European Innovation Council

Backing visionary entrepreneurs

Marco Pantaleo
Program manager, European Innovation Council

EERA Workshop on applications for thermal energy storage in industrial sector
Utrecht
7th Nov 2023

Outline

- Horizon EU and European Innovation Council
- Research and innovation priorities for energy transition
- Innovation trends in energy storage
- Funding opportunities: EIC pathfinder and accelerator

EU instruments to support R&I in energy storage

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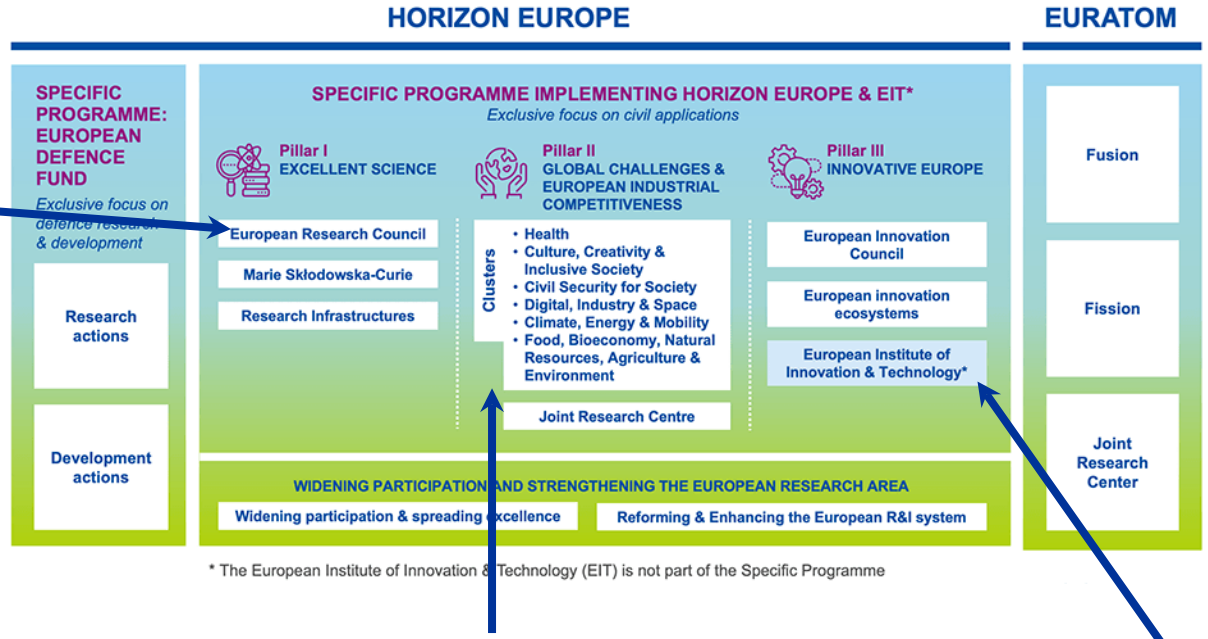
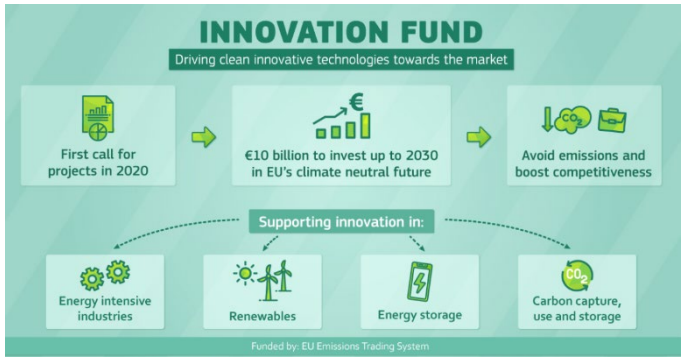


Other EU public funding options



IPCEI BATTERIES

European Investment Bank The EU bank

Pillar 2 – HEU Clusters and Partnerships

Clean Hydrogen Partnership

CSP The Clean Steel Partnership

2ZERO

HEU Cluster 5: TES, transport, grids, industrial decarbonization, buildings..

HEU Cluster 4: EU Raw Materials Alliance, EIP raw materials; Manufacturing; automation AI and robotics; Key Digital Technologies

eit European Institute of Innovation & Technology

Institutionalised European Partnerships in the portfolio

PILLAR II - Global challenges & European industrial competitiveness

CLUSTER 1: Health

- Innovative Health Initiative
- Global Health Partnership
- Transformation of health systems
- Chemicals risk assessment
- ERA for Health
- Rare diseases*
- One-Health Anti Microbial Resistance*
- Personalised Medicine*
- Pandemic Preparedness* *Co-funded or co-programmed*

CLUSTER 4: Digital, Industry & Space

- Key Digital Technologies
- Smart Networks & Services
- High Performance Computing
- European Metrology (Art. 185)
- AI-Data-Robotics
- Photonics
- Made in Europe
- Clean steel – low-carbon steelmaking
- Processes4Planet
- Global competitive space systems**

CLUSTER 5: Climate, Energy & Mobility

- Clean Hydrogen
- Clean Aviation
- Single European Sky ATM Research 3
- Europe's Rail
- Connected and Automated Mobility (CCAM)
- Batteries
- Zero-emission waterborne transport
- Zero-emission road transport
- Built4People
- Clean Energy Transition
- Driving Urban Transitions

CLUSTER 6: Food, Bioeconomy, Agriculture, …

- Circular Bio-based Europe
- Rescuing Biodiversity to Safeguard Life on Earth
- Climate Neutral, Sustainable & Productive Blue Economy
- Water4All
- Animal Health & Welfare*
- Accelerating Farming Systems Transitions*
- Agriculture of Data*
- Safe & Sustainable Food System*

PILLAR III - Innovative Europe

EIT

- InnoEnergy
- Climate
- Digital
- Food
- Health
- Raw Materials
- Manufacturing
- Urban Mobility
- Cultural and Creative Industries

SUPPORT TO INNOVATION ECOSYSTEMS

- Innovative SMEs

CROSS-PILLARS II AND III

- European Open Science Cloud

Institutionalised Partnerships (Art 185/7)
Institutionaised partnerships / EIT KICs
Co-Programmed
Co-Funded

** Calls with opening dates in 2023-24*
*** Calls with opening dates not before 2022*

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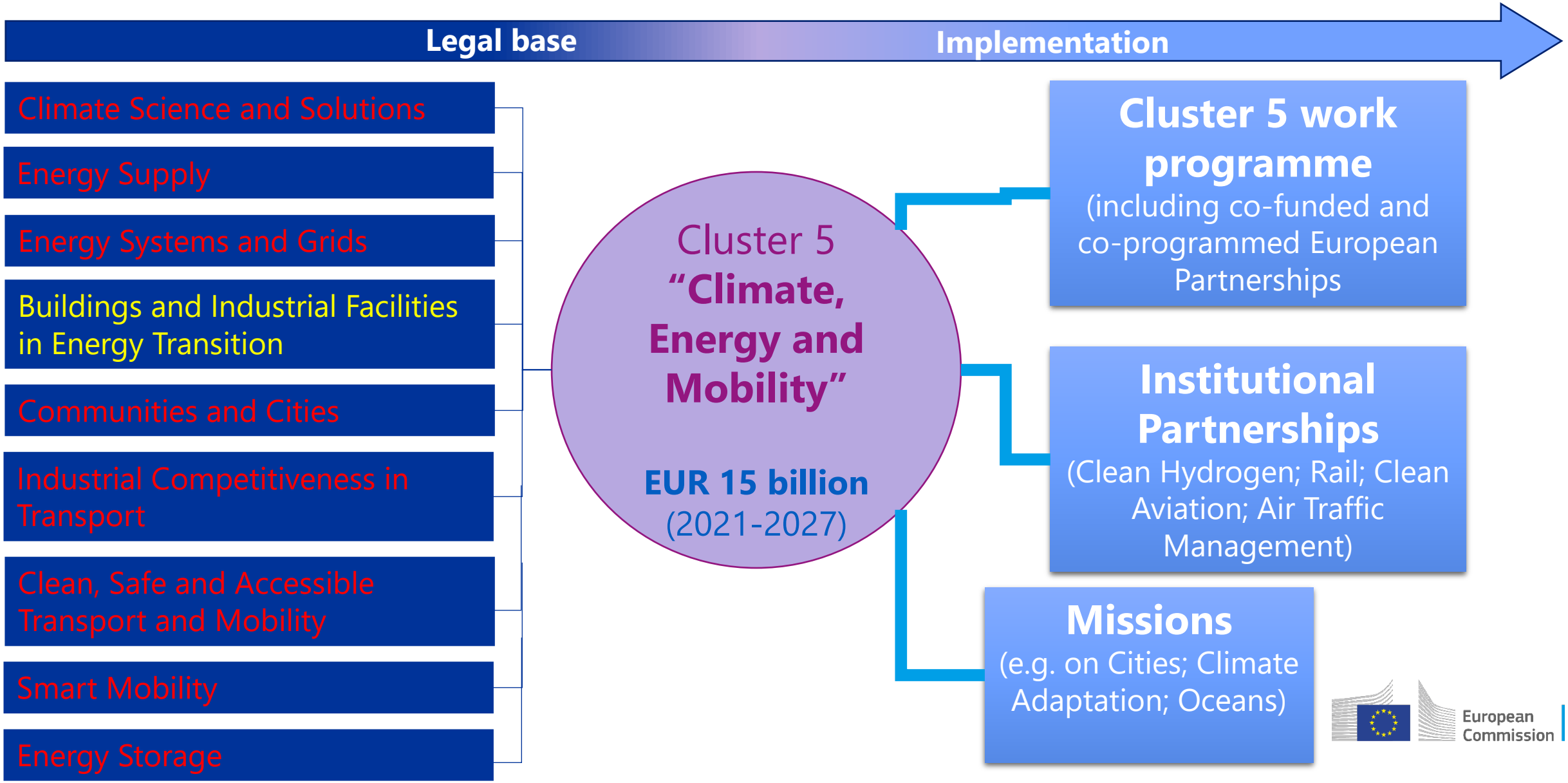
Cluster 5 - overview



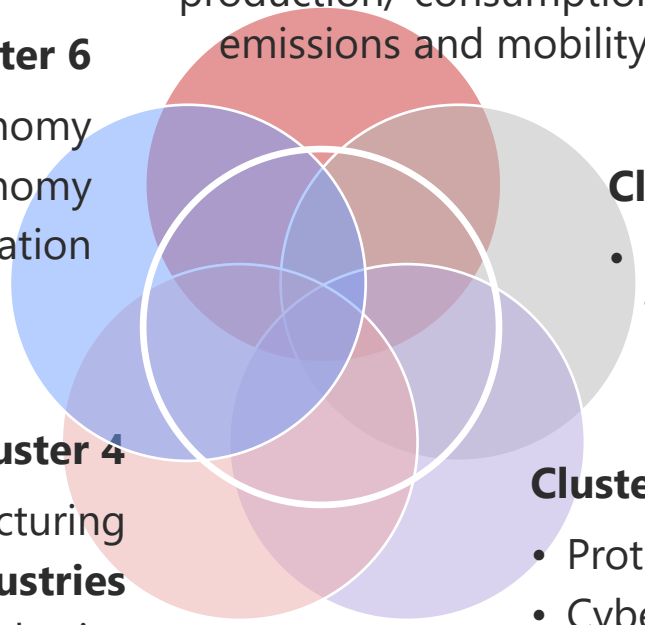
Cluster 5 – Links to other clusters

Cluster 1

- Health impacts of climate change, energy production/ consumption, transport emissions and mobility patterns

