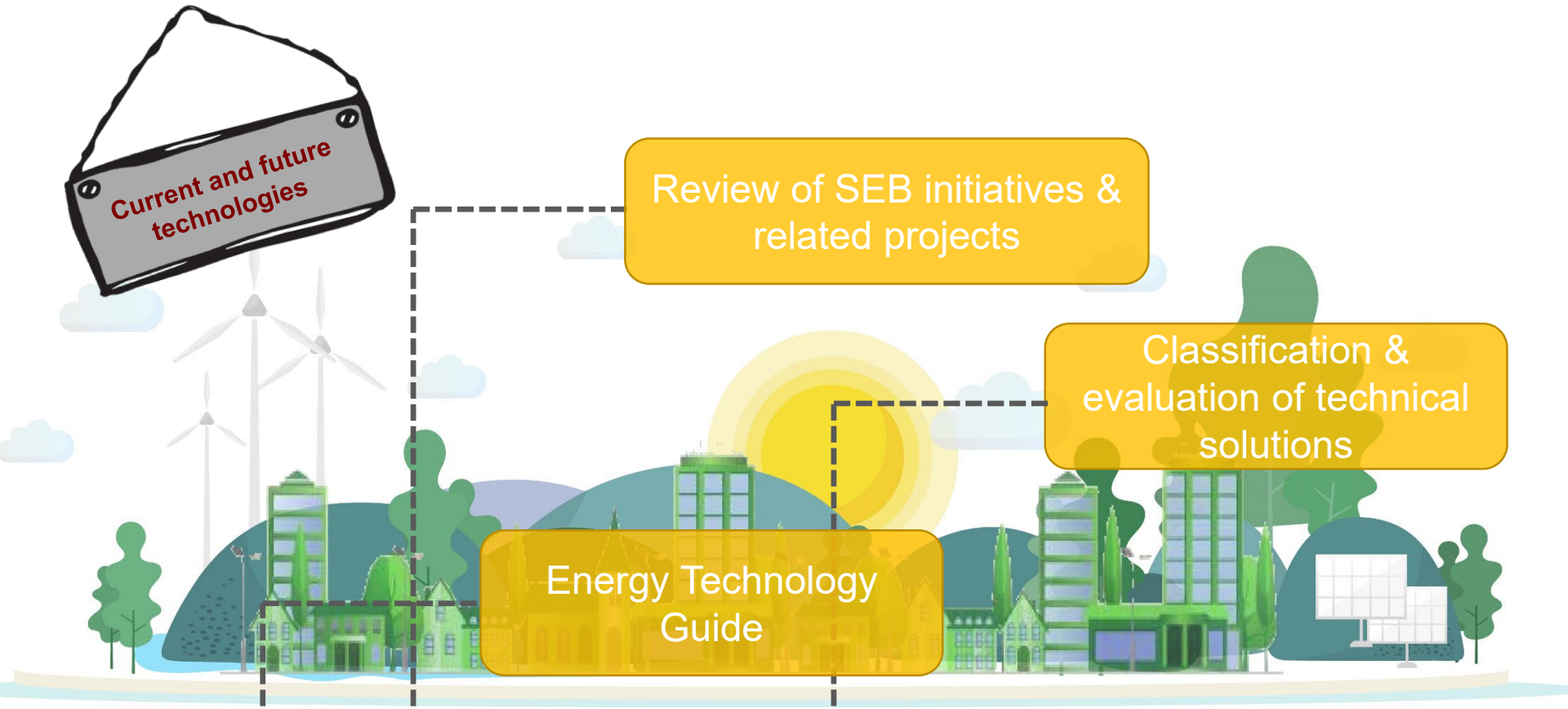
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Current and future technologies and components for Solar Energy Buildings

Michael Gumhalter, Thomas Ramschak, AEE INTEC, Austria

Task 66 Solar Energy Buildings – Subtask D



Review of SEB initiatives & related projects

Two main sources

- Case studie descriptions – real implementations
  - Demo cases from Task B/C
- Case studies from sources beyond Task 66
  - EU-Projects, IEA Tasks, …

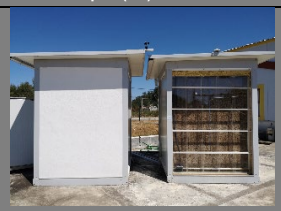
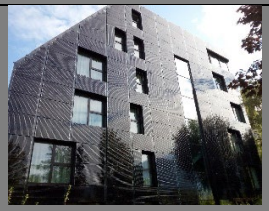
Classification of SEBs

- Technology variations between the SEBs
- Clustering in generation, storage, grid and building related
- Geographic differences (climate regions-ranging from warm climates with Low HDD to cold climate with high HDD)

Review of SEB initiatives & related projects

Demo Cases from Task 66

- Stand alone buildings to city districts (+ test chambers)
- Very ambitions demonstration cases
- Emerging technologies
- Upgrading single technologies to be part of a larger system

