SOLAR-ERA.NET

EUROPEAN NETWORK OF NATIONAL AND REGIONAL RESEARCH AND INNOVATION PROGRAMMES - LATEST DEVELOPMENTS OF JOINT TRANSNATIONAL COOPERATION, PROJECT RESULTS AND OPPORTUNITIES

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ABSTRACT: SOLAR-ERA.NET is a network that brings together more than 20 RTD and innovation programmes in the field of solar electricity technologies in the European Research Area. The network of national and regional funding organisations has been established in order to increase transnational cooperation between RTD and innovation programmes and to contribute to achieving the objectives of the Strategic Energy Technology Plan (SET-Plan) through dedicated transnational activities (especially transnational calls). Through 7 joint calls, 87 research and innovation projects are supported, involving 456 organisations and mobilising more than 110 MEUR. In this contribution, results are presented for the transnational SOLAR-ERA.NET calls.

Keywords: R&D and Demonstration Programmes, Photovoltaic, Funding and Incentives, Strategy

1 INTRODUCTION AND CONTEXT

SOLAR-ERA.NET is a European network of national and regional funding organisations and RTD and innovation programmes in the field of solar electricity generation, i.e. photovoltaics (PV) and solar thermal electricity (STE) / concentrating solar power (CSP). SOLAR-ERA.NET shall contribute to reach the objectives of the European SET-Plan, by carrying out the coordination and support actions between national and regional research and innovation programmes.

The SET-Plan aims to increase, coordinate and focus EU support on key low-carbon energy technologies in order to achieve Europe's 2020 and 2030 energy and climate objectives in the future.

2 NETWORK AND MISSION

2.1 Network

SOLAR-ERA.NET involves more than 20 national and regional RTD and innovation programmes dealing with PV and CSP. This high level of involvement of most relevant stakeholders provides excellent outreach and allows for a solid coordination needed for an efficient and coherent approach in the highly diverse RTD landscape.

The network has been composed of some 20 organisations being programme owners and managers. Most countries and regions belonging to the SOLAR-ERA.NET consortium also participate in most calls.

2.2 Missions and goals

SOLAR-ERA.NET has two fundamental missions. As a network supported by the EC within the ERA-NET (2012-2016) respectively ERA-NET Cofund (since 2016) scheme, the mission is to improve the coordination and cooperation between national and regional programmes. In the context of the SET-Plan, the mission of the network is to implement central parts of the SET-Plan on a transnational level and thus contribute to achieving the goals defined in the SET-Plan.

The more specific and essential goals and activities of SOLAR-ERA.NET are i) to launch joint calls for RTD proposals by national and regional RTD and innovation programmes and ii) to define and support the best joint

activities, strategic information exchange and use of implementation tools.

By identifying and choosing priority topics based on the Implementation Plans for PV respectively CSP for transnational calls, the SOLAR-ERA.NET network selects and funds industrially relevant transnational RTD and innovation projects in the field of solar electricity technologies.

In quantitative, financial terms, SOLAR-ERA.NET shall result in a total funding volume by the participating national and regional programmes of some 10 to 15 MEUR per call for innovative projects.

Figure 1: Countries and regions active in the ongoing SOLAR-ERA.NET Cofund 2.

3 ACTIVITIES, FACTS AND FIGURES

3.1 Set up of transnational calls

SOLAR-ERA.NET started in November 2012. Seven joint calls have been launched so far, with the participation of up to 17 countries / regions covering PV and CSP topics. Call topics in photovoltaics (PV) and concentrating solar power (CSP) are commonly defined by the SOLAR-ERA.NET consortium and adopted by the participating programmes and countries according to their national / regional priorities. The most recent topics can be found in Figure 2.

The transnational call is based on a 2-step / stage-procedure with i) a preproposal and ii) a full proposal stage. Preproposals are checked according to the national / regional regulations and then discussed in the SOLAR-ERA.NET consortium setting up lists of preproposals recommended respectively not recommended for stepping on to the full proposal phase.

