Brief information about the project

Name of the project	AP14872287 «Study of cascade solar thermal energy storage efficiency using phase change materials in continental climate»
Relevance	According to the International Energy Agency (IEA), thermal energy accounted for 50% of global final energy consumption in 2021, making it the largest final energy consumer and responsible for 40% of global carbon dioxide (CO2) emissions. As industries move towards decarbonization, the share of heat pumps and other sources of thermal renewable energy, such as solar water heaters, is increasing. Solar thermal energy is one of the three climate protection drivers, alongside photovoltaics and wind turbines. However, due to the intermittent nature of solar energy, daily and seasonal thermal energy storage will enable a continuous heat supply. The use of phase change materials (PCMs) for thermal energy storage can serve as a useful tool for storing and utilizing thermal energy for various needs. This study proposes a cascading mechanism for storing solar thermal energy using various PCMs for continental climatic conditions.
Purpose	The project aims to develop a thermal accumulator based on PCM for cascading storage of solar thermal energy in continental climatic conditions. The project is aimed at researching an efficient geometric configuration of finned structures of cylindrical PCM containers, finding suitable PCMs for use in continental climatic conditions, and creating an algorithm for calculating complex heat and mass transfer processes with phase transformations.
Objectives	-Development of a numerical algorithm for studying complex heat and mass transfer processes considering phase transitions. -Numerical analysis of the solar thermal energy potential in various regions of Kazakhstan for the utilization of the proposed thermal accumulator in continental conditions. -Investigation of an efficient geometric configuration of internal finned structures of cylindrical containers for PCM. -Selection of phase change materials for cascading heat storage, considering the characteristics of continental climate.
Expected and achieved results	According to the schedule, several configurations of the thermal accumulator with a cascaded arrangement of PCMs were assembled. These configurations allow for the investigation of thermal efficiency and energy storage performance by utilizing the latent heat of phase change materials (PCMs). Assembly of three thermal accumulator configurations with a cascaded arrangement of PCMs has been completed. In all three configurations, PCM materials

	are poured into cylindrical containers, which are vertically positioned inside the outer cylindrical tube. A 3D numerical tool for calculating the efficiency of the thermal accumulator with a cascaded arrangement of PCMs has been developed based on COMSOL Multiphysics 5.6 software. Various computational fluid dynamics (CFD) simulations and parametric studies of the charging and discharging efficiency of the thermal accumulator have been conducted. Calculations of different geometric configurations for the internal finned structures of PCM containers have been performed.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	1. Project Manager – Yerzhan Belyayev, Acting Professor of the Department of Mechanics Farabi University, Ph.D., Associate Professor. h index– 9, Researcher ID AAA-7041-2020; N-4425-2014, ORCID: 0000-0002-7947-2179, Scopus author ID: 57195693973. 2. Amankeldy Toleukhanov, LSS. h index – 2, ResearcherID: AAA-8468-2020, ORCID: 0000-0002-7386-3494, Scopus author ID: 56085593800. 3. Abzal Seitov, LSS. h index – 2, Researcher ID AAS-5730-2020, ORCID:0000-0002-7317-3047, Scopus author ID: 55343824600 4. Yelnar Yerdesh, h index– 2, Researcher ID: IZE-0908-2023, AAS-5097-2020; ORCID: 0000-0001-9623-5610; Scopus author ID: 57209467493. 5. Alina Abdidin, ORCID: 0009-0003-2488-9414. 6. Yelizaveta Karlina. As part of the project, Abzal Seytov's Ph.D. thesis is being prepared; he is the responsible executor and conducts experiments and complex 3D calculations. Master's students Aiym Kereykulova (M2) and Alina Abdidin (M1) are also being trained together with Professor Olivier Botella from the R&D center LEMTA of the University of Lorraine in France.
List of publications with links to them	(1) Yerzhan Belyayev, Amankeldy Toleukhanov, Yelnar Yerdesh, Abzal Seitov, Abdurashid Aliuly, Olivier Botella. Numerical Simulation of Cascade Latent Heat Thermal Energy Storage Device Thermal Performance using Multiple PCMs // Proceedings of Thermophysics 2023 Conference, October 3rd – 5th, 2023, Dalesice, Czech Republic. (2) Amankeldy Toleukhanov, Yerzhan Belyayev, Yelnar Yerdesh, Abzal Seitov, Tannur Amanzholov, Huasheng Wang. Energy and Exergy Performance Study of Ground Source Heat Pump in Continental Climate Conditions // October 3rd – 5th, 2023, Dalesice, Czech Republic. (3) A. Abdidin, Ye. Belyayev, Numerical modeling of heat and mass transfer processes taking into

	account the phenomenon of latent heat-storage in a thermal energy storage tank. // Proceeding of International Scientific and Practical Conference "Satbayev Conference – 2023", 12 April 2023. - Vol.3-P.9-15. (4) A. Abdidin, Ye. Belyayev, Numerical modeling of heat exchange and liquid flow in the thermal energy storage tank by latent heat method // Materials of International Scientific Conference of Students and Young Scientists «Farabi Alemi» Almaty, Kazakhstan, April 6-7, 2023.- Vol.1-P.51. (5) A. Abdidin, A. Seitov, Ye. Belyayev, Melting enhancement of PCM in a tube latent heat thermal energy storage. // ABSTRACTS of the VII World Congress of Turkic World Mathematicians (TWMS Congress-2023), September 20–23, 2023, Turkestan, Kazakhstan.Vol.1-P.466.
Patents	-

