CENTRO STUDI
DI ECONOMIA E TECNICA DELL'ENERGIA
"GIORGIO LEVI CASES"

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UNIVERSITÀ DEGLI STUDI DI PADOVA

Sustainable AddiTive ManufactuRing of Low-temperAture Thermochemical Energy StoraGe Systems for BuildIng AppliCations (STRATEGIC)

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Ricercatore a Tempo Determinato (RTD-A)

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE (DII)

CERAM GLASS RESEARCH GROUP

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Scientific and Research background of the principal investigator (PI)

Research field: Material science and engineering

Interests: additive manufacturing; upcycling of inorganic wastes; engineering design of porous glasses and ceramics

- PhD in Industrial Engineering, DII, Padova, 2017.
- 100 papers, 3 Reviews, and 1 book chapter.
- "H index : 28, Citations: 2085, i10 index: 56 (accessed 15/09/2023)"
- ASN: Abilitazione Scientifica Nazionale, Seconda Fascia, 09/D1-SCIENZA E TECNOLOGIA DEI MATERIALI.

Past research related to the additive manufacturing

- An international patent on Additive manufacturing of geopolymers via cleaner and sustainable production
- IDEAL project "Industrial ResiDues for Smart FirE-resistAnt PhotocataLytic Components"
- Project D3Vero "La stampa 3D nel settore del Vetro Artistico»
- Project "ADditive Manifacturing & INdustry 4.0 as innovation Driver", (ADMIN 4D)
- Project AMITIE "Additive Manufacturing Initiative for Transnational Innovation in Europe"

Project team

Materials selection, and optimization Materials and Scale-up.

Prof. **Paolo Colombo**, Co-I (Dipartimento DII)

Thermodynamics, heat transfer, thermal characterization

Dr. **Andrea Diani** (Dipartimento DII)

Chemical modification and efficiency of systems.

Prof. **Enzo Menna** (Diparimento DiSC)

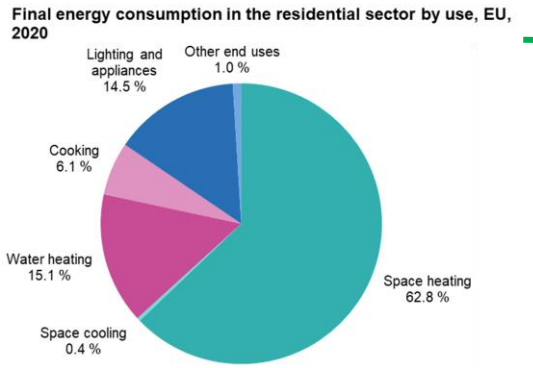
Modelling of techno-economic analysis.

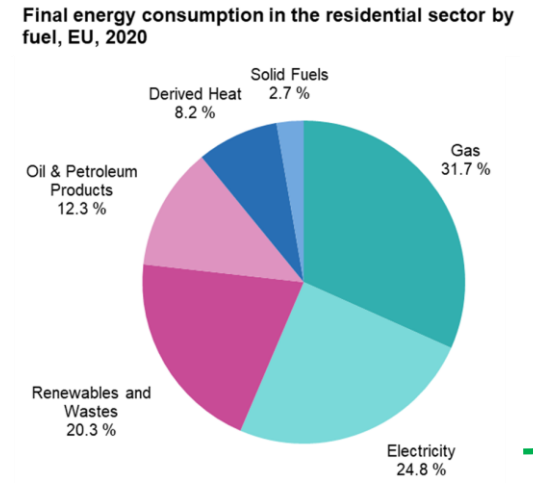
Prof. **Mara Thiene** (Dipartimento TESAF)

Linked project: Exploring the market for thermochemical energy storage systems in building applications (Proponent: Cristiano Franceschinis, Dipartimento TESAF)

