



European
Commission



SET PLAN

PROGRESS REPORT 2022

Research and innovation for repowering
the energy system



2022
REPORT





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FOREWORD



A Strategic Energy Technology Plan revamp to strengthen the impact of research and innovation

The new policy landscape and current geopolitical developments call for a reinforced Strategic Energy Technology Plan (SET Plan).

Whether in scope, objectives or governance, we need to equip the SET Plan with the right tools to face the energy-related challenges.

We need to find a solution that works for Europe. I would like to warmly thank stakeholders from across Europe for their visionary contribution, in the past year, to the discussions on the future of the SET Plan.

With this revamp, we have a unique opportunity to strengthen our research and innovation impact, and increase our technological independence, global competitiveness, geo-political resilience, and security of our energy supply.

Such strategic independence, however, holds true only if sustainable in the long term. For this reason, we will accelerate the development of clean technologies by

capitalising on synergies between programmes, both nationally and internationally, as well as by addressing key crosscutting issues such as circularity, energy storage, digitalisation or critical materials.

The SET Plan has already helped to unite national efforts into industrial alliances, generate Important Projects of Common European Interest (IPCEIs), and pool over EUR 500 million from EU Member States and Associated Countries into the Clean Energy Transition Co-fund partnership under Horizon Europe. We need to capitalise on this important progress and continue our efforts by fully utilising all tools at our disposal and by strengthening cooperation between European and national investments in research and innovation on energy.

With the crucial contribution of the SET Plan steering group, SET Plan implementation working groups and the European Energy Research Alliance, we are on a good path to deliver all the ambitious goals of REPowerEU, the Green Deal, the Energy Union, and the Policy Agenda of the European Research Area.

Mariya Gabriel

European Commissioner for Innovation, Research, Culture, Education and Youth



The era of cheap fossil fuels is over. The faster we move to affordable, clean, and renewables, the sooner Europe will fully remove Russian influence from our energy system. The starting point for a rapid end to Russian energy supply dependency is the full implementation of the “Fit for 55” proposals, presented by the Commission last year, and reinforced by the REPowerEU Plan.

To achieve our climate and energy security goals, we need to boost energy efficiency and energy savings and accelerate the rollout of renewables (e.g. solar, wind, hydrogen). This means a higher EU renewable energy target of 45% in the EU’s energy mix by 2030.

The rapid development and deployment of clean energy technologies in the EU is also key to responding to the current energy crisis in a cost-effective manner.

However, we need more public and private investments in clean energy research and innovation. Scale up and deployment activities are pivotal, while EU regulatory and financial frameworks should play a crucial role to this end.

This goes along with the implementation of the New European Innovation Agenda, a stronger R&I ecosystem supported by the EU funding programmes, enhanced cooperation between Member States, and a continuous monitoring of national R&I activities.

Here the Strategic Energy Technology Plan (SET Plan) plays a key role: it supports the green transition by supporting the clean energy innovations necessary to achieve Europe’s climate neutrality by 2050.

Furthermore, decarbonisation, electrification and decentralisation of the energy system require digitalisation to make it work. Digitalisation is an ongoing transition that requires structural change. It needs continuous support for R&I and market uptake of digital solutions everywhere in the energy system. Therefore, we developed an Action Plan for the digitalisation of the energy system, just published by the Commission.

In all this, the SET Plan is instrumental in anticipating and designing the innovation needed and aligning funding efforts at national and European level. Considering that half of the emissions reductions expected by 2050 will come from technologies that are not yet on the market, R&I activities and coordination are crucial for achieving the Green Deal objectives. They are also crucial for increasing EU technology sovereignty and our competitiveness on the global stage.

Massively increasing our emphasis on the green and digital transition and underpinning both with solid R&I is the only way forward for our energy system.

Kadri Simson
European Commissioner for Energy

EXECUTIVE SUMMARY

Since its launch in 2007, the Strategic Energy Technology Plan (SET Plan) has become the reference framework for addressing clean energy research and innovation developments in Europe. Through the work of its 14 Implementation Working Groups, it has been successful in setting common EU, national and industrial research priorities on low-carbon energy to influence R&I agendas, and has leveraged much-needed resources at both European and national level.

The SET Plan was last revised in 2015, but since then, much has changed. The introduction of the European Green Deal in 2019 and its associated Climate Law, adopted in 2021, have set ambitious greenhouse gas emissions reduction targets for 2030 and 2050. Just this year, as a response to the energy crisis and the issues of energy security raised by Russia's military aggression against Ukraine, the REPowerEU Plan was introduced to accelerate the 2030 targets.

Against this backdrop of a rapidly changing policy framework, the SET Plan needs some realignment to ensure that it continues to support Europe to achieve its energy research & innovation objectives as effectively as possible. The European Commission is therefore preparing a SET Plan Communication to introduce the necessary changes.

This year's progress report is designed to support the 'revamp' by bringing together the views of stakeholders on possible ways forward for the SET Plan. Some consensus can already be identified on issues such as thematic, cross-cutting challenges, the engagement of SET Plan countries and visibility.

The results of this year's reporting exercise also highlight some of the success stories of the SET Plan, including the European Clean Energy Transition Partnership (CETPartnership), Batteries Europe, and the SET Plan's presence in the majority of national energy and climate plans (NECPs).

The 2022 SET Plan Conference in Prague, Czechia, will provide a platform to consider the future of the SET Plan in the broader context of the new European energy landscape, the New European Innovation Agenda and the new European Research Area.





INTRODUCTION

The 2022 Strategic Energy Technology Plan (SET Plan) Progress Report has been compiled for publication on the occasion of the 16th SET Plan Conference in Prague, Czechia.

Every year, the report takes stock of progress in each of the Implementation Working Groups (hereafter referred to as working groups), and this year is special: with an official revision underway, it lays out the case for strengthening the SET Plan and gathers the views expressed so far about its evolution. It showcases the importance of the SET Plan to the R&I community in each of its technology areas, and offers an overview of its effectiveness in supporting overarching European energy and research policies.

The report begins by providing an overview of the evolving policy context, including key drivers and challenges. It offers highlights of the SET Plan's successes so far and an analysis of the current state of play in EU clean energy R&I investment. It provides a visualisation of the increasing participation of SET Plan stakeholders in the section on collaboration within the SET Plan community.

This year a section is devoted to the upcoming SET Plan Communication, which will 'revamp' the SET Plan to align it with the changing policy landscape. A short discussion of the consultation processes undertaken so far is followed by a summary of some of the key areas in need of change about which there appears to be consensus. These contributions to the discussion will be considered alongside the results of the public consultation, which are expected after the publication of this report.

The final section, as in previous years, reports on the perspectives of the working groups themselves, highlighting their key successes, impacts, challenges and expectations. It is important to note that the opinions expressed are those of the working groups, whose critical views are welcomed in anticipation of the revamp. While these views do not necessarily represent those of the European Commission, they form a valuable contribution to the revision process.

Much important work lies ahead for the SET Plan community. Europe is looking to technological innovation to help solve the urgent issues of climate change and security of supply, and to simultaneously ensure the competitiveness and resource efficiency of the European economy. The SET Plan is well placed to play a key role in making this research and innovation happen, and the revamp is well timed to ensure that it is equipped for the task.

This report was prepared by the Joint Research Centre of the European Commission in close collaboration with DG Energy, DG Research and Innovation, and the 14 SET Plan working groups.

THE EVOLVING POLICY LANDSCAPE

Architects: Lucien De Vestel, Jean Gilsen, A&J Polak; Renovation: Berlaymont 2000



THE SET PLAN REVAMP: LONG-TERM DRIVERS

The production and use of energy account for more than 75% of the EU's greenhouse gas emissions. Decarbonising the energy system is therefore critical to reaching the EU's 2030 climate objectives and long-term strategy of achieving carbon neutrality by 2050. The targets set out in the European Green Deal were made legally binding in 2021 by the European Climate Law, which requires EU Institutions and Member States to take the necessary measures to meet them.

The Climate Law includes measures to keep track of progress and adjust actions accordingly, based on existing systems including the governance process for Member States' national energy and climate plans (NECPs). The SET Plan is named in almost all of the 2020 NECPs and is well positioned to play a more systematic role in future updates and reporting, working with Member States to identify research priorities and plan for their implementation.

Over the course of 2021, the Commission presented its Fit-for-55 legislative package to lay the detailed groundwork for meeting the 2030 target of a 55% reduction in emissions. The package includes the revision of existing legislation on greenhouse gas emissions, energy markets, renewable energy and energy efficiency. All of these measures need to be underpinned by strong European R&I efforts, in which the SET Plan plays a central role, developing a portfolio of technology options, creating cost efficiencies, and bringing together the best minds from across Europe.

Moreover, the Pact for Research and Innovation, adopted in 2021, is designed to further mobilise research and innovation policies with concrete actions addressing the challenges of today, including the green and digital transitions. Among the 20 priority actions identified in the ERA Policy Agenda for 2022-2024¹, Action 11, "An ERA for green transformation", specifically addresses the need for strengthening and refocusing research and innovation (R&I) in clean energy technologies through a revamped SET Plan. So far, 18 Member States, two Associated Countries and four stakeholders in the ERA Forum have committed to this action², recognising the strategic importance of a revamped SET Plan to accelerate R&I, as well as public-private R&I collaboration for the early deployment of clean energy technologies.

¹ https://ec.europa.eu/info/sites/default/files/research_and_innovation/strategy_on_research_and_innovation/documents/ec_rtd_era-policy-agenda-2021.pdf

² The EU Member States are Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Slovakia, Spain and Sweden. The Associated Countries are Norway and Georgia. The four stakeholders are the Committee of the Regions, the European Regions Research and Innovation Network (ERRIN), Coimbra Group and the European University Association (EUA).

THE SET PLAN REVAMP: SHORT-TERM DRIVERS

The post-pandemic surge in global energy demand and Russia's military aggression against Ukraine have led to an unprecedented shock for European energy markets and put the energy transition under the spotlight. Soaring prices, economic uncertainty and shifting attitudes among investors have created new challenges for the energy transition, but at the same time they have pushed it firmly to the top of the political agenda.

The development and deployment of clean energy solutions is not only the answer to the problem of climate change, but also to security of energy supply. In May 2022, the Commission proposed the REPowerEU Plan³ to phase out Europe's dependence on Russian fossil fuels by (alongside energy efficiency and diversification of supply) accelerating the deployment of clean energy technologies such as wind, solar PV, heat pumps and hydrogen.

These are unprecedented times for the SET Plan community. Now more than ever, it is vital to position clean energy technology research and innovation as a sound investment which will not only address the urgent issues of climate change and security of supply, but will also ensure the competitiveness and resource efficiency of the European economy.



³ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483>



SET PLAN TODAY

EVOLUTION OF THE SET PLAN

Launched in 2007⁴, the SET Plan was designed as a crucial first step towards establishing an energy technology policy for Europe. Its objective is to provide a common vision, goals and coordination of EU, national and industrial energy research and innovation activities in accelerating the development and deployment of efficient and cost-competitive low-carbon technologies, and to enhance the EU’s geo-political resilience and security of energy supply.

The SET Plan was updated in 2015⁵ when it was aligned with the Research, innovation and Competitiveness Dimension

of the Energy Union framework strategy. Ten actions were introduced, supported by European Technology and Innovation Platforms (ETIPs), to develop Strategic Research and Innovation Agendas, and 14 corresponding Implementation Working Groups were formed to accelerate the transformation of the energy system.

Through its evolution, the SET Plan has become the reference framework for addressing R&I developments in Europe. Throughout the years, by tackling the full spectrum of technological challenges, the number of stakeholders and partners in the SET Plan ecosystem (see Figure 1) has increased. This has resulted in a network of dedicated experts working towards the alignment of R&I approaches in 14 strategic clean energy technologies.

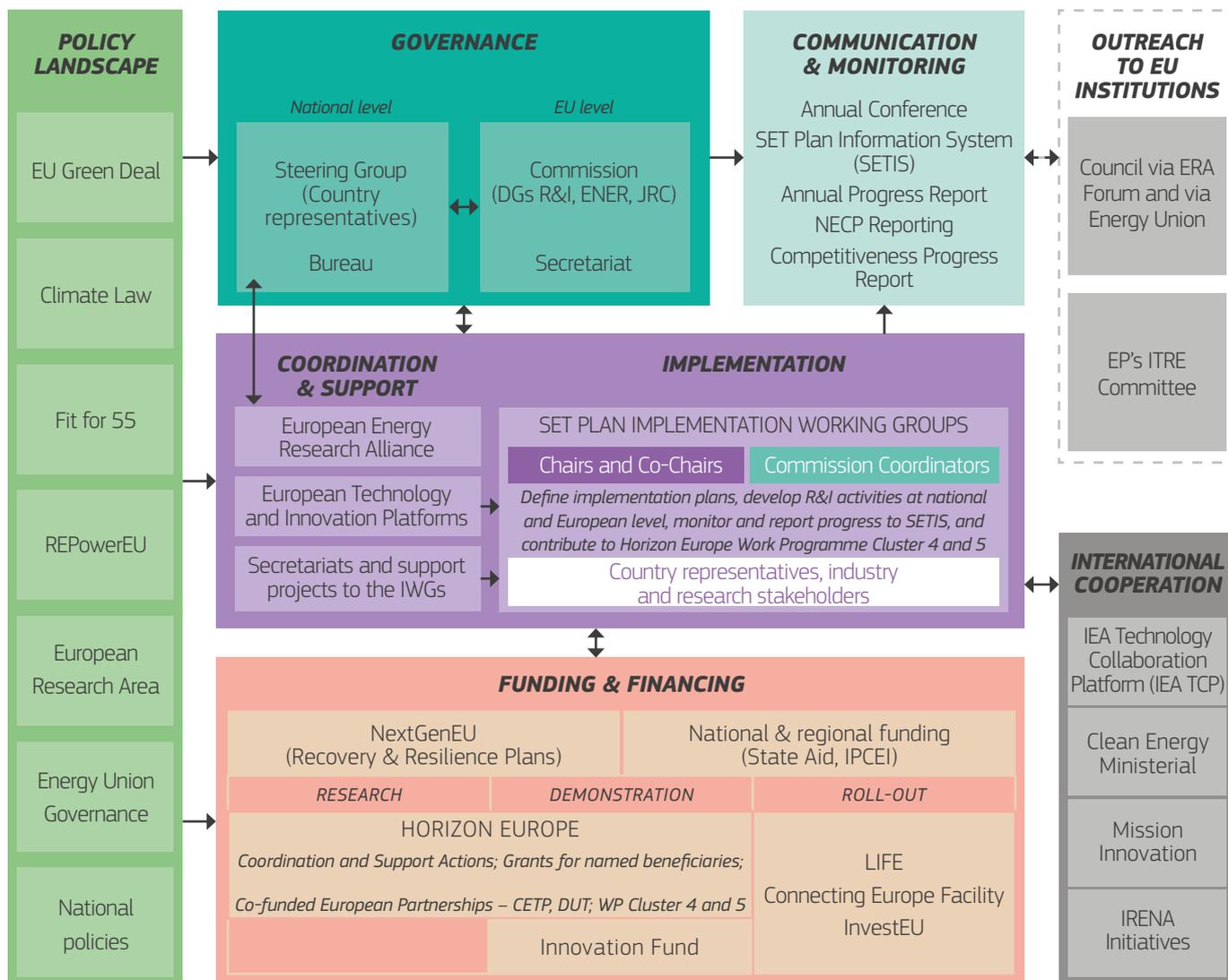


Figure 1: SET Plan Governance (2022)

4 <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52007DC0723&from=EN>
 5 https://setis.ec.europa.eu/system/files/2021-03/communication_set-plan_15_sept_2015.pdf

SET PLAN SUCCESSIONS

The SET Plan has played a central role in implementing the Research, Innovation & Competitiveness dimension of the Energy Union, and in providing guidance to national energy research strategies, as reflected in 25 of the 27 National Energy and Climate Plans in 2020. This is a concrete demonstration of its crucial role in aligning national clean energy R&I agendas.

The creation of the European Clean Energy Transition Partnership (CETPartnership)⁶ is one of the major recent accomplishments of SET Plan actors and a success story of European cross-sectoral cooperation. Several working groups (including solar PV, wind, geothermal, positive energy districts, energy systems, and energy efficiency in industry and buildings) have been instrumental in the strategic design of energy transition initiatives within the CETPartnership, co-authoring input papers and helping to develop the Strategic Research and Innovation Agenda (SRIA)⁷. The CETPartnership will help to boost the energy transition and foster R&I collaborations at all levels from regional to international, supported by industry, government organisations, academic institutions and citizen organisations.

In September 2022, the CETPartnership launched its first annual call under the Horizon Europe Partnership scheme, co-funded by the Commission⁸. Projects applying in the two-stage call are expected to aim for solutions meeting medium to high technology readiness levels, combining technologies, transition solutions and stakeholder involvement in a cross-cutting way. The total expected funding of the Joint Call 2022 is over

EUR 140 million and consists of national/regional funding alongside an EU contribution.

Another major recent success for the SET Plan is the creation of Batteries Europe – the technology platform of the European Battery Alliance, supported by the European Commission since 2019, which was based on the work of the working group on Batteries. Batteries Europe is tasked with coordinating the creation, at the technical level, of a competitive, sustainable and innovative European batteries ecosystem, covering the entire value chain, from the ethical sourcing and refining of raw materials, to battery cell production, and finally recycling and re-use.

The 2022 reporting of the 14 working groups to SETIS reveals the SET Plan's key role as an essential vehicle for R&I coordination and collaboration, bringing together industry, academia and policy stakeholders. The work of the SET Plan working groups contributed to the formation of a number of dedicated calls under Horizon2020 and Horizon Europe.

The working groups recognise that through their work, industry and research institutions have come together to develop international technology standards. They also note that the SET Plan enhances networking opportunities and boosts collaboration in the preparation of project proposals at European, national, and regional levels, creating a real R&D community to mobilise our human capital and financial resources.

The majority of the stakeholders agree that working under the SET Plan framework provides better visibility and representation of the technologies concerned. The feedback of each working group is detailed later in this report.

6 <https://cetpartnership.eu/>

7 https://cetpartnership.eu/sites/default/files/documentation/cetp_sria_1.0.pdf

8 <https://cetpartnership.eu/calls/joint-call-2022>

THE STATE OF R&I INVESTMENT IN THE EU

In 2019, the latest year for which near-complete investment data is available, an estimated EUR 29 billion was invested in the clean energy technology R&I priorities of the Energy Union. Roughly 79% came from the private sector, while the remainder came from Member States' public funding (15%) and the EU (6%) (Figure 2). The overall amount remained roughly the same as the year before, however, the share of public investment grew.

R&I investment grew by almost 26% in the period 2015-2019. This is mostly due to increased spending by the private sector and, to a lesser extent, by the EU. The latter has been steadily increasing throughout the years to reach EUR 1.6 billion in 2019.

With the exception of nuclear safety, which is primarily funded through public (national) investment, the private sector is the major source of R&I investment

in all clean energy technology. This trend has remained constant throughout the years.

As in previous years, the industry with the largest R&I investment share across all priorities in 2019 was sustainable transport – attracting 47% of R&I investment overall, and 55% of private investment. Similarly, R&I investment also increased in renewable energy technologies, energy efficiency measures and smart systems, albeit at a slower pace. Figures 3-5 show the R&I investment and patenting trends in the SET Plan actions.

