Expanding the Global Reach of the TCPs

A handbook for TCPs and other clean energy initiatives

International Energy Agency

INTERNATIONAL ENERGY AGENCY

The IEA examines the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability and sustainability of energy in its 30 member countries, 8 association countries and beyond.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA

IEA association countries:

Brazil
China
India
Indonesia
Morocco
Singapore
South Africa
Thailand

International Energy Agency
Website: www.iea.org

Acknowledgements

This report was prepared as a collaborative effort between the International Energy Agency (IEA) Energy Technology Policy (ETP) Division in the Directorate for Sustainability, Technology and Outlooks (STO) and the Office of Legal Counsel (OLC). The report's principal authors were Jean-Baptiste Le Marois (STO/ETP) and K.C. Michaels (OLC). Mechthild Wörsdörfer (STO) and Timur Gül (ETP) provided invaluable guidance, comments and feedback. Ruben Davis and Sakeena Moeen carried out interviews and research and provided significant contributions to support the preparation and drafting of this handbook.

We are indebted to the high calibre of advice, information and support provided by participants of the IEA Technology Collaboration Programmes (TCPs), including: the Bioenergy TCP, the Hydrogen TCP, the Hydropower TCP, the Solar Heating and Cooling TCP, the Solar Power and Chemical Energy Systems (SolarPACES) TCP, the Photovoltaic Power Systems TCP and the Wind Energy Systems TCP. This handbook is based on interviews with representatives from these initiatives and institutions, but the recommendations below do not necessarily reflect the views of any of the referenced groups.

Colleagues at the IEA provided inputs throughout the research and reviews, including those in: the Energy Supply and Investment Division (Simon Bennett); the Energy Technology Policy Division (Per Anders Widell, Araceli Fernandez Pales, Claire Hilton and Diana Louis); the Global Energy Relations Division (Nathaniel Lewis-George); the Renewable Energy Division (Paolo Frankl and Kazuhiro Kurumi); and the Strategic Initiatives Office (Simone Landolina). Thanks also to Astrid Dumond, Isabelle Nonain-Semelin and Therese Walsh from the Communications and Digital Office. Justin French-Brooks edited the manuscript.

The Clean Energy Transitions in Emerging Economies programme has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952363

Table of contents

Highlights **5**
Why this handbook? **6**
The world needs a major push in innovation to achieve global clean energy transitions 6
International collaboration is essential, with great opportunities for emerging markets 6
We aim to overcome the challenges to expanding the TCPs' global reach 7
This is a compilation of TCP good practice and guidance for prospective member countries .. 8
1. What are the TCPs and how do they work in practice? **10**
The TCPs are unique multilateral platforms for co-operation on energy innovation 10
The TCPs are a focus for global engagement among IEA members and non-members alike 12
The legal underpinnings of the TCPs have been updated for greater global engagement 16
Understanding the relationship between the TCPs and the IEA 17
Different modes of participation are available for flexible membership of the TCPs 17
2. What are key benefits of TCP membership? **19**
Gaining access to shared resources for energy innovation 19
Shaping the global energy innovation agenda 21
Identifying opportunities to boost technology development 23
Strengthening domestic innovation capacity and expanding knowledge networks 25
Stimulating domestic investment and markets for energy technologies 27
3. How can the TCPs become global and foster participation from more countries? ... **28**
Expanding outreach and raising awareness of TCP activities and impact 28
Addressing concerns over resources and the cost of participation in TCP activities 33
Setting up activities aligned with prospective member country priorities 36
Annex **40**
Abbreviations and acronyms 40

Highlights

The global energy technology community has enormous opportunity to expand international collaboration and broaden the range of countries that participate in joint projects. Achieving this can ensure that the benefits of co-operation – for people and the planet – are realised across the world.

Emerging and developing countries are expected to account for much of future growth in energy demand and are already major markets for new technologies. International collaboration can play a critical role in accelerating innovation and ensuring that new energy technologies, and the associated know-how, reach all countries. The IEA Technology Collaboration Programmes (TCPs) are an important piece of this puzzle and provide a platform for IEA members and non-members alike to work together to accelerate the development of clean energy technologies.

Benefits of TCP membership include opportunities to gain access to shared resources for energy innovation, to influence the global innovation agenda, to identify strengths and gaps in domestic innovation activities, and to find ways to strengthen capacity and stimulate energy technology markets.

There are many opportunities for further countries to get involved in the TCPs, and in turn for the TCPs to become more global. This handbook is based on conversations with key actors from TCPs and decision makers from IEA family countries, who have shared their experience on the challenges and potential solutions to fostering more global participation.

This handbook is aimed at decision makers in prospective member countries who are seeking to understand more about how the TCPs work and identify the possible benefits of TCP membership. It provides general information on the different options for joining TCP activities and the membership process.

The handbook also introduces a selection of good practice approaches and practical steps that the TCPs – and indeed other clean energy initiatives – can take to expand membership, increase participation and foster active engagement, with a focus on emerging and developing economies.

Why this handbook?

The world needs a major push in innovation to achieve global clean energy transitions

Innovation in energy technology will be critical to meeting long-term energy needs and climate targets. The last few decades have seen unprecedented action to accelerate clean energy development, particularly on renewable sources of energy and low-carbon mobility. However, greater progress is needed.

The IEA Tracking Clean Energy Progress reports show that most energy technologies and sectors are not on track to meet global energy and climate goals. Without a major acceleration in clean energy innovation, reaching net zero emissions by 2050 will not be achievable. In the IEA Net Zero Emissions by 2050 Scenario nearly 50% of the CO_2 emission reductions needed in 2050 are from technologies currently at the demonstration or prototype stage. This percentage is even higher in sectors such as heavy industry and long-distance transport, where emissions are particularly hard to abate. Many of the technologies that already exist need to have a lower cost and perform better, and also be adapted to conditions in different countries, for example the climate or local preferences.

International collaboration is essential, with great opportunities for emerging markets

International collaboration will play a vital role in accelerating progress on clean energy innovation and applying it to achieve net zero emissions. Given the scale of the energy and climate challenges, multilateral approaches are needed to improve existing clean energy technologies and develop new ones, and to support their deployment around the world beyond their country of origin. Without international co-operation on the development of technologies, global clean energy transitions could be delayed by several decades.

Partnerships across borders can accelerate global innovation by providing a vehicle for countries to:

- Gain access to shared resources for energy innovation.
- Develop a collective understanding of common priorities and challenges.
- Identify potential opportunities in global clean energy technology supply chains and areas for improvement at the domestic level.

- Strengthen local innovation capacity and knowledge networks.
- Stimulate local markets for energy technologies.

The IEA's own multilateral platforms, the Technology Collaboration Programmes (TCPs), are a unique international network of energy researchers spanning 55 countries, and are a prime example of collaboration in action.

Emerging and developing countries are expected to account for much of future growth in energy demand and are already major markets for new technologies. The number of innovative energy concepts and products developed in emerging markets – such as in Brazil, the People's Republic of China (hereafter "China") and India – is also steadily growing as governments there ramp up efforts to strengthen domestic innovation and capacity for technology development. International collaboration provides an opportunity not only to gain access to technologies and knowledge developed abroad more quickly, but also to showcase home-grown concepts and enable their diffusion through exports. This can be particularly useful in countries where resources for innovation are more constrained (perhaps by R&D and demonstration budgets, the cost of capital or the availability of human capital), or where economic development priorities limit willingness to invest in less-mature technologies.

During the Covid-19 pandemic, travel restrictions limited the opportunities to meet in person and pursue collaborative projects. The TCPs and other multilateral platforms have had to adapt and adjust their working culture and programme of activities accordingly. But the transition to a virtual setting has enabled participants to sustain co-operation and strengthen engagement with their global partners, particularly those who would not typically be able to join in-person meetings due to constrained budgets for international travel. Global co-operation will be critical to achieving sustainable post-Covid recoveries.

We aim to overcome the challenges to expanding the TCPs' global reach

In recent years the global energy innovation community has grown as it welcomes innovators in emerging and developing countries. This has been reflected in participation in the TCPs, which has expanded. Yet many TCPs would still like to bring in new members. So while there have been promising results, more progress is needed, both to broaden the range of participating countries and to fully realise the benefits of collaboration.

Despite strong interest from TCPs to become more global and from many countries around the world to get involved, most TCPs are still predominantly

made up of IEA members. We have therefore compiled this handbook of TCP experiences and good practice recommendations to foster wider membership. We prepared it in close collaboration with TCP participants and based it on a series of interviews with key actors from across the TCP network.

