Ultra-Dense Energy Storage

Utilizing High Melting Point Metallic Alloys and Photovoltaic Cells

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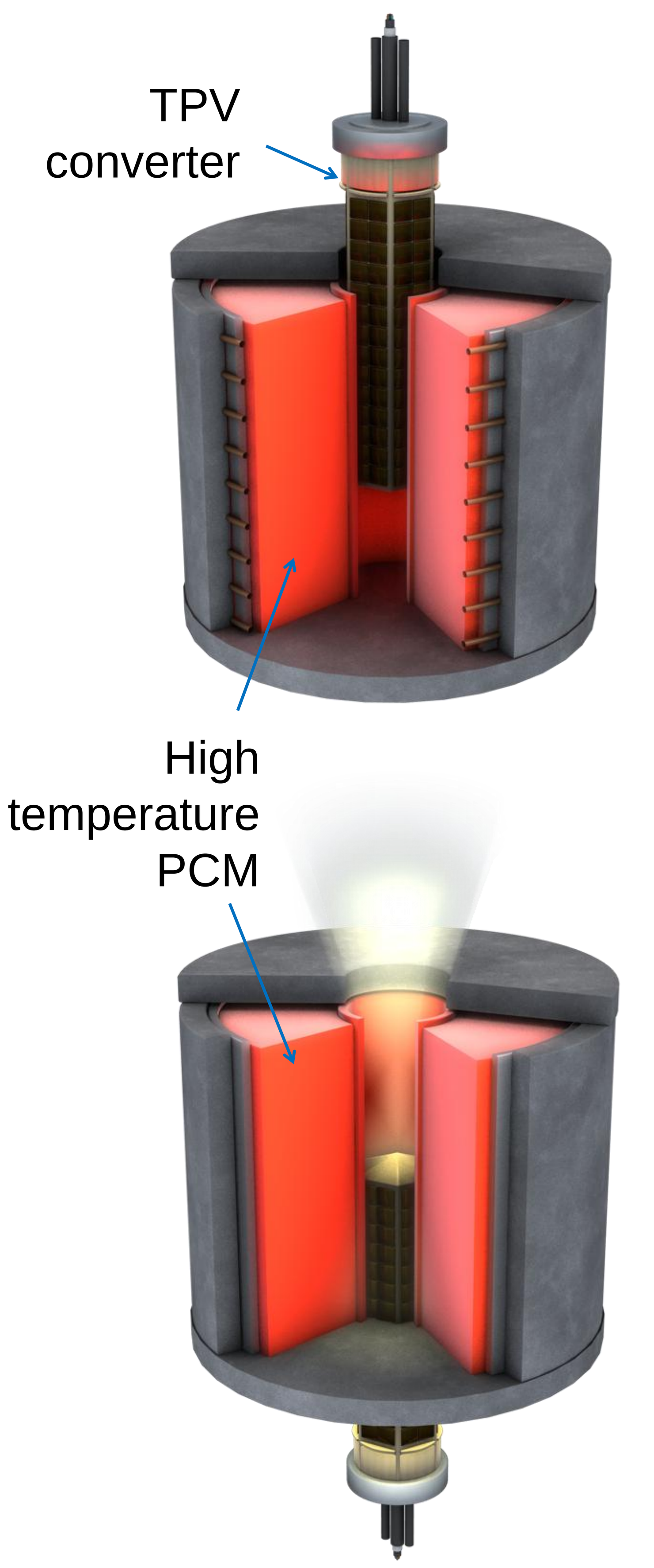
The Concept



Key elements

- Energy storage in the form of latent heat in high melting point (>1000ºC) phase change materials (PCM)
- Thermophotovoltaic (TPV) power conversion (contact-less, high temperature, no moving parts, low maintenance cost, silent operation)

Applications

✓ **Electricity storage**

Combined heat and power (CHP) for stand alone and grid-connected systems.

✓ **Solar Energy**

Substitute molten salts in Concentrated Solar Power (CSP) systems: small, modular, silent, and low maintenance (no moving parts).

