GREEN POWERED FUTURE
MISSION

December 2023

Annual Report 2023

DISCLAIMER

THE YEAR IN WORDS

To achieve the full decarbonisation of global energy systems needed to keep the 1.5^{C} in reach, we need full commitment from governments and organisations across the world. The Green Powered Future Mission (GPFM), launched within the second phase of Mission Innovation (MI2.0), is among the world's leading initiatives working to accelerate decarbonisation. GPFM brings together efforts to transform global green power systems and drive research and innovation to integrate up to 100% variable renewable energy (VRE) in electricity generation systems by 2030, across different geographical and regulatory contexts.

The GPFM leadership have developed and published key reports, such as the Joint Roadmap of Global Innovation Priorities, to guide members in launching projects and demonstrations towards achieving this goal. The Joint Roadmap identified the top 100 global innovation priorities to be tackled by 2030 to accelerate the energy systems transformation. The Action Plan 2022-2024 recognised the 50 most urgent innovation priorities and has set the timeline for the delivery of the GPFM flagship projects.

Every year GPFM members are requested to update on the progress of the projects and their research and innovation activities. This annual report outlines these updates and provides an overview of the Mission's progress, while supporting knowledge-sharing across the initiative. Accountability, including monitoring the key performance indicators (KPIs) against the Action Plan, is essential for keeping activities on track to deliver by the end of the action period and to ensure the Mission delivers real-world impact and helps bring about a green powered future for all.

MISSION DIRECTOR

Luciano Martini

"With its two ambitious Flagship Projects, the GPFM is working to accelerate innovation towards power system transformation and decarbonisation, recognising the paramount importance of international collaboration. The National Pilots Report, showcasing 80 ongoing and planned pilot projects from GPFM members and the Joint Call Module with the CETPartnership are excellent examples of the important progress made this year."

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GPFM COALITION MEMBERS

Co-Leads	China
	Italy
	United Kingdom
Core Team	Australia
	India
	Saudi Arabia
	Spain
	Alperia SpA
	Areti SpA
	Enel Grids
	Goldwind
	Icebreaker One
	IRENA
	LONGI
	National Grid Group
	World Bank Group
Support Team	Austria
	Brazil
	Canada
	European Commission
	Germany
	Japan
	Republic of Korea
	BSI
	ENA
	GSE
	IEA
	TERNA

1. INTRODUCTION

Green Powered Future Mission (GPFM), a part of Mission Innovation, champions the vital role of innovation in addressing climate change and driving decarbonisation at the pace needed to limit global warming to 1.5^{C} and to avoid the adverse impacts of a changing climate. Our members are contributing to global decarbonisation efforts, with country members pledging to lower their emissions and achieve net-zero.

GPFM is one of the key global initiatives accelerating efforts towards green global power systems and driving research and innovation to achieve the ambitious goal of integrating up to 100% variable renewable energy (VRE) in electricity generation by 2030, while maintaining the security of supply and operating resilient energy systems in a cost-effective manner.

Since its launch GPFM has brought together its international members to collaborate on global initiatives and deliver pilot and large demonstration projects spanning continents. The Mission's *Joint Roadmap of Global Innovation Priorities* was published at COP26 in November 2021 in Glasgow, identifying 100 innovation priorities through an extensive consultative process. This was followed by the structured "Action Plan 2022-2024" which recognised the 50 most urgent innovation priorities to be tackled by 2024, to build on the Joint Roadmap.

GPFM's innovation goals and strategic success is built on three Research and Innovation (R&I) pillars:

Pillar 1 - Affordable and reliable VRE: reduce cost and increase efficiency, resilience, and reliability of VRE technologies in various climates and system configurations.

Pillar 2 - System Flexibility and Market Design: develop flexible solutions to meet network infrastructure needs, to be supported by regulation and innovative markets design.

Pillar 3 - Data and Digitalisation for System Integration: accelerate the digitalisation of energy systems through the development of interoperable data exchange and effective system integration to unlock the full value of VRE.

The Mission has identified key Tipping Points against each pillar which need to be met to achieve its goal.

