Impact Objectives

- Enhance the predictability and flexibility of Concentrated Solar Power (CSP) generation to address the evolving needs of regulators, grid operators and plant operators
- Demonstrate a significant improvement in the dispatchability of CSP plants

Solar Power for the future

__Dr Vipluv Aga__ talks about his involvement with __PreFlexMS__, a project developing novel features for Concentrated Solar Power plants funded by the EU's Framework Programme for Research and Innovation – Horizon 2020 and led by General Electric. Aga reveals the exciting potential of the initiative to develop large-scale renewable technology that could replace fossil fuels

Could you begin by introducing yourself and telling us how you became interested in researching Concentrated Solar Power (CSP) plants?

I was working in the Advanced Technology R&D Department of my company screening multiple energy concepts for the future. At that time we were looking at new business areas in renewable energy and investigating many different solar generation concepts. CSP with molten salt storage jumped out as a technology with a strong future, especially with more and more renewables coming online. The true potential of the solar thermal technology is still not completely realised as we are still in the growing phases and there is lots to do to increase the value of the technology to the utility-scale market. CSP plants are uniquely able to provide the flexibility and predictability that utilities are used to expecting from their fossil fuel fleet. The main reason is that the energy storage is today a fraction of the cost of comparable batteries and at a scale of many gigawatt hours.

What were the key drivers behind establishing the PreFlexMS (Predictable & Flexible solar power with Molten Salt energy storage) project?

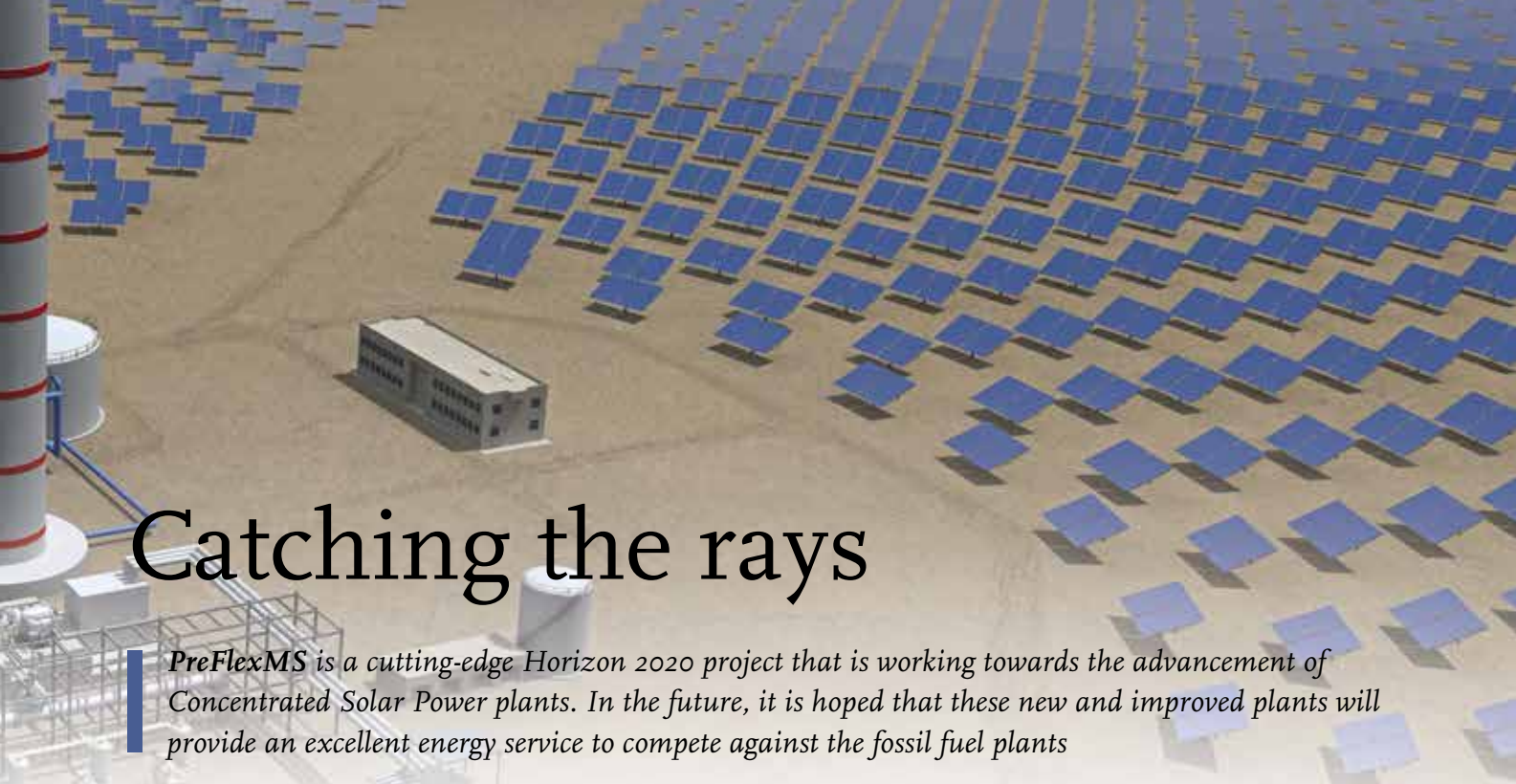
The PreFlexMS project has a very strong business focus. General Electric is active as a technology provider and integrator for CSP based on molten salt tower technology, and we had observed some important trends that the key markets for CSP require. The coordinators were fortunate to find an excellent mix of the top research institutes and industries in Europe that share this common vision in commercialising novel technologies.