MIXED USE by AEE INTEC Former Industrial complex (AT)  SEB No.1	COMMERCIAL by DTU Ramboll Head Office (DK)  SEB No. 2	RESIDENTIAL by Simply Solar  SEB No.3	RESIDENTIAL by IGTE Flying Space (DE)  SEB No.4
RESIDENTIAL by TU Freibg Apartment Buildings (DE)  SEB No.5	TEST CHAMBERS by LNGE LNGE Campus (PT)  SEB No.6	COMMERCIAL by AEE INTEC Orphange (PL)  SEB No.7	RESIDENTIAL by SIZ energieplus Multi-family houses (DE)  SEB No.8
RESIDENTIAL by AEE INTEC Sol4City-Simulation Study  SEB No.9	RESIDENTIAL by SIZ energieplus Multi-family house (DE)  SEB No.10	MIXED USE by (UIBK) An der Lan (AT)  SEB No.11	RESIDENTIAL by (UIBK) Vögelebichl (AT)  SEB No.12

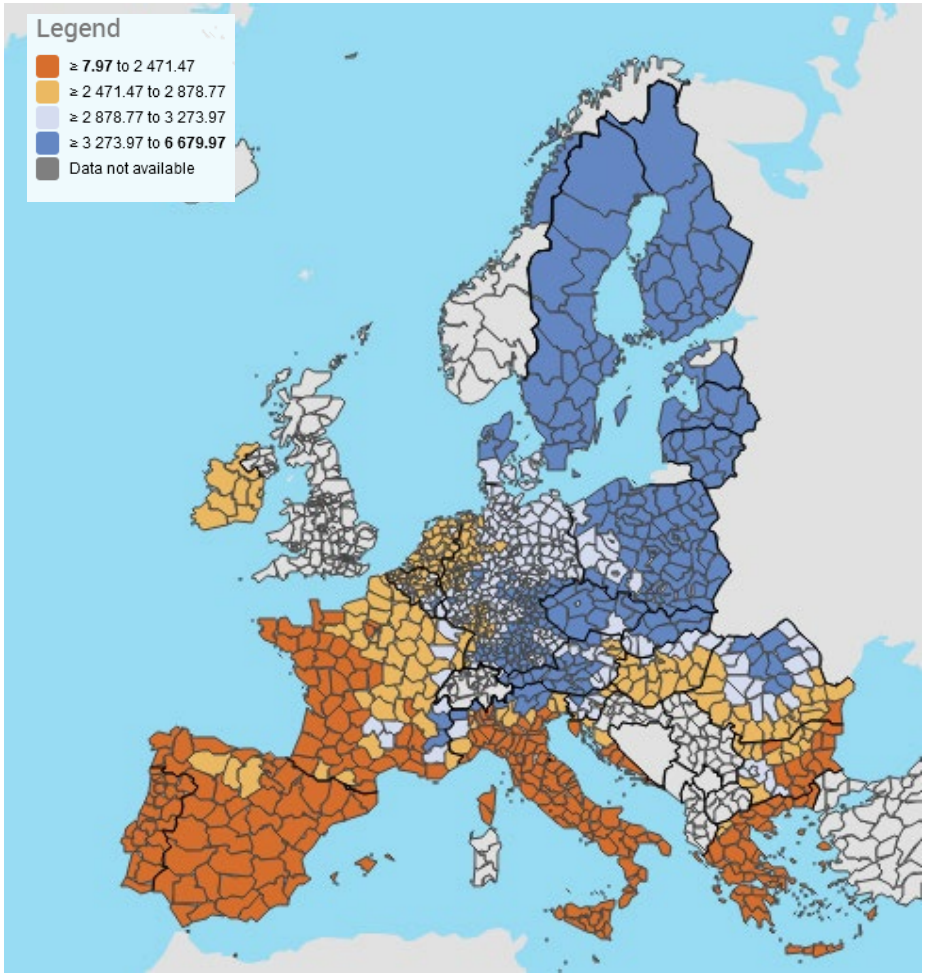
Review of SEB initiatives & related projects