In our discussions, TCP participants frequently mentioned that efforts to secure new members can encounter a number of issues, including:

- Lack of awareness or limited understanding – in the prospective member country – of TCP activities, their impact and the benefits of participating.
- Difficulty in identifying and reaching appropriate contact points in government or industry in new countries.
- Potential members' budgetary and resource constraints, and the cost of becoming a TCP member and taking part in activities proactively over time.
- Concerns that TCP activities may not be fully tailored to the needs of new members, especially in the case of emerging and developing countries.

The TCPs have taken a varied approach to addressing these challenges. Although they share a common legal structure, each individual TCP is unique, and many have developed their own practices and ways of working over the years. In many cases, TCPs have been responsible for developing their own solutions to expand and deepen the participation of new countries.

This is a compilation of TCP good practice and guidance for prospective member countries

In this handbook we have compiled general information on the different options for joining TCP activities and the membership process, plus useful tools and strategies for existing TCP participants and other stakeholders to support the drive for TCPs to become more global. We have provided practical examples with short case studies – featured in boxes – shared by the TCPs.

This handbook addresses two primary target audiences:

- **Decision makers in prospective member countries** who are seeking to identify the possible benefits of TCP membership and better understand the process and expectations before taking part in activities.
- **TCP participants** who are interested in expanding the TCP membership base to become more global, and who are looking for good practice approaches or possible strategies to foster participation among new countries.

This handbook is structured as follows:

- Chapter 1 provides an overview of what TCPs are and how they work in practice, including their legal underpinnings, the options for participation and current level of global engagement.
- Chapter 2 examines the various benefits of TCP membership – for both member countries and the TCPs – with a focus on what prospective member countries might gain from taking part in TCP work, providing a clearer understanding of the TCPs' value proposition.
- Chapter 3 identifies strategies to broaden and deepen global engagement within the TCPs. It includes options to tackle the current challenges to greater engagement and active participation, and ideas and suggestions for potential members and participants on ways to counter resource constraints and make the most of their participation in TCPs.

1. What are the TCPs and how do they work in practice?

Summary

- The IEA established the TCP mechanism to provide a multilateral platform for countries to work together to accelerate innovation and deployment of energy technologies. There are currently 38 TCPs working across the energy sector, including in end-use technologies, renewable energy, fossil energy, and nuclear fusion power.
- The TCPs are one of the IEA's premier global outreach tools as they are open to membership from all countries. In recent years the IEA has focused on modernising the TCP mechanism to facilitate even greater participation from countries beyond the IEA family.

The TCPs are unique multilateral platforms for co-operation on energy innovation

The TCPs are a unique international network for energy technology research, a focus for multilateral co-operation where governments and other stakeholders come together to pursue a wide range of activities related to energy technology innovation. These activities include research, development and demonstration (RD&D), analysis, dissemination, knowledge sharing and scientific exchange. Many TCPs undertake applied research and innovation activities, while some carry out fundamental research. Currently there are 38 individual TCPs working across several technology or sector categories, embracing end-use technologies (buildings, transport, industry and electricity), renewable energy and hydrogen, fossil energy, and nuclear fusion power. Collectively the TCPs are made up of thousands of experts across government, academia and industry, representing almost 300 public and private institutions in 55 countries.

Known as "Implementing Agreements" prior to 2016, the TCP mechanism was established in 1975, the same year as the IEA. In total some 81 TCPs have been created in the past four decades, spanning virtually every facet of energy technology. Many of the original TCPs still exist today, but have over time adapted their programme of work to address emerging technologies specific to their energy topic or sector.

Each TCP is driven by the needs and goals of its individual members, which can include IEA members and non-members alike. While the primary actors in most TCPs are governments or public research institutions, non-governmental organisations and institutions, including corporates, may also participate in certain contexts, such as when they are designated by their government. The TCPs are an important part of the IEA family, but they are functionally and legally autonomous and are not formally part of the IEA.

The activities of each TCP are overseen by an Executive Committee (ExCo) comprising representatives designated by each participant. The ExCo makes decisions on the management, participation and implementation aspects of the TCP. The ExCo also decides on the specific work programme of the TCP, which is executed through a series of specific projects or undertakings – usually known as "Tasks".

Overview of active TCPs in 2021

Category	TCPs
Buildings Innovation activities relating to efficiency gains in buildings, such as heat pumps, district heating and cooling and energy storage	1. Energy in Buildings and Communities (EBC TCP) 2. District Heating and Cooling including Combined Heat and Power (DHC TCP) 3. Energy Efficient End-Use Equipment (4E TCP) 4. Energy Storage (Energy Storage TCP) 5. Heat Pumping Technologies (HPT TCP)
Cross-cutting Cross-cutting activities relevant to all energy sectors and sources, including energy scenario modelling, and women's participation in clean energy	1. Clean Energy Education and Empowerment (C3E TCP) 2. Energy Technology Systems Analysis Program (ETSAP TCP)
Electricity Activities relating to innovation in electricity systems, such as smart grids, demand-side management and superconductivity technology	1. User-Centred Energy Systems (Users TCP) 2. High Temperature Superconductivity (HTS TCP) 3. International Smart Grid Action Network (ISGAN TCP)
Fossil energy Focusing on technologies to reduce costs and enhance the sustainability of fossil fuels, including carbon capture, utilisation and storage, enhanced oil recovery and fluidised bed conversion technology	1. International Centre for Sustainable Carbon (ICSC TCP) 2. Enhanced Oil Recovery (EOR TCP) 3. Fluidized Bed Conversion (FBC TCP) 4. Gas and Oil (GOTCP) 5. Greenhouse Gas R&D Programme (GHG TCP)

Category	TCPs
Fusion power Fundamental and applied research, including device-specific research and cross-cutting research into materials and safety	1. Environmental, Safety and Economic Aspects of Fusion Power (ESEFP TCP) 2. Fusion Materials (FM TCP) 3. Nuclear Technology of Fusion Reactors (NTFR TCP) 4. Plasma Wall Interaction (PWI TCP) 5. Reversed Field Pinches (RFP TCP) 6. Spherical Tori (ST TCP) 7. Stellarators and Heliotron (SH TCP) 8. Tokamak Programmes (CTP TCP)
Industry Enabling greater industrial energy efficiency and supporting innovation for cost-effective industrial technologies and system configurations	1. Industrial Energy-Related Technologies and Systems (IETS TCP)
Renewable energy Related to renewable energy sources and hydrogen, including bioenergy, solar, wind, geothermal, hydropower and ocean energy	1. Bioenergy (Bioenergy TCP) 2. Solar Power and Chemical Energy Systems (SolarPACES TCP) 3. Geothermal Energy (Geothermal TCP) 4. Hydrogen (Hydrogen TCP) 5. Hydropower (Hydropower TCP) 6. Ocean Energy Systems (OES TCP) 7. Photovoltaic Power Systems (PVPS TCP) 8. Solar Heating and Cooling (SHC TCP) 9. Wind Energy Systems (Wind TCP)
Transport Research and analysis of technologies such as fuel cells, electric vehicles and emission reductions in combustion, as well as advanced materials and fuels	1. Advanced Fuel Cells (AFC TCP) 2. Advanced Materials for Transportation (AMT TCP) 3. Advanced Motor Fuels (AMF TCP) 4. Clean and Efficient Combustion (Combustion TCP) 5. Hybrid and Electric Vehicles (HEV TCP)

Source: List of active TCPs as of October 2021.

The TCPs are a focus for global engagement among IEA members and non-members alike

Since the early days of the programme, the TCPs have been an important mechanism for IEA member countries and countries from beyond the IEA to engage one another. Under the current version of the TCP framework, IEA member, accession and association countries have the same rights and responsibilities in the TCPs (see Glossary of terms relating to IEA membership

status). Countries from beyond the IEA family are also encouraged to participate in the TCPs, but each country needs the prior approval of the IEA Committee on Energy Research and Technology (CERT) before it can join a TCP for the first time. More information is available in the TCP Guide on the IEA website.

At the moment most TCPs are predominantly made up of IEA members. Nonetheless, many TCPs have a diverse membership that includes many non-member countries. In recent years the TCPs have seen their participation grow strongly to include key emerging economies. However, there is ample room for progress and the degree of participation in the TCPs varies by country, membership category and technology focus area.

Glossary of terms relating to IEA membership status

IEA member countries. The IEA consists of 30 member countries, all of which are a member of the OECD and fulfil a range of requirements necessary to be a member country, plus the European Union as an observer and major partner.

