Underground Hydrogen Storage

The Austrian Experience

RAG AUSTRIA AG

Vision

The key for a safe energy future

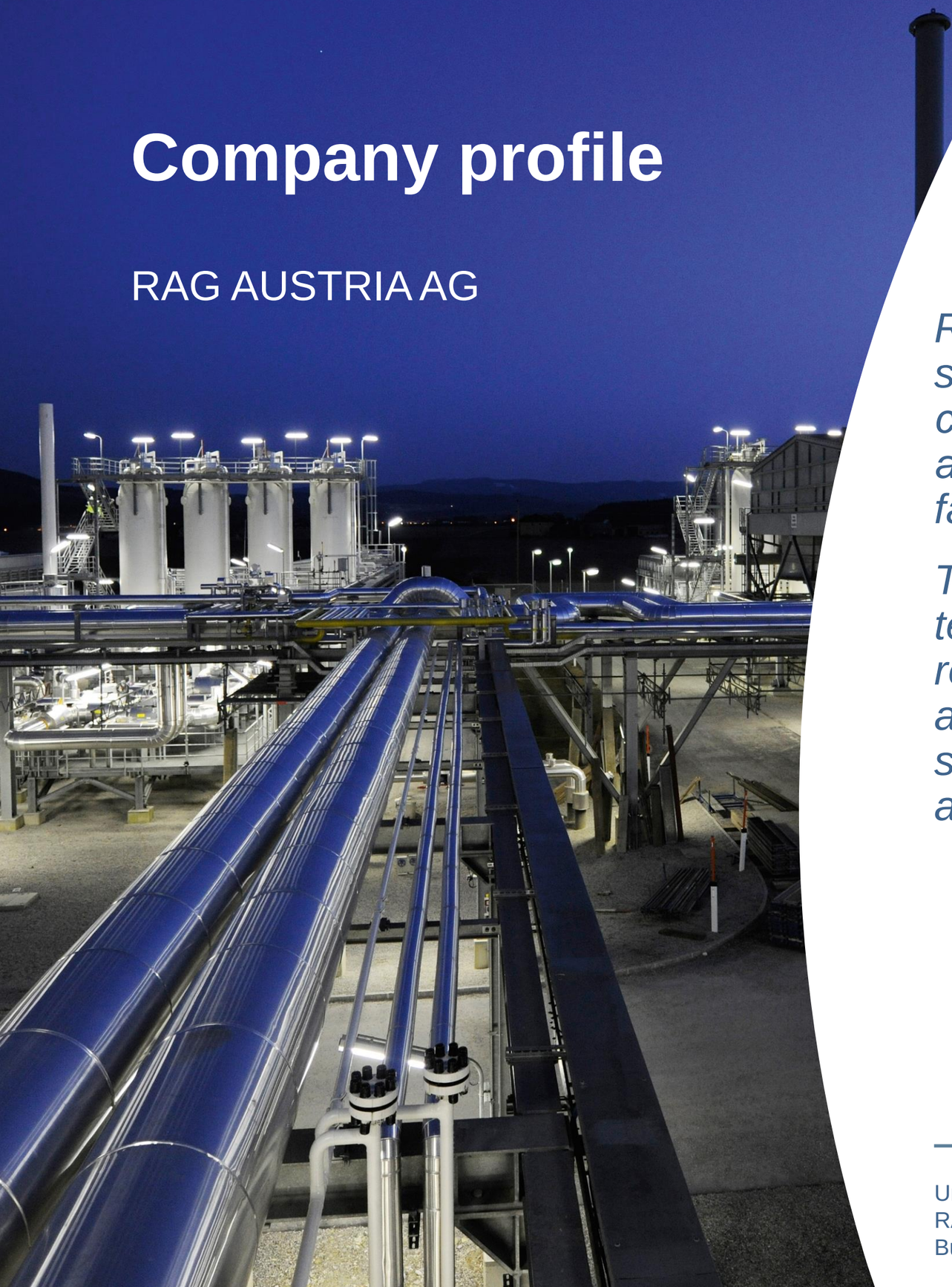
strong expansion of

HIGH VOLUME SEASONAL STORAGES

+ Wind + Sun = ++ Storage

Company profile

RAG AUSTRIA AG



RAG Austria AG is Austria's largest gas storage operating company – making it the country's biggest energy storage provider – and one of Europe's leading gas storage facility operators.

The company develops pioneering energy technologies that act as partners to renewables. Its portfolio of business activities also includes gas production, supply and trading, as well as the use of gas as a transport fuel.

Key Performance Indicators Gasstorage

Sum of all RAG Austria AG Storages		09/2019
Working Gas Volume	mn cm^3	5.991
Max. Withdrawal Capacity	cu m/h	2.783.900
Max. Injection Capacity	cu m/h	2.279.00