126 SEBs in 17 countries

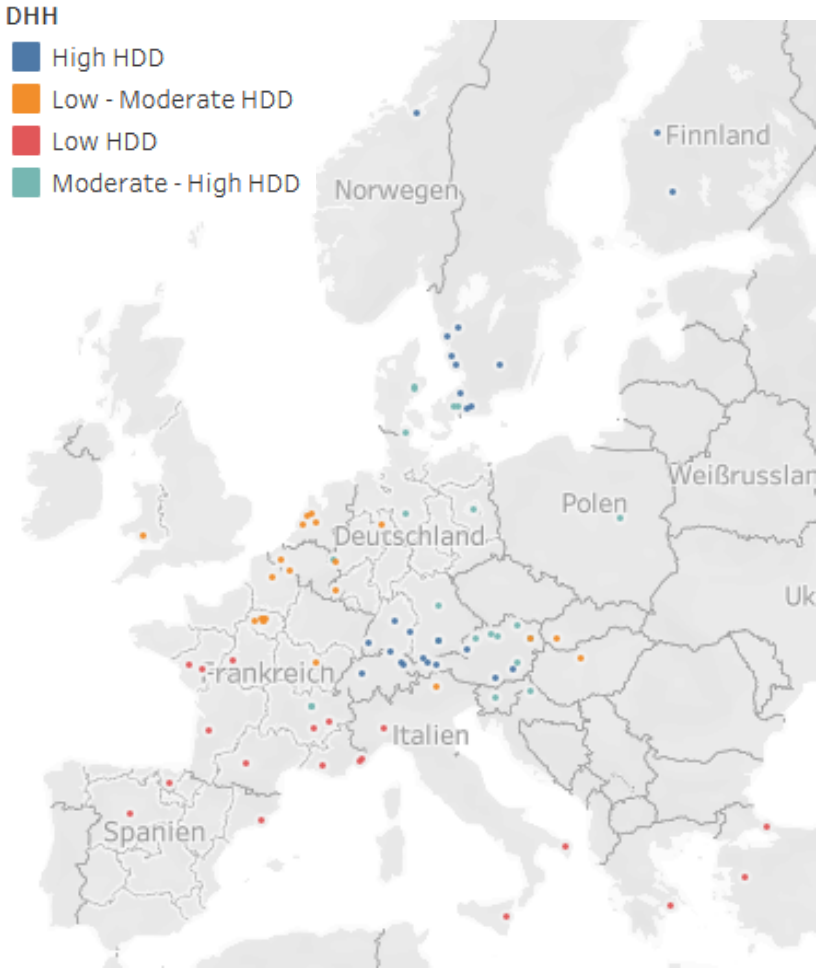
SEB No.	Name of SEB Example	Country	DHH	Link
1	Act2	Germany	Moderate - High HDD	Link
2	Act2	France	Low HDD	Link
3	Active office	United Kingdom	Low - Moderate HDD	Link
4	Aerem factory	France	Low HDD	Link
5	AquaTurm Water Tower Hotel	Germany	High HDD	Link
6	BEEM-UP	Sweden	High HDD	Link
7	BEEM-UP	Netherlands	Low - Moderate HDD	Link
8	BEEM-UP	France	Low - Moderate HDD	Link
9	BUILDSMART	Sweden	High HDD	Link
10	CITyFiED	Sweden	High HDD	Link
11	CITyFiED	Turkey	Low HDD	Link
12	CITY-ZEN	Netherlands	Low - Moderate HDD	Link
13	CITY-ZEN	France	Low HDD	Link
14	CLASS1	Sweden	High HDD	Link
15	Commercial Building Kobra	Slovenia	Moderate - High HDD	Link
16	Concert or Conference Hall "The House for All"	France	Moderate - High HDD	Link
17	Concerto AL Piano	Italy	Low HDD	Link
18	DIRECTION	Germany	Moderate - High HDD	Link
19	DIRECTION	Spain	Low HDD	Link
20	ECO-Life	Denmark	Moderate - High HDD	Link
21	ECO-Life	Belgium	Low - Moderate HDD	Link
22	Eco-Renovation of KTR France HQ	France	no information on exact location	Link
23	Education and Leisure Hub	France	Low - Moderate HDD	Link
24	EE-HIGHRISE	Slovenia	Moderate - High HDD	Link
25	Efficiency House Plus	Germany	no information on exact location	Link
26	Elithis Tower	France	Low - Moderate HDD	Link
27	Energy in Minds!	Sweden	High HDD	Link
28	Energy Positive Dwelling	Netherlands	Low - Moderate HDD	Link

Classification of SEBs

Geography and climate



Source: Eurobase Cooling and Heating degree days



Source: AEE INTEC

Classification of SEBs

Technologies

Generation Technologies → Storage Technologies → Thermal Grids → Buildings/Communities

Technology ..	Technology	Sub-Technnology
Generation	Solar Electric	Photovoltaic systems (PV)
	Solar Thermal	Solar thermal collector (ST)
	Hybrid (solar thermal and solar electric)	Air PVT-collectors
		Concentraing PVT-collectors
		Covered water PVT-collectors
		Evacuated tube PVT-collectors
		Uncovered water PVT-collectors
		Uncovered water PVT-collectors with fin heat exchanger to incre..
	Sorption collectors	Charge Boost-sorption collector
	Heat pumps	Absorption heat pump
		Adsorption heat pump
		Air-source heat pump using heat recovery
		Ground-source heatpump with ground heat exchanger
		Ground-source heatpump with inclined or deep horizontal wells
		Heat pumps with (PV)T-collectors as heat source
		Heat pumps with direct solar evaporator
		High-temperatur heat pumps
		Metal hybrid heat pump
		Natural refrigerant heat pump
		Sate of the art air-to-air heat pump
		Synthetic methane heat pump
		Water to water heat pump
	Wind	Micro wind turbines
	Hybdro	Small hydropower plant
	Cogeneration	Fuel cell micro-CHP
	Biomass	Pellets burning stove and boiler
		Wood-burning stove
	Biogas	Biogas plants

