TECHNISCHE UNIVERSITÄT DRESDEN

Boysen-TU Dresden-Graduiertenkolleg

Integration of seasonal heat storage systems in existing building structures

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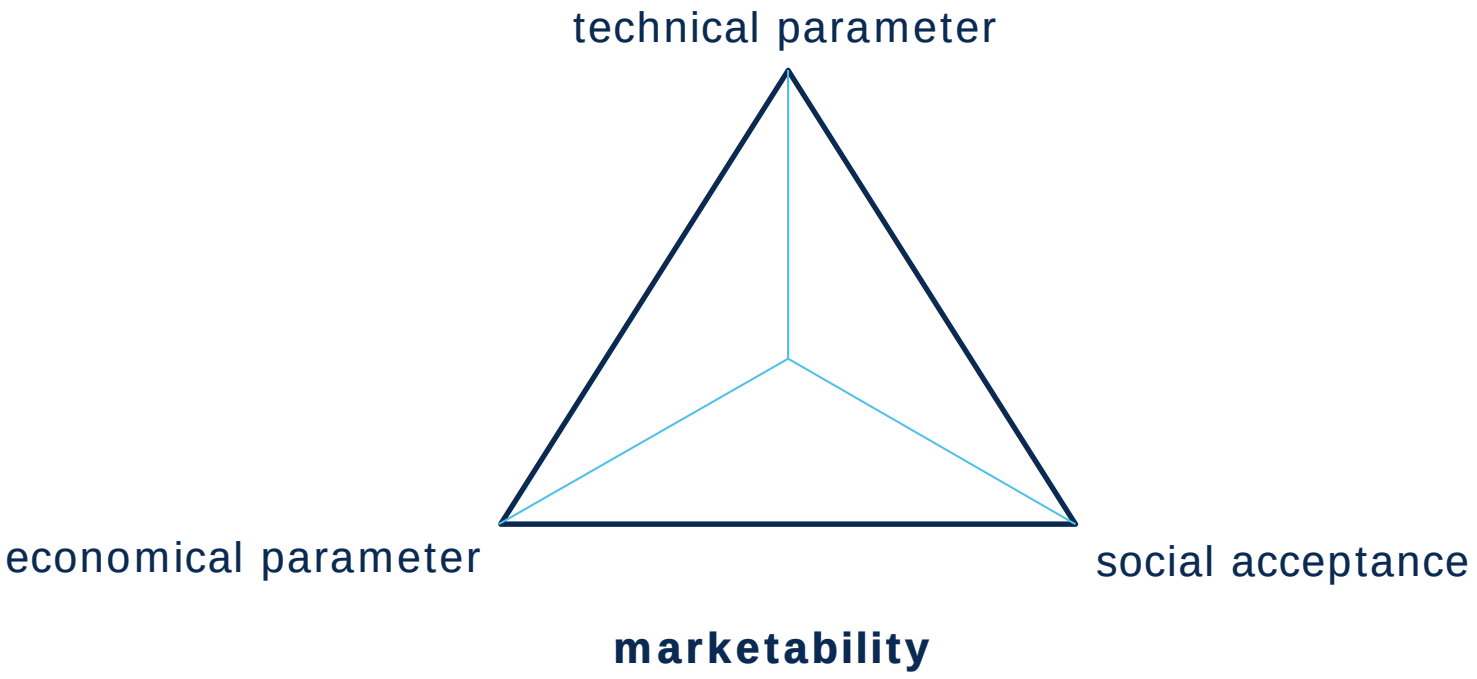
Copenhagen, 12 September 2017

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Research question

How far technical, economical and social parameters influence the marketability of seasonal hot-water heat storage tanks ?



Simulation model

heat generation

heat distribution

seasonal heat storage

heat consumer

Scenarios of building standards and solar coverage

solar coverage	scenario 0 ‘base’	scenario 1 ‘energetic standard’	scenario 2 ‘energetic optimization’
50 %	scenario 0	scenario 1.1	scenario 2.1
65 %		scenario 1.2	scenario 2.2
80 %		scenario 1.3	scenario 2.3

Methods – technical parameters

- Optimization of the building parameters (primary and end energy consumption) with refurbishment
- Calculation and optimization of the solar thermal system and the heat storage based on the heat demand and the solar coverage
- Optimization of the geometry of the storage with iteration processes
- Matrix of scenarios based on solar coverage and heat demand of the buildings