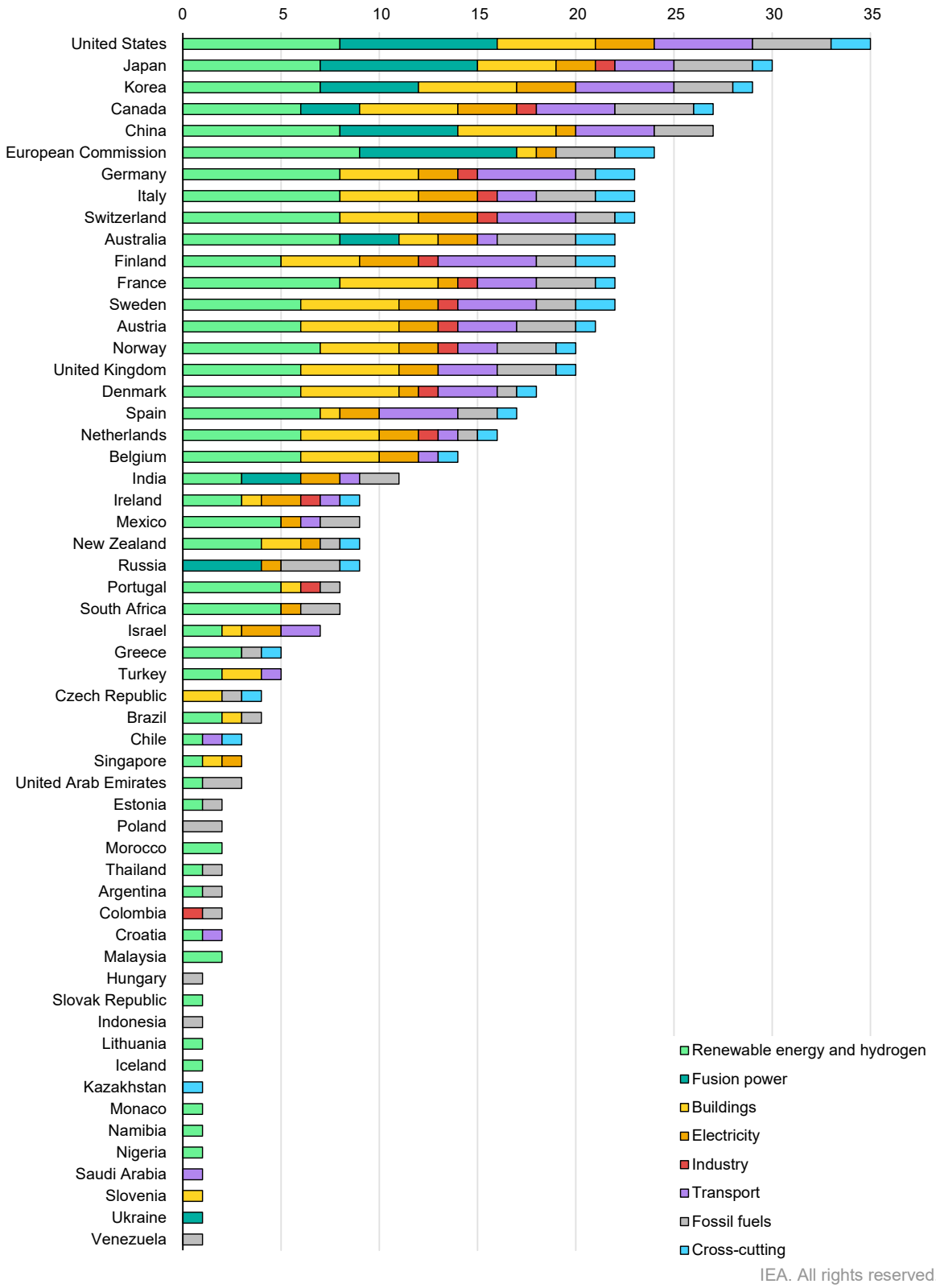
IEA association countries. The IEA sustains close relationships with governments and other energy stakeholders in eight non-member countries: Brazil, China, India, Indonesia, Morocco, Singapore, South Africa and Thailand.

IEA accession countries. The IEA counts three non-member countries that are currently seeking full membership: Chile, Israel and Lithuania.

IEA family countries. The IEA family refers to IEA member, association and accession countries alike. Under the TCP Framework, IEA family countries have the same rights and responsibilities in the TCPs.

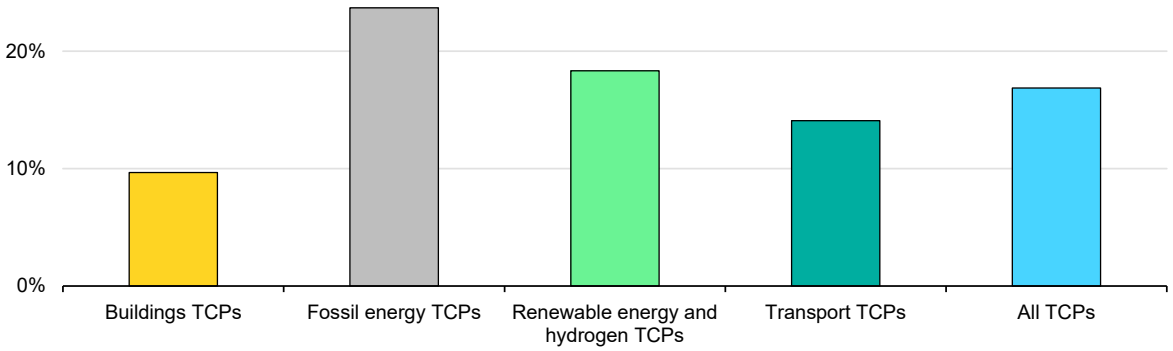
IEA Clean Energy Transitions Programme (CETP). Established in 2017, the CETP capitalises on the IEA's unique energy expertise across all fuels and technologies to accelerate global clean energy transitions, particularly in major emerging economies. CETP activities include collaborative analytical work, technical co-operation, training and capacity building and strategic dialogue. Target countries include Brazil, China, India, Indonesia, Mexico and South Africa, as well as other IEA association countries and key regions such as Southeast Asia, Latin America and Africa.

Participation in TCPs by country and technology focus area



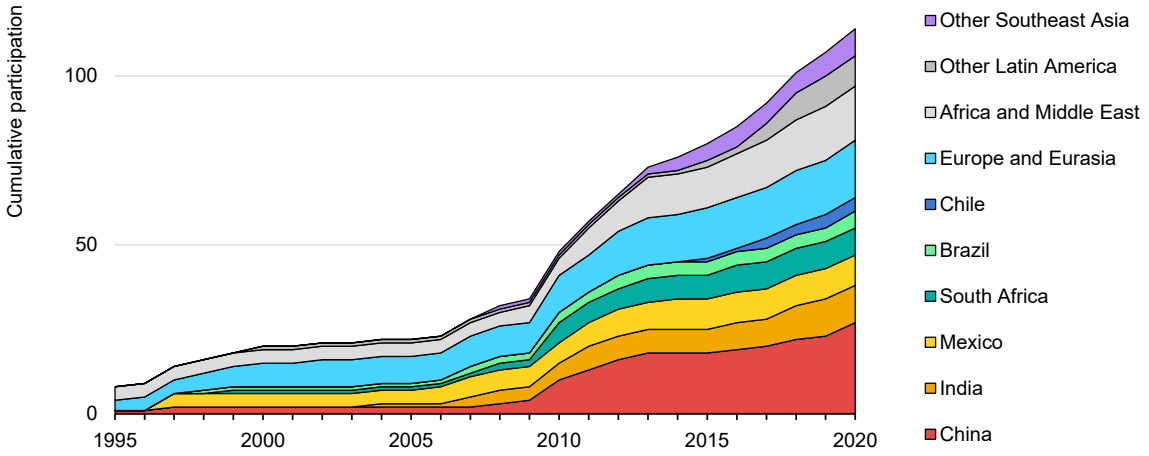
Note: Participation numbers as of 24 August 2021.
Source: Adapted from IEA Tracking Clean Energy Innovation.

Share of TCP members that are IEA association, accession or other non-member countries, in selected technology focus areas and all TCPs



Note: Participation numbers as of 24 August 2021.

Cumulative participation of IEA non-members in the TCPs over time



Notes: Participation numbers as of 2020. “Europe and Eurasia” comprises Croatia, Iceland, Lithuania, Monaco, Slovenia, Kazakhstan, Ukraine and the Russian Federation; “Africa and Middle East” comprises Israel, Morocco, Saudi Arabia, the United Arab Emirates, Namibia and Nigeria; “Other Latin America” comprises Argentina, Colombia and Venezuela; “Other Southeast Asia” comprises Indonesia, Malaysia, Singapore and Thailand.

The legal underpinnings of the TCPs have been updated for greater global engagement

The legal basis for the TCPs comes from the IEA Framework for the Technology Collaboration Programme, the most recent of which was adopted by the IEA Governing Board in 2020. The framework describes the basic structures common to all TCPs, defines who may participate and sets out the TCPs' relationship to the IEA and its governing bodies. Each individual TCP is then organised under a separate legally binding Implementing Agreement that establishes the specific terms and conditions for participation in the TCP.