Once the full proposals are evaluated by independent international experts as well as by national experts, a list of projects suggested for funding is established.

The first four transnational SOLAR-ERA.NET joint calls were each allocated with a total public funding budget of approximately 10 to 12 MEUR provided by the participating national / regional programmes and agencies.

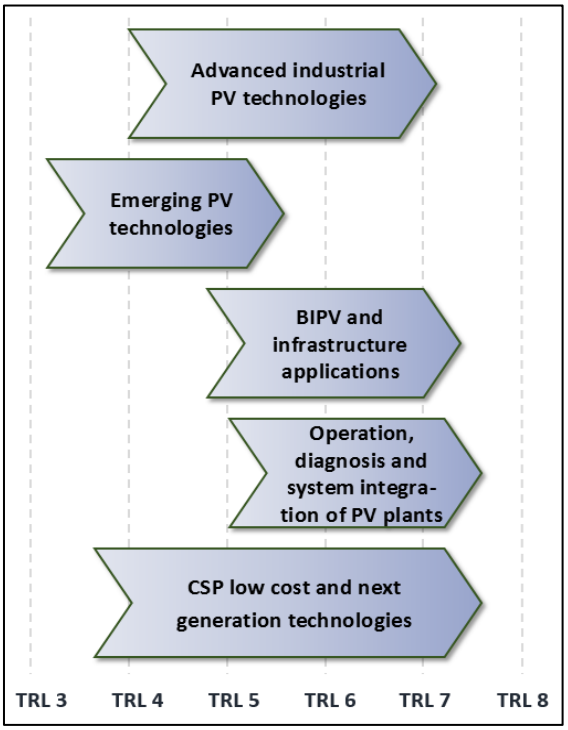

Figure 2: Topics defined for the 7th SOLAR-ERA.NET joint call carried out in 2019/2020

Within the ERA-NET Cofund scheme (since 2016), SOLAR-ERA.NET calls (5th and 6th call) come along with an even higher funding budget as the EC provides the so-called Top-Up presenting 33% of the total funding effectively used. The selection procedure includes a ranking list, established by independent international experts, which has to be strictly followed from top downwards. Finally, SOLAR-ERA.NET carried out an additional joint call (7th call, 2019/2020) with funding from the participating national and regional agencies.

Applicants may also come from other countries but they do have to provide their own funding for their participation in the projects.

3.2 Participation in transnational calls

The joint calls found good interest in the solar power industry sector and research community. 310 preproposals were submitted with a total budget of around 410 MEUR (of which 287 MEUR funding requested) involving 1'467 partners (multiple counting – some partners have been involved in several preproposals). About half of the preproposals were selected for the second stage of the call procedure, resulting in 166 full proposals.

87 transnational projects are supported, including the projects selected for funding in the recently closed 7th call. The total public funding amounts to approx. 75 MEUR for a total project volume of around 111 MEUR. 456 organisations are involved in these transnational projects funded (multiple counting). A slight majority of the organisations involved belong to the categories of small and medium sized enterprises and large enterprises.

Figure 3 displays the thematic split of the 87 projects.

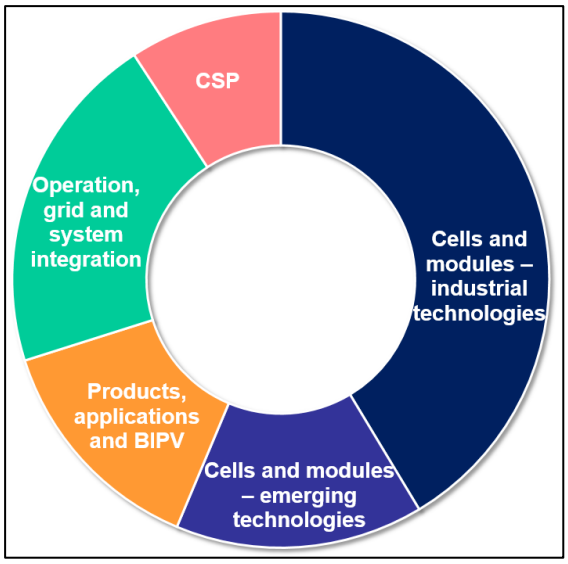

Figure 3: Thematic split of the 87 SOLAR-ERA.NET projects.