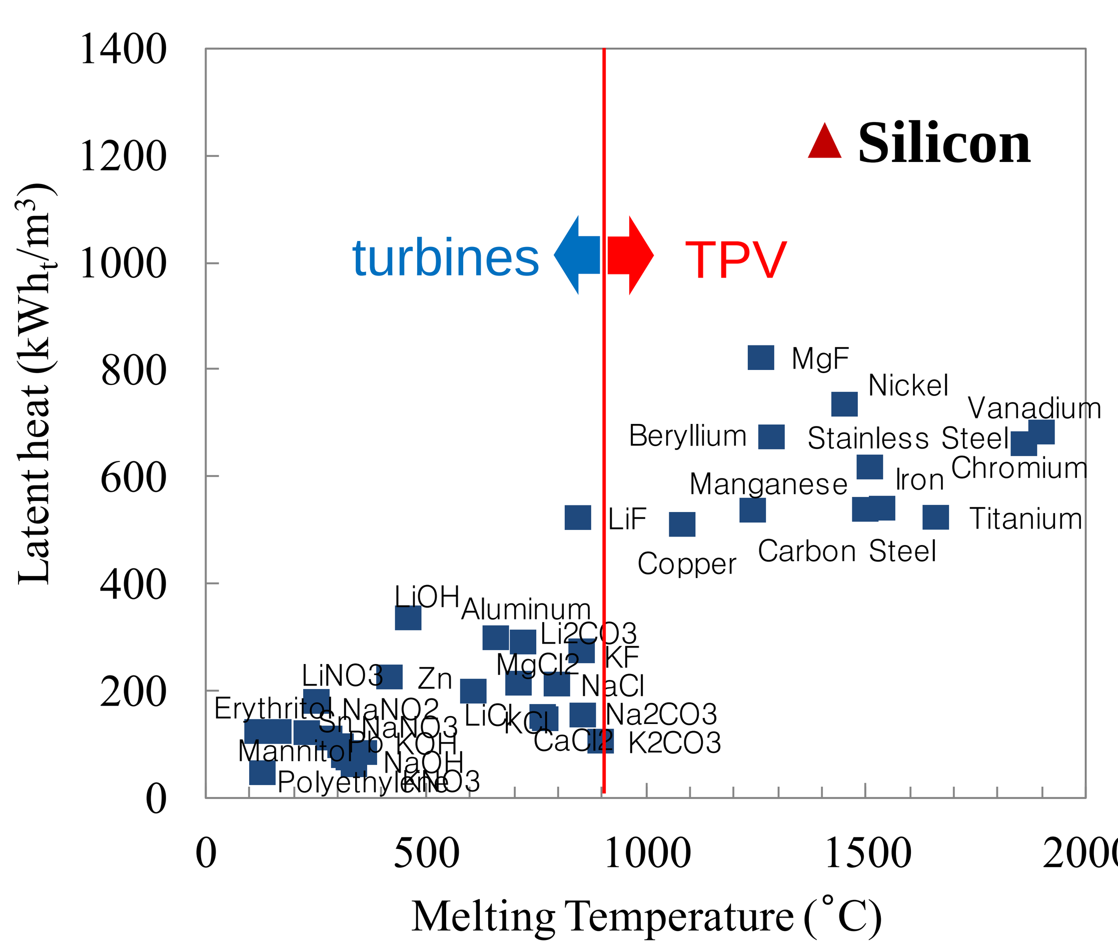
✓ **Waste Heat Recovery**

High temperature industries (steel, iron, etc.)