Classification of SEBs

Technologies

Generation Technologies → **Storage Technologies** → Thermal Grids → Buildings/Communities

Technology ..	Technology	Sub-Technnology
Storage	Electricity	Battery storage
		Community Battery storage
		Mobile electircal storage (E-mobility with vehicle to Grid)
		Redox flow battery
		Salt water battery
	Latent	Thermal storage- Latent (PCM)-solid-liquid ice storage
	Mechanical	Pumped storage
	Sensible	Hot water tanks
		Large scale sensibel storage
		Thermal activated building mass
		Thermal storage with vacuum insulation
	TCM (thermo chemical sto..	Null
	Ungerground thermal storage	Aquifer thermal energy storage
		Borehole thermal energy storage

Classification of SEBs

Technologies

Generation Technologies → Storage Technologies → **Thermal Grids** → Buildings/Communities

Technology ..	Technology	Sub-Technnology
Thermal grids	Heating and Cooling	Absorption-heat exchangers
		Booster heatpumps
	System integration and operation	Anergy or ultra-low temperature networks
		Demand Side Management / Demand Response
		District cooling
		Integrated energy systems
		Integration of waste heat and low exergy sources
		Low temperature district heating grids
		Model predictive and adaptive Control Strategy for the Operatio..
		Solar thermal district heating
		Virtual power plant

