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Making renewable energies drivers of competitiveness in the EU Outermost Regions

This document was authorised for publication by Ragnheiður Elín Árnadóttir, Director of the OECD Development Centre.

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Abstract

This paper provides a snapshot of the development of renewable energies in the European Union Outermost Regions (EU ORs), focusing on their potential to contribute to the green transition while creating sustainable economic development opportunities. It reviews the policy frameworks and tools in place in EU ORs with respect to renewable energies, and provides specific policy recommendations. The paper is developed within the framework of the EU-OECD project on Global Outermost Regions.

Foreword

The global economic landscape is uncertain, complex and fast changing. Governments, businesses and societies are endeavouring to better understand and, ultimately, govern the ongoing reorganisation of global trade with a view to optimising international exchanges, preserving openness and inclusiveness, and achieving an environmental and sustainable transition.

This paper is part of the OECD-EU project on “Transforming economies in EU outermost regions (EU ORs): fostering learning and making the most of global interconnectedness”, funded by the European Commission Directorate General for Regional and Urban Policy. Between 2021 and 2023, this project has supported a process of dialogue and knowledge sharing between EU ORs and international partners to identify opportunities for sustainable value creation and enhanced participation in global and regional value chains.

The European Outermost Regions (EU ORs) are EU member states’ territories located in the Atlantic Ocean, Caribbean basin, South America and the Indian Ocean and they are an integral part of the Union. They include Guadeloupe, French Guiana, Martinique, Réunion, Saint-Martin and Mayotte (France), the Azores and Madeira (Portugal), and the Canary Islands (Spain). Due to their remoteness, insularity, small size, difficult topography and climate they benefit from targeted support measures. Thanks to their distinctive characteristics and assets, including a rich biodiversity and strategic location, the EU ORs can play an important role in the overarching EU internationalisation and co-operation strategy and policy.

This paper provides an overview of the renewable energies in the EU Outermost Regions (EU ORs), revealing their unique strengths and growth opportunities. The study emphasises the potential for international collaborations with a wide range of partners. It also clarifies future opportunities for increasing internationalisation and co-operation with partners beyond the EU, including neighbouring countries in Africa, Latin America and the Caribbean and other developing and emerging economies like Small Island Developing States (SIDS). Furthermore, the paper identifies opportunities for future reforms to make the most of the multi-annual planning and resources of the EU, including the Communication on “Putting people first, securing sustainable and inclusive growth, unlocking the potential of the EU’s outermost regions” adopted in 2022.

This paper is one of several outputs of the project, which include two Production Transformation Policy Reviews: Spotlight on the Azores’ and Guadeloupe’s internationalisation and four policy papers on the innovation and patenting, ocean economy, the agro-food sector, and cultural and creative sectors.

Acknowledgements

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Abbreviations and acronyms

ADEME	French Agency for Ecological Transition
AFD	French Development Agency
ANR	French National Research Agency
ECEA	Canary Islands Blue Economy Strategy 2030
EEZ	Exclusive economic zone
EMFAF	European Maritime, Fisheries and Aquaculture Fund
ERDF	European Regional Development Fund
ESF	European Social Fund
EU	European Union
FDI	Foreign direct investment
FPV	Solar photovoltaic energy
GDP	Gross domestic product
GVA	Gross value added
ICT	Information and communication technology
IEA	International Energy Agency
IEDOM	*Institute d'émission des départements d'outre-mer*
Interreg	European Territorial Cooperation
IRENA	International Renewable Energy Agency
IUCN	International Union for Conservation of Nature
MSP	Marine Spatial Planning
MW	Megawatt
OCTs	Overseas Countries and Territories
OECD	Organisation for Economic Co-operation and Development
OR	Outermost Regions
OTEC	Ocean Thermal Energy Conversion
SIDS	Small Island Development States
SNA	System of National Accounts
SRDEII	Regional scheme for economic development, innovation and internationalisation
STI	Science, technology and innovation
SUT	Supply and use table
TAC	Total allowable catch
UNCLOS	United Nations Convention on the Law of the Sea

Executive summary

This policy paper, developed as part of the EU-OECD project on Global Outermost Regions, presents a comprehensive overview of renewable energies in the European Outermost Regions (EU ORs). It focuses on the potential of renewable energies to drive the green transition while fostering sustainable economic development. It assesses the status and opportunities in the EU ORs regarding various renewable energy sources, considering their unique characteristics. It also provides an overview of the existing policy frameworks and tools in place, concluding with policy recommendations for the future.

The EU Outermost Regions (EU ORs) face a critical imperative to shift towards sustainable production and consumption models. This shift is essential to preserve their distinct natural endowments and derive sustainable value from their abundant natural assets. One key avenue for achieving this sustainability lies in the realm of renewable energies, which offer substantial development prospects for the EU ORs.

The EU ORs possess significant potential for harnessing renewable energy sources such as solar, wind, geothermal, and hydropower. Furthermore, they can develop ecosystems around renewable energies to drive sustainable economic development. This transformative potential is vital for regions highly dependent on fossil fuels, reducing their vulnerability to external shocks and contributing to economic resilience.

The unique geographical locations and natural endowments of the EU ORs play a pivotal role in shaping their renewable energy deployment possibilities. These regions are spread across three distinct geographical areas, each with their own physical attributes: Amazonia and the Caribbean basin, the Macaronesia region in the Atlantic, and the Indian Ocean coast. This diversity allows the EU ORs to access and develop a wide range of renewable energy assets, aligning them with their energy needs and climate change mitigation and adaptation goals.