Have you experienced any challenges while conducting your research? If so, how have you strived to overcome them?

PreFlexMS is a demonstration project. This means a large part of the funds are earmarked to build a large industrial-scale demonstrator, so it has to be approached like a construction project with many stakeholders. The mix of industry and academic partners for this complex engineering and construction task required us to overcome many preconceived notions and speak a common language. No partner works in a silo, and the workflow structure involves critical interaction. Separately, delays beyond our control due to other site-specific activities, which are common on any construction site, also need to be handled. Ultimately, the engineering rigour of the industrial partners coupled with the innovation and creativity of the academic partners leads us to find the most optimal solutions.

Can you reveal what most excites you about your endeavours to improve CSP technology?

CSP technology provides huge opportunities to displace fossil fuels at massive scale without compromising on grid safety. Improving CSP technology is by nature a strongly interdisciplinary endeavour, from optics and materials to control technology. CSP development exploits the significant strides made in the overall industrial sector and applies these advances to this large-scale problem. CSP technology development is a win-win for advanced as well as developing countries. European firms and institutions can focus their effort on exploiting the deep industrial knowledge base to maintain engineering and technology leadership. Meanwhile, developing countries that want to integrate CSP into their energy mix can localise most of the value of the CSP in construction and components, while still building strong partnerships with European institutions for technology and engineering support. This helps to build a sustainable industry with strong knock-off benefits in energy, construction and automotive sectors. Even though, the technology has come very far by some estimates the full potential is still only 30–40 per cent achieved.



Catching the rays

__PreFlexMS__ is a cutting-edge Horizon 2020 project that is working towards the advancement of Concentrated Solar Power plants. In the future, it is hoped that these new and improved plants will provide an excellent energy service to compete against the fossil fuel plants

Many countries, particularly those in warmer climates, are becoming increasingly interested in using Concentrated Solar Power (CSP) plants as a key method for obtaining energy. These are large plants that generate solar power by using a huge quantity of well-controlled, movable mirrors capable of concentrating the sunlight onto one small area. This concentrated light heats up thermal fluid, typically a molten salt running through the receiver structure, which is liquid at extremely high temperatures. This hot fluid is stored in large tanks and, when required, is pumped through a steam generator that uses the heat to generate steam. Electricity is produced when the hot steam turns a steam turbine. The salt is now relatively cooler and stored in a separate tank ready to be reheated when needed. What is particularly advantageous about these plants is that they produce far more thermal energy than can be used for producing electricity during the day, thus enabling them to use the remaining salt to generate electricity throughout the night as well.

The growing interest in these plants is not only because they are becoming cheaper to run, but also because of their potential to have a controllable output that is not weather-dependent, which is currently a major barrier to many forms of renewable energy. But, before CSP plants can compete with the conventional coal and gas plants and be considered a viable mainstream energy source, there is still some work to be done to advance the technologies. Arguing this point is renewable energy expert Dr Vipluv Aga: 'There is a growing realisation that CSP plants will be required either through market design or energy economics to be as predicable and flexible as any fast response fossil fuel plant,' he remarks. 'A novel set of hardware and software technologies, therefore, need to be developed and demonstrated to increase customer confidence and rapid uptake of the technology.'

PREDICTABILITY AND FLEXIBILITY ARE KEY

Aga is Project Coordinator of a cutting-edge project that sees CSP plants with molten salt thermal storage as having the potential to obtain the same level of predictability and flexibility that the fossil fuel fleet can achieve. In terms of flexibility, the PreFlexMS (Predictable & Flexible solar power with Molten Salt energy storage) project will seek to demonstrate that a once-through steam generator (OTSG) is capable of effectively managing the fluctuations of the electricity grid and meeting all market expectations. In terms of predictability, the initiative will be working to improve weather forecasting software so that CSP plants can be run in a predictable and economically optimised manner, whatever weather conditions they are faced with.

To fund this costly research project, PreFlexMS has an investment budget of €18 million for its consortium of 13 European partners, of which €14 million is funded by the EU's Framework Programme for Research and Innovation (Horizon 2020). Bringing unique skillsets to this highly collaborative endeavour, each of the partners plays a critical role in the effective implementation of the project. 'This project has a strong mix of well-known industrial players in CSP with renowned academic and public-funded research institutions forming an expert interdisciplinary team – from weather science to steam generation, from machine learning to water-steam processes, and from dynamic modelling to site construction,' explains Aga.