Figures 4 and 5 show the number of projects and the funding share by country / region resulting from the first six SOLAR-ERA.NET calls comprising 79 projects. The data for the remaining 8 projects from the 7th call is being consolidated in the negotiation phase.

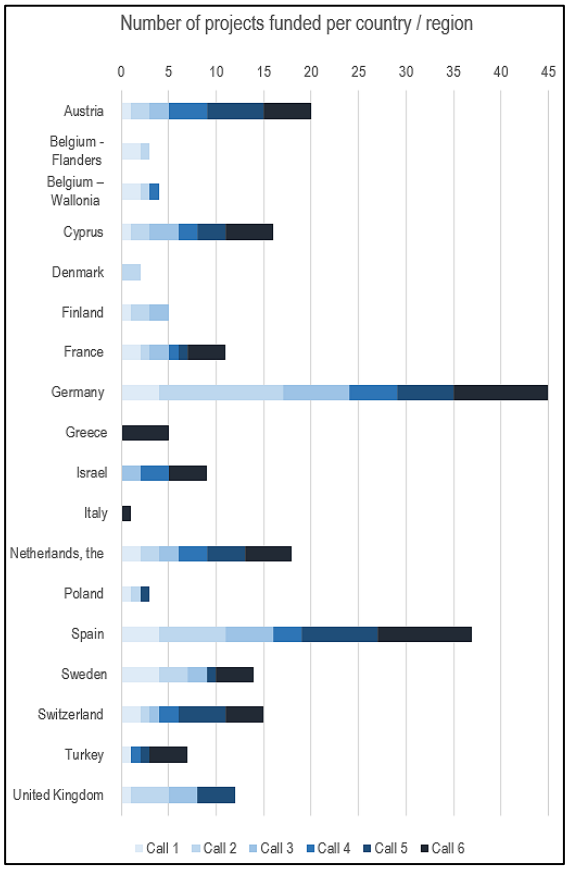

Figure 4: Number of projects by country / region as well as by call resulting from the first six SOLAR-ERA.NET calls.

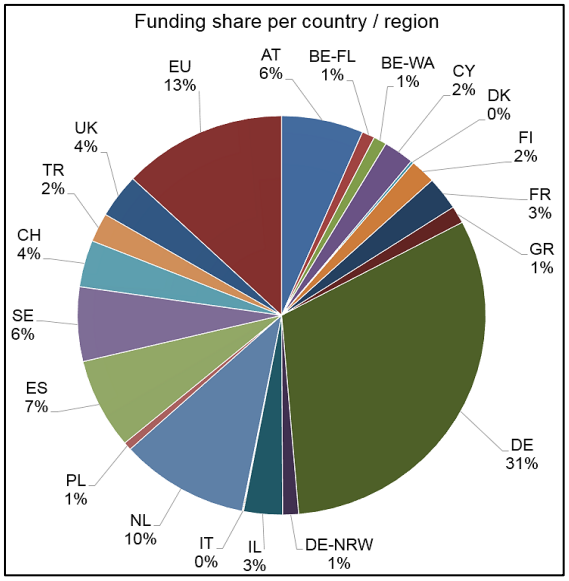

Figure 5: Funding share per country / region for the first six joint calls carried out by SOLAR-ERA.NET.