This paper underscores the assertion that the EU ORs can benefit from targeted policies at the EU level to promote renewable energies. It outlines three fundamental pillars for unlocking renewable energy potential:

- Innovation: Innovation is central to driving the development and deployment of cutting-edge renewable technologies. Establishing robust innovation ecosystems, collaborating with multilateral organisations and global industries, and securing access to capital and expertise are critical steps in leveraging abundant natural resources effectively.
- Connectivity: Enhanced connectivity is essential for promoting renewable energy in the EU ORs. This includes strengthening international partnerships both within the EU ORs and with other EU partners, as well as connecting with geographically and historically close neighbours. Existing cross-national and intra-regional partnerships can be expanded to encompass energy-related activities.
- Investment: Encouraging investments in renewable energy is pivotal for success. Updated financing and legal frameworks should actively incentivise investments in this sector, with the aim of stimulating sustainable growth and development across various sectors and activities.

By embracing these pillars of innovation, connectivity, and investment, the EU ORs can not only reshape their local economies but also strengthen their international ties. With financial resources, dedicated programmes, and strong political support at various levels, the EU ORs can make renewable energies a catalyst for a renewed development model.

1 Introduction

Shifting towards sustainable production and consumption modes is essential for the EU outermost regions (EU ORs) to preserve their unique natural endowments and to generate sustainable value from their natural assets. Renewable energies are on the rise globally and offer important development opportunities for EU ORs.

These regions have the possibility to exploit renewable energy sources, like solar, wind, geothermal and hydropower, and can also develop ecosystems around renewable energies to use them as drivers of sustainable economic development.

EU ORs are highly dependent on fossil fuels, which not only harm the capacity of these regions to transition to net zero, but also increases their vulnerability to external shocks. This makes them highly dependent on imports and subject to global price volatility. For example, in 2020 the price of electricity in Mayotte was EUR 383/MWh, almost four times higher than in mainland France (MAESHA, 2020[1]). Renewable energies, if properly exploited, have the potential to reshape local development in EU ORs, thus impacting all economic activities in these regions and creating more investment, innovation, and entrepreneurship opportunities.

This paper, developed as part of the EU-OECD project on Global Outermost Regions, provides a snapshot of global trends in renewable energies, focusing on their potential to contribute to both the green transition and to sustainable economic development opportunities. It discusses the status and opportunities for EU ORs with regard to the various sources of renewable energies and their specificities. It briefly overviews the policy frameworks and tools that EU ORs have in place with respect to renewable energies and concludes with policy indications for the future.

2 Global trends in renewable energy can benefit the EU ORs' green transition

Renewable energies can be a game changer for the development of the EU ORs. The EU ORs are net energy importers of fossil fuels with a large impact on local economies. On average 90% of energy is imported, imposing large constraints on their economic development. For example, in Martinique and Guadeloupe total imports of fuels accounted for roughly 9% of GDP in 2021. For some other countries with similar geographical constraints the toll on the economy is even larger. For both Palau in the Pacific Ocean and the Maldives in the Indian Ocean total fossil fuel imports account for almost 20% of GDP. Furthermore, many islands and territories with tourism-dependent economies heavily rely on energy-intensive industries (Atteridge and Savvidou, 2019[2]; Shah, 2022[3]). However, because of their geomorphic characteristics and locations, these territories have strong potential to benefit from the deployment of renewable energies by leveraging on their solar, wind, geothermal – and in some cases – oceanic and hydropower potential. The combination of such assets with emerging global trends can provide new opportunities for increased internationalisation with traditional partners – typically from Europe – and emerging, regional and private partners in their respective geographic regions in the areas of Foreign Direct Investment (FDI), value chain development, and research and innovation activities.

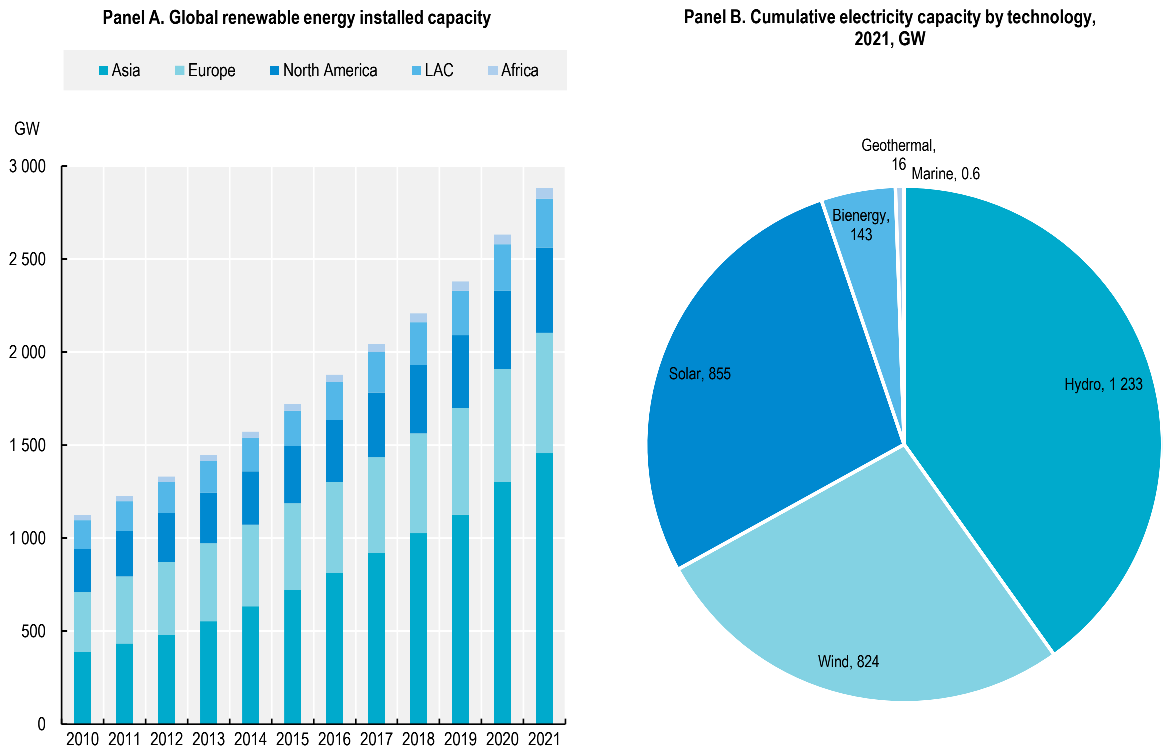
Renewables are growing and becoming cheaper globally