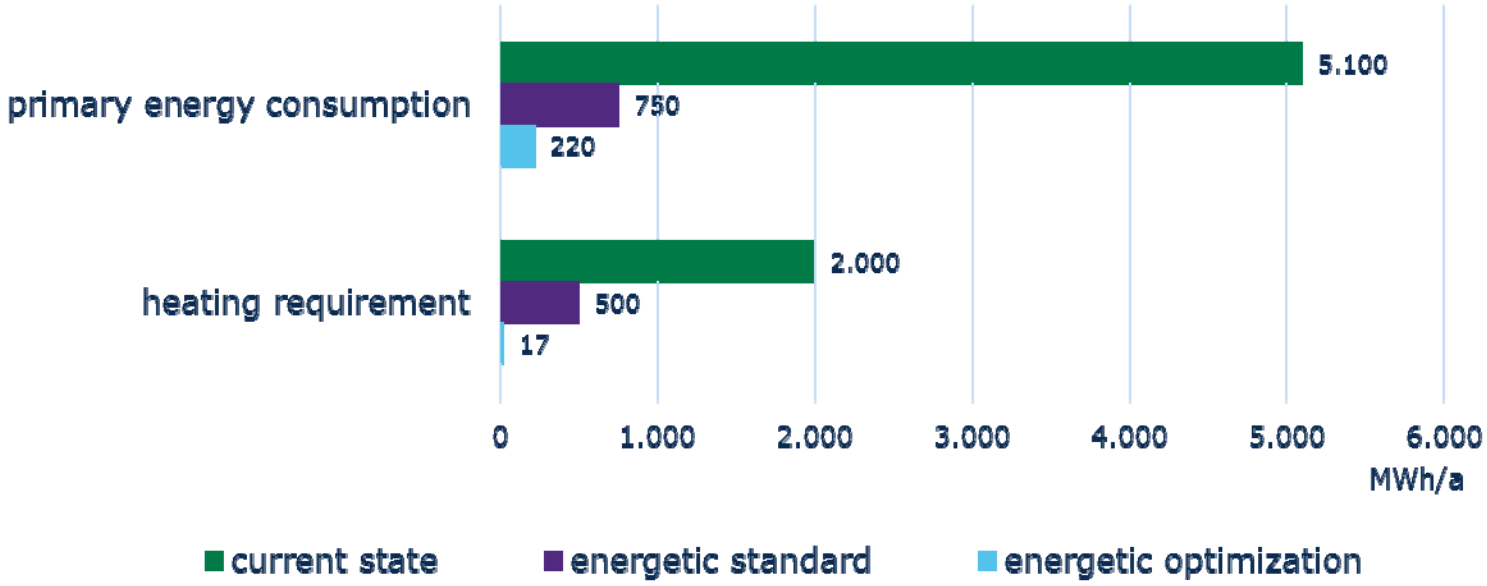
Methods – economical parameters

- Calculation of investment and operating costs
- Finance plans for all scenarios, calculation of return on equity
- Monte-Carlo Simulation for risky parameters
- Verification of the finance plans