Cluster 6

- Bioeconomy
- Circular economy
- Environmental observation



Cluster 2

- Societal dimension of transformation

Cluster 4

- Manufacturing
- **Low-carbon, clean, circular industries**
- Artificial Intelligence and Robotics
- Advanced Materials
- Space

Cluster 3

- Protection of critical infrastructure
- Cybersecurity
- Climate-related disaster risk management

Cluster 5 Work programme - overview

Destination 1 – Climate science

- Climate science

Destination 2 – Cross-cutting solutions

- Batteries
- Cities
- Breakthrough technologies
- Citizen and stakeholder engagement

Destination 3 – Energy supply

- Renewable energy
- Energy system, grids and storage
- CCUS
- Cross-cutting activities

Destination 4 – Energy demand

- Buildings
- **Industry**

Destination 5 - Clean and competitive solutions for all transport modes

- Zero-emission road transport
- Aviation
- Waterborne transport
- Transport-related health and environmental issues

Destination 6 - Transport and Smart Mobility services

- Connected, Cooperative and Automated Mobility
- Multimodal and sustainable transport systems for passengers and goods
- Safety and resilience

European Commission

EIC main instruments and characteristics

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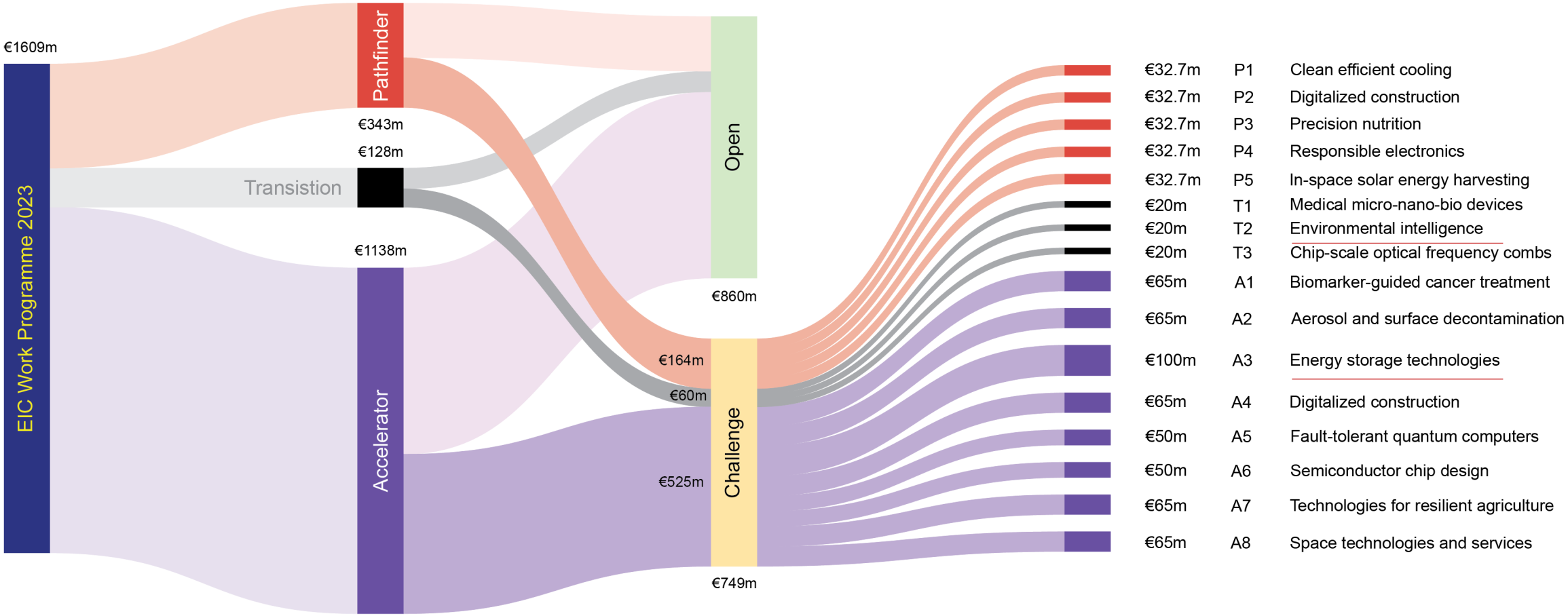
Pathfinder
- **Early stage research** on breakthrough technologies
- Grants up to €3/4 million
- Successor of FET (Open & Proactive)

Transition
- **Technology maturation** from proof of concept to validation
- **Business & market readiness**
- Grants up to €2.5 million

Accelerator
- **Development & scale up** of deep-tech/ disruptive innovations by startups/ SMEs
- Blended finance (grants up to €2.5 million; equity investment up to €15 million)
- Successor of SME instrument

- Focus on **breakthrough, market-creating, deep-tech innovations**
- Steered by **EIC Board** of leading innovators (entrepreneurs, investors, researchers, ecosystem)
- **Business Acceleration Services** (coaches/ mentors, corporates, investors, ecosystem)
- **Pro-active management by EIC Programme Managers**
- **Follow up funding for results from Horizon** (ERC, EIT, collaborative) & national programmes

In 2023 EIC allocates ~€1.6bn to Open and Challenge calls by its Pathfinder, Transition, Accelerator programs



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EIC Cleantech challenges

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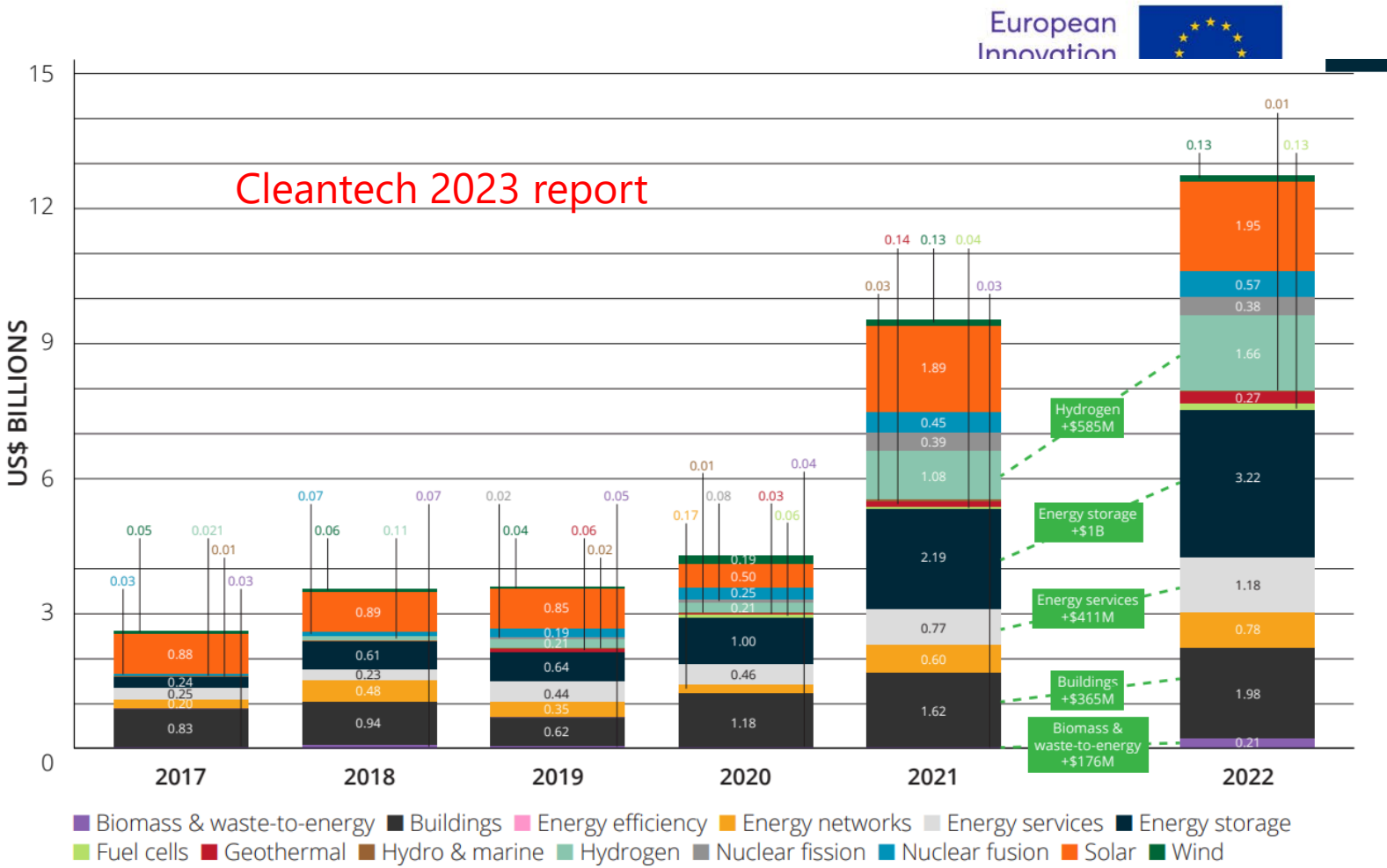
EIC Challenges 2021			
	Pathfinder	**Transition**	**Accelerator**
Cleantech	• Novel routes to green hydrogen production (Portfolio kick off meeting October 2022)	• Energy harvesting and storage technologies	• Green Deal innovations for the economic recovery

EIC Challenges 2022			
	Pathfinder	**Transition**	**Accelerator**
Cleantech	• Carbon dioxide & Nitrogen management and valorisation (final retained list end March 2023) • Mid-long term, systems-integrated energy storage (final retained list end March 2023)	• Process and system integration of clean energy technologies • Green digital devices for the future	• Technologies for 'Fit for 55'

EIC Challenges 2023			
	Pathfinder (32.7mln Euro)	**Transition (20mln Euro)**	**Accelerator (100mln Euro)**
Cleantech	• Clean and efficient cooling (submission deadline 18th October 2023)	• Environmental Intelligence (submission deadline 12th April and 27th September 2023)	• Energy Storage (submission deadline 22nd March, 7th June, 4th October 2023)

Portfolios

- Green hydrogen generation and uses
- Energy storage and systems integration
- CO2 and N management valorization
- Energy harvesting and conversion
- Clean cooling and cold chains
- Energy services and digital solutions



Future research and innovation trends (MNR, georeactors and deep geothermal, sustainable mining/sea mining, materials substitution, solar chemistry, click chemistry..)