4 RESULTS AND OUTLOOK

4.1 Selected results

On the level of research, development and innovation, SOLAR-ERA.NET has enabled the support of 87 transnational PV and CSP projects mobilising some 111 million euros and involving some 456 organisations from the scientific community and the industry sector. By the time of writing this paper, 38 transnational projects have been finalised so far of which 36 projects were launched within the first four SOLAR-ERA.NET calls. They can be summarised as follows:

- HESiTSC: exploited the innovative direct III-V/Si heterojunction concept for improving the efficiency and paving the way for an aggressive cost reduction of c-Si based tandem solar cells (SiTSC) at industrial scale.
- Monoscribe: integrated the selective laser ablation processes and printing processes allowing for producing roll-to-roll CIGS PV modules with varying voltages, sizes and shapes.
- CNT-PV: developed press-transferred, semi-transparent, extremely flexible single-wall carbon nanotube films (CNT) functioning as a hybrid hole-transporting and collecting layer in the perovskite solar cell and avoiding expensive hole-transporting materials and silver or gold contacts.
- InnoModu: demonstrated that it is possible to build PV modules with reduced silver content and without using lead.
- NovaZOlar: eliminated Cd-containing buffer layer in CIGS solar cells and achieved a record efficiency of 21,0%.
- NOVACOST: developed eco-friendly metallic salt-based inks suitable for CZTS deposition and building devices with an efficiency of 6,6%, paving the way to 10% efficiencies.
- LIMES: worked on the glass composition and adding optically active components which absorb harmful UV light (at least 4% less) and simultaneously convert those UV photons into visible light (related efficiency

increase of 4%). The optimisation of the glass composition allowed for thinner glass and improvements of the crack resp. chemical resistance by a factor of 3 respectively 4.