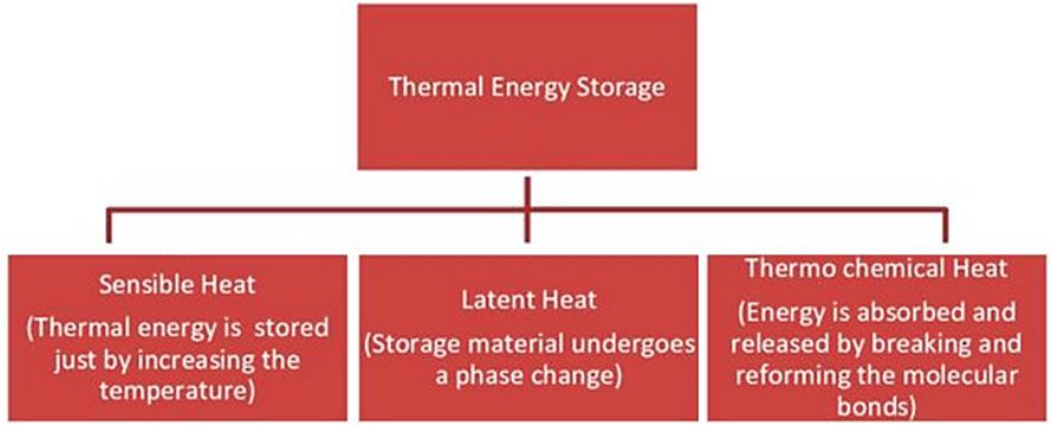
Background and aim of the project [Challenge : Energy Storage is Needed]

