NEXT GENERATION THERMAL ENERGY STORAGE FOR INDUSTRY AND BUILDING SECTOR

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For realization of the heat transition it is widely accepted that heat for buildings and industry must be 100% RE (Renewable Energy) latest in 2050. The focus of this paper is on heating of buildings via District Grids (DG), but the results are also applicable in industry for T<150°, which is within reach of a 2-stage heat pump and state of the art RE heat sources. For production of RE and especially Low Temperature (LT) heat the following technologies are commonly used: (A) Heat pumps operated with RE electricity or green gases and (B) Solar Thermal (ST), allowing to heat a collector medium between 80°C (flat collectors) and 400°C (concentrating ST).
In case of buildings the heat demand occurs mostly in 4 winter months, while for industry the time window varies between continuous and shift-wise operation of factories. If we like to utilize ST-heat produced preferably in summer also in winter, seasonal thermal storages are needed.
This paper is about new possibilities to design cost efficient, scalable and large seasonal thermal storages. The cost advantage is realized by replacement of costly ST-collectors (≅300 €/m²) by a cheap and efficient earth collector, which is part of the storage. In winter, the heat is extracted by means of highly efficient Energy Sheet Piles (ESP).
Possible customers are municipal utilities as DG-operators, or industry, which can use the low-temperature-heat as source for operation of the evaporator circuit of a heat pump. Optimization of the system performance requires prognostic tools for balancing supply and demand [7]. As a first result, a benchmark regarding technology and cost has been performed between state of the art DG-concepts using ST and small storages and the seasonal storage concept.
Keywords: Heat transition, Low temperature heat, Solar thermal collectors, Heat pumps, Seasonal storage, Demand Side Management, Sheet Piles.