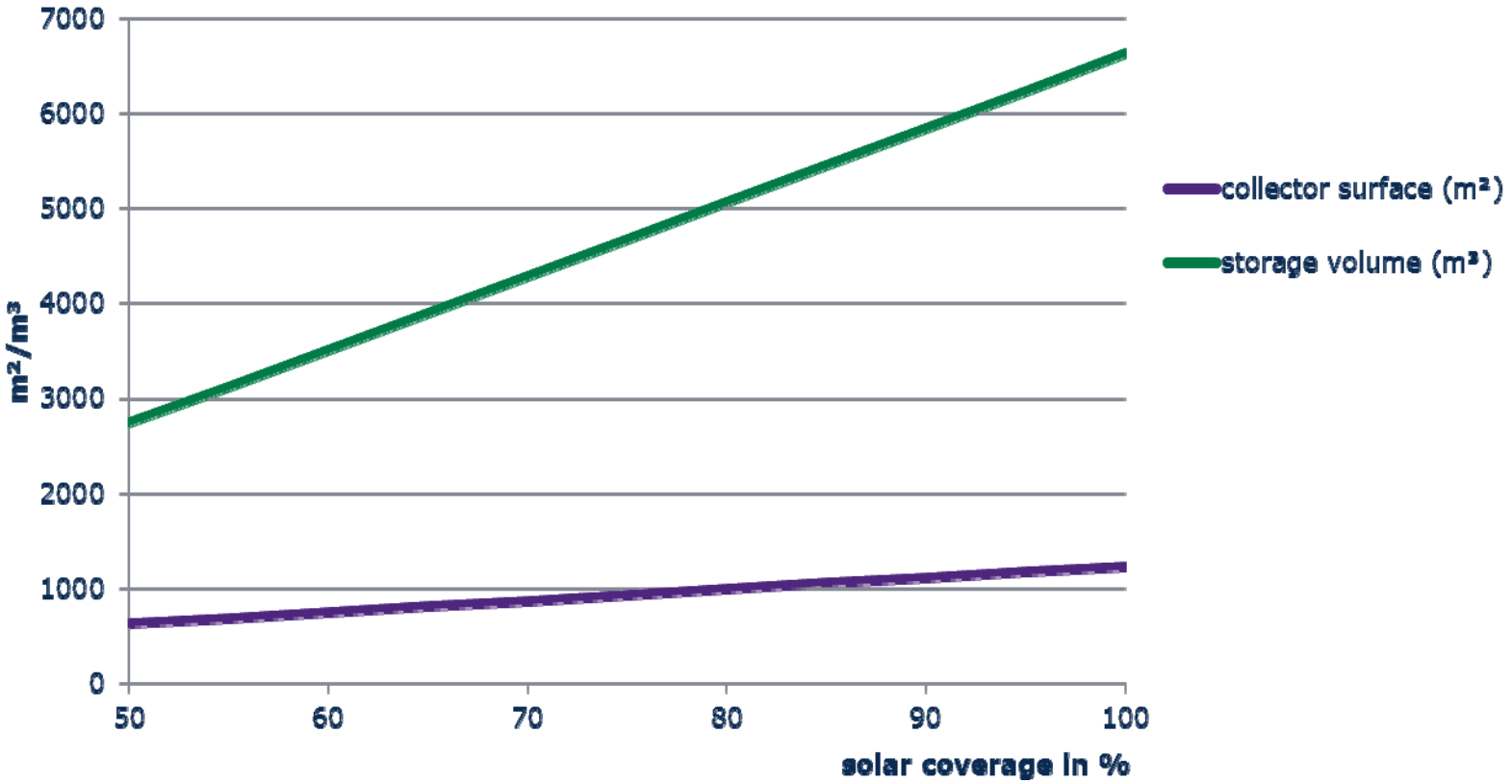
Methods – social acceptance

- Expert interviews with owners, investors and building contractors
- Findings about chances, risks and knowledge about seasonal heat storages
- Marketing options for investors
- Verification with theory of ‘diffusion of innovations’