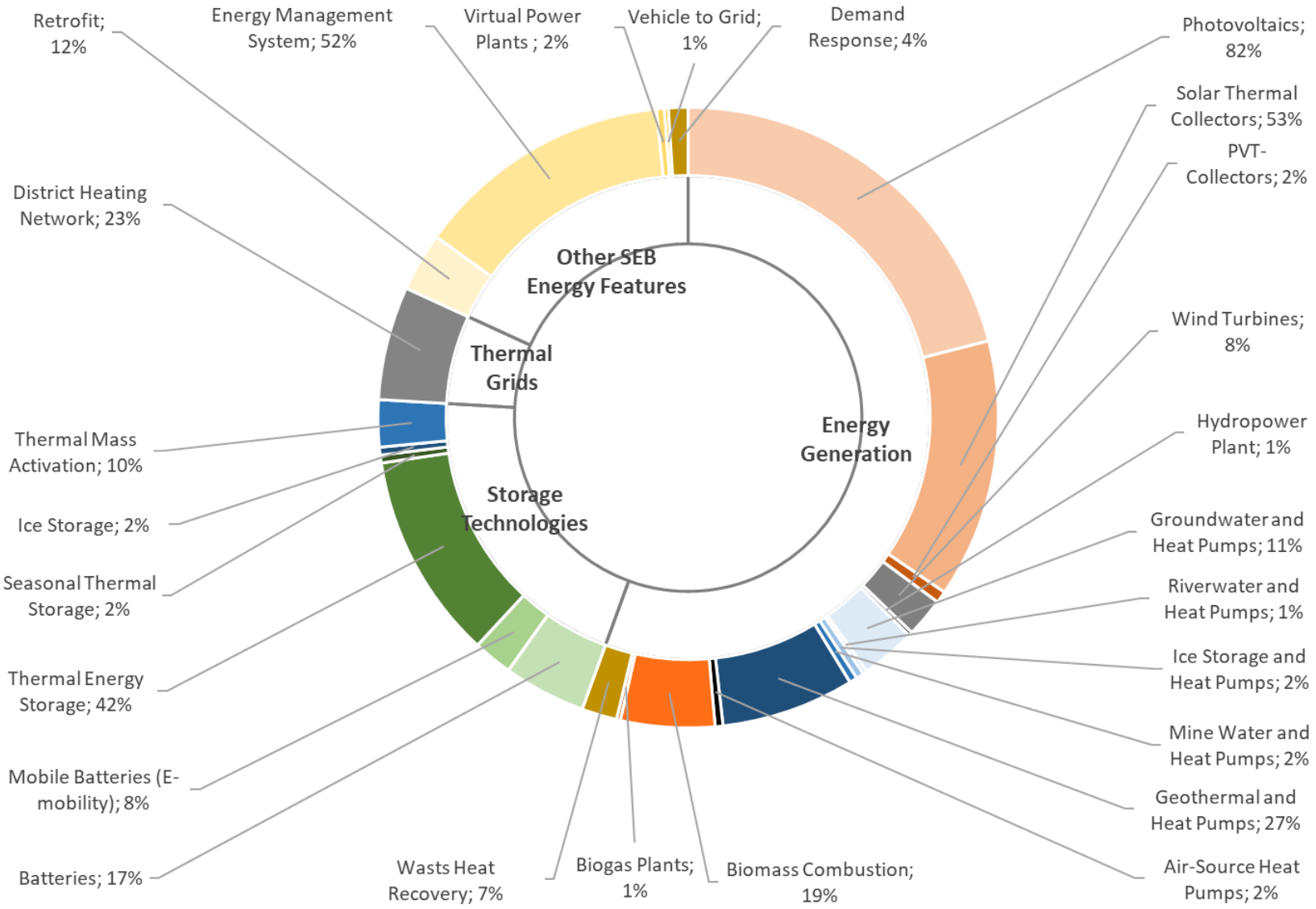
Classification of SEBs

Technologies

Generation Technologies → Storage Technologies → Thermal Grids → Buildings/Communities

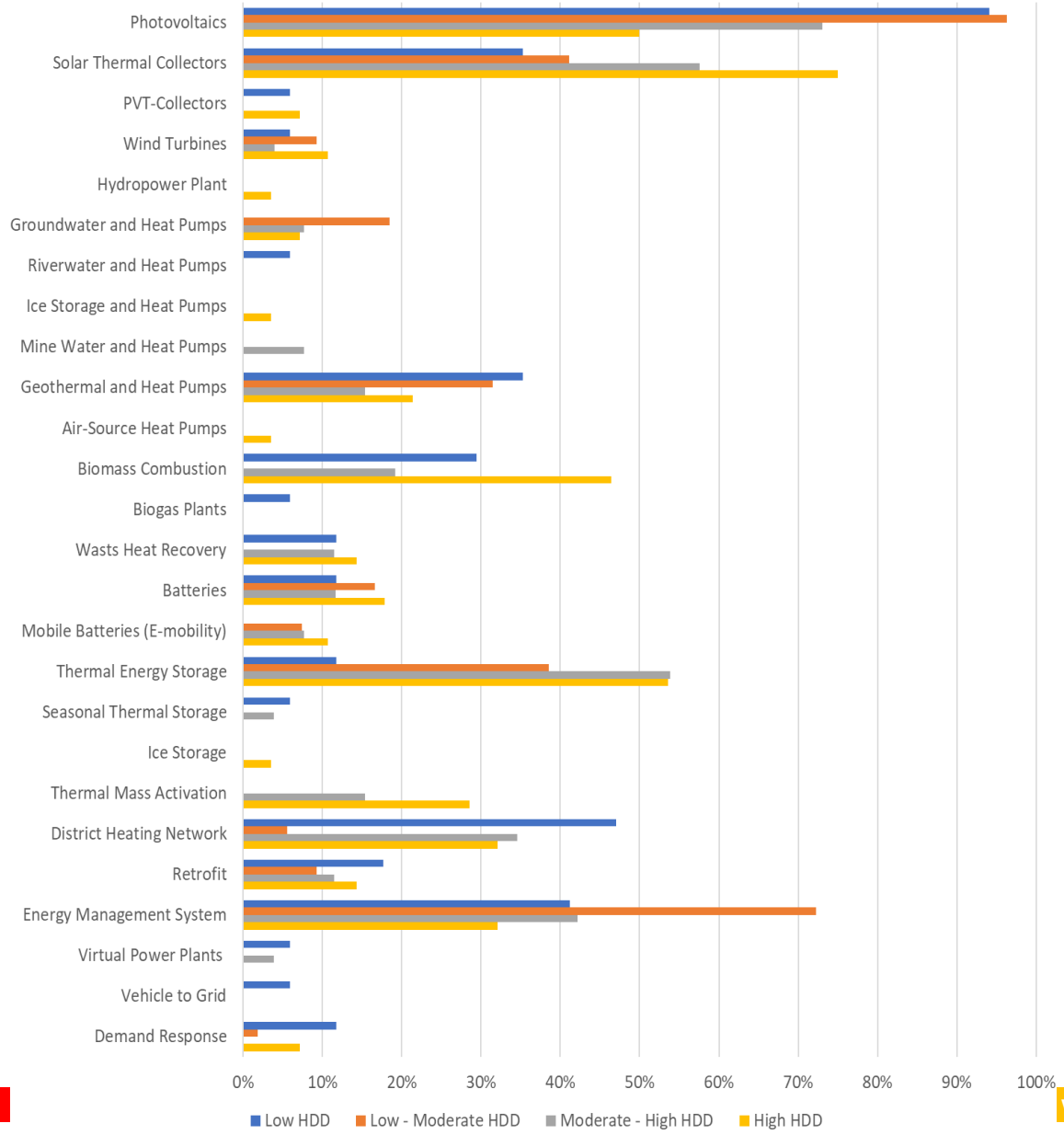
Technology Grouping	Technology	Sub-Technnology
Buildings/Communities	Heating and Cooling	Dynamic thermo-regulative walls/windows
		Energy active Facades
		Facade integrated mico heatpump
		Thermal building mass activation
		Thermal mass activation under building
	System integration and operation	Assisted fault detection & efficiency diagnostic system
		Demand (electricity, DHW, Space heatig space cooling) and gen..
		Demand response - Gamification devices
		Demand response - Virtual net metering
		Demand response- Open automated demand response
		Digital building (community) twins
		Smart Energy Management Systems
		User-centered pro-active building management system