Underground Hydrogen Storage
RAG Austria AG
Budapest 04.12.2019

Gas storage facilities

Underground Hydrogen Storage
RAG Austria AG
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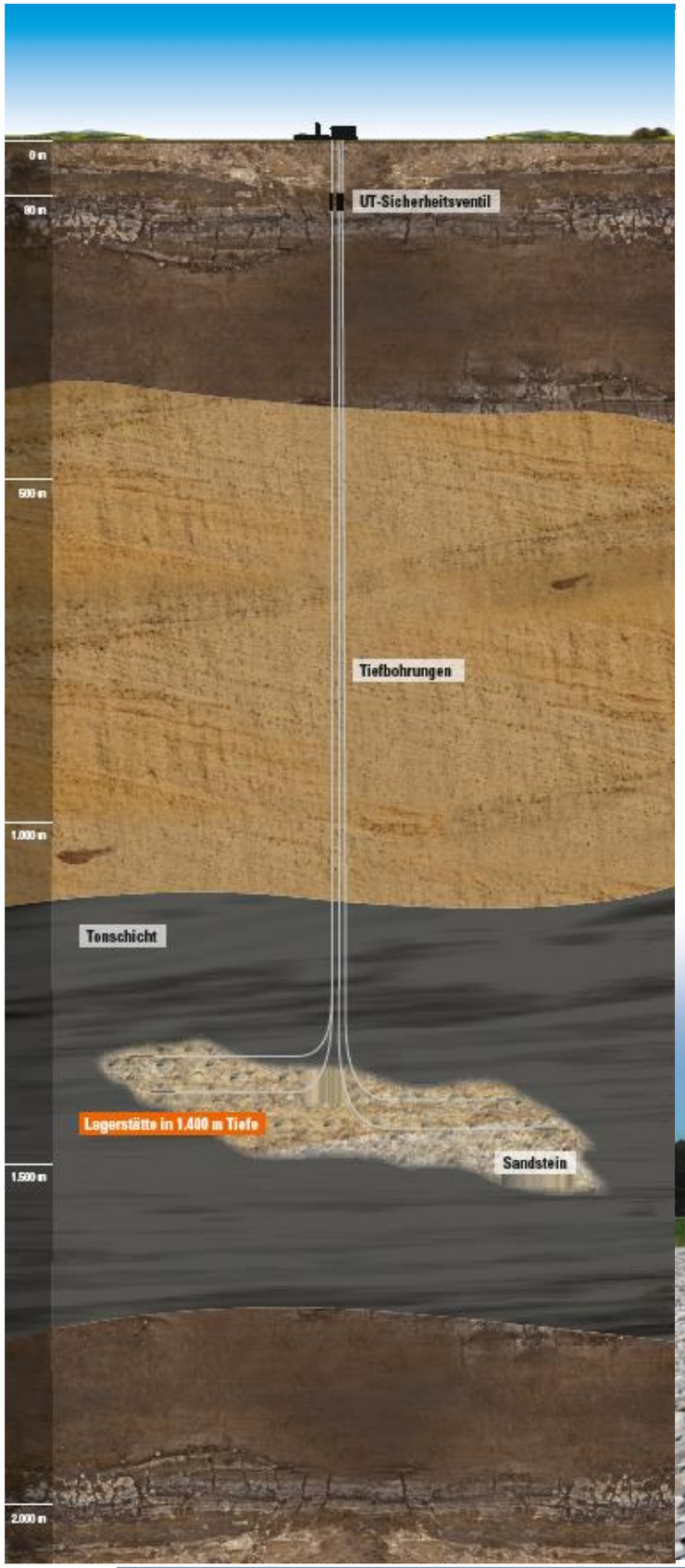
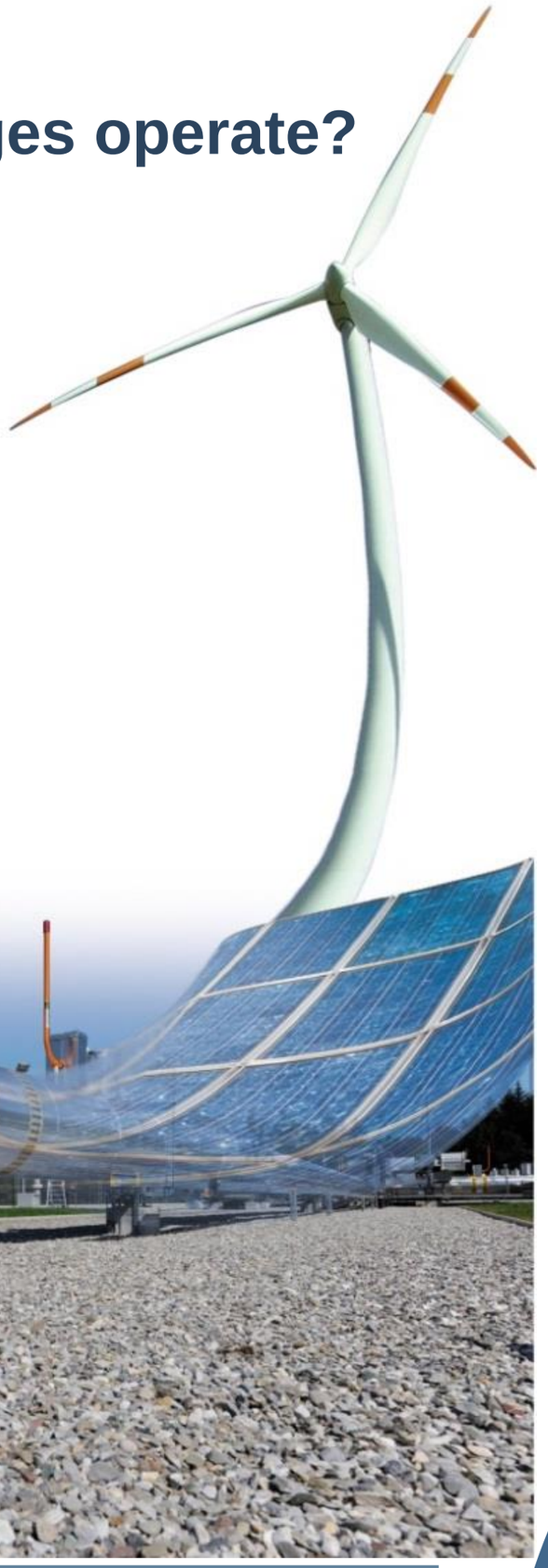
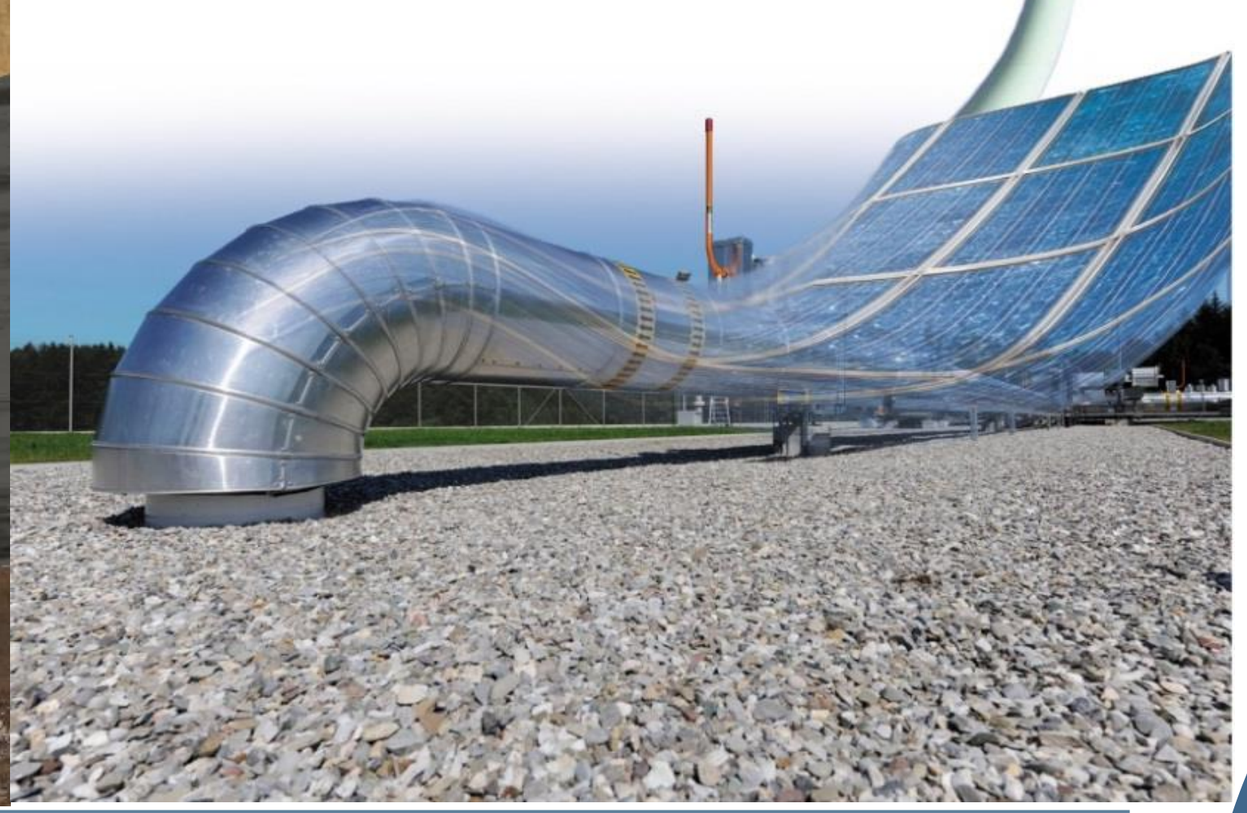
How do gas storages operate?