Results – building renovation

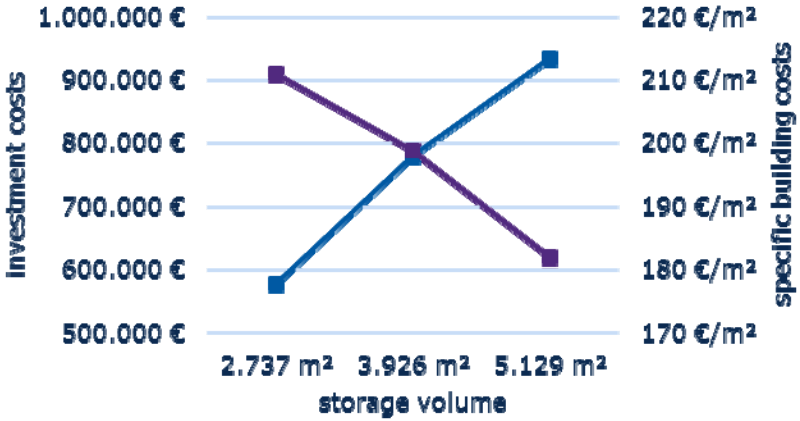


Results – heat storage and solar thermal system

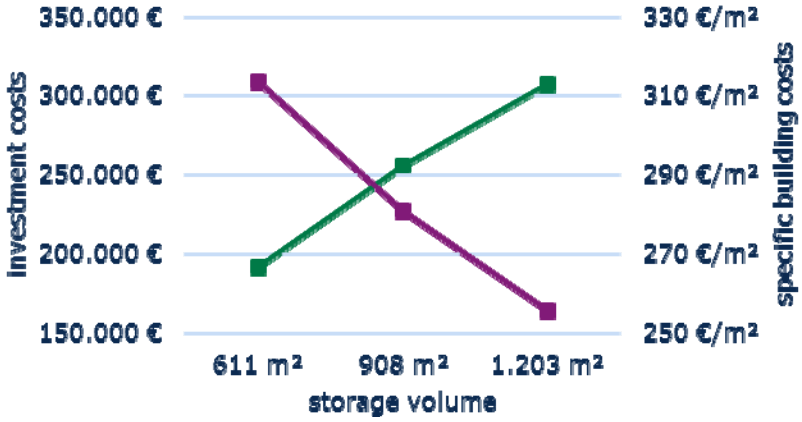


Based on the results of a calculation of Prof. Peter Lund, Aalto University Helsinki

Results – investment cost heat storage

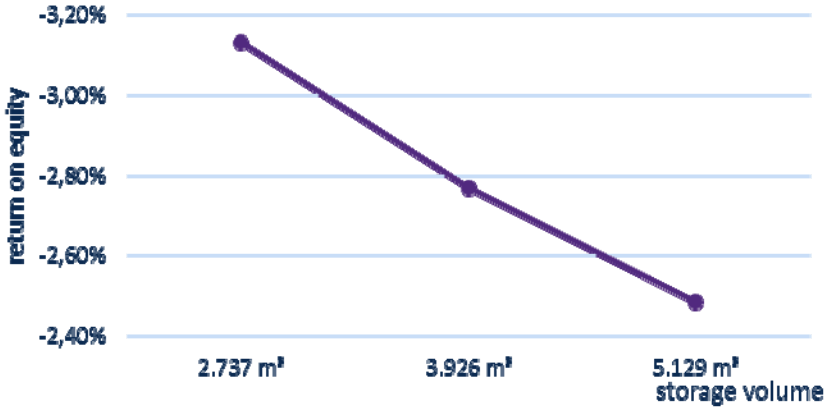


Scenario 1:
energetic standard building;
solar coverage 50 %, 65 %, 80 %

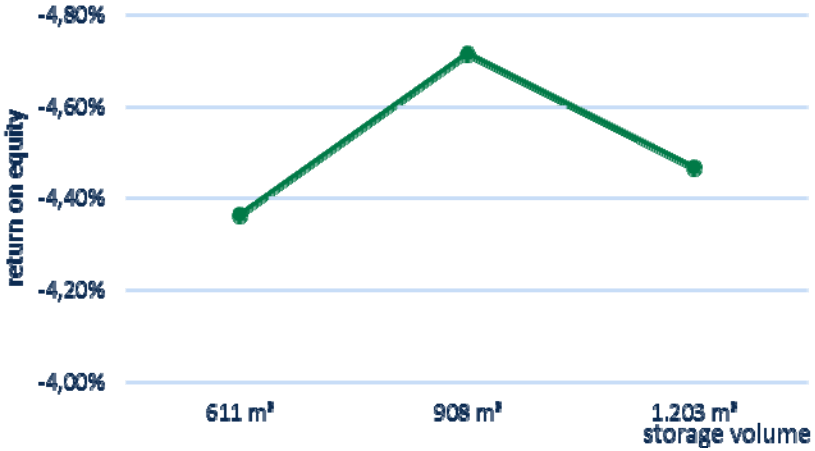


Scenario 2:
energetic optimized building;
solar coverage 50 %, 65 %, 80 %

Results – return on equity



Scenario 1:
energetic standard building;
solar coverage 50 %, 65 %, 80 %



Scenario 2:
energetic optimized building;
solar coverage 50 %, 65 %, 80 %

Outlook

- Decentralized heat supply within urban areas technically is possible
- Identification of different parameters for reducing barriers to market entry
  - Costs of the technical system
  - Knowledge of the investors
  - Political willingness
- Recommendation for investors and politics

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Thank you for your attention!