R&I priorities for the energy transition

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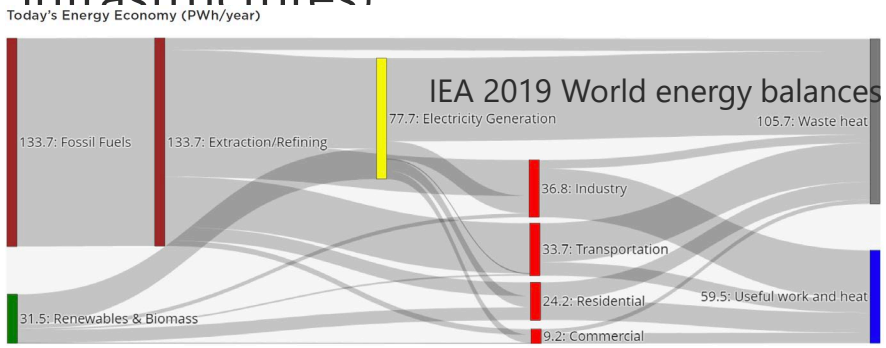
1.Final use of energy (renewable valleys, energy saving and efficiency, digital transition)

2.Circularity and security (reuse and recycle, critical materials, domestic resources)

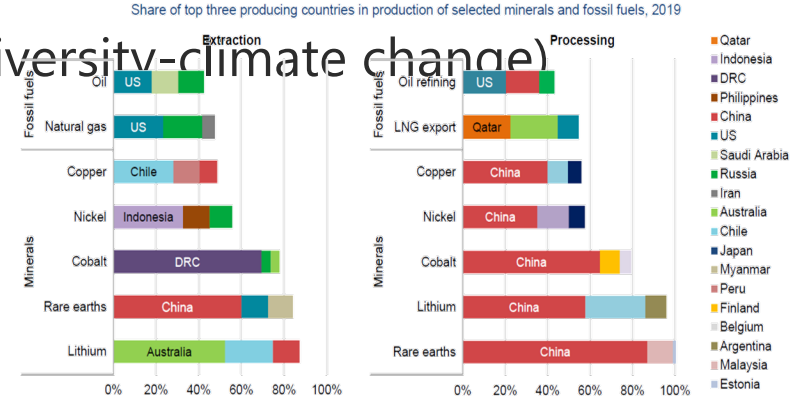
3.Systems integration (sectors coupling, industrial symbiosis, reconversion infrastructures)

Circular Economy Action Plan
The European Green Deal

biodiversity-climate change)



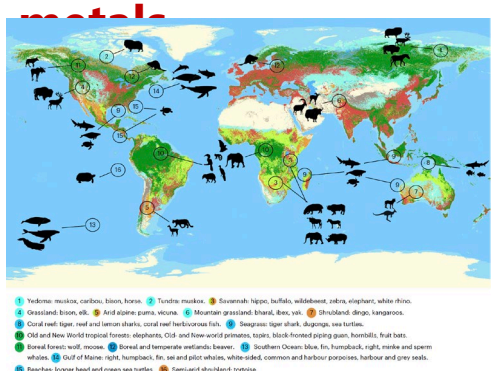
64% of primary energy is lost



EU: 75% to 100% reliant on import for metals

UN environment program, 2020

Emissions from materials production
CO2 becomes a resource



Nature Climate Change
Vol 13, April 2023

Nature climate solutions and biodiversity

- Fit for 55%
- RepowerEU, RefuelEU
- Green deal industrial plan
- Net zero industry act
- Critical raw materials act
- Electricity market design

Key needs for innovation:
speed, simplicity, scale

Medium-long duration energy storage (10-100 hours capacity)

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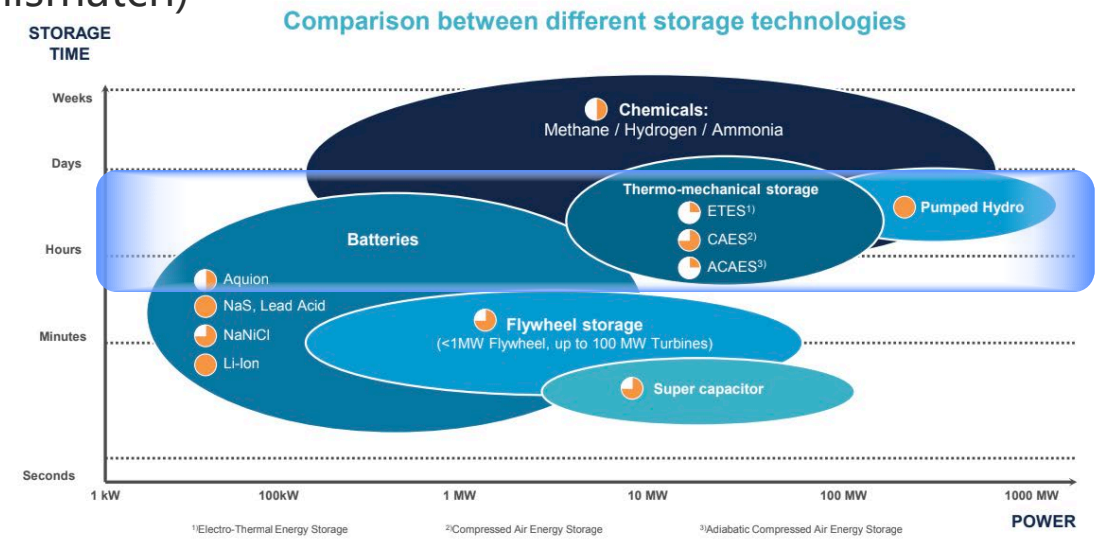
Electricity storage need mainly driven by the intermittency of wind/PV (temporal mismatch)



Source: U.S. Department of Energy Fuel Cell Technologies Office

Energy systems flexibility, a COMBINATION of:

- Dispatchable generation (embedded storage)
- Grid infrastructure and synthetic inertia
- Demand response and fast load control
- Sectors coupling
- Storage assets

Fully renewable EU power system by 2050:
+240% grid transmission (+ 140 GW)

+

flexible zero carbon firm capacity (programmable RES, seasonal storage) Applied Energy 233–234 (2019)

Spatial mismatch: generation vs transmission trade offs

The scale of intermittent RES balancing is critical: continental-scale balancing leads to low-cost electricity with higher transmission costs. supply scale vs infrastructure requirements (Trondle et al., Joule 4, Sept 16, 2020https://doi.org/10.1016/j.joule.2020.07.018

Cross border capacity needed at high NG cost:
64 GW by 2030, 88 GW 2040 (75% of 2025) + 41 GW storage ENTSO-E TYNDP 2022 · System Needs Study | July 2022

Portfolio composition for pathfinder challenge on energy storage

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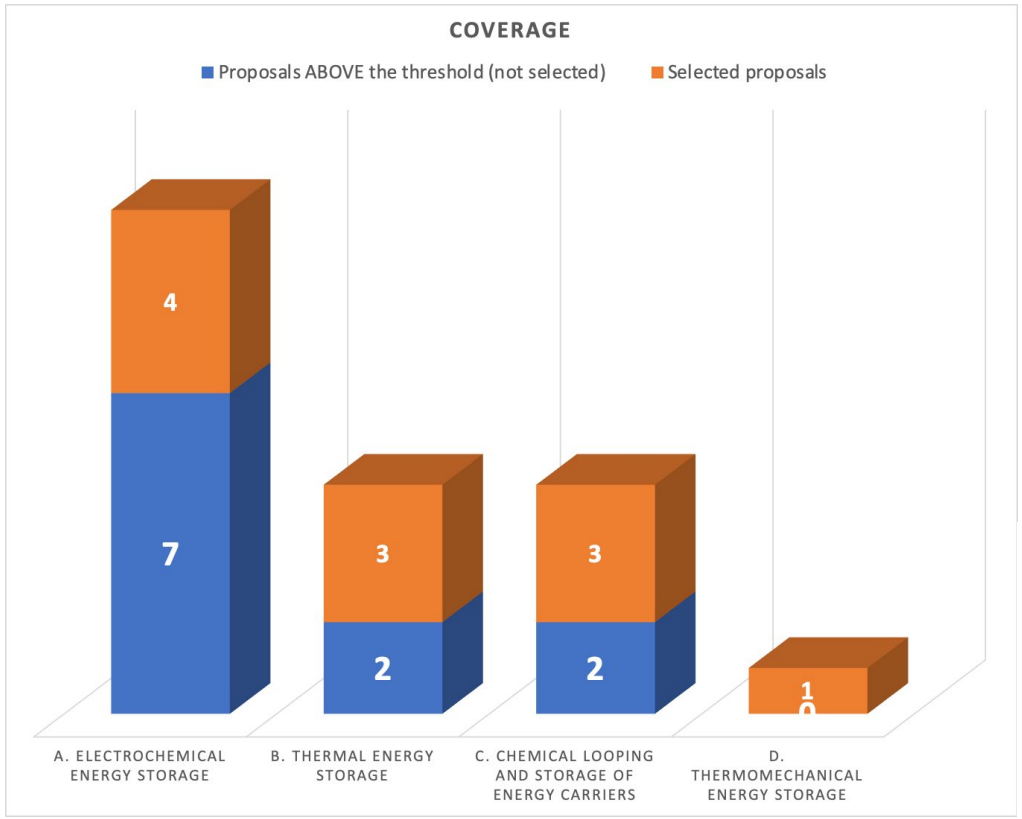
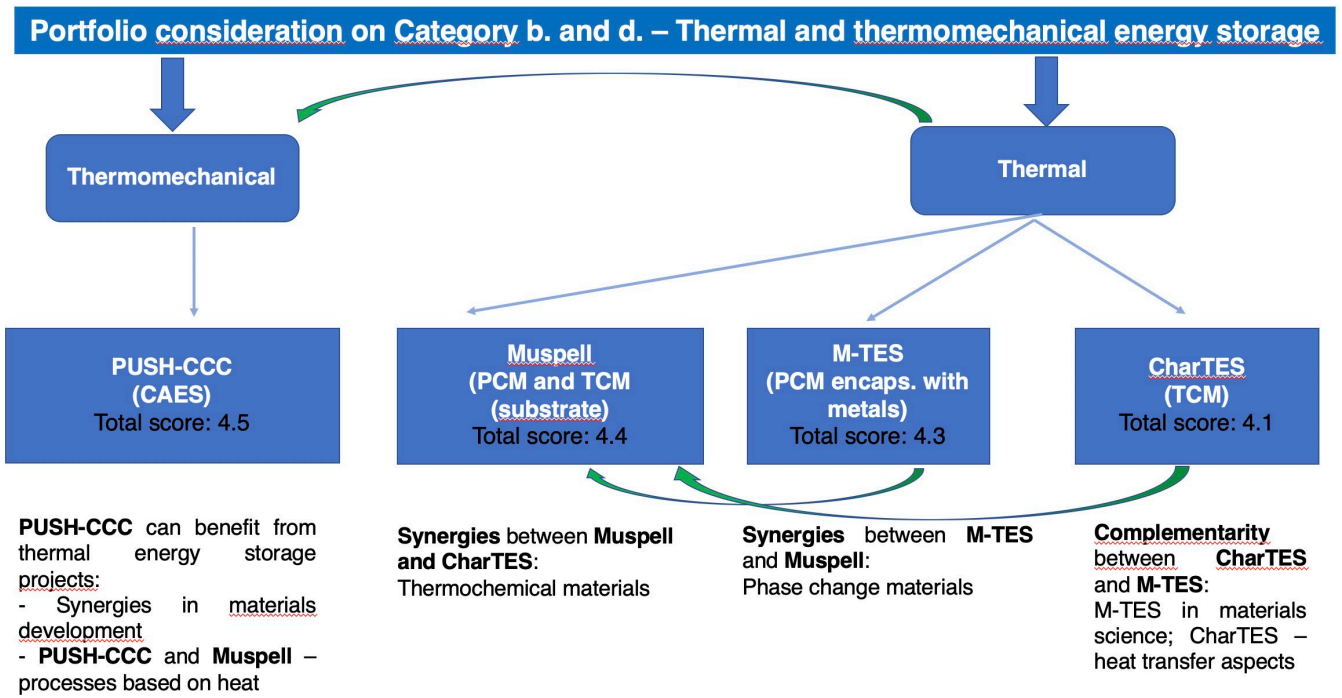
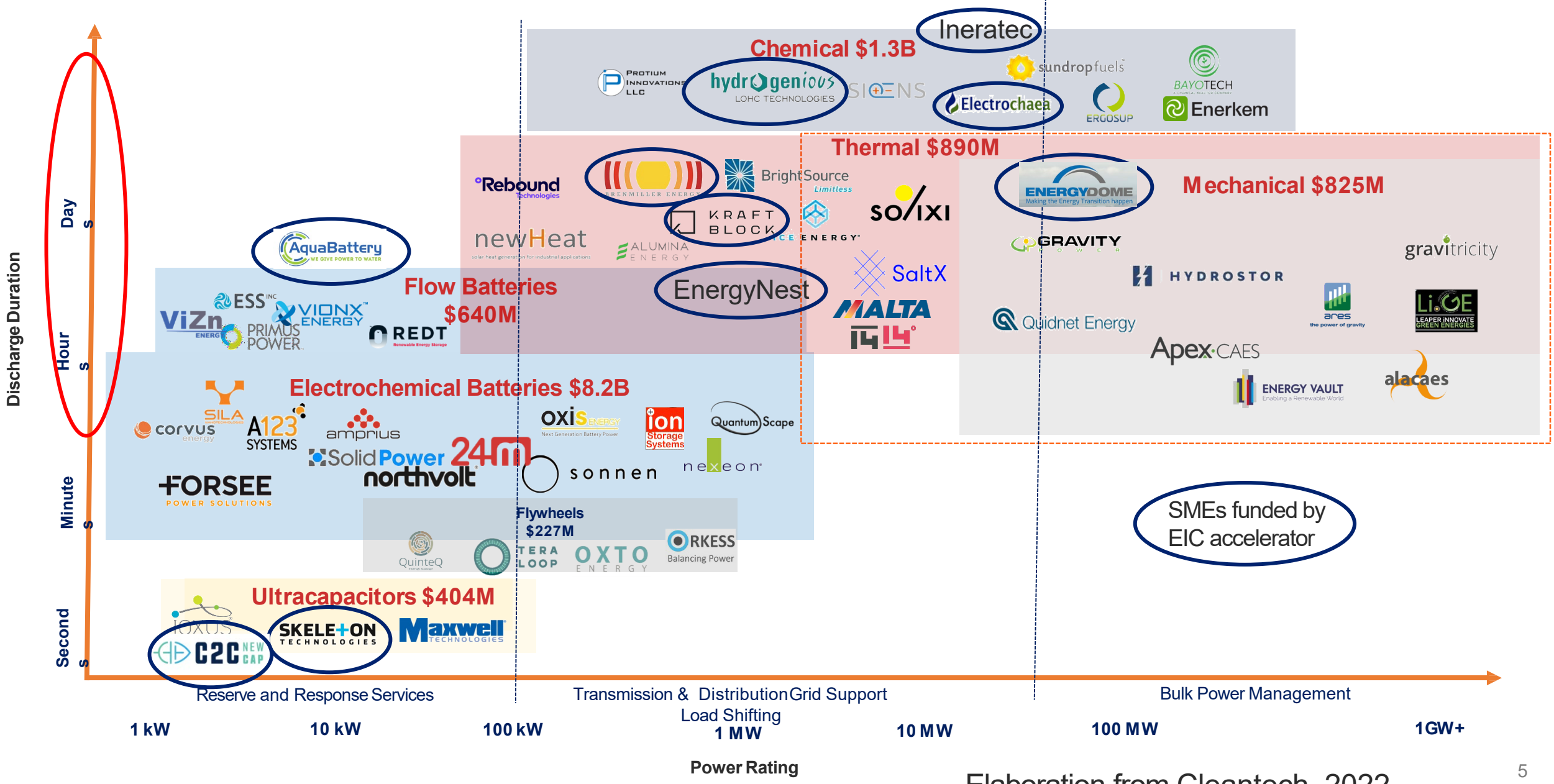