Renewable energies are growing rapidly. Between 2010 and 2021, global renewable energies' installed capacity increased trebled, reaching roughly 3 000 GW. The share of renewables in total capacity expansion reached 80% in 2021, compared to 38% in 2010. This increase has been driven by Asia, which accounts for 58% of total new installed capacity, followed by Europe, accounting for 18% and North America with 12%. Within the different renewable energies, hydropower is the leading technology accounting for 40% of total installed capacity in 2021, followed by solar and wind, representing 28% each. Other renewable energy sources include 143 GW of bioenergy, 16 GW of geothermal, and 524 MW of marine energy, accounting for 5% of total (Figure 1). Moreover, in 2022-27, renewables are expected to grow by another 2 400 GW (IEA, 2022[4]). These trends not only support environmental goals by reducing local pollutants and carbon dioxide (CO_2) emissions, they also create new economic opportunities.

Renewables are becoming cost-attractive options (Table 2). The competitiveness of renewables has improved significantly over the last decade. Between 2010 and 2021, the global weighted average levelised cost of electricity (LCOE) of newly commissioned utility-scale solar photovoltaic (PV) projects declined by 88%, onshore wind and concentrated solar power (CSP) by 68%, and offshore wind by 60%, making renewables competitive with respect to incumbent fossil fuel and nuclear options. For example, the global LCOE new utility-scale solar PV and hydropower in 2021 was 11% lower than the cheapest new fossil fuel-fired power generation plant. For bioenergy, geothermal and hydropower, installed costs and capacity factors are highly project- and location-specific. For example, the increase in LCOE since 2010 in hydropower has been driven by rising installed costs and more expensive infrastructure requirements due to operational conditions in more challenging sites. Still, in 2021, 85% of the hydropower capacity commissioned had an LCOE lower than the cheapest new fossil fuel-fired cost option (IRENA, 2022[5]).

Figure 1. Renewable energies are expanding rapidly

Global renewable energies' installed capacity by region and technology



Source: Based on IRENA (2022[6]), *Statistics Data*, https://www.irena.org/Data.

Several factors, one of which is technological advancements, have contributed to falling costs. For example, the increased use of trackers and bifacial modules of PVs as well as higher hub heights, larger turbines, and swept blade areas for wind turbines all contribute to increased efficiency. Likewise, augmented scale manufacturing as well as optimisation and reductions in materials' intensity have also played a critical role. Targeted policies have been key in both supporting technological progress geared towards renewables and in shaping demand. A growing number of countries are supporting the development of renewable energies, with a strong component of local content and aiming to address not only environmental sustainability through energy sufficiency but also self-reliance and increased resilience.

Increasing global policy attention is also supporting the deployment of renewables. The EU utilises with a targeted approach the Fit for 55 packages under the European Green Deal, as well as other initiatives like the Repower EU and the Green Deal Industrial Plan for the Net-Zero Age. The United States released the 2022 Inflation Reduction Act, and Japan has followed suit with the GX Green Transformation plan, which includes specific incentives and provisions for deployment of renewable energies. Carbon pricing actions are also shaping markets and helping make renewables marketable investment options. For example, with the implementation of the EU Emissions Trading Scheme (ETS) emission prices increased fossil fuel costs to USD 0.27/kWh in 2022, 645% higher than in 2021. This made them four to six times more expensive than the new solar or onshore wind capacity added in 2021 (IRENA, 2022[5]).

Table 1. Solar and wind power have rapidly become highly cost-effective electricity solutions

Total Installed costs (USD/kW), Capacity Factor and Levelised cost of electricity (USD/kWh), 2010-21

	Total installed costs (2021 USD/kW)			Capacity factor (%)			Levelised cost of electricity (2021 USD/kWh)		
	2010	2021	% change	2010	2021	% change	2010	2021	% change
Bioenergy	2 714	2 353	-13	72	68	-6	0.078	0.067	-14
Geothermal	2 714	3 991	47	87	77	-11	0.05	0.068	34
Hydropower	1 315	2 135	62	44	45	2	0.039	0.048	24
Solar PV	4 808	857	-82	14	17	25	0.417	0.048	-88
CSP	9 422	9 091	-4	30	80	167	0.358	0.114	-68
Onshore wind	2 042	1 325	-35	27	39	44	0.102	0.033	-68
Offshore wind	4 876	2 858	-41	38	39	3	0.188	0.075	-60

Source: IRENA (2021[7]), *Renewable Power Generation Costs in 2021*, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Power_Generation_Costs_2021_Summary.pdf.

