Analysis of a UHS business case in Poland

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Hydrogen Storage in European Subsurface

Acknowledgment

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Clean Hydrogen Partnership

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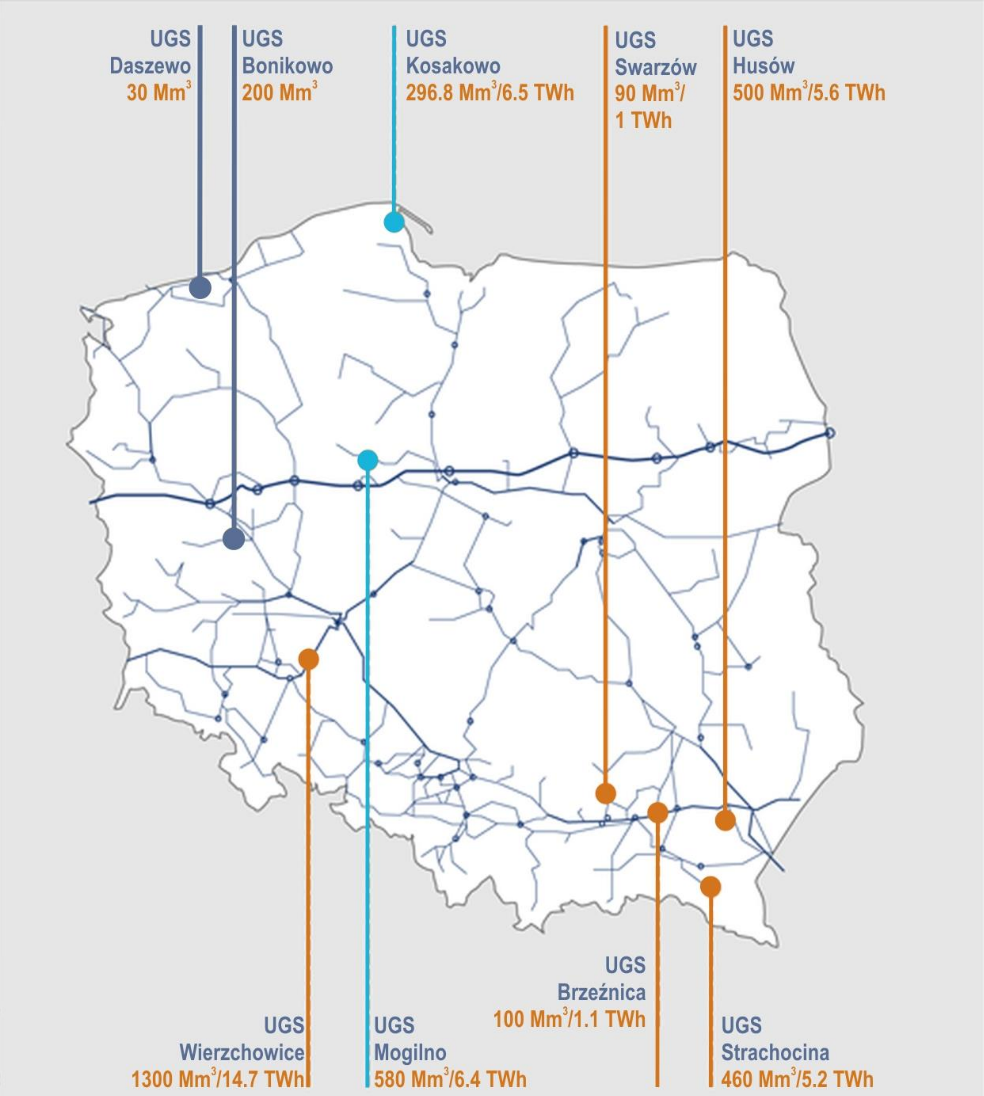
Storage market in Poland

Storage market in Poland

There are seven underground high-methane natural gas storage facilities (UGS) in operation in Poland, connected to the natural gas pipeline network:

- Five UGS in depleted natural gas deposits: Husów, Wierzchowice, Swarzów, Brzeźnica, and Strachocina,
- Two UGS in salt caverns: Mogilno and Kosakowo.

In addition, two UGS, Daszewo and Bonikowo, are used to stabilize the production of nitrogen-rich natural gas.