Finally, the preliminary (incomplete) data on public investment for 2020 shows continuous growth of the EU share and a small decline in national public funding, which might be attributed to the initial shifting of funds towards healthcare and public safety.

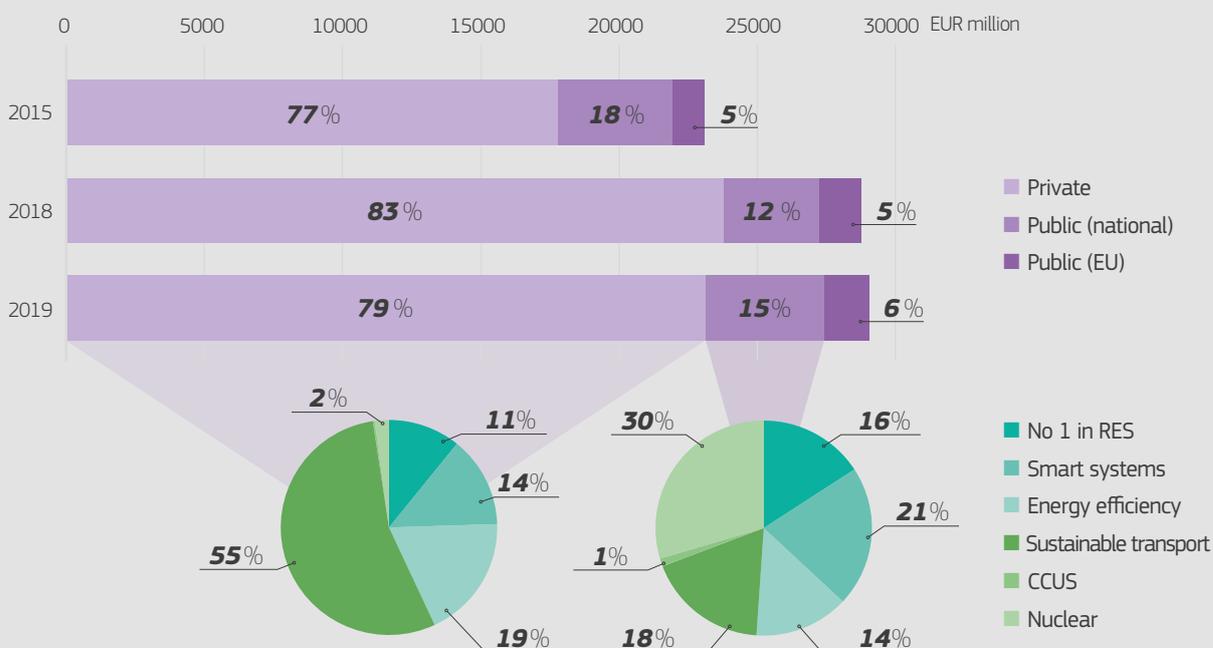


Figure 2: Investment in Energy Union R&I priorities in the EU (2015-2019)⁹

9 SETIS Research and Innovation data https://setis.ec.europa.eu/publications/setis-research-and-innovation-data_en
 Mountraki, A., Georgakaki, A., Shtjefni, D., Ince, E. and Charleston, G., R&I data for SETIS and the State of the Energy Union Report, European Commission, 2022, JRC130405 <https://data.jrc.ec.europa.eu/dataset/jrc-10115-10001>

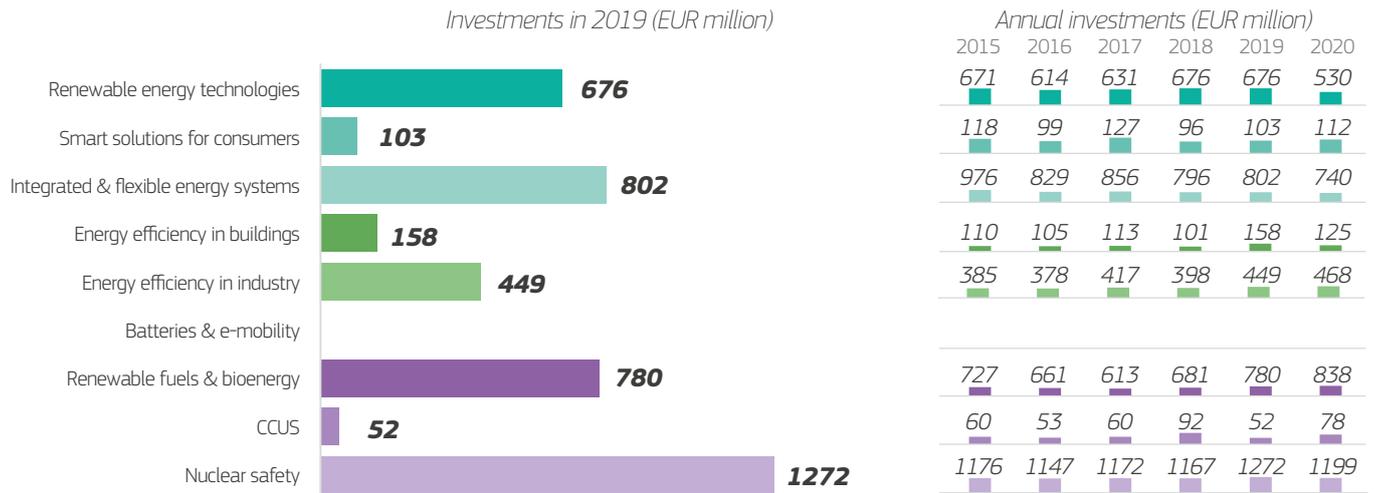


Figure 3: Member State public R&I investment in the SET Plan Actions¹⁰

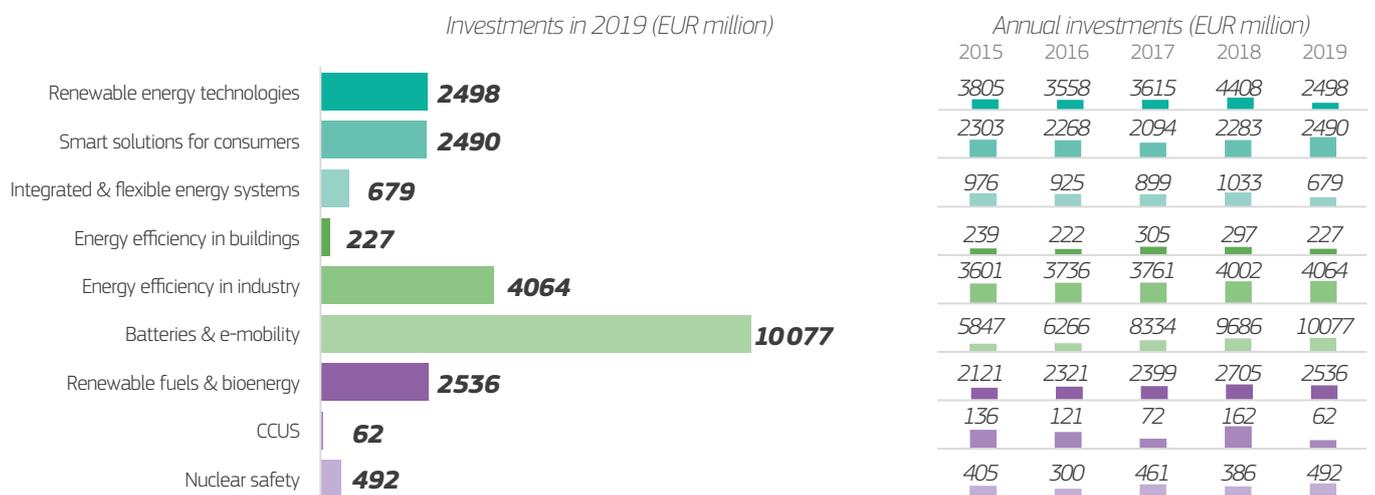


Figure 4: Member State private R&I investment in the SET Plan Actions¹¹

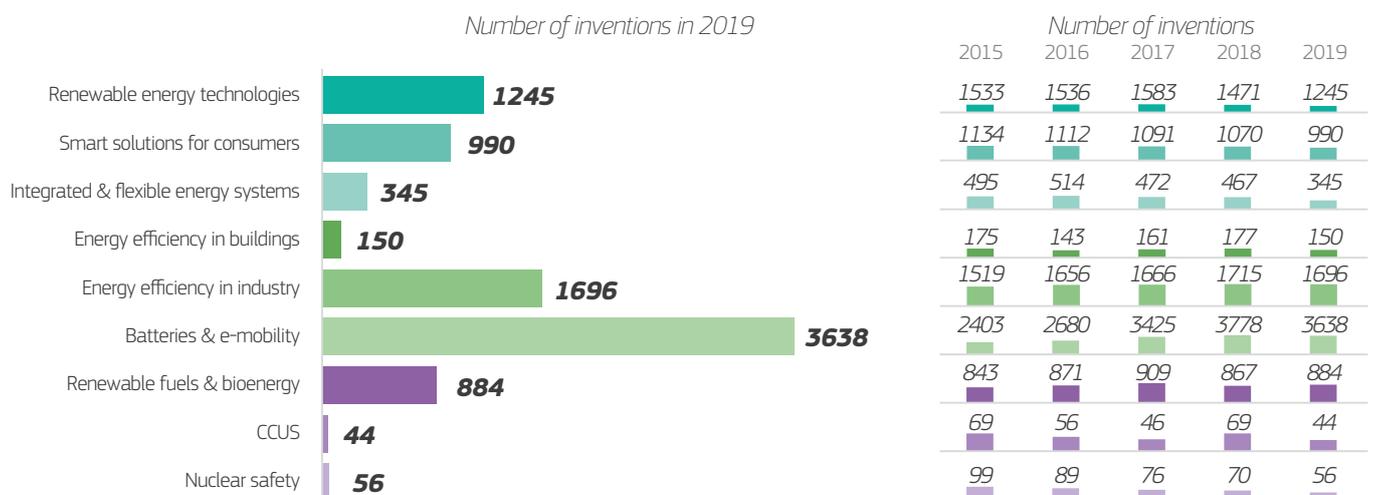


Figure 5: Member State patenting trends in the SET Plan Actions¹²

10 SETIS Research and Innovation data https://setis.ec.europa.eu/publications/setis-research-and-innovation-data_en
Mountraki, A., Georgakaki, A., Shtjefni, D., Ince, E. and Charleston, G., R&I data for SETIS and the State of the Energy Union Report, European Commission, 2022, JRC130405
<https://data.jrc.ec.europa.eu/dataset/jrc-10115-10001>

11 SETIS Research and Innovation data for 2019 incomplete.

12 SETIS Research and Innovation data for 2019 incomplete.

CHANGES TO THE IMPLEMENTATION PLANS

In this reporting period (2021-2022), the working groups on Energy systems, Energy efficiency in industry, and Offshore wind energy updated their implementation plans. Five further plans are currently under revision (see Table 1).

Original Formulation	Revised
Nuclear safety (2019)	Batteries (2020)
HVDC (2021)	CCS – CCU (2020)
Under Revision	Deep geothermal (2020)
CSP / STE (2022/2023)	Ocean energy (2021)
EE in buildings (2022/2023)	Energy systems (2021)
Positive energy districts (2022/2023)	EE in industry (2021)
Renewable fuels and bioenergy (2022/2023)	Offshore wind energy (2022)
Solar photovoltaics (2022/2023)	

With the addition of the three recently updated plans, half of all the working groups have now updated their actions and ambitions. Two groups have kept the original formulation as their plans were adopted recently and their ongoing actions are aligned with the current ambitions of their respective sector and the EU.

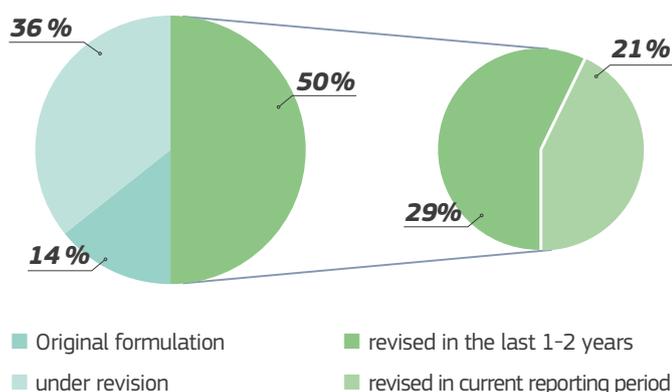


Figure 6: Status of the SET Plan implementation plans

Of the 12 groups that have revised or are currently revising their implementation plans, eight noted that the main reason for the changes was to align the work of the respective group with the current EU policy framework and the European Green Deal (see Figure 8).

Seven groups noted that their targets and R&I activities were

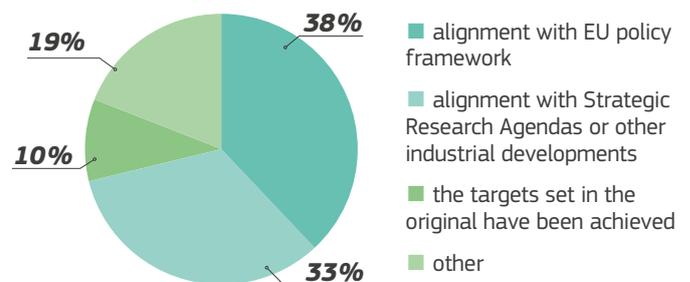


Figure 7: Reasoning behind the changes of implementation plans

achieved or outdated and have therefore been revised to take into account updated Strategic Research and Innovation Agendas (SRIAs) or other key industrial developments.

Some other factors noted by working groups contributing to the need to revise targets and activities include:

- Getting the commercial framework right; accelerating timely deployment at scale; driving costs down; and enabling EU citizens to make informed choices regarding the benefits of the technology in the case of CCUS.
- The rapid evolution of battery technology and the European ecosystem, with the establishment of a domestic battery value chain from raw and advanced materials, cell production and integration to use and recycling, necessitating a revision of the R&I requirements for batteries.
- The ongoing integration of the work of the SET Plan group on Positive energy districts (PEDs) into the co-funded Horizon Europe Partnership, Driving Urban Transitions (DUT).
- Alignment of research activities with those of the corresponding ETIP in the case of the working group on energy systems.

COLLABORATION WITHIN THE SET PLAN

One of the crucial successes of the SET Plan over the years has been the establishment and growth of cross-sectoral collaboration. As is evident in Figure 9, working groups are collaborating on linking their implementation plans and addressing cross-thematic challenges.

Within the SET Plan, discussion is ongoing on cooperation across working groups and thematic areas. In October 2021, preliminary cross-thematic areas for cooperation were identified in a dedicated workshop. In February 2022, the working groups met to discuss the strengthening of their cooperation and identified three cross-sectoral themes to focus on:

- Cooperation area 1: Integration of renewable energy power generation technologies, flexibility and storage
- Cooperation area 2: Integration of renewable heat sources with storage, heat/cold management
- Cooperation area 3: Circularity, Life Cycle Analysis, materials, and advanced manufacturing

In March 2022, the working group on Energy efficiency in industry organised an event in which these cooperation areas were explored in three parallel sessions, which combined presentations and discussions in smaller groups. During these exchanges, more than 130 participants shared their experiences to allow cross-fertilisation of ideas and reinforce interaction among the 14 working groups. The fruitful discussions led to the identification of key sub-areas of cooperation, interested working groups and possible next steps.

Following the 2022 workshops, there are now 19 established collaborations between the working groups, compared to 11 in 2021.

In the future, the working groups plan to further strengthen collaboration (Figure 10) and integration between technologies, to address cross-cutting aspects of the energy and digital transitions.



Figure 8: Existing collaborations reported by the working groups



Figure 9: Potential collaborations reported by the working groups

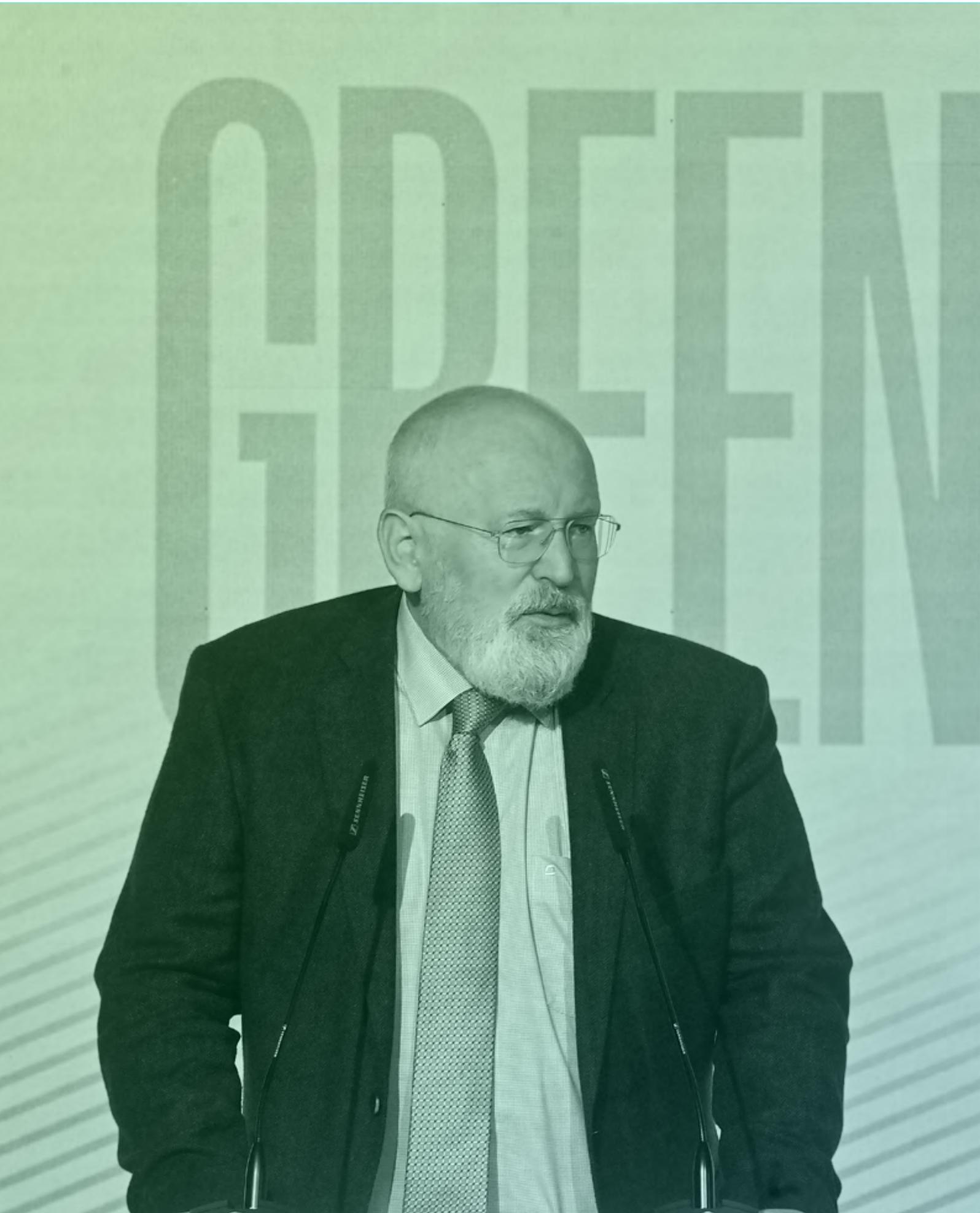
- | | |
|---|--|
| <ul style="list-style-type: none"> ■ Solar photovoltaics ■ CSP/STE ■ Offshore wind ■ Deep geothermal ■ Ocean energy ■ HVDC ■ Positive energy districts | <ul style="list-style-type: none"> ■ Energy systems ■ EE in buildings ■ EE in industry ■ Batteries ■ Renewable fuels and bioenergy ■ CCS-CCU ■ Nuclear safety |
|---|--|