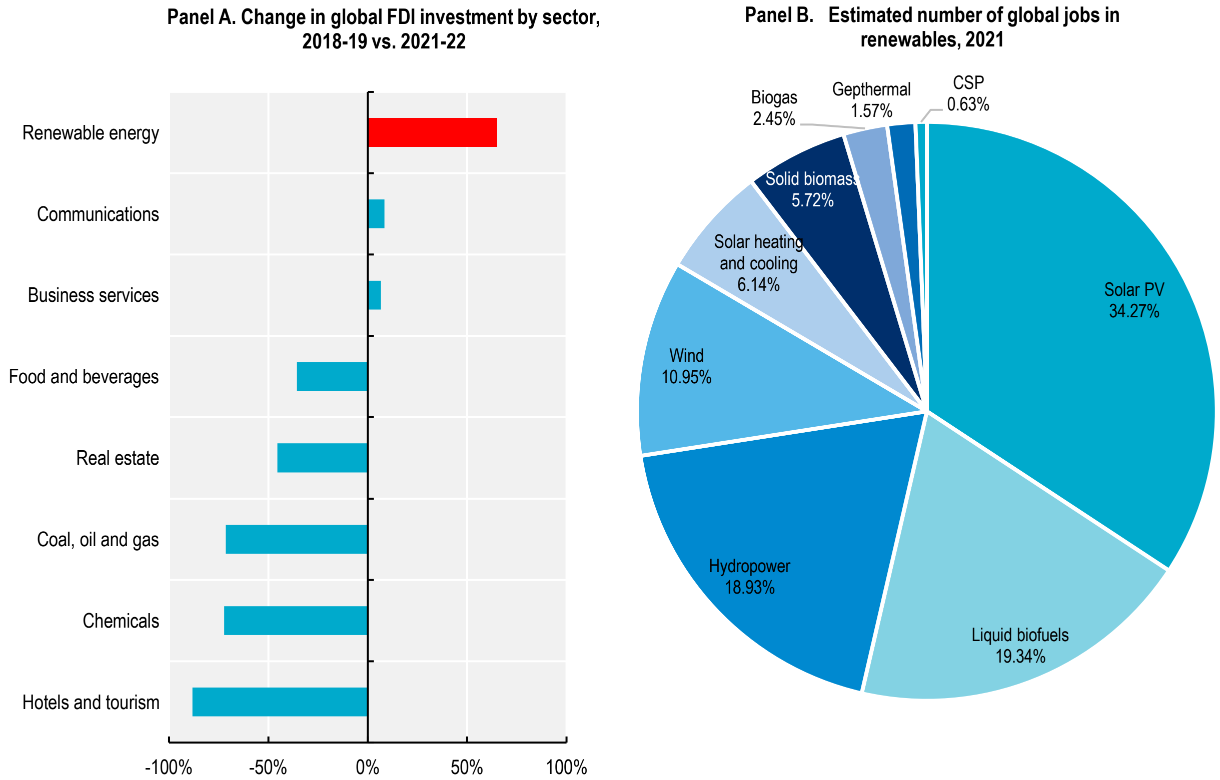
Renewables embed investment, jobs and innovation opportunities into environmental goals

Renewable energy projects are attracting FDI. Between 2018 and 2022, with USD 620 billion in global flows, renewable energies were the top global greenfield FDI sector, accounting for 15% of new investments. The largest global investors are from the United States with 18%, followed by Germany with 8%, France, China, and the United Kingdom with 6% each. Despite the global contraction of FDI induced by the Covid-19 pandemic, which led to a 70% contraction in global FDI in 2020, FDI into renewable energy increased by 60% (Figure 2 Panel A) from the 2018-19 period to the 2021-22 period, the largest increase of any sector, showcasing its resilience. FDI in the field bounced back rapidly, with an increase of 65% between 2018-19 and 2021-22 (Figure 2 Panel B). EU countries are the largest exporters of wind turbines, accounting for 80% of total exports whereas Asian countries, led by China, are the largest exporters of solar panels and lithium batteries for electric vehicles (EVs), with 84% and 67% of the global total respectively. The latter is a relative newcomer to the energy transition process but shows rapid uptake, with EVs already representing 8.3% of global car sales in 2021 and predicted to continue rising in the coming years. Moreover, annual battery manufacturing capacity is set to quadruple between 2021 and 2025, to approximately 2 500 GWh (IEA, 2022[8]).

Renewable energies have the potential to create green jobs. In fact, jobs in renewables could treble by 2030 according to available estimates. In 2021, it was estimated that globally almost 13 million jobs were in the renewable energy sectors, almost double the number in 2012. Solar PV accounted for a third of total jobs followed by bioenergy with 27% and hydropower with 18% (Figure 2, Panel B). According to the most recent estimates, in a under 1.5°C target scenario, direct jobs will reach 38.2 million in 2030, more than three times the number in 2021. Together with an additional 58 million indirect jobs in energy efficiency, power grids and flexibility, and hydrogen this could offset the 12 million jobs lost in the fossil fuel and nuclear industries (IRENA, 2022[9]).