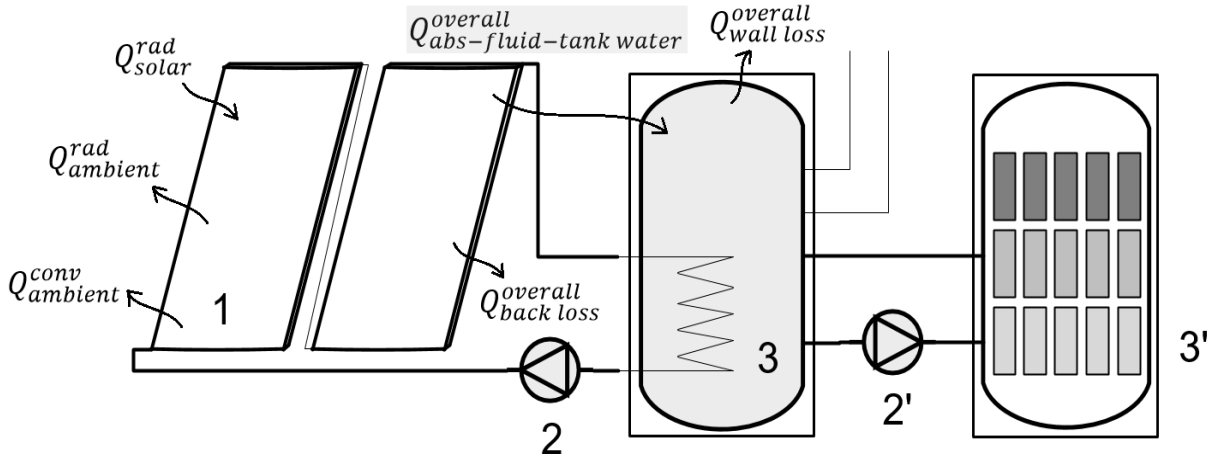

Figure 1 – Solar water heater with cascade thermal storage

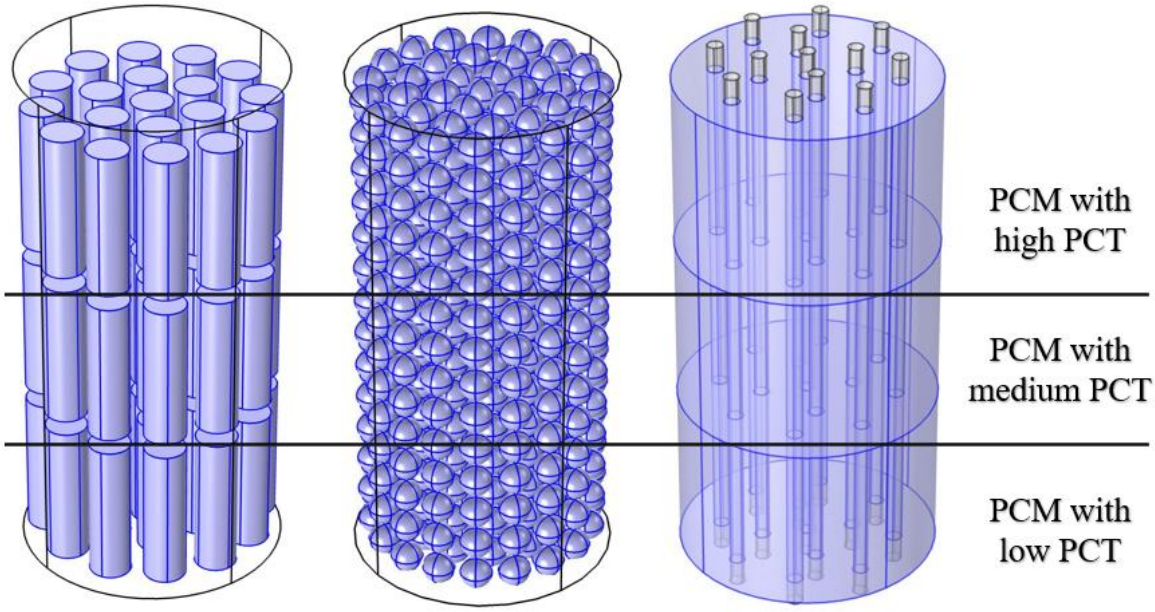

Figure 2 – Different geometric configurations of cascade thermal storage with different PCMs