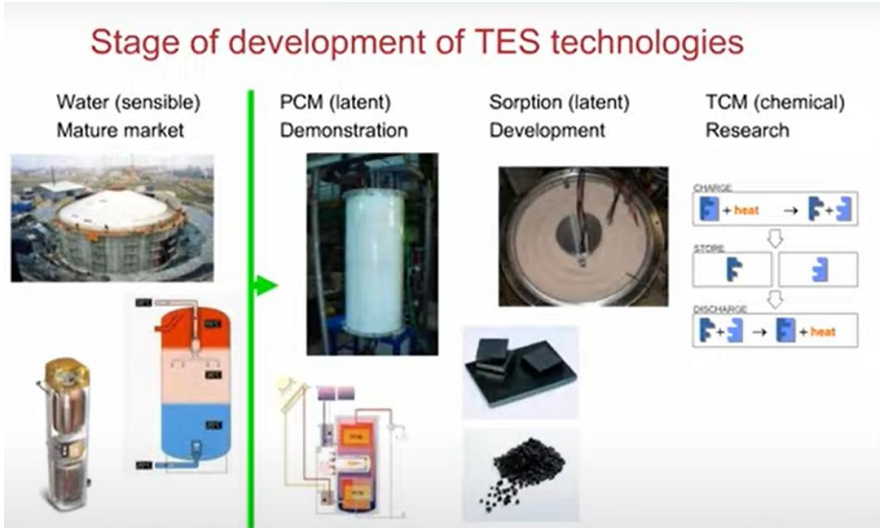
CO_2 emissions

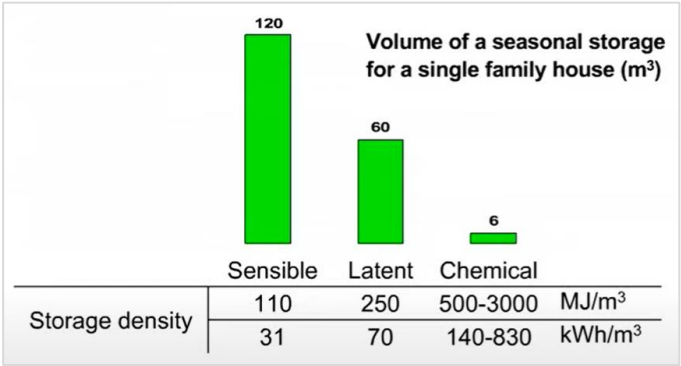




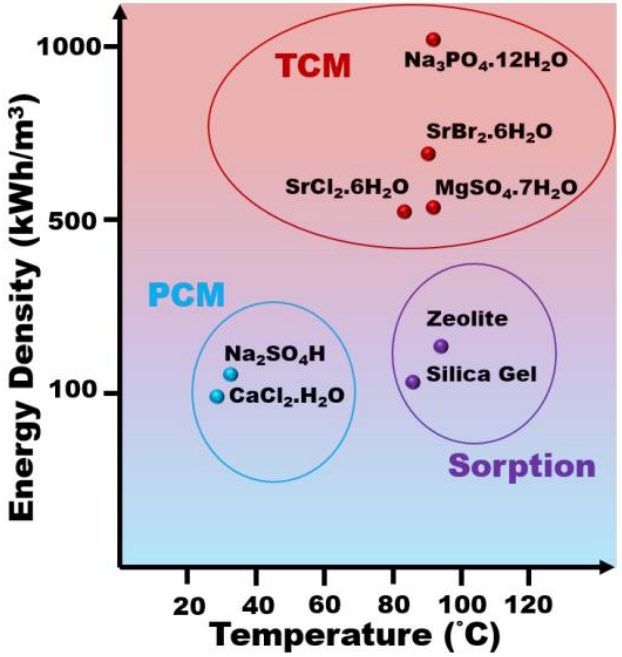
Households accounted for **27%** of final energy consumption in the EU, the majority was used for heating **(62.8%).**



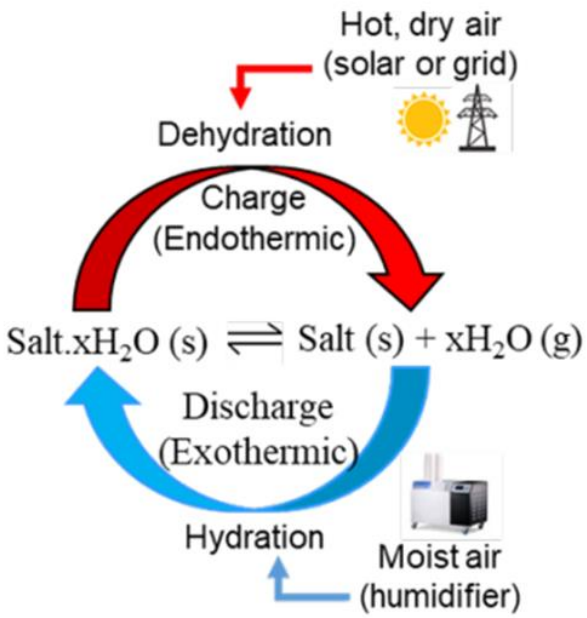




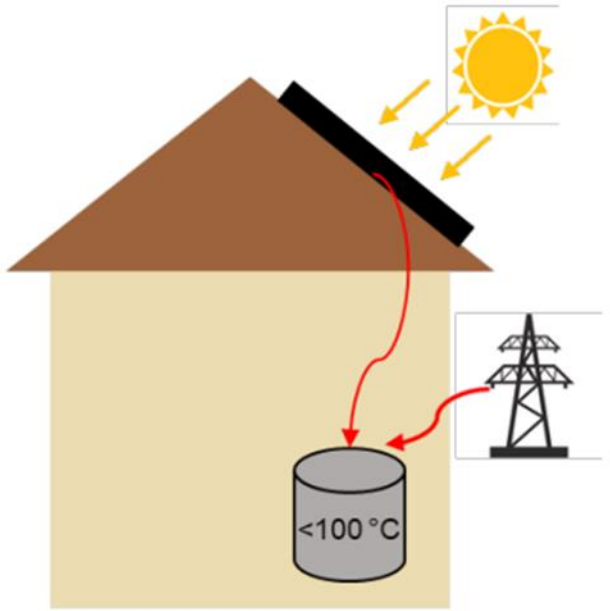
Approach: Thermal Energy Storage for on-site Storage