SET PLAN IMPLEMENTATION LANDSCAPE

	WWW	ETIP	CSA
Solar photovoltaics	www.iwg-pv.eu	www.etip-pv.eu	www.pvimpact.eu
CSP/STE	http://www.horizon-ste.eu/		www.horizon-ste.eu
Offshore wind	https://setis.ec.europa.eu/implementing-actions/offshore-wind-energy_en	www.etipwind.eu	
Deep geothermal	https://www.deepgeothermal-iwg.eu/	www.etip-dg.eu/	www.deepgeothermal-iwg.eu/
Ocean energy	https://setis.ec.europa.eu/implementing-actions/ocean-energy_en	www.etipocean.eu/	www.oceanset.eu/
HVDC	https://setis.ec.europa.eu/implementing-actions/high-voltage-direct-current-hvdc-direct-current-dc-technologies_en		
Positive energy districts	https://jpi-urbaneurope.eu/ped/	https://www.ectp.org/ https://www.euroheat.org/ https://www.rhc-platform.org/	
Energy systems	https://setis.ec.europa.eu/implementing-actions/energy-systems_it	www.etip-snet.eu/	
EE in buildings	www.iwg5-buildings.eu	www.rhc-platform.org	
EE in industry	https://setis.ec.europa.eu/implementing-actions/energy-efficiency-industry_en		
Batteries	https://energy.ec.europa.eu/topics/research-and-technology/batteries-europe_en	https://energy.ec.europa.eu/topics/research-and-technology/batteries-europe_en	
Renewable fuels and bioenergy	https://setis.ec.europa.eu/implementing-actions/renewable-fuels-and-bioenergy_en	www.etipbioenergy.eu/	www.set4bio.eu
CCS-CCU	https://www.ccus-setplan.eu/	www.zeroemissionsplatform.eu/	
Nuclear safety	https://setis.ec.europa.eu/implementing-actions/nuclear-safety-implementation-working-group_en	www.snetp.eu	

Table 1: Status of the SET Plan implementation plans

Cofunded European Partnership (previously ERANET)	Industrial association	Additional project or other European coordination group	
www.solar-era.net/			
www.csp-eranet.eu	www.estelasolar.org	https://www.eera-csp.eu/	
	www.windeurope.org/	https://www.eerajpwind.eu/	
www.geothermica.eu	www.egec.org	https://www.rhc-platform.org/	
www.oceancofund.eu/	www.oceanenergy-europe.eu/		
	https://www.entsoe.eu	https://www.tdeurope.eu/	
https://jpi-urbaneurope.eu/driving-urban-transitions-to-a-sustainable-future-dut/		https://jpi-urbaneurope.eu/	
www.eranet-smartenergysystems.eu/		https://cetpartnership.eu/	
	www.ectp.org		
	https://www.aspire2050.eu		
			
	https://hydrogeneurope.eu/ https://www.eera-bioenergy.eu/ https://bioenergyeurope.org/		
www.act-ccs.eu/	https://co2value.eu/	www.ccusnetwork.eu/	
	www.foratom.org	https://www.euro-fusion.org/ https://igdtp.eu/ https://www.eera-set.eu/ https://www.ech2a.eu/	



DEVELOPING THE SET PLAN OF THE FUTURE

THE CASE FOR THE SET PLAN REVAMP

After 15 years of the SET Plan and its most recent update in 2015, the EU energy agenda has changed considerably (described above). It is time now for a review of the SET Plan's objectives, governance, scope, and activities, to align it fully with the European Green Deal¹³, the Fit-for-55 package¹⁴, the REPowerEU Plan¹⁵, and the new European Research Area (ERA) Agenda¹⁶.

The Commission is preparing a Communication to strengthen the SET Plan and ensure that it is fit to address the challenges of today and tomorrow by playing a central role in the alignment of EU, national and industrial energy research & innovation actions.

The renewed SET Plan will aim to:

- continuously improve the performance and cost efficiency of clean energy technologies as well as the efficiency and resilience of clean energy value chains, including at industrial manufacturing level;
 - further facilitate the acceleration of development and deployment of less mature clean energy technologies;
 - create a stronger link with the preparation of, and reporting on, the Research, Innovation and Competitiveness chapters in the National Energy and Climate Plans;
 - address cross-cutting, thematic issues, such as environmental aspects (sustainability, circularity, best use of resources) and social aspects (health, safety, security, availability and affordability of energy, public engagement);
 - consider challenges to the energy transition which have emerged since the creation of the SET Plan, such as the availability of critical materials, digitalisation, technology dependence and resilience;
 - address the growing role of specific enabling technologies and fuels such as energy storage and hydrogen.
- employ an updated strategy to better capitalise on synergies between R&I strategies and the innovation landscape at national, European, and international levels;
 - identify synergies between regional, national and EU financial support mechanisms for R&I;

¹³ https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

¹⁴ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0550>

¹⁵ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483>

¹⁶ https://ec.europa.eu/info/sites/default/files/research_and_innovation/strategy_on_research_and_innovation/documents/ec_rtd_era-policy-agenda-2021.pdf

THE PROCESS SO FAR

The SET Plan revamp is not a legislative process and therefore does not require a formal public consultation. However, to ensure that the resulting Communication draws on the valuable experience and ideas of all stakeholders, the Commission has undertaken an inclusive and transparent process to gather input from across the SET Plan community.

The SET Plan Steering Group, the European Energy Research Alliance (EERA), and the SET Plan Implementation Working Groups have all been consulted. In addition, an external contractor carried out interviews and surveys with the SET Plan community.

Another important step in the consultation process ahead of the Communication is the publication of the Call for Evidence. The document was published on the Europa site, 'Have your say'¹⁷, with a feedback period from 5 October to 2 November 2022. The evidence collected from SET Plan stakeholders will provide additional input to the reshaping of the SET Plan's overarching objectives, governance, synergies and targets.

On 9-10 November 2022, the 16th SET Plan Conference is taking place in Prague, Czechia, in unprecedented times for the energy sector and for Europe as a whole. The theme of the Conference, 'Towards a new SET Plan', marks the need to match the SET Plan with the EU's increased energy and climate policy ambitions. The 2022 Conference covers important policy and technological developments, but crucially acts as a platform to place the revamp process in the broader context of the new European energy landscape, the new European Innovation Agenda and the new European Research Area.

EXTERNAL INTERIM EVALUATION

In July 2022, the external contractor Deloitte, in collaboration with empirica, produced a comprehensive interim evaluation¹⁸ of the SET Plan, including

an analysis of possible ways forward. The study employed a mixed qualitative approach, involving analytical desk research, stakeholder interviews and a questionnaire distributed to the wider SET Plan ecosystem from 2 May to 30 June 2022.

Interviews were conducted with 46 stakeholders directly involved in the SET Plan, from the Steering Group, Implementation Working Groups, ETIPs, ERA-NETs, CSAs, EERA and more. The questionnaire garnered a further 68 responses from a very wide range of organisations and stakeholders. Overall, insights were shared from 20 SET Plan Countries and all working groups.

Based on this input, the external evaluation reached 28 conclusions on a wide range of issues. These were discussed during the third SET Plan Steering Group meeting of the year on 29 September 2022, and are currently under analysis by the European Commission.

INPUT FROM THE STEERING GROUP

In 2022, prior to the SET Plan Conference and the publication of this report, the Steering Group (SG) met four times: there have been three regular meetings (in March, May and September) and one special meeting focused on the revamp, on 17 June, organised by the French Presidency of the Council. Additionally, in April 2022, the SG Bureau met with the SET Plan Secretariat to coordinate the next steps of the process. During these brainstorming events, the SG provided useful input on the advantages, challenges, priorities, governance, impact and expectations of the SET Plan.

INPUT FROM THE WORKING GROUPS

In addition to the external evaluation and call for evidence, the input of the working groups was collected as part of the 2022 SETIS monitoring exercise, from 1 April to 31 May 2022, and from the cross-sector cooperation workshops held in March 2022.

The working groups outlined their successes, the impact of the SET Plan, the challenges they faced, and their future expectations of the SET Plan. These make up the latter part of this report.

¹⁷ https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13260-Communication-on-revamping-the-SET-Plan-_en

¹⁸ The external interim evaluation can be accessed here: <https://op.europa.eu/en/publication-detail/-/publication/aeb23db7-3896-11ed-9c68-01aa75ed71a1/language-en/format-PDF/source-267312164>

SUGGESTED WAYS FORWARD

Taking together the suggestions made from across the input so far, there is general consensus on some of the aspects which need to be considered in order to refocus the SET Plan's overarching objectives; redefine its purpose; improve its governance; strengthen cooperation, both internally and externally; and increase its visibility.

- The SET Plan's overarching objectives should be renewed and updated to give it new impetus and to facilitate the achievement of the objectives of the European Green Deal and the REPowerEU Plan. The SET Plan should play an increasingly strategic role in the clean energy European research and innovation agenda.
- Steps should be taken to ensure that all SET Plan countries are actively engaged.
- The revamped SET Plan should be more visible at European and national levels.
- There should be alignment with the ERA framework to draw on existing EU-wide structures, allowing the subsidiarity principle to be better applied, enriching synergies and providing scientific evidence for enabling policies such as the design of actions for skills development.
- The SET Plan should play a key role in improving the way that NECPs are updated and monitored.
- There should be an enhanced holistic approach, integrating cross-cutting challenges into the existing working groups. These could include, for example, material resources, manufacturing capabilities, digitalisation, circularity and social aspects.
- Within the ETIPs and working groups, the relationship with industry should be strengthened to help accelerate the development and deployment of clean technologies and increase competitiveness.
- The exchange of scientific evidence and best practices should be further enhanced, to support regulatory and standardisation processes.







THE PERSPECTIVE OF THE WORKING GROUPS

The opinions expressed in this chapter are those of the Implementation Working Groups and their Chairs and should not be considered as representative of the European Commission's official position.



SOLAR PHOTOVOLTAICS (PV)

In November 2017, the SET Plan Steering Group endorsed the implementation plan for PV¹⁹ and the working group on solar PV was established in early 2018. From the very beginning, the group developed a close cooperation with the European Technology and Innovation Platform for Photovoltaics (ETIP PV), which proved to be essential for the preparation and monitoring of the implementation plan and the follow up of its actions.

A revision of the implementation plan started in 2021, because the group had met some of its original targets; needed to bring the targets and R&I activities up to date to take into account updates in the Strategic Research Agenda and other key industrial developments; and wanted to align its work with the current EU policy framework for the delivery of the European Green Deal and the REPowerEU Plan.

The new implementation plan will be based on the Strategic Research and Innovation Agenda (SRIA) of ETIP PV and will offer added value by taking the activities of the working group's Member States and regions into account. In this context, the monitoring of national RD&I activities conducted by the Coordination and Support Activity, PV Impact, plays an important role.

Since mid-2021, the work of the working group on solar PV has been showcased on its own website²⁰.

19 https://setis.ec.europa.eu/document/download/c11476be-213b-4692-b6b1-f2f6948d7124_en?filename=set_plan_pv_implementation_plan.pdf
20 www.iwg-pv.eu



MAIN ACHIEVEMENTS

One of the main topics covered by the working group on solar PV is the monitoring of national RD&I activities. The aim is to identify the focal points of activities within the working group's Member States and regions and to describe the scope of these initiatives. In December 2018, as a first outcome, an internal report was drafted with a subsequent update in 2019²¹.

From mid-2019 onwards, the monitoring of national RD&I activities was transferred to the Coordination and Support Activity (CSA), PV Impact²². One aim of PV Impact was the development of a European PV Project Database and the analysis of the information gathered. Since early 2020, PV Impact has been in regular exchange with the chairs of the working group, with mutual support provided concerning the collection of data. One outcome, for instance, is the PV Impact report, 'Journal articles on R&D spending'²³. More analysis will come. The activity has shown that there is significant support for RD&I on PV throughout Europe. At the same time, the motivation, intensity and focal points of interest differ from country to country.

The working group on solar PV has supported SET Plan activities over recent years in different ways. Initially, the implementation plan was presented and discussed at the 2017 SET Plan conference in Bratislava. An update on the progress of the working group was given at the SET Plan Steering Group Meeting in September 2019. In addition, representatives of the group participated in the matchmaking events of SOLAR-ERA.NET²⁴ (May 2019) and PV Impact (September 2019). In 2020, the solar PV working group provided input on the project pipeline for recovery funds at the SET Plan Conference and was also present at the EU Sustainable Energy Week. Finally, in April 2022, the working group, in cooperation with ETIP PV, made a statement on regulatory sandboxes, addressing the environmental aspects for PV installations.

SET PLAN'S IMPACT AND ADDED VALUE

The PV RD&I activities described in the implementation plan have had a tangible impact on European programming. They built, at least partly, the basis for the setting of topics for dedicated calls under Horizon2020 and Horizon Europe, and the SOLAR-ERA.NET joint calls from 2018 onwards. In addition, the working group was actively involved in the strategic design of the PV topics within

21 https://www.iwg-pv.eu/lw_resource/datapool/systemfiles/elements/files/cb070ebb-d1ed-11ec-9e1a-901b0ed05e16/live/document/PV_Annual_IWG_input_2019_V1.0.pdf

22 <https://cordis.europa.eu/project/id/842547> & <https://pvimpact.eu/>

23 <https://pvimpact.eu/news-resources/reports/?page=2>

24 <https://www.solar-era.net/>

the Clean Energy Transition Partnership (CETPartnership). From May 2020 to November 2020, the working group on solar PV was part of the topical CETPartnership team and acted as co-author for the CETPartnership Input Paper on PV, as part of the development of a CETPartnership SRIA.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

An important task of the working group is the monitoring of the technical and market-related progress of PV in the EU. At two meetings, one in Brussels in October 2019, and one online in May 2020, Key Performance Indicators (KPI) for PV and consequences for the implementation plan were discussed. This led to an initiative for a revision of the plan that started in late 2021²⁵. The new implementation plan will be based on the Strategic Research and Innovation Agenda (SRIA) of ETIP PV and will offer added value by taking the activities of the solar PV working group Member States and regions into account. Here, again, the monitoring of national RD&I activities conducted by PV Impact plays an important role.

MAIN CHALLENGES AND DIFFICULTIES

The visibility and impact of the SET Plan and the working groups in the renewable energy sector should receive more attention at European as well as at national and regional level. These actions should be considered in view of the current security of energy supply crisis, as well as the challenges posed by the agreed targets set at the UNFCCC Paris Climate Conference (COP21) and specifically, in light of the EU 55% emission reduction target for 2030.

In this context, the level of participation of Member States and regions in the working group also offers substantial room for improvement. The management of the solar PV working group is continuously challenged to maintain even basic support for its work. By clearly communicating the continued or even growing importance of the SET Plan today, amidst and in relation to all the other initiatives and instruments, the Commission can provide essential support to the working group and its success.

MAIN EXPECTATIONS FROM THE SET PLAN

The working group on solar PV is ready to support all measures to strengthen the role of the SET Plan and its implementation plans concerning a more strategic orientation of the EU and national RD&I policies in the energy sector, especially against a background of climate change mitigation targets and the current energy supply crisis.



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Still ongoing at the moment of drafting this report.



CONCENTRATED SOLAR POWER/ SOLAR THERMAL ELECTRICITY

The Concentrated Solar Power (CSP) / Solar Thermal Electricity (STE) working group is currently revising its implementation plan²⁶. This is to address outdated targets and R&I activities, and to align the work of the group more closely with the current EU policy framework in the context of the European Green Deal.

Most CSP stakeholders actively participated in the update of the Implementation Plan, which included: 1) revision and consensus of strategic targets in terms of cost reduction and efficiency, including two new CSP-related targets related to solar heat for industrial processes and solar fuels; and 2) the identification of 18 R&I activities and their adaptation to the new energy policy context.

At the beginning of 2022, this working group, together with ESTELA and other CSP stakeholders, coordinated the response to the public consultation²⁷ that fed into the new EU solar energy strategy²⁸. The main objective of this activity was to highlight some of the limitations of the initial design of the questionnaire and to call for an update of the survey to reflect a truly inclusive approach to all solar technologies and their respective applications and market potential.

²⁶ At the moment of drafting of this report.

²⁷ https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13338-EU-solar-energy-strategy_en

²⁸ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A221%3AFIN&qid=1653034500503>

MAIN ACHIEVEMENTS

One of the main success stories of the working group is the HORIZON-STE²⁹ project, funded through H2020 with the aim of supporting the implementation of the work on CSP/STE. HORIZON-STE has contacted decision-makers and stakeholders from nine countries to help understand their needs and energy strategies and to ensure that CSP is not overshadowed by other solutions in the energy transition planning process.

The discussions highlighted the need to decarbonise beyond the electricity system (including, for example, heat and hydrogen networks). This project also assessed the conditions for replicating in EU countries the commercial cost levels (<EUR 10 cts/kWh, already achieved by the industry on CSP/STE world markets), such as financial conditions, type of auctions, and innovation, to implement first-of-a-kind projects. HORIZON-STE is on track to produce the pending deliverables, which comprise the final reports for the countries of focus as well as the organisation of the national Joint Industry and R&I Events, which led to the final project event in September 2022. Moreover, the HORIZON-STE partners have worked closely with the CSP/STE working group members to produce the implementation plan update, while the same partners will continue to provide support to the working group via the recently approved Horizon Europe project CST4ALL.

Another successful collaboration is CSP-Eranet. In 2020, a joint call for transnational projects was launched. Six projects were funded (EuroPatMoS³⁰, Si-Co³¹, InnoSolPower³², TES4Trig³³, Newline³⁴, CSPplus³⁵), of which 50% were focused on thermal energy storage technologies. Eight countries were involved (Germany, Italy, Iceland, Greece, Portugal, Spain, Switzerland, and Türkiye). A new call has been launched in 2021 whose results are not yet available.

Finally, R&D projects (e.g. Nextower³⁶; Photon; Polyphem³⁷, Pegasus³⁸, Hyflex³⁹, Capture, Mosaic⁴⁰) have been successfully funded at European & national levels, which shows the progress made in achieving the targets & R&D activities of the working group.