Source: PGNiG, Gas Storage Poland

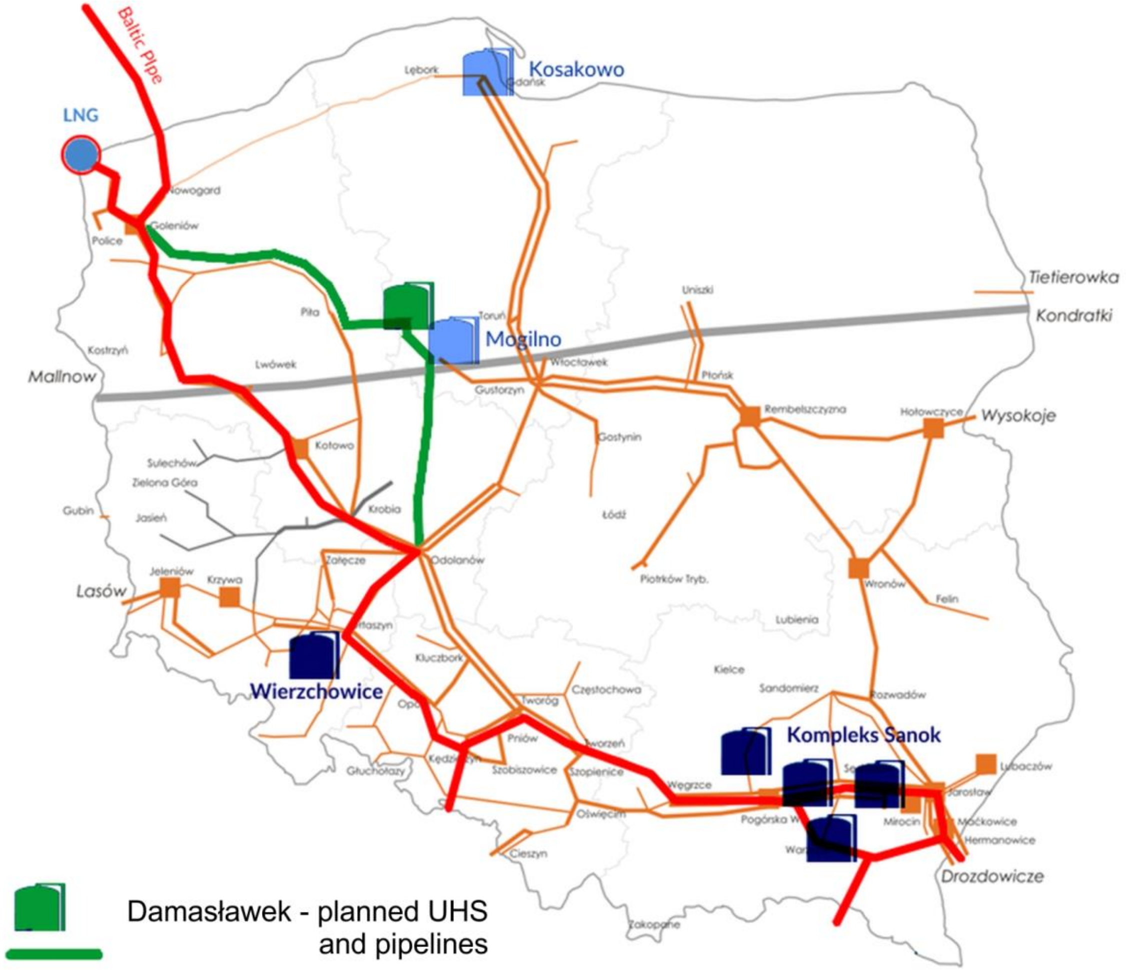
Storage market in Poland

Group of storage facilities	Storage	Working volume		Max. injection capacity		Max. withdrawal capacity	
		million m^3	GWh*	million m^3 /day	GWh/day	million m^3 /day	GWh/day
GSF Kawerna	CUGS Mogilno	580,92	6 471,4	9,60	106,9	18,00	200,5
	CUGS Kosakowo	296,8	3 309,3	2,40	26,8	9,60	107,0
GSF Sanok	UGS Husów	500,0	5 650,0	4,15	46,7	5,76	64,6
	UGS Strachocina	460,0	5 211,8	2,64	29,7	3,36	37,9
	UGS Swarzów	90,0	1 013,4	1,00	11,2	0,93	10,4
	UGS Brzeźnica	100,0	1 126,0	1,44	16,2	1,44	16,1
-	UGS Wierzchowice	1 300,0	14 729,0	9,60	107,5	14,40	158,4
Total		3 327,72	37 510,9	30,83	345,0	53,49	594,9

Storage market in Poland

The National Energy and Climate Plan for 2021-2030 assumes to expand storage capacity to a minimum of 43.8 TWh.

It is planned to develop a UGS facility in the Damasławek salt dome, including 20 salt caverns.



Source: Gaz-System

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Storage potential in Poland

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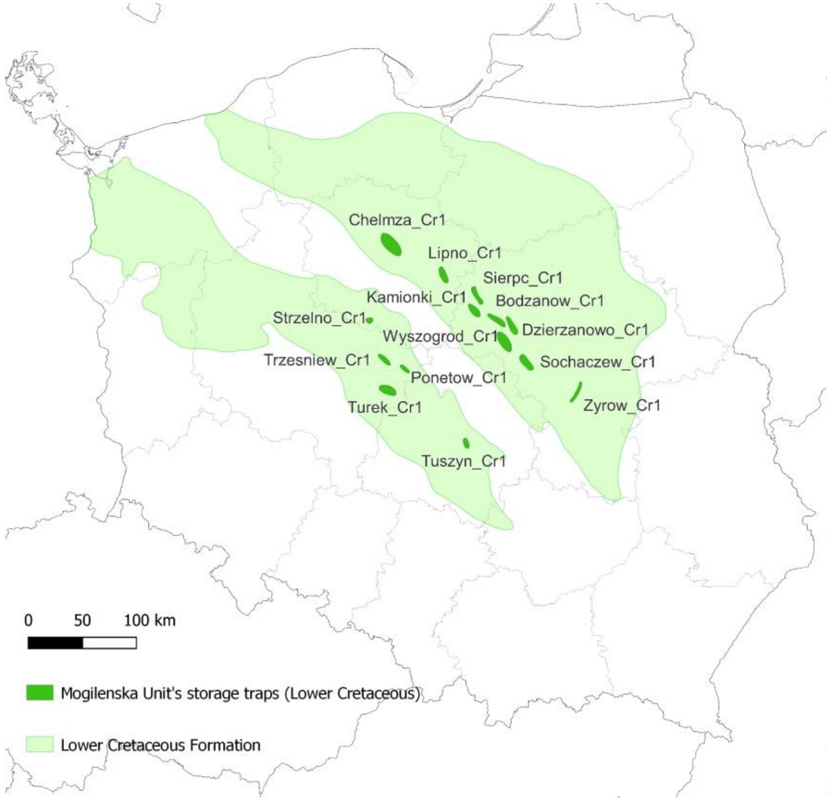
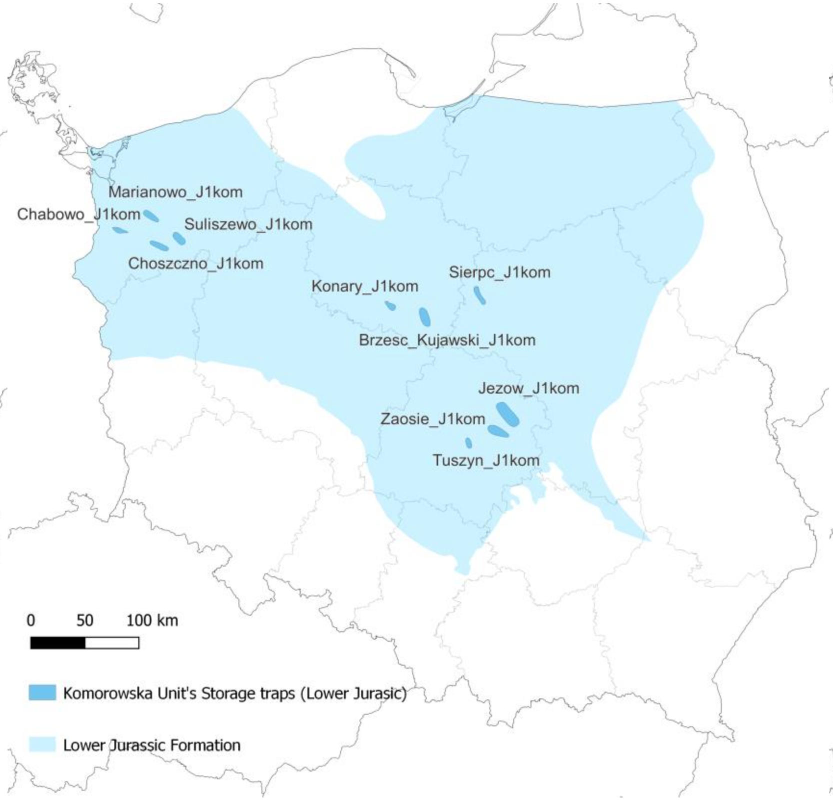
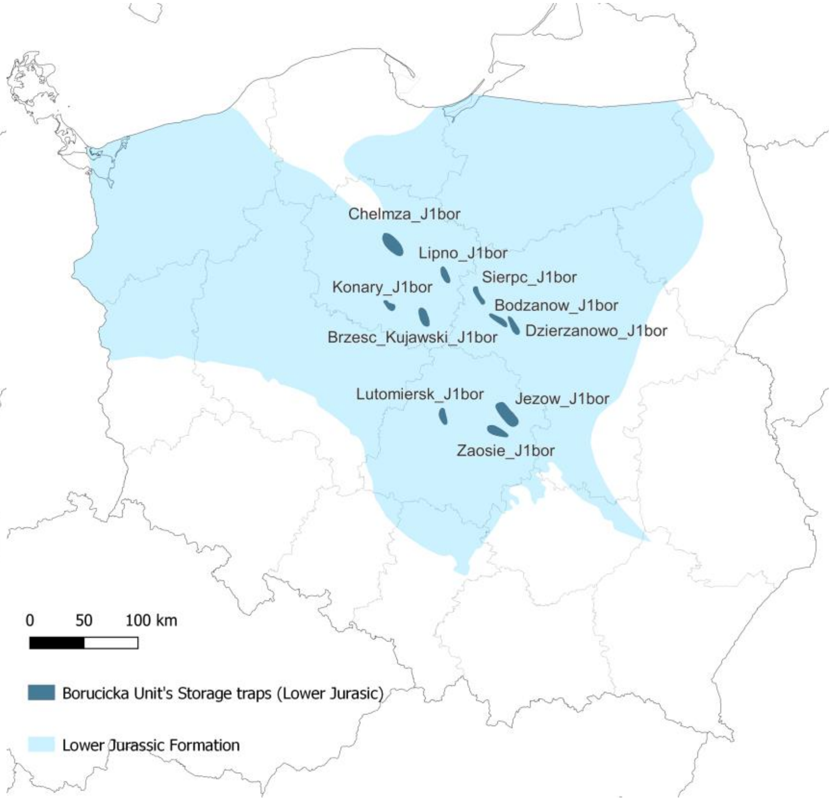
Storage potential – deep aquifers



