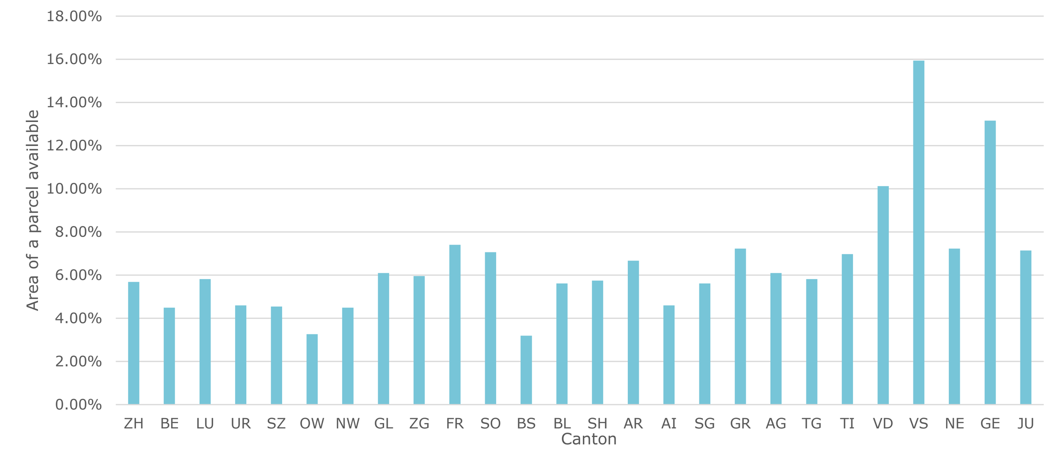
HSLU Hochschule Luzern

Technik & Architektur
Master of Science in Engineering
Business Engineering

Master-Thesis – Master of Science in Engineering

Leveraging existing Sunamp products for seasonal storage in Switzerland

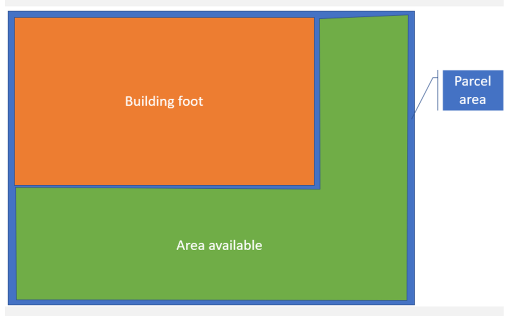
Building period	Electricity consumption over the year [kWh]		
	With Ice storage	With Permafrost P5	With Permafrost P11
Before 1919	5,089.16	4,497.40	3,867.76
1919-1945	5,046.56	4,459.75	3,835.39
1946-1960	5,050.65	4,463.37	3,838.50
1961-1970	5,252.01	4,641.31	3,991.53
1971-1980	5,719.39	5,054.34	4,346.73
1981-1990	4,489.44	4061.88	3,481.61
1991-2000	4,784.80	4,317.99	3,934.17
2001-2005	2,544.64	2,313.31	2,035.71
2006-2021	2,560.52	2,327.74	2,048.42

Szenarios for strategy 2 (W4O2)

Building period	Savings over 20 years if a P5 is installed instead of ice [CHF]	Savings over 20 years if a P11 is installed instead of ice [CHF]
Before 1919	3,219.19	6,644.41
1919-1945	3,192.25	6,588.80
1946-1960	3,194.83	6,594.13
1961-1970	3,322.20	6,857.02
1971-1980	3,617.84	7,467.23
1981-1990	2,325.96	5,482.62
1991-2000	2,539.44	4,627.43
2001-2005	1,258.43	2,768.57
2006-2021	1,266.29	2,785.85

Savings strategy 2


High temperature storages (HTS)