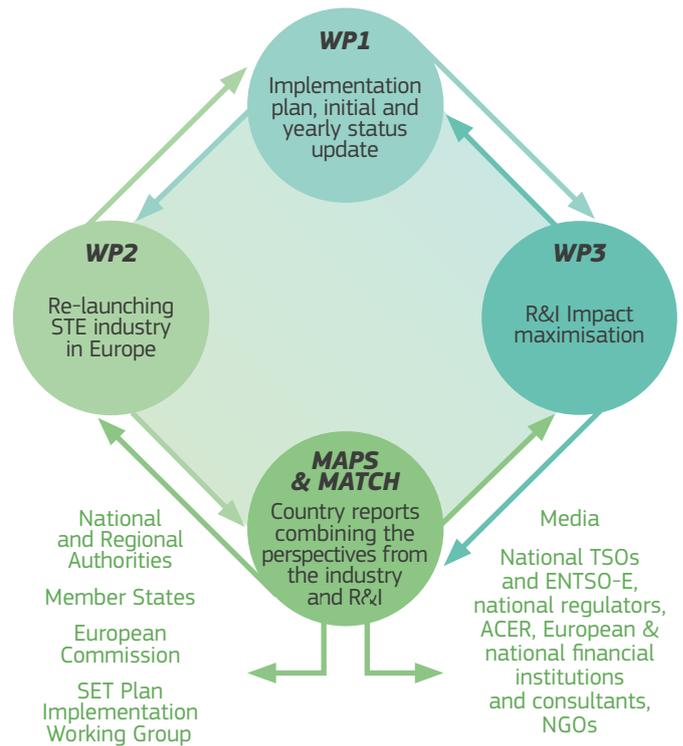


Figure 10: HORIZON-STE Functioning

SET PLAN'S IMPACT AND ADDED VALUE

Since its creation, industry and R&D centres have worked together closely in this working group. The strategies have been discussed according to the needs and wishes of all actors. The influence of industry has been greater for short-term strategies while R&D centres have a stronger role in defining long-term R&D strategies. Several R&D activities have been proposed, discussed and prioritised among all participants to be included in the SET Plan (e.g. activities concerning the turbine industry). An essential function of the working group has been to bring the input of both research and industry back to individual decision-making bodies of the SET Plan countries (i.e. the competent ministries for research, but also for industry issues). It also gathers all the CSP stakeholders in a single point of contact and allows all interested partners to be involved in the discussion. European industry and R&D institutions work together

29 <https://horizon-ste.eu/>

30 <https://csp-eranet.eu/european-parabolic-trough-molten-salt-europatmos>

31 <https://www.era-learn.eu/network-information/networks/lc-sc3-ja-1-2018/1st-csp-joint-call/high-performance-parabolic-trough-collector-and-innovative-silicone-fluid-for-csp-power-plants>

32 <http://innosolpower.com/>

33 <https://csp-eranet.eu/results/thermal-energy-storage-demand-solar-trigeneration-tes4trig>

34 <http://www.newcline.eu/>

35 <https://csp-eranet.eu/results/techno-economical-evaluation-different-thermal-energy-storage-concepts-csp-plants-cspplus>

36 <https://www.h2020-nextower.eu/>

37 <https://www.polyphem-project.eu/>

38 <https://www.gasdotitalia.it/en/content/pegasus-project>

39 <https://www.hyflexpower.eu/>

40 <https://mosaic-mission.eu/>

successfully to develop international standards to improve quality control and technology competitiveness at forums such as the International Electrotechnical Commission Technical Committee 117 on Solar Thermal Electric Plants⁴¹. When it comes to the added value of the SET Plan for the CSP/STE industry, the working group points out that it:

- has reserved a basic level of public funding for R&I on Concentrated Solar Technologies, which will be extended to applications beyond electricity generation, including industrial process heat and solar fuels production.
- provides better representation of CSP technology in the NECPs, formulated by the Member States represented on the working group on CSP/STE.
- provides better access to the decision-making bodies of the SET Plan countries.
- enhances networking opportunities and boosts collaboration in the preparation of R&I projects submitted to funding programmes at European, national and regional level, especially with regard to the industrial sector.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

CSP is a technology with potential, specific capabilities (especially as dispatchable renewable energy) and a medium-high degree of maturity, **where European companies continue to play a leading technological role worldwide**. In 2020, the European Solar Thermal Electricity Association (ESTELA)⁴², with the support of this working group (and 176 European stakeholders), published the position paper, 'From Green Deal to Green Recovery: A Joint Initiative of the EU Solar Industry'⁴³. In it, the large stakeholder initiative provided a global overview of the extended uses of the technology. According to the study, in nine countries evaluated by the HORIZON-STE project, CSP can mitigate the effects of the current gas crisis and contribute to European climate and energy policies and goals.

For electricity systems, CSP has a system value, and together with the industry's maturity could provide short-term answers to the challenge of a quicker transition to renewable energy. CSP is always at utility-scale (above 100 MW) with full-load storage in the range of 8-12h that can provide night baseload energy, which is synchronous.

Therefore, the transmission system operator (TSO) does not require any additional systems to keep stability of the grid. It is more of a strategic reserve facility for states. In Spain, there are 2.3 GW of installed capacity (870 MW includes storage), but they were designed to add thermal storage at a later stage. There is potential to double this storage capacity in less than 12 months, reaching more than 12 GWh. CSP could partially replace the consumption of natural gas and help to achieve energy autonomy while reducing electricity prices for consumers.

There is significant market potential for CSP technologies for industrial process heat (temperature ranges above 200°C, with a high capacity factor and lower costs) and solar fuels (to ramp up centralised, large-scale production in Southern Europe and with hybrid CSP/PV technology).

MAIN CHALLENGES AND DIFFICULTIES

One of the main challenges identified for the CSP working group is the involvement of SET Plan countries' representatives in lifting the barriers that have been blocking a change of attitude and new developments at national level. The role of the SET Plan countries is key, since they are the sole entities able to:

- overcome disparate national energy policies based on local natural resources, own industry capabilities, national energy system needs (depending on geographical position, degree of interconnection, capacity for imports, market coupling and regulatory framework);
- tackle a lack of cooperation, due to lack of trust by countries in cooperation instruments (perception of no win-win mechanisms); cooperation level is mostly limited to R&I projects;
- address the low controllability of investments, absence of own customers in other countries;
- adjust procurement mechanisms (i.e. auctions) that can open or close doors to the deployment of a technology (conditions set for power purchase agreement duration, grid access constraints, limitations to hybridisation, exposure to markets and state-aid impact); and
- remove regulatory barriers to hybridisation of CSP with other renewable energy sources, incentivise new operational patterns (responses to TSO's needs and offering strategic reserves).

41 https://www.iec.ch/dyn/www/?p=103:7:0:::FSP_ORG_ID,FSP_LANG_ID:7851,25

42 <https://estelasolar.org/>

43 https://estelasolar.org/20200528_joint-initiative-of-the-eu-solar-industry/

CSP is still largely unknown to most policymakers, politicians and the public. CSP technology is often under-represented in energy transition policies that encourage the adoption of renewable energy sources, whereas other less mature technologies have attracted greater attention and a major portion of innovation funds.

The active participation of the SET Plan countries' representatives and the Commission in the activity of the working group is crucial for the redirection of a proportion of public funding to industrial projects in order to advance the innovation and competitiveness of the CSP sector at European level in a closer-to-market approach.

MAIN EXPECTATIONS FROM THE SET PLAN

Although the commitment of all members in the working group and the impact of the activities in the SET Plan are high, the final influence on EU policies is still limited. The expectations of the CSP working group are that the SET Plan:

1) Will contribute to increasing CSP visibility and will have a real and practical influence on policymakers. The final goal is to promote the utilisation of CSP with thermal energy storage to facilitate high penetration rates of variable RES in the electrical system and therefore contribute effectively to the energy transition and the REPowerEU objectives. The SET Plan is also expected to contribute to unlocking the potential of concentrated solar technologies for industrial process heat, and for solar fuels.

2) Will discuss with the Commission the possibility of i) setting a minimum target as per cent of dispatchable RES in each Member State; ii) ensuring further support for innovation in concentrated solar thermal technologies; and iii) calling for harmonisation of energy policies and incentivising cooperation.

3) Is aligned to industry needs, essentially through funding to high TRL research across all potential uses of concentrated solar thermal technologies.





OFFSHORE WIND ENERGY

The Offshore wind energy working group has been key in providing a specific focus on offshore wind energy R&I. It offers a platform for R&I agenda-setting that brings together the SET Plan community with international fora such as the IEA Technology Collaboration Programme on Wind.

In 2022, the Offshore wind energy working group coordinated and delivered the update of the Implementation plan⁴⁴, taking into account input from various stakeholders, including the HVDC working group. The revision was necessary in order to align the work of the group with the European Green Deal, and to update some of its targets and R&I activities to take into account key industrial developments.

In addition to the updated implementation plan, the main achievements of the working group on offshore wind include:

- The Reliablade project⁴⁵, which grew out of the Integrated Research Programme for Wind Energy (IRPWind) initiative of the EERA Joint Programme on Wind, as a Berlin-model project. It has delivered a beta-version of the digital twin of turbine blades developed by industry software.
- A first cross-border coordinated project originating in SETWind, which combines two projects funded by German and Dutch funding agencies.
- The addition of wind energy (both offshore and onshore) to the CETPartnership SRIA⁴⁶.
- The presentation of the Lighthouse initiatives for offshore wind by the SETWind project⁴⁷.

44 https://setis.ec.europa.eu/system/files/2022-04/2nd%20SET-Plan%20Implementation%20Plan%20for%20Offshore%20Wind_2022.pdf

45 <https://www.reliablade.com/>

46 https://eranet-smartenergysystems.eu/global/images/cms/CETP/CETP_SRIA_v1.0_endorsed.pdf

47 <https://setwind.eu/setwind-lighthouse-projects/>

IMPACT OF SET PLAN AND OF THE WORKING GROUP

The SET Plan remains an essential vehicle for R&I coordination and collaboration in Europe for both industry and academia. It also creates a joint framework for understanding key topics on the R&I agenda as it evolves.

MAIN CHALLENGES AND DIFFICULTIES

The main challenges faced by the working group include:

- Balancing expectations and achievements: on some occasions very high stakeholder expectations make the working groups' successes along the way appear insufficient to deliver on the larger ambitions.
- The need to find the right way to engage SET Plan countries in the framework, which has a clear added value beyond what is achieved through other fora.
- The apparent underrepresentation of the Implementation Working Groups in the NECP reporting process, leading to their work going unmentioned in some of the final documents.

MAIN EXPECTATIONS FROM THE SET PLAN

The working group has proposed the following ways for the SET Plan to add additional value:

- Beyond R&I projects, the SET Plan could be a strong vehicle to improve the development of data management platforms and other forms of enabling capabilities in Europe. This will require funding (as has been done with recent projects) but more can probably be done to advance this agenda.
- Maintain the position of EERA JP Wind and ETIPWIND and the balance between them.
- Enable large-scale, low-TRL European projects linked to one or more working groups (e.g. between Offshore wind and HVDC). These projects are reference projects for Research and Technology Organisations/academia and industry collaboration for 5-10 years after completion and facilitate commercial products, new research strands and education.
- The way that SET Plan countries are engaged needs to be considered. A possible option would be to have fewer groups which require the involvement of SET Plan countries, and the establishment of an annual forum where high-level funding agency executives discuss the advancement of R&I for Europe's green transition.





DEEP GEOTHERMAL ENERGY

The Geothermal working group is a strategic platform for SET Plan countries, researchers and the geothermal industry to pool their efforts to support the use of geothermal to its full potential.

Geothermal energy is a valuable and local source of energy that can provide baseload dispatchable electricity, heat or a combination of both, in a cost-effective way. With these features, it has the potential to provide real alternatives to power plants and heating systems emitting greenhouse gases, not only in Europe but also globally, and in particular in some developing countries.

In addition, geothermal reservoirs may also act as sites for the storage of energy, and geothermal minerals such as lithium can be produced in parallel with geothermal energy production. Geothermal energy has the potential to play a major role in the energy transition in most European countries, mainly focusing on the direct use of heat in the supply of newly constructed buildings and existing building stock, and on low to medium temperature processes.

In 2020, the deep geothermal energy working group revised its implementation plan⁴⁸. Some of its targets and R&I activities were outdated and have been revised to take into account updated Strategic Research Agendas and other key industrial developments. The group formally focuses on four key areas: Heating & Cooling, Power Production, Thermal Storage and Geothermal Minerals.

48

<https://www.deepgeothermal-iwg.eu/updatedimplementationplan>

MAIN ACHIEVEMENTS

The Implementation Plan improves coherence and identifies a joint agenda for R&I as well as cross-cutting issues. Geothermal can supply heating and cooling, power, thermal storage and geothermal minerals. The Implementation Plan supports the various uses of geothermal and co-ordinates the efforts of 14 countries, and research and industry bodies.

The most important achievement is the coordination of the various technical and non-technical projects in line with the targets and R&I priorities of the Implementation Plan. These projects were funded by GEOTHERMICA, H2020 and national funding programmes. They focus, for instance, on lower cost per kWh produced, a better understanding and the de-risking of subsurface thermal energy storage, and risk management programmes for geothermal. Results of the projects are contributing to all the targets and R&I priorities. All in all, some EUR 100 million was dedicated to R&I projects in geothermal each year, with an additional EUR 40 million biannually in GEOTHERMICA Calls.

The working group contributes successfully to a lasting collaboration on geothermal energy. It has mobilised its network to integrate its work in the Clean Energy Transition Partnership (CETPartnership) in a challenge-driven way. It makes sure that the Implementation Plan is kept up to date, taking on board new areas such as thermal storage and geothermal minerals, ensuring its relevance.

There is good collaboration with the ETIP Deep Geothermal and the EERA, which both hold Co-Chair positions in the working group. The European Geothermal Energy Council (EGEC) and the Support Unit for the Deep geothermal working group⁴⁹ (SU-DG-IWG) project as well as GEOTHERMICA also contribute significantly to the work of the working group. The group has been instrumental in establishing a collaboration between the European Joint Programming Platform Smart Energy Systems (JPP SES) and GEOTHERMICA in a Joint Call on Heating & Cooling⁵⁰.

SET PLAN'S IMPACT AND ADDED VALUE

From its establishment, the Geothermal working group has advocated for a stronger role for geothermal energy in the climate transition. Underlining the contribution that geothermal can make for heating and cooling, power generation, thermal energy storage and geothermal minerals has contributed to a higher level of awareness and prioritisation in a growing number of European countries.

The urgency of the climate transition and the wish to become independent of Russia's natural gas underlines the need for alternatives. As a positive example, Germany has increased its ambition for geothermal quite significantly since 2020 in various fields. The international coordinated work on geothermal is one of the factors that have contributed to this development.

The Geothermal group has also contributed to a broad approach that encompasses the whole energy sector and is not limited only to electricity. The SET Plan cross-cooperation on heating and cooling illustrates that this resonates with other working groups as well. Finally, the coordination between member countries, industry and researchers contributes to a stronger sector and even greater potential for geothermal utilisation in Europe and globally.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

An objective of the working group is to improve the competitiveness of geothermal technologies, through R&I activities and more. The Geothermal group has set up reference plants and assets to monitor this learning curve. The group has also attracted new companies implementing R&I projects that contribute to the Implementation Plan.

Throughout 2021, six new geothermal power plants with more than 35 MWe were commissioned in Europe. These new additions bring the total installed capacity for geothermal power plants to 3.4 GWe in Europe, at an average capacity factor of 76%. Additionally, in 2021, 13 new geothermal district heating and cooling plants with more than 154 MWth were also commissioned, bringing the total European installed geothermal district heating and cooling capacity to 5.6 GWth. Thus, the market is steadily developing.

The importance of international collaboration in geothermal energy is great since the sector is relatively small in all European countries except Iceland. Joining forces internationally, guided by the SET Plan and the Geothermal Implementation Plan, innovation is accelerated and the sector is considerably strengthened. The strategic exchange of views and policies and the open exchange between national representatives, industry and researchers contributes to more alignment and cross-fertilisation to overcome the barriers facing geothermal energy. In this respect, the SET Plan plays a significant role.

The developments in geothermal energy are also entirely in line with the European Green Deal. The rather new niche of

49 <https://cordis.europa.eu/project/id/838814>

50 <https://jpp-ses-geothermica-matchmaking-jointcall.eranet.b2match.io/>



'geothermal minerals' adds even more to the potential because several locations suitable for geothermal energy production could co-produce lithium and other critical minerals from geothermal brine, which has the potential to reduce the European dependency on critical raw materials needed for the energy transition. In 2021, the first European kilograms of battery-grade lithium were produced from geothermal brine. Such developments are expected to contribute greatly to the security of supply and strategic independence of Europe.

MAIN CHALLENGES AND DIFFICULTIES

Geothermal has not been high on the political agenda for most countries. Geothermal energy constitutes less than 5% of the national energy systems in Europe (not counting Iceland). However, R&I projects and recent advances make it clear that the potential is much higher. This is being recognised by an increasing number of countries and highlights the importance of international collaboration in geothermal energy.

It has been a challenge to ensure proper attention to the full potential of geothermal – especially for heating and cooling, which has only recently been given more prominence. Seasonal thermal storage and geothermal minerals have also started to attract more interest and recognition.

Also challenging are the limited opportunities for interaction with the SET Plan Steering Group and the services of the European Commission. Continued attention, more meeting preparation, and in-person attendance – which was hindered by the pandemic – of SET Plan conferences could help significantly.

Engaging additional countries outside the core members in

geothermal in Europe also poses a challenge. From 2022 onwards, this will be a priority for the working group.

The continued support of the Commission to the collaboration with the working group, through support of SU-DG-IWG and GEOTHERM-FORA, but also the very important collaboration in GEOTHERMICA and CET Partnership, has helped, and will in the future continue to be extremely valuable.

Finally, the value of international collaboration for geothermal energy is very high because of the current niche nature of the sector in so many countries. In this sense, it needs to be further developed.