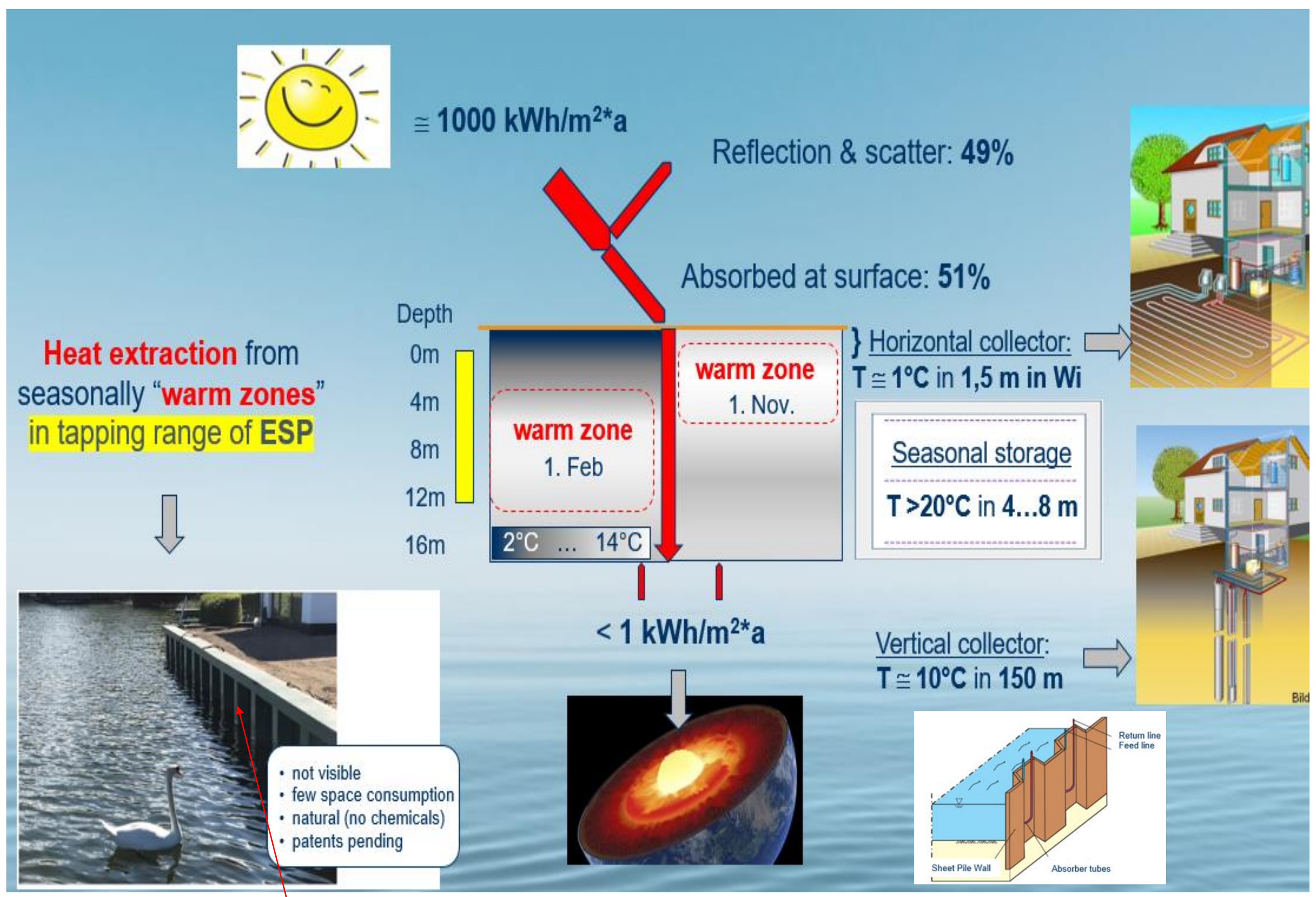

Figure 1-1: Benchmark "Heat harvesting via near-surface geothermal and deep geothermal heat sources"

(Thermally activated) **Energy Sheet piles (ESP)** are a new enabler technology for efficiently extracting Low-Temperature (LT) heat from the ground or (flowing) water, which may be used in LowExDGs with temperatures preferably in the range of 20…30°C. As this is 10…20°C above the seasonal temperature profiles in the ground, the following questions have to be answered:

Q1: How to increase the temperature using 100% RE and

Q2: How to store huge amounts of LT-heat in the ground?