- Electrochemical storage
- Thermal storage
- Chemical storage in energy carriers
- Thermomechanical storage



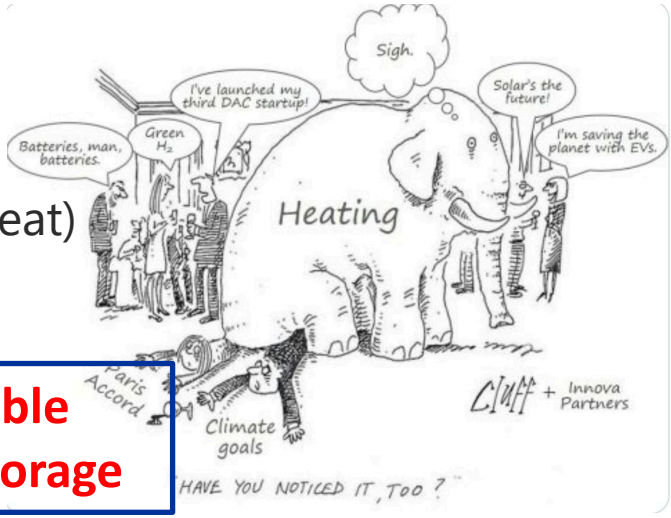
Energy Storage: market trends

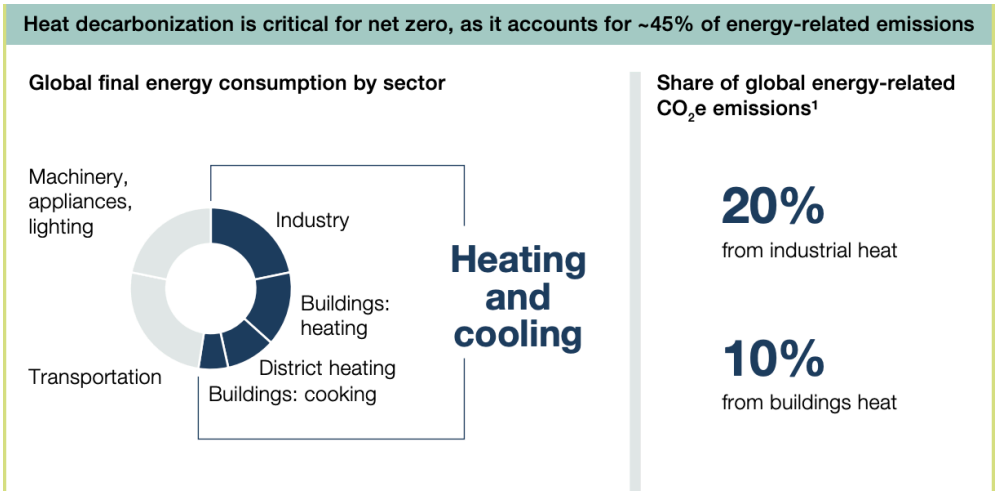


Elaboration from Cleantech, 2022

Storage and heat decarbonization

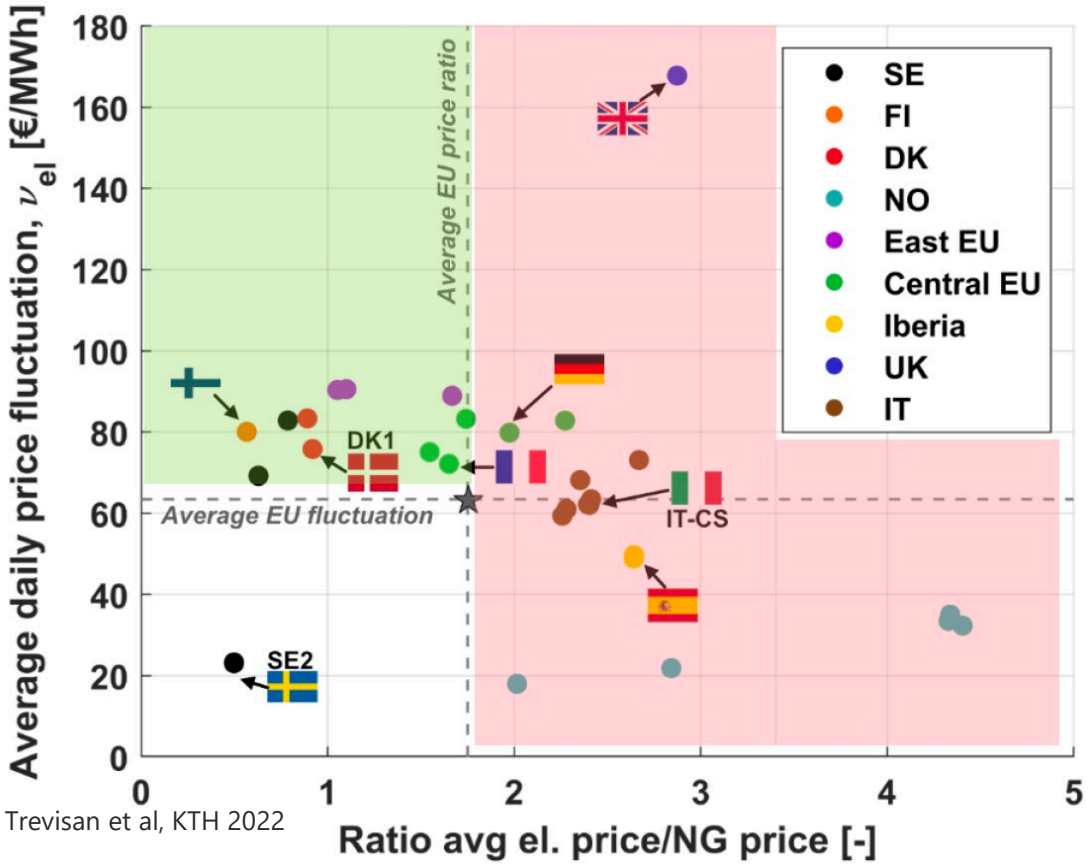
- Heat is the largest energy end-use: around 50% of total energy consumption
- Industries are responsible for 51% of the energy consumed for heat (mid to high T heat)





Net-zero heat: Long Duration Energy Storage to accelerate energy system decarbonization LDES Council, McKinsey