Reference GPFM Publications and Links

[*July*, 2023]
The Green Powered Future Mission released at the CEM14/MI8 the National Pilots Report

[*September*, 2022]
The Green Powered Future Mission released at the GCEAF (Pittsburgh, U.S.) the Action Plan 2022-2024

[*November*, 2021]
The Green Powered Future Mission released at COP26 (Glasgow, UK) the Joint Roadmap of Global Innovation Priorities

- GPFM launch videos
- GPFM website
- GPFM LinkedIn page

2.PROGRESS TOWARDS THE MISSION GOALS

The annual progress report updates our members on the status and the progress of the Mission. Mainly, it informs the Mission on the timeline for the projects working to tackle the 50 most urgent innovation priorities to address in the interim action period leading up to 2030, and details the upcoming flagship projects, international demonstrations, and R&I activities currently being undertaken by GPFM members. It also establishes our standing against the Action Plan timeline and ensures that our global partners and projects are on track for delivery.

Action Plan Gantt Chart

The Joint Roadmap set out the path towards 2030, providing the context for high profile international collaborations and joint efforts. The updated Gantt chart from Action Plan 2022-2023 on this page, details the milestones for the flagship projects, along with the core activities developed to support those projects, and key GPFM meetings and scheduled events.

GPFM organises and holds periodic events to bring members together to discuss and facilitate the delivery of projects. These coincide with the Clean Energy Ministerial (CEM) and the Mission Innovation (MI) joint annual Ministerial, which recently took place in Goa, India; the annual Mission Innovation annual gathering, which recently took place this year in Rio de Janeiro; and COP28 taking place in Dubai, UAE this year where the Mission will be represented.

