# NEXT-CSP
# A NOVEL CONCEPT

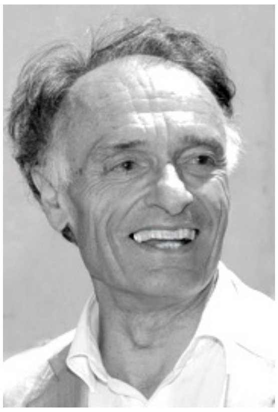
## HIGH TEMPERATURE CONCENTRATED SOLAR THERMAL POWER PLANT WITH PARTICLE RECEIVER AND DIRECT THERMAL STORAGE

# PRESS PACK FOR THE MEDIA

July 2021

EU RESEARCH FOR RENEWABLE ENERGIES

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO 727762



## Foreword by Gilles Flamant (CNRS-PROMES) Next-CSP coordinator

"The Next-CSP project is the result of more than 40 years of research on the use of particles in concentrated solar energy conversion. I published (in French) the concept of Next-CSP in 1980. Then came the original idea of the fluidized particles-in-tube solar receiver patented in 2010. The CNRS and then the European Union funded the research rapidly in 2011. The CSP2 (Concentrated Solar Power in Particles) European project, funded under FP7, resulted in the successful operation of a 150 kW solar receiver with fluidized particle recirculation.

Next-CSP's ambition is to demonstrate the project at industrial pilot scale with the testing of a 3-MW solar receiver and the complete solid and conversion loops including a gas turbine. A great challenge that strengthens the leadership position of Europe in the domain of CSP technology innovation.

After nearly 5 years of collaborative research between 10 partners from 7 countries, Next-CSP will come to an end in July 2021. Therefore, we will organise the project's final event: an hybrid Info Day showcasing Next-CSP's key results and scientific achievements as well as a side visit to the CNRS-PROMES solar facilities. In this publication, you will find more information about this special event, as well as all the key features about Next-CSP."

# Press Release: Next-CSP Final InfoDay

On behalf of the Next-CSP project team, we are pleased to announce the organisation of the **Next-CSP Final Info Day**! This **hybrid** event will take place on **Thursday, 8 July 2021**, from **09:30 to 13:00 CET**.

Due to the health context, the Info Day will be organised **online**, through the **Zoom platform**. Nonetheless, there is also an option to attend the Info Day **on site at the CNRS-PROMES facilities** in Font Romeu Odeillo, France (limited). **Registration** is free, but mandatory.

Come and find out about the innovative technologies for Concentrated Solar Power as well as the main challenges, results and perspectives of the project! In the **programme**:

**09:30** Concentrated solar power in particles: concepts and challenges
Gilles Flamant, CNRS, France

**10:00** Particles in solar heat capture, heat storage and heat recovery
Renaud Ansart, INPT, France and Jan Baeyens, EPPT, Belgium

**10:30** Construction and implementation of the Next-CSP prototype
Ken Whittaker, Whittaker Engineering, UK

**11:00** First operation results in the Next-CSP prototype
Alex Le Gal, CNRS, France

**11:30** Scaling-up the Next-CSP concept at commercial size:
- High efficiency conversion cycles - Manuel Romero, IMDEA Energy, Spain
- Positioning of CSP in Future Electricity Networks – Frédéric Siros, EDF, France

**12:30** Q&A and closing session

Download the programme in PDF

Register here (Virtual Info Day)

Register here (On site Info Day)


In the afternoon of 8 July 2021, after the InfoDay, journalists and stakeholders are invited to an on-site visit of the CNRS-PROMES facilities in Font-Romeu to showcase the concrete experiments and innovations from Next-CSP. If you wish to participate, don't hesitate to contact us!

# Concentrated Solar Power to tackle climate change

To accelerate the **fight against climate change** and to reach the EU target of **27% of renewable energies by 2030**, Europe needs to rapidly expand the use of all renewable energy sources, such as solar energy. However, this requires developing further new solutions that are emerging today, particularly technologies that solve the key issue of energy storage.

The Next-CSP project responds to this need and addresses **significant improvements** related to concentrated solar power (CSP):
- heat transfer fluids, which can be used for direct thermal energy storage;
- solar field;
- high temperature receivers al-lowing new high efficiency thermodynamic cycles.

