Cofund 2

Additional Joint Call

Transnational Project

Start Report

Smart Solar System - S3

Table of Contents

General Project Information

Project acronym: S3
Project title: Smart Solar System
Project number: SOLAR-ERA.NET Cofund 2 Additional Joint Call Project N° *009*
Project website: -

Start date of the project: *01.04.2021*
End date of the project: 31.03.2023

Start Report date: 16.06.2021

Total project costs (EUR): 499'277
Requested funding budget (EUR): 452'918
Coordinator contact details:

Short name of organisation	PT
Full name of organisation	Protarget AG
Department of organisation	-
Type of organisation*	SME
First and family name of coordinator	Siddharth Dutta
Full address	Zeissstraße 5 50859 Köln
Country	Germany
E-mail	dutta@protarget-ag.com
Phone number	+49 172 7020 881
PIC (9-digit Participant Identification Code)	930317107

Consortium Partner 2 contact details

Short name of organisation	DLR
Full name of organisation	Deutsches Zentrum für Luft- und Raumfahrt e. V.
Department of organisation	Institut für Solarforschung
Type of organisation*	Public research organisation
First and family name of coordinator	Christian Jung
Full address	Linder Höhe, 51147 Köln
Country	Germany
E-mail	christian.jung@dlr.de
Phone number	+49 2203 601 2940
PIC (9-digit Participant Identification Code)	999981731

Consortium Partner 3 contact details

Short name of organisation	SIJ
Full name of organisation	FH Aachen University of Applied Sciences
Department of organisation	Solar-Institut Jülich (SIJ)
Type of organisation*	University
First and family name of coordinator	Prof. Dr.-Ing. Spiros Alexopoulos
Full address	Heinrich-Mußmann-Str. 5, 52428 Jülich
Country	Germany
E-mail	alexopoulos@sij.fh-aachen.de

Phone number	+49 241 6009 53522
PIC (9-digit Participant Identification Code)	996033928

Consortium Partner 3 contact details

Short name of organisation	UPat
Full name of organisation	University of Patras
Department of organisation	Physics Department
Type of organisation*	Academia
First and family name of coordinator	Ioannis Kioutsioukis
Full address	University of Patras Physics Department (Bld A) Laboratory of Atmospheric Physics University campus 26500 Rio
Country	Greece
E-mail	kioutio@upatras.gr
Phone number	+302610997281
PIC (9-digit Participant Identification Code)	999894528

Number of researchers involved and jobs created

Total number of researchers involved	Number of young researchers involved	Number of female researchers involved	Number of permanent jobs created	Number of temporary jobs created
Protarget AG				
3	2	0	0	0
DLR				
6	1 - 3	1 - 3	0	1 - 3
SIJ				
3	0	0	0	Up to 0.81
UPat				
6	3	2	0	3

Publishable Project Summary

With high fuel costs, the increased likelihood of carbon taxation and pressure to reduce the environmental impact of their business activities, various industrial sectors are becoming increasingly aware of the need to become less dependent on fossil fuels. In order for industry to do this, suitable technologies have to be available that can provide them with cost effective and user-friendly alternatives.
One of the best renewable options to supply industrial process heat is Concentrated Solar Thermal (CST) technology, especially as it can use Thermal Energy Storage (TES) to provide heat on demand. During the EDITOR project (co-funded by SOLAR-ERA.NET), a Parabolic Trough Collector (PTC) and TES were installed at KEAN Soft Drinks Ltd in Limassol, Cyprus, demonstrating full dispatchability of process heat. To further improve the overall performance of this system, as well as transition towards Industry 4.0, it is necessary to develop a smarter control system.
The primary objective of this industrial research project is to realise a next generation Smart Solar System (S3) for steam generation based on CST technology. The smart control system will feature self-learning, adaptive, predictive and automatic characteristics and will be demonstrated for the solar plant installed at KEAN Soft Drinks Ltd in Limassol, Cyprus. The smart control system will consist of a Main Control Unit (MCU), and based on operational data from Local Control Units (LCU), weather & load forecasting inputs and the customer demand schedule, the MCU will automatically select an optimum operation strategy. The degree of intelligence of the smart control system targeted, is in accordance with the objectives of the SOLAR-ERA.NET call (subtopics E1, E5 and E6) and the aims of the European strategic energy technology (SET) plan for CSP to improve the performance of a CST system and will lead to lower operation and maintenance costs, while in line with the goals of Industry 4.0.