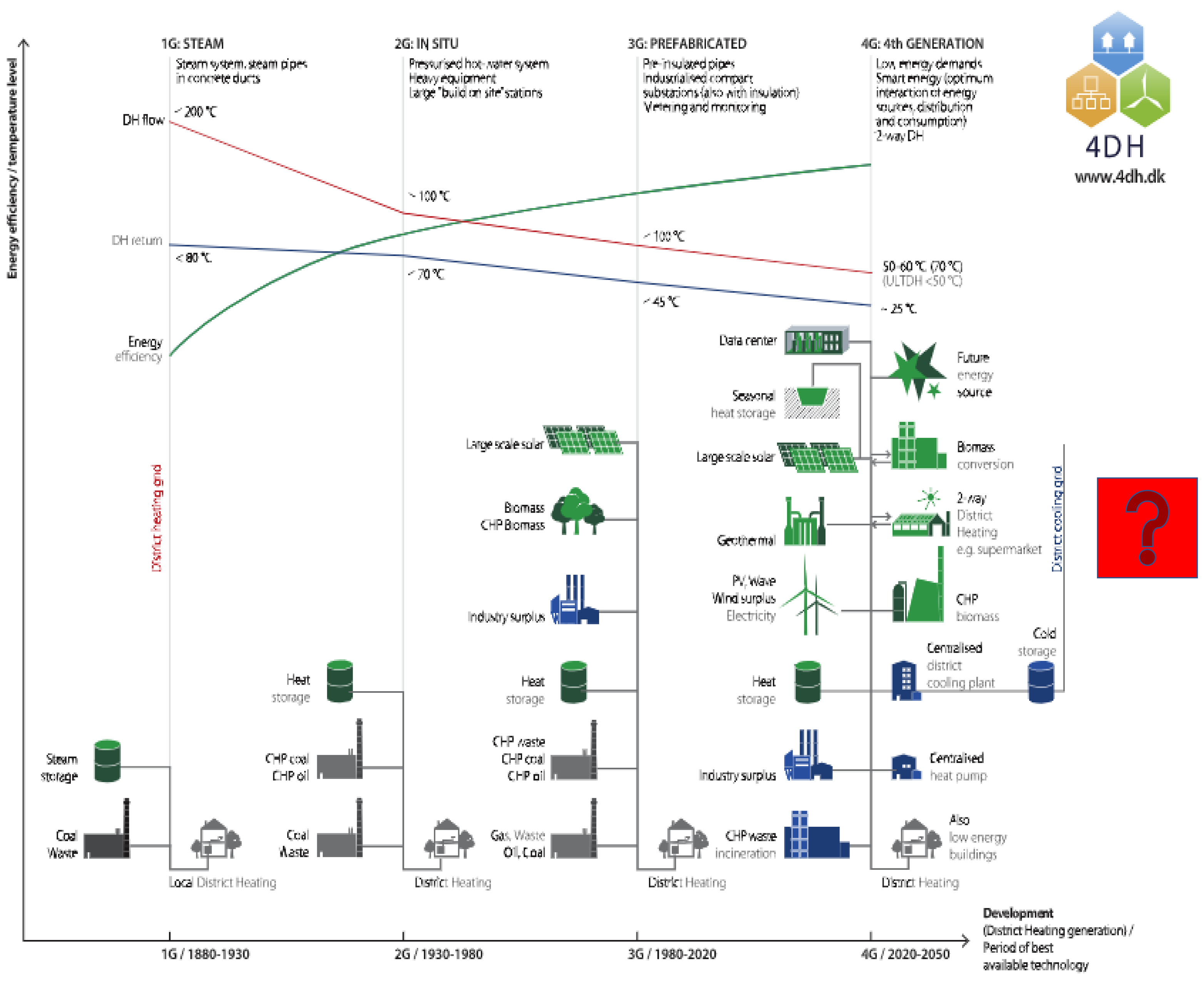

Figure 2-1:Evolution of District Grids (DG) [6]; the question arises:

Q3: What is coming next to DG 4.0?

Here, **LowExDGs** with (intelligent) **Prosumers** & **Consumers** are our favorites due to their ability to realize **Supply & Demand Side Management** and **Sector Coupling**.