Figure 2. Renewable energies are inducing new investments and jobs

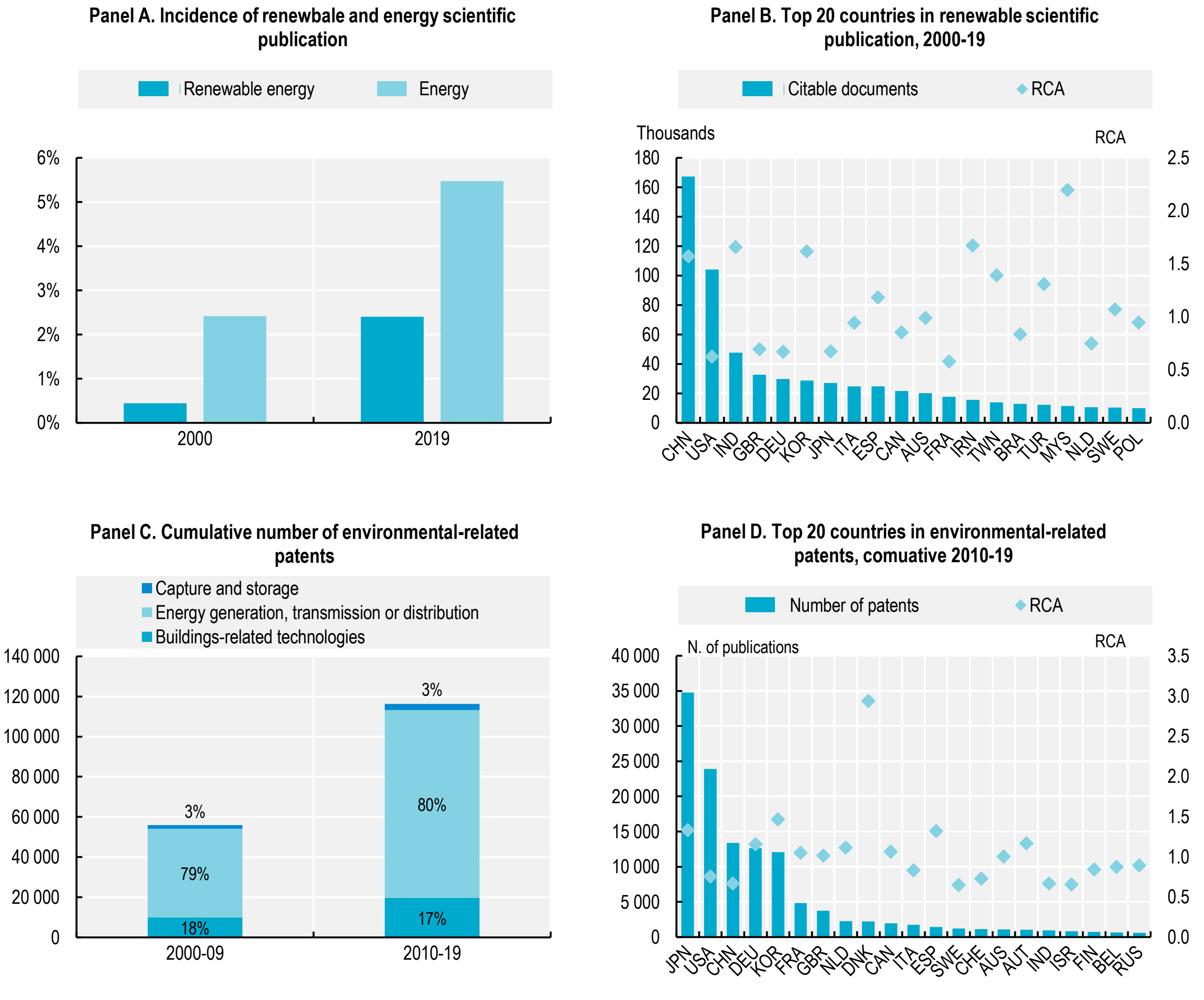
Greenfield FDI by sector and estimated jobs in renewable energies



Note: Panel A only includes top and worst sectors, in terms of growth and decline between the two periods.
Source: Based on IRENA (2022[6]), *Statistics Data*, https://www.irena.org/Data and FDI Market (2022[10]), *Database*, https://www.fdimarkets.com/.

Renewable energies are fostering technological and business innovation. Over the last 20 years scientific and technological development associated with renewable energies have boomed. While in 2000 scientific publication on renewables account for 0.4% of total scientific publications and for 20% of total energy scientific production, in 2019 they reached 2.3% and 50% respectively. Similarly patent applications related to environmental technologies more than doubled with energy transmission and generation accounting for 80% of these patents. The EU remains at the frontier with Nordic countries such as Sweden, Denmark and Finland displaying strong specialisation in renewables technologies. ORs' mainland countries such as France and Spain are also among the top scientific producers and innovators globally. Europe holds 66% of the global patents in tidal energy and 44% of the patents in wave energy (European Commission, 2020[11]), a technology of relevance to the majority of the ORs. However, new actors are emerging including countries such as China and India but also Indonesia, Malaysia, and Brazil (Figure 3).

Figure 3. Scientific and technological development in renewables is expanding in both OECD and non-OECD countries



Note: The patents' analysis considers PCT applications, with priority dates and inventors' country of residence. More information on patents in environment-related technologies can be downloaded at https://stats.oecd.org/wbos/fileview2.aspx?IDFile=c5c477c0-d300-42fe-af1f-d4a450c79a39. RCA stands for Revealed Comparative Advantage.

Source: Based on OECD (2023[12]), *OECD Patent Statistics*, https://doi.org/10.1787/patent-data-en and Scopus, https://www.elsevier.com/solutions/scopus, 2022.

3 Geographical location and natural endowments shape the EU ORs' renewable energies potential

The uniqueness of the EU ORs in terms of location and natural endowments shapes the regional possibilities of the deployment of renewable energies. To understand the current state and the potential for future developments linked to renewable energies in the EU ORs it is crucial to consider the specificities and variety of these regions in terms of location, geographical characteristics, and natural endowments. The EU ORs are located in three distinctive geographical areas with different physical attributes that include Amazonia and the Caribbean basin, the Macaronesia region in the Atlantic, and off the coast of east Africa in the Indian ocean. The EU ORs can access and develop a wide spectrum of natural assets to develop renewable energies to match their energy needs and to contribute to climate change mitigation and adaptation. In doing so, they can transform their economies to make them more sustainable. The EU ORs have considerable potential in traditional renewable energies, such as hydro and biomass, and in emerging areas linked to new technologies such as solar, wind and marine energy. Their geographical location, including differences in size, geological conformation and climate, means they are more suitable to some renewable solutions than others. Moreover, their challenges and opportunities in unlocking this potential are determined by the overall economic development and economic structures of each individual EU OR.