Lower Cretaceous
Mogileńska Storage Unit
14 storage traps



Lower Jurassic
Komorowska Storage Unit
10 storage traps



Lower Jurassic
Borucicka Storage Unit
12 storage traps

Storage potential - deep aquifers

Detailed exemplary model studies of selected Lower Jurassic structures indicate significant hydrogen storage capacities.

	Unit	Suliszewo	Konary
Total capacity	Mg	445 486	70 820
	Mm^3	4 956	788
Working capacity	Mg	133 623	18 992
	Mm^3	1 487	211
	TWh_{H2}	4.46	0.63

Storage potential - rock salt deposits

In Poland, there are also favorable conditions for storage in salt caverns.

There are two salt formations of industrial importance.

- Zechstein Formation (Permian)
- Miocene Formation (Neogen)

Storage potential – rock salt deposits

Only in the Zechstein Formation, there are appropriate geological conditions (thickness and depth) for constructing salt storage caverns of industrial importance.

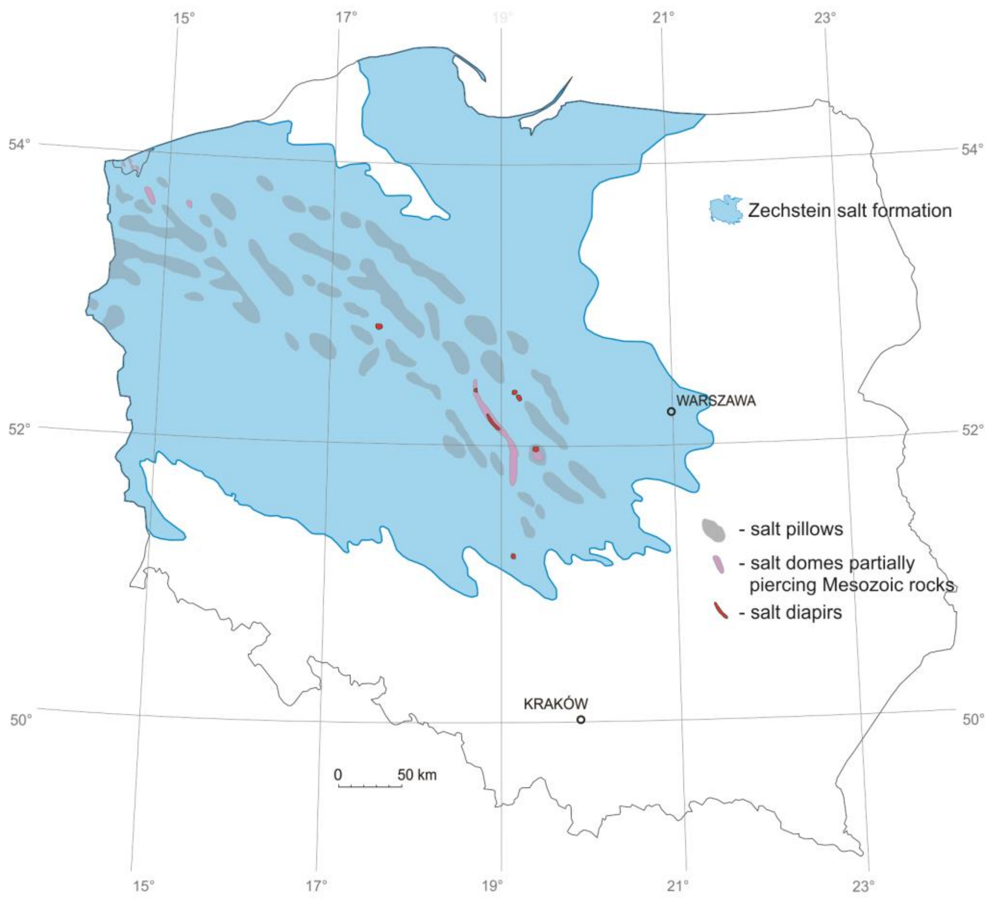
Storage potential – rock salt deposits

Although the formation covers 2/3 of the territory of Poland, most of it occurs at great depths.

Only some uplifted :

- salt pillows, and
- salt domes piercing the Mesozoic formations

are suitable for the UHS in salt caverns.