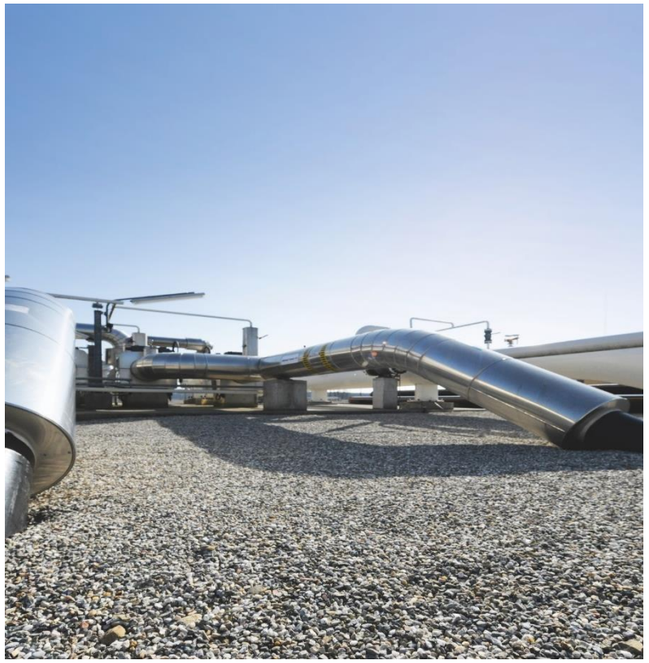
Fourth Largest Storage operator in Europe

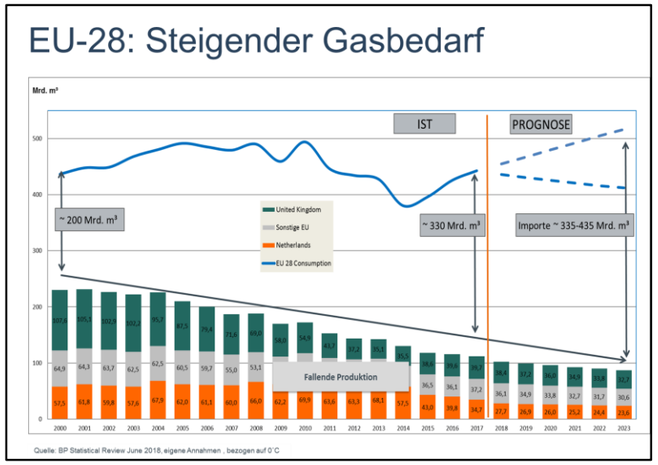
RAG ENERGY STORAGE

JOINT VENTURE Storages

AUSTRIA AG

The role of underground gas storage in a future gas market



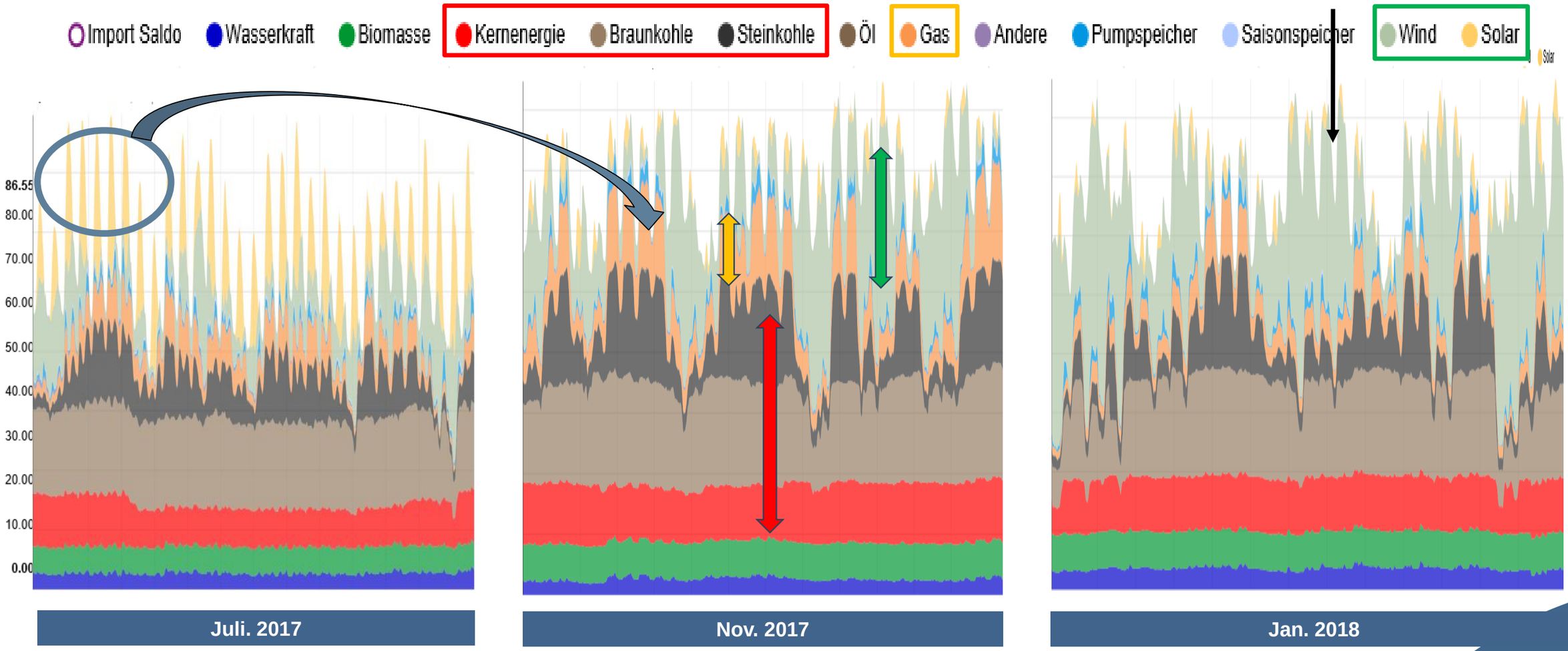


- Europe needs GASstorages
  - Decreasing domestic production
  - High dependency on imports (75% for Hungary)
  - High demand on energy security
- Additionally strongly increasing demand on energy storage because of fluctuating renewable energy generation (wind, sun, water)