The framework was most recently updated in April 2020, after having been unchanged since 2003. Since that time, the field of energy technology innovation has continued to evolve away from the traditional notions of technology-based R&D to a system-level approach, which requires greater collaboration across fields.

Within this context, the updated framework seeks to update the existing legal structures to enable the TCP network to develop new creative approaches and enhance their reach. Following adoption of the framework, the IEA is working with the TCPs to fully implement these improvements with five broad priorities:

1. Deepening engagement with emerging economies.
2. Further improving the way the IEA Secretariat works with the TCPs.
3. Introducing new mechanisms to engage with industry.
4. Encouraging a stronger role for external partnerships and collaborations.
5. Simplifying administrative processes and procedures.

Since the previous update to the framework in 2003, the TCP network has been responding to the new challenges brought about by shifts in the nature of energy innovation. The TCPs have increasingly been collaborating across topical areas and broadening the range of stakeholders engaged in their work, particularly through increased engagement with emerging economies and multilateral partnerships. The 2020 updates reinforce these trends and provide new engagement tools for the TCPs to use as they seek to widen and deepen engagement.

Understanding the relationship between the TCPs and the IEA

The TCPs are not formally part of the IEA and are functionally and legally autonomous. The IEA does not provide them with direct financial support and is not generally involved in their day-to-day operations.

Nevertheless, the TCPs are overseen by the CERT and its four Working Parties on fossil energy, renewable energy, energy end-use technologies, and fusion power.[1] Under the TCP legal framework, the TCP ExCo is empowered to make most decisions regarding the TCP's activities, but the CERT retains a role in certain decision-making processes, such as the approval of term extensions and new Sponsors (see below), and also provides strategic guidance across the TCP network.

In addition, the IEA Secretariat closely follows the work of each TCP and provides guidance, advice and support by acting as a conduit between the TCPs and policy makers, strengthening interlinkages with other multilateral mechanisms such as Mission Innovation and the Clean Energy Ministerial, and by promoting TCP outcomes where possible. The Clean Energy Technology Guide, which is a living resource published as part of Energy Technology Perspectives 2020, is a concrete outcome of IEA-TCP collaboration. The Today in the Lab – Tomorrow in Energy? initiative highlights research projects under development in the TCPs. The IEA Office of Legal Counsel also provides legal advice in relation to the TCPs' processes, procedures and the legal structure.

Different modes of participation are available for flexible membership of the TCPs

The TCPs offer three possible categories of membership. In general, governments and other public institutions join as **Contracting Parties**, while private organisations typically join as **Sponsors**. The **Limited Sponsor** is a new participant type created in 2020 that is open to private organisations on a limited basis and under certain conditions. Additionally, a variety of mechanisms are available for external organisations to work together with a TCP on joint projects without formally joining a TCP. This may include establishing a joint partnership

[1] There is also a Working Party on Energy Efficiency, which reports to the IEA Standing Group on Long-Term Co-operation (SLT), but is not responsible for any TCP.

or other collaborative arrangement. A step-by-step guide explaining the membership process for each of these participation categories is available in the TCP Guide on the IEA website.

Overview of the different options for participating in the TCPs

Type	Description	Rights and conditions
Contracting Party	**Government entity:** Any national government, the European Commission, or any intergovernmental organisation **Designated entity:** Any public, quasi-public or private entity designated by any of the above	• May appoint representatives to the ExCo • May serve as Chair or Vice-Chair of the ExCo • May participate in all Tasks and activities • Has full voting rights • Pays fees (if any) established by the ExCo • Prior approval of the CERT is required for new participants that are not IEA member, accession or association countries
Sponsor	Any quasi-public or private entity that has not been designated as a Contracting Party	• May appoint representatives to the ExCo • May participate in all Tasks and activities • Has limited voting rights • Pays fees (if any) established by the ExCo • The ExCo may specify other conditions • Prior approval of the CERT is required
Limited Sponsor	Any quasi-public or private entity from an IEA member, accession or association country	• Has no official representatives on the ExCo • May participate in only one Task • Has no voting rights • Pays fees (if any) established by the ExCo • Participation limited to three years • The ExCo may specify other conditions • No prior approval of the CERT is required
Joint Partnership	Any multilateral initiative or external organisation seeking to carry out joint work with the TCP	• Has no official representatives on the ExCo • May form part of “Joint” Tasks • Any contributions and joint work programme are agreed by negotiation • No prior approval of the CERT is required

Notes: ExCo = Executive Committee. CERT = IEA Committee on Energy Research and Technology. A detailed explanation of the process to join a TCP for each participant type can be found in the TCP Guide.

2. What are key benefits of TCP membership?

Summary

- This chapter examines the various benefits of joining a TCP, with a focus on the possible gains from taking part in TCP activities for prospective participants, providing a clearer understanding of the TCP's value proposition.
- Joining one or more of the TCPs can bring tangible benefits, especially for countries seeking to build up domestic capacity or without a long history of indigenous energy technology development.
- Benefits may include:
  (i) Gaining access to shared resources for energy innovation with other countries and improving the quality of technology development through collaboration.
  (ii) Influencing the global innovation agenda, and bringing attention and expertise to domestic priorities or needs.
  (iii) Identifying domestic strengths and pressing gaps in energy innovation to inform priority setting and address technical and non-technical barriers to the introduction of new energy technologies.
  (iv) Strengthening domestic innovation capacity and expanding knowledge networks, particularly with international peers.
  (v) Stimulating domestic investment and markets for energy technologies.

Gaining access to shared resources for energy innovation

Energy technology development is expensive, uncertain and risky. Resources that governments and companies allocate to energy innovation or the uptake of emerging technologies are generally limited in comparison with other investments in the energy sector. In 2020 governments spent about USD 32 billion on energy R&D (of which 80% was for low-carbon technology development) and globally listed corporations about USD 90 billion. This remains small relative to global energy investment estimated at USD 1.9 trillion in 2021.

Resources available for energy RD&D are typically more constrained in smaller and emerging or developing economies. In some instances, governments find it

challenging to provide steady flows of investment for technology innovation relative to other energy policy priorities, such as expanding energy access or improving energy security and reliability. Budgets for high-risk but potentially breakthrough initiatives can therefore suffer. Periodic economic crises and "stop-go" support for innovation – in which public R&D funding becomes volatile – have hindered innovation in many regions.

The TCPs enable their members to get more out of domestic innovation activities at similar levels of investment by leveraging international experience and linking domestic innovation activities across borders. Through multilateral activities in the TCPs, countries pool some of their resources and knowledge to foster global energy technology development and accelerate the deployment of emerging technologies and concepts. This may be done either through direct collaborative RD&D of technology and infrastructure, or through exchanges of information, data, personnel, equipment and good practices (see case study on Namibia).

Direct access to global knowledge and expertise from leading institutions brings more value added than relying on publicly available information. Members can receive tailored advice, guidance and feedback based on local conditions, needs and priorities. Learning from other country experiences and TCP insights and data can help:

- Identify potentially costly roadblocks or dead ends in technology development (e.g. for complex projects at risk of cost overruns and delays).
- Better allocate domestic R&D investment to focus on local needs or frontier technologies.
- Leverage comparative advantage based on existing capacity and domestic strengths.
- Avoid duplication of effort from parallel global activities.

A broad variety of innovation actors may benefit from TCP experiences, including researchers, academics and R&D managers in fields relevant to energy, government officials overseeing innovation programmes, energy policy makers and regulators, investors and entrepreneurs.

Membership of multilateral partnerships for energy innovation such as the TCPs can complement, support and increase the potential of domestic projects, and may help increase the value for money of public investment in innovation activities.

Case study: Concentrated solar power in Namibia

Namibia's national power utility, NamPower, has been developing a concentrated solar power (CSP) project in recent years, benefiting from membership of the SolarPACES TCP. Among other achievements, Namibia has proactively taken part in the preparation of a report led by the TCP examining best practices in the construction and operation of CSP plants. Activities included the first-ever collection of data from among TCP members, with a focus on identifying critical roadblocks and proposing tailored solutions. These have contributed to smoother and more effective project design and management, to the benefit of NamPower and the project.

Countries new to developing certain energy technologies, or seeking to deploy first-of-a-kind commercial facilities, stand to benefit from TCP experience. There are valuable insights to learn from decades of cumulative experience in other countries, which can help avoid potentially costly mistakes, accelerate equipment upgrading to potentially enable leapfrogging, and contribute to developing the local pool of energy experts and talents.