Motivation: High temperature PCMs

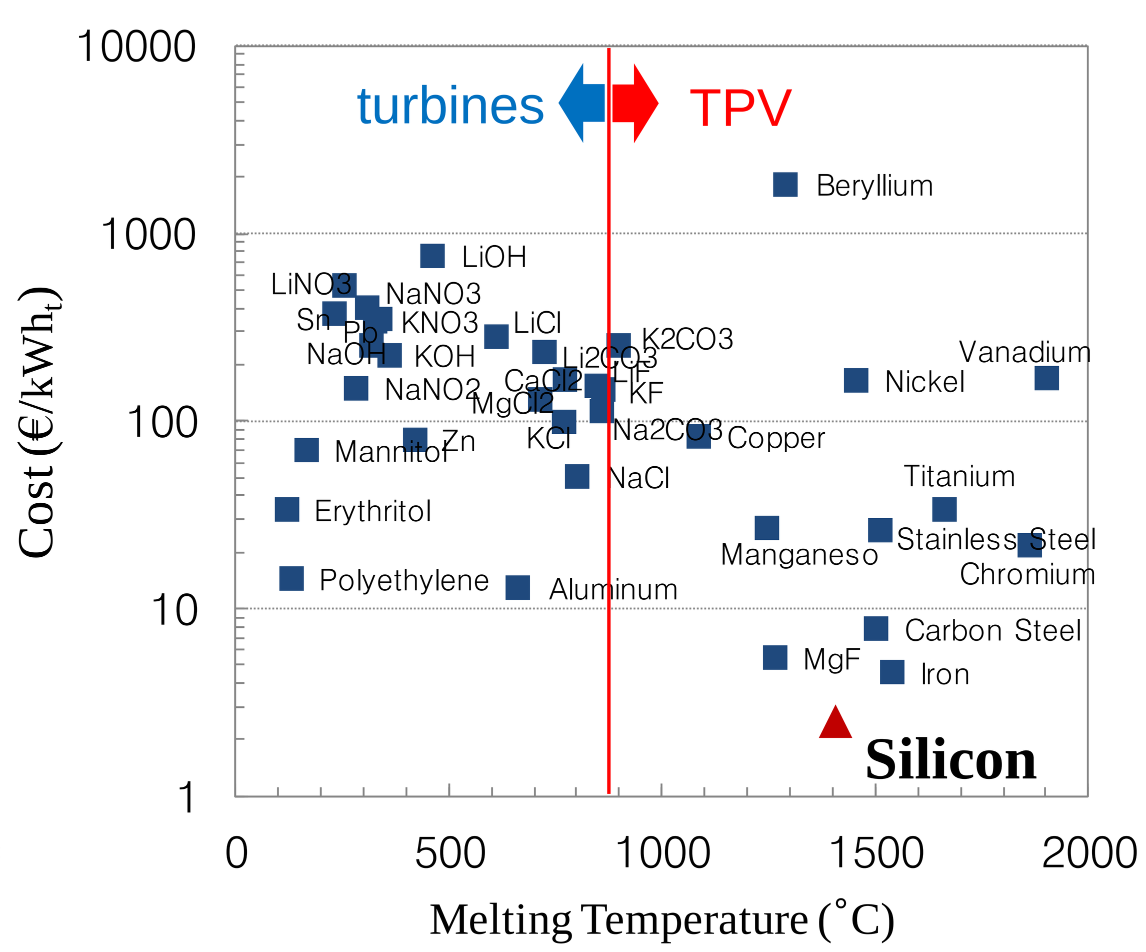
Latent heat

~10 times higher than molten salts

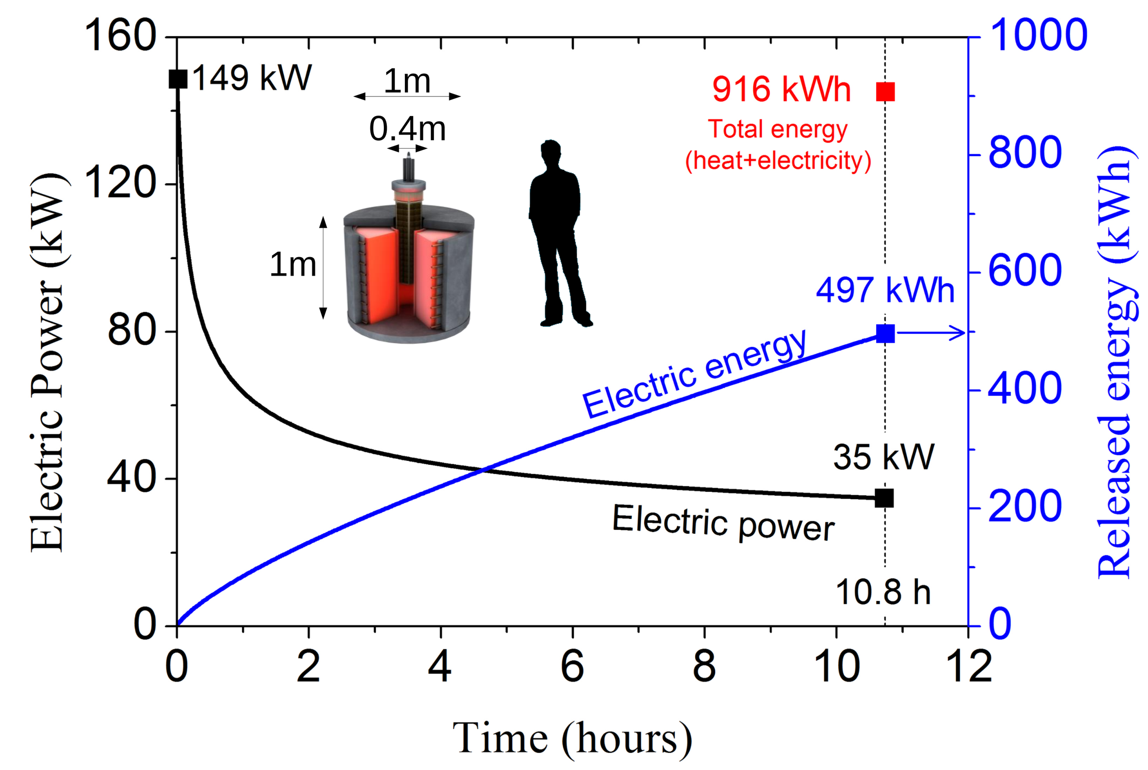


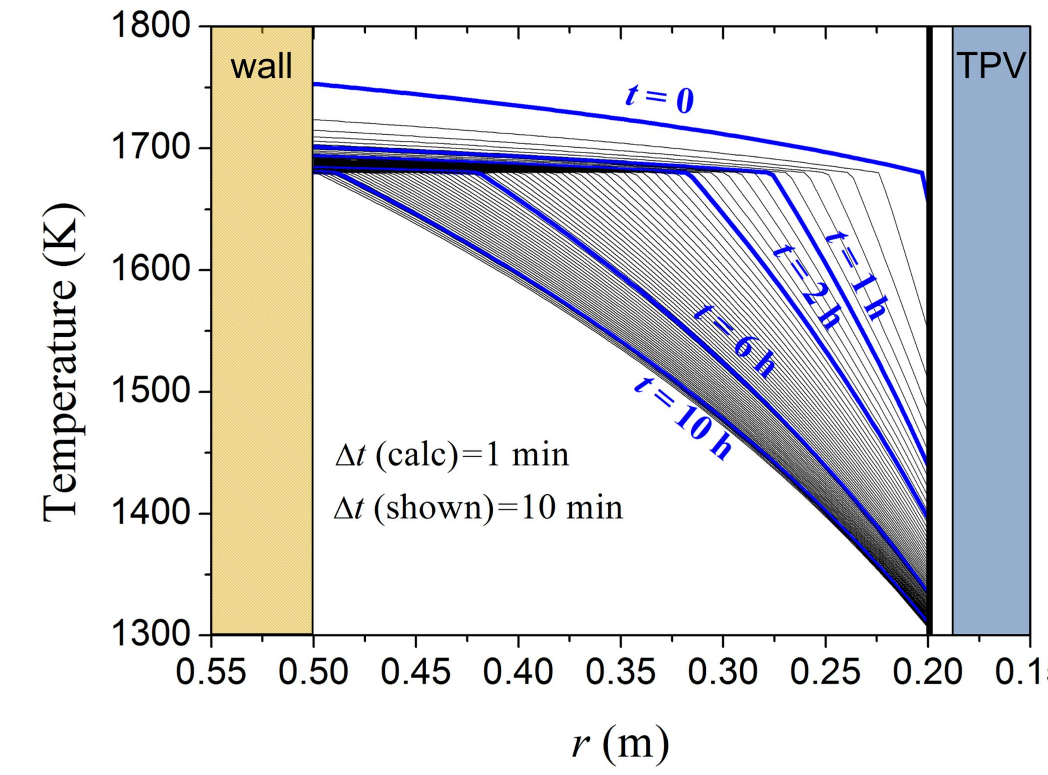
Cost per kWh

~100 times lower than molten salts



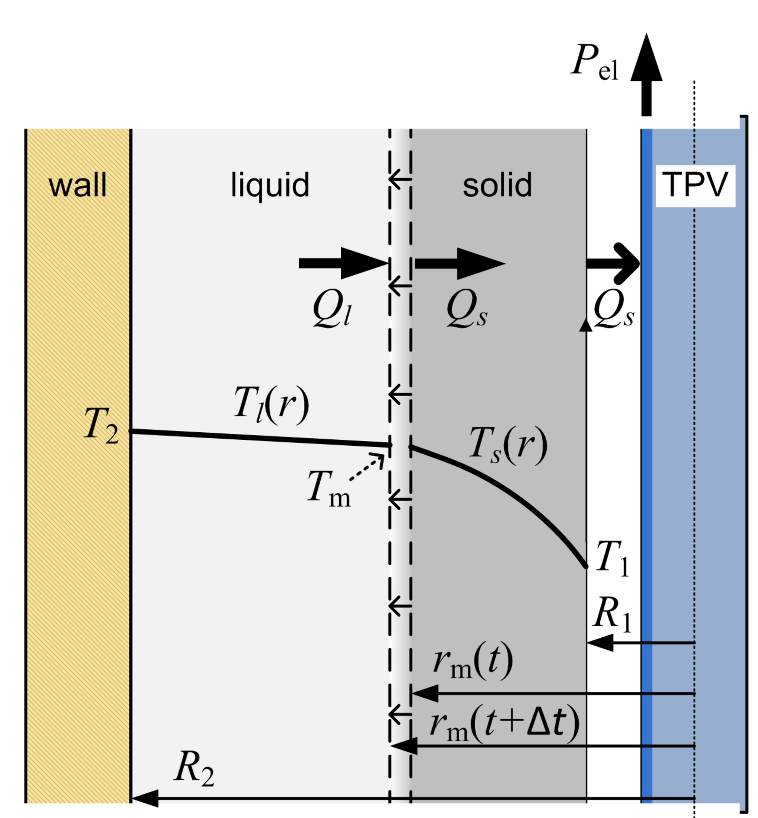
Simulation Results

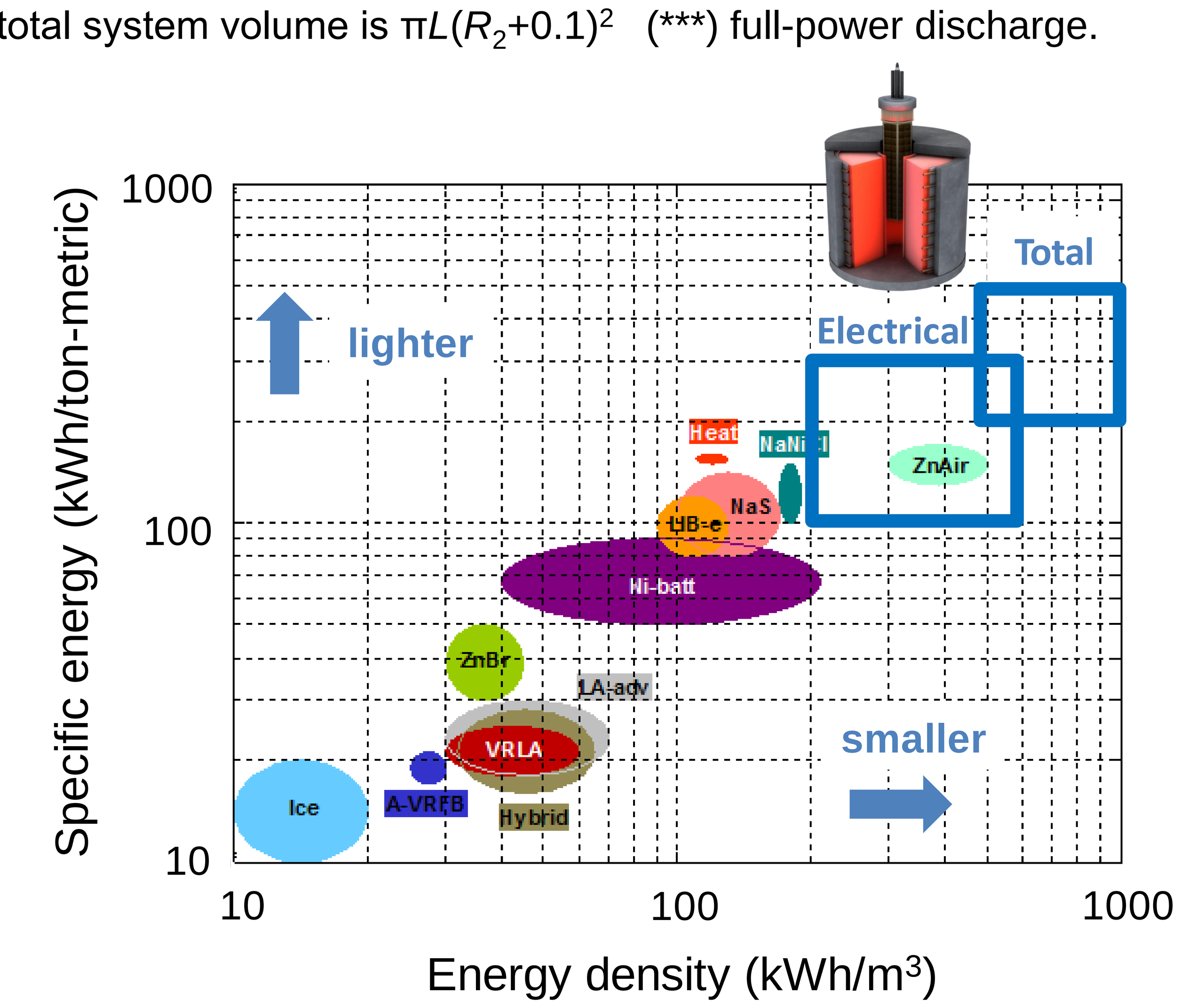




TPV converter (0.5eV)	Size (*) (m)			Released Energy (kWh)		Energy density (**) (kWh/m³)			Output Electrical Power (kW)			Discharge time (***) (hours)