IMPROVING PREDICTABILITY

A current obstacle for all renewables, including solar power, is their lack of predictability. Changing weather conditions and below par weather forecasting technologies lead to grid-balancing problems that are not faced by coal or gas plants, which simply have to monitor the amount of fossil fuel available to burn. To address this problem, Aga and his team will collaborate with expert meteorological scientists and statistical experts to develop more accurate, site-adapted weather predictions specifically for use within CSP plants. These will be capable of calculating the amount of solar radiation reaching the plant. Such information will be accessible to plant operators via a digital platform, which will additionally provide control strategies to help produce the optimal energy production plan. For example, it will help the plant to meet electricity demands during periods of low solar radiation and instruct on when it's best to save a certain amount of hot molten salt to use at a later date, when more will be paid for the electricity produced. This optimisation software will be further enhanced via machine learning algorithms that will continuously assess the plant's activities to update the performance assumptions used by the optimiser.

THE NEED FOR FLEXIBILITY

Currently, the way that steam is generated in CSP plants is via locomotive-type steam generators. This process involves the use of

“The demonstrator will give us an excellent opportunity to validate our performance and design models, thereby establishing confidence in the behaviour of the technology at a large scale”

a drum separator in which water is circulated to produce steam. It is time-consuming and uses up valuable stored solar energy, meaning that it’s not capable of being powered up or down quickly to meet changing conditions. The need for flexibility, however, is critical for CSP plants; in the near future, they are expected to run alongside wind and photovoltaic power plants, and be capable of quickly increasing or decreasing their power generation in response to the grid’s requirements at any given moment.

To overcome this issue, PreFlexMS is investigating the application of OTSG in CSP plants. This technology, which is typically used in combined cycle gas turbine power plants, has never before been designed for use with molten salt fluids. Here, there is no drum separator and associated water re-circulation. The team believe that their innovative molten salt OTSG hardware technology will mean that CSP plants will able to quickly speed up power production and provide flexible load changes, while also offering a reduction in installation costs.

To prove the worth of this novel CSP plant model and in turn ensure market uptake, the PreFlexMS team will develop a demo plant with built-in forecast and dispatch optimisation technology for rigorous pilot testing. If substantial benefits can be achieved, Aga believes this advanced renewable technology could displace the favoured use of fossil fuel. ‘A CSP plant should be able to start up and ramp up or ramp down in response to a grid signal just like any fossil fuel plant,’ says Aga. ‘In this way, the CSP plant can displace not only fossil fuel generation but also all the grid services that people assume can only be fulfilled by fossil fuel back up.’

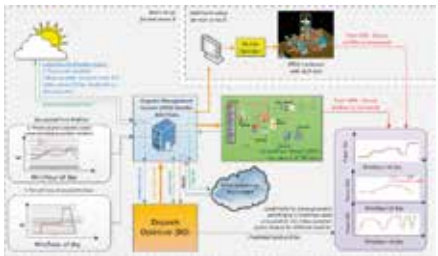
A RENEWABLE FUTURE

Marked progress has been made already by PreFlexMS with regard to addressing both the predictability and flexibility challenges faced by CSP plants. Much light has been shed by the meteorological experts on the specific weather forecasting needs of the plants, and an understanding of CSP electricity pricing in future markets has been obtained to support the development of the optimisation technology. Furthermore, OTSG modelling for a full-scale power plant has been completed and the team is ready to begin constructing their demo plant. ‘The demonstrator will give us an excellent opportunity to validate our performance and design models, thereby establishing confidence in the behaviour of the technology at a large scale,’ says Aga. ‘Tendering for the demonstrator components is already under way and we are always looking for more suppliers to respond to our tenders, which are available on our website (http://preflexms.eu).’

The PreFlexMS team is confident that they can demonstrate the full potential of a large-scale CSP plant with enhanced predictability and flexibility. In the not-so-distant future, it is hoped that energy generated by CSP plants will become a firm favourite in the renewable energy mix and ultimately compete with the fossil fuel giants – offering a service that is not only cost-effective, stable and variable, but also sustainable for future generations.

5 MWt Once through steam generator demonstrator

Construction site at the Evora Molten Salt Platform, University of Evora, Portugal



Test plan demonstrating hardware and software elements for predictability and flexibility

Project Insights

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Dr Vipluv Aga obtained his PhD in Mechanical Engineering from ETH Zurich in Switzerland. He has been employed by General Electric (GE; formerly Alstom Power) since 2010 in R&D and product development, primarily for solar energy and thermal storage systems. His experience includes business case development for novel technologies, development project leadership and academic collaborations. At GE Renewable Energy he focuses on molten salt central receiver CSP plants, digital solutions for renewables, and new product development in energy storage.

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