Electricity to heat can be sustainable and competitive – if coupled to storage



Trevisan et al, KTH 2022

Key drivers for power to heat

High natural gas price

High electricity price fluctuations

Thermal Energy Storage for hard to abate industrial sector

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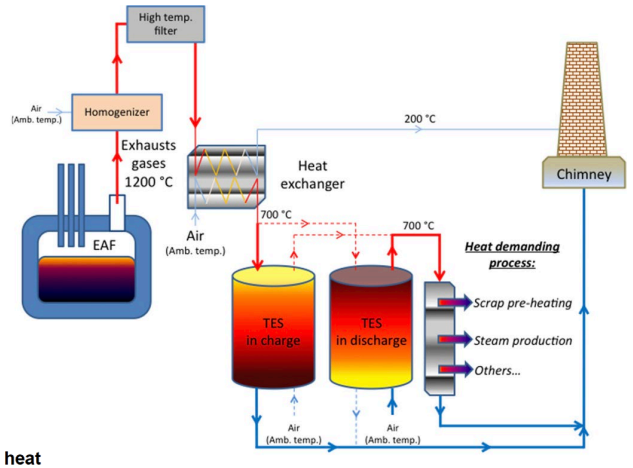
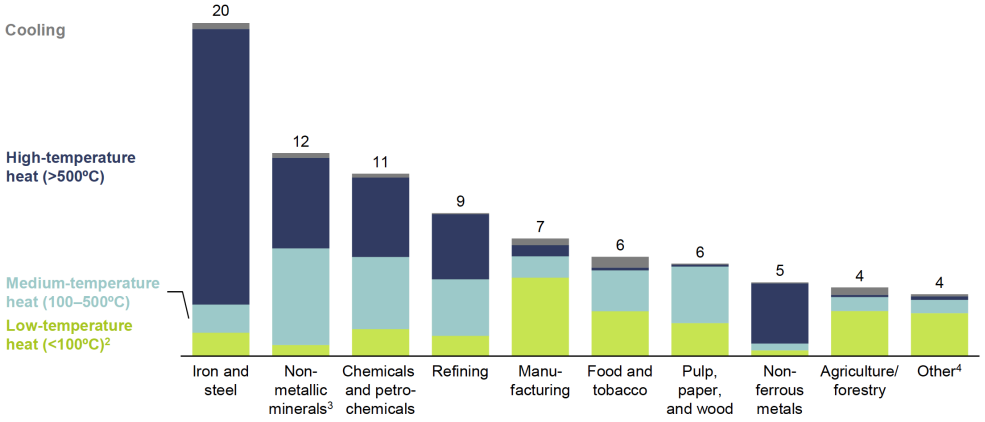
Industrial batch processes: intermittent waste heat storage
Steel decarbonization: electric air furnaces + high T heat recovery
Cement and limestone (SaltX)



s://doi.org/10.1016/j.apenergy.2019.01.007

Industrial energy consumption is concentrated in high-temperature applications

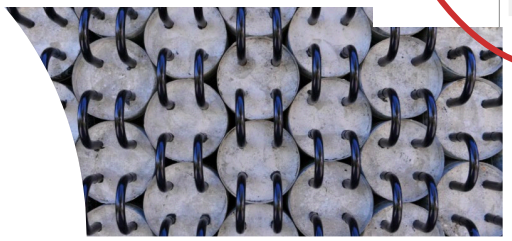
Global industrial final energy consumption by sector[1]
Exajoules, 2019

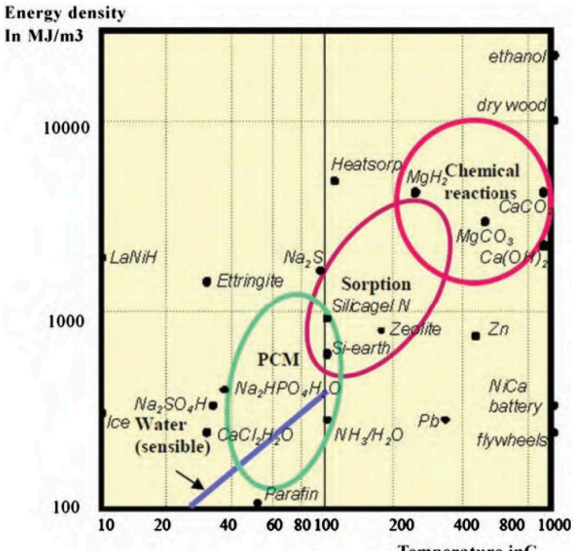


TES can support broad temperature ranges and energy storage durations

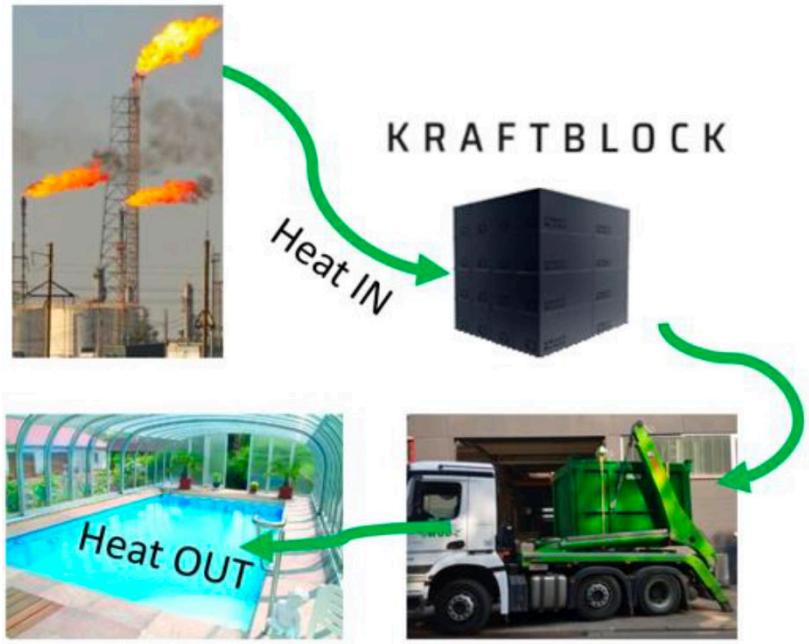
	Sensible heat	Latent heat	Thermochemical heat
Temperature	**<0–2,400°C** Most technologies able to span a large range of temperatures	**<0–1,600°C** Specific temperature ranges served by specific technologies	**0–900°C** Spans a smaller range of temperatures due to less variety in available technologies
Duration use case	**Minutes to months** Most technologies are able to serve intraday to multiday durations, with several being able to serve monthly durations	**Hours to days** Most technologies serve intraday to multiday durations	**Hours to months** Potential to serve intraday to monthly durations
Technical maturity	**Most commercially available** Most technologies are already commercially available with track records of pilots and use cases	**Some commercially available** Large range of technical maturity, with some already commercially available and others in the R&D phase	**Pilots and R&D sta** Relatively nascent most technologies i the R&D or pilot phases

Waste heat or power to heat solution
Sensible heat storage (HEATCRETE®)
EnergyNest EIC accelerator





The spatial dimension of energy storage: modular TES



Waste heat recovery and transport
Packed bed sensible TES up to 1300°C : **Kraftblock**
Possibility of direct heat transfer to particle beds

Storage enables spatial and temporal decoupling of heat supply/demand

Research/innovation challenges in TES:
Charging/discharging **dynamics** (power to heat via induction, microwave heating) – **heating/cooling quality**
Heat transfer: combination of cascaded latent, sensible and thermochemical storage; integration of highly thermal conductive particles, micro-nano encapsulated PCM; design of heat exchangers
High Temperature of stored heat– durability, ciclability, insulation

Thermochemical and molecular energy storage

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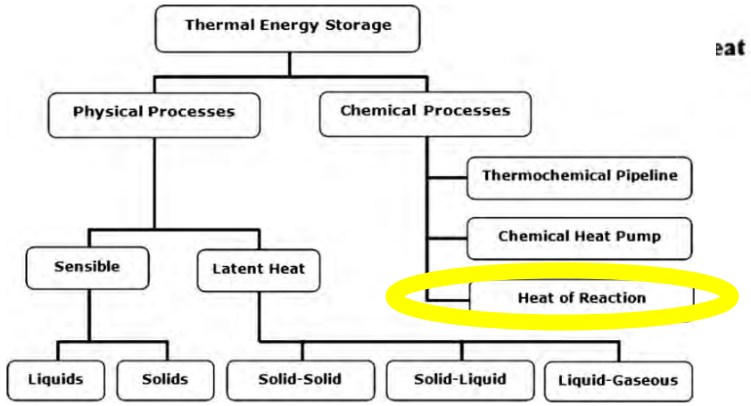
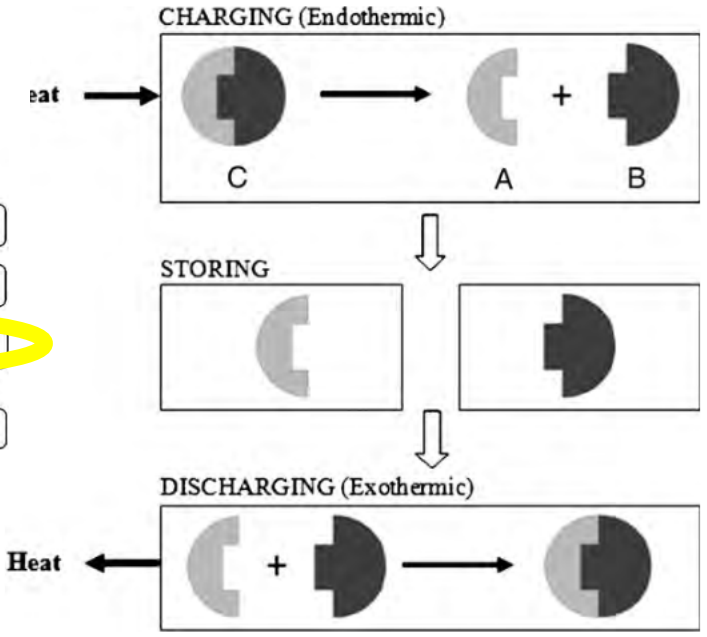