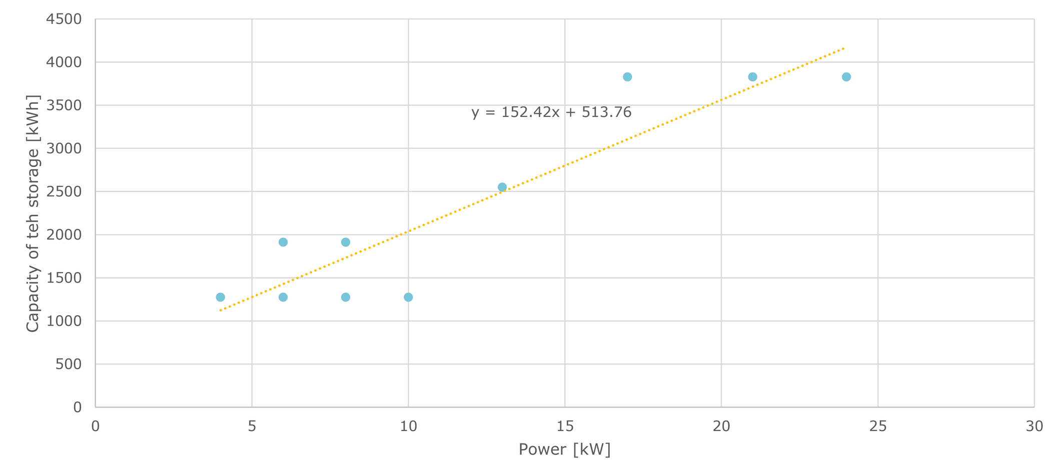


Month	Heat demand distribution (Heating + hot water) (Bauer, et al., 2019)	Heat demand distribution (Heating)	Heat demand heating [kWh]	COP (W35)	COP (W55)	Electricity consumption (W35) [kWh]	Electricity consumption (W55) [kWh]
Jan	16.00%	14.00%	1,680	4.2	2.75	400	610.91
Feb	13.00%	11.00%	1,320	4.2	2.75	314.28	480
Mar	12.00%	10.00%	1,200	4.8	3	250	400
Apr	8.00%	6.00%	720	4.8	3	150	240
May	3.00%	1.00%	120	Not relevant as this would be the charging time of the thermal storage			
Jun	2.00%	0.00%	0				
Jul	2.00%	0.00%	0				
Aug	2.00%	0.00%	0				
Sep	5.00%	3.00%	360				
Oct	9.00%	7.00%	840				
Nov	12.00%	10.00%	1,200	4.8	3	250	400
Dec	16.00%	14.00%	1,680	4.2	2.75	400	610.91
Total			7,800			1,764.29	2,741.82

Electricity savings with HTS

Thermal power of the storage[kW]		Building period								
		Before 1919	1919-1945	1946-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2005	2006-2021
Hot water share		20%					25%	30%	40%	
Multiapartment buildings with x apartments	2	7.92	7.31	6.72	6.93	7.47	6.21	6.51	4.29	3.92
	4	15.83	14.61	13.45	13.87	14.95	12.42	13.01	8.59	7.84
	7	27.70	25.57	23.54	24.27	26.16	21.74	22.77	15.02	13.72
	10	39.58	36.53	33.62	34.67	37.37	31.05	32.53	21.46	19.60

Szenarios for strategy 1 (S3O4)

Relation of power and capacity for ice storages

	Amount of apartments	Ice storage	Permafrost 20 – P5	Permafrost 40 – P11
Capacity [kWh]	7 (before 1980)	4,400.00	2,400.00	3,243.00
	7 (1980 – 2000)	3,900.00		
	10	6,055.00		
Volume [m^3]	7 (before 1980)	35.00	33.00	68.00
	7 (1980 – 2000)	30.00		
	10	48.00		