Electricity Generation in Germany

Additionally heating and traffic should also be electrified

≈

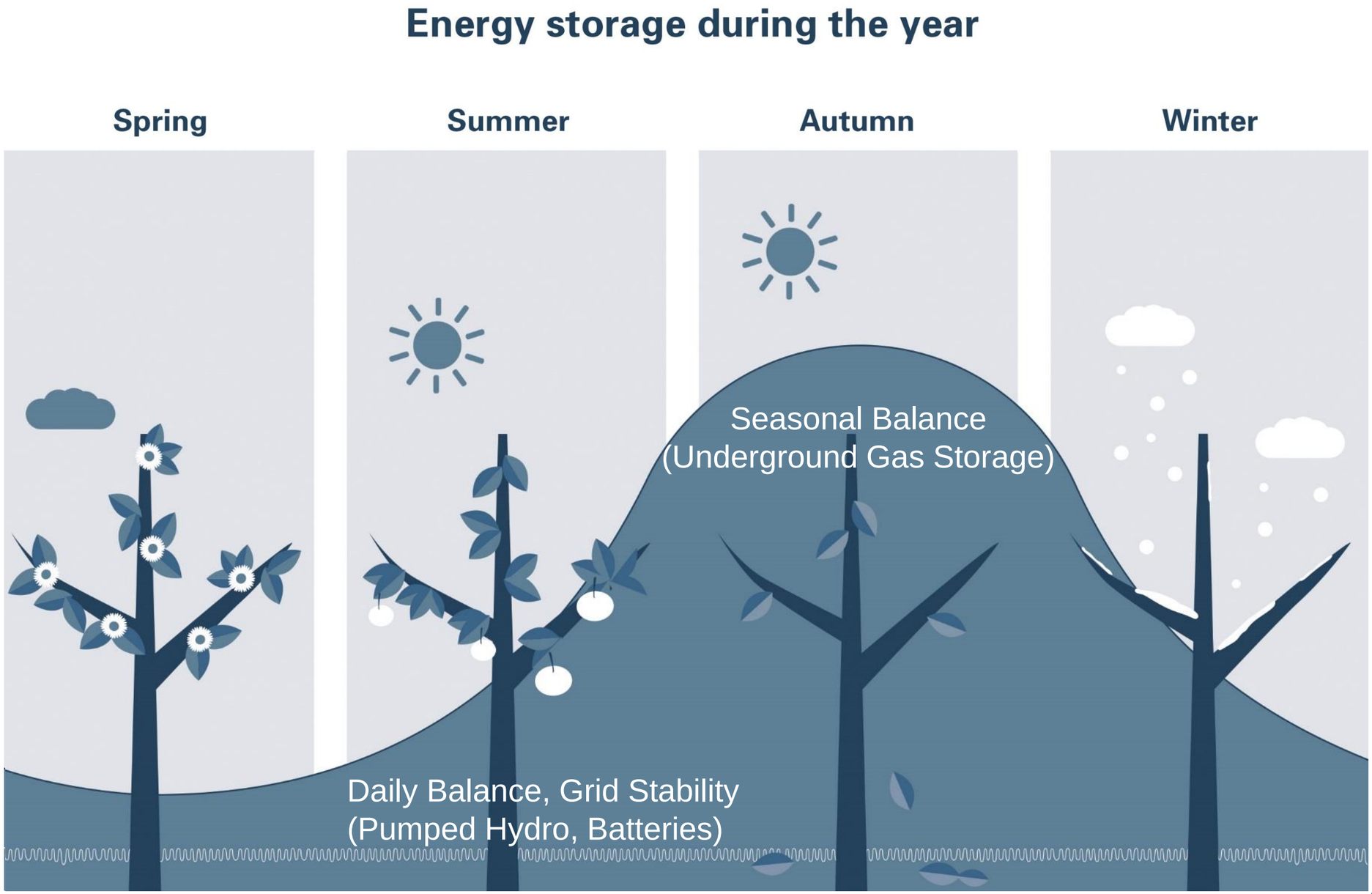


Juli. 2017 | **Nov. 2017** | **Jan. 2018**

Quelle: energy-charts.de

- Replacement of coal and nuclear energy via wind, solar and gas
- Extensive use of gas power plants increases storage demand
- Seasonal shifting of renewable energy is necessary

Different Services:

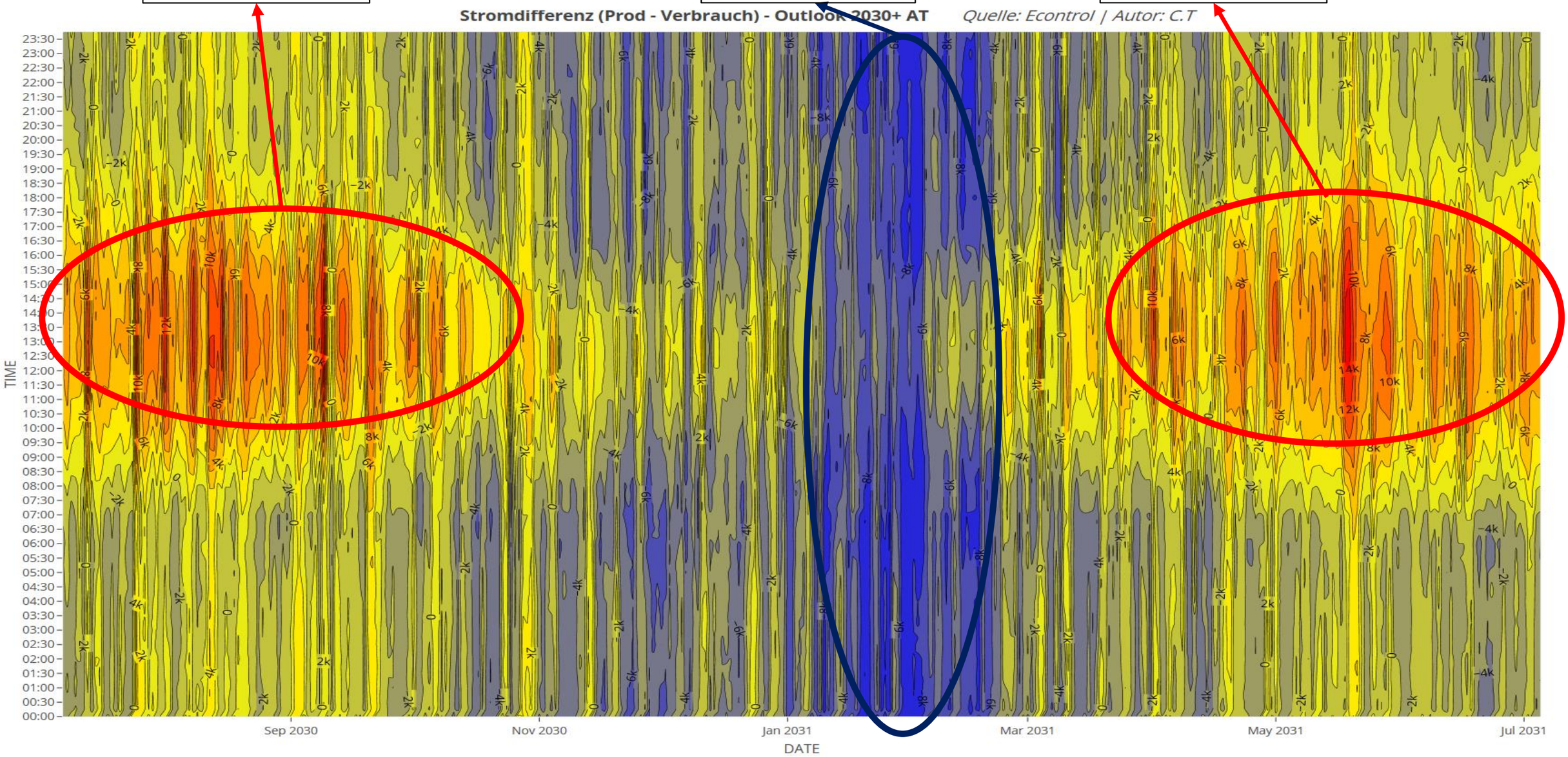


2030+ residual scenario for electricity in AT

+ 12.000 MW
lasting for months

- 8.000 MW
lasting for months

+ 12.000 MW
lasting for months

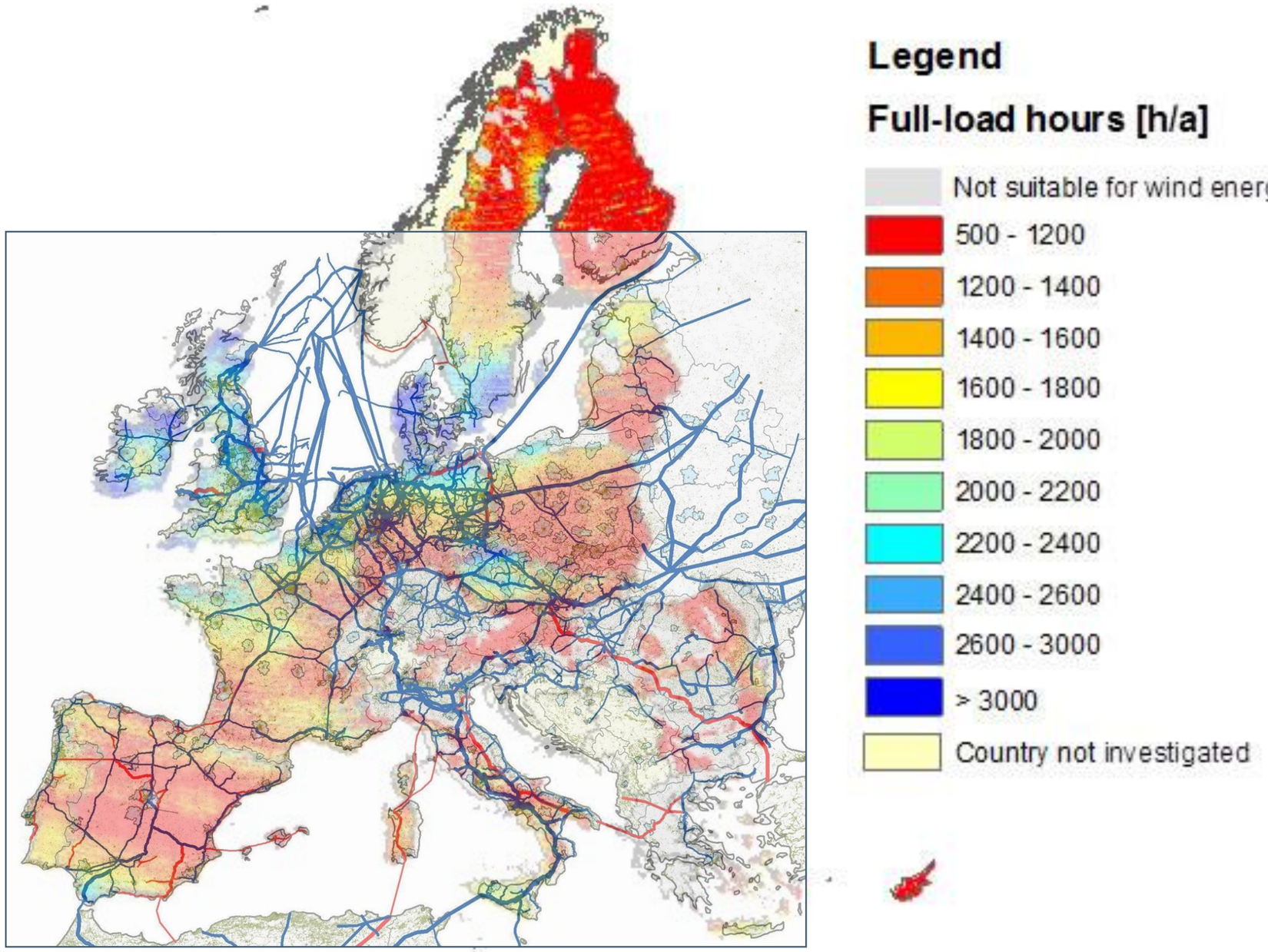


INPUT data: 2030+ vs. 2017 @15 minute intervals:

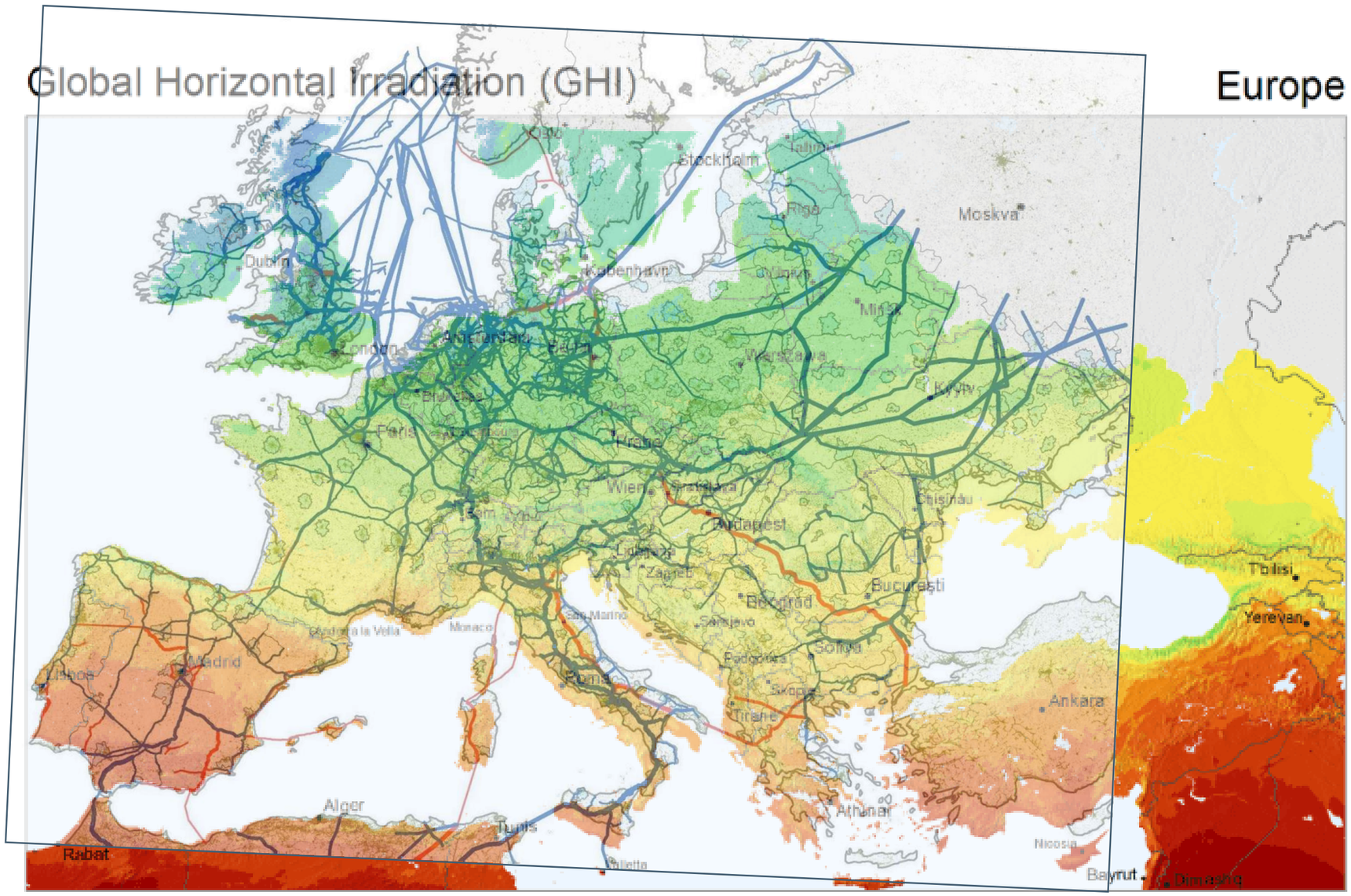
- Demand: +30% (~63 to 81 TWh/a)
- RES generation : Wind x3, Solar x20, Hydro x1 (~ 41 auf 80 TWh/a)

=> Big scale seasonal storage needed

European Potential for Wind Energy Generation



European Potential for Solar Energy Generation



Development of the Underground Sun Storage Project

Motivation

- Gas Storage is Energy Storage
- Gas Storage is ‘invisible‘ and ‘available on demand‘-Energy
- Gas has an existing infrastructure in many regions of the world
- Gas can be greened from 0-100% without changing the system

Goals of the Project

- Demonstration of Storability of renewable gases in Gas Storage facilities
- Research on effects of 10% hydrogen admixtures in existing Gas Storage Facilities