### WHAT IS CONCENTRATED SOLAR POWER?

Concentrated Solar Power (CSP) plants use **mirrors** to concentrate **sunlight** onto **receivers** where it is converted into **heat**. A **heat transfer fluid** transports the **thermal energy** to a **storage system** or a **power block** where it is used to produce steam that drives a steam turbine to generate **electricity**. The integration of a **storage system** enables power production during cloudy periods and **after sunset**.

## The four main CSP technologies

Parabolic Dish

Parabolic Trough

Linear Fresnel

Solar Tower

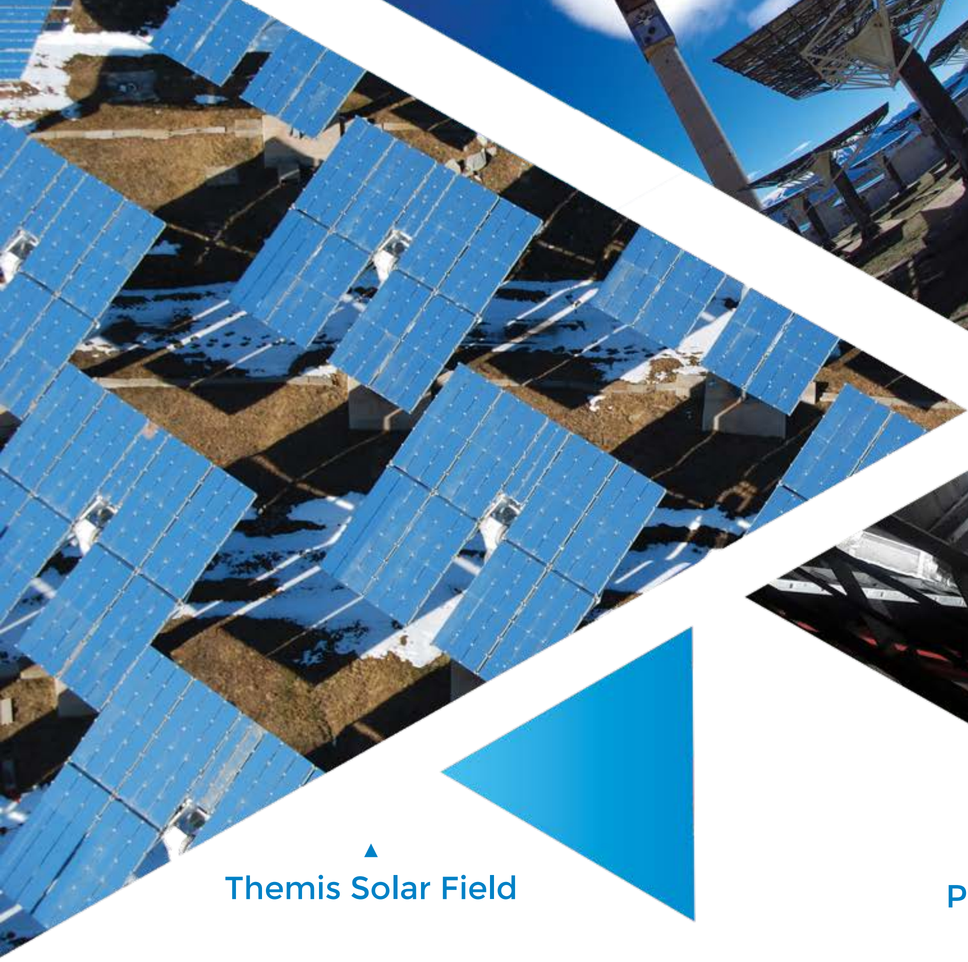
# Next-CSP: Innovative components for Concentrated Solar Power plants

Launched in 2016, the **Next-CSP** project stands for “High Temperature concentrated solar thermal power plan with particle receiver and direct thermal storage”. It responds to **4 main objectives**:
- improve the reliability and performance of Concentrated Solar Power (CSP) plants
- develop and integrate a new technology into CSP plants
- use high temperature particles as heat transfer fluid and storage medium
- demonstrate the technology in a relevant environment and at the MW size.