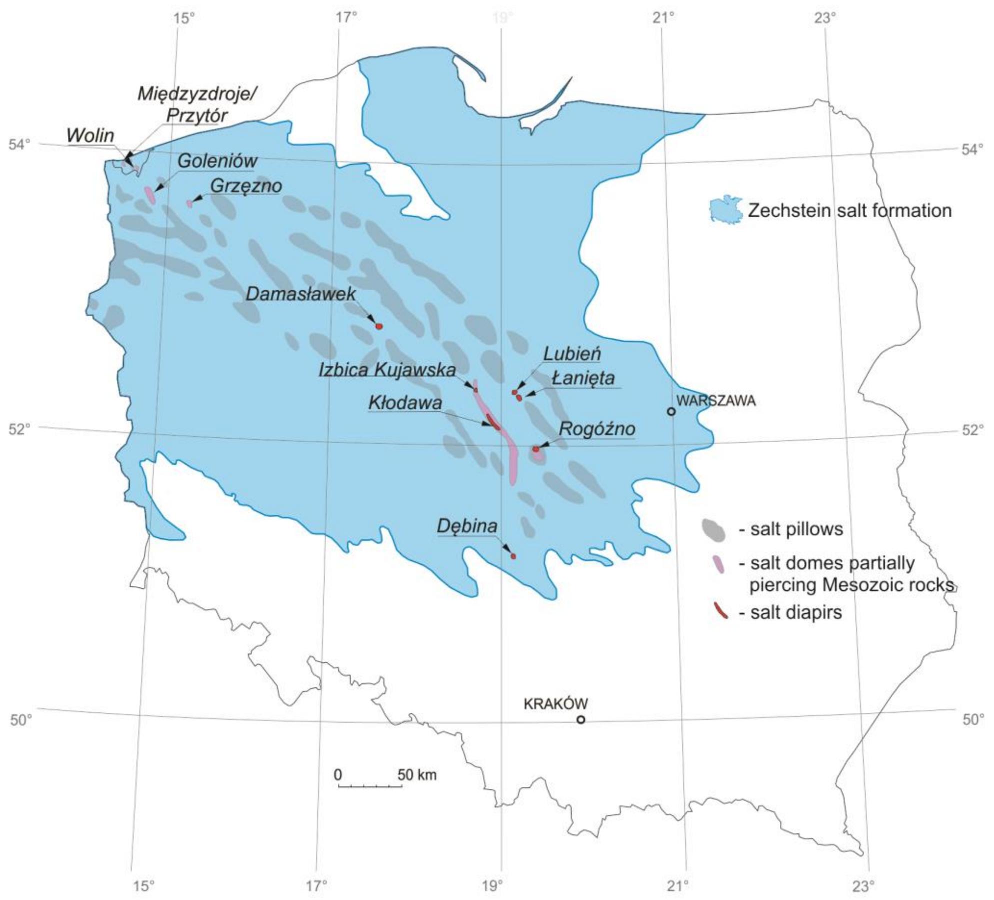


Storage potential - rock salt deposits

Detailed studies of the geological conditions confirmed the suitability of

- four salt pillows in NW Poland, and
- seven salt domes in Central Poland

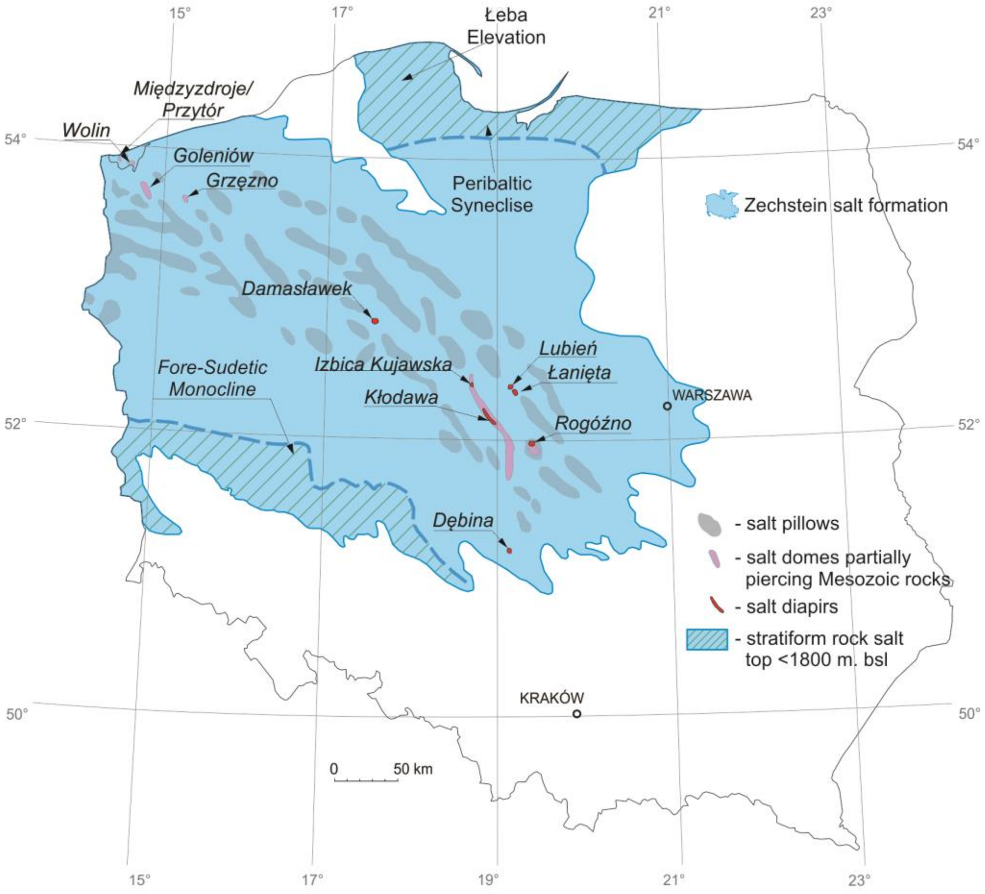
for the UHS in salt caverns.



Storage potential - rock salt deposits

Within the Zechstein Formation, there are also prospective areas for the UHS in bedded salt deposits:

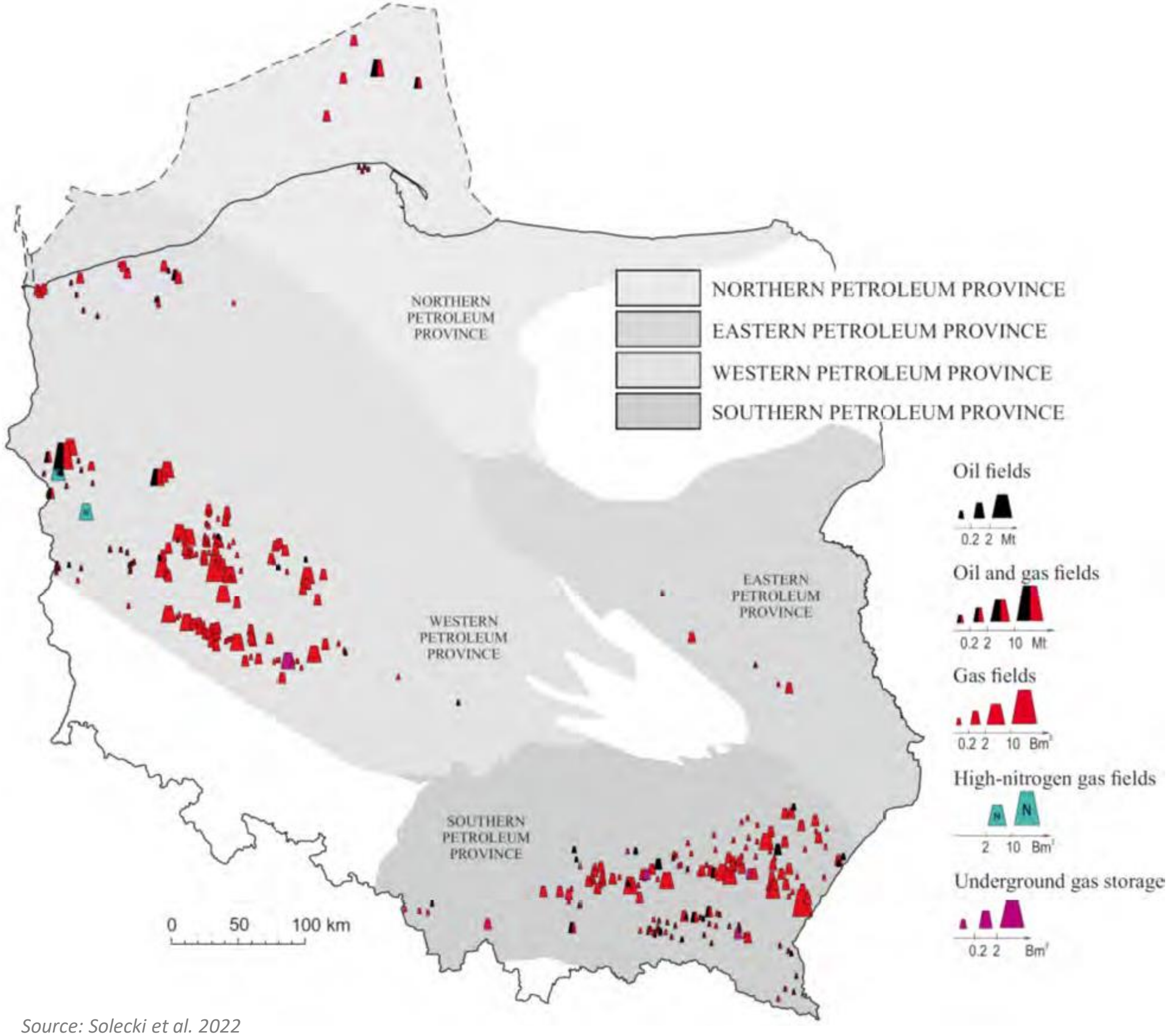
- in the Fore-Sudetic monocline in SW Poland, and
- in the Łeba Elevation in N Poland.