The seven objectives of this project are:

1) Development of a smart solar system that runs efficiently and can predict the optimum strategy at all times depending on weather and load (energy demand) forecasting.
2) Evaluation of the fossil fuel cost saving potential for KEAN (and industry in general) that could be achieved by the use of an up-scaled CST system. This would involve a study of KEAN's fossil-fuel fired boiler performance as well as the CST's solar boiler performance, to develop better forecasting of KEAN's energy demand and CST's demand matching.
3) Development of new hybrid operating modes and further operation strategies to better match the customers demand patterns.
4) Increase CST boiler's performance through smarter and more robust control system.
5) Testing of a new Heat Transfer Fluid (HTF) HELISOL® XLP, that will reduce plant purchase and operating costs, in an industrial application. This will allow the more widespread use of this product.
6) Identification of optimal cleaning schedules of the mirror assembly and heat collecting element (HCE) for the different seasons of the year with the aim to reduce the water consumption and O&M costs.
7) Identification of optimum maintenance of the silicone Heat Transfer Fluid (HTF) system to control hydrogen concentration.

Summary on Project Progress

Has there been any changes in the	No	Minor	Substantial
Consortium composition?	X		
Work progress?	X		
Expenses (vs budget)?	X		

Work Progress

List of Milestones (to be continued and completed year by year)

Milestone number	Milestone title	Planned in project month	Achieved in project month	Further information
M1.1	Hardware and sensors installed	15		The data and communication network is designed, the new sensors and equipment are installed, and the network is completely set up at the CST plant in Cyprus.
M2.1	First version of forecasting algorithm	11		A first working version of the weather and soiling forecasting algorithms by SIJ and UPatras is completed.
M3.1	Final hybrid modes tested	21		The developed MCU, including the weather and forecasting algorithm is set up at the CST plant in Cyprus.
M3.2	MCU tested and demonstrated	24		The smart solar system is demonstrated, where the MCU operates and chooses the optimum strategy based on the inputs described in WP 3.3.
M4.1	HTF analysis and strategy developed	24		New HTF is analysed and hydrogen control strategy is developed.
M5.1	Performance and cost analysis completed	24		Performance analysis of the CST and KEAN boiler. Cost reduction in the O&M is analysed and achieved

List of Deliverables (to be continued and completed year by year)

Deliverable number	Deliverable title	Planned in project month	Achieved in project month	Further information
D1.1	Acquisition of hardware and sensors	6		Planned hardware and sensors are ordered (specification list)
D1.2	Installation of hardware and sensors	15		Hardware and sensors are delivered and installed onsite
D2.1	First version of WFA and SFA	11		First working version of WFA and SFA is developed
D2.2	Final version of WFA and SFA	24		Final working version of WFA and SFA is documented (report)
D3.1	First version of MCU	15		First working version of MCU with the WFA and SFA is developed
D3.2	Analysis of hybrid operating modes	21		Analysis of the developed hybrid operating modes (report)
D3.3	Analysis of MCU performance	24		Analysis of performance of the MCU with WFA/SFA (report)
D4.1	Hydrogen control strategy	15		Hydrogen control strategy is developed (handbook)
D4.2	Analysis of HELISOL XLP	24		New HTF is analysed (report)
D5.1	Boiler analysis report	12		Analysis of consumption and fossil fuel cost saving (at present) for KEAN with present CST system (report)
D5.2	O&M optimisation report	21		Optimum cleaning scheduled of SCA and HCE to reduce the O&M costs (manual)
D5.3	Analysis of scaled-up CST plant	24		Evaluation of the fossil fuel cost savings for the KEAN factory for a scaled-up CST plant (report)

Results and Impact

Issue / Indicator	Initial value at start of project	Expected value at the end of project	Reached value	Further information
TRL progress	*5*	*7*		
Performance / efficiency	Partial automation	*Full intelligent automation*		
LCOE in absolute figures				
LCOE decrease in %				
Cost of product				
GHG emissions decrease in absolute figures (e.g. g CO_{2eq} / kWh)				
Material use / savings				
Etc.				