The project proposes a **breakthrough innovation**: a **fluidised particle-in-tube concept**, which opens the route to the development of a new generation of CSP plants. It would allow:
- high efficiency new cycles (50% and more),
- 20% improvement of CSP plant efficiency,
- modular concept
- and an electricity cost reduction of about 38%

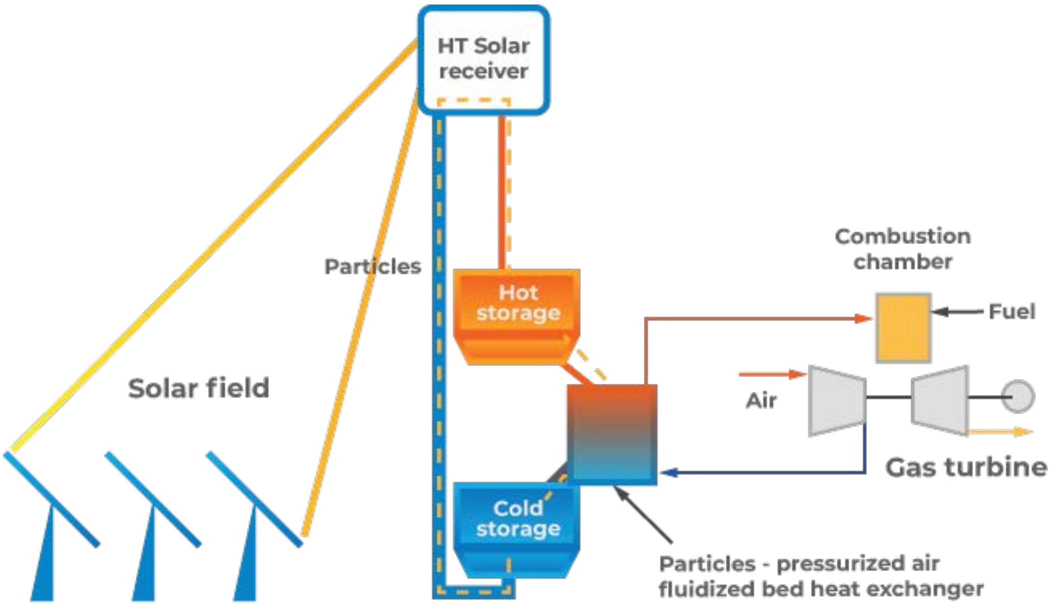
Next-CSP aims to demonstrate the validity of the fluidized particle-in-tube (PIT-CSP) concept atop the **THEMIS solar power tower** in France, at **large prototype scale** (TRL5). A **3-MWth tubular solar receiver** able to heat particles up **to 650-750°C** is being tested, as well as the rest of the **conversion loop** (a two-tank particle heat storage and a particle-to-pressurized air heat exchanger coupled to a 1.2 MWel gas turbine). The **full system** is being tested and evaluated in 2021, paving the way for future **prototype demonstration and commercial development**.

Themis Solar Tower ▸



▴
Themis Solar Field

Pilot Loop ▸




The Next-CSP concept

# A collaborative project funded by the European Union

The Next-CSP project has been supported by **Horizon 2020**, the European Union's Framework Programme for Research and Innovation. It was funded by the "**Secure, clean and efficient energy**" programme, under the specific topic "Developing the next generation technologies of renewable electricity and heating/cooling" (LCE-07-2016-2017).

| TOTAL BUDGET | EU CONTRIBUTION | CONSORTIUM | COORDINATOR | DURATION |
|---|---|---|---|---|
| € 4,947,420 | € 4,947,420 | 10 Partners<br>5 Countries | CNRS-PROMES<br>France | 58 Months<br>from Oct. 2016<br>to July 2021 |

# Main innovations and results of the project

### SOLAR RECEIVER

- Develop an innovative solar receiver using fluidized particles that circulate in 40 solar irradiated tubes at pilot scale,
- Manufacture a 3 MWth solar receiver and test it in a wide range of operation parameters, develop and integrate a new technology into CSP plants.

### HEAT TRANSFER FLUID

- Use particle as heat transfer fluid (HTF) instead of molten salt in solar power tower and develop the adapted solar receiver (new product),
- Increase the HTF temperature by about 200°C,
- Identify the main limitations of the fluidized particle-in-tube technology (PIT-CSP technology) with respect to the scaling-up issues and propose solutions to overcome them.

### STORAGE

- Use the same solid particles used as HTF to store thermal energy in a close loop without dust emission,
- Increase the storage capacity of the two-tank thermal energy storage (TES) by increasing the temperature difference between the hot and cold tanks: about 400°C instead of 270°C for molten salt,
- Prove and identify the issues related to the storage technology principle, in particular the hot particles handling and conveying.