Storage potential – rock salt deposits

The research by Lankof and Tarkowski (2022) indicates that the storage capacity of salt deposits in the Fore-Sudetic monocline may amount to several hundred TWh.

Storage potential - depleted gas deposits



Source: Solecki et al. 2022

In Poland, 306 natural gas deposits have been documented.

Deposits, which were or are still exploited, may also constitute a significant base for underground hydrogen storage.

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UHS business case in Poland

Business case context

The business case analysis was based on the UHS cost model developed in WP7 and the calculation tool developed in WP8.

The analysis concerns hypothetical hydrogen storage in salt caverns in Poland. The analysis was based on several assumptions concerning:

- geological conditions,
- subsurface and surface facility parameters,
- hydrogen production and storage cost parameters,
- financial parameters.

Reference scenario's input parameters and assumptions

Geology and subsurface facilities parameters adopted in the reference scenario

The reference scenario assumes, e.g.:

- the UHS consists of eight salt caverns,
- the total storage capacity is 250 M Sm^3,
- the number of storage cycles per year is 2.1,
- the total UHS throughput is 46.6 M kg/year.

Parameters	Description	Value
V_{cavern}	Free gas volume per cavern [millions Sm^3]	0.38
V_{max}	Maximum Gas Inventory per cavern [millions Sm^3]	31
n_{WH}	Number of caverns (assumption: one well head per cavern)	8
LCCS	Last cemented casing shoe [m]	1000
DC_i	Drilling complexity index	1.0
L_{fw}	Fresh water pipeline length [km]	15
L_{bd}	Brine disposal pipeline length [km]	30
x_{salt}	Cushion gas / Total gas ratio	0.43
V_{wg}	Working Gas volume [millions SM^3]	250
V_{wg}/Q_w	Working gas volume/Total storage maximum withdrawal flowrate capacity [days]	15
$Q_{debrining}$	Debrining flowrate per cavern [m^3/h]	200
$d_{full\ cycle}$	Duration of one full storage of the cycle [days]	58
N_{fc}	Number of full cycles per year	2.1
$N_{fc,\ MAX}$	Maximum number of full cycles per year	6.3
$d_{T,L}$	Leaching duration [year]	4.5
$d_{T,C}$	Debrining duration [year]	1.1
LF	Load Factor	0.33

Reference scenario's input parameters and assumptions

Surface facilities parameters adopted in the reference scenario.

Surface facilities parameters included, e.g.,:

- material costs,
- number of compression stages,
- operating pressures,
- field lines size,
- cost of electricity.

Parameters	Description	Value
MCFi	Material cost factor for injection (compression) stream	1
MCFw	Material cost factor for withdrawal stream	1
Qw	Total storage maximum withdrawal flowrate capacity [millions Sm^3/day]	16.50
τ	Overall compression ratio (ratio of discharging pressure over suction pressure)	3.23
n	Number of required compression stages	2
WTIR	Withdrawal to injection capacity ratio	2.8
netOP	Minimum suction pressure of compression stream (pipeline operating pressure) [barg]	55
MOP	Maximum storage operating pressure [barg]	180
minOP	Minimum storage operating pressure [barg]	70
Lfl	Field lines size [km]	2
COE	Cost of Electricity [€/MWh]	100

Reference scenario's input parameters and assumptions

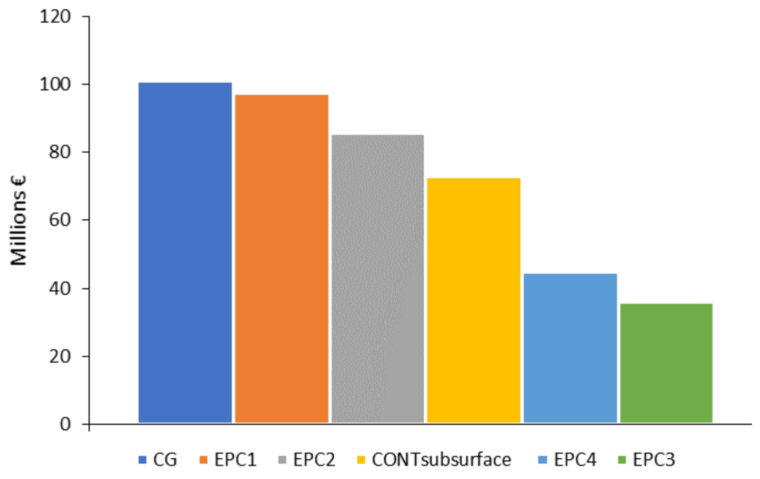
Hydrogen production and storage cost parameters and financial parameters

Hydrogen price	Value
Hydrogen production cost (€/kg)	6.29 €
Other costs (€/kg)	1.89 €
Storage cost (€/kg)	1.81 €
Storage service margin profit (%)	12.99%
Storage service price (€/kg)	2.04 €
Minimum Hydrogen selling price (€/kg)	10.22 €
Margin profit (%)	15.00%
Hydrogen selling price (€/kg)	11.75 €
Price spread	46%

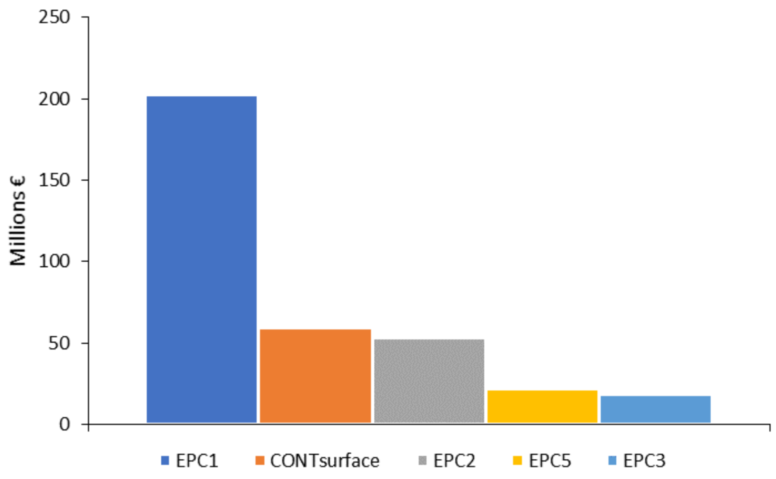
Parameter	Value
Subsidy	20,000,000 €
Venture period [years]	30
Residual value	20%
Storage service price [€/kg]	2.04 €
Corporate tax	25%
Financing fund	0
Interests	5%
Financing duration [years]	30
Rate of return (Discount rate)	5.75%