- PV me: integrated organic PV modules into steel resp. glass based façades, developed a hard coat that can be roll-to-roll coated on top barrier foils and realised a micro-inverter specifically suitable for organic PV modules. The project ended with one of the largest organic-based BIPV façade installation in Benelux.
- BLACK: demonstrated that high quality black silicon surface is applicable in industrial-scale solar cell processes, namely in passivated and emitter rear cells. Additionally, the nanostructured surfaces eliminated the light-induced power conversion degradation.
- AER II: developed, industrialised and brought to market the aesthetic energy roof (AER) concept. A project realised with this concept won the prize "Most beautiful solar project of the Netherlands".
- PV4FACADES: developed low-cost, high-efficiency c-Si back contact cell technologies (metal wrap through and interdigitated back contact) with improved aesthetics and higher energy yield for industrial take-up.
- InGrid: developed a new module technology for high efficiency rear contact and bifacial solar cells by interconnecting cells with conductive tracks embedded in the encapsulation material, replacing the ribbon typically used.
- PV2GRID: designed a grid side converter improving performance ensuring the proper grid integration of PV systems under any grid conditions.
- INTESEM: implemented a virtual power plant (VPP) to optimise intermittent generation and storage assets and to facilitate efficient distribution of energy. The simulations showed a 10-20% better revenue on the day-ahead market compared to a normal PV site.
- ACCESS-CIGS: explored atmospheric cost competitive elemental Sulpho-Selenisation for CIGS in order to reduce the CIGSSe processing cost and improve the conversion efficiency.
- U-light: developed new light weight, high efficiency and long life-time modules by using thin, strong, low-cost glass and mineral or organic compositions like glass-fibre reinforced plastic.
- HighCast: focused on research and development of advanced casting and wafering techniques for producing silicon wafers suitable for higher efficiency solar cells, using alternative casting techniques comprising "High Performance Multicrystalline Silicon" (HPmcSi) and "Mono-Casting".
- APPI: developed high-efficiency Passivated Emitter and Rear Cell (PERC) solar cells manufactured by using low-cost atmospheric pressure processing, namely advanced texturing, high-efficiency emitter and atmospheric pressure passivation.
- FunGlass: developed chemically functionalised surfaces for glass enabling optimised (anti-reflective, light trapping and light diffusion) glass properties without deposition of additional coatings.
- SPRINTCELL: proposed an innovative thin-film photovoltaic fabrication route offering lower manufacturing costs, using earth abundant photovoltaic materials, namely Cu2ZnSnS4, in terms of natural reserve and annual ore production, and selecting technologies for large-scale commercial powder synthesis, advanced powder milling, novel solar ink formulation and solution-based non-vacuum film processing.
- HVolt-PV: designed and developed High Voltage IBC Photovoltaic i-Cells and Modules by integrating several smaller cells onto a single silicon wafer and eliminating line losses, achieving efficiency of >20%.
- PROOF: worked on an industrialised concept for BIPV/BAPV roofs visualising several added values and minimising additional costs.
- EDITOR: evaluated and tested the dispatchability of a parabolic trough collector system with concrete storage, successfully covering solar thermal needs in an industrial context and application.
- SolFieOpt: developed optimization tools, which deliver very cost-efficient heliostat layouts for solar tower power plants.
- DINAMIC: worked on dilute Nitride based concentrator multijunction solar cells, aiming at efficiencies over 47%.
- ALCHEMI: demonstrated a new type of low cost, high concentration photovoltaic (HCPV) module using small III-V multi-junction solar cells, with a DC module efficiency (η) >37%, operating at a concentration factor of ~1000x.
- IPERMON: developed an innovative performance monitoring system including formulation of data acquisition guidelines, development of performance loss, failure and degradation rate detection algorithms, improved forecasting and, finally, a reliable solution for PV monitoring.
- Bifalo: fabricated pPERT cells and respective full size (60 cells) modules with a bifacial factor of 0,9, resulting in a relative increase of bifacial gain – compared to monofacial modules – by 28% and 44% demonstrated for two different Bifalo module designs.
- HESTPV: developed a pure tin / lead-free and mixed tin-lead perovskite based solar cells reaching power conversion efficiency as high as 14 % and a novel measurement platform for lifetime evaluation of perovskite solar cells.
- INFORPV: developed a PV power production forecasting solution with improved accuracy for point and aggregated forecasts at day- and hour-ahead forecasting horizons, with interoperable data-flow modules using an interface with numerical weather predictions and PV system monitoring systems for automated active grid management (alerting and signalling to mitigate power quality issues).
- FrontCIGS: demonstrated a corrosion-resistant transparent contact for flexible CIGS modules, which should enable a less expensive frontsheet.
- HIPER: realized a record four terminal tandem device by combining a 22,7% c-Si solar cell with a 18,0% semi-transparent perovskite solar cell, yielding in 28,0% for the hybrid tandem solar cell, and tested industrially scalable processes resulting in a 22,4% 6 inch hybrid tandem module.
- SITEF: demonstrated the loop scale functionality and applicability of a new silicone heat transfer fluid and associated parabolic trough collector components at temperatures up to 450°C.
- SNOOPI: set up an autonomous and transferable Smart Network Control with Coordinated PV Infeed Box controlling PV and battery inverters so that all

inverters along a feeder provide reactive power in a coordinated way.
- THESEUS worked on the development of novel, very high efficiency tandem flat plate solar cells utilising III-V semiconductors grown onto Silicon substrates, using advanced epitaxial techniques to grow SiGe and SiGeSn structures, and their integration into high efficiency modules.

The still ongoing PV and CSP projects funded within the first four SOLAR-ERA.NET joint calls are:
- BIPVpod: Building Integrated Photovoltaics Panels on Demand
- HIPPO: High-Efficiency Poly-Si Passivated Contact Solar Cells and Modules
- Liquid Si 2.0: Liquid Phase Deposition of Functional Silicon Layers for Cost-Effective High Efficiency Solar Cells
- SIMON: Silicone Fluid Maintenance and Operation
- DURACIS: Advanced Global Encapsulation Solutions for Long Term Stability in Industrial Flexible Cu(In,Ga)Se2 Photovoltaic Technology
- Refined PV: Reduction of Losses by Ultra Fine Metallization and Interconnection of Photovoltaic Solar Cells
- ENHANCE: Enhanced Rooftop PV Integration through Kinetic Storage and Wide Area Monitoring
- PEARL TF-PV: Performance and Electroluminescence Analysis on Reliability and Lifetime of Thin-Film Photovoltaics