Partners

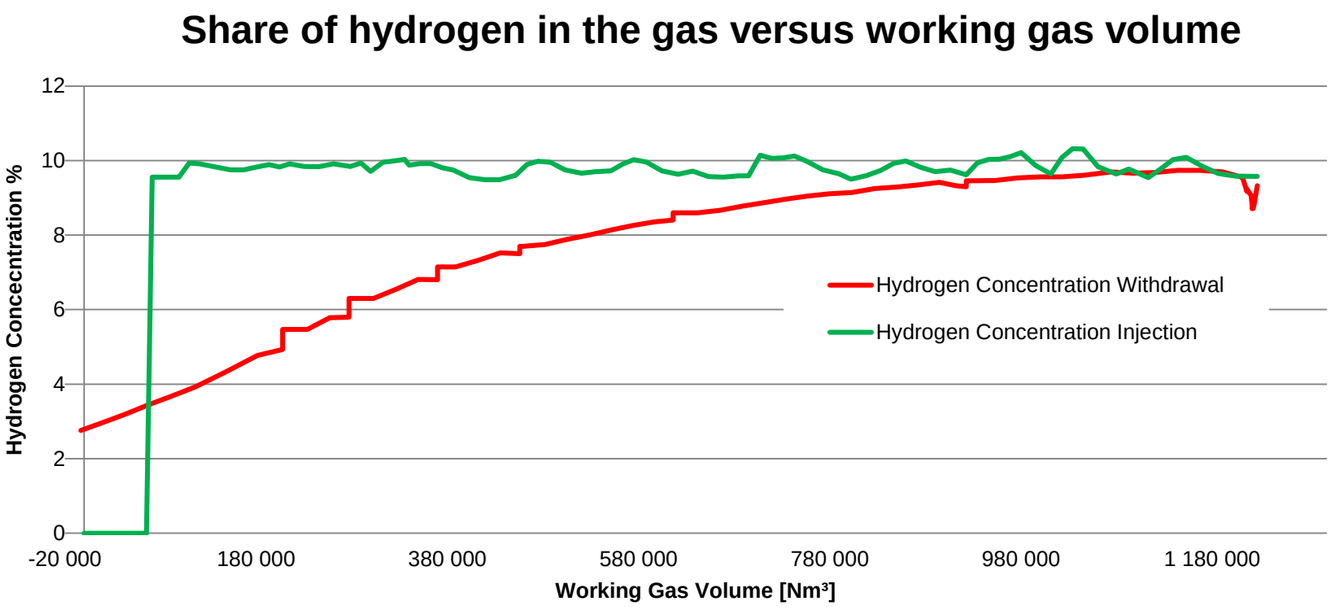
Underground Sun Storage

UNDERGROUND SUN.STORAGE

- Renewable Energy can be stored as Hydrogen in underground gas reservoirs.
- 10 % share of H_2 tested
- Project confirmed scale up potential to RAGs commercial facilities
- Open: Assignability to other geological reservoir settings
- Key Parameters Identified
- 100 % Hydrogen in natural gas reservoirs is the next development objective
- https://www.underground-sun-storage.at/

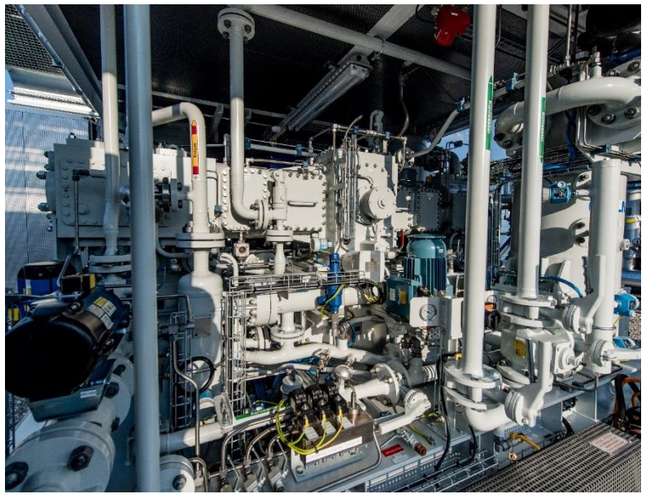
Conclusion Underground Sun Storage Reservoir

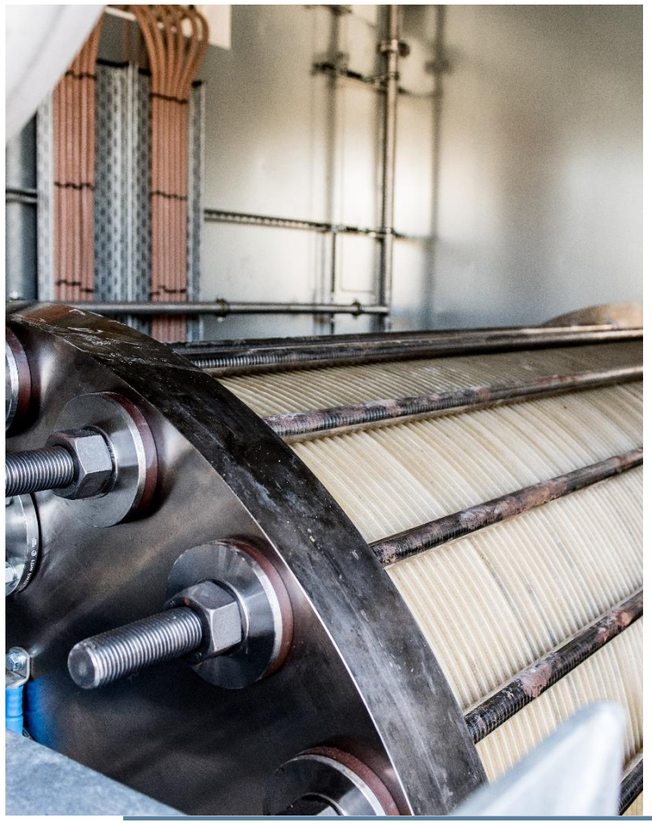
- 82% of injected hydrogen could be reproduced
- Most of the remaining hydrogen could be related to one time losses
- 100% of overall volume reproduced
  - => cushion gas is replaced by hydrogen