Smart CST systems for industrial application are not state-of-the-art and the project partners are unaware of any competitors implementing smart control. The CST system currently installed at KEAN Soft Drinks Ltd does not use smart control, i.e. it does not communicate with the factory or uses forecasting. Instead it controls its operation based on parameters such as steam pressure, DNI and time of the day (schedule), thereby achieving full dispatchability. However, in the case that unexpected changes occur to the factory side demand, or people are not always available to operate the system or do maintenance then the current control system would not be able to find the optimum operation strategy, hence the need for full intelligent automation.
An expected result at the end of the project S3 is that the newly reached level of the state-of-the-art will lead to significant advantages with respect to commercialisation, as the CST system will outperform any competitors' system who do not apply smart control strategies. The main selling point is that the improvement in the overall performance of the system and reduction of man hours for O$M, due to the smart control via sensors and algorithms will be available for little additional cost.

The expected results from this project are listed below:
1) Smart Solar System with self-learning, adaptive, predictive and automatic features, developed and tested at KEAN. In connection with this, the following deliverables are expected:

a. Development of the main control unit (MCU)

b. Setup of a communication network between local control unit (LCU) and MCU

c. Implementation of a weather forecasting algorithm that predicts the solar irradiation conditions allowing the MCU to choose optimal control strategies for the overall system operation (e.g. storage charging and discharging periods, decision on steam production etc.)

d. Development of a new error logging and alerting system.

2) The Smart Solar System is expected to improve the CST boiler performance, thereby resulting in reduction of fossil fuel consumption of the KEAN boiler. The analysis of both KEAN and CST boiler performance is also of central importance to understand the customer energy demand patterns and CST systems demand matching. The boiler analysis also is important to determine the potential for cost savings at an industrial plant through the use of a smart solar system.
3) New hybrid operating modes and further operation strategies developed and tested, after inclusion of a new valve and mass flow sensor in the thermal oil loop. The new strategies will allow the CST system to adapt better to the customers energy requirements and match the demand patterns and will allow a heat loss reduction mode to be developed to counter the cooling effects associated with sudden reductions in solar radiation.
4) Fuel consumption and boiler performance analysis will be evaluated in this project. This leads to a better understanding of the potential for fossil fuel cost savings for scaled-up CST system at KEAN.
5) New fluid HELISOL® XLP tested. The latest development in the HELISOL range has yet to be tested in an industrial environment where its extended lifetime and reduction of component cost in the HTF loop due to the lower pressure will result in overall cost savings over the life of the CST plant. The HTF will be evaluated by DLR according to DIN 51528 and in-house procedures for high temperatures.
6) Development on an optimised maintenance strategy regarding mirror cleaning and water consumption. By optimising the cleaning schedule, a lower number of cleaning cycles will be needed every year, thereby reducing water consumption as well as the required manhours for cleaning the collectors. All in all, this leads to a reduction in O&M costs. The cleaning schedule will vary depending on the season of the year.
7) Optimised maintenance strategy of silicone fluid system for hydrogen control.

Within this industrial research project, new sensors and equipment will be integrated into the plant in order to realise the smart control. The results of experimental tests to be carried out in Cyprus are highly valuable for the future implementation and commercialisation of this technology in Cyprus and Mediterranean countries.

Financial Issues

Financial key figures in EUR* – overall budget** at the start of the project

Organisation (*Full name of organisation)*	Country	Total project costs	Public funding from the agency	Funding agency short name
Protarget AG	Germany	166091	132873	PtJ-ETN
Deutsches Zentrum für Luft- und Raumfahrt e. V.	Germany	103973	103973	PtJ-ETN
FH Aachen University of Applied Sciences Solar-Institut Jülich	Germany	131413	118272	PtJ-ETN
University of Patras	Greece	97800	97800	GSRT
	Total	*499'277*	*452'918*	

Financial key figures in EUR for Year 1 (months 1-12) * Project months

Organisation	Country	Budget for the project	Effective expenses		Funding planned	Funding received
			Personnel costs	Other costs		
PT	Germany	118292			In discussion	
DLR	Germany	102784			58556	
SIJ	Germany	10000			10000	
UPat	Greece	48900			48900	
Total						