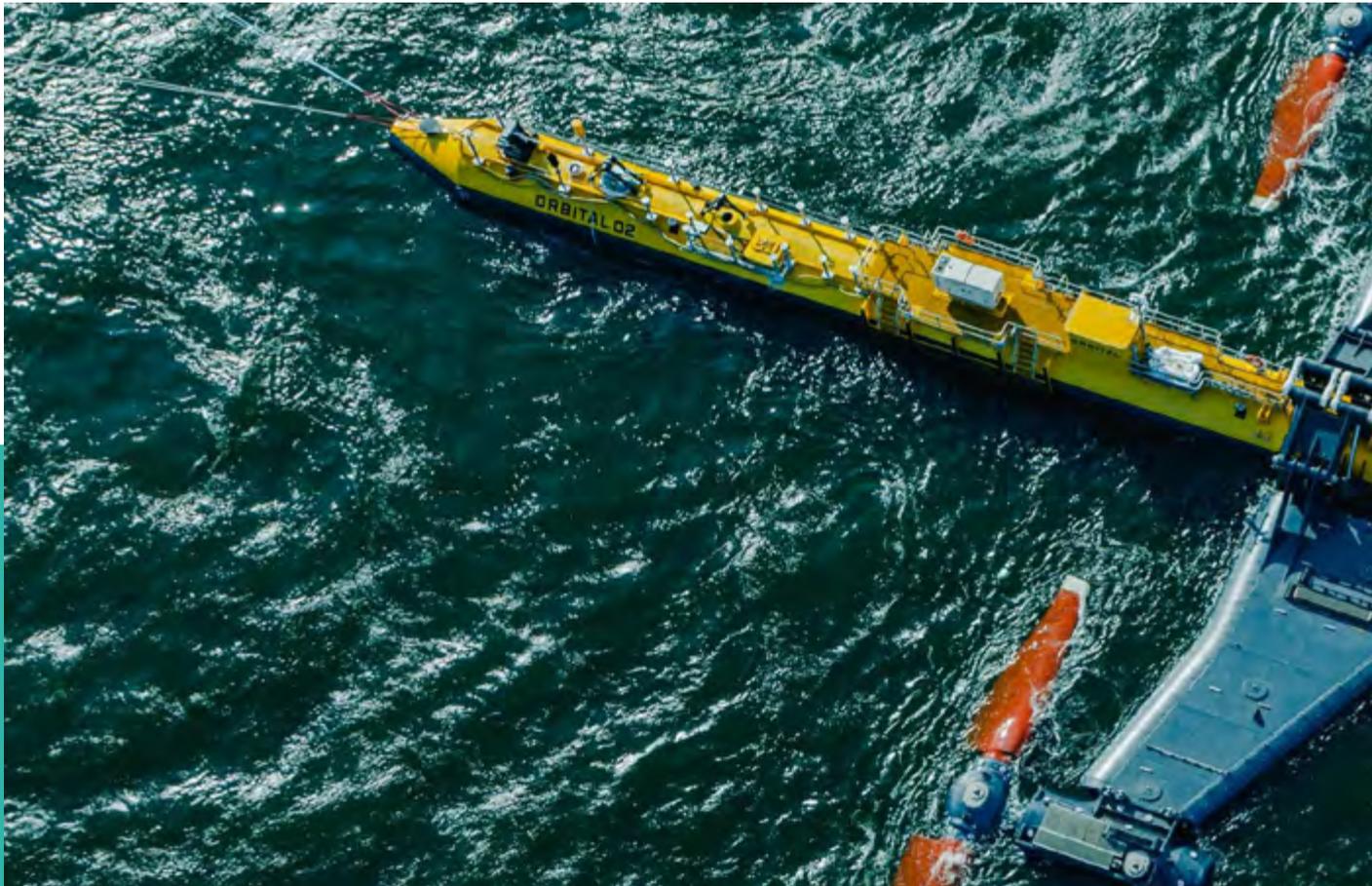
MAIN EXPECTATIONS FROM THE SET PLAN

According to the geothermal group, the SET Plan should retain a broad focus, where progress on climate-neutral technologies, integration in the energy system and integral interaction with society on the climate transition and the implications at the European system level are all taken into account (e.g. CETPartnership SRIA⁵¹).

It is crucial that the SET Plan considers the entire energy system, power, heating & cooling, fuels and the match between supply and demand through storage. It should also consider all energy users: built environment, industry, agriculture and transport. Technological progress can be enhanced and facilitated through international collaboration. While consumer needs in various countries differ, better technologies serve all.

The SET Plan must continue to capitalise on its advantages by supporting the execution of the Fit-for-55 package as well as the 2030 and 2050 climate goals.

51 https://cetpartnership.eu/sites/default/files/documentation/cetp_sria_1.0.pdf See p17 CETP SRIA's Figure 3 - From enabling technologies towards and integrated energy system



OCEAN ENERGY

In 2018, the Temporary Working Group (TWG) for Ocean Energy presented its first Implementation Plan, which was revised in 2021 by the current Ocean energy working group⁵² to align its work with the European Green Deal. The new action plan is based upon two key sources:

- The Strategic Research & Innovation Agenda⁵³ – released in May 2020 by ETIP OCEAN. It highlights as a priority the integration of ocean energy pilot farms into the energy system, as well as the sector's readiness to enter the market at a larger scale. The SRIA also calls for improvements in sub-systems, marine operations, foundations and connections, which will reduce costs and increase the reliability and yield of ocean energy devices.
- The EU Strategy on Offshore Renewable Energy⁵⁴ – released in November 2020 by the Commission. It sets out the EU's potential and ambitions in the field of offshore wind and ocean energy. The Strategy recognises that initial deployments are needed to kick-start cost reduction trajectories for wave and tidal energy. It commits the European Commission to coordinating funding with national and regional authorities to fund the deployment of 100 MW of ocean energy by 2025 and around 1 GW by 2030.

52 https://www.oceanset.eu/wp-content/uploads/2022/02/220125_oceanset_newsletter_05-final.pdf

53 <https://www.oceanenergy-europe.eu/wp-content/uploads/2020/05/ETIP-Ocean-SRIA.pdf>

54 <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:741:FIN&qid=1605792629666>



MAIN ACHIEVEMENTS

One of the greatest successes of the working group has been the establishment of strong links with a range of initiatives and networks all working to promote and develop ocean energy in Europe. Strong connections and synergies have been created with ETIP Ocean, OCEANERA-NET, the OceanSET CSA Project and Ocean Energy Europe.

In particular, ETIP Ocean is supporting progress towards the SET Plan targets by working in close collaboration with the Implementation Working Group, mainly through the OceanSET CSA project. In the period between 2019 and 2021, the actions included:

- participating in the preparation and meetings of the working group;
- gathering consolidated sectoral positions and structured information;
- responding to consultations; provision of specific advice where needed;
- informing the ocean energy sector about the work of SET Plan for Ocean Energy Working Group; and
- facilitating participation of the sector in individual SET Plan Implementation Plan actions.

The actions strengthened the link between ETIP Ocean and the working group and ensured that the actions within the former are in line with the work of the latter. The continuous liaison with the OceanSET project enabled efficient information sharing, which ensured consistency in the efforts of the two projects.

In addition, participating in the wider SET Plan activities allowed for the development of a good understanding of the progress of the whole SET Plan. It also enabled ETIP Ocean to share updates with the wider SET Plan community and explore synergies with other sectors.

SET PLAN'S IMPACT AND ADDED VALUE

The SET Plan provides the EU ocean energy sector with the necessary institutional framework to align and speed up progress among participating countries.

The main impacts of the working group have been:

- Stronger co-ordination between SET Plan countries and regions to share and track critical information annually;
- Demonstration of the clear development of ocean energy technologies in Europe;

- Contribution to bringing ocean energy to commercial deployment;
- Contribution to maintaining and growing Europe's leading position in ocean energy.
- three Financial Actions to ensure investment and insurance support funds are available to support the development of the sectors; and
- two Environmental Actions to share knowledge on safety and environmental matters.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

Support for the ocean energy sector to date has focused on the development of research and of roadmaps which have set out the aspirations of the wave and tidal sector. The aim of the SET Plan Ocean Energy Implementation Plan is to transform those aspirations into operational actions. The ambition of the plan is to outline a structured approach that will enable both wave and tidal technologies to follow a development path with the ultimate destination of a commercially viable wave and tidal industry.

Thus, the implementation plan sets out the following targets for the wave and tidal sector:

- Development of cost competitive ocean energy technologies with high market potential for Europe.
- Reduce the LCOE for tidal stream energy to:
 - 15 ct€/kWh in 2025
 - 10 ct€/kWh in 2030
- Reduce the LCOE for wave energy technology to:
 - 20 ct€/kWh in 2025
 - 15 ct€/kWh in 2030
 - 10 ct€/kWh in 2035

The working group has identified eleven Technology Development Actions needed for the advancement of the sector at a national and EU level. The actions are both cross-cutting (i.e. relating to all ocean energy technologies) and technology-specific (i.e. relating to either wave or tidal). They include:

- six Technical Actions to provide support at all TRLs to ensure the development of tidal arrays and to drive convergence in wave technologies;
- The creation of an Insurance and Guarantee Fund for ocean energy should be supported.

MAIN CHALLENGES AND DIFFICULTIES

According to the Ocean energy group, the main challenge was the practical involvement of some national contact points. SET Plan countries should be encouraged to consider the selection of their representatives carefully to ensure continuity.

Currently, there is no evidence of progress towards the creation of a collaborative investment fund, combining EU and national funds, dedicated to supporting the initial deployment of ocean energy technology. Some countries are hesitant to express support for such a fund without more detailed information. The group sees the need for a suitably scoped feasibility study into the viability of an appropriate form of dedicated investment fund for ocean energy.

MAIN EXPECTATIONS FROM THE SET PLAN

Some of the working group's main expectations of the future SET Plan are listed below.

- SET Plan countries with an expressed interest in the ocean energy sector should be encouraged to establish mechanisms for better recording and reporting their budget provision and actual spend.
- The sector should be informed about the work of the Ocean energy working group to facilitate public-private cooperation.
- High quality documents and comprehensive information on the sector would enable the development of appropriate positions.
- The creation of an Insurance and Guarantee Fund for ocean energy should be supported.



HIGH VOLTAGE DIRECT CURRENT (HVDC)

The working group on HVDC was established in 2021. It has developed a first version of the implementation plan⁵⁵, with wide interest from industry and good support from many of its stakeholders and a significant number of SET Plan countries.

This was the first year of the working group, following its initial approval at the 15th SET Plan Conference in Bled, Slovenia, on 25–26 November 2021. The group put forward priority activities that were successfully developed into activity fiches. These fiches and the activities of the group will be carried out in collaboration with some of the other SET Plan groups.

⁵⁵ https://setis.ec.europa.eu/document/download/155eda2e-327d-41b5-b4cd-b89845055a0a_en?filename=SET%20Plan%20Action%20HVDC_Declaration%20of%20Intent_endorsed.pdf

SET PLAN'S IMPACT AND ADDED VALUE

HVDC is an enabling technology, rather than a technology that will realise a net-zero emissions society by itself. Nevertheless, it is a technology where the European industry is particularly strong. Furthermore, European ambitions are accelerating the need for it urgently.

A coordinated research and development approach is critical to its success. To this end, the main added value and impact of the SET Plan is to set clear ambitions in this domain that are jointly developed by the various working groups and stakeholders.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

The working group aims to develop a coordinated research needs assessment and plan for R&D activities.

The results from the working group will act as an enabler for renewable deployment, in particular for offshore wind, which requires developed HVDC technology on a short-term basis.

The development of HVDC technology is expected to lead to a stronger dependence on local renewable energy sources, and can lead to a diversification of energy sources from different regions in the long-term.

CHALLENGES AND EXPECTATIONS

The main challenges faced by the HVDC working group include formulating immediate goals and managing the short and long-term expectations of the SET Plan community. On its inception, the group was not clear on the precise terms of its mandate for action. More clarity is therefore required on the future of the SET Plan, in order to assess the way forward for this new group.





POSITIVE ENERGY DISTRICTS

The Positive energy districts (PED) working group is currently revising its implementation plan⁵⁶. This will integrate its programme into the co-funded Horizon Europe Partnership, Driving Urban Transitions (DUT). The programme is being integrated as the PED Transition Pathway (PED TP) part of the DUT.

As part of the integration, the PED Programme will have an extended planning horizon from 2025 to 2030 and a re-defined role as an implementation partner to the HE Mission, Climate-neutral and Smart Cities, and be a partner of the European Commission in the Mission Innovation Urban Transitions Mission.

56

https://setis.ec.europa.eu/system/files/2021-04/setplan_smartcities_implementationplan.pdf

MAIN ACHIEVEMENTS

A framework definition for PEDs was established together with all relevant stakeholders in Europe (EERA, Lighthouse Cities, etc.), and is currently being refined into practical applicability in cities.

This PED definition was implemented as the basis for an inventory of this working group’s PED Programme that will highlight 100 or more PEDs in Europe by 2025.

With the booklet, ‘Europe towards Positive Energy Districts’ (2019/ update 2020)⁵⁷, the PED Programme has provided a comprehensive overview of urban strategies for the energy transition.

As the PED Programme puts a strong emphasis on stakeholder consultation and co-creation, a PED City Panel was established in 2019⁵⁸ as an advisory board to the PED Programme. City representatives are consulted at ground level regarding their challenges and needs. These consultations feed into the strategic development of the programme. Currently, the PED City Panel is re-constituted (integration process with the DUT).

A first joint call for transnational R&I projects was successfully conducted together with countries from the global Mission Innovation (MI) Initiative. A second call has been launched in October 2021, and applications are currently under evaluation.

Together with the European Commission and the Global Covenant of Mayors, the PED Programme established the MI Urban Transitions Mission, which was launched at COP 26 in Glasgow in November 2021.

SET PLAN’S IMPACT AND ADDED VALUE

The main benefits of the SET Plan for the PED Programme include:

- adding visibility to the joint programming activities of the PED Programme; and
- helping to reach out to new members during the course of putting together the proposal for the new HE DUT Partnership, which is the new funding framework for the PED working group/PED TP.

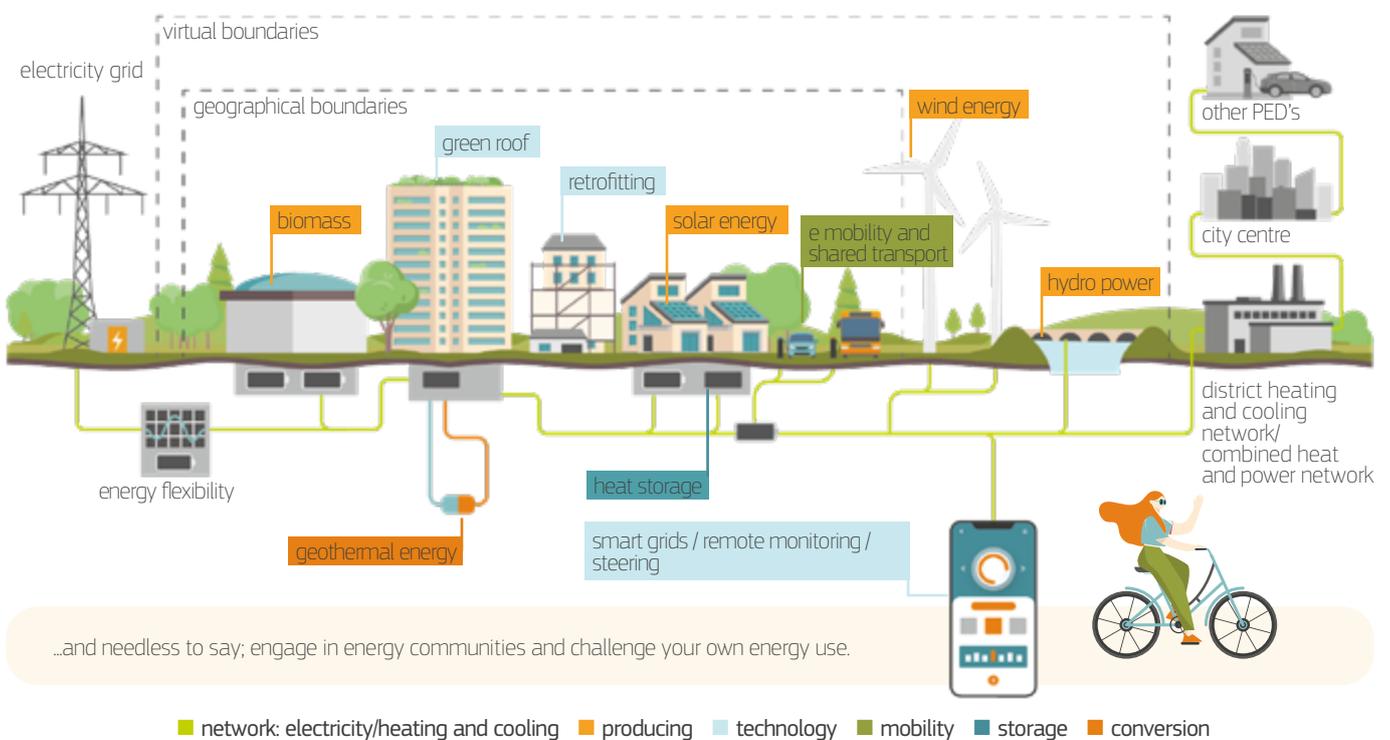


Figure 11: What are Positive Energy Districts (PEDs)

57 https://jpi-urbaneurope.eu/wp-content/uploads/2020/06/PED-Booklet-Update-Feb-2020_2.pdf
 58 <https://jpi-urbaneurope.eu/news/kick-off-in-the-positive-energy-districts-city-panel/>

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

The main PED working group impacts on the industry include:

- Successfully mobilising cities and other stakeholders in the quest of bringing about 100 PEDs in Europe by 2025. This work has manifested in annual joint calls for transnational R&I projects since 2020 and in concrete projects for capacity building and implementation in European cities and in the creation of the Co-funded HE DUT Partnership.
- Successfully reaching out to new partners at global level via the MI Calls and the new Urban Transitions Mission of the MI Initiative.
- Positioning itself through the DUT Partnership as a partner of the Horizon Europe Mission on Climate-neutral and Smart Cities, which represents the European countries. In this capacity, the new PED Transition Pathway of DUT will actively collaborate with the Co-programmed Horizon Europe Partnership, Built4People (B4P), and with the Co-funded Horizon Europe Partnership, Clean Energy Transitions.

Contribution to strengthening and coordination of European R&I: The new DUT Partnership (which includes the PED Transition Pathway/PED working group) has positioned itself as the main entry point for urban-related R&I funding and implementation in Europe. The Partnership is actively working with European cities, city networks, utilities, and the real estate development sector, which includes the relevant ETIPs/TPs in energy, construction, mobility and renewables.

Contribution to advancing innovation and competitiveness: By developing a clear framework for the definition of PEDs and supporting European cities in building capacity for the transition towards climate neutrality, the PED Programme/Transition Pathway in DUT fosters the implementation of net-zero demonstrators in Europe.

Contribution to European innovation, climate and energy policies: With its targeted consultation and implementation framework, the PED Programme is creating an important stepping stone for European cities to join the Horizon Europe Mission on Climate-neutral and Smart Cities, and actively supports the set-up of national city networks and missions that complement the efforts of the Horizon Europe Mission. In this way, the PED Programme will serve as a cornerstone of the implementation of climate neutrality in the urban dimension in Europe.

Contribution to strengthening European competitiveness, security of supply, energy diversification and strategic autonomy: The urban dimension is the origin of about 80% of climate-relevant emissions worldwide. The efforts of the PED Programme have the potential to deliver results on net-zero demonstrators in European cities by 2025 and to substantially support the European Mission on Climate-neutral and Smart Cities in reaching its goals by 2030.

MAIN CHALLENGES AND DIFFICULTIES

The working group finds that competitiveness rules in the European energy sector do not facilitate cities' experimentation with new climate-neutral solutions.

The working group also points to weak linkages between the structures in charge of energy/mobility policy and energy/mobility technology, at national SET Plan country level and at European level. This means fewer incentives for radical innovation at urban level and offers room for improvement. The results so far regarding urban mobility have been disappointing.

Finally, a number of gaps in the ESIF rules in the Multiannual Financial Framework (MFF) 2014-2020 made it possible for Operational Programmes to overlook the specific needs of cities. In the MFF 2021-2027 there is insufficient focus on financial incentives for net-zero investment in cities. The Recovery and Resilience Facility (RRF) was also overly focused on speedy deployment to meet the demands of urban investment for climate neutrality.

The new Energy Communities regulation might help cities to create 'experimental sandboxes' for PEDs. Furthermore, with the establishment of the new DUT Partnership, complemented by the Horizon Europe Mission Climate-neutral and Smart Cities, there is potential for further empowering cities and decisive capacity building through national support programmes and transnational implementation of best practices. European Structural Funds and the European Urban Agenda could be catalysts for creating new capacities and funding opportunities for cities to address climate change.