- Other changes in withdrawn gas due to
  - Dissolution
  - Conversion

Conclusion Underground Sun Storage Facility



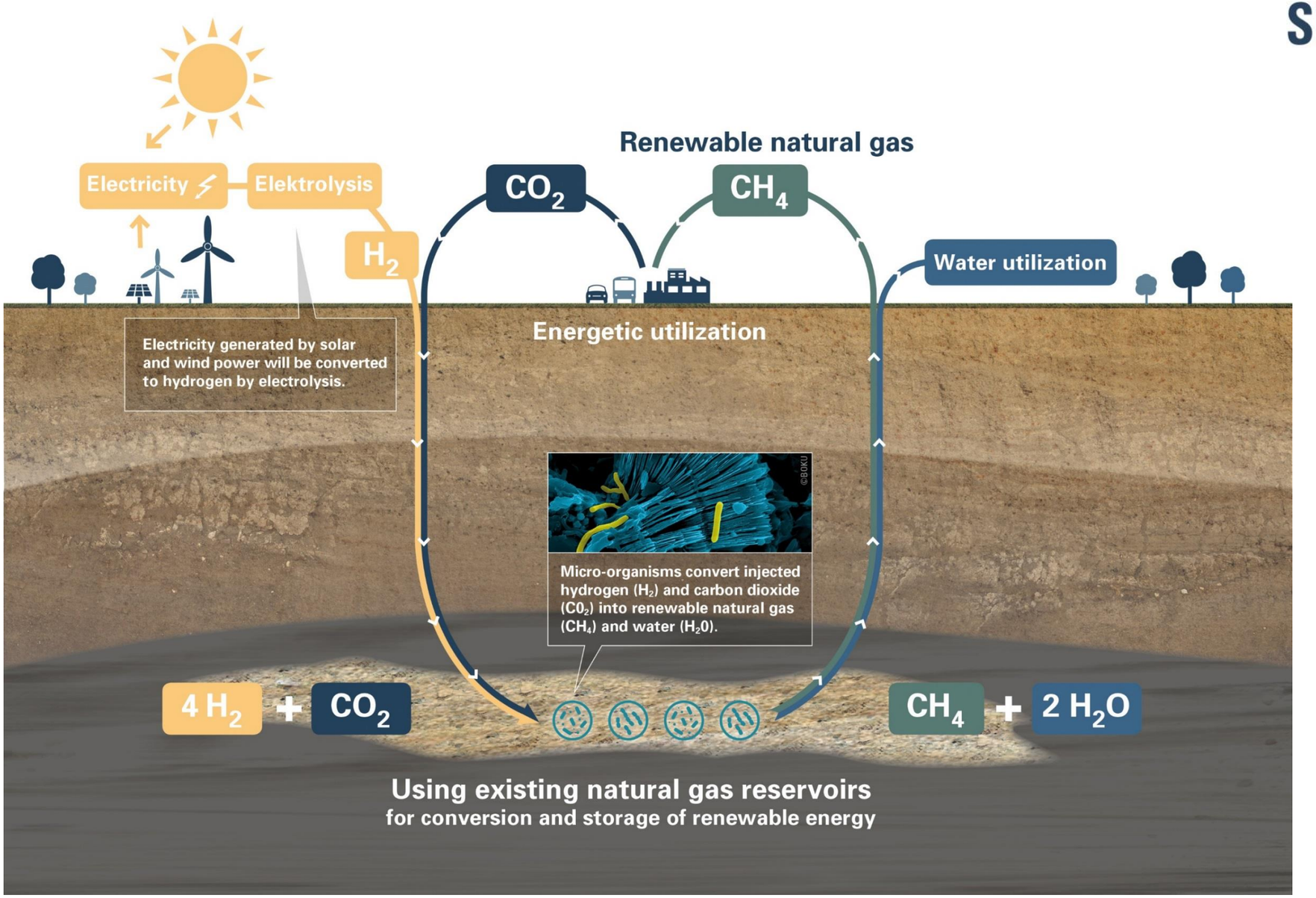


- No integrity problems where detected in the storage facility
- Steel grades, Cements and Elastomers successfully tested on hydrogen durability
- No H_2S generation
- No changes in gas reservoir performance
- Excellent comparability with lab experiments
- Execution within the existing legal framework
- Potential for future application could be identified