### POWER BLOCK

- Design and test a multistage fluidized bed heat exchanger that transfers the energy from the particles to the working fluid,
- Construct a 2.5 MWth particle-to-pressurized air fluidized bed heat exchanger and assess its performance,
- Operate a solarized 1.2 MWel gas turbine in hybrid mode

### INTEGRATION

- Integrate the particle loop (solar receiver + TES) with the energy conversion loop (particle heat exchanger + hybrid gas turbine) in a single industrial pilot,
- Measure the performance of the complete system at Themis solar tower,
- Design a commercial scale (150 MWel) power plant on the basis of the technology and estimate the cost,
- Identify the main bottlenecks for large-scale development of the particle-in-tube technology (PIT) technology,
- Analyse the environmental impact of the technology and compare it to the state-of-the-art.

# Impacts of the project

| | |
|---|---|
| **CSP TECHNOLOGY PERFORMANCE** ➜ | The project prepares the next generation of CSP plants with high performance thermodynamic cycles at temperature higher than 650°C. 50% efficiency is targeted by comparison with 42% for state-of-the-art CSP technology. |
| **REDUCTION OF CO2 EMISSION** ➜ | While operating, CSP is a CO2 free technology that can produce dispatchable electricity. The project features a 40% emissions reduction target. |
| **COMPETITIVENESS AND INCREASE OF SOLAR ENERGY USE** ➜ | The Next-CSP technology provides optimised dispatchability thanks to thermal storage at reasonable cost. The cost target is about 80 €/MWhel (LCOE) in 2030. This cost depends of the operation mode of the plant, higher costs are acceptable for a plant operating as a peaker. |
| **REDUCTION OF OPERATIONAL COSTS** ➜ | The heliostat field accounts for about 40% of the CAPEX (Capital expenditure) and OPEX (Operating expense) of a solar tower power plant. This field be downsized by 20% thanks to the increased conversion efficiency thus reducing considerably the CAPEX. |
| **INCREASING THE RELIABILITY AND LIFETIME OF CSP PLANTS** ➜ | The project prepares the next generation of CSP plants with high performance thermodynamic cycles at temperature higher than 650°C. 50% efficiency is targeted by comparison with 42% for state-of-the-art CSP technology. |

# Communication and dissemination material

## PRINT MATERIAL

- The **Next-CSP Brochure:** a 12-page publication with key information – objectives, innovations, impact and expected results – about the project. Available for download here.
- The **Next-CSP Flyer:** all you need to know about the project in a nutshell! Available for download here.
- The **Next-CSP Timeline**: the key achievements and milestones of the project in 12 key dates. Available for download in PDF and JPG.

## VIDEOS

- The **Next-CSP Video (02:48)** produced in 2021, with takes from the Themis solar tower in France and a testimony of Next-CSP coordinator Gilles Flamant (CNRS-PROMES). Watch here.
- An animated video explaining the principles of the **Next-CSP solar thermal power plant**. Watch here.
- An animation of the **Themis solar field simulation** and interaction with the **solar receiver**. Watch here.
- An animated video of **the Heliostat optical optimisation**. Watch here.

## INTERVIEWS OF THE NEXT-CSP PARTNERS

- Jean-Florian Brau, **EDF R&D** (France). Watch here.
- Miguel Reyes, **IMDEA Energy Institute** (Spain). Watch here.
- Renaud Ansart, **INP Toulouse** (France). Watch here.
- Raf Dewil, **KU Leuven** (Belgium). Watch here.
- Ken Whittaker, **Whittaker Engineering** (UK). Watch here.

## EVENTS

- The **Next-CSP Online Workshop**, organised on 16 June 2021. In the programme: an overview of the achievements of the project, its technology and the commercial perspectives by 4 Next-CSP partners. You can watch the replay of the webinar on YouTube.
- The **Workshop "Dispatchable Renewable Energies: From a Myth to Reality"**, organised on 6 June 2018 in Edinburgh (UK). Discover the programme and download the presentations.

## VISUALS

- The **Next-CSP Logo** available for download here.
- Discover a **selection of pictures** related to Next-CSP ready to use for publications. Download the image file here.