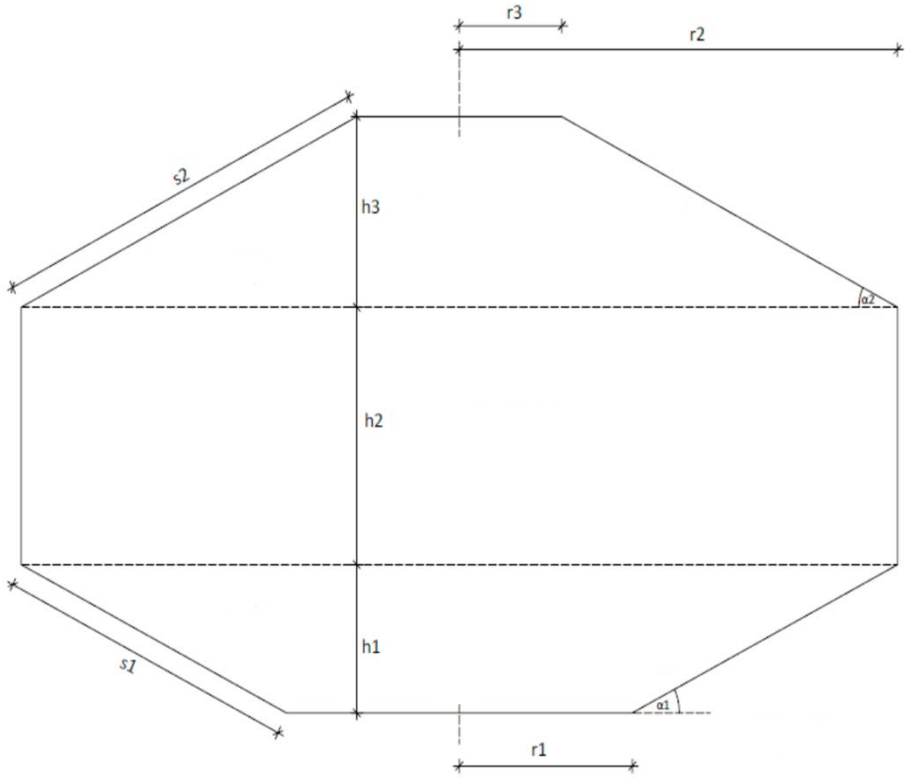
DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Building parameters

- Three apartment buildings
- Existing building from 1960 – 1970
- 216 residential units
- 16 700 m² living area

source: google maps

Dimensions of storage geometry



energetic standard
height: 12,90 m – 20 m
diameter: ca. 13 m – 19 m

energetic optimization
height: 8,50 m – 11,00 m
diameter: ca. 8 m – 12 m

Storage geometry energetic standard building

h1	h2	h3	r1	r2	r3	α1	α2	s1	s2
[m]	[m]	[m]	[m]	[m]	[m]	[°]	[°]	[m]	[m]
3,00	6,90	3,00	2,77	9,38	4,08	24,40	29,50	7,26	6,09
3,00	8,00	3,00	2,88	9,49	3,23	24,40	25,60	7,26	6,94
3,00	8,00	3,00	3,44	10,05	3,79	24,40	25,60	7,26	6,94
3,00	8,00	3,00	3,92	10,53	4,27	24,40	25,60	7,26	6,94
4,00	10,00	4,00	1,44	10,26	1,91	24,40	25,60	9,68	9,26
4,00	10,00	4,00	1,82	10,64	2,29	24,40	25,60	9,68	9,26
4,00	10,00	4,00	2,16	10,98	2,63	24,40	25,60	9,68	9,26
4,00	10,00	4,00	2,45	11,27	2,92	24,40	25,60	9,68	9,26
4,00	10,00	4,00	2,83	11,65	3,30	24,40	25,60	9,68	9,26
4,50	11,00	4,50	1,75	11,67	2,27	24,40	25,60	10,89	10,41
4,50	11,00	4,50	2,22	12,14	2,75	24,40	25,60	10,89	10,41