Comparison of strategy 2

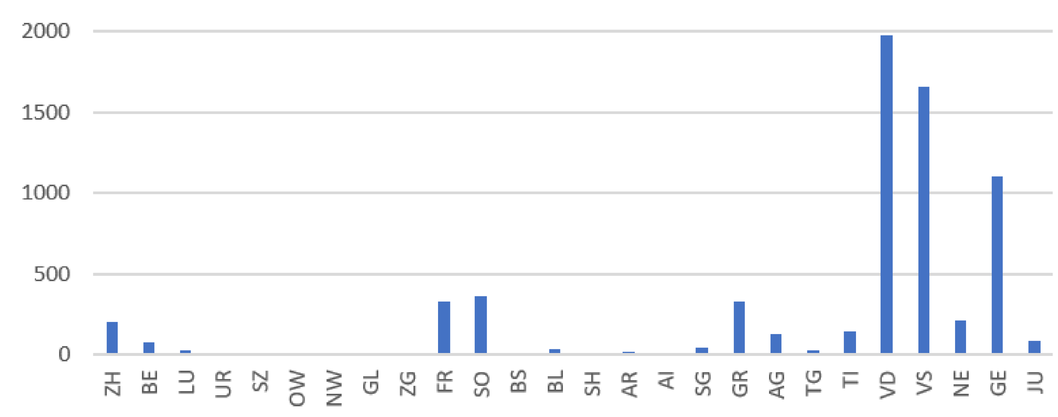
Value criteria	Author's evaluation		Leverage	Market perspective	
	Ice storage	Permafrost 20 – P5		Ice storage	Permafrost 20 – P5
Comfort	2	1	6.79	13.58	6.79
Efficient	1	2	7.36	7.36	14.72
Having an energy label (A++ to G)	2	1	4.57	9.14	4.57
Low CO_2 emissions	1	2	5.64	5.64	11.28
Low buying price	1	2	5.36	5.36	10.72
Low maintenance	1	2	5.07	5.07	10.14
Low running costs	1	2	7	7	14
Proven and known technology	2	1	2.71	5.42	2.71
Safety	2	1	7.86	15.72	7.86
Space saving	2	1	2.64	5.28	2.64
Total				79.57	85.43

Market view of strategy 2

Low temperature storgages (LTS)

SWOT - TOWS		External analysis	
		Opportunities	Threats
Internal analysis	Strengths	Strength - Opportunity strategies S3O4 - Tackle existing buildings with high power demand	Strength – Threat strategies
	Weaknesses	Weakness - Opportunity strategies W4O2 - Use higher efficiency to reduce running costs	Weakness - Threat strategies

SWOT and strategies identified for Sunamp



Market potential for Permafrost 20 – P5

Research problem
Thermal seasonal storage exists and has been implemented in Europe on a district level. The questions arises if this implementation could be used as well for single buildings. The analysis focuses on Sunamp's technical capabilities compared to existing products. A key finding is that the use of high-temperature storage with air-to-water heat pumps for seasonal applications is not beneficial. Even with ideal conditions (no thermal losses) and free summer charging, it is more cost-effective to operate the heat pump less efficiently during winter than to invest in a large seasonal storage. Therefore, the focus shifts to low temperature products like the ice storage. Additionally, the market view is considered with interviews and a survey. It is considered that ice storages are a competitive product against ground source heat pumps, as the research showed. The main driver for installing and ice storage though is the regulations to not drill boreholes at the location. This fact was studied during the research.

Solutions
Sunamp's PCM options, P5 and P11, are analysed in comparison with ice storages in two scenarios: single-family homes and multiapartment buildings (with two, four, seven and ten apartments).

Evaluation
The results show that Sunamp's products cannot compete with standardized ice storages in single-family homes due to higher investment costs. Even with the heat pump's increased efficiency (lower running costs), it is not possible to compensate the initial costs. However, an important observation is made for ice storages: as power increases linearly, ice storage requires exponentially more water. The analysis identifies multiapartment buildings with seven apartments in Canton Vaud and Canton Geneva as the target market for Sunamp's P5. Over 6,700 buildings in Switzerland could benefit from these solutions.

Advantages include lower investment costs (around CHF 40,000 less than ice storage for the same application) and reduced running costs due to higher storage temperatures and improved heat pump efficiency.

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