SOLAR-ERA.NET Cofund 1

16 projects are funded within the SOLAR-ERA.NET Cofund 1 call carried out in 2016/2017. 2 projects have already been finalised:
- 1500-SIC: allowed to choose the power electronics solution better suited to implement a competitive PV inverter capable of full-power operation at 1500 Vdc and to draw clear conclusions about the improvements brought by hybrid power modules (SiC diodes).
- NELL: designed a novel encapsulant specifically for enduring PID in installations with 1500 V system voltage, based on a unique combination of resins and additives, which offers high bulk resistance even at high operating temperatures, low WVTR, excellent optical transmission and mechanical protection of the solar cells, together with fast curing kinetics and a competitive cost.

14 projects are still ongoing, namely:
- PANELPV: Sandwich panels with integrated PV with freedom of size and color
- MASTERPV: Innovative manufacturing solutions for cost-efficient semitransparent BIPV
- Pearl: PERC meets self-aligned selective emitter technologies based on inkjet printing and silver less plating
- BI-FACE: High-efficiency bifacial PV Modules and Systems for flat roof applications
- Cover Power: Smart Glass Coatings for Innovative BiPV Solutions
- CEFRABID: Clean energy from road acoustic barriers infrastructure development
- NEXT-FOIL: Next generation conductive solar foil for flexible photovoltaics
- HEAVENLY: High-efficiency PERT and IBC cell development focussing on paste and CVD optimization for longterm stability
- Erigeneia: Enabling rising penetration and added value of photovoltaic generation by implementation of advanced storage systems
- Hyconsys: Hydrogen control in solar thermal parabolic trough heat transfer fluid systems
- ENMESH: ENabling Micro-ConcEntrator PhotovoltaicS with Novel Interconnection MetHods
- PVtool: Development of tools for effective control of large PV power plants
- RHINO: Realization of High efficiency Industrial N-type sOlar cells
- PROGNOSIS: Intra-hour prediction of solar electricity generation from Photovoltaics

Within the framework of the SOLAR-ERA.NET Cofund 2 cofunded joint call carried out in 2018/2019, 19 projects were selected for funding. 16 projects have already started, namely:

- UNIQUE: Carbon Based Perovskite Solar Cells with UNI-Directional Electron Bulk Transport: in the QUEst of a Short Time to Market
- ECOSun: Economic COgeneration by Efficiently COncentrated SUNlight
- PERDRY: Dry production routes for large-area benign metal halide perovskite solar cells
- 1C4PV: One intelligent cloud for PV Assets Diagnosis and Maintenance
- CHEER-UP: Low Cost High EfficiEnt and Reliable Umg Pv cells (CHEER-UP)
- SCALEUP: Large scale molecular simulation of perovskite solar cells
- BOBTANDEM: Band Offset selective Barrier Three Terminal perovskite on silicon high efficiency Tandem Solar Cell
- SUCCESS: Sequential, high Uniformity, Cost Competitive Elemental Selenization and Sulphurization for CIGSSe2
- In4CIS: New in-line optical methodologies for advanced assessment of high efficiency CIGS industrial processes
- TubeMon: New online flux density and temperature measuring systems for MONitoring and optimized operation of external TUBE receivers
- CUSTCO: Cost efficient, upscalable and stable transparent conductive oxides for silicon solar cells based on passivated contacts.
- FUN: Sputtered and otherwise deposited a-Si for Fabricating passivated screen- printed contacts for an indUstrially feasible productioN
- PANAMA: Prescriptive analytics and advanced workforce management for optimized O&M of solar power plants
- AmBiPV: Adapted Modules for Bifacial Photovoltaics
- NFA4R2ROPV: Industrial roll-to-roll (R2R) printing of highly efficient non-fullerene acceptor (NFA)-based organic photovoltaics (OPV)
- PV-ANALYTIC: Advanced photovoltaic system monitoring and analytics solution enhanced with intelligent interoperable data-driven features for efficient big data real-time analysis, failure diagnosis, automated management and integrated micro-grid control

Finally, 8 projects have been selected for funding within the recently closed SOLAR-ERA.NET Cofund 2 additional joint call (7th call). They are currently in the negotiation phase and will start in the coming months.