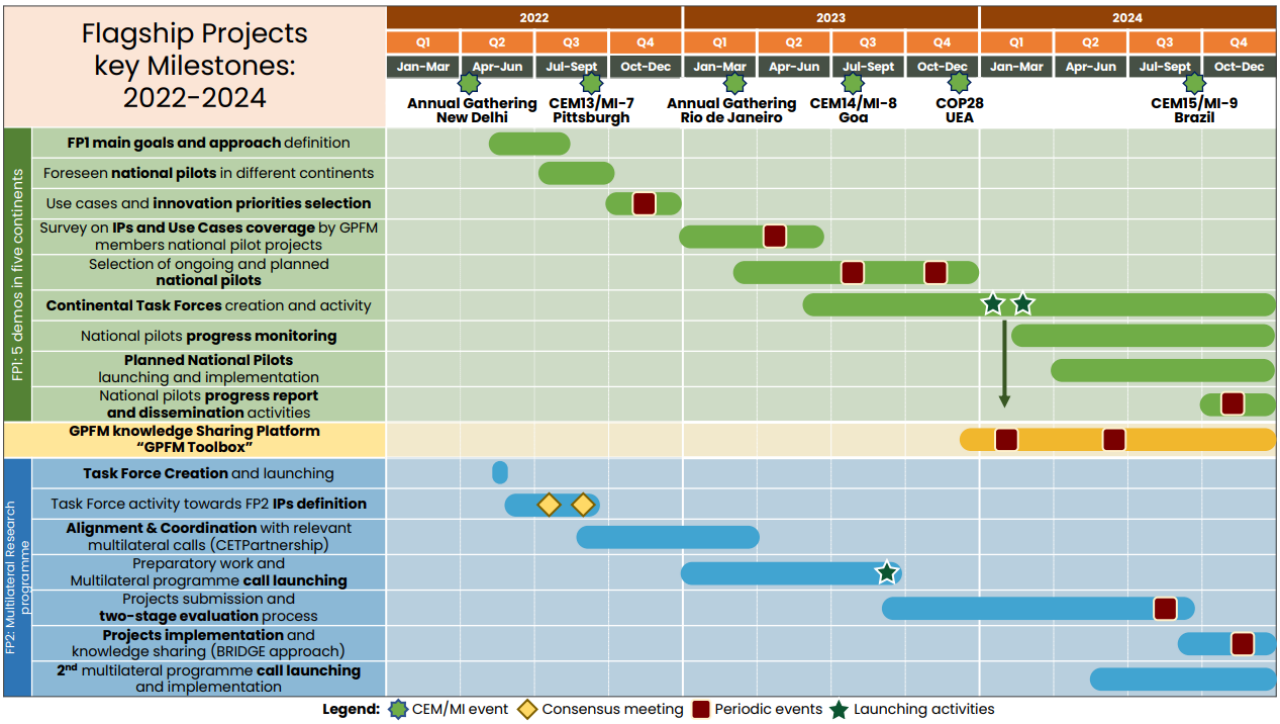

Figure 1 - Flagship projects milestones and MI/GPFM events 2022 - 2024

2.1. Annual Survey Outcome

The Mission supports its members in the delivery of projects and monitors progress every year to ensure that we are on track to deliver the 2030 goal. To measure progress against the Action Plan, the Mission maintains a central database of programmes and projects, which we ask all our members to update periodically. This annual monitoring process offers clarity to our members on the status of the Mission and what further outcomes are planned and expected for the rest of the present action period.

This annual survey asks participating countries and partner organisations questions about the status of their programmes and projects, including engagement activities and recorded spending. It also gives members the opportunity to inform the Mission about any additional risks identified or challenges faced while working on the projects, providing valuable insights on best practice, and supporting members to learn from each other while new solutions are developed and demonstrated. The survey allows members to record other activities not directly related to the projects, such as collaborations on government and industry programmes or participation in international workshops and conferences.

The annual survey is testament to our members' commitment and leadership. Although not all project leads provided updates for this year's survey, 80 projects continue to be progressed across the membership. The survey results are summarised below.