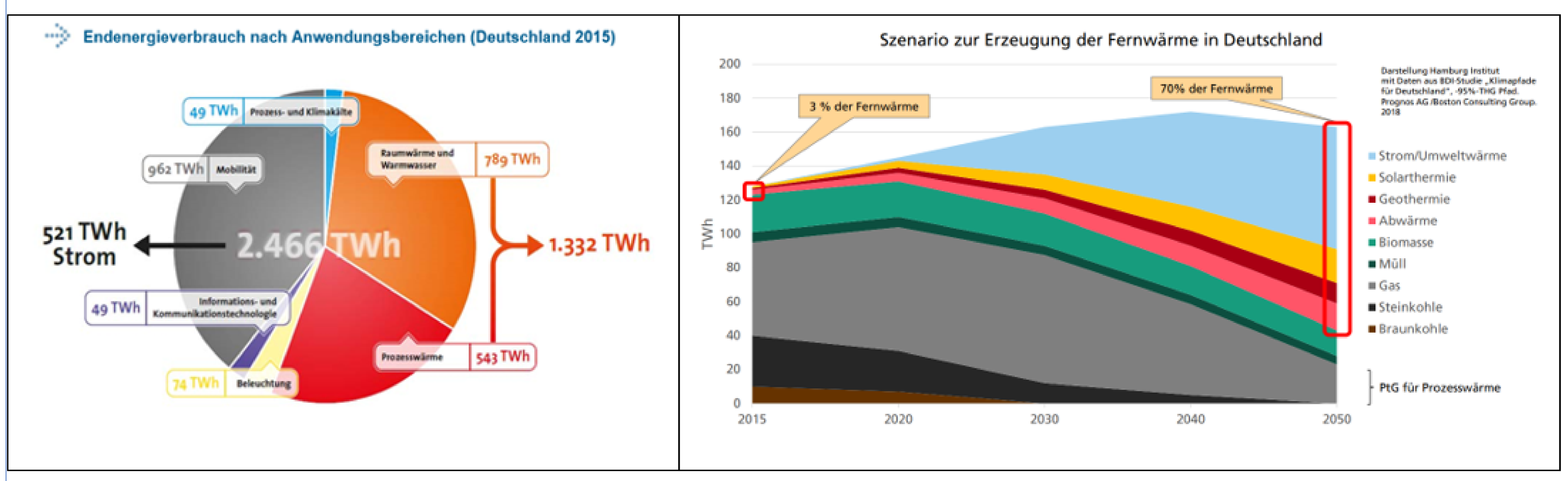

Figure 2-2: Left: Energy consumption in Germany by sectors [3]; right: Growth of DGs by energy sources [1]

Situation: Until 2050, 790 TWh of heat used in buildings must be replaced by RE, whereof **15%...20% are used in DGs**, which are gaining share. The question:

Q4: How to significantly increase the RE-part of DGs (top 5 bullets) **and simultaneously avoid less efficient air-based HP** (**blue**), which is the only megatrend today when it comes to RE-heating?

Looking at Fig. 1-1 and 2-2 it gets obvious that only ST has the power to provide large amounts of LT-heat. The next question:

Q5: How to store this heat in a seasonal storage for use in winter?

#	Ort	Betreiber	Kollektortyp	Speicher/m³	drucklos	Kollektor Fläche/m²	Kollektorleistung/MW	Aufstellfläche/m²	Ertrag/GWh/a	spez. Kollektorleistung/ kWh/m²	CO2-Einsparung/t	Zusatzheizung	dto, Leistung/GWh	Netztemperatur/°C	%RE	Entfernung/km	Wohneinheiten	Wohneinheiten 100% versorgt
1	Ettenheim	Fernwärme Ettenheim GmbH	Flachkollektor	200	nein	1.788		4.200	0,86	478	238	Hackschnitzel, öl	5,3	85/60	16,1%	4	246	53
2	Senftenberg	Stadtwerke Senftenberg	CPC	10	nein	8.300	5,0	20.000	4,2	506	1.064	Gas, Braunkohlestaub	100,0	85/65	4,2%	33	6.250	238
3	Horb	Stadtwerke Horb	VRC	3.000	ja	2.416	1,5	3.243	1,2	?	349	Holz, Hackschnitzel	15,0	85/60	8,0%	7,9	938	78
4	Lemgo	Stadtwerge Lemgo GmbH	VRC	./.	./.	9.118	5,4	17.000	3,3	?	924	KWK Erdgas	155,0	90/65	2,1%	83	9.688	206
5	Ludwigsburg	Stadtwerke Ludwigsburg	Flachkollektor	2.053	nein	14.808	10,4	25.000	5,9	392	1.624	Biomasse, Hackschnitzel	76,9	70/50	7,7%	29,2	4.803	363
6	???	???	Erdreich	500.000	ja	62.500	50.625	55.688	10,0	900	5.558	Wärmepumpe	1,39	30/50	720,0%	???	700	700

Table 4-1: Benchmark of State of the art ST-assisted DGs (#1…#5) with seasonal storage (#6)

Today, in state of the art ST-assisted DGs, the ST-part varies between **2% and 16%** (Source: BSW).

Q6: Is there a possibility to increase the RE-part towards 100%?