4.2 Conclusions and Outlook

The successful projects demonstrate i) potential commercial impact / relevance to industrial and market needs / contribution to the SET-Plan and added transnational value, ii) scientific and technological excellence and iii) high quality and efficiency of the implementation and the management.

SOLAR-ERA.NET provides added-value and opportunities for the research and industry sector, namely:

- Complementarity between national and EU funded programmes
- Building a more robust and consistent research landscape
- Increasing strengths and reducing weaknesses
- Stepping stone for international cooperation
- Flexibility and bottom-up nature, no "one size fits all" approach
- New routes and innovative transnational research for medium-sized projects

Considering the experience made in seven joint calls, the following success factors can be identified for potential applicants:

- Start with a good idea and have a vision how to realize it
- Build strong, complementary and trustful partnerships
- Communicate with partners and funding agencies
- Respect formal requirements / conditions
- Avoid redundancies with existing projects / proposals
- Identify innovation – excellence
- Head for industrial orientation – impact
- Provide convincing project plan – implementation
- Secure a high transnational value
- SMART Goals (Specific, Measurable, Ambitious, Realistic, Time Bound) / Key Performance Indicators

SOLAR-ERA.NET not only allows for supporting innovative research projects on a transnational level but also provides added value in terms of networking and programming, namely:

- New industry-led innovation projects and partnerships in a strongly competitive environment
- More transnational cooperation bottom-up and "cut to measure"
- Larger and more diverse portfolio
- Common initiatives and implementation activities
- Networking and collaboration between countries across Europe
- Overview on European research and insight into trends
- Best practice for supporting projects on the transnational level

Yet, there is a number of challenges respectively opportunities for further improvements related to the ERA-NET Cofund instrument used in Horizon2020.

- Adequacy and adaptability of European, national and regional funding budgets (Funding needs identified in the SET-Plan are considerably higher than funding budgets actually made available.)
- Flexibility to overcome the "funding gap" by following the ranking list with individual funding budgets running out already further up in the ranking list
- Consideration and inclusion of less strong ERA countries
- Visibility of impact through transnational projects and related projects
- Targeted and fair redistribution / use of Top-Up (Ideally, all funding agencies and transnational projects get the same share of the Top-Up.)
- Minimum extra administrative workload for agencies and project partners on transnational level
- Synchronisation of the timeline with all funding agencies (especially in the negotiation and contractual phase)
- Pragmatic handling (e.g. making reserve list possible)

Summing up, SOLAR-ERA.NET and SOLAR-ERA.NET Cofund have become a key instrument for cooperation among research and innovation agencies in Europe.

The coordinator of a finalised transnational projects summarised the role of SOLAR-ERA.NET as follows: "SOLAR-ERA.NET allows for real added value, namely transnational cooperation with complementary skills, equipment and facilities, along the value chain from research to industry and better reaching out to the different markets in Europe and beyond."

Within the current and soon ending EC support scheme / framework programme Horizon 2020, no further joint calls are planned by SOLAR-ERA.NET. In the context of the future Horizon Europe, new options are discussed – notably the Clean Energy Transition Partnership (CETP) – for public-public partnerships bringing together national and regional funding organisations and RTD and innovation programmes in the field of solar electricity generation, i.e. photovoltaics (PV).

PV is in the pole position to become a backbone of the future clean energy system. Yet new bold initiatives are needed, taking advantage of the wide experience and good practice gained over the past decade, keeping the momentum and accelerating the efforts.

REFERENCES

Further information on running projects from the transnational joint calls as well as news on ongoing and future SOLAR-ERA.NET activities are channelled through the www.solar-era.net website and the websites of the funding agencies involved.

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