Key modeling results

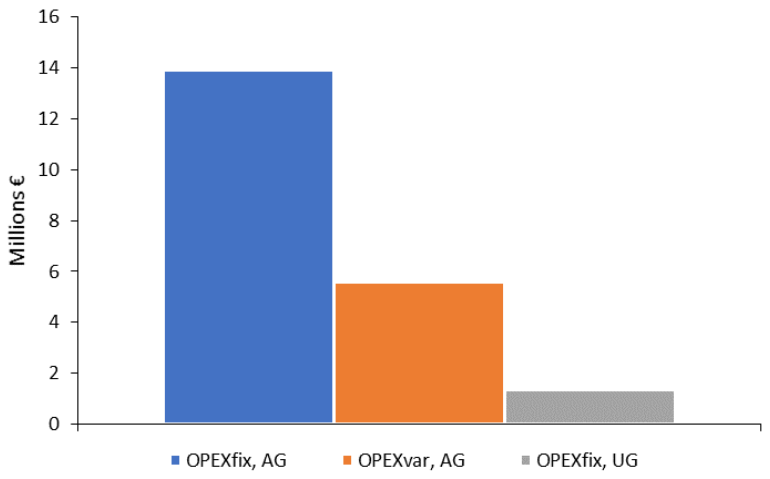
Parameter	Unit	Value [€]
CAPEX - subsurface	million €	**437.8**
CAPEX - surface	million €	**355.1**
OPEX	million € / year	**20.8**
ABEX	million €	**138.3**



Subsurface CAPEX breakdown



Surface CAPEX breakdown



OPEX breakdown

Cash flow analysis

Key Performance Indicator of UHS business case

Key UHS project KPIs include:

- Net Present Value (NPV),
- Internal Rate of Return (IRR),
- Net Present Cost (NPC), and
- Levelized Cost Of Storage (LCOS).

Key indicators	Values
Net Present Value (NPV)	0.00 €
IRR	5.75%
Net Present Cost (NPC)	762,239,331 €
LCOS [€/kg]	1.81 €

Business case optimization

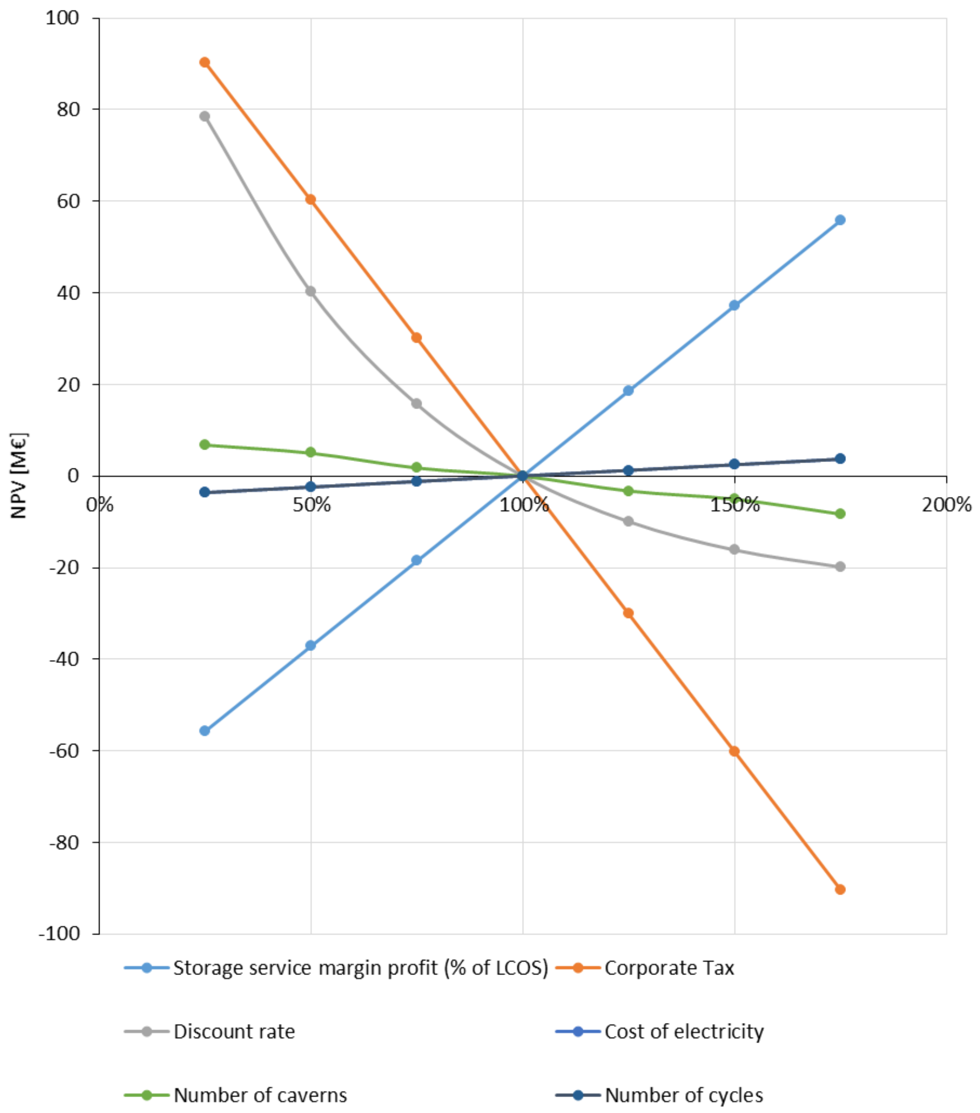
- To optimize the business case, a sensitivity analysis was carried out. The study aimed to check the model's sensitivity to the key input parameters and to optimize the model toward the business justification for storing hydrogen in salt caverns.
- The analysis covered the impact of the following parameters on the KPI’s :
  - storage service margin profit,
  - corporate tax,
  - discount rate,
  - cost of electricity,
  - number of caverns,
  - number of cycles.

Business case optimization

The figure shows the impact of the analyzed parameters (from 25% to 175% of the reference value) on the Net Present Value.

The analysis shows that three parameters have the most significant impact on the financial result:

- corporate tax,
- discount rate,
- storage service margin profit.