All the communication material are also available on the Next-CSP Website:
**http://next-csp.eu/dissemination/communication-materials/**

You can also watch all the videos related to Next-CSP on the "Next-CSP - Horizon 2020 Project" playlist on YouTube: **https://youtube.com/playlist?list=PLBNLB4htebTtKGDzjPDaaB8ddXMwvYt75**

## Scientific Publications

| Title | Partner Authors | Published in / DOI |
|---|---|---|
| Dense Upflow Fluidized Bed (DUFB) Solar Receivers of High Aspect Ratio: different fluidization modes through inserting Bubble Rupture Promoters (Not in Open Access) | CNRS<br>EPPT<br>INPT | Chemical Engineering Journal (2021) 418, 129376<br>https://doi.org/10.1016/j.cej.2021.129376 |
| Design and off-design performance comparison of supercritical carbon dioxide Brayton cycles for particle-based high temperature concentrating solar power plants | IMDEA | Energy Conversion and Management 232 (2021) 113870<br>https://doi.org/10.1016/j.enconman.2021.113870 |
| Aiming Strategy on a Prototype-Scale Solar Receiver: Coupling of Tabu Search, Ray-Tracing and Thermal Models | CNRS | Sustainability 2021, 13(7), 3920<br>https://doi.org/10.3390/su13073920 |
| Design and performance of a modular combined cycle solar power plant using the fluidized particle solar receiver technology (Not in Open Access) | CNRS | Energy Conversion and Management 220 (2020) 113108<br>https://doi.org/10.1016/j.enconman.2020.113108 |
| Shaping High Efficiency, High Temperature Cavity Tubular Solar Central Receivers | CNRS | Energies 2020, 13(18), 4803<br>https://doi.org/10.3390/en13184803 |
| Computation of canting errors in heliostats by flux map fitting: experimental assessment | CNRS | Optics Express Vol. 28, Issue 26, pp. 39868-39889 (2020)<br>https://doi.org/10.1364/OE.412116 |
| Solids Flow in a "Particle-in-Tube" Concentrated Solar Heat Absorber (Not in Open Access) | EPPT<br>CNRS | Ind. Eng. Chem. Res. 2019, 58, 11, 4598–4608<br>https://doi.org/10.1021/acs.iecr.8b04544 |
| Flexible electricity dispatch for CSP plant using un-fired closed air Brayton cycle with particles based thermal energy storage system | IMDEA | Energy 173 (2019) 971-984<br>https://doi.org/10.1016/j.energy.2019.02.135 |
| Annual performance of subcritical Rankine cycle coupled to an innovative particle receiver solar power plant | IMDEA | Renewable Energy 130 (2019) 786-795<br>https://doi.org/10.1016/j.renene.2018.06.109 |
| Thermal analysis of fluidized particle flows in a finned tube solar receiver | CNRS | Solar Energy 191 (2019) 19–33<br>https://doi.org/10.1016/j.solener.2019.08.062 |
| Experiments support simulations by the NEPTUNE_CFD code in an Upflow Bubbling Fluidized Bed reactor (Not in Open Access) | CNRS<br>INPT | Chemical Engineering Journal (2021) 385, 123568<br>https://doi.org/10.1016/j.cej.2019.123568 |
| Particles in a circulation loop for solar energy capture and storage (Not in Open Access) | KU LEUVEN<br>CNRS<br>EPPT | Particuology 43 (2019) 149-156<br>https://doi.org/10.1016/j.partic.2018.01.009 |
| Energy analysis of a particle suspension solar combined cycle power plant (Not in Open Access) | KU LEUVEN | Energy Conversion and Management 163 (2018) 292-303<br>https://doi.org/10.1016/j.enconman.2018.02.067 |
| High-efficiency solar power towers using particle suspensions as heat carrier in the receiver and in the thermal energy storage (Not in Open Access) | CNRS<br>EPPT | Renewable Energy 111 (2017) 438-446<br>https://doi.org/10.1016/j.renene.2017.03.101 |
| Bubbling and Slugging of Geldart Group A Powders in Small Diameter Columns (Not in Open Access) | EPPT<br>CNRS | Ind. Eng. Chem. Res. 2017, 56, 14, 4136–4144<br>https://doi.org/10.1021/acs.iecr.6b04798 |
| Experiments support an improved model for particle transport in fluidized beds | KU LEUVEN<br>EPPT<br>CNRS | Sci Rep 7, 10178 (2017)<br>https://doi.org/10.1038/s41598-017-10597-3 |

The list and all the abstracts of the Next-CSP publications are available on our Website:
http://next-csp.eu/documents/scientific-productions/