Shaping the global energy innovation agenda

To be successful in all kinds of settings, energy transitions need new technologies and the adaptation of existing technologies to meet the local requirements, needs and climates of many countries with no legacy of energy technology development. These countries have the opportunity, through the TCPs, to increase the recognition of specific and local contexts.

TCP members collectively contribute to shaping the global innovation agenda across energy technologies by setting priority areas for collaborative work. On becoming a TCP member, countries have the opportunity to bring attention to local challenges or needs and become a focus of international expertise (see case study on Brazil). While accessing publicly available information can be a starting point in many instances, membership opens the possibility of setting up projects dedicated to specific domestic opportunities for the development of new technology, or the deployment of emerging technologies developed elsewhere, mobilising data, insights and resources accordingly.

The TCPs also stand to benefit from new and diverse perspectives as they set work priorities. Research institutions from existing member countries can learn from new contexts and explore emerging ideas and concepts that might have been otherwise overlooked. Industry actors may be attracted by the prospects and

advantages of bringing new energy products and services to market. Over time, the overall TCP agenda and programme of work may also increasingly include focus areas that appeal to other prospective member countries.

Furthermore, TCP membership creates the opportunity to feed into the IEA's broader programme of work and analytical outputs, which regularly draw from TCP expertise and data. The IEA collaborates closely with the TCPs to improve global understanding of technology readiness levels and market uptake rates, key players and projects, performance and cost trends and forecasts, and pressing needs or gaps to be addressed. The TCP member countries benefit from being appropriately represented in IEA outputs – which entails proactively sharing data and information on local developments with peers – and can typically access the latest findings and data, as well as market insights.

Case study: Brazil's contributions to the Hydropower TCP

Upon becoming represented on the ExCo of the Hydropower TCP in 2007, Brazil had the opportunity to propose strategies and themes for TCP activities, as well as to discuss those put forward by other member countries. This participatory process allowed for mutual priorities to be aligned.

Brazil notably proposed a Task on measuring greenhouse gas (GHG) emissions from hydropower installations. Following this proposal, in 2009 the Hydropower TCP launched a Task on Managing the Carbon Balance of Freshwater Reservoirs under its Hydropower & the Environment programme of work. The Task is led by Brazil's Electrical Energy Research Centre (CEPEL) and in collaboration with universities and research institutions from Brazil and other member countries. The activities, some of which are still ongoing, aim to increase knowledge of processes linked to reservoir GHG emissions and establish standardised guidelines and methodologies to study the carbon balance in reservoirs.

Between 2012 and 2018 the TCP published three volumes introducing the world's first "Guidelines for the Quantitative Analysis of Net GHG Emissions from Reservoirs". As it had proposed the activities, Brazil took an active part in shaping and co-leading the preparation of these TCP outputs – tangible global contributions that bring direct value to Brazil. These volumes may, for example, be useful for hydropower project developers seeking to meet specific GHG emission requirements to access funding.

In 2021 the Hydropower TCP also published a report and White Paper on the role of flexible hydropower in renewable energy integration, "Valuing Flexibility in Evolving Electricity Markets: Current Status and Future Outlook for Hydropower".

This work drew from international case studies and survey responses from TCP members, including Brazil, Colombia and India, which were considered alongside IEA member countries such as Australia, Canada, Germany, Japan, Norway, Switzerland and the United States. This diversity of perspectives illustrates how inputs from emerging and developing economies can influence global discussions through TCP projects and, in this case, strengthen the case for hydropower globally.

Identifying opportunities to boost technology development

The clean energy transition presents significant opportunities for countries seeking to build their domestic innovation capacity and position themselves in global supply chains for clean energy technologies. In recent years a number of major emerging and developing economies, including China and India, have signalled their ambition to become net producers of knowledge – that is, generating more knowledge domestically, developing more home-grown concepts and relying less on the import of technologies invented, developed or manufactured abroad.

A strategic approach for such countries is to focus on specific local needs and explore opportunities based on pressing innovation gaps (e.g. in performance or cost), existing capacity and comparative advantage. This is especially true in countries where R&D budgets might be limited, to avoid fragmenting resources across a large number of projects in different technology areas by prioritising some of them.

Membership of the TCPs helps countries benchmark themselves against regional and global front-runners and identify domestic strengths, potential opportunities, gaps and areas for improvement. New members can draw on TCP activities to assess their relative ability to innovate, develop, manufacture or deploy effectively in a given technology area. Among other benefits, TCP members gain from collective experience in:

- Compiling uniform and comparable data across countries and regions to enable effective benchmarking (e.g. technical, performance and cost specifications, life-cycle analyses).
- Testing new and existing technologies under various operating conditions (e.g. climate and geo-physical constraints, safety or environmental impact, specific local needs or requirements).

- Developing technology guidelines and standards to ensure global comparability and compatibility.
- Assessing the potential for energy technologies in different countries and regions, anticipating possible technical and non-technical barriers to their introduction and deployment, and identifying the market and policy conditions that may best enable diffusion of new concepts.

Case study: Identifying global good practice for PV development and emerging market segments and applications

TCP activities typically include analyses of technology cost, performance, policy and market trends. The TCPs produce country, technical and market reports, as well as annual TCP reports, compiling the latest intelligence in a comparative way and with the broadest possible geographical scope. This opens the opportunity for countries to benchmark themselves against global progress on technology development and deployment, and to identify areas of domestic strength.

Under its Task 1, "Strategic PV Analysis and Outreach", the PVPS TCP publishes an annual report on "Trends in Photovoltaic Applications". The 2020 edition compiled the latest data and provided comparative analysis of market development trends, policy frameworks and support schemes, and technology costs for different segments and applications across the world. The report included detailed information on emerging markets based on the experiences of and data collected in PVPS TCP member countries (e.g. Chile, China, Malaysia, Mexico, Morocco, South Africa, Thailand and Turkey) as well as non-member countries (e.g. Argentina, Brazil, Colombia, Egypt, India and Viet Nam). The report explored emerging technology concepts and opportunities, including off-grid energy access, combined solar and energy storage systems, floating solar, agricultural applications, buildings integration and recycling.

Such publicly available reports constitute valuable resources for governments to inform energy technology policy choices and identify domestic opportunities to boost PV development. TCP member countries take part in the entire process underpinning the preparation of these resources – from data collection and analysis to identifying good practice approaches – and are therefore able to fully realise the benefits of collaboration and mutual learning.

Strengthening domestic innovation capacity and expanding knowledge networks

Developing an effective domestic innovation ecosystem for a given energy technology is difficult, costly, may take years or decades – if successful – and requires concerted effort from a broad range of stakeholders. This can be challenging for countries seeking to adopt or develop new technology concepts quickly to meet pressing domestic energy needs, including energy access, security and sustainability.

Membership of the TCPs can help build up domestic innovation capacity more quickly. New members can benefit from mentorship guidance upon request in some instances. Members have direct access to training programmes, regular information sharing, and peer-to-peer expert advice based on the collective experiences of other members (see case study on Southern Africa), all of which are typically unavailable in the public domain. The areas covered relate to:

- Collecting, managing and analysing data.
- Designing and carrying out R&D, demonstration and infrastructure projects.
- Setting up laboratory or innovation facilities or equipment.
- Monitoring and evaluation of research activities to feed back into innovation priority setting.
- Setting up simulations and using best practice methodologies.
- Strengthening domestic knowledge networks and fostering collaboration, not only between research institutes, but also with government and industry.
- Engaging and collaborating with regional neighbours and global peers with similar needs.

Case study: Training and networking in Southern Africa

The Solar Academy is a training programme developed by the Solar Heating and Cooling (SHC) TCP since 2016. To date, 18 webinars gathering a total of 4 000 participants and four on-site training sessions have been organised, covering a broad range of themes related to SHC technology development.

One on-site training programme took place over three days in Stellenbosch (South Africa) in November 2018, with over 40 participants (e.g. researchers, solar suppliers and public officials) from Botswana, Lesotho, Mozambique, Namibia, South Africa and Zimbabwe. These countries are members of the Southern African

Development Community (SADC) Centre for Renewable Energy and Energy Efficiency (SACREEE).

SACREEE is one of the five regional centres in the United Nations Industrial Development Organization (UNIDO) Global Network of Regional Sustainable Energy Centres (GN-SECs) that have joined the SHC TCP as Sponsors. Through SACREEE, countries were given the opportunity to benefit from this training even though they are not themselves members of the SHC TCP. These programmes aim to share information and develop regional innovation capacity, and contribute to strengthening regional knowledge.

The on-site training was carried out in co-operation with the SOLtrain project, a local demonstration initiative set up under the auspices of UNIDO's local GN-SEC. This presented an opportunity after the training sessions for South Africa – a TCP member – to showcase SHC installations to key innovation actors such as investors and decision makers, with a view to strengthening the local innovation ecosystem.

