(d+1) = stock(d) + Prod(d+1) - cons(d+1)
- > C_{max} → Stock = C_{max} →

Prod = production,
Cons = consumption,
Stock = level of storage ,
C_{max}: maximal capacity of storage

The structural elements to cover the demand are: initial stock in the cavern (day = 0), working H_2 capacity of storage, electrolysis capacity on site, maximal withdrawal flowrate (time to load a trailer)

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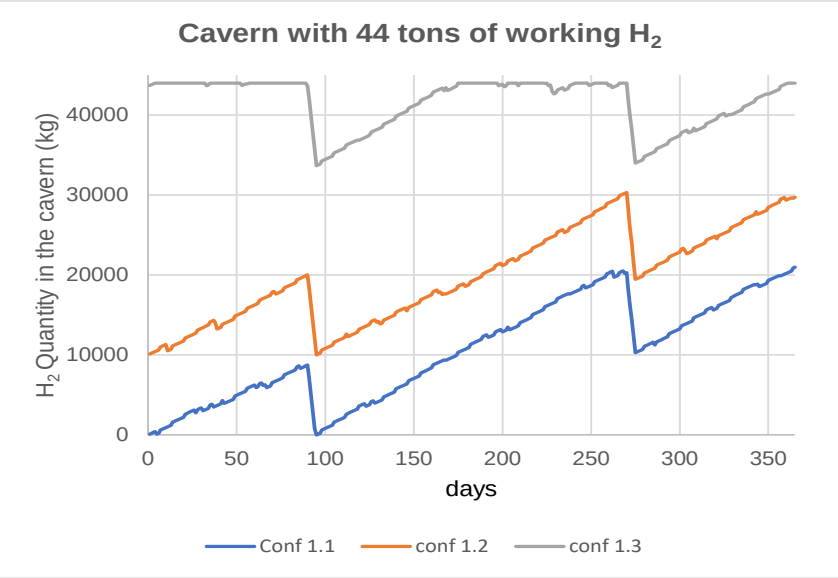
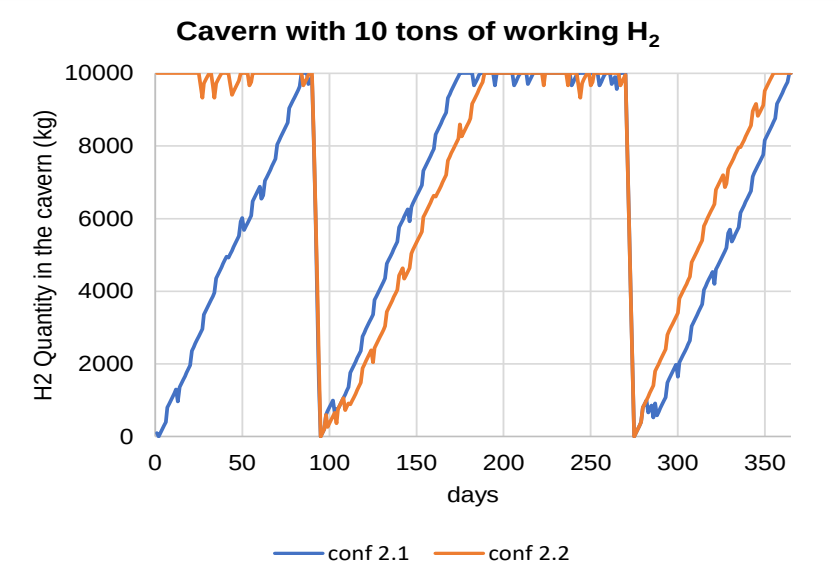
RESULTS OF THE SIMULATION





Configurations	Working H_2 capacity (t)	Initial level of H_2 stored in the cavern (t)	Lack of supplying (t/y)
Conf 1.1	44	0	2,5
Conf 1.2	44	10	0
Conf 1.3	44	44	0
Conf 2.1	10	0	~ 4
Conf 2.2	10	10	~ 2

Hypothesis 1: **worst case** – preventive maintenance at the same time in the year

Hypothesis 2: **Back-up** (~6,6 t/y + 48 t/y) + **Regular supplying** (~ 100 t/y) = **~ 150 t/y**

Hypothesis 3: **No irregularity** in the electric supplying for the electrolyser (electricity from the network)

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RESULTS OF THE SIMULATION

Result of the analysis:

- Today, with the 3 hypothesis, for 1 MW of electrolysis capacity on site and with the identified uses, if the cavern is initially empty (configuration 1.1), the demand cannot be totally covered (lack of supply of 2.5 tons).

  If the cavern is initially full (configuration 1.3), there is no lack of supply.

  The simulation allows to optimize the level of initial filling: the cavern initially filled with only 10 tons allows to cover all the demand.

- A second calculation takes into account a working H_2 capacity of 10 tons instead of 44 tons (possible with a partial first filling in EZ53). It shows (configuration 2.2) that the lack of supply is limited (lack of supply of about 2 tons).

  An optimization shows that with a storage capacity of **14.5 tons** allows to cover all the demand.

  This 14,5 tons has to be compared to the 44 tons of EZ53 maximal capacity. New clients of renewable H_2 have to be found to use this maximal capacity.

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04 | CONCLUSION

CONCLUSION

This document correspond to the Deliverable 1.2 of the Work Package 1 of the HyPSTER project.

It is based on the possible H_2 production with 1MW electrolyser on site and the identified projects in the area of Etrez which will need renewable H_2 or back up services of renewable H_2 in near future.

Simulations show that, today, a capacity of 14.5 tons of hydrogen is enough to cover the demand of the identified projects.

Nevertheless, nowadays, the market of renewable hydrogen is in permanent evolution, the demand is growing with new projects days after days.

In a first step, the 44 tons maximal capacity of EZ53 cavern could be a good size to support the development of this H_2 market in the area for the 5 next years.

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