# Conference Proceedings

## SolarPACES 2017

- Fluidized particle-in-tube solar receiver and reactor: A versatile concept for particulate calcination and high efficiency thermodynamic cycles (CNRS) I https://doi.org/10.1063/1.5067053
- Optimization of an integrated solar combined cycle (IMDEA) I https://doi.org/10.1063/1.5067214
- Particles-based thermal energy storage systems for concentrated solar power (IMDEA) I https://doi.org/10.1063/1.5067215

## SolarPACES 2018

- Application of un-fired closed Brayton cycle with mass flow regulation and particles-based thermal energy storage systems for CSP (IMDEA) I https://doi.org/10.1063/1.5117559
- Scale-up considerations of the UBFB solar receiver (CNRS, EPPT) I https://doi.org/10.1063/1.5117579
- Optimization of a decoupled combined cycle gas turbine integrated in a particle receiver solar power plant (EDF) I https://doi.org/10.1063/1.5117655
- The fluidized bed air heat exchanger in a hybrid Brayton-cycle solar power plant (CNRS, EPPT) I https://doi.org/10.1063/1.5117650

## SolarPACES 2019

- Application of SbpRAY for simulation and optimization of a heliostat field and cavity receiver (SBP) I https://doi.org/10.1063/5.0030257
- Hybrid optical method for characterizing a heliostat field in a concentrated solar power plant (CNRS) I https://doi.org/10.1063/5.0029270
- Particle flow and heat transfer in fluidized bed-in-tube solar receivers (CNRS) I https://doi.org/10.1063/5.0028761
- Integrated solar combined cycle using particles as heat transfer fluid and thermal energy storage medium for flexible electricity dispatch (IMDEA) I https://doi.org/10.1063/5.0029297

## SolarPACES 2020

- The Conference Proceedings for the 2020 edition have not been published yet. However, Next-CSP presented 5 papers as well as a poster. More information here.

ICESE 2020
May 18-21, Vienna, Austria

## International Conference on Environment Science and Engineering (ICESE 2020)

- Bio-energy Carriers as Back-up Fuel in Hybrid Solar Power Plants (EPPT, KU Leuven, CNRS, INPT) I https://doi.org/10.1088/1755-1315/544/1/012012

# Next-CSP in the media

## European Commission – CORDIS Results Pack (September 2020)

Fluidised particles turn up the heat in a novel solar power design. LINK.

## CSP Focus (May 2018)

The assembly of the Next-CSP pilot solar loop at the Themis solar tower started end of April 2019. LINK.

## China Solar Thermal Alliance (May 2018)

NEXT-CSP pilot solar loop will be ready soon, using 800°C particles as heat transfer and storage medium. LINK.

## HELIOCSP – Solar Thermal Energy News (November 2017)

A breath of fresh air for concentrated solar power. LINK.

## CONTACT

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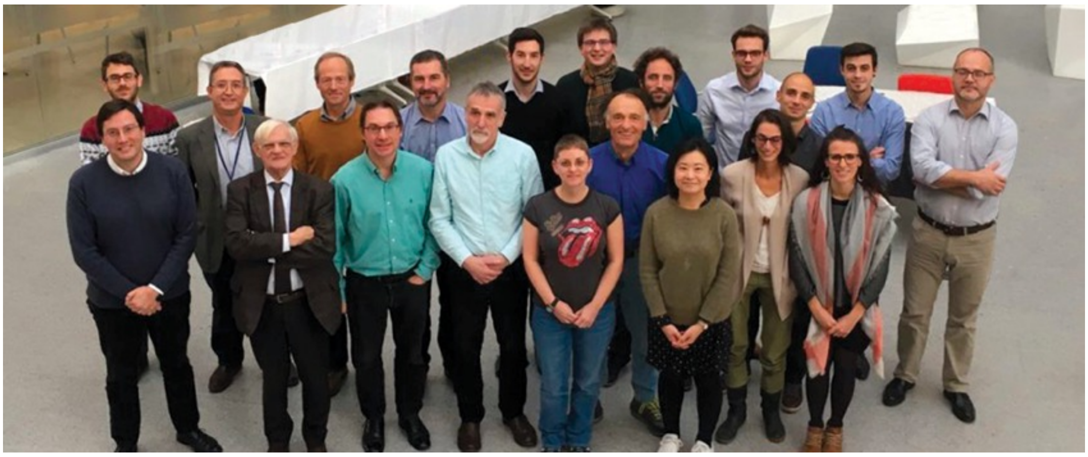
http://next-csp.eu/



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