Case study: Expanding Colombia's knowledge networks relating to user-centred energy models and digitalisation

TCP activities typically include workshops and training programmes that provide the opportunity to expand the reach of national knowledge networks.

In July 2021 the User-Centred Energy Systems (Users) TCP co-organised a workshop with Colombia's Universidad EIA and the IEA on "Peer-to-Peer, Community Self-Consumption and Transactive Energy in Latin America". The workshop aimed to support knowledge sharing on user-centred energy models and digitally enabled power grids, which are energy research priorities for the Colombian government. The event focused on the Colombian case and lessons that can be drawn for both local and international good practice, as well as on the socio-economic implications of rolling out new energy models in Latin America.

By leveraging the network built under the Users TCP and the IEA Digital Demand-Driven Electricity Networks Initiative, the workshop successfully gathered academics, decision makers and sectoral experts from Latin America (e.g. Brazil, Chile and Colombia), Europe (e.g. Ireland, Italy and the United Kingdom) and the United States. The discussions not only generated substantive outputs that could inform Colombia's policy making, they also provided an opportunity for the government and local practitioners to expand their networks and connect with peers who share similar interests.

Stimulating domestic investment and markets for energy technologies

Meeting energy and climate goals will require a rapid ramp-up in the development and diffusion of low-carbon energy technologies around the world. This presents significant opportunities for emerging and developing economies to support the creation of a domestic industry that meets the needs of local markets. International collaboration strategies can help accelerate this process.

Being a member of the TCPs can help support domestic markets for energy technologies (see case study on Morocco and China). Information and experience sharing among participating entities in government, research and industry helps raise awareness and build local support for new technologies and concepts. Members also share good practice approaches to policy and regulation for effective technology development and market uptake, with a view to informing local decision making and contributing to the creation of local markets for energy technologies.

Case study: CSP in Morocco and China

Morocco's membership of the SolarPACES TCP has contributed to building a domestic market for CSP technologies. As a new member of the TCP, Morocco quickly set up several large-scale CSP projects building on close exchanges and collaborative work between the Moroccan Agency for Sustainable Energy and other TCP members. Information, data and experience sharing contributed to the increasing confidence of funding agencies to support CSP projects.

China's membership in the SolarPACES TCP helped strengthen domestic technology development and manufacturing capacity. Through collaboration with TCP members – such as to examine component quality standards, develop computer modelling tools and explore different technology options – China was able to accelerate the building of a local CSP industry. Overall, China has contributed to significant cost reductions globally in this technology area.

3. How can the TCPs become global and foster participation from more countries?

Summary

- This chapter introduces a selection of good practice approaches, new ideas and practical steps shared by TCP participants to help expand membership, increase participation and foster active engagement, with a focus on emerging and developing countries.
- Recommendations for action may be targeted towards:
  (i) Strengthening and diversifying outreach strategies to increase awareness of TCP activities and their potential impact.
  (ii) Addressing concerns over budgetary and resource constraints as they relate to membership.
  (iii) Ensuring that TCP activities are fully relevant to the needs and characteristics of potential member countries.
  (iv) Providing assistance to prospective members throughout the membership process.

Expanding outreach and raising awareness of TCP activities and impact

Given the increasing number of multilateral partnerships relevant to energy technology development, it can be challenging for governments and innovation actors to maintain an accurate view of all existing and new initiatives and how they fit together. In recent years several TCPs have shared concerns over a lack of global awareness and understanding of their activities and their impact. In some instances, for example, they have encountered misconceptions about the way in which the TCPs operate and the nature of their work.

Against this backdrop, the first step for TCPs wishing to expand participation should be to ensure that decision makers are aware of what the TCPs do and how they operate. This can be a particular challenge in countries that do not have a

long history of engaging with TCPs and other multilateral initiatives, as is the case in some emerging and developing economies.

While it is possible for non-governmental entities to participate in the work of the TCPs, they are ultimately forums for governments to work together on energy technology issues, and most TCPs see governments as their primary audience. In practice, this means that they are the focus of most TCP outreach, which requires the right contact points to be identified to make meaningful connections. This exercise can be challenging for TCPs that lack strong local connections, when facing complex multi-layered government entities, or due to turnover within local administrations. In many instances, gaining wider local connections effectively relies on the personal networks of individuals from member countries already participating actively in the TCP.

Current TCP members have shared a number of good practice approaches, building on years of experience engaging with countries around the world, including emerging markets. A selection of these strategies is illustrated in the table below.

Strategies shared by TCPs to increase awareness of TCP activities and their impact, and to strengthen outreach and the membership base

Approach	Description
Disseminate TCP brochures and welcome kits to target audiences	• Producing a digital overview of ongoing TCP activities, including current research focus areas and latest achievements, may help decision makers in countries with limited experience of engaging with TCPs better understand how membership can bring tangible benefits. Beyond existing online TCP brochures, which could be updated regularly by TCPs to reflect the most up-to-date achievements, welcome kits could serve as pitching materials for prospective members. • Welcome kits could include elements specific to target member countries, such as the potential for the TCP's technology focus areas in the country or region, key TCP activities that may be most relevant to local contexts and needs, proposals for new joint collaboration in topical areas of work, and illustrations of what membership has brought about in comparable countries or settings. They could also include step-by-step recommendations on the membership process and lessons learnt and advice from newest members. • Finding adequate communication channels is important to make sure brochures and welcome kits have an impact with the right audience. Such channels may include international conferences, online events and webinars, and local academic and research institutions. Producing materials that are easily consumed may require translating in some instances, especially in countries where English is not sufficient.

Approach	Description
Organise on-site visits with selected country officials	• Organising on-site visits, such as to research or industrial facilities, large demonstrators or power plants, gathering not only TCP members but also experts and officials from non-member countries, can help showcase TCP achievements and the potential benefits of engagement. • Alongside increasing awareness of international collaboration in the field among decision makers from various countries, such visits can help demystify complex or lesser-known technology concepts, and strengthen international networks.
Organise TCP missions in prospective member countries	• Direct engagement with government actors can be effective at explaining TCP activities and their potential impact, and walk decision makers through the membership process. In some instances, TCP Chairs travelling on mission to prospective member countries have been decisive in securing membership. Such opportunities may be pursued again post-Covid. • TCPs may also organise activities or conferences in potential member countries and invite local representatives to participate in person, thereby fostering networking with existing TCP members and encouraging membership.
Build a network with key domestic actors	• In instances where establishing direct communication channels with government is challenging, reaching out to local universities and research institutions, or the research and innovation arms of government, can be an effective way to start building a local network. Inviting such actors to observe TCP activities may help make the case for membership, provide valuable feedback to current TCP members on the programme of work and its relevance to the local context, and enable joint outreach to decision makers. • Many governments organise their participation in TCPs through a "Designated Entity", which is a private or quasi-public organisation or institution that is authorised to join the TCP on behalf of the government. Establishing links with organisations that may eventually serve this function can help to build a local partner that can leverage its connections within the government.
Build a case for membership through other participation mechanisms	• Under the TCP legal framework, TCPs may invite non-governmental institutions from a country to participate as "Sponsors" or "Limited Sponsors" even though the government is not a member. Sponsors and Limited Sponsors have the right to participate in TCP Tasks and activities, subject to certain conditions. • Formal participation by local partners through these mechanisms can act as a bridge to a country joining by demonstrating the value of local actors working with the TCP. Having one or more Sponsors or Limited Sponsors in the TCP will build an evidence base for the benefits of participating in the TCP, which can help to justify full membership.

Approach	Description
Leverage virtual communication tools	• Throughout the Covid-19 pandemic, TCPs have transitioned to fully online activities in many instances. New communication tools such as online seminars and conferences have become more widespread, and are likely to remain valuable complements to in-person exchanges. This opens significant opportunities to expand outreach for TCPs, including to target participants from emerging economies who typically have lower budgets for international travel and face greater constraints. • When inviting potential member countries to selected virtual activities, targeting a delegation of participants with diverse backgrounds and responsibilities can be useful to showcase TCP activities and their impact. For example, inviting local high-profile technical experts, researchers and academics alongside government decision makers can foster interactive exchange around local priorities and needs, help build an inclusive process, and increase the likelihood of technical observers attending TCP meetings and events with government blessing. • In some instances, it can be relevant to invite potential member countries to observe TCP ExCo meetings virtually, especially if the guest institution is well connected to the local ecosystem and government. Outreach may also be done through virtual technical tours in project areas.
Encourage outreach at all levels of the TCP, and build on the networks of current TCP participants	• It can be meaningful to conduct outreach at various levels of the TCP, that is, not only at the ExCo level, but also among participants in specific Tasks. This can be done jointly, such as during in-country missions or at conferences by putting together a diverse group of TCP members to represent the partnership, or independently, by encouraging all TCP participants to proactively pursue outreach with potential member countries. • Specific areas of focus of the TCP may be more appealing to different actors in prospective member countries (e.g. different research activities). In many instances, explaining TCP activities appears to be more effective with individual connections in industry, research institutions or government, than through generic outreach on behalf of the TCP. As a result, multiplying outreach flows and showcasing a broad set of activities via a more diverse pool of current TCP participants can increase the chances of successful outreach. • Engagement and outreach can be enhanced by pooling the respective professional networks of current TCP participants, such as in a TCP contact point database updated over time, thereby benefiting from the cumulative experience of its members. Such a tool would also serve as valuable institutional memory in case of turnover. In many instances, sharing such information across TCPs can be useful and should be promoted.