Evaluation of technical solutions



Evaluation of technical solutions

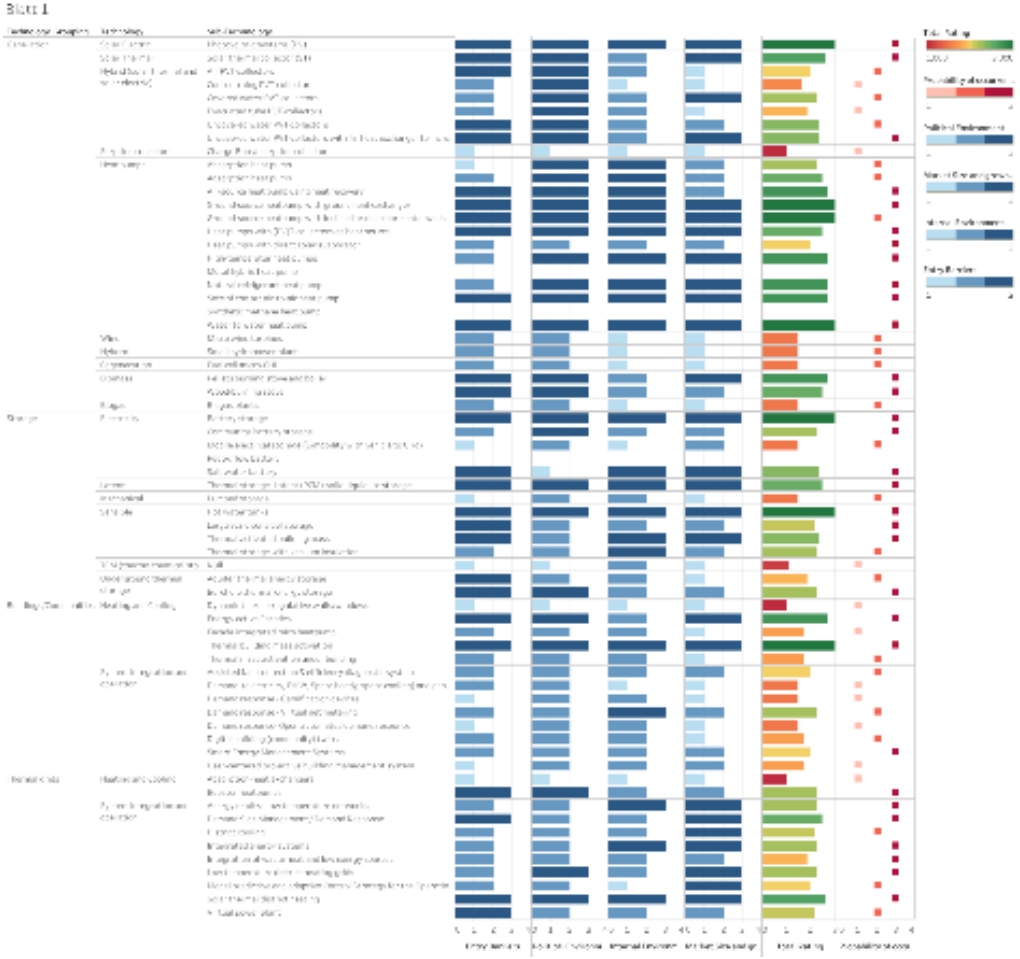
Geographic distribution



Market potential of technical solutions

Entry Barriers	Political Environment	Internal Environment	Market Size and growth rate	Total rating	Probability of occurrence
Are there any real barriers to entry into the existing market and in marked within the next three years	International or national regulations (initiatives) support or hinder a specific technology or activity	Is the technology "strong enough" to compete in the market with suitable offering, cost, competition?	The total value of customers, clients, buildings for the technology and potential growth rate and trends	Mean value of scores	The likelihood that a particular technology will be a relevant option for solar Energy buildings until 2026. This may be quantitatively assigned based on TRL-Level or qualitative assigned based on the expertise and experience.
rating (1 to 3) (3 low barriers, 1 high barriers)	rating (1 to 3) (3 good environment, 1 bad environment)	rating (1 to 3) (3 good environment, 1 bad environment)	rating (1 to 3) (3 big market, 1 small market,)	total rating market potential (1 to 3) (3 high potential, 1 low potential)	rating (1 to 3) (3 high relevance, 1 low relevance)