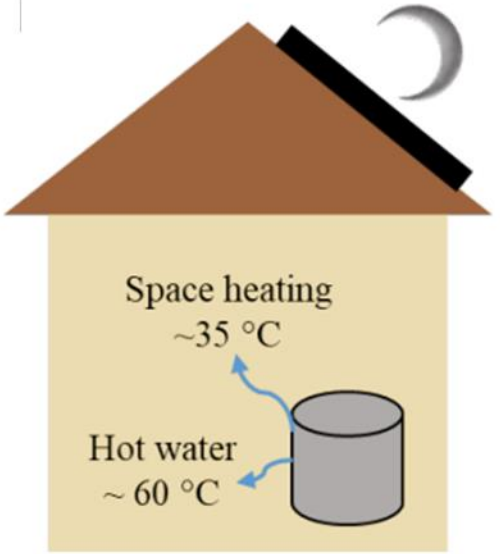
500+ salt, ***25 salts good for lowT***



Reversible reactions,
(salt hydrate, open system)



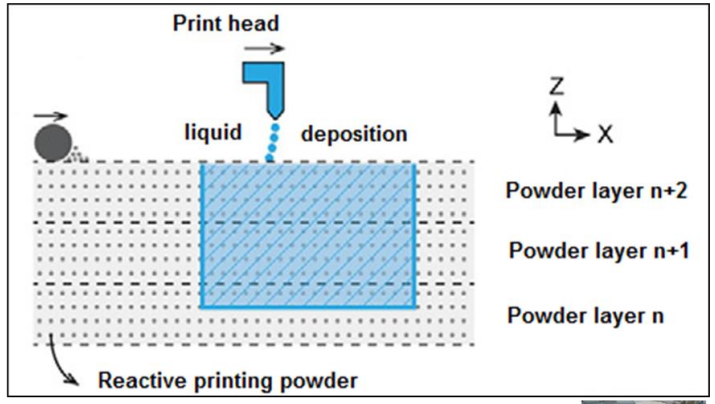
TCMs ***charging*** using solar energy system.

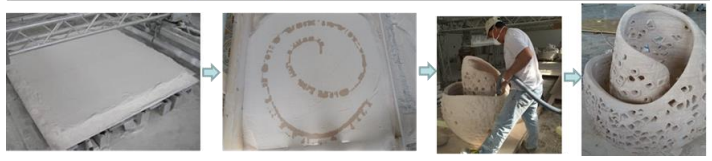


TCM ***discharging*** at desired T

- ***Phase Change Materials*** **(PCMs) and** ***sorption*****-based storage have energy density in the ranges of ~100 kWh/m³**
- ***Thermochemical Materials*** ***(TCMs)*** **have higher theoretical energy densities of ~ 500 kWh/m³, making them stand-alone solutions for daily-seasonal energy storage in buildings**

Methods: Binder Jetting of sustainable geopolymers

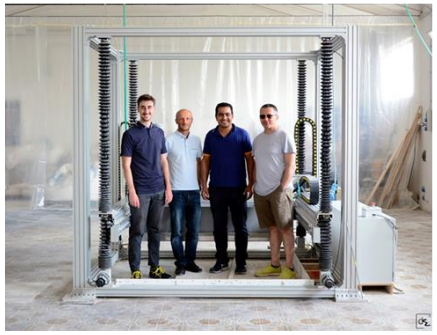




Geopolymers consist of a polymeric Si–O–Al framework, similar to zeolites

- Geopolymers offer a low-cost, solid and stable thermal energy storage
- Appropriate mechanical strength, thermal performance at high working temperatures
- Sustainability, Providing long service life
- Limited environmental impact; CO_2 fingerprint is much lower than Portland cement

1. **Impregnation, encasement, and encapsulation of thermochemical materials (hydrated salts TCMs) into 3D printed geopolymer matrixes**
2. **Lightweight aggregates such as expanded clay, expanded glass granules as well as expanded graphite will be added to increase the reaction surface, thermal conductivity, and heat transfer**
3. **Geopolymer boards and bespoke bricks with complex shapes will be manufactured in a sustainable way, using industrial waste as raw material for the geopolymer**




Expected outcomes

- Upcycling of industrial residues to develop geopolymer thermal energy storage systems using solar energy

- The development of a thermal energy storage (TES) system as a solution and opportunity to reduce energy consumption, emissions and cost

- Thermochemical based TES with high storage capacities for daily-seasonal storage for residential and large commercial buildings applications

Acknowledgements

Grazie per la vostra attenzione!