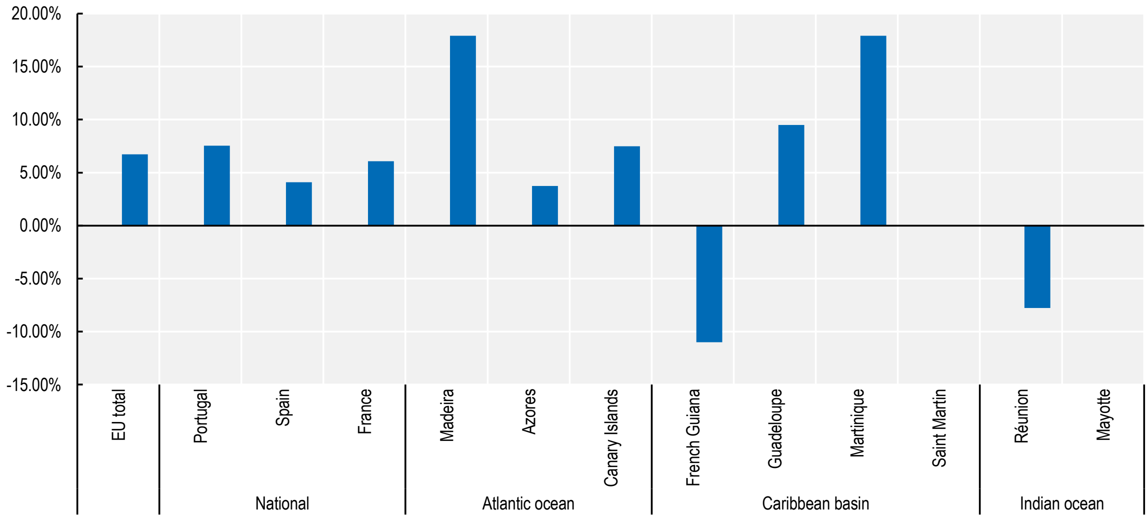
The EU ORs have advanced in the use of renewable energies at different paces. Despite the rich natural energy resources that the EU ORs have, seven of the nine EU ORs fall below the EU average in overall renewable penetration in production (Figure 4). Only Madeira (41.9%) and French Guiana (53%) have greater renewable shares of total electricity production than the total EU 27, which at present stands at 36.4%. The variability in renewable penetration and its changes over time is due to the heterogeneity in geographical characteristics, natural endowments, and economic profiles across the EU ORs.

- Five EU ORs – Madeira, the Azores, the Canary Islands, Guadeloupe, and Martinique – increased their renewable penetration between 2016 and 2021. In four out of five of these regions, the increase in renewable energy penetration has been higher than the EU total increase of 6.73% with Madeira and Martinique achieving an increase of 17.9% – over double the change in the EU total. However, in the Azores, renewable energy penetration increased by 3.8%, half of the average growth in mainland Portugal.
- Two EU ORs registered a decline in the share of renewables in electricity generation over this period: French Guiana (-11%) and Réunion (-7.76%), despite a net increase in overall installed capacity in both. This has been the result of several factors. Firstly, the lack of rainfall led to a sharp drop in hydroelectric production in 2021. Secondly, due to transmission losses caused by outdated grids connections the increase in production struggled to keep pace with the increase in demand. In addition, the expansion of access to electricity in remote off-grid areas has been driven mostly by non-renewable sources. Still, French Guiana remains the French department with the highest renewable penetration in electricity production (IRENA, 2023[13]).

- Two EU ORs – Mayotte and Saint-Martin – have the lowest share of renewables in electricity production, which was stable at around 5% over 2016-20. These regions are also amongst the EU ORs smallest territories with disconnected grids and limited scalability for new renewable energy projects.

Figure 4. Uptake of renewable energies varies across EU ORs

Change in the percentage of total primary electricity produced by renewable energy, 2016-22 or last available year



Note: Azores and Madeira are from 2022; all the remaining ORs refer to 2021.
Source: Based on Maldonado (2017[14]), *Energy in the EU Outermost Regions (Renewable Energy, Energy Efficiency)*; IRENA (2023[15]), *Energy Profiles*, https://www.irena.org/Data/Energy-Profiles; APREN (2022[16]), *Electricity Production for Portugal*, https://www.apren.pt/en/renewable-energies/production/; EMBER Climate (2023[17]), *Electricity Data Explorer*, https://ember-climate.org/data/data-explorer/; Consejería de Transición Ecológica, Lucha contra el Cambio Climático y Planificación Territoriallimático (2022[18]), *Energy Strategy Sustainable in the Canary Islands*; OER (2023[19]), *Production d'électricité*, https://oer.spl-horizonreunion.com/electricite/production-electricite-la-reunion; Interreg (2019[20]), *RESOR Project Joint Regional Analysis*; OREC (2022[21]), *Guadeloupe Energy Bulletin - S1-2022*, Observatoire de l'Energie et du Climat.

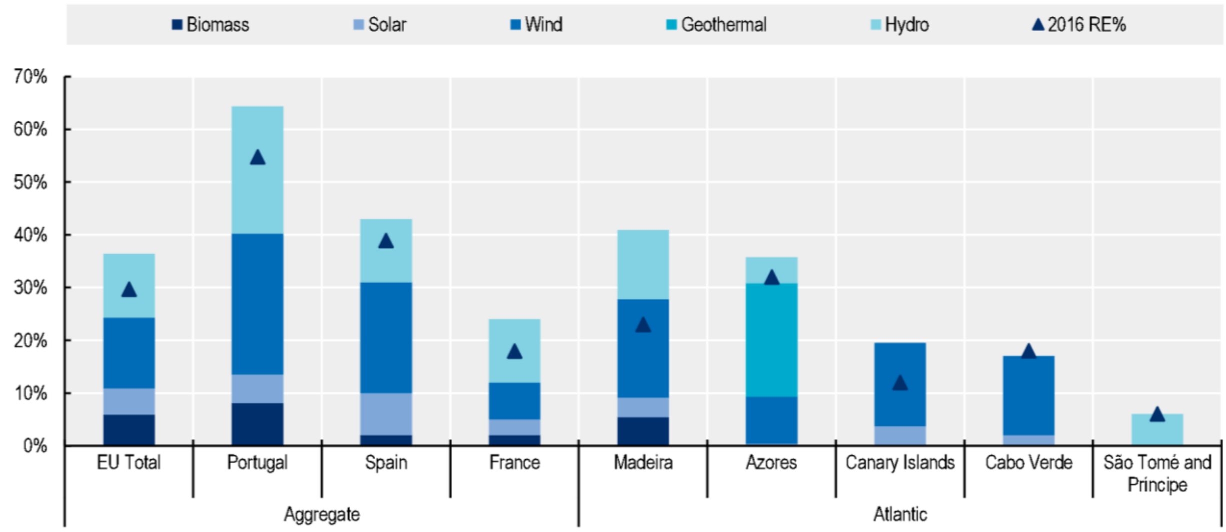
The following paragraphs summarise the current and future potential for deploying renewable energies in the EU ORs, grouped according to three geographic regions.