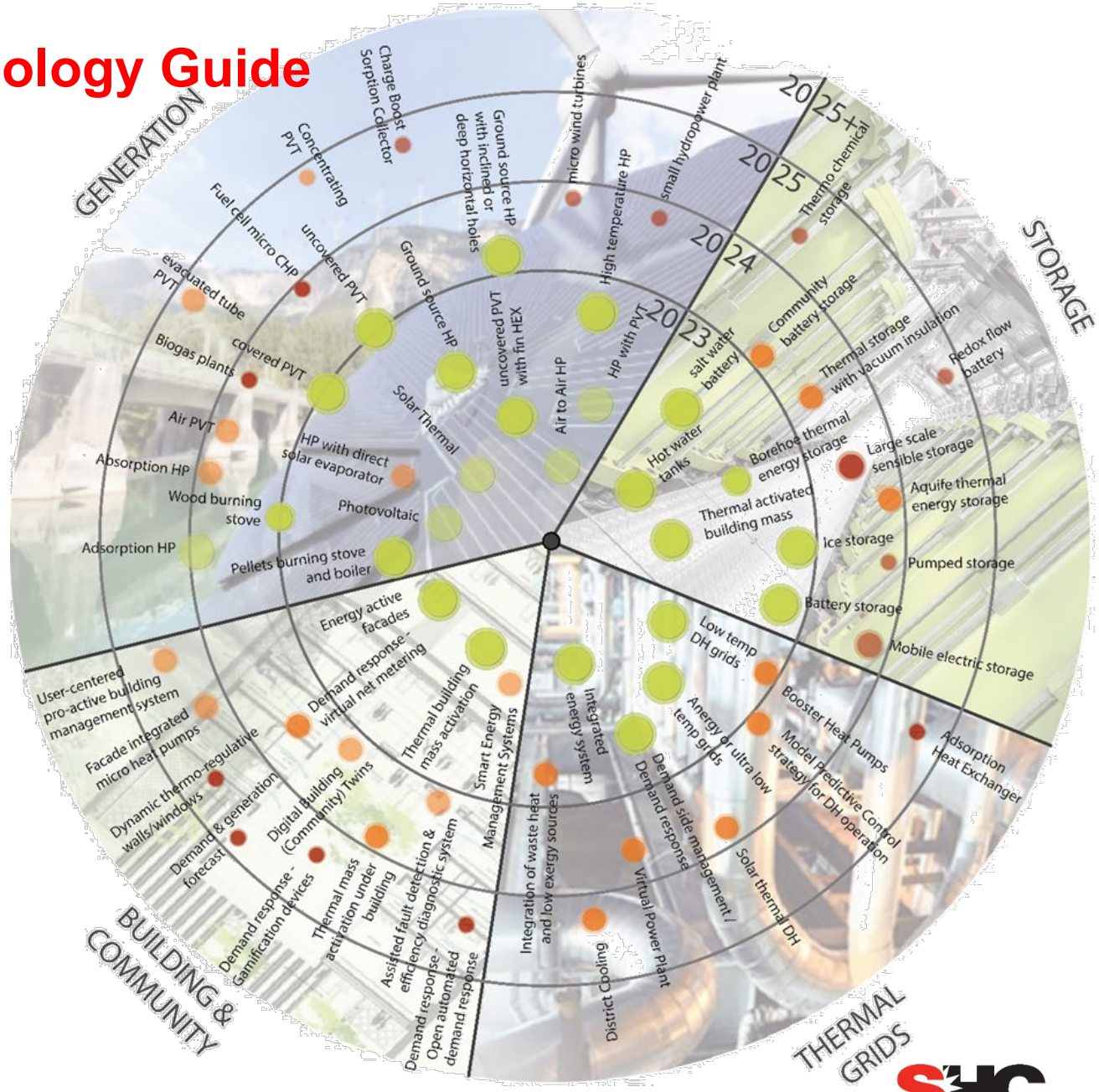
Market potential of technical solutions



SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Energy Technology Guide

Clean Energy Technology Radar



65 individual technologies and components across the whole energy system that contribute to achieve the goal of SEBs