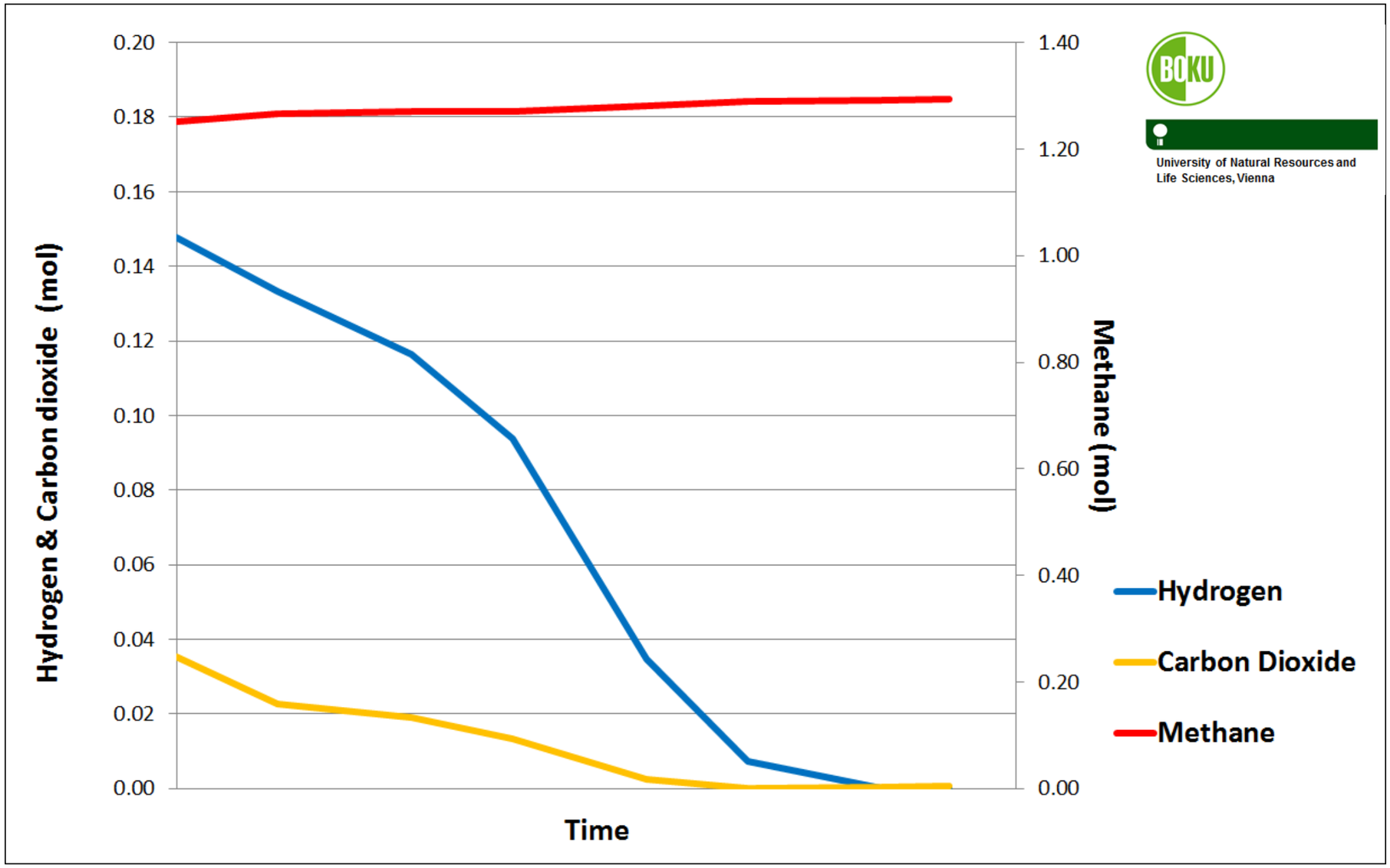
UNDERGROUND SUN.CONVERSION

Convert a one way industry into a sustainable cycle industry

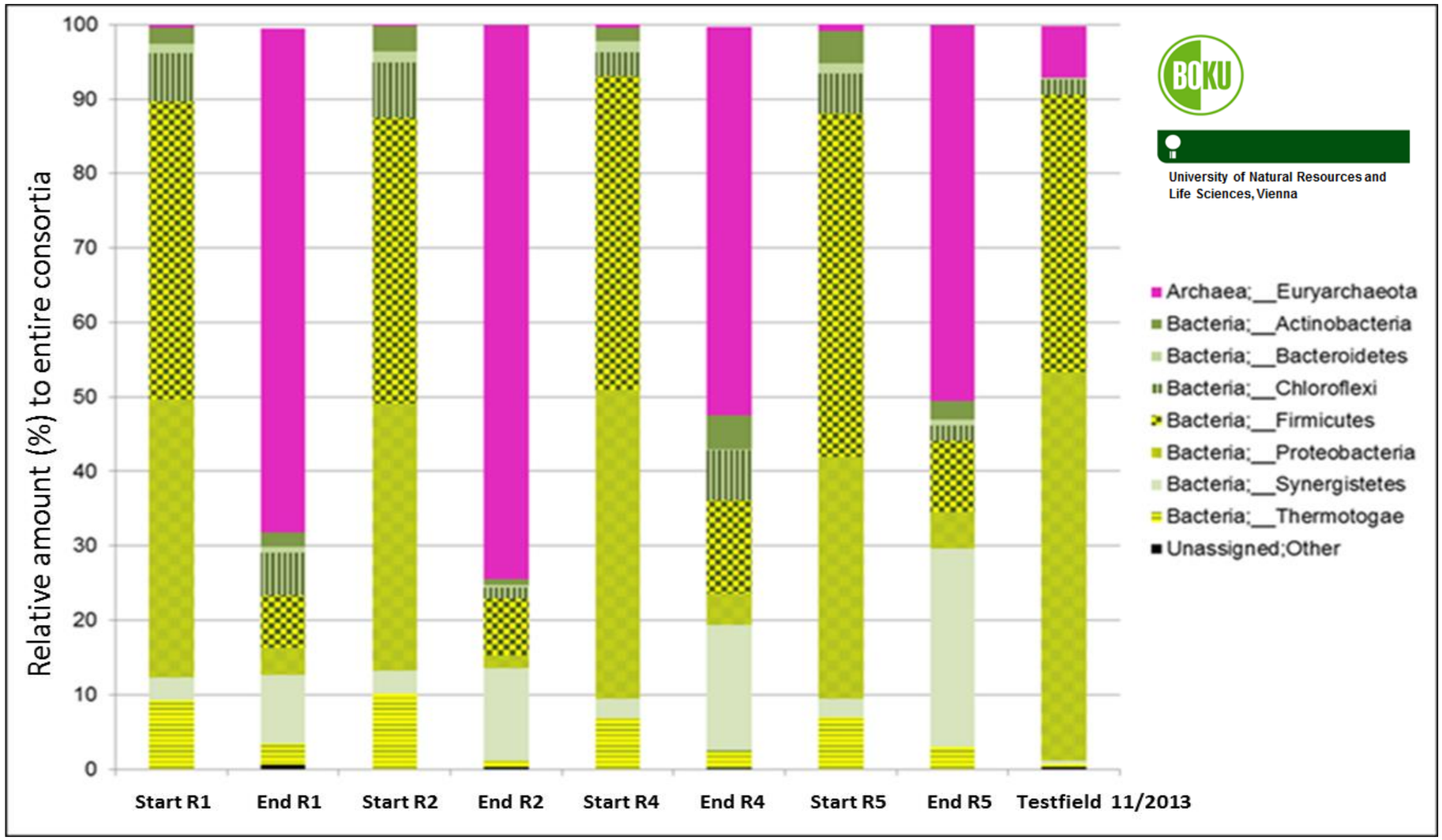
UNDERGROUND SUN.CONVERSION

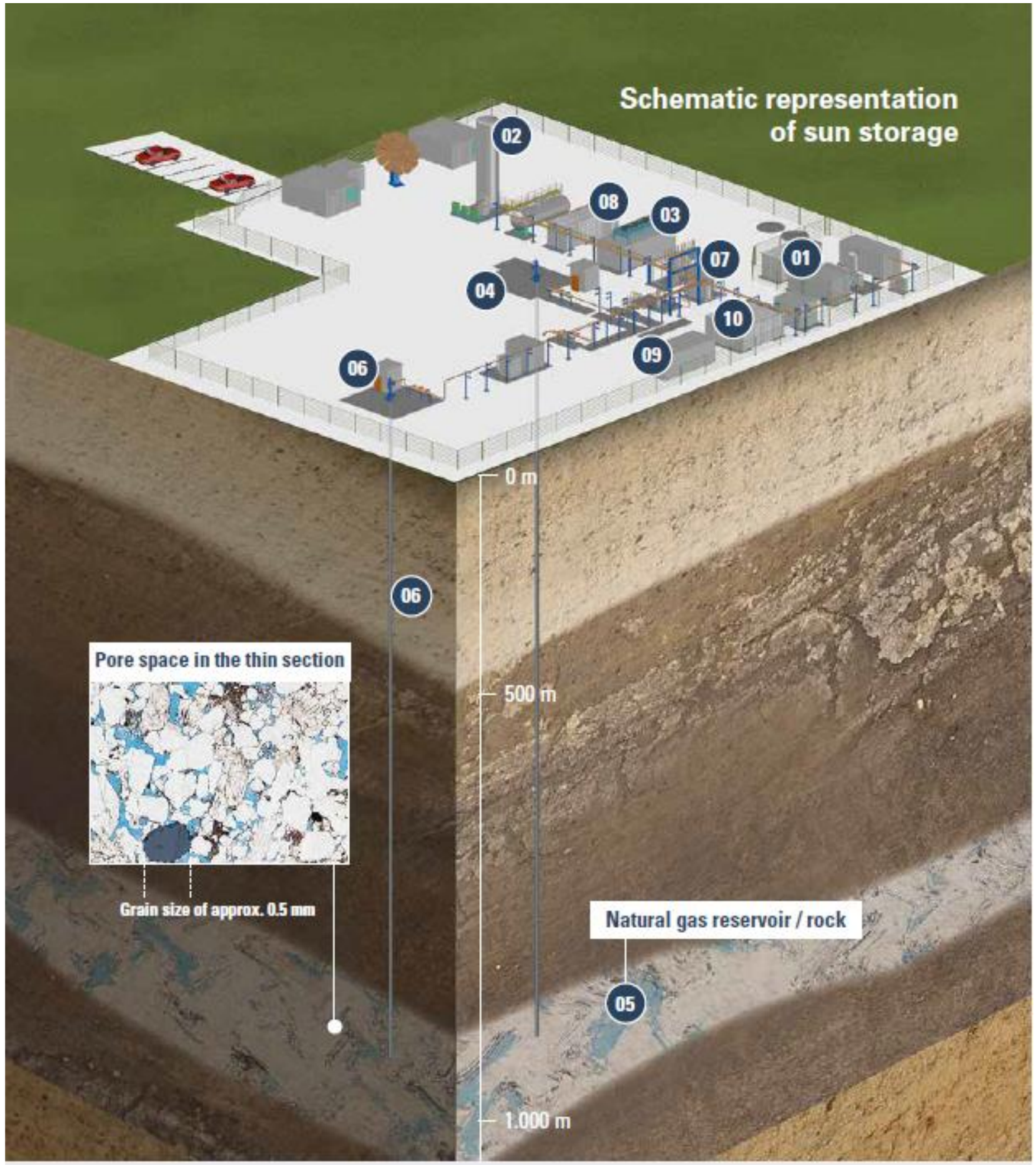


Changes in Gas Composition



Changes in microbiology





UNDERGROUND SUN.CONVERSION

RAG AUSTRIA AG

Outlook

- Cycle Experiments in USC until end of 2020
- Several requests for European funding have been filed
- Evaluation of two additional hydrogen storages in Q1 2020
- Injection of 20% renewable hydrogen in commercial storages planned

Conclusion

- **State of the art underground gas storage facilities are essential for Europe´s security of energy supply**
- Increase of erratic renewable energy generation and the integration of natural gas and electricity markets in turn will generate additional demand in seasonal and high-capacity large scale storage options

- Underground Sun Storage as well as Underground Sun Conversion technology can solve the problem of seasonal power storage
- Generation of renewable natural gas closes a sustainable natural carbon cycle
- Integration of renewable gas combines the benefits from classical natural gas infrastructure and the sociopolitical target of renewable energy supply

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Project Partners:

Thank You For Your Attention