In the Atlantic

The Atlantic region hosts three EU ORs (Madeira, the Azores, and the Canary Islands) with diverse energy profiles. Accounting for 20% of total primary electricity production in the Canary Islands and 40% in Madeira, renewables play an important role in electricity production, spread across several different technologies and have been increasing steadily over the last seven years. While remaining below their respective national levels, penetration in the Canary Islands and Madeira is above other countries in the Atlantic such as São Tomé and Cabo Verde, with 6% and 16% respectively. From a technological point of view, wind plays a critical role in renewable electricity generation in all EU ORs, ranging from 25% of total renewable electricity generation in the Azores and 45% in Madeira to 81% of total renewable electricity generation in the Canary Islands (Figure 5).

Figure 5. Wind is an important source of renewables in the Atlantic

Change in the percentage of total primary electricity produced by technology, 2016-22



Note: Cabo Verde and São Tomé and Príncipe data are from 2020.
Source: Based on Maldonado, E. (2017[14]), *Energy in the EU Outermost Regions (Renewable Energy, Energy Efficiency)*; IRENA (2023[15]), *Energy Profiles*, https://www.irena.org/Data/Energy-Profiles; APREN (2022[16]), *Electricity Production for Portugal*, https://www.apren.pt/en/renewable-energies/production/; EMBER Climate (2023[17]), *Electricity Data Explorer*, https://ember-climate.org/data/data-explorer/; Consejería de Transición Ecológica, Lucha contra el Cambio Climático y Planificación Territoriallimático (2022[18]), *Energy Strategy Sustainable in the Canary Islands*.

The Canary Islands have strong solar and wind potential with six of the seven main islands having high solar intensity and strong winds year-round. With more than 1 850 kWh/kWp PV power output (PVOUT),[1] the Canary Islands are the EU OR with the largest solar potential. In 2021, the Spanish government and the European Regional Development Fund (ERDF) invested EUR 20 million in 65 new solar power systems with a total estimated capacity of 255 MW (PV Tech, 2021[22]). Also, over 2003-22 solar renewable energies attracted most of the FDI in the region, accounting for 30% of total FDI inflows from Norway, Italy, Denmark, Australia, and United Kingdom. The region is also experimenting with other renewable technologies. These include a 5 MW offshore wind turbine deployed in 2019 in the Canary Islands (Wind Europe, 2021[23]), which was Spain's first offshore wind power plant, and the deployment of a pilot offshore solar plant in 2021 (Garanovic, 2021[24]).

The regional government of the Canary Islands is prioritising the expansion of renewable energy potential, which entails increasing demand, improving management, and augmenting storage capacity. The region has an ambitious target of trebling electricity generation from renewables by 2030 for a total of 3.2 GW. A particular focus in developing the Canary Islands' renewable potential will be demand management strategies, such as the use of excess capacity to run water desalination plants at off-peak times and incentivising the charging of electric vehicles and water heaters during off-peak times as well as providing energy storage solutions to ensure a constant and sufficient supply of electricity that wind and solar sources alone cannot achieve (Interreg, 2019[20]). To meet these objectives the Regional Government is planning to develop pumped storage solutions in Salto de Chira, which will provide 3 200 MWh of storage capacity as well as the expansion of the Gorona del Viento plant for an additional 150 MWh (Consejería de Transición Ecológica, Lucha contra el Cambio Climático y Planificación Territoriallimático, 2022[18]).

[1] PVOUT represents the amount of power generated per unit of the installed PV capacity over the long term, and it is measured in kilowatt hours per installed kilowatt-peak of the system capacity (kWh/kWp).

An issue which will deserve particular attention in the future is considering the option to fully utilise the renewable energy resources in the region, while considering the need to preserve and protect natural areas. At present, the Canary Islands have 146 protected natural areas, covering 40% of their landmass. An in-depth analysis, discussion, and consultation between all stakeholders in the region will be needed to balance environmental protection and economic exploitation, leading to an eventual update of the legal frameworks regulating natural protected areas (Consejería de Transición Ecológica, Lucha contra el Cambio Climático y Planificación Territoriallimático, 2022[18]).

The Azores have strong geothermal and hydroelectric potential, and currently generate 21.5% and 4.9% of their total electricity, respectively. These resources are less spatially intensive than either solar or wind energy. This makes them more viable for the Azores given their archipelago nature and the small size of all the nine islands. By comparison, the Azores has a landmass of 2 322 km^2, compared to the Canary Islands' 7 447 km^2. However, geothermal and hydroelectric energy sources tend to require a larger project and investment scale to be economically viable, requiring the ability to mobilise large upfront capital investments.

The scattered geographic distribution of the Azores islands leads to disconnected grids, which limits demand capacity. A technologically feasible solution to this would be connecting these grids via undersea cables. This is, however, at present very expensive and operationally challenging considering that the ocean depth often exceeds 1 000 m and given the scarred basalt sea floor (Interreg, 2019[20]). The regional government is looking to address these operational challenges by opting for a modular approach that aims to strengthen geothermal capacity and support the deployment of wind technologies. In addition, it seeks to increase storage capacity of batteries in the Azores in order to compensate for the lack of consistent baseload electricity supply.