Approach	Description
Network strategically at the margins of events and conferences	• Seeking informal exchanges at the margins of TCP activities or international conferences and events is an effective way to build connections with a view to expanding membership over time. In addition to inviting potential member country officials to TCP events, it can be beneficial to identify key participants at third-party events and then schedule informal meetings. • This can also take place during IEA Working Party meetings and other multilateral gatherings, which provide a platform to make connections and allow exchange between TCP participants and potential new member countries. • Co-locating TCP activities and more high-level events could be explored to increase interactions with decision makers who are critical to the membership process, showcasing the potential benefits of TCP membership. Some TCPs have found it useful to do this at the Task level, to find new participants to engage with.

Case study: Showcasing TCP work at international conferences

The Hydropower TCP has been one of Aqua Media's non-paying supporting organisations for over eight years. Aqua Media publishes the International Journal of Hydropower and Dams and organises international conferences, including an annual Hydropower Conference in Europe and one in either Asia or Africa on alternate years. These conferences gather over a thousand participants. The Hydropower TCP regularly publishes articles in the journal and organises two or three sessions at the conference, each focusing on the work of a selected Task. This has provided the Hydropower TCP with the opportunity to showcase its work to a wide array of audiences from around the world.

The Hydropower ExCo meetings are often strategically organised during the two days of these conferences. This allows other conference participants interested in the work of the TCP to attend an ExCo meeting as a guest.

Case study: Reaching out to potential participants through domestic partners and institutions

Major research institutions: Rather than beginning outreach with ministry officials, the PVPS TCP has found that the most fruitful contacts regarding membership have been with senior experts or management representatives from major research institutes within the country. Notable examples include SANEDI in

South Africa and IRESEN in Morocco, which have strong relationships with respective government officials. Initial contact is often established at the technical expert level, in particular at scientific conferences and workshops or through scientific publications, technical reports and databases published by PVPS.

Universities: The Users TCP has sought to build a relationship with Colombia by inviting the Universidad EIA to join the TCP's Global Observatory on Peer-to-Peer, Community Self-Consumption and Transactive Energy Models (GO-P2P) as a Limited Sponsor. By engaging with local institutions, the TCP managed to raise awareness at national level about the value of being a member of the TCP – namely gaining knowledge on the enabling conditions needed to promote peer-to-peer, community self-consumption and transactive energy models in Colombia – and built a case for future membership at the national level.

Organising training: The Energy Technology Systems Analysis Program (ETSAP) organised a three-day training course in Mexico City for its TIMES model. The TCP's training introduced Mexican actors to the uses and possibilities that TIMES modelling could offer and the potential benefits of joining an extended network of users. In addition to developing contacts with relevant stakeholders in Mexico, the formal and informal discussions provided insider knowledge about the barriers or difficulties that a country could be facing and that prevent it from joining this type of activity.

Addressing concerns over resources and the cost of participation in TCP activities

Despite the numerous benefits of TCP membership, the costs associated with participation can sometimes be a challenge for prospective member countries. Typical costs may include membership fees, but also resources to mobilise experts to take part in activities and related international travel expenses for in-person meetings, or to set up equipment and facilities locally as part of TCP activities. The costs of active participation often go beyond simply joining ExCo meetings and paying the annual membership fee. Getting the most out of TCP membership requires supporting domestic participants to actively engage at the Task level, contributing to various projects and sharing specific issues and experiences from the national context. All of this requires time and resources.

To ensure sustained participation in TCP activities and avoid stop-go contributions undermining the effectiveness of TCP work, prospective members may need to secure multi-annual funding – beyond what is needed for the annual fee –

co-ordinate with other domestic institutions involved in the TCP, and aim to make TCP activities a core element of their energy innovation strategy.

Addressing such concerns can be particularly challenging with some smaller or emerging and developing economies, for which resources for international collaboration in energy innovation are more constrained. In the past few decades some TCPs have successfully overcome these difficulties and made the business case for membership. A selection of good practice approaches shared by TCP participants are illustrated in the table below.

Strategies shared by TCPs to help address concerns over resources and the cost of participation with a view to expanding the membership base

Approach	Description
Clarify expectations and build a track for progressive membership	• Providing clear guidance and advice on participation in TCP activities can help smooth the membership process by setting the right expectations on both sides. Typical expectations may include, among others, taking part in meetings and activities, embracing peer-to-peer exchange and work culture, sharing data and information, providing advice and feedback to other members, and contributing to TCP strategic thinking. Expectations should be progressive and help new members enhance the TCP, broadening and deepening its expertise and stakeholder engagement. • Prospective member countries may benefit from information about the resources members are likely to require at various levels of commitment to TCP activities (e.g. participation in one or a handful of Tasks or annexes vs full membership, resources required to propose new Tasks or annexes). This can help identify the right starting point for new members, which over time may consider stronger participation depending on local capacity and interest. • Considering participation with Sponsors as a starting point – as opposed to a contracting party – can help overcome concerns around membership fees and make the case for full membership later on. Recent examples include that of India in the Hydrogen TCP, which it first joined through two private companies as Sponsors before becoming a contracting party. • To stimulate proactive participation, setting up activities with responsibilities and contributions shared among members according to respective resources and comparative advantage can be effective. Transparent communication on available capacity can help align expectations and mitigate risks of low engagement.

Approach	Description
Encourage domestic collaboration to leverage scarce resources	• In many countries, several ministries or institutions share responsibilities relevant to energy innovation and technology development, with similar research agendas, mandates or priorities in some cases. Engaging with several bodies in prospective member countries and encouraging collaboration between them can help pool resources around common goals to meet the requirements of TCP membership (e.g. costs, know-how, and availability of technical experts). • In some cases it can be challenging for newer members to set up activities from scratch or co-lead Tasks or annexes, especially in emerging and developing economies without a long legacy of energy technology development or international collaboration. It can be effective to mobilise several domestic institutions to collaborate and share the responsibilities of co-leading Tasks or annexes in the early stages of membership. • When relevant, prospective and current members can explore joint membership of several domestic institutions to facilitate or strengthen their participation.
Engage with multilateral development organisations	Several TCPs have found it helpful to involve third-party international organisations, such as multilateral development agencies, to support membership. For example, membership fees may temporarily be covered by donor organisations to enable participation while domestic resources are being pooled.
Explore opportunities for virtual and hybrid activities	As illustrated in the previous section, TCPs can reduce operational expenses post-Covid by hosting more virtual and hybrid meetings and activities. This may foster inclusiveness and facilitate engagement by decreasing costs for international travel. Personal networking opportunities, such as more informal and social virtual gatherings, could be used for new participants to meet TCP representatives in a more casual way.

Case study: Arranging funds for prospective members

Adjusting TCP membership fees. Several TCPs have specifically adapted their fee structures to encourage membership from emerging or smaller economies by reducing the cost of membership. Some have adopted a graduated fee structure where countries are organised into groups according to variables such as GDP or population size. This is intended to enable smaller countries to pay a reduced fee in recognition of the smaller size of their economy and national budgets.

Other TCPs adopt a more ad hoc approach, which may include waiving or reducing fees for specific members. The Hybrid and Electric Vehicle (HEV) TCP, for example, waives all costs of membership for developing countries for the first two years, with fees of EUR 1 500 each year thereafter. This is a steep reduction from

the regular membership fee of EUR 9 500. On a case-by-case basis, membership fees may be waived altogether to attract membership from developing countries.

Other notable examples of TCPs that tailor their fees structure for the benefit of emerging economies are the Energy Storage TCP, the Advanced Fuel Cells (AFC) TCP, the District Heating and Cooling (DHC) TCP and the Energy in Buildings and Communities (EBC) TCP.