MAIN EXPECTATIONS FROM THE SET PLAN

A major expectation from the future SET Plan is to support a new and coherent collaboration between energy/mobility policies and their respective R&I funding counterparts. This could be fostered at national level through the NECPs and at European level by concrete implementation initiatives that bring together energy/mobility policies and technological innovation.



ENERGY SYSTEMS

In 2021, the Energy systems working group revised its implementation plan⁵⁹. The plan is built around two flagship initiatives: Flagship 1, *Develop an optimised European power grid*, for which the research activities must be aligned with those of the ETIP-SNET; and Flagship 2, *Develop integrated local and regional energy systems*, whose revision is not yet finalised.

An extensive mapping exercise was carried out to align the roadmaps and plans of several initiatives. It is crucial to ensure their coherence and to prioritise consistently across initiatives to maximise impact. While the Fiches of Flagship 1 are fully covered by the Research Areas of ETIP SNET Roadmap and the implementation plan, the Flagship 2 activities are only partially covered by ETIP SNET and RHC SRIA. An update of the implementation plan was carried out and the Fiches are fully endorsed, with the exception of two in Flagship 2. A mandate was obtained from the members for a continuous alignment of the ETIP SNET Implementation Plan with the working group documents.

59

<https://setis.ec.europa.eu/system/files/2022-02/SET%20Plan%20ENERGY%20SYSTEMS%20Implementation%20plan.pdf>



MAIN ACHIEVEMENTS

One of the working group's initial achievements was to establish widespread recognition across the community of the importance of an integrated energy system and the necessary alignment of priorities and approaches in all contexts (i.e at national level; European level including ETIPs, Implementation Working Groups, Co-funded Partnerships; and international level in the form of Mission Innovation).

Achievements of Flagship 1 include:

- Observability – the working group target to reach the possibility of having 85% of full automation of high and medium voltage (HV/MV) substations; 25% of medium to low voltage (MV-LV) substations has been achieved;
- Flexibility – the matter is considered actively in the CETPartnership and specific call modules are planned within its Transition Initiative (TRI) 1. However, there is still more work to be done to achieve the set target.

- Demand response and storage – projects reached good TRLs, particularly regarding the role of prosumers; integrated energy system architectures; the contribution to flexibility of renewable energy sources, storage and energy conversion. Further R&D is required for advanced integrated energy systems planning and operational planning; asset management; decentralised real-time voltage and frequency control; market design for large-scale demand response; and fuel flexibility of thermal power plants.

Achievements of Flagship 2 include:

Target 1: Development of heating and cooling systems that are able to integrate energy from different sources at different temperature levels.

In May 2021, the Joint Programming Platform Smart Energy Systems (JPP SES), in cooperation with the ERA-NET GEOTHERMICA, launched a Joint ERA-NET Call⁶⁰, which focused on the following challenges:

- Climate-neutral resources for heating and cooling, including subsurface and utilisation of local and regional excess resources;
- The resource-efficient and sustainable distribution, storage and utilisation of heating and cooling;
- The integration of heating and cooling in local and regional energy systems.

Target 2: Development of innovative mix solutions that will reduce variability by combining multi low-carbon solutions.

The HE Clean Energy Transition Partnership (CETPartnership) was formed to help achieve this goal.

SET PLAN'S IMPACT AND ADDED VALUE

The integration of resources into the energy system is a fundamental enabler for the energy transition. This is now a well understood notion, owing in part to the efforts of this working group. This is also evident from the continuous interest of other working groups in collaboration, as demonstrated during the March 2022 session on SET Plan collaboration organised by the working group on Energy efficiency in industry.

The work carried out in the Energy systems working group in collaboration with EERA has contributed to the creation of the CETPartnership, with particular reference to the Transition Initiative 1 (TRI 1: integrated energy systems). In this framework

partnership, financing agencies will fund transnational projects dedicated to system integration, thus contributing to the achievements and goals of the working group. This alignment of priorities is a group success in and of itself.

Additional impacts can be highlighted for Flagship 2, with particular reference to its contribution to the development of the strategy for CETPartnership TRI 5 (local and regional energy systems). The systems and solutions developed enable the integration of energy supply from various sustainable and variable sources and secure the optimal utilisation of limited local and regional infrastructure and resources. At the same time, regional and local systems connect to the overall energy and associated digital system, contributing to its stability, resilience, flexibility and efficiency.

Research and demonstration projects pertaining to the implementation plan priorities have been financed under related initiatives such as ERA-NET SES, thus contributing to achieving the working group's positive results in advancing the development of all technologies and solutions in its scope.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

Integrated local and regional energy systems contribute to European security of supply, energy diversification and strategic autonomy. Since energy networks are at the core as well as enablers of the decarbonised energy system, the achievements of the working group are instrumental on the pathway to net-zero emissions.

The continuous alignment of priorities, and the related interactions among the working groups concerned, has contributed to the strengthening of the stakeholders' community and has fostered a willingness to interact and collaborate at European and international levels.

The projects carried out in accordance with the implementation plan are contributing to the advancement of technologies and their applications. There is outstanding advancement when it comes to the goals of observability and flexibility. Furthermore, the Energy systems working group has made

significant contributions to the formulation of the HE CETPartnership strategic research agenda.

MAIN CHALLENGES AND DIFFICULTIES

According to the working group, some of the main challenges include:

- **Resources:** the activities of the working group are not supported directly by any support project or CSA. The work is therefore carried out on a voluntary basis by participants and this raises a risk of under-participation by some working group members. In addition, not all countries that have expressed an interest in the creation of the group are proactive. The limited participation from many parties does not favour the collection of key exploitable results from national and regional projects. This fact limits the real impact of the working group and requires a continuous reference to other initiatives (e.g. ETIP, CETPartnership, ERA-NET) to report results, each being governed with its own framework and financed according to its own rules.
- **Duplication/overlap:** the number of European and international initiatives in the domain of the working group is increasing and the risk of duplication and overlap is real. Examples include Mission Innovation, Power Breakthrough Initiative, CETPartnership TRI 1 and TRI 5. For this reason, high attention is given in the working group to constant coordination and alignment with the other associated initiatives. This ensures that at least from the point of view of the major national funding of projects in the energy system, the national programmes are carried out, at least partially, in respect to jointly decided priorities, thus limiting duplication.

MAIN EXPECTATIONS FROM THE SET PLAN

The leadership team of the working group plans to continue the successful collaboration of the group with the other stakeholders and to further improve the effectiveness of the work.

Several organisations have indicated their strong interest to collaborate and better align with the Energy systems working group, as shown on Figure 9.



ENERGY EFFICIENCY IN BUILDINGS

At the time of writing, the Energy efficiency in buildings working group is revising its implementation plan⁶¹ to align its work with the current EU policy framework. Two key changes, to the two subgroups into which the group is divided, are as follows:

- Subgroup 5.1 targets and activities will be aligned with the Built4People Partnership KPIs⁶² and innovation clusters.
- Subgroup 5.2 targets and activities will be aligned with the ETIP RHC SRIAs⁶³ for heat pumps, DHC, thermal storage, solar thermal and biomass, which were revised last year.

61 https://go.fzj.de/TWG_5_Implementation_Plan_final_endorsed.pdf

62 <https://www.era-learn.eu/network-information/networks/built4people>

63 <https://www.rhc-platform.org/publications/>

MAIN ACHIEVEMENTS

Some of the successful contributions, collaborations and initiatives of this working group are as follows:

- The Energy efficient Buildings (EeB) Public Private Partnership (PPP) Project Review 2021⁶⁴ is an output of the ECTP⁶⁵ and summarises the industry's key innovation achievements from 103 projects between 2014 and 2020. Notably, the innovations achieved an average reduction in energy consumption of ~25% and an average CO₂ reduction of ~24%.
- Several collaborative projects under H2020 have developed contributions to new materials for buildings, such as newly developed components that replace CO₂-emitting Portland cement with Belite-Ye'elimite-Ferrite.
- Other projects have developed key technologies for active building envelopes. Examples include prefabricated panels to reduce energy demand while maintaining the building's aesthetics.
- The construction process requires reliable information to make decisions for process optimisation. In this sense, the use of the Digital Twin data-driven platform for 4D simulation and visualisation of the process allows the synchronisation of as-design and as-built models and the updating of decision-making to data-driven performance.
- The recent work of the ETIP RHC is captured in the Strategic Report on Implementation of Research and Innovation Priorities and Deployment Trends for Renewable Heating and Cooling Technologies⁶⁶. The findings of the report indicate that the RHC SRIA priorities align well with the R&I priorities of the RHC stakeholders and are being implemented. There is a clear trend towards cross-cutting technologies, sector coupling, and integrated or hybrid systems that can increase optimisation and efficiency, as well as increasing integration and cooperation with other renewable technologies. The project database on the RHC platform currently includes more than 160 projects and contains the topics of district heating and cooling, heat pumps, hybrid systems and thermal storage.

SET PLAN'S IMPACT AND ADDED VALUE

The Energy efficiency in buildings Implementation Plan supported the elaboration of the B4P Partnership, its SRIA, and associated KPIs. Information on current EU initiatives which are related to this group, such as the EU Partnerships (e.g. ECTP, DUT, B4P), the

Renovation Wave and the New European Bauhaus, is provided via regular meetings with the stakeholders.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

The main objectives of the working group are the development and implementation of new materials and technologies as well as heating and cooling technologies for energy-efficient buildings in order to achieve a doubling of the renovation rate and the climate neutrality of building stock in Europe.

In recent years, members of the working group have initiated and carried out hundreds of regional, national and EU-wide research and development projects in the building sector.

Members of the working group are involved in the establishment of several EU partnerships. The CETPartnership facilitates joint research and development programmes at regional, national, and global levels supported by industry, public, research, and civil organisations. Another partnership involving members of the working group is the DUT, which aims to strengthen collective efforts towards a sustainable urban development and to put knowledge into action. The B4P Partnership, initiated by ECTP, aims to accumulate people-centric innovations in the built environment, which is realised within the commitment of its partners and a European network of innovation clusters.

Additionally, the working group seeks to collaborate with other SET Plan groups. At the meeting on cross-cooperation between the SET Plan Implementation Working Groups, the Energy efficiency in buildings group was proposed as the focal point for collaboration in the areas of solar heat, geothermal, bioenergy CHP, heat pumps, thermal energy storage, and the integration of district heating and cooling.

MAIN CHALLENGES AND DIFFICULTIES

The Energy efficiency in buildings group conducts its work without funding or CSA support. This makes it difficult to activate, on a regular basis, the industry and research community and the SET Plan countries, and to make tangible and continuous progress. Ensuring a stable financial framework could better support the working group in achieving its goals.

Aligning the extensive and complicated national roadmaps is another significant hurdle. The harmonisation process could be simplified by aligning the individual national roadmaps with the roadmap of the B4P Partnership by identifying complementarities in each.

64 http://ectp.ectp.org/cws/params/ectp/download_files/36D4584v1_EeB_PPP_Project_Review.pdf

65 <https://www.ectp.org/>

66 <https://rhc-platform.org/content/uploads/2021/10/RHC-Report-MRes-1.pdf>

MAIN EXPECTATIONS FROM THE SET PLAN

Some of the expectations of the working group include:

- New initiatives to increase the presence and active participation of Member States and associated countries in the SET Plan, especially the Eastern European countries (e.g. through technical assistance projects, helpdesk etc.).
- A more internationalised SET Plan (e.g. through joint activities with Mission Innovation).
- The revision of specific SET Plan targets to align with the timeline considered for the Renewable Energy Directive targets.
- Revision of the format of the SET Plan to address energy supply, distribution and demand issues in each working group.
- The inclusion in SET Plan priorities of renewable heating and cooling such as solar thermal (in addition to the existing CSP technologies) in the power generation options, not just on the demand side. This would place a stronger focus on heating and cooling.
- The consideration of some additional aspects for inclusion in the SET Plan scope – chip shortages and long supply chain disruptions; rapid ramp-up of production; rapid training of skilled workers along the entire value chain; and large-scale flagship acceleration initiatives.





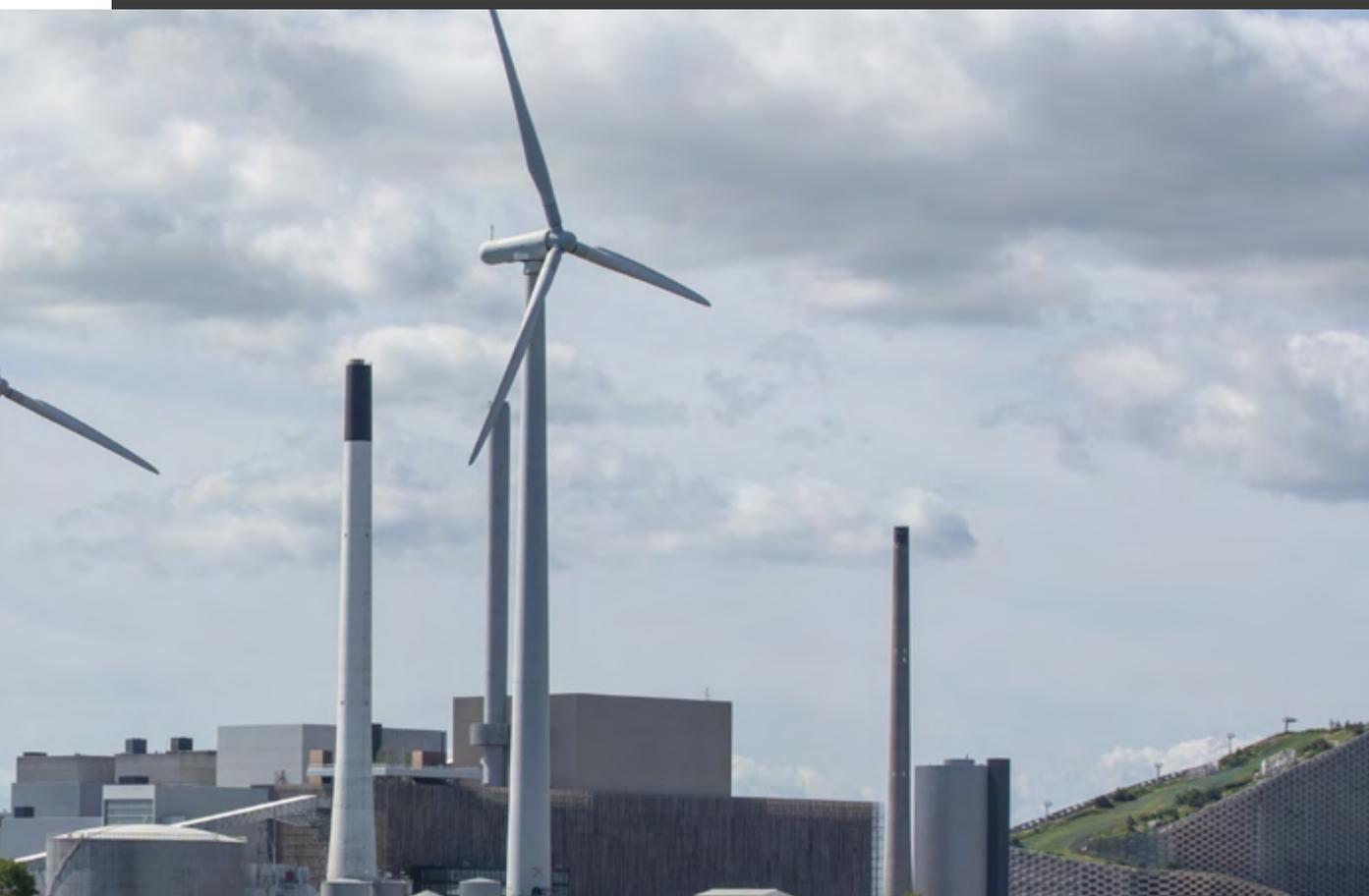
ENERGY EFFICIENCY IN INDUSTRY

In 2021, the Energy efficiency in industry working group revised its implementation plan ⁶⁷ in order to update outdated targets and R&I activities to take into account key industrial developments, and to align its work with the EU policy landscape.

The revised Implementation Plan and working group have increased in scope since its inception in the following ways:

- Inclusion of ‘Cement’ and ‘Pulp & Paper’ as new sectors to aid collaboration and enable their progress towards energy efficiency and emissions reductions;
- Expansion in focus to include emissions reductions as well as energy and resource efficiency to reflect changes in the EU policy framework (such as the European Green Deal);
- Inclusion of ‘Enablers’ and ‘Non-Technical Barriers’ as additional cross-cutting thematic areas of focus for the whole working group;
- Adoption of a longer-term perspective to consider the market uptake of innovative solutions and R&I activities beyond 2030.

⁶⁷ <https://setis.ec.europa.eu/system/files/2021-12/SET%20Plan%20Action6%20on%20EE%20in%20industry-Implementation%20Plan-Rev2021-final-endorsed.pdf>



MAIN ACHIEVEMENTS

Over the past five years, the working group has been an active and prominent player in the industrial sector. The help of the Secretariat⁶⁸ has been a particularly helpful asset for the organisation and facilitation of workshops and similar activities. The working group has been instrumental in bringing stakeholders together and finding synergies.

Some of the main achievements include:

- **Revision of the implementation plan**, with updated and/or refined targets and extension to two new sectors (cement and pulp & paper). Additionally, a roadmap was established for the development and deployment of industrial waste heat recovery.
- **Creation of a new strand of R&I topics** in Horizon 2020 and in Cluster 5 of Horizon Europe, dedicated to energy aspects of the transition in the energy-intensive industries. Launch of the H2020 project CO2OLHEAT⁶⁹ on industrial waste heat recovery and conversion to electrical power.
- As part of the **SPIRE partnership** under H2020, now continuing under Processes4Planet under Horizon Europe, a portfolio of projects is ongoing⁷⁰. Of these projects, there are now technologies/solutions that are ready to go to high TRL at the levels of industrial symbiosis and transition to climate neutrality, CCU and development of heat exchange and upgrade in process industry environment.
- Within the **HYBRIT project** for making steel using green hydrogen, the pilot plant was launched with private and national funding. In addition, a large-scale grant was obtained from the Innovation Fund for its first-of-a-kind full-scale demonstration.
- **Events:** In March 2022, the working group organised a three-day event. During the first day, all SET Plan working groups were invited to a workshop to explore the potential for synergies and cooperation between the various technologies and solutions. The second day was dedicated to the validation of the roadmap for industrial waste heat recovery. During the last day, the stakeholders explored the non-technical barriers to the industrial transition.

68 At the time of writing, the contract with the Secretariat has expired.

69 <https://co2olheat-h2020.eu>

70 Other exemplary projects include: EMB3Rs, INCUBIS, MAESTRI, MEFCO2, TASIO, SUSPIRE, VULKANO, FRESME, ICO2CHEM, SIDERWIN, ETEKINA.

SET PLAN'S IMPACT AND ADDED VALUE

By bringing stakeholders together and finding synergies across the industry, the working group has helped to get publicity and visibility for projects and activities.