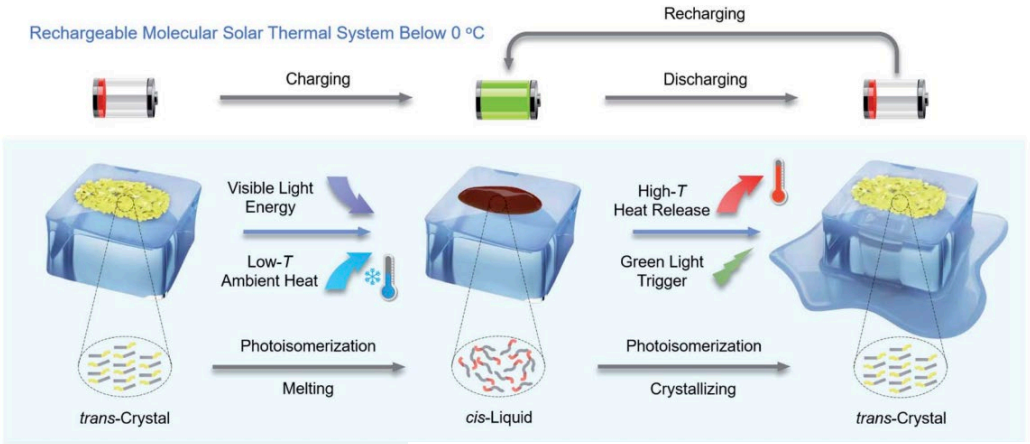


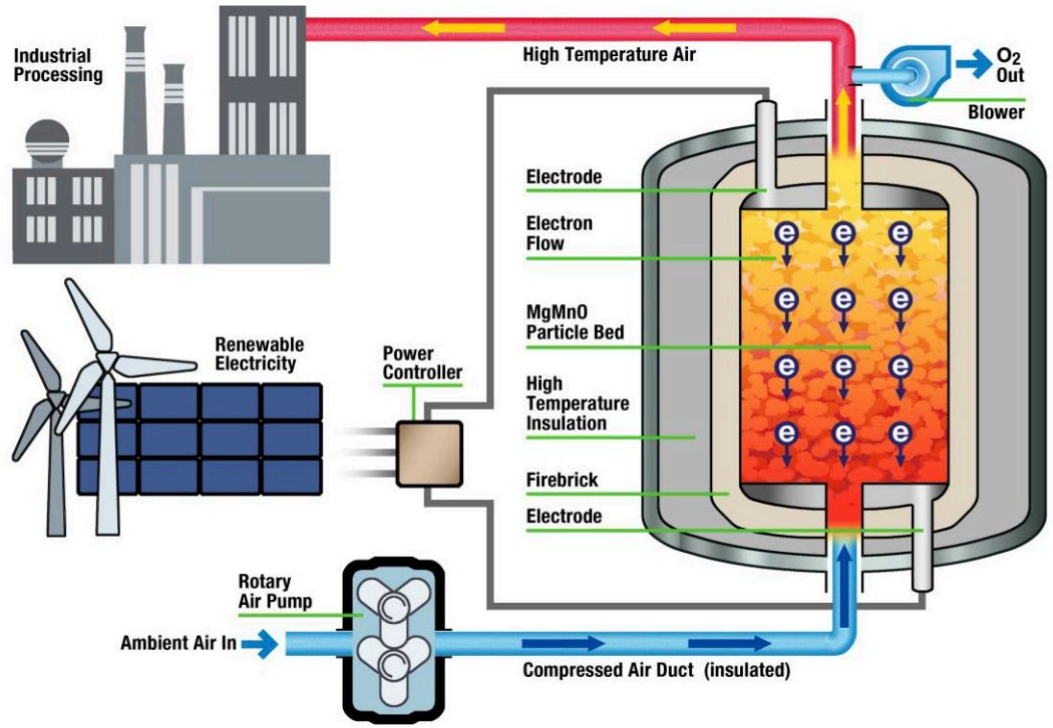
RedoxBox

Packed bed of magnesium manganese oxide pellets

Reduction (charge): $MgMnO_3(s) + \text{heat} \rightarrow MgMnO_2(s) + \frac{1}{2}O_2(g)$

Oxidation (discharge): $MgMnO_2(s) + \frac{1}{2}O_2(\text{in air}) \rightarrow MgMnO_3(s) + \text{heat}$





MOST, ESIM

Molecular photoswitching + PCM

Heat harvesting + storage in chemical bonds

DOI: 10.1039/d2sc01873j

Thermochemical storage integration in power cycles

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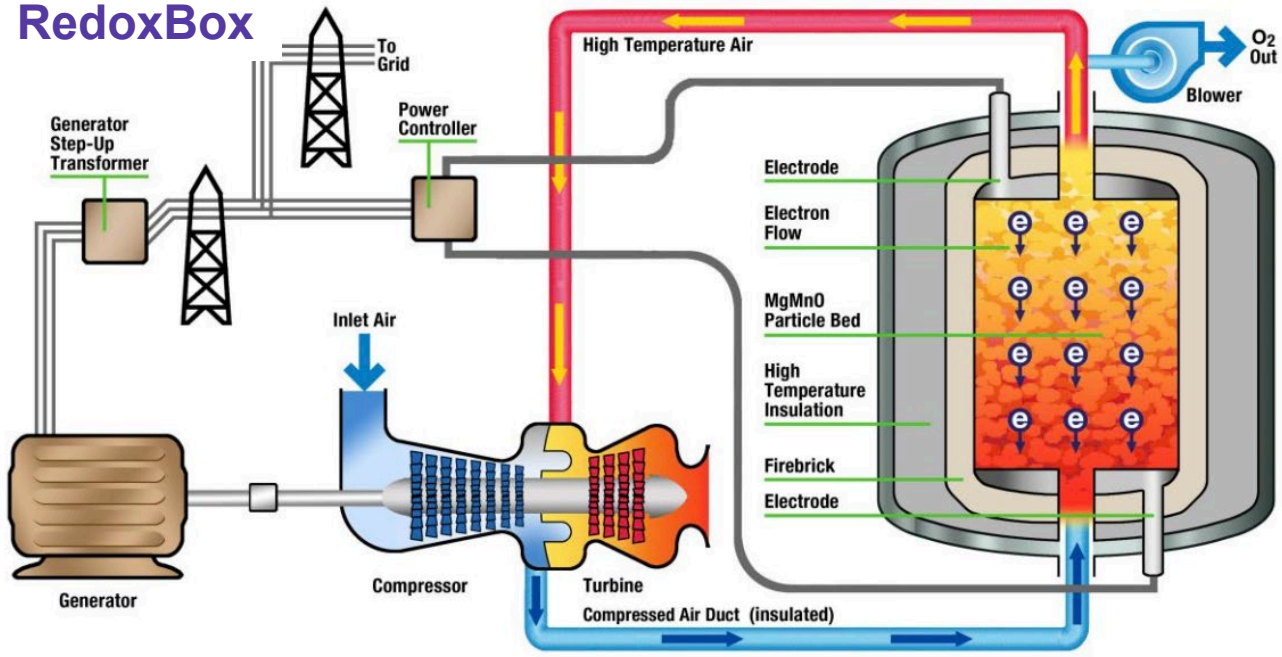
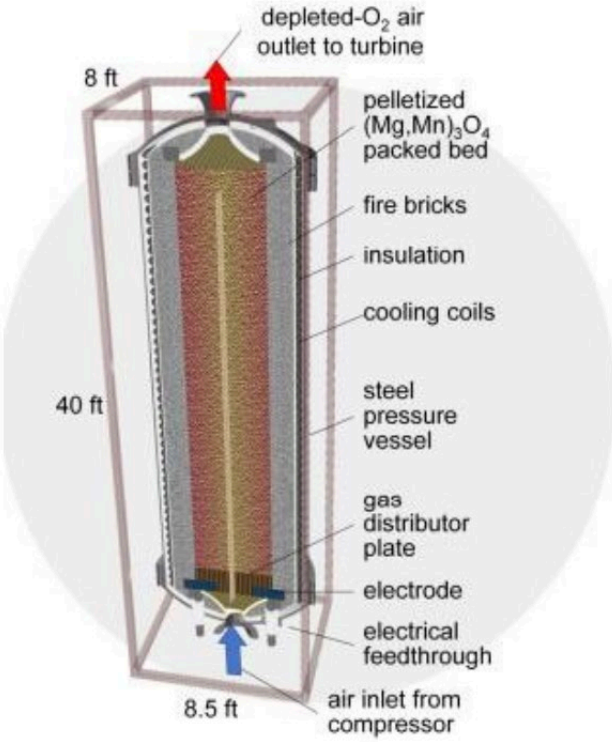
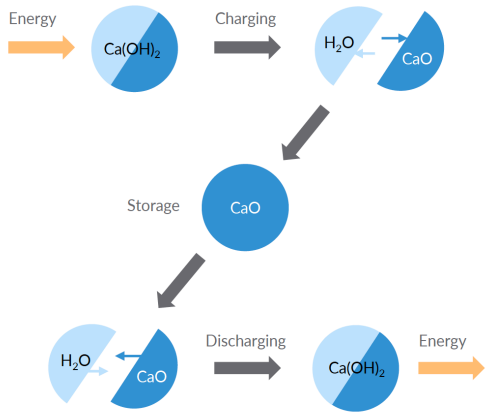
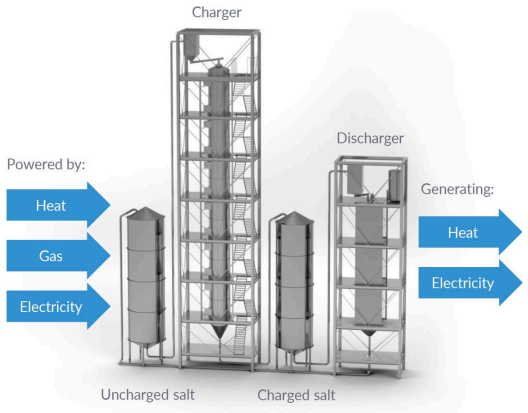
RedoxBox





SaltX





Energy storage integration in the generation mix

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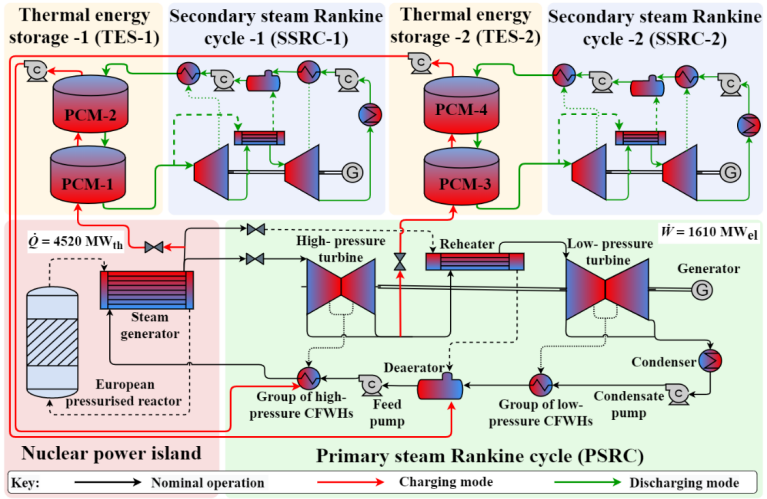
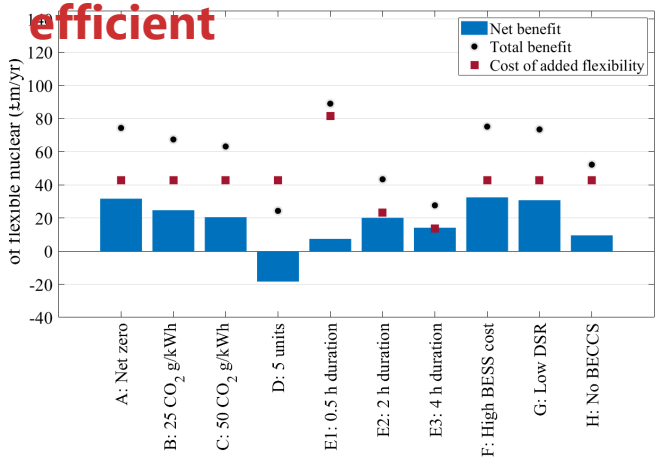
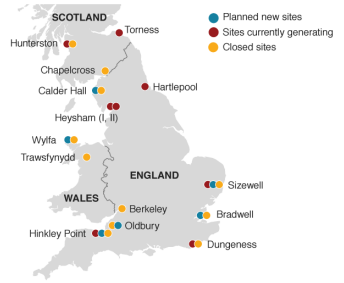