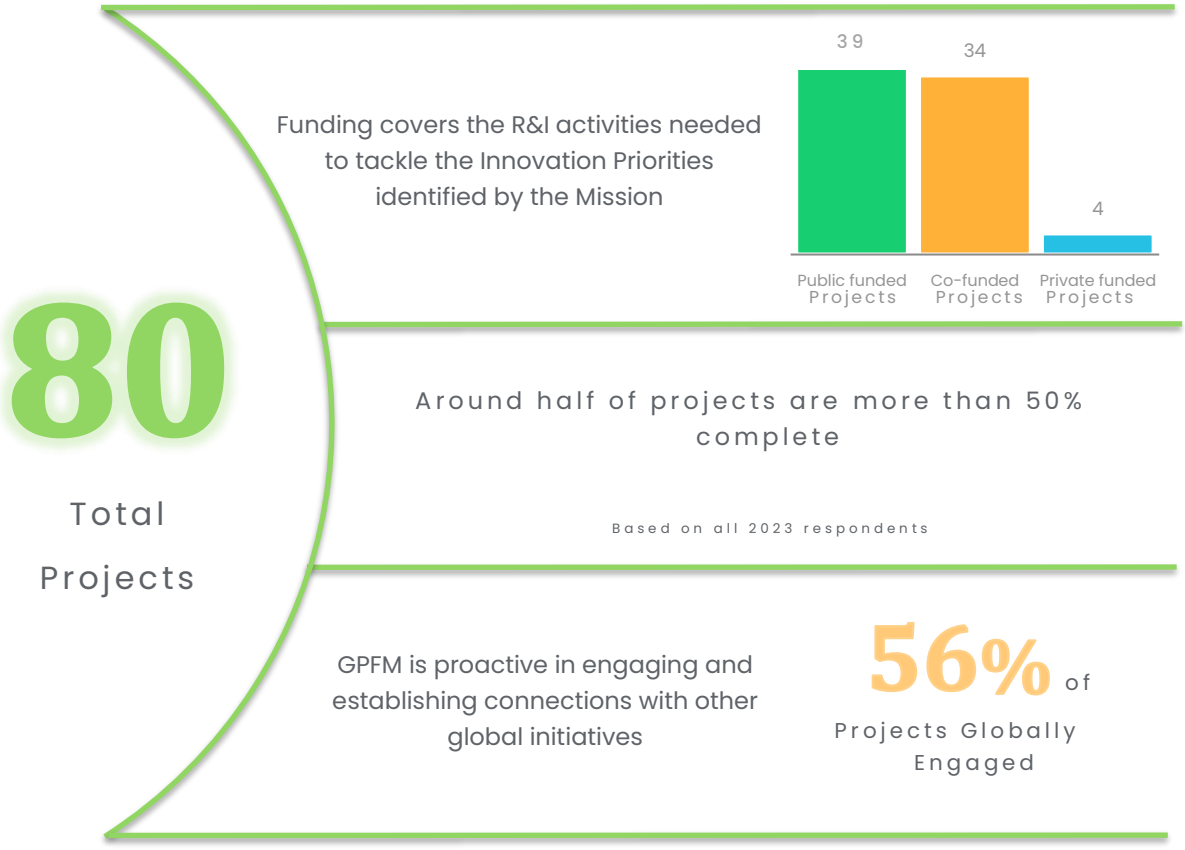

Figure 2 – GPFM members' R&I programmes and projects (indicative based on the responses received in Nov, 2023)

2.2. Mission Status and KPIs

The Mission has identified seven Key Performance Indicators (KPIs) in the GPFM Action Plan 2022-2024. The agreed KPIs cover funding, member engagement, and progress made against the identified innovation priorities:

- **Cumulative funding spent:** this is the cumulative expenditure on R&I activities highlighted by members as contributing to the most urgent Innovation Priorities as set out in GPFM Action Plan 2022-2024
- **Number of Innovation priorities tackled by Mission partners:** this is a combination of the Innovation Priorities tackled by members' R&I activity and addressed by two Flagship projects:
  - Flagship Project 1 (FP1) "5 demos in five continents"
  - Flagship Project 2 (FP2) - Multilateral research programme to tackle 20 of the identified Innovation Priorities by 2023
- **Number of demo projects underway:** this is the number of projects which are promoted as part of the continental demos under Flagship Project 1
- **Number of members actively contributing to the Mission:** this is the number of members contributing R&I activities and involved in the Flagship Projects
- **Regular organisation and engagement in Mission ExCo meetings:** this is taken from statistics of attendance at regular Mission ExCos (meetings of the Mission membership)
- **Regular update of the GPFM progress against the Action Plan:** this is the annual progress update collected from all Mission members
- **External engagement and knowledge dissemination of the Mission outputs:** this represents updates on the GPFM internet-based platform, and engagement in dissemination activities conducted by members

Mission Delivery

GPFM members delivered various outputs while working towards achieving the Mission objective of accelerating innovation, including published reports, and engaging workshops:

Reports published

GPFM publishes reports regularly to guide R&I investments and to promote the effort and cooperation between members internationally:

- **Joint Roadmap of Global Innovation Priorities**, identifying the top 100 global Innovation Priorities to achieve the Mission Goal and ranked them in terms of impact and urgency (November 2021)
- **Action Plan 2022-2024,** showcasing the flagship projects and activities GPFM members are undertaking to address the high and near-term global innovation priorities identified in the mission roadmap for the period between 2022 and 2024 (September 2022)
- **National Pilots Report**, a high-level report that showcases relevant information from 25 GPFM members about 80 ongoing or planned national pilot projects fully aligned with the Mission's scope and priorities (July 2023)

Workshops delivered

Mission members across contributing countries and public/private entities have organised and joined several workshops:

- **Joint GPFM-ISGAN side event** "Boosting the Power System Transition: Innovation through GPFM and ISGAN" at CEM13/MI-7 organised by GPFM (September 2022)

- **Green Powered Future Mission Workshop** "Novel Photovoltaic: Policy and Technology" organised by Japanese members from the Ministry of Economy, Trade and Industry - METI (February 2023)
- **The First Yancheng Renewable Energy Innovation Conference and GPFM International Workshop** hosted by GPFM member IEE CAS, China (October 2023)
- **Joint side events co-organised with ISGAN and 21CPP** at CEM14/MI-8 in Goa, India "CEM ISGAN – MI GPFM collaboration for power system transformation, with special focus on policy and private sector engagement" and "CEM-MI collaboration for technology innovation and implementation, policy, and regulatory actions to rapidly decarbonise power systems" (July 2023)

Progress against KPIs

The latest update to the Mission progress, gathered from our members' activities, records the achievements made towards 2024. The Mission is on track to achieve its 2030 objectives as set out in the Joint Roadmap, including the interim goals of 2024 outlined in the Action Plan 2022-2024.