Business case optimization

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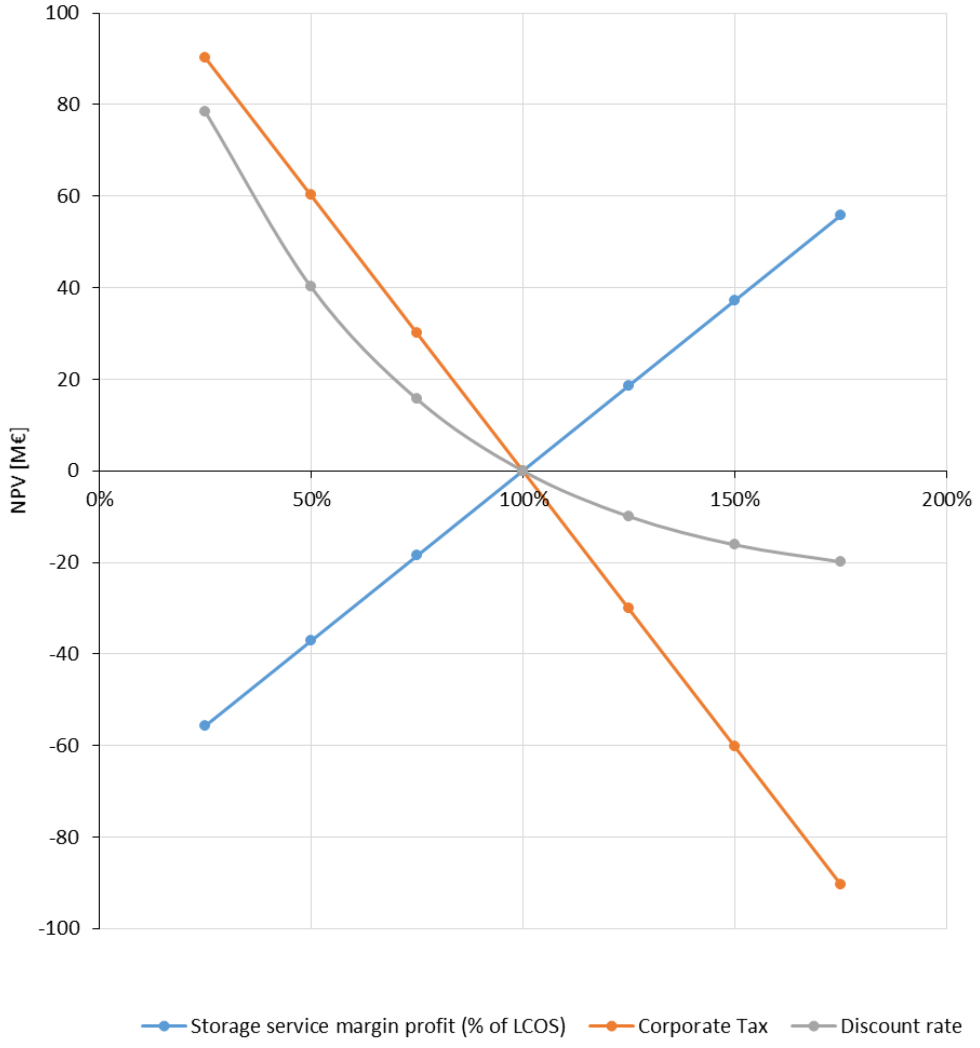
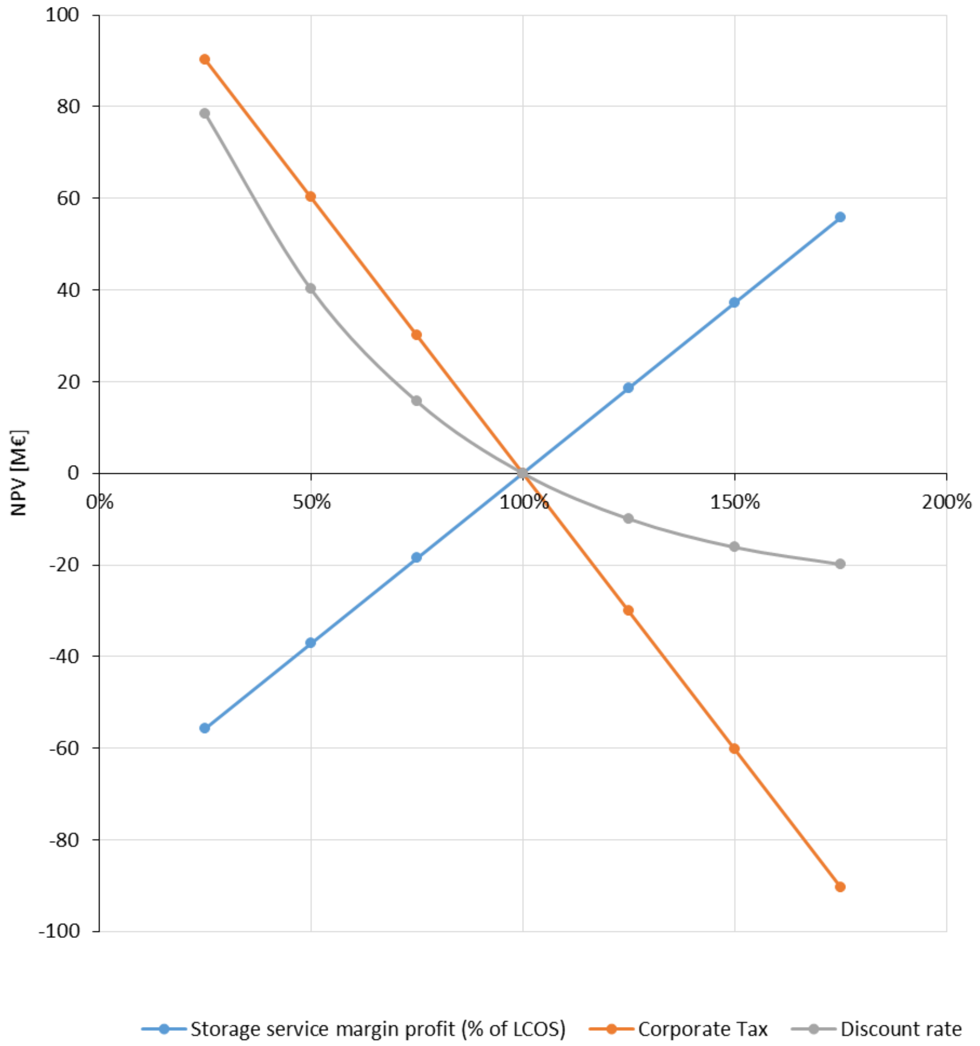


Business case optimization

The NPV changed in the range:

- -90 to 90 M€ for corporate tax,
- -21 to 90 M€ for a discount rate,
- -74 to 74 M€ for storage service margin profit.