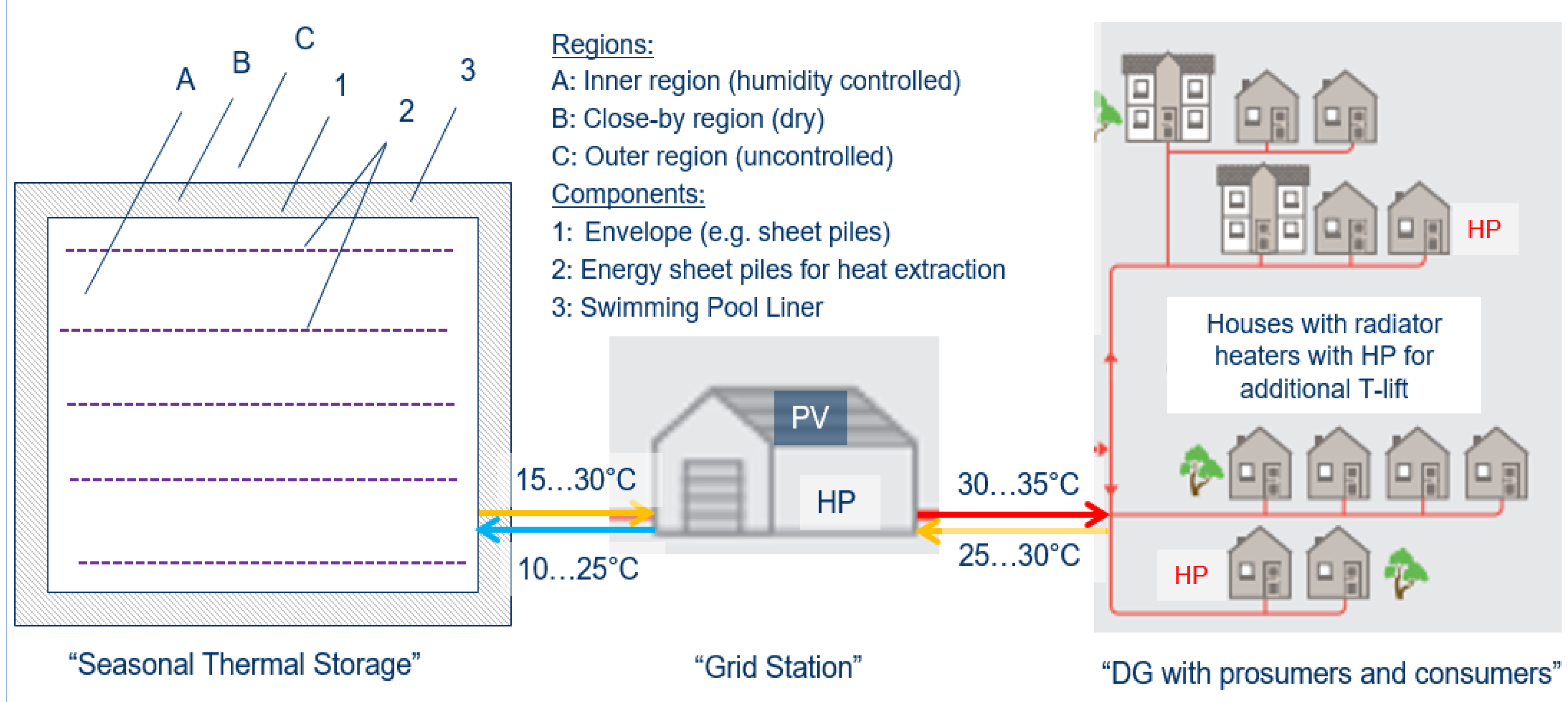

Figure 3-1: Sketch of Seasonal Heat Storage (SS)

Such a storage consists of a inner region (A) with controlled humidity, a close-by region (B) with low humidity and an outer region (C) with uncontrolled humidity. Heat is extracted via ESP and fed to a grid station, where the temperature may be raised via a highly efficient **water-water-HP with COP>10**. Houses with **radiator heaters** need an **additional water-water-HP** for raising the temperature to the needs of the building and are preferably **prosumers**, as they supply additional heat to the DG. Houses with **area heaters** are preferably **consumers**.