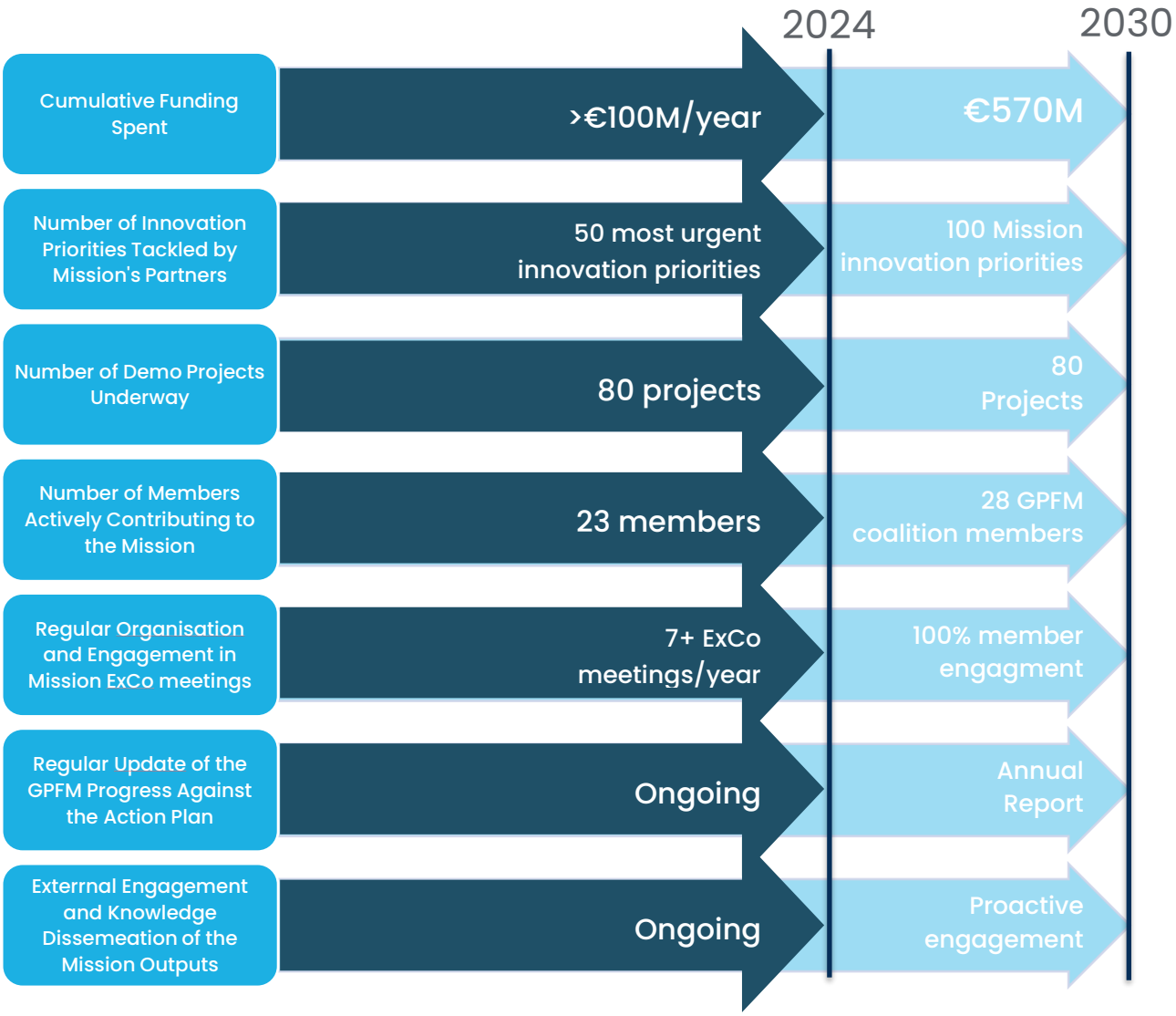

Figure 3 – GPFM KPIs progress so far – against the Mission's 2030 goals (period covered: 2022-2024)