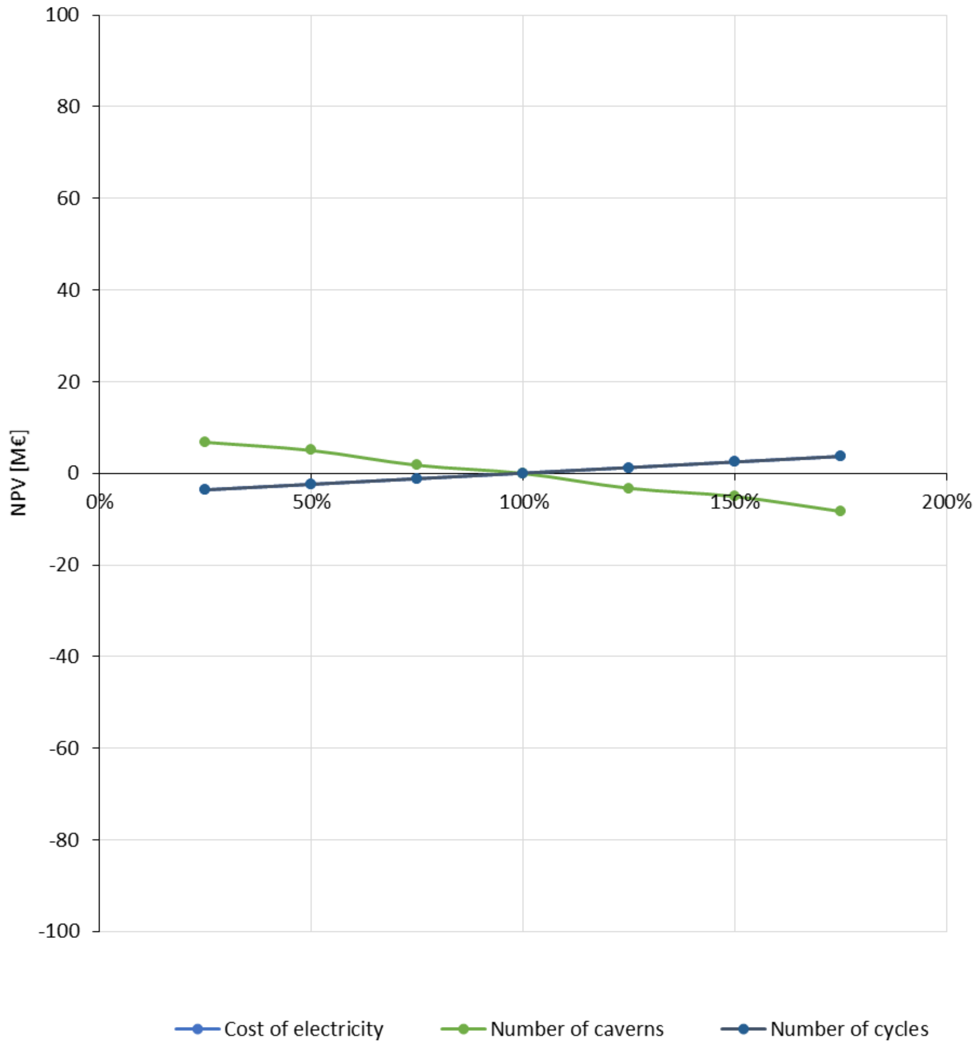
Business case optimization

The remaining parameters:

- cost of electricity,
- number of caverns,
- number of cycles

had little impact on the final NPV value.

The largest change in NPV from -8 M€ to approx. 7 M€ was recorded in the case of the number of caverns.

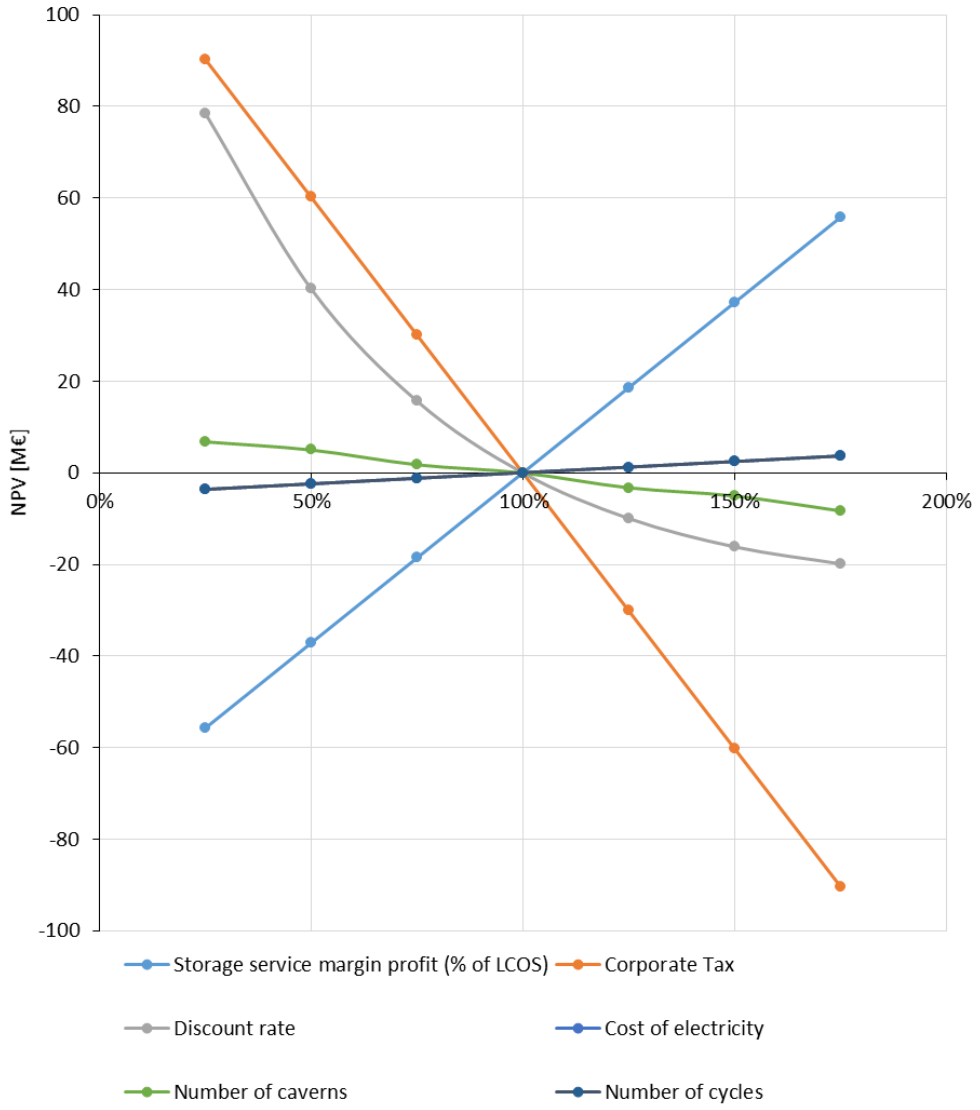


Business case optimization

Sensitivity analysis indicates, that a slight change in at least one of the analyzed parameters, i.e.:

- increasing the storage service margin profit above 13%,
- lowering corporate tax below 25% (currently 19% in Poland),
- lowering the discount rate below 5.25%,
- increasing the number of caverns, or
- increasing the number of cycles

makes the analyzed project profitable.



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Conclusions

Conclusions

- Poland has extensive experience in underground gas storage, primarily from storing natural gas for around 70 years.
- In Poland, there is a significant storage potential in deep aquifers, salt caverns, and depleted gas deposits.
- The business case study in Poland concerned the UHS in 8 salt caverns.
- The CAPEX of such a UHS is 792 M€, the OPEX is 21 M€/year, and the ABEX is 138 M€.
- Sensitivity analysis shows a significant impact of corporate tax, discount rate, and storage service margin profit on the project's profitability.
- The analyzed business case may be profitable, with the conditions shown in the sensitivity analysis.

Hystories project consortium

Acknowledgment

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The Project is co-founded by European Union

Thank you !

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