1.Nuclear flexibility upgrade is cost-efficient





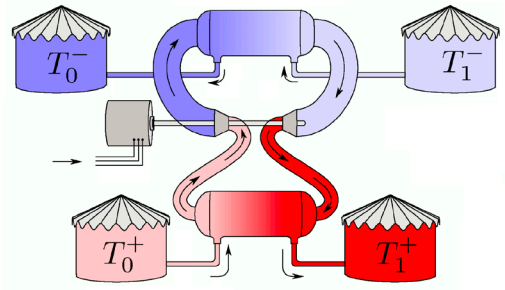
Sites of nuclear power stations in the UK

benefit from **£60.1–63.1m/yr** (50 gCO_2/kWh) to **£67.4–74.3m/yr** for a net-zero carbon system

Al Kindi A.A., Aunedi M., Pantaleo A.M., Strbac G., Markides C.N. (2022) Energy Conversion and Management

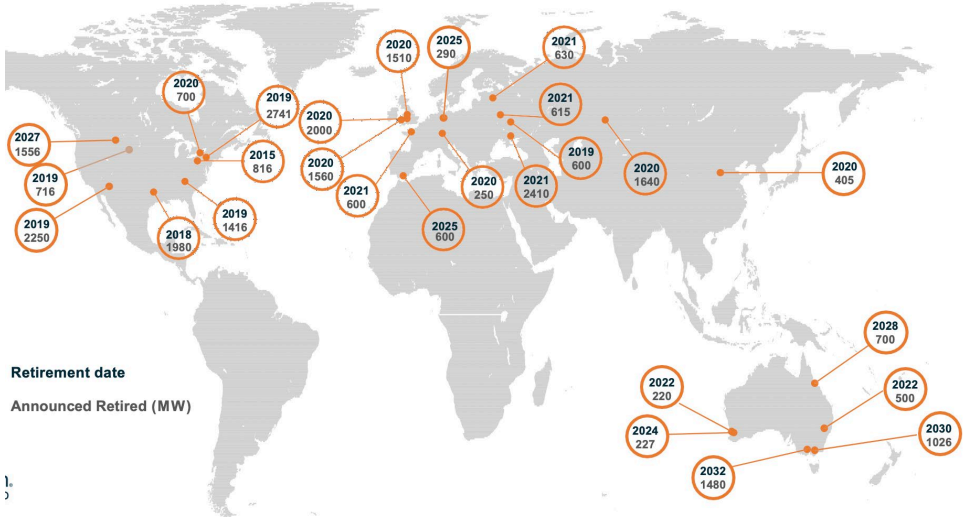
2.Coal power plants refurbishment to storage: the Bryton Energy concept (Arpa-e)

Nobel Laureate R. Laughlin: '*energy storage is a problem of 19th century science. No future laboratory breakthroughs or discoveries are required for solving it. All that is needed is* ***fine engineering*** *and* ***assiduous attention to detail****.*'

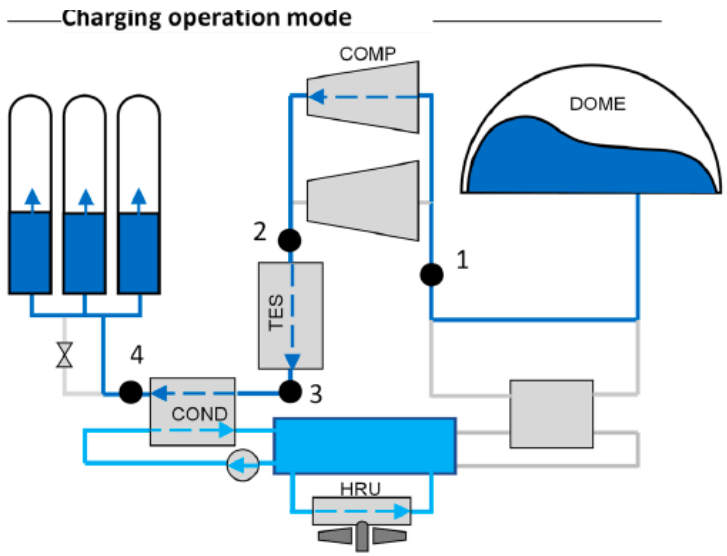


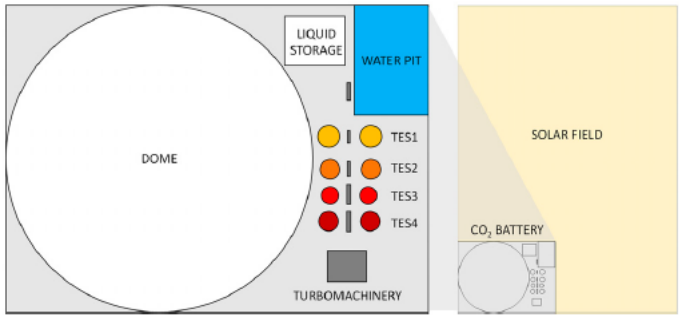
'..the storage capacity of months becomes feasible once the engine and HX exists as a product one can purchase at a **known cost**, particularly if the **heat is further transferred into cheaper media** for longer-term storage. Thus, pumped thermal storage with HX is not a niche solution to the energy storage problem but a global one...'

Pumped thermal grid storage with heat exchange," by R. B. Laughlin, *Journal of Ren and Sustain Energy* (2017)



EIC accelerator: EnergyDome





	CO_2 Battery	PHS + CAES	GRAVITATIONAL	Iron Flow Battery
Company	ENERGYDOME	HYDROSTOR	ENERGY VAULT	ESS INC
RTE (%)	75 – 80+	60	75 – 80+	65 - 70
CAPEX (€/kWh)	150-200 for First of a Kind*	Competitive only on very large scale	300	>200 under strong cost reduction hypothesis**
Lifetime (years)	30+	30+	30+	20 - 25 (not proven)
Working demo plant at scale	Yes	Yes	No	Yes
Commercialization date	2022	Commercial	>2024	Commercial
Dependency on raw material	Low	Low	High due to the large amounts of materials needed.	Iron, salt, and H2O but dependant on liquid electrolyte production
Typical capacity and duration	20MW; 4-24h	50MW; >10h	Unknown, but expected to be moderate	kW scale; 4 to 12 hours
Footprint (kWh/m2)	4-5	15 - 20	<5	2 - 4
Site dependency	None	High	Moderate	None
Others	No dependency on ambient temperature; No supply chain constraints; Potential visual impact concerns depending on location;	Long development time; high geological risk.	Very high visual impact, not proven technology	100% Depth of discharge; Non-hazardous electrolyte; Supply chain constraint on electrolyte availability

Journal of Engin. for Gas Turbines and Power AUGUST 2022, Vol. 144 / 081012-1

Key Metrics	Li-ion battery	First of a kind	Mature technology
Round-Trip Efficiency (RTE)	~90% With degradation over time	75% Without degradation over time	81% Without degradation over time
CAPEX	280 €/kWh (Mass Scale)	150-200 €/kWh	103 €/kWh with 50 units a year
Lifetime	10 yrs – cell replacement	30 yrs	
Capacity	20%-80%, with degradation over time; 10% overbuilt required	0%-100% Without degradation over time No overbuild required	

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2023 **2024**

Milestone 1 (GRANT) **€3.5M**

- Design and Testing of an axial compressor
- CO2 Battery efficiency improvement
- IPR empowerment

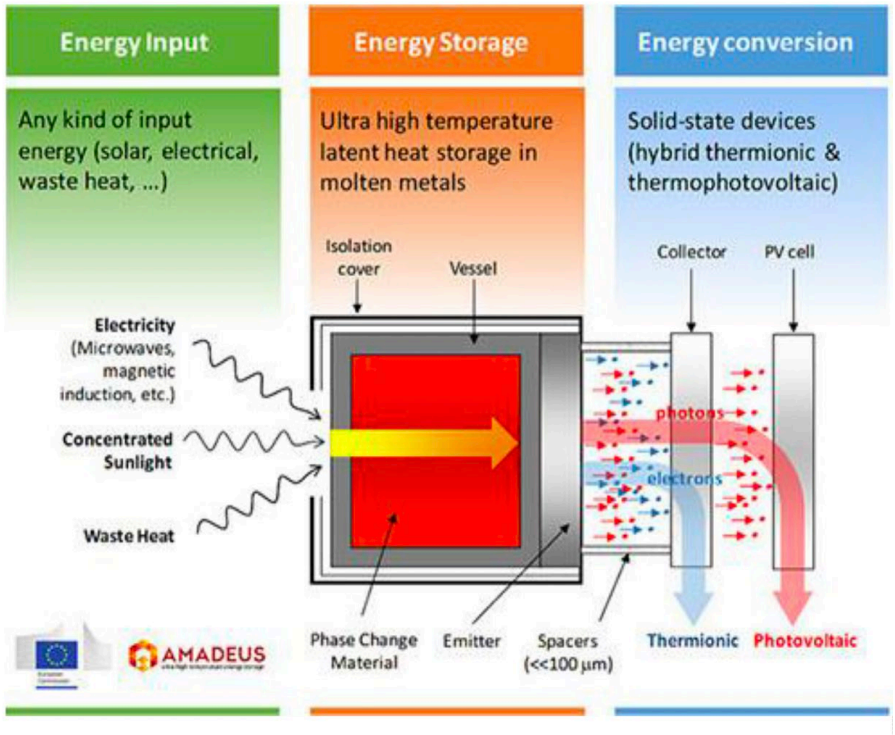
Milestone 2 (EQUITY) **€50M**

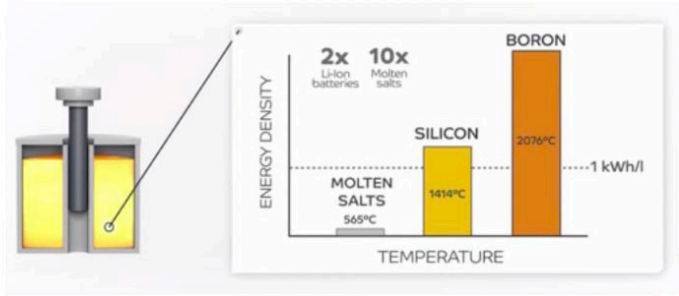
- 20 MW/200 MWh plant manufacturing and testing
- Results certification
- Company scale-up
- CO2 Battery full commercialization

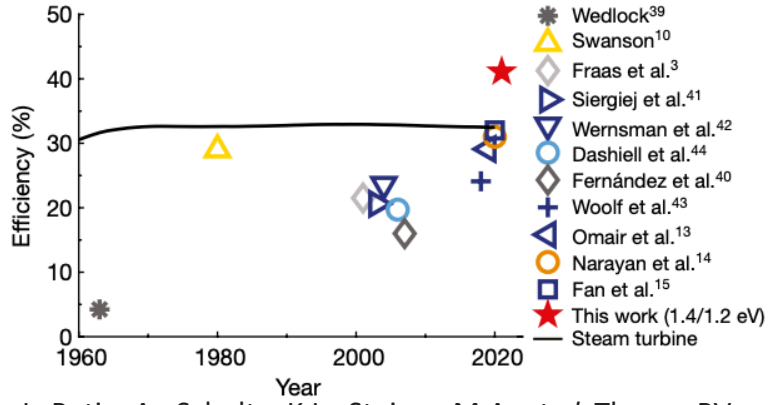
Investments already raised
– €4M through angel investors in June and December 2020
- €10M from 360 Capital, Barclays, Novum Capital Partners and Third Derivative in November 2021
- €10M as convertible with CDP Venture Capital and the existing shareholders in April 2022

Power to heat to power: perspectives of thermoPV and the EIC transition instrument

European Innovation Council



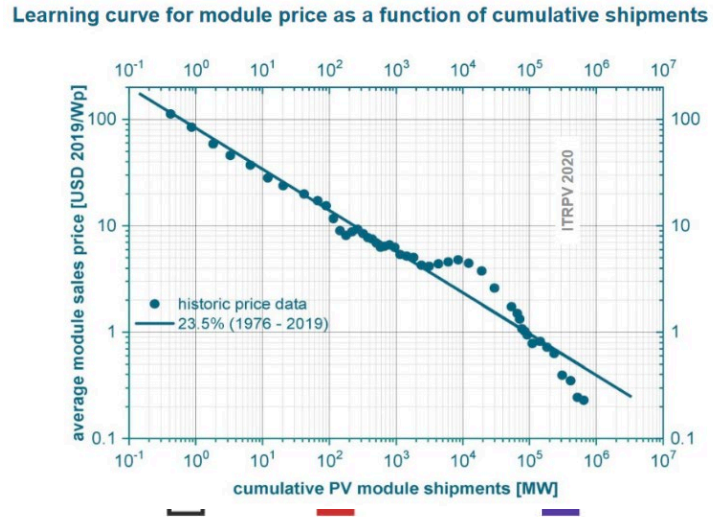




LaPotin, A., Schulte, K.L., Steiner, M.A. *et al.* ThermoPV efficiency of 40%. *Nature* **604**, 287–291 (2022).