In addition, the group has set overall strategic priorities and targets for energy, resource efficiency and emissions reduction while maintaining the competitiveness of the industry. These are valuable inputs for defining national R&I strategies and as a result have strengthened European industrial R&I.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

Some of the main impacts of the working group include:

- **Industrial symbiosis and transition to climate neutrality:** The group has supported a number of actions in CO₂ emission reduction, energy efficiency and the use of emitted carbon. Due to its solid basis in industrial and industrial-urban symbiosis, Hubs4Circularity is well-prepared to move towards enhanced circularity based on geographic proximity – focusing on energy networks (e.g. steam networks, heat networks), CCS/CCU, primary renewable energy connections with hydrogen production, and the circular use of materials and residues (still in the preliminary phase). The next significant stages are expected to be the usage of hydrogen and electrification.
- **Heat and cold management:** The group has advocated for the development of heat exchange and upgrade in process industry environment. The H2020 CO2OLHEAT project was launched for demonstrating supercritical CO₂ cycles for the conversion of industrial waste heat to power. A Roadmap was established for the development and deployment of industrial waste heat recovery, identifying different categories of barrier for waste heat recovery and highlighting the need for demo projects, including the associated project risk.

- Notably for the steel sector, the group has indirectly contributed to the creation of the **Clean Steel Partnership** thanks to meetings of the steel industry and R&I community where the presence of the Commission guaranteed free speech without suspicion of breaching anti-trust rules.

MAIN CHALLENGES AND DIFFICULTIES

According to the EE in industry working group, one of the main challenges has been the **low visibility of the SET Plan**. European industry is made up of many stakeholder groups, and some are not familiar with the SET Plan. A higher profile is needed, even inside the Commission and its publications – it's noted, for example, that the REPowerEU Plan does not make reference to the SET Plan.

Another important challenge is the **decreasing engagement of national representatives** of strongly-industrialised countries in the working group meetings. This is reflected in the failure to establish concrete R&I cooperation between the SET Plan countries in joint R&I ERA-NETs or bi/trilateral cooperation between national R&I programmes. It might be improved to an extent through more visibility of the group's work in SG meetings and SET Plan conferences.

MAIN EXPECTATIONS FROM THE SET PLAN

Some of the expectations of the group include:

- Increased impact of the Implementation Working Group activities by formally providing inputs to the Horizon Europe work programmes, thereby enhancing the attractiveness to SET Plan countries of active participation in the group.
- Regular presentation of the working group's progress to the SG, or during the SET Plan conference, so that its added value can be communicated to the SET Plan countries.
- The use of working group secretariat contracts to organise cross-cooperation sessions.



BATTERIES

Batteries Europe, the technology platform of the European Battery Alliance supported by the European Commission, carries out the activities of the SET Plan working group on batteries. Figure 13 provides more detail on the various European batteries initiatives.

The Batteries Europe Strategic Research Agenda, which was updated in 2020⁷¹, acts as the implementation plan of the group. It was revised to take into account the rapid evolution of battery technology and of the European ecosystem, with the establishment of a domestic battery value chain and new applications in transport and stationary storage.

Some of the key developments include:

- The publication within Batteries Europe of six roadmaps covering R&I needs, along with KPIs along the entire battery value chain.
- The establishment of battery partnership BATT4EU and the BEPA association, and associated commitments to the evolution of battery research for industrialisation.
- The establishment of a widescale group initiative called Edu Network, evolving from the ETIP, focused on battery education and skills development.
- The launch of the first Horizon Europe calls directly related to battery manufacturing.
- The evolution of several new applications for batteries in the maritime, aviation and stationary storage sectors.
- The publication and continued dissemination of the Reporting Methodologies document from Batteries Europe, along with the first attempts to implement such reporting methodologies, in order to create clarity and uniformity in reporting methods for battery performance by the research community.

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https://energy.ec.europa.eu/batteries-europe-strategic-research-agenda_en

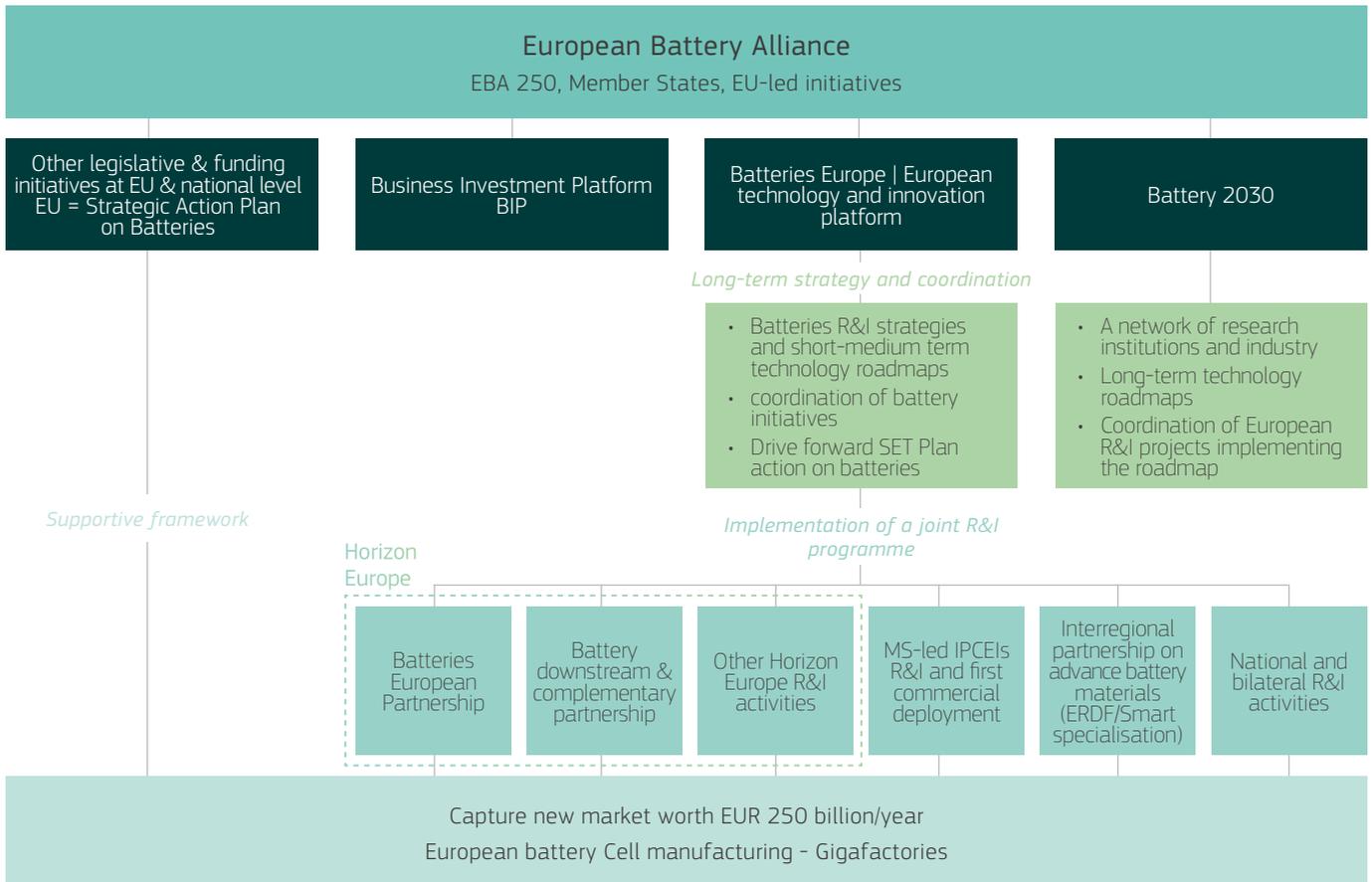


Figure 12: European Battery Initiatives

MAIN ACHIEVEMENTS

1. Batteries Europe ETIP provided the foundation of the European Calls:

- 2019 R&I Topics Document
- 2020 Strategic Research Agenda
- 2020 Benchmarking with J.Power Sources

2. Special Issue 10 Peer-reviewed publications:

- Roadmap Raw materials & Recycling Edt.1
- Overview of European Battery projects available to members 2020

3. 2019/2020/2021 – Performance KPIs – annual updates input to SET Plan Reporting

4. 2021 Position Papers (a. Education & Skills, b. Sustainability, c. Safety, d. Digitalisation)

5. 2021 6 Roadmaps covering Battery value chain

- New and Emerging Battery Technologies
- Batteries Raw Materials & Recycling
- Advanced Materials for Batteries
- Battery Cell Design & Manufacturing
- Mobility Applications
- Stationary Applications

6. 2021 Reporting Methodologies

7. Education Network (Edu Network)

8. National Overview of projects in Europe, which was available on a repository to the stakeholders of Batteries Europe.

SET PLAN'S IMPACT AND ADDED VALUE

Overall impact: The creation of the Batteries Europe ETIP and all the material and knowledge that have been produced, together with the large network of stakeholders it has created, all evolved from work implemented under the SET Plan.

Academic impact: A network where everyone from along the battery value chain working on any type of battery chemistry can be involved and connect with other researchers and industry stakeholders.

Industry impact: A meeting point to discuss and develop KPIs and targets, taking into account users, researchers and more.

Impact at national level: Overview of research gaps in battery energy research.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

Main highlight: The long-term work implemented under the SET Plan over the past years was one of the driving forces behind the establishment and evolution of the battery partnership, BATT4EU.

MAIN CHALLENGES AND DIFFICULTIES

The main challenges identified by the Batteries group include:

- Coordinating the input from SET Plan countries concerning publicly funded projects and their topics.
- Coordinating input about large-scale industrial research in SET Plan countries.
- The limitations of the initial reporting framework. The battery KPIs are complex and very specific to each target application.

MAIN EXPECTATIONS FROM THE SET PLAN

Expectations of the Batteries group include:

- A mission-oriented approach: Given the fast-changing environment, the SET Plan should allow sufficient flexibility to adjust its objectives and implementation plans to the evolving policy landscape, with clear impacts for society.
- Governance: Simplifying certain aspects could facilitate the achievement of mid-term strategic objectives. The Steering Group should form a permanent high level expert structure of the SET Plan, composed of Member States/Associated Countries experts that will guarantee its linear execution. In addition, the main stakeholders (such as ETIPs) should be regularly invited to provide input and feedback on the implementation plan execution.
- Accelerated innovation and deployment: The SET Plan could provide a mechanism for periodic adjustments of national policies in order to reflect EU priorities (for example REPowerEU, Fit for 55 and the European Green Deal).
- Holistic nature: Since it is hoped that the revamp of the SET Plan will increase its strategic importance and political visibility, its high-level objectives and targets should reflect a more holistic approach to the transition. This means embedding not just technologies in implementation plans, but also cross-thematic aspects such as a just transition, energy poverty, citizen engagement, the environment and biodiversity.





RENEWABLE FUELS AND BIOENERGY

At the time of writing, the Renewable fuels and bioenergy working group is revising its implementation plan⁷² to align it with the new policy landscape. Since the last reporting exercise in 2021, there have been no major market developments. The pandemic significantly affected the work of the group.

The solutions within the scope of the working group have significant potential for contributing to climate targets and achieving energy security. Given the right policy context, renewable fuels and bioenergy may make a significant contribution and provide synergies when combined with other energy-related solutions in the energy field, as well as with other areas such as sustainable food production. Currently, the market is in upheaval, as a result of the ongoing energy crisis, and SET Plan countries are changing their policy frameworks related to blending obligations, taxation etc. This once again endangers the long-term stability required for the significant investment that is needed in the short-term.

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https://setis.ec.europa.eu/system/files/2021-07/setplan_bioenergy_implementationplan.pdf



MAIN ACHIEVEMENTS

The group repeated its view that the sector has suffered from a lack of long-term policy frameworks in this domain, reducing the support available and causing some stakeholders to question its viability. This has resulted in limited market uptake even though many technologies have taken several steps up in the TRL scale.

The policy context has improved with the European Green Deal and Fit-for-55 package. As the legislative process for the latter is still ongoing, it is vital to ensure that bioenergy is included through an open and transparent approach.

In general, the working group's implementation plan targets have been underachieved although there are exceptions. The CSA SET4BIO has passed its mid-term and a number of activities supporting the implementation plan have been finalised.

One of the important results is the finalised innovation challenge, where several teams were supported to develop

their ideas and concepts. Nearly all of the participants took several steps towards achieving their targets, thanks to the challenge. The winner of the SET4BIO innovation challenge, BIOCORE, made significant progress and benefitted from expert advice on value chain potential, innovation, business viability and scalability.

In the SET4BIO project, an industry need and gap assessment was carried out. The results showed that 52% of the respondents are familiar with the SET Plan. The interviewees stated that they are carrying out the 13 R&I activities mainly as demonstration and development in the following categories: Advanced Biofuels, Other renewable liquid and gaseous fuels, Renewable Hydrogen, Bioenergy and Intermediate Bioenergy Carriers. There is still a lot of potential for scale-up, especially in the category of bioenergy. SET4BIO developed factsheets mapping bioenergy projects, funding roadmaps and instruments for bioenergy. SET4BIO also carried out extensive dissemination and communication activities promoting the SET Plan and its linked activities.

SET PLAN'S IMPACT AND ADDED VALUE

The SET Plan contributes to the co-ordination of EU research through regular meetings, especially of the core group, and the exchange of information that keeps stakeholders in renewable fuels and bioenergy up to date, as well as allowing them to investigate synergies, avoiding duplication.

The overall benefit of the SET Plan is that it gathers industry, countries, academia and others together, and therefore provides room for consensus, strategy formation and the exchange of views and knowledge.

The topics discussed in the ETIP Bioenergy are mostly preparatory and supportive to the SET Plan implementation plan context. Many of these stakeholder interactions therefore lead to synergies.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

The working group's activities have supported a better understanding of the value chain approach, which is of particular importance for bioenergy and biofuels.

The group has also reinforced the need to look at research and innovation across all Technology Readiness Levels (TRLs), and to take a holistic view of the energy system. This comes at a time of dynamic developments for all renewable energies, market disruptions caused by Russia's war against Ukraine and climate change challenges. All possible alternatives to fossil fuels will need to be considered, and market rollout has to speed up significantly to make a meaningful contribution to climate and energy targets. To this end, renewable fuels and bioenergy could complement other technologies and play an important role.

Throughout 2021, the SET4BIO Innovation Challenge engaged promising and ambitious innovators all over Europe. Leading experts from all stakeholder groups addressed innovation for sustainability through contests. Seven teams demonstrated their accelerated solutions.

The Russian aggression against Ukraine in early 2022 has given renewed importance to decarbonising energy and transport and securing energy and resources. Bioenergy and Biofuels can play an important role in interacting with and complementing other renewables in the green transition. However, under the current policy framework, including

REPowerEU, the role of the working group's technologies remains underrated.

MAIN CHALLENGES AND DIFFICULTIES

According to the group, it is a constant challenge to provide a level of information and detail that attracts wide industry involvement. Industry representatives have limited time to attend meetings and sometimes activities are spread across too many overlapping initiatives. For small and medium sized enterprises it is particularly hard to devote time to meetings unless there are direct business benefits.

The main strategy undertaken to overcome this is to work actively in the core team and drive the tasks in the CSA SET4BIO. For example, activities in SET4BIO attracted a number of start-ups and smaller companies. They were supported to develop their ideas in the SET4BIO innovation challenge and were presented to potential financiers from both public and private initiatives.

An additional challenge is the way in which the SET Plan is used and integrated in each country. The link with the National Energy & Climate Plans is not uniform. To this end, SET4BIO, together with the working group members, has worked towards enhancing cooperation and identifying best practices.

MAIN EXPECTATIONS FROM THE SET PLAN

The renewable fuels and bioenergy group expects the SET Plan to take a comprehensive and integrated view that supports the development of all the working groups. The SET Plan should be fully integrated and able to support EU leadership in the energy research and innovation area by acting as a tool to fulfil the European Green Deal and the underlying work to 2030 (i.e. Fit for 55), as well as the REPowerEU Plan. To this end, it is important that the SET Plan is promoted and made known in broader circles.

According to a recent position paper by the working group⁷³, sustainable bioenergy has a key role to play in reducing GHG emissions in the EU energy mix, while at the same time decreasing fossil fuel dependence and building a circular economy. The promotion of bioenergy in the EU should be based on sound sustainability criteria, including the requirement to reduce GHG emissions significantly without compromising on other environmental impacts.



CARBON CAPTURE AND STORAGE - CARBON CAPTURE AND UTILISATION (CCS-CCU)

In 2020, the CCS-CCU working group revised its implementation plan⁷⁴, having already met some of its original targets. Furthermore, there were important industrial and policy developments that had to be taken into account in the new R&I activities of the group.

Other reasons include:

- Getting the commercial framework right;
- Accelerating timely deployment at scale of CCS and CCU technologies;
- Driving costs down – through R&I, learning by doing and economies of scale;
- Enabling rapid scale-up to deliver on the climate goals;
- Enabling EU citizens to make informed choices regarding the benefits that CCS and CCU bring.

The most recent policy changes that impacted the work of the group and the CCS-CCU industry as a whole include:

- Horizon Europe Work programme 2023-24;
- Mission Innovation: Carbon Dioxide Removal, Clean Hydrogen;
- EU-US cooperation on CCUS;
- Fit-for-55 package – process ongoing;
- CCUS Forum, work programme – process ongoing;
- Hydrogen and Decarbonised Gas Market Package – process ongoing;
- Sustainable Carbon Cycles communication – process ongoing;
- TEN-E Regulation revision;
- EU Taxonomy Climate Delegated Act;
- REPowerEU; and
- IPCC 6th Working Group 3 report Climate Change Mitigation.

Some of the changes that have impact on funding for CCS-CCU projects include:

- Innovation Fund: the results from the first call were very positive, with 6 CCS and/or CCU projects being selected, the second call was also oversubscribed, and the third call will be front-loaded.
- 5th PCI list approved, and linked funding from the Connecting Europe Facility.
- Many new and updated funding schemes at national level (e.g., support scheme for Bio-CCS in Sweden, CLIMIT in Norway, SDE++ in the Netherlands and PIA in France).

MAIN ACHIEVEMENTS

The group has reported increased engagement with the CCUS community, and coordination with other CCUS platforms and projects, strongly increasing stakeholder cooperation on CCS and CCU within Europe and globally. The process of updating the CCUS SET Plan targets in line with the European Green Deal and climate-neutrality goal was considered a particular success as it engaged the whole CCUS community. The group also reports positive progress on all eight R&I activities.

The group also reported the increased emergence and visibility of CCS and CCU technologies, and awareness of what is needed to progress and accelerate research and innovation as well as deployment. The working group has also increased engagement with policymakers on CCS and CCU. As a result, there is substantial momentum for policy development (e.g. TEN-E revision, Sustainable Carbon Cycles, etc.) at EU level.

Crucial flagship projects are moving forward, including Longship/Northern Lights, Porthos and UK clusters. Several CCS and/or CCU projects were selected under the Innovation Fund as well as the 5th Projects of Common Interest list, reflecting the importance of these projects to achieving climate neutrality.

Market-ready projects (to be operational before 2030) are being planned in several European countries, which were further showcased during the CCS-CCU working group public events.

In November 2021, the group launched the CCUS Roadmap to 2030⁷⁵. This was followed by a series of events highlighting CCU and CCS technologies.