	L	R_1	R_2	Heat	Electricity	Total	Heat	Electricity	Peak	Average	Minimum	
Ideal (loss-less)	0.4	0.04	0.2	28.8	34.6	557.7	254.7	302.9	12.0	5.9	5.1	5.8
	0.4	0.02	0.2	29.3	34.8	567.3	259.2	308.1	6.0	3.3	3.0	10.7
	1	0.2	0.5	419.5	496.9	810.2	370.9	439.3	149.3	46.1	34.7	10.8
	1	0.1	0.5	459.4	544.5	887.6	406.2	481.4	74.6	22.9	18.8	23.7
	3	1	1.5	9,931	11,651	894.5	411.6	482.9	2,240	464.5	299.3	25.1
	3	0.6	1.5	12,225	14,187	1,095	506.7	588.0	1,344	200.7	142.7	70.7
	3	0.3	1.5	12,933	15,009	1,158	536.0	622.1	672.0	100.0	78.8	150.2
20% sub-bandgap optical losses	0.4	0.04	0.2	40.0	23.3	559.8	353.7	206.1	11.0	4.7	3.9	5.0
	0.4	0.02	0.2	40.3	24.1	569.0	356.2	212.7	5.5	2.7	2.4	9.1
	1	0.2	0.5	611.7	314.3	818.7	540.8	277.9	137.3	33.5	23.5	9.4
	1	0.1	0.5	668.3	341.9	893.2	590.9	302.3	68.7	16.7	13.0	20.5
	3	1	1.5	15,450	7,019	931.2	640.3	290.9	2,060	310.8	174.8	22.6
	3	0.6	1.5	19,238	7,658	1,115	797.3	317.4	1,236	122.7	77.4	62.4
	3	0.3	1.5	20,252	7,982	1,170	839.4	330.8	617.9	60.7	44.2	131.4

(*) Outer vessel walls are 10cm thick (**) total system volume is $\pi L(R_2+0.1)^2$ (***) full-power discharge.





References

[1] A. Datas, A. Martí, C. del Cañizo, and A. Luque, US patent 14/198,14.

[2] A. Datas, D. L. Chubb, and A. Veeraragavan" *Sol. Energy*, vol. 96, pp. 33 – 45, 2013.

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[4] A. Datas, *Sol. Energy Mater. Sol. Cells*, vol. 134, pp. 275 – 290, 2015.

[5] A. Veeraragavan, L. Montgomery, and A. Datas, *Sol. Energy*, vol. 108, pp. 377–389, 2014.