Partnering with international organisations and development agencies. The SHC TCP partnered with UNIDO to promote participation from different entities in prospective member countries. UNIDO facilitated meetings and exchanges between regional sustainable energy centres, shared information on the relevance of SHC TCP activities with selected prospective members, and covered the participation fee for entities joining the SHC TCP as a Sponsor for the first two years. To ensure proactive participation, UNIDO required entities benefiting from the programme to attend ExCo meetings and specific Tasks or annexes when relevant.

Setting up activities aligned with prospective member country priorities

While the TCPs currently cover a wide range of research topics and focus areas relevant to energy technologies, they may not align with the specific needs, contexts and priorities of prospective member countries. It can be challenging to appeal to prospective members, especially emerging and developing economies, when ongoing activities are mostly designed to fit the needs and priorities of current members, or when the programme of work is closely linked to funding contributions.

To help make the case for TCP membership, it may be necessary to tailor activities and outputs to a more diverse array of countries and stakeholders. This can be achieved through consultation with government officials and technology institutions and experts from potential member countries. Such an approach can be enhanced by engaging with various ministries and local institutions to build an inclusive whole-of-government process, identify local needs and priorities, gather feedback and proposals for new activities, and anticipate possible resource constraints associated with membership. Collaboration with regional institutions and development agencies can also help TCPs understand local technology needs and working culture ahead of targeted engagement with local actors. In some instances, involving entities beyond the energy sector – such as in the

transport, industrial and environmental fields – can demonstrate the potential spillover benefits of improving domestic capacity for energy technology development.

To better align TCP focus areas with the needs and priorities of potential member countries, one option is to loosen the decision-making process for setting up new Tasks or annexes to include perspectives from both current and prospective members. Potential member countries could be offered the opportunity to develop or co-design activities prior to being able to lead it, with the view to adapting TCP work to local needs, and thereby signalling openness and commitment. The previous chapter illustrated how Brazil initially co-designed activities with the Hydropower TCP before seeking full membership (Case study: Brazil's contributions to the Hydropower TCP). Prospective or new member countries typically participate more proactively after they are empowered to join ongoing and new activities and become able to demonstrate tangible contributions to TCP work.

Case study: Fostering regional outreach to identify local needs in Western Africa

In recent years the SHC TCP has designated a member of the ExCo to act as an outreach co-ordinator for a specific region to develop and foster engagement. Sustained engagement with prospective members has enabled the TCP to increase the relevance of its work to other countries.

In 2015 the SHC TCP jointly initiated the SOLtrain West Africa Programme with the Centre for Renewable Energy and Energy Efficiency (ECREEE) of the Economic Community of West African States (ECOWAS). The project, which was implemented by ECREEE with technical support from Austria's Institute for Sustainable Technologies and funding from Austrian and Spanish development banks, involved training and demonstration activities for solar thermal heat technologies. It focused on water heating for sanitary and industrial needs, drying of agricultural products, and solar process heat in ECOWAS countries, with a view to achieving regional policy goals of using less fossil energy, electricity and biomass.

In 2014, prior to the launch, ECREEE consulted eight solar thermal institutions in five West African countries – Burkina Faso, Cabo Verde, Ghana, Nigeria and Senegal – to identify local needs and pressing challenges. As a result the programme was geared around three key themes of interest: thermosiphon systems with a collector area of up to 10 m^2, solar thermal drying of crops and other agricultural products, and pumped systems for a collector area up to 200 m^2. This

regional consultation exercise carried out in close collaboration with West African stakeholders enabled the TCP to align its substantive activities with local needs.

For three years representatives of the SHC TCP co-ordinated with officials from energy and buildings ministries and research institutions in West Africa to support implementation by ECREEE. Activities included: theoretical and practical training, solar thermal system co-development, technical support for local producers and other companies in regional supply chains, the installation of 25 demonstration systems and one testing facility per participating country, and training for administrative, political and financial stakeholders. Participants of the SOLtrain West Africa Programme were also invited to meet and exchange information and good practice with actors from the SOLtrain Southern Africa Programme, which started in 2009 covering six countries.

Through this engagement, the SHC TCP was also able to identify appropriate research and academic institutions interested in participating in TCP Tasks.

Case study: Developing new Tasks with specific relevance to new members or prospective member countries

Prospective TCP member countries can be attracted by the relevance of certain Tasks to their local needs and energy innovation agenda. Therefore, co-developing ideas for new Tasks with non-members can help foster new membership.

The PVPS TCP was able to secure the membership of Thailand and Malaysia primarily thanks to specific Tasks that were relevant to these countries – even though the activities may not have initially been designed with the purpose of attracting new members.

In 2012 the PVPS TCP initiated Task 14 on “High Penetration PV in Electricity Grids”, now called “Solar PV in a Future 100% RES-Based Power System”. This Task was instrumental in raising Thailand’s interest in becoming a member. Specifically, Task 14 addressed technical issues, guidance and good practice approaches related to the integration of high shares of solar PV into power grids. This Task became relevant to Thailand and could equally be relevant to other emerging or developing economies where high PV penetration could be reached earlier than in more established electricity systems. The PVPS TCP found that this Task was also of interest to Singapore, although it is not yet a member.

Malaysia’s membership of the PVPS TCP was related to an important Global Environment Facility Project on building-integrated PV (BIPV), in which key PVPS

TCP experts were involved. As BIPV was a strategic focus for Malaysia in the early 2000s, the TCP's Task 7 on BIPV (1997-2001) and its outputs were central to developing Malaysia's interest in the TCP. As PV became a strategic field in the country – both for domestic deployment and to pursue opportunities for industry – other PVPS Tasks became relevant to Malaysia's strategic agenda.

Annex

Abbreviations and acronyms

4E TCP	Energy Efficient End-Use Equipment TCP
AFC TCP	Advanced Fuel Cells TCP
AMF TCP	Advanced Motor Fuels TCP
AMT TCP	Advanced Materials for Transportation TCP
BIPV	building-integrated PV
C3E TCP	Clean Energy Education and Empowerment TCP
CERT	Committee on Energy Research and Technology
CETP	Clean Energy Transition Programme
Combustion TCP	Clean and Efficient Combustion TCP
CSP	concentrated solar power
CTP TCP	Tokamak Programmes TCP
DHC TCP	District Heating and Cooling TCP
EBC TCP	Energy in Buildings and Communities TCP
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EOR TCP	Enhanced Oil Recovery TCP
ESEFP TCP	Environment Safety and Ecological Aspects of Fusion Power TCP
ETSAP TCP	Energy Technology Systems Analysis Program TCP
ExCo	Executive Committee
FBC TCP	Fluidized Bed Conversion TCP
FM TCP	Fusion Materials TCP
GN-SECs	Global Network of Regional Sustainable Energy Centres
GHG	greenhouse gas
GOTCP	Gas and Oil TCP
HEV TCP	Hybrid and Electric Vehicles TCP
HPT TCP	Heat Pumping Technologies TCP
HTS TCP	High Temperature Superconductivity TCP
IEA	International Energy Agency
GHG TCP	Greenhouse Gas R&D Programme TCP
IETS TCP	Industrial Energy-Related Technologies and Systems TCP
ICSC TCP	International Centre for Sustainable Carbon TCP
ISGAN TCP	International Smart Grid Network TCP
NFTR TCP	Nuclear Technology of Fusion Reactors TCP
OECD	Organisation for Economic Co-operation and Development
OES TCP	Ocean Energy Systems TCP
PVPS TCP	Photovoltaic Power Systems TCP
PWI TCP	Plasma Wall Interaction TCP
R&D	research and development
RD&D	research, development and demonstration

RFP TCP	Reversed Field Pinches TCP
SACREEE	Southern African Development Community (SADC) Centre for Renewable Energy and Energy Efficiency
SHC TCP	Solar Heating and Cooling TCP
ST TCP	Spherical Tori TCP
SH TCP	Stellarators and Heliotrons TCP
SolarPACES TCP	Solar Power and Chemical Energy Systems TCP
TCP	Technology Collaboration Programme
UNIDO	United Nations Industrial Development Organisation
Users TCP	User-Centred Energy Systems TCP
Wind TCP	Wind Energy Systems TCP

This publication has been produced in part with the financial assistance of the European Union as part of the Clean Energy Transitions in Emerging Economies programme. This publication reflects the views of the International Energy Agency (IEA) Secretariat but does not necessarily reflect those of individual IEA member countries or the European Union (EU). Neither the IEA nor the EU make any representation or warranty, express or implied, in respect to the publication's contents (including its completeness or accuracy) and shall not be responsible for any use of, or reliance on, the publication. Unless otherwise indicated, all material presented in figures and tables is derived from IEA data and analysis.

IEA Publications

International Energy Agency

Website: www.iea.org

Contact information: www.iea.org/about/contact

Typeset in France by IEA – November 2021

Cover design: IEA

Photo credits: © ShutterStock