ThermoPV: cost reduction similar to PV
Electric efficiency 40% lab scale

Antora Energy (Arpa-e), Amadeus/Thermobat (EIC), Nano-TEC (ERC CoG)
Trade offs cost vs efficiency: thermoeconomic comparison in different market segments



EIC Accelerator – The evaluation process

European Innovation Council

We will help **you** to prepare your **business plan** and draft a **proposal** with AI tool and coaching

Full Proposal

You submit your full **proposal** which will be **assessed** by Remote evaluators

You have a disruptive / deep tech **idea** with a potential to **scale up** and you need **financial support**

Tell us your story in 5 pages

You will **pitch** your innovation in front of EIC Jury Members

If selected, you will sign the **contract**

A four-steps process

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Investment component

- minimum EUR 0.5 million and maximum EUR 15 million,

-usually in the form of direct equity or quasi-equity,

- maximum 25% of the voting shares of the company,

-“patient capital” principle (7-10 years perspective on average).

Grant component

- maximum EUR 2.5 million,

-eligible costs are reimbursed up to a maximum of 70%,

-innovation activities supported should be completed within 24 months,

-small mid-caps are not eligible for grant (but can apply for investment only).

Alignment with EU Policies and synergies

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Relevance to EU policies and initiatives

- HEU SET Plan; Green Deal; Next generation EU; FIT-for-55; Repower EU

Synergy/complementarity with other EU programmes (examples)

- CL5, Destination 2: Cross sectorial solutions for the climate transition, '*A competitive and sustainable EU battery value chain*', calls HORIZON-CL5-2023-D2-01-01 to HORIZON-CL5-2023-D2-01-05
- CL5, Destination 2: Cross sectorial solutions for the climate transition, 'A competitive and sustainable EU battery value chain', calls HORIZON-CL5-2023-D2-02-01 to HORIZON-CL5-2023-D2-02-03
- CL5, Destination 2: Cross sectorial solutions for the climate transition, 'A competitive and sustainable EU battery value chain', calls HORIZON-CL5-2024-D2-01-01 to HORIZON-CL5-2024-D2-01-03
- CL5, Destination 2: Cross sectorial solutions for the climate transition, 'A competitive and sustainable EU battery value chain', calls HORIZON-CL5-2024-D2-02-01 to HORIZON-CL5-2024-D2-02-04
- **CL5, Destination 3: Sustainable, secure and competitive energy supply, 'Energy systems, grid and storage', call HORIZON-CL5-2024-D3-01-16**
- CL5, Destination 5: Clean and competitive solutions for all transport modes, 'Zero emission road transport', calls HORIZON-CL5-2023-D5-01-02 , HORIZON-CL5-2024-D5-01-03 to HORIZON-CL5-2024-D5-01-05

Key remarks: Success and failure in HEU

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- **Policy background**: link projects to policy context and Horizon EU strategic framework
- **Projects focused on scope of call**
- **Projects addressing all aspects**: exploitation, communication, dissemination etc
- **Cross sector contamination and multidisciplinarity**: focus on sectors contaminations
- **Interaction with Policy Officers**
- **EIC accelerator**: several attempts often needed, gender parity, team with good mix of knowledge (CEO, CTO, CFO), market and competitors analysis; good pitch and business model, product already patented and/or mature for the market

Specific aims of PM proactive management

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- **follow-up projects closely**, from scientifical and technological sides
- Build and manage **programmes** composed by projects with shared components/complementarities; enforce collaborations among portfolios
- **support, re-orient, suspend or terminate** projects
- stimulate serendipity, research and knowledge contamination for new **applications**
- **share results,** facilitate innovation ecosystems and facilitate networking
- address and overcome legislative bottlenecks
- **exploitation first**, instead of publication
- **address the rights for inventors** to do something with 'their' results
- Launch **innovation deals:** interservices working groups to address regulatory – legislative barriers
- **Identify, nurture and catalyse innovations in EIC beneficiaries**

Key remarks on energy storage: scientific-technological challenges

European Innovation Council

- Circularity by design and non critical / non toxic raw materials (security vs efficiency)
- Technologies and processes integration (storage duration hybridization)
- Real time control and computational tools for smart energy systems
- Sector coupling and industrial decarbonization opportunities (process systems optimization)
- Heating/cooling sector decarbonization (spatial and temporal dimensions)
- Comparative techno-economic analyses and **merit order of uses** (for policymakers)

Key remarks: regulatory and socio-economic drivers for innovation in storage

- Permitting issues (grid Interconnection) and access to grid (prosumers)
- Social participation and energy communities to enable demand response
- Market mechanisms to reward flexibility and a unique European energy market
- Carbon markets: broader picture view

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Thank you!

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EIC Programme Manager: a new role

European Innovation Council

Building strategic visions for technology and scientific breakthroughs, identification of emerging research needs and definition of challenges, chair of evaluation panel (pathfinder) and portfolio implementation

Clustering projects in thematic portfolios, enhance cross-sectorial contaminations and serendipity

Scientific knowledge + networking + entrepreneurial vision to pull through research towards innovation

Scientific intelligence

Proactive Management

Ecosystem building

Temporary role as scientific and innovation expert to bring vision, technical knowledge, management capabilities and networking to EC

Outreach to R&I stakeholders, links to other EU programmes and engagement with innovation ecosystem community (investors, innovators, researchers, corporates) to build an ecosystem around technology breakthroughs

Bridging policy and implementation

Pathfinder | Ongoing thematic portfolios

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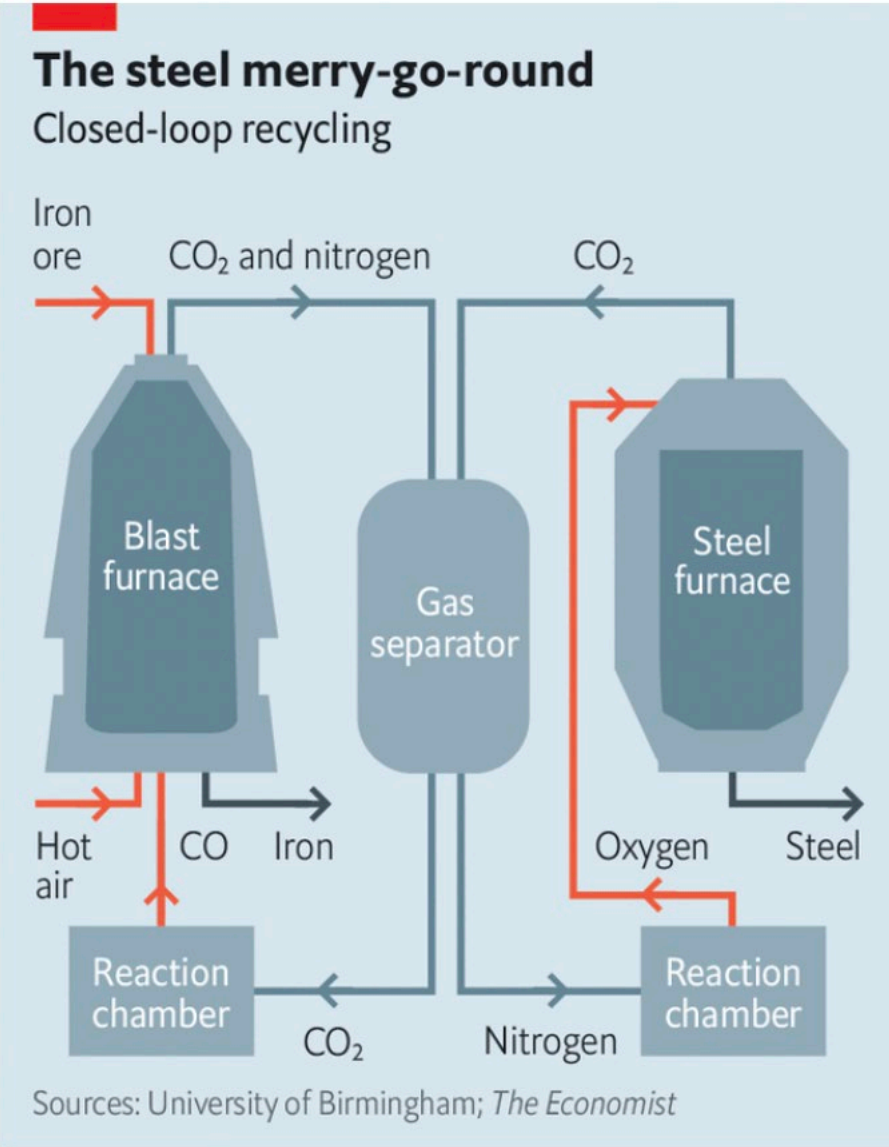
- **Renewable Hydrogen** (production, storage, logistics, end use)
- **Energy storage** (electrical, thermal, chemical, mechanical and electrochemical)
- **Solar conversion technologies** (solar-to: thermal, fuel, electricity) and solar chemistry
- **Energy harvesting and conversion**
- **CO2 and N management and valorization**
- **Climate and Environment** (air/water/soil monitoring/depolluting, environmental intelligence)

Research topics for future challenges

- Clean cooling technologies
- Water-food-energy nexus and environmental remediation/energy
- Modular nuclear reactors
- Carbon capture, negative emission technologies
- Natural H2 (georeactors) – deep geothermal
- sustainable mining
- Bio-inspired and biobased solutions for energy harvesting and conversion

Decarbonizing steel industry



H2 and Steel:

Closed loop carbon recycling system to replace coke, pumping CO in the blast furnace

CO2 is recovered and transformed in CO with perovskites

Y. Ding et al, https://doi.org/10.1016/j.jclepro.2023.135963

Energy storage: research and innovation needs

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- Mid to long duration (10-100 hours): pathfinder challenge
- Systems integrated energy storage: industrial processes
- Spatial and temporal decoupling
- Short and mid duration integration, demand response
- Decarbonization of heating and heat pumps
- Molecular storage