Financial key figures in EUR for Year 2 (months 13-24) * Project months

Organisation	Country	Budget for the project	Effective expenses		Funding planned	Funding received
			Personnel costs	Other costs		
PT	Germany	47803			In discussion	
DLR	Germany	77761			45417	
SIJ	Germany	18272			18272	
UPat	Greece	48900			48900	
Total						

Financial key figures in EUR for Year 3 (months 25-36)

Organisation	Country	Budget for the project	Effective expenses		Funding planned	Funding received
			Personnel costs	Other costs		
[Coordinator:]						
[Partner 2:]						
[Partner 3:]						
[Partner 4:]						
Total						

Financial key figures in EUR for total project duration

Organisation	Country	Budget for the project	Effective expenses		Funding planned	Funding received
			Personnel costs	Other costs		
PT	Germany	166095			127680	
DLR	Germany	180545			103973	
SIJ	Germany	131413			118272	
UPat	Greece	97800			97800	
Total						

Dissemination and Communication Activities

Dissemination activities in numbers

Type of dissemination activities achieved	Year 1	Year 2	Year 3	Total
Peer reviewed articles, books, book chapters etc. published with or submitted to academic publishers	*number*	*number*	*number*	*number*
Non-peer reviewed publications (reports, briefs, books, articles targeting policy-makers, industry or other end users)	*number*	*number*	*number*	*number*
Citations to publications generated in the project	*number*	*number*	*number*	*number*
Media coverage (opinion pieces or interviews/appearances in all types of mass media)	*number*	*number*	*number*	*number*
Events targeting end users organised by the project (such as conferences, side events or workshops)	*number*	*number*	*number*	*number*
Presentations targeting end users given by project participants (including participation in panel debates)	*number*	*number*	*number*	*number*
In how much conferences / events did your project participate (not organised by project itself)?	*number*	*number*	*number*	*number*
Patent/license applications	*number*	*number*	*number*	*number*
PhD thesis	*number*	*number*	*number*	*number*
Project internal meetings (face-to-face, teleconference, videoconference, etc.)	*number*	*number*	*number*	*number*

List of peer reviewed articles, books, book chapters etc. published with or submitted to academic publishers

Type (article, report, book, compendium, journal)	Author(s) *Name(s)*	Title	Published in (*Name of publication medium)*	Page no.	ISSN/ISBN	Issued/ volume/ year
Choose type						
…	…	…	…	…	…	…

List of non-peer reviewed publications (reports, briefs, books, articles targeting policy-makers, industry or other end users)

Type (report, brief, book, article etc.)	Author(s)	Year / publication	Title
Choose type	*Name of author*	*Year of publication*	*Title of publication*
…	…	…	…

List of other dissemination activities (media coverage, events organized by project, presentations and panel debates, participation in third-party events)

Type (media coverage, events organized by project, presentations and panel debates, participation in third-party events)	Description	Year
Choose type	*Description of activities*	*Year in which activity was conducted*
…	…	…

List of patents

Patent Application Number / License	Title of the patent application / license	Name of the applicant	Name of the inventor

Contractual Information

Organisation	Funding Agency	Contract N° and Title	Duration
Protarget AG	Projektträger Jülich Forschungszentrum Jülich GmbH Energie-Technologie-Nachhaltigkeit (ETN 1)	PRO/0089A Zuwendungsbescheid	01.04.2021 – 31.12.2023
Deutsches Zentrum für Luft- und Raumfahrt e. V.	Projektträger Jülich Forschungszentrum Jülich GmbH Energie-Technologie-Nachhaltigkeit (ETN 1)	PRO/0089C Zuwendungsbescheid	01.04.2021 – 31.12.2023
FH Aachen University of Applied Sciences Solar-Institut Jülich	Projektträger Jülich Forschungszentrum Jülich GmbH Energie-Technologie-Nachhaltigkeit (ETN 1)	PRO/0089B Zuwendungsbescheid	01.04.2021 – 31.12.2023
University of Patras		Have not received it yet	