SET PLAN'S IMPACT AND ADDED VALUE

According to the group, coordination and support actions are crucial for the development and deployment of CCS and CCU in Europe. The SET Plan work is indispensable – bringing together industry, academia, civil society, and policymakers at EU and national level. The work of the group over the past three years has been successful and well received, and it is crucial that it continues with consistency. The group highlights that the main added value of the SET Plan comes from bringing all stakeholders and policymakers together.

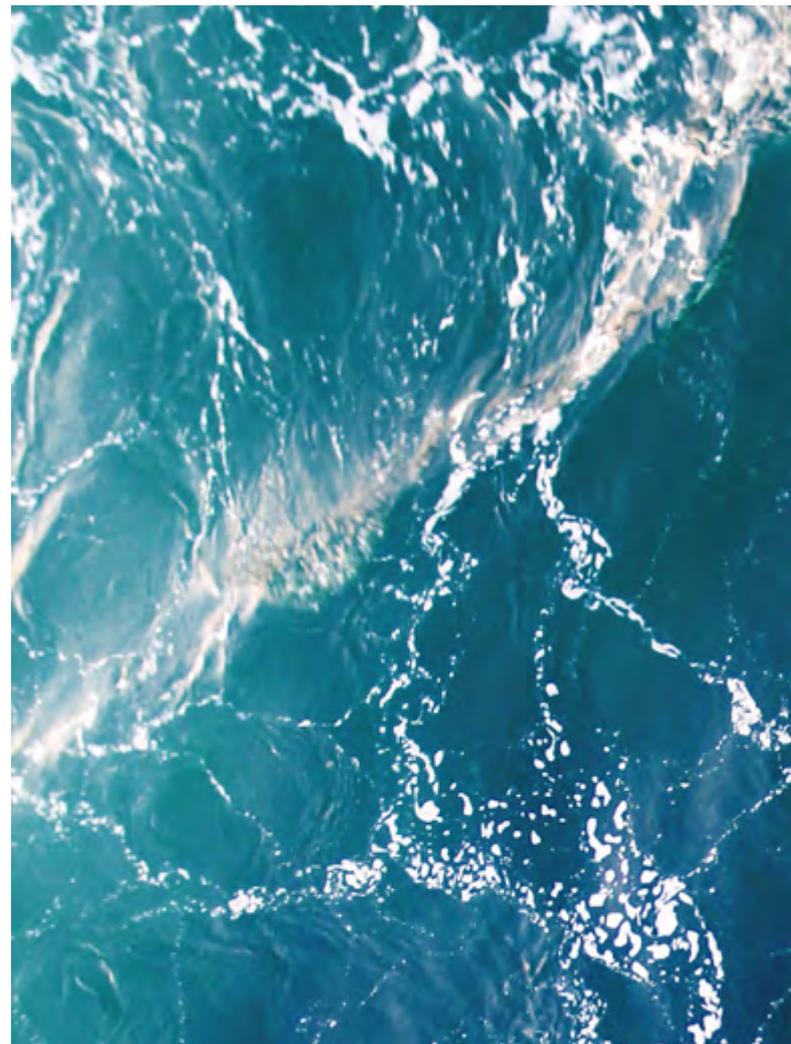
The coordination and support action contributing to the delivery of the R&I activities has been very effective. This constructive collaboration enabled and developed political

dialogue on CCU and CCS at national and EU level. It also increased the willingness of industrial actors to engage with other stakeholders, by providing input on the policy and funding instruments needed to develop and deploy these technologies. Additionally, the successful interaction between different SET Plan working groups enhances collaboration on climate mitigation solutions and promotes cross-industry knowledge sharing.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

According to the group, the main benefits of the SET Plan include:

- advancing opportunities for dialogue on clean technology priorities and providing a coordinating platform to accelerate the deployment of such technologies;
- bringing visibility to innovative projects, by providing advice and input that foster innovation; and



- bringing to the attention of policymakers the challenges faced by industrial actors, by trying to overcome obstacles that prevent CCS and CCU projects from delivering and contributing to climate goals.
- The administrative work related to reporting mechanisms and the implementation plan is time-consuming. This could be improved with fairly simple adjustments to reduce the administrative burden.

MAIN CHALLENGES AND DIFFICULTIES

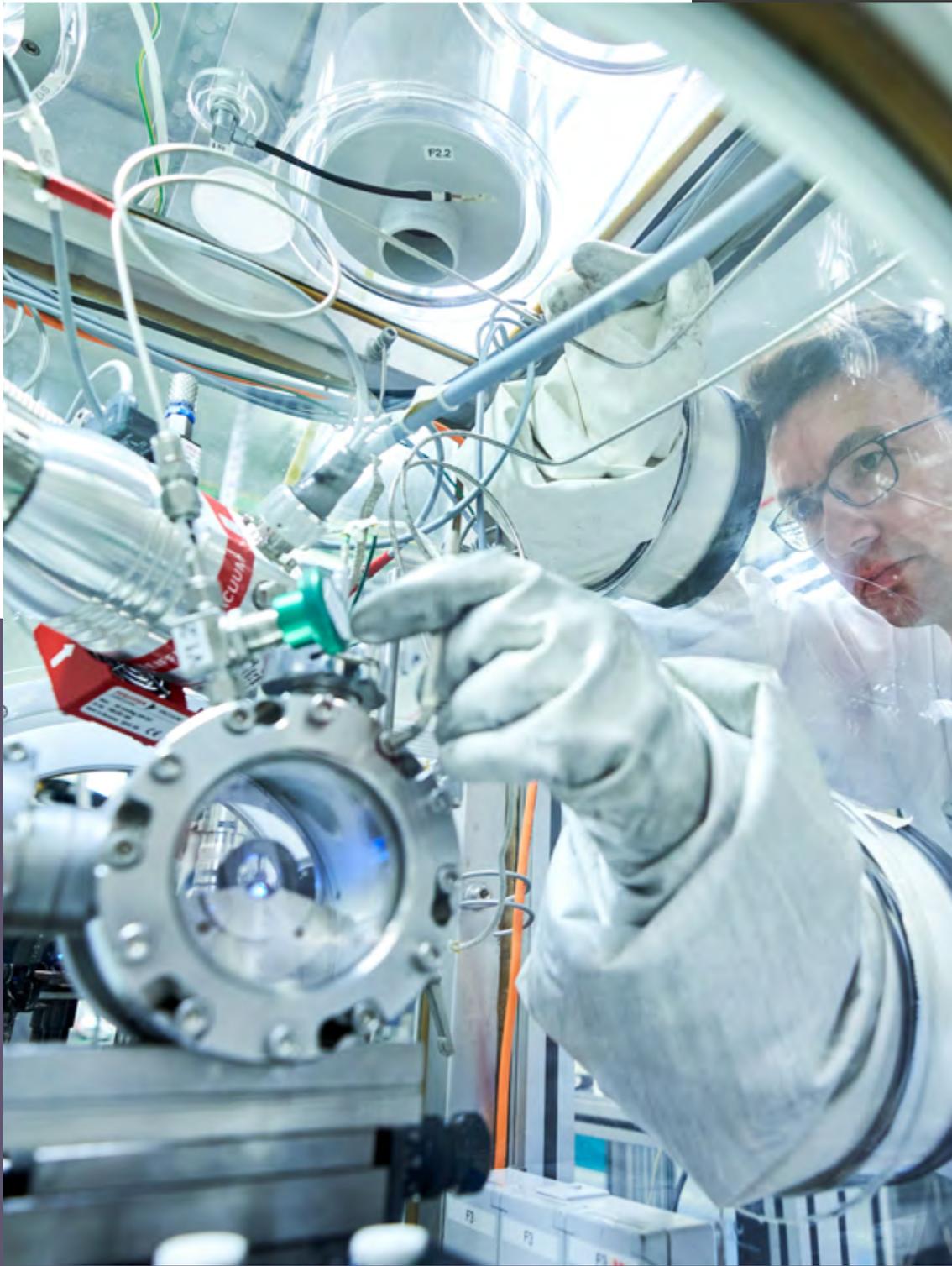
According to the CCS-CCU working group, some of the main challenges to driving and supporting the development and deployment of CCS and CCU include:

- Political recognition of and commitment to CCS and CCU. Public perception is also a challenge, especially for CCS.
- Difficulty in engaging a wider number of SET Plan countries in accelerating their activities towards broader recognition and support of CCS and CCU. This calls for a top-down approach with supportive EU legislation which can be taken up at national level quickly and widely.

MAIN EXPECTATIONS FROM THE SET PLAN

The European Commission has indicated the need for a SET Plan revamp, and the CCUS working group has already taken measures to assess the work and align targets and activities with the European Green Deal and European Climate Law. The CCUS working group has also, together with ETIP ZEP, prepared specific guidelines for applicants of the next Coordination and Support Action (CSA) project within the CCUS sector – describing a pathway towards the next three-year grant period.





NUCLEAR SAFETY

Following its establishment in 2016, the working group on nuclear safety drafted its implementation plan in 2019⁷⁶. The plan is in its original formulation since the targets and actions are still relevant.

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https://setis.ec.europa.eu/implementing-actions/set-plan-documents_en

MAIN ACHIEVEMENTS

Some of the key achievements of the working group include:

- Contributions to the Olkiluoto 3 (OL3) project – an EPR (European Pressurised Water Reactor) plant unit that includes modern proven technology and advanced new safety features. Particular attention has been paid to factors that further increase the safety of the plant, such as the prevention and management of severe accidents, as well as to the efficiency.
- Contributions to various Small Modular Reactor (SMRs) initiatives (e.g. NUWARD-TM, GEMINI4.0) within Europe. SMRs are being developed to help decarbonise power systems efficiently from early 2030. For this purpose, a European pre-partnership has been launched. EU-funded projects (e.g. ELSMOR, ECC-SMART, GEMINI, PASTELS) are being carried out to design methods and tools for stakeholders to assess and verify SMR safety for deployment in the EU.
- A European Joint Programme (EJP) on Radioactive Waste Management, Geological Disposal and decommissioning (EURAD with EUR 62.5 million total budget), launched in June 2019, benefitting from support from the Implementing Geological Disposal of radioactive waste Technology Platform, national/EU/Euratom research programmes, increased cooperation and exchange of good practices.
- An EERA Joint Programme on Nuclear Material (EERA-JPNM) on Innovative materials to improve plant safety and efficiency, and qualification for advanced nuclear fission and fusion systems.
- A European Joint Programme on radiation protection, CONCERT, launched in 2015, followed up by PIANOFORTE as of 2022, benefitting for MENAS associations to implement the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) roadmap.
- A contribution to EUROfusion, the Euratom Joint Programme Implementing the European Fusion technology roadmap, and Fusion for Energy Euratom Joint Undertaking, supporting the construction of ITER and following operation.
- A contribution to MYRRHA (Multi-purpose hYbrid Research Reactor for High-tech Applications) – the world's first large-scale, accelerator-driven system project that offers unparalleled research opportunities in spent nuclear fuel, nuclear medicine and fundamental and applied physics.

SET PLAN'S IMPACT AND ADDED VALUE

In its decarbonisation strategy, the European Commission recognises the continued contribution of nuclear energy in several Member States' 2030 National Energy and Climate Plans; also to energy security, solidarity and trust, a green recovery for Europe and a carbon-neutral economy by 2050. Member States have very different views on nuclear energy but the SET Plan implementation plan is supported by 20 countries, including Switzerland and Türkiye.

The priority remains the safety and long-term operation of current plants (LTO), of new-build, of management of spent nuclear fuel and radioactive waste, a circular economy, and decommissioning activities. The current competitiveness focus is set on developing and constructing on schedule, and on guaranteeing safety for the entire nuclear lifecycle. This involves organisational, operational and regulatory aspects, as well as further research and innovation, the latter often depending on the availability of research infrastructures of pan-European relevance.

To accelerate the transformation of the European energy system and to bring new low-carbon energy technologies to market, the plan identifies R&I actions throughout the innovation chain, including nuclear innovation and technologies enhancing European industrial leadership. Towards 2050, the availability of designs offering increased uranium resource efficiency and lower long-lived waste production may become attractive for utilities, and process heat, SMRs and co-generation plants (e.g. H₂ production) may develop on a shorter timescale.

IMPACT OF WORKING GROUP ON R&I DEVELOPMENTS IN THE INDUSTRY

Nuclear energy, as a low carbon, dispatchable and affordable source, has been recognised by many Member States to be necessary to their energy mix. Currently, there are more than 25 industrial projects (both large nuclear power plants and SMRs) considered in the NECPs of 16 Member States and a few more neighbouring countries.

The SET Plan action on nuclear safety includes ten R&I activities benefitting from increased cooperation and joint programming between the Member States and EU/Euratom, where research consortia, public and private investments involve industry, research centres, academia and technical safety organisations.

Nuclear energy is the largest dispatchable, low-carbon technology, non-weather dependent and therefore already contributing to the EU's GHG emissions reduction, and will continue to do so in the long run. Both the existing fleet that

needs to continue operating, and development and deployment of a new fleet of reactors including SMRs, will help towards achieving a carbon-free European economy. Importantly, nuclear reactors also have a low impact on raw materials consumption compared to other technologies, as well as a small land use footprint.

In addition, SMRs will go beyond power production and will provide capabilities of crucial importance to hydrogen production, heat production for industrial applications, district heating and desalination, among others. Due to its technical characteristics, SMRs can bring benefits to small and remote communities for energy production as well as industrial clusters, which seek a stable and secure electricity or heat source for the development of their industrial activities.

MAIN CHALLENGES AND DIFFICULTIES

Some of the key aspects that require more work according to the group include:

- As the core instrument, aiming to align European and national clean energy research priorities, the SET Plan will be technology-neutral, based on scientific and technical facts. Each technology is working according to its own plan and the synergies so far have been insufficient to become concrete projects and outcomes.
- The innovation is everywhere and can benefit multiple industrial sectors provided that there are no barriers to bringing solutions from the lab to market, and supporting the clean energy ecosystem.

The working group faces the following challenges for the nuclear sector:

- Establishment of long-term visibility of a consistent R&D&I programme that defines clear objectives and adequate milestones and KPIs to enable focused coordination between all interested stakeholders (R&D

centres, industries, regulators, financial institutions, etc.).

- Accelerating and supporting the development of skills and competences in Europe (e.g. SMRs are innovative products that can be highly attractive to the younger generation, from design to realisation).
- Maintenance and development of up-to-date research infrastructures to allow the experimental verification and validation of innovation.
- Access to critical data, design, licensing or equipment to reach a strategic EU autonomy on these technologies, making use of advanced technologies such as AI and IoT.
- Boosting EU competitiveness and ensuring EU independence through the promotion of European SMR models according to local needs. Such projects would be designed and built by European companies using a sustainable and performant supply chain with the help of regulatory harmonisation across the EU.

MAIN EXPECTATIONS FROM THE SET PLAN

To achieve equilibrium between access rights, security of supply, and safety and sustainability in light of social, environmental and economic concerns, as recommended by the European Group of Ethics, it is necessary to establish a technologically neutral approach and allow cross-sectoral fertilisation of innovations.

The SET Plan should be mission-oriented, using a multi-sectorial, multi-disciplinary methodology to increase the overall impact of all the technologies needed to achieve the European Green Deal goals.

Due to recent geopolitical developments, the replacement of Russian-made fuel for the old water-water energetic reactor (VVER) will be an important issue to solve in a coordinated way.







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GLOSSARY

AC – Associated country	EPR – European Pressurised Water Reactor	LTO – Long-Term Operation of current plants
AI – Artificial intelligence	ERA – European Research Area	LV – Low voltage
B4P – Built4People Partnership	ERA-NET – European Research Area Network	MFF – Multiannual Financial Framework
BEPA – Batteries European Partnership Association	ERA-NET SES – European Research Area Network for Smart Energy Systems	MI – Mission Innovation
BEST – Batteries Europe Secretariat	ERRIN – European Regions Research and Innovation Network	MS – Member State
BIP – Business Investment Platform	ESIF – European structural and investment funds	MV – Medium voltage
CCS-CCU – Carbon capture and storage - carbon capture and utilisation	ESTELA – European Solar Thermal Electricity Association	MW – Megawatt
CCUS – Carbon capture utilisation and storage	ETIP – European Technology and Innovation Platform	MYRRHA – Multi-purpose hybrid Research Reactor for High-tech Applications
CDR – Carbon Dioxide Removal	EU – European Union	NECP – National energy and climate plan
CEF – Connecting Europe Facility	EUA – European University Association	PCI – Project of common interest
CETP – Clean Energy Transition Partnership	EUR – Euro	PED – Positive energy district
CHP – Combined heat and power	EURAD – European Joint Programme on Radioactive Waste Management	PPP – Public Private Partnership
CIEMAT – Centre for Energy, Environmental and Technological Research (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas)	F4E – Fusion for Energy	PSA – Plataforma Solar de Almería
CO ₂ – Carbon dioxide	GHG – Greenhouse gas	PV – Solar photovoltaic
CO ₂ VE – Carbon Value Engineering	GW – Gigawatt	RD&I – Research, development and innovation
COP – Conference of the Parties to the United Nations Framework Convention on Climate Change	H ₂ – Hydrogen	RES – Renewable energy source
CSA – Coordination and support action	H2020 – Horizon 2020	RHC – Renewable Heating and Cooling
CSP-STE – Concentrated solar power - solar thermal electricity	HE – Horizon Europe	RRF – Recovery and Resilience Facility
DG – Directorate General of the European Commission	HV – High voltage	RWP – Working Party on Research
DG ENER – Directorate General for Energy	HVDC – High voltage direct current	SAMIRA – Strategic Agenda for Medical Ionising Radiation Applications
DG R&I – Directorate General for Research and Innovation	IEA – International Energy Agency	SET Plan – Strategic Energy Technology Plan
DHC – District heating & cooling	IGDTP – Implementing Geological Disposal of radioactive waste Technology Platform	SETIS – Strategic Energy Technology Information System
DUT – Driving Urban Transitions to a Sustainable Future Partnership	IPCC – Intergovernmental Panel on Climate Change	SG – Steering Group
EBA – European Battery Alliance	IPCEI – Important Project of Common European Interest	SMR – Small Modular Reactor
ECTP – European Construction, built environment and energy efficient building Technology Platform	IRPWind – Integrated Research Programme for Wind Energy	SNET – Smart Networks for Energy Transition
EE – Energy efficiency	ITER – International Thermonuclear Experimental Reactor	SRIA – Strategic Research and Innovation Agenda
EeB – Energy efficient Buildings	IWG – Implementation Working Group	STE – Solar Thermal Electricity
EERA – European Energy Research Alliance	JP – Joint Programme	SU-DG-IWG – Support Unit for the Deep geothermal implementation working group
EGEC – European Geothermal Energy Council	JPI – Joint Programming Initiative	TP – Transition Pathway
EJP – European Joint Programme	JPNM – Joint Programme on Nuclear Material	TRI – Transition Initiative
EP – European Parliament	JPP SES – Joint Programming Platform Smart Energy Systems	TRL – Technology readiness level
	JRC – Joint Research Centre	TSO – Transmission system operator
	KPI – Key performance indicator	TWG – Temporary Working Group
	LCOE – Levelised cost of energy	VVER – Water-water energetic reactor
		WG – Working group
		ZEP – Zero Emission Platform



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