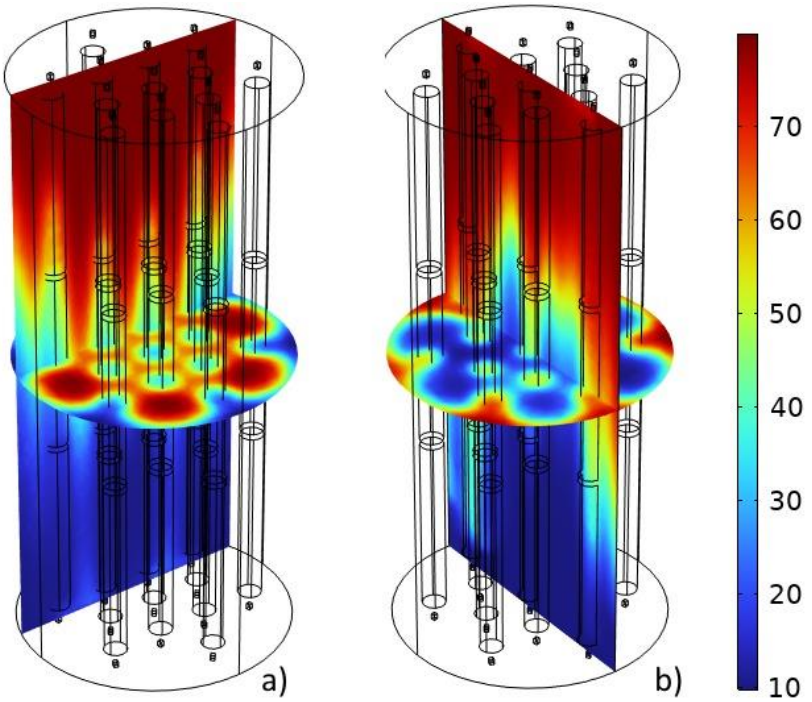

Figure 3 – 3D contour plot of temperature distribution in cascade accumulator: a) charging, b) discharging.

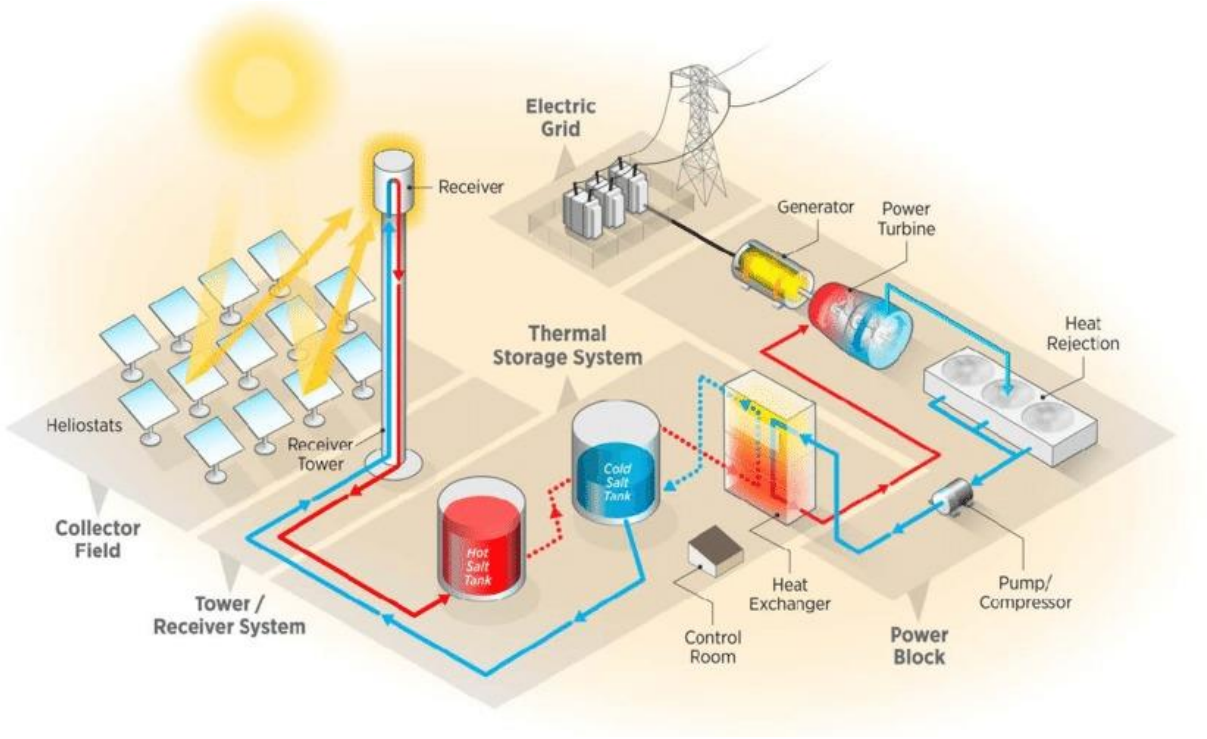

Figure 4 – Application of Cascade Thermal Accumulator in Concentrated Solar Power Plants