2.3. Flagship Projects

The Action Plan 2022-24 outlined the Missions' Flagship Projects, which were set up to accelerate clean energy innovation aligned with our innovation priorities. The two flagship projects are:

2.3.1. Flagship Project 1 (FP1) – "5 demos in five continents"

This flagship project launched with the main objective of demonstrating innovation activities in the five continents of Asia, Australia, Europe, North America, and South America where each of the national pilot projects are taking place to tackle 50 of the most urgent innovation priorities (refer to Appendix A for a list of R&I Topics and the 50 most urgent Innovation Priorities as identified in the GPFM Action Plan 2022-2024). The FP1 provides all 28 GPFM members with the opportunity to collaborate. The launching of large demos with up to 80% VRE by 2024, have been grouped as follows:

1. Asian National Pilots
2. European National Pilots
3. North & South America and Australia National Pilots
4. International Organisations Pilots

The National Pilots Report (July 2023) outlined detailed reports on National Pilot projects as aligned with identified Innovation Priorities.

2.3.2. Flagship Project 2 (FP2) – "Multilateral research programme to tackle 20 of the identified Innovation Priorities by 2023"

FP2 launched in Q1 2023 with the objective of addressing 20 of the most urgent 50 innovation priorities and to promote engagement with other international initiatives, forming a multilateral research programme. This encourages collaboration between Mission Innovation and coalition members and ensures the Mission can focus on aspects beyond technology barriers such as market design and regulatory frameworks to find the most innovative solutions.

The first implementation of FP2 has been the launching of the joint call module with the CETPartnership "Energy system flexibility: renewables production, storage and system integration".

2.3.3. Flagship Projects Highlight

As part of GPFM FP1 "5 demos in five continents", the Asian Demonstration Project was launched during the First Yancheng Renewable Energy Innovation Conference "Global GPFM: Embracing Offshore Wind and PV Brilliance" which took place in Yancheng, China (October 2023). It involved representatives from governments, academia, international organisations, and leading industrial companies from across the GPFM membership.

Figure 4 – Launch Ceremony of Asian Demo Project (China, Oct 2023)

2.3.4. Launched Collaborations and Main Interactions

The GPFM recognises the importance of international cooperation and has started to collaborate with the global initiatives listed below by sharing information and organising joint events – harmonising activities and avoiding the duplication of efforts.

- **International Smart Grid Action Network (ISGAN)**, which aims to accelerate the development and deployment around the world of smarter and cleaner electricity grids. ISGAN signed an MoU with the GPFM to formalise the will to collaborate on areas of mutual interest

- **Clean Energy Transition Partnership (CETPartnership)**, a multilateral and strategic partnership of national and regional research, development, and innovation (RDI) programmes in European Member States and Associated Countries, aiming to boost green energy transition and the resulting GPFM- CETPartnership joint call module was launched in Sept. 2023

- **Digital Demand-Driven Electricity Networks (3DEN) Initiative**, that is working to accelerate power system modernisation and effective utilisation of distributed energy resources through digitalisation as well as innovative policies and regulatory approaches

- **MI Urban Transitions Mission (UTM)**, that aims to identify solutions, approaches and knowledge for the net-zero transition of cities and the resulting plans for a few joint pilot projects focusing on urban networks

- **21st Century Power Partnership (21CPP)**, that aims to accelerate the global transformation of power systems

3. CHALLENGES AND BARRIERS

As with many global initiatives, the efforts to decarbonise global power systems face common technical, political, and systemic challenges and barriers. But the advantage of a coalition is that such barriers can be tackled collaboratively and on an individual project level, with lessons learned being shared across the Mission – and beyond.