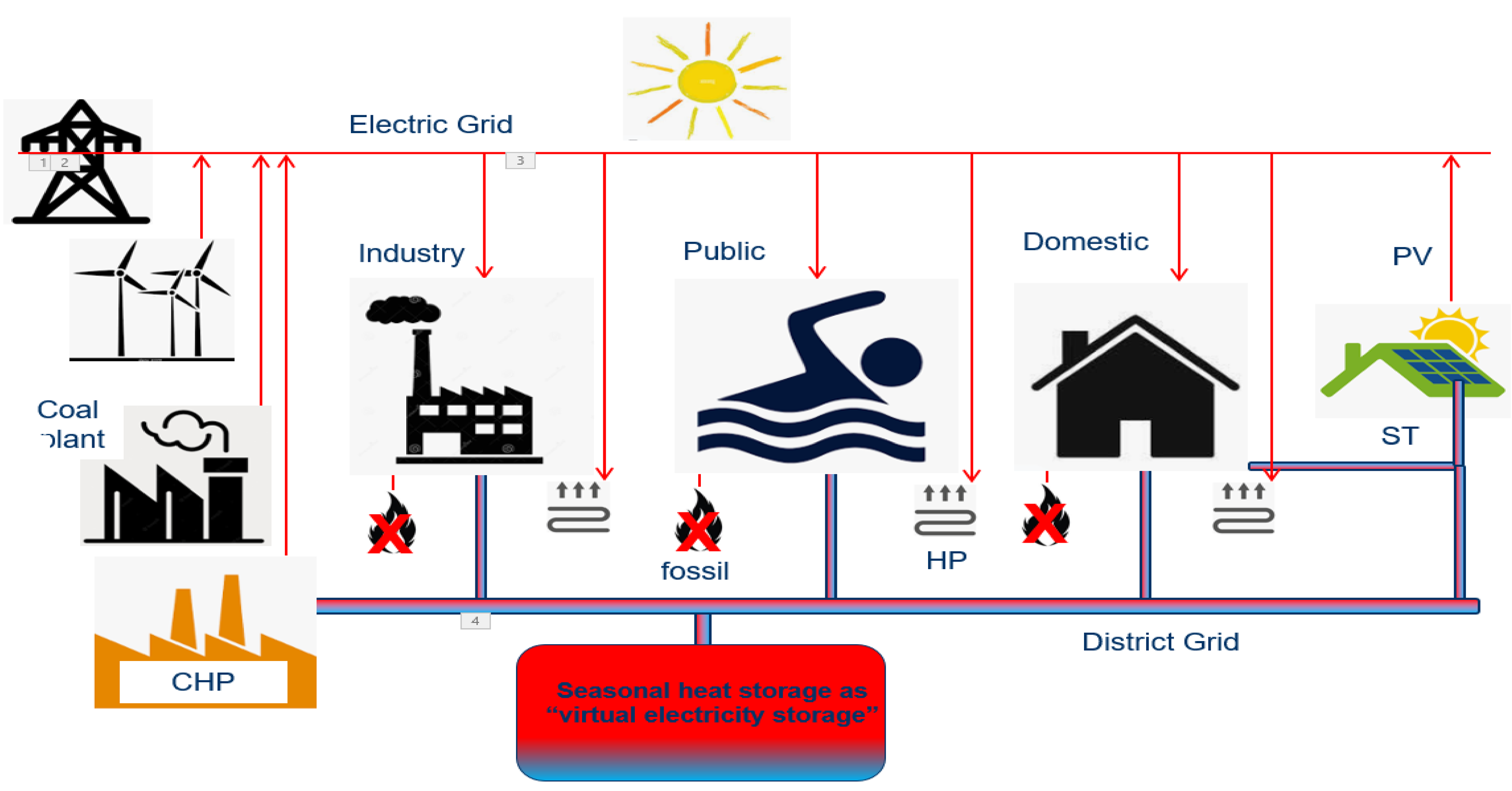

Figure 3-3: Importance of Sector Coupling and effect of seasonal storage

At the end of the day, seasonal storages for heat) will act as **virtual electricity storages** allowing **sector coupling** and thus to balance demand & response of the grid due to the **thermal mass storage capacity of buildings**, which is in focus of the new SHC-task "Thermal Building Mass Activation".

Companies with interest in this technology are invited for collaboration.

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