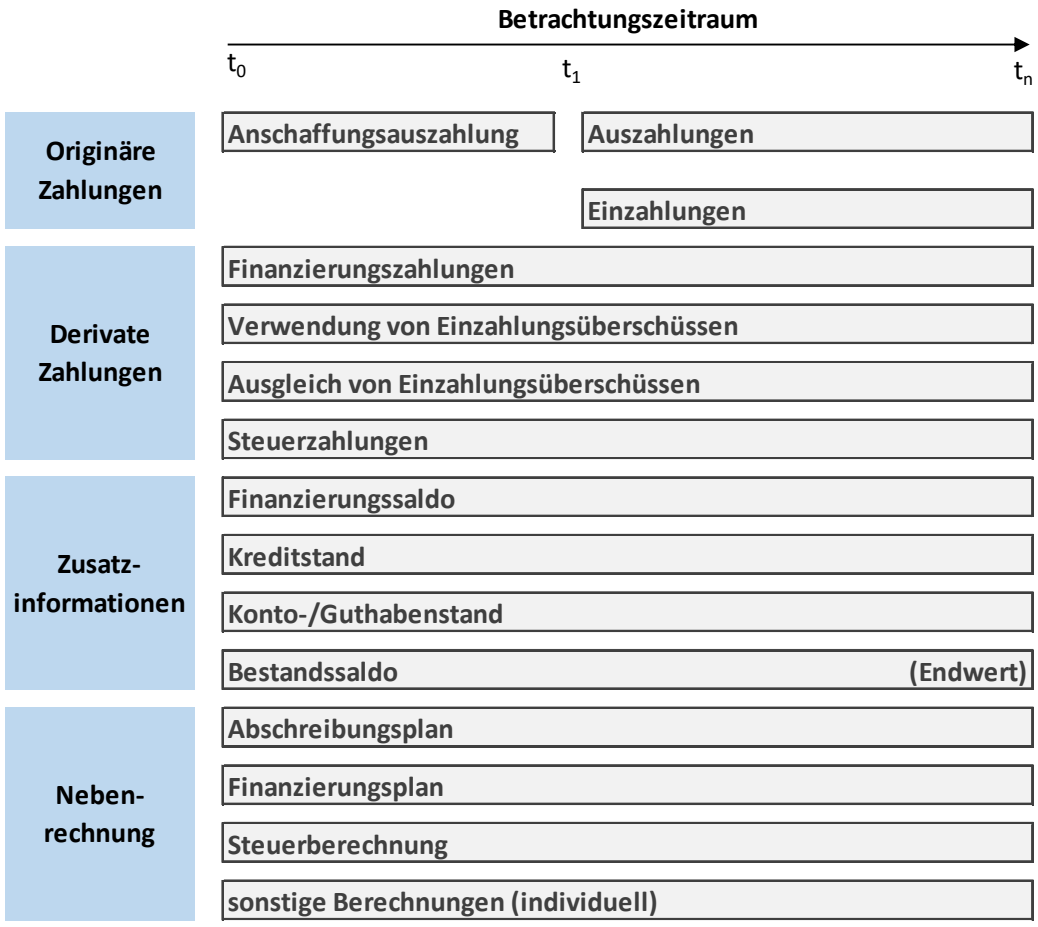
V1	V2	V3	V_{gesamt}	Differenz	**V_{gesamt}**	A_{Boden}	$A_{unterer\ KS}$	A_{Mantel}	$A_{oberer\ KS}$	A_{Deckel}	A_{gesamt}	**A_{gesamt}**	**A/V**	**A/V_{Kugel}**	**h/d**
[m^3]	[m^3]	[m^3]	[m^3]	%	**[m^3]**	[m^2]	[m^2]	[m^2]	[m^2]	[m^2]	[m^2]	**[m^2]**	**[1/m]**		
381,90	1.906,94	448,71	2.737,54	99,55%	**2750,00**	24,03	277,08	406,63	257,54	52,21	1017,50	1017,50	0,37	0,35	0,69
394,81	2.263,95	412,06	3.070,81	98,11%	**3130,00**	26,01	282,18	477,07	277,46	32,77	1095,50	1095,50	0,35	0,33	0,74
462,84	2.538,20	481,94	3.482,99	98,95%	**3520,00**	37,09	307,66	505,14	301,83	45,08	1196,80	1196,80	0,34	0,32	0,70
526,02	2.786,45	546,71	3.859,18	98,95%	**3900,00**	48,18	329,57	529,27	322,77	57,23	1287,00	1287,00	0,33	0,31	0,66
511,76	3.307,67	538,53	4.357,97	101,58%	**4290,00**	6,54	356,02	644,71	354,03	11,49	1372,80	1372,80	0,32	0,30	0,88
569,46	3.557,15	598,46	4.725,06	100,96%	**4680,00**	10,44	379,14	668,58	376,13	16,51	1450,80	1450,80	0,31	0,29	0,85
623,27	3.784,38	654,25	5.061,90	99,84%	**5070,00**	14,62	399,50	689,61	395,60	21,68	1521,00	1521,00	0,30	0,28	0,82
672,52	3.988,39	705,23	5.366,14	98,28%	**5460,00**	18,85	417,26	707,95	412,58	26,76	1583,40	1583,40	0,29	0,27	0,80
740,69	4.265,36	775,66	5.781,71	98,83%	**5850,00**	25,23	440,66	732,12	434,95	34,28	1667,25	1667,25	0,29	0,27	0,77
751,69	4.703,21	790,72	6.245,62	100,09%	**6240,00**	9,58	458,98	806,30	456,09	16,24	1747,20	1747,20	0,28	0,26	0,86
844,39	5.091,71	886,94	6.823,05	102,91%	**6630,00**	15,46	491,31	838,94	487,00	23,69	1856,40	1856,40	0,28	0,26	0,82