The risks and barriers anticipated by GPFM on our path to achieving the Mission objectives were first identified in the Joint Roadmap, including the most relevant technical barriers to innovation priorities. Some of the challenges faced by projects arise from pandemic-related delivery delays in recent years. In addition to the economic pressure from increasing prices and rising inflation in many countries, resourcing for field trials and data collection for pilots is becoming increasingly challenging. These factors directly affect supply chains and may delay the project delivery. However, GPFM ensures an open platform for members to voice their concerns, seek answers collaboratively, and learn from each other's experiences to mitigate these challenges.

4. THE MISSION LOOK AHEAD

The Mission is committed to driving tangible impact by facilitating targeted, strategic knowledge-sharing and implementation between its members and beyond. Expanding the Mission's outreach is vital to ensure a green future that is sustainable for all.

As part of these efforts, GPFM recognises the importance of collaboration with other initiatives active in the power systems landscape. Possible future collaboration is being explored with a number of organisations in the field, including:

- **Global Smart Energy Federation (GSEF)**, a global stakeholder organisation of national smart grid associations with the aim to facilitate national and international collaborations, support rapid development of smart grid technologies, and foster exchange of ideas and best practices.
- **Green Grids Initiative (GGI)** that aims to accelerate the construction of new infrastructure needed for a world powered by renewable energy.

GPFM closely follows the activities of other initiatives active in the clean energy transition, including:

- **Global Power System Transformation Consortium (G-PST)** that convenes expertise from system operators, manufacturers, utilities, standardisation bodies and research institutions with a goal of accelerating solutions that enable grids around the world to run on 100% renewable energy.
- **One Sun One World One Grid (OSOWOG)** that aims to connect different regional grids through a common grid that will be used to transfer renewable energy power and realise the potential of renewable energy sources, especially solar energy.

GPFM Toolbox

Next year will see the launch of the internet-based knowledge sharing platform "GPFM Toolbox" from which countries can pick and customise innovative solutions that are appropriate to their geography, system conditions, and national strategies. The GPFM toolbox is designed to be a live platform, leading and promoting GPFM technological innovation and multilateral international cooperation.

COP28 Engagement

- GPFM event "**Mission Innovation Green Powered Future Mission: National pilot projects for net zero power systems**" This event represents a great opportunity for the Mission to showcase its achievements and progress made towards Flagship Project FP1 "5 demos in five continents". GPFM will also announce the launch of the demo version of the internet-based knowledge-sharing platform supporting the dissemination activities of the Mission at this event.
- Urban Transitions Mission-GPFM joint event "**Innovation Catalysts: Powering cities on a mission towards net zero**" This event will strengthen the ongoing collaboration between Mission Innovation's Urban Transitions and Green Powered Future Mission and member countries. It will provide a platform to discuss readily available solutions, explore further needs and innovation gaps, to respond to the most urgent challenges faced by cities to accelerate the implementation of their net-zero pathways through green-powered futures.

GPFM will also participate in and contribute to the following events:

- GSE-RES4Africa event *"Gearing up Africa's energy transition by conducive policy and legislative frameworks"*
- Breakthrough Agenda event: *"Power Breakthrough Roundtable"*
- Digital Demand-Driven Electricity Networks (3DEN) event *"3DEN Initiative: implementing tomorrow's smart power systems"*
- IRENA & Mission Innovation event *"Transition in Practice: Leveraging Mission Innovation for Developing Countries"*

FP1 Next Steps and Task Force Activities

- Monitor the progress of national pilot projects' by engaging with pilot coordinators and our public and private sector partners
- Demonstrate different innovative technical, regulatory and market solutions to be implemented and validated in different climates and geographies
- Share key learnings and exploitable results as soon as national pilot projects start their dissemination phase
- Populate the GPFM Toolbox with proven innovative solutions, to be disseminated broadly

Other Next Important Engagements

- Private Sector Engagement Workshop to be organised in Q1 2024
- International Online Workshop hosted by one of our partners in Q1 2024
- GPFM Participation in MI Annual Gathering and to CEM15/MI-9 in Brazil
- GPFM Participation at COP29

APPENDIX A

List of R&I Topics and the 50 most urgent Innovation Priorities as identified in the GPFM Action Plan 2022-2024.