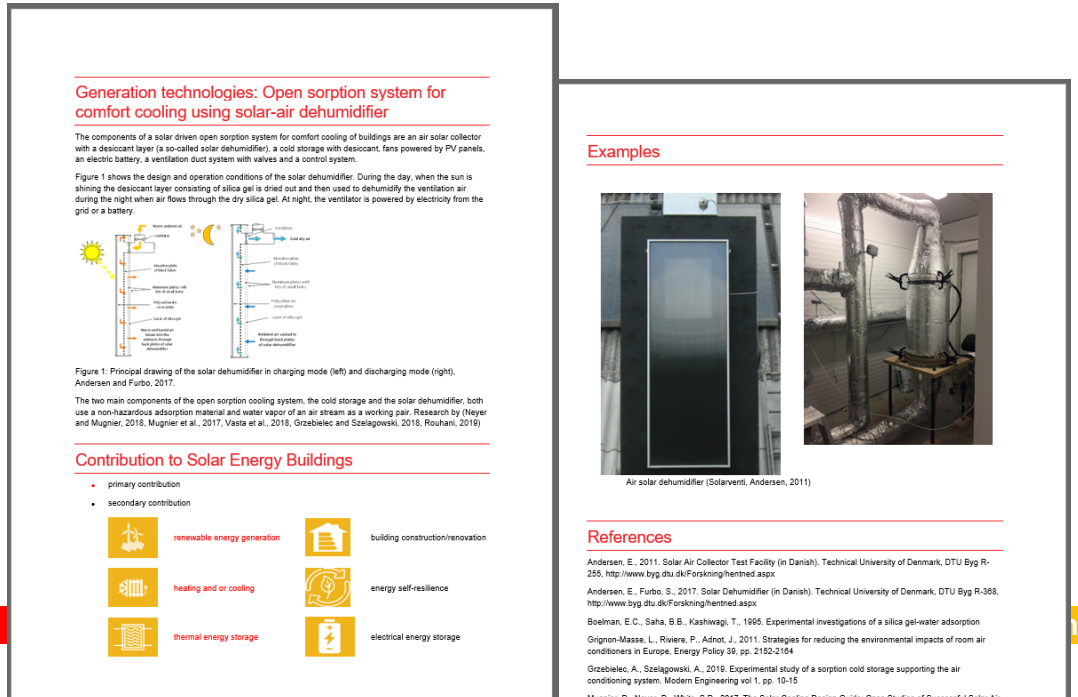
Market Potential

Total Rating

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

Energy Technology Guide

- The information about each (selected) solution will be presented in “Fact sheets”
  - Description of the solution
  - Examples: Images of the application of solutions
  - References: scientific literature, journals, links to relevant documents and projects



Generation technologies: Open sorption system for comfort cooling using solar-air dehumidifier

The components of a solar driven open sorption system for comfort cooling of buildings are an air solar collector with a desiccant layer (a so-called solar dehumidifier), a cold storage with desiccant, fans powered by PV panels, an electric battery, a ventilation duct system with valves and a control system.

Figure 1 shows the design and operation conditions of the solar dehumidifier. During the day, when the sun is shining the desiccant layer consisting of silica gel is dried out and then used to dehumidify the ventilation air during the night when air flows through the dry silica gel. At night, the ventilator is powered by electricity from the grid or a battery.

Figure 1: Principal drawing of the solar dehumidifier in charging mode (left) and discharging mode (right), Andersen and Furbo, 2017.

The two main components of the open sorption cooling system, the cold storage and the solar dehumidifier, both use a non-hazardous adsorption material and water vapor of an air stream as a working pair. Research by (Neyer and Mugnier, 2018, Mugnier et al., 2017, Vasta et al., 2018, Grzebielec and Szelagowski, 2018, Rouhani, 2019)

Contribution to Solar Energy Buildings

- primary contribution
- secondary contribution

renewable energy generation
building construction/renovation
heating and or cooling
energy self-resilience
thermal energy storage
electrical energy storage

Examples

Air solar dehumidifier (Solarventi, Andersen, 2011)

References

Andersen, E., 2011. Solar Air Collector Test Facility (in Danish). Technical University of Denmark, DTU Byg R-255, http://www.byg.dtu.dk/Forskning/hentned.aspx

Andersen, E., Furbo, S., 2017. Solar Dehumidifier (in Danish). Technical University of Denmark, DTU Byg R-368, http://www.byg.dtu.dk/Forskning/hentned.aspx

Boelman, E.C., Saha, B.B., Kashiwagi, T., 1995. Experimental investigations of a silica gel-water adsorption

Grignon-Masse, L., Riviere, P., Adnot, J., 2011. Strategies for reducing the environmental impacts of room air conditioners in Europe, Energy Policy 39, pp. 2152-2164

Grzebielec, A., Szelagowski, A., 2019. Experimental study of a sorption cold storage supporting the air conditioning system. Modern Engineering vol 1, pp. 10-15

SHC SOLAR HEATING & COOLING PROGRAMME INTERNATIONAL ENERGY AGENCY

www.iea-shc.org

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Michael Gumhalter, AEE INTEC
IEA TASK 66
IEA SHC Solar Academy Webinar, 19.09.2023