Storage geometry energetic optimized building

h1	h2	h3	r1	r2	r3	α1	α2	s1	s2
[m]	[m]	[m]	[m]	[m]	[m]	[°]	[°]	[m]	[m]
2,00	4,00	2,50	1,29	5,70	1,28	24,40	29,50	4,84	5,08
2,00	4,00	2,50	1,67	6,08	1,66	24,40	29,50	4,84	5,08
2,00	4,00	2,50	2,06	6,47	2,05	24,40	29,50	4,84	5,08
2,00	4,00	2,50	2,39	6,80	2,39	24,40	29,50	4,84	5,08
2,00	4,00	2,50	2,69	7,10	2,68	24,40	29,50	4,84	5,08
3,00	5,00	2,50	0,29	6,90	2,48	24,40	29,50	7,26	5,08
3,00	5,00	2,50	0,58	7,20	2,78	24,40	29,50	7,26	5,08
3,00	5,00	2,50	0,86	7,47	3,05	24,40	29,50	7,26	5,08
3,00	5,00	2,50	1,11	7,72	3,30	24,40	29,50	7,26	5,08
3,00	5,00	3,00	1,35	7,97	2,67	24,40	29,50	7,26	6,09
3,00	5,00	3,00	1,57	8,18	2,88	24,40	29,50	7,26	6,09

V1	V2	V3	V_{gesamt}	Differenz	**V_{gesamt}**	A_{Boden}	$A_{unterer\ KS}$	A_{Mantel}	$A_{oberer\ KS}$	A_{Deckel}	A_{gesamt}	**A_{gesamt}**	**A/V**	**A/V_{Kugel}**	**h/d**
[m^3]	[m^3]	[m^3]	[m^3]	%	**[m^3]**	[m^2]	[m^2]	[m^2]	[m^2]	[m^2]	[m^2]	**[m^2]**	**[1/m]**		
86,97	408,35	108,50	603,82	100,81%	**599,00**	5,24	106,35	143,27	111,36	5,16	371,38	371,38	0,62	0,57	0,75
104,64	464,83	130,56	700,04	100,29%	**698,00**	8,79	117,95	152,86	123,53	8,69	411,82	411,82	0,59	0,55	0,70
124,51	526,07	155,37	805,95	101,00%	**798,00**	13,35	129,76	162,61	135,92	13,22	454,86	454,86	0,57	0,52	0,66
143,09	581,71	178,56	903,37	100,71%	**897,00**	18,02	139,91	171,00	146,56	17,87	493,35	493,35	0,55	0,50	0,62
160,88	633,82	200,78	995,48	99,75%	**998,00**	22,78	148,98	178,49	156,07	22,62	528,94	528,94	0,53	0,48	0,60
156,06	747,93	185,61	1.089,61	99,06%	**1100,00**	0,26	163,97	216,78	149,64	19,35	550,00	550,00	0,50	0,47	0,76
176,97	813,57	208,14	1.198,68	99,89%	**1200,00**	1,07	177,50	226,09	159,09	24,25	588,00	588,00	0,49	0,46	0,73
197,71	876,51	230,13	1.304,34	100,33%	**1300,00**	2,30	189,96	234,68	167,81	29,25	624,00	624,00	0,48	0,44	0,70
218,05	936,57	251,42	1.406,05	100,43%	**1400,00**	3,86	201,45	242,58	175,84	34,27	658,00	658,00	0,47	0,43	0,68
239,12	997,25	288,49	1.524,86	100,98%	**1510,00**	5,76	212,68	250,32	203,52	22,32	694,60	694,60	0,46	0,42	0,69
258,05	1.050,69	310,02	1.618,76	100,54%	**1610,00**	7,70	222,30	256,94	211,58	25,99	724,50	724,50	0,45	0,41	0,67

Vollständiger Finanzplan – Schema



Quelle: Abbildung nach Schmuck, 2016