Pillar 1 - Affordable and Reliable VRE

T1.1 – Novel Photovoltaic	1.1.1 High efficiency PV cells and modules
	1.1.3 Reliability evaluation of PV modules and systems
	1.1.5 Software and database for PV systems
	1.1.6 Recycling and eco-design of PV cells and modules
	1.1.7 Agri-PV technologies
T1.2 - Offshore Wind	1.2.2 Floating offshore wind turbines
T1.3 - Integrated Renewable Energy (IRE)	1.3.2 Large-scale IRE generation for improving system reliability and stability
	1.3.3 Distributed IRE generation at grid edge
T1.5 - Energy Storage Supply Chain, Recycle and Reuse	1.5.1 Analysis of batteries life cycle and monitor, test and recycle of batteries
	1.5.2 Recycling and reuse batteries design
	1.5.3 Innovation in energy storage technologies
	1.5.4 Driving cost-reduction across the battery supply chain
	1.5.6 Safety assessment of electrochemical storage
T1.6 - Technologies for System Stability	1.6.1 Grid-forming devices applied to solar PV and wind
	1.6.2 Grid-supporting technologies from inverter-based resources

Pillar 2 - System Flexibility and Market Design

T2.1 - Flexible Generation	2.1.1 VRE flexibility provision and contribution to generation capacity
	2.1.2 Further exploitation of hydropower and pumped hydro flexibility
T2.2 - Grid Flexibility	2.2.1 Innovative components and dynamic line rating
	2.2.4 Enhanced control rooms and automated decision systems
T2.3 - System Stability and Flexible Operations	2.3.1 System stability assessment considering high VRE penetration
	2.3.2 Enhanced TSO-DSO coordination platform for flexibility markets optimisation
	2.3.3 Innovative frequency and non-frequency ancillary services specifications
	2.3.4 Tools and solutions for DSO flexibility management
	2.3.5 DSOs and TSOs enhanced grid and DER observability
T2.4 - Energy Storage Integration	2.4.1 Need and requirements assessment for storage systems new services
	2.4.3 Utility scale storage systems for innovative flexibility services

	2.4.4 Assessment of energy management for multi-service energy storage systems
	2.4.6 Identification of main barriers hindering storage systems mass deployment
T2.5 - Demand-side and EV Flexibility	2.5.1 Methods to estimate the available actual demand-side flexibility
	2.5.2 Unlocking commercial and residential buildings flexibility potential
	2.5.4 Demand response, EV services and grid impact assessment
	2.5.5 Tools for optimal smart charging and V2G management
	2.5.6 Impact assessment of flexibility services on EV batteries
T2.6 - Flexible Systems Planning	2.6.1 Integrated transmission and distribution planning tool
	2.6.3 New planning strategies and methods for flexibility solutions and system services
	2.6.5 EV charging infrastructure planning and deployment
T2.7 - Markets, Business Models and Regulatory Framework	2.7.1 Flexibility markets for innovative ancillary services by VRE and storage
	2.7.4 Business models and regulatory framework for flexible resources
	2.7.5 Market access rules, grid tariffs and price schemes to exploit EV flexibility
	2.7.7 Regulatory solutions to foster flexibility provision from end-uses
	2.7.8 Output-based regulation to incentivise grid flexibility exploitation
	2.7.11 Social acceptance of innovative technologies and required behavioural change
T2.8 - Flexibility from Sector Integration	2.8.1 Sector Coupling flexibility assessment
	2.8.2 Optimal planning and operation of integrated energy systems

Pillar 3 - Data and Digitalisation for System Integration

T3.1 - Standards for Interoperability	3.1.1 Data discovery, access, and licensing
	3.1.2 Standardisation of devices and control platforms
	3.1.4 Data security standards and data privacy
T3.2 - Secure and Resilient Digital Energy Systems	3.2.2 Identify priority dataset for system security
T3.3 - Integrated Solutions	3.3.1 Interoperable markets, devices, and data
	3.3.2 Connected data platforms for enhanced forecasting and flexible operation

GREEN POWERED FUTURE MISSION

Green Powered Future Mission

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