In Madeira, in 2022 electricity generation produced by renewables reached 40% of the regional total for the first time. This has been possible thanks to the expansion of solar, hydropower and, particularly, wind, which in 2016-22 increased by 62% from 84 to 137 GWh. The region is working to expand its storage capacity to support new wind and solar projects and leverage the marine and wave energy potential of both the main island, Madeira, and Porto Santo (Ramos et al., 2021[25]). As part of the Portuguese Recovery and Resilience Plan, Madeira also aims to mobilise public and private resources to phase out thermoelectrical production and to foster co-integration of different renewable energy sources and support the digitalisation of the electricity network through the development of smart grids (IEA, 2022[26]).

In the Caribbean and Amazonia

The Caribbean and Amazonia region hosts four EU ORs. French Guiana, Guadeloupe and Martinique have larger total renewable primary electricity production shares compared to both neighbouring countries and mainland France. Biomass and solar are the two primary renewable energy sources; geothermal is gaining momentum due to the strong regional potential and the already established regional geothermal industry. French Guiana produces the most primary electricity from renewable sources than any other EU OR. This is primarily due to its geographic location on the South American continent, which grants the region access to multiple large river networks with strong hydroelectric potential (Figure 6). While all EU ORs in the Caribbean have progressed in renewable energies, there is room to scale up and foster further progress (OECD, 2022[27]).

In Guadeloupe, renewables contribute to 23% of electricity generation. In 2021, geothermal, with 115 GWh, followed by solar, with 104 GWh, are the main renewable energy sources for electricity generation. The geothermal plant of Bouillante, active since 1986, provides 11% of the electricity of the region. Since 2015, the plant is owned by a US-based conglomerate. An extension plan, currently under study, should lead to a total production of 45 MW that could cover 20% of total electricity demand in the region.

The eastern Caribbean features strong and consistent winds, such as *Les Alizés*, that together with solar irradiation due to their position in the tropics, are particularly relevant assets for renewable energy generation. Between 2010-21, solar PV installation increased sixfold in terms of electricity production. Photovoltaic installations connected to the network are concentrated in four municipalities on Guadeloupe: Baie-Mahault, Petit-Canal, le Moule and Saint-François. Wind power is also gaining momentum in the region. In 2019, the region opened a wind power plant with a total capacity of 15 MW and a production capacity of 33 GW that can provide electricity to 17 000 people. It is the result of a public and private partnership that includes a 30% stake from the French development bank *Caisse des dépôts et consignations.* The region also hosts a cogeneration plant with an installed capacity of 102 MW. Fuelled with coal and bagasse – a fibrous residue of sugar cane – it supplies 20% of electricity of the entire island. By 2023, unit 3 of the power plant is supposed to be converted to burn 100% biomass, yielding a drop in carbon dioxide emissions of 87% and increase total renewable penetration in the region to 35%.

Martinique is also accelerating its shift towards renewables. Between 2016 and 2021, the share of renewable energy almost trebled due to several new investments. In 2018, the Albioma group inaugurated the first power plant in an OR to produce electricity and low-pressure steam using biomass only. The plant has an installed capacity of 40 MW and can potentially supply 19% of the total demand from the grid. Over time, the share of locally sourced biomass it burns is expected to increase to 40%. The same group operates several PV plants in the region. In 2018, these plants supplied 17.6 GWh of renewable electricity to the Martinique network, representing nearly one-quarter of all photovoltaic power generated on the island. Martinique is also pushing to develop its untapped wind potential with two main projects: the Grand Rivière power plant (a 14 MW wind farm) and the construction of Beauséjour, a 65 MW wind farm in the north of the island, with an integrated battery energy storage system (BESS) (Interreg, 2019[20]). The recent advancements in increasing the forecasting accuracy of these systems (from 70% to 90%) allows for a better discharge rate and maintain a reliable supply of energy without needing to invest in additional baseload energy solutions (Interreg, 2019[20]).

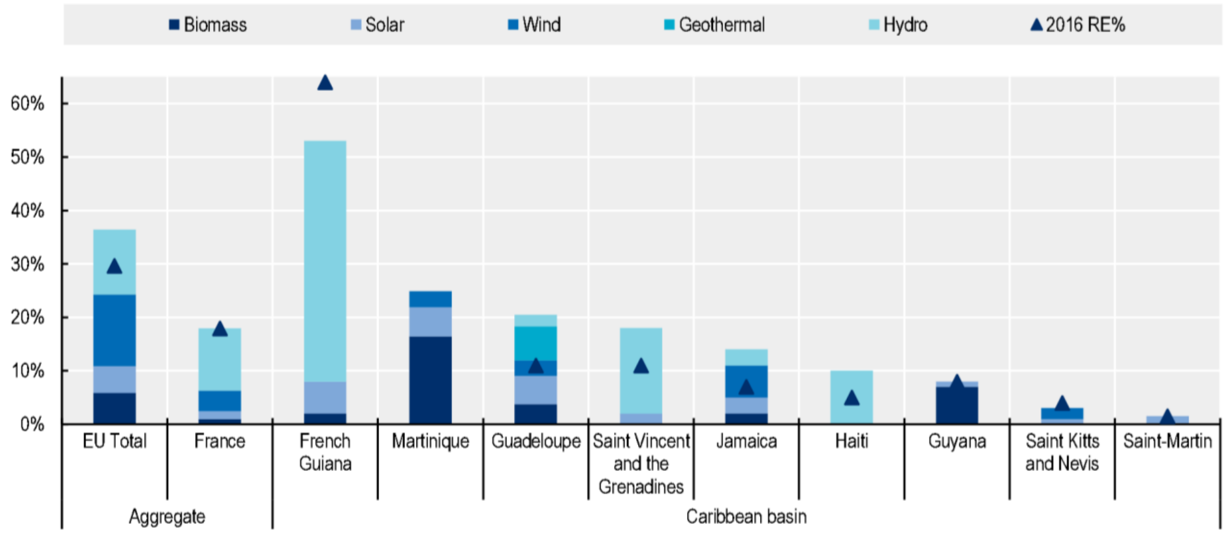
With more than 50% of electricity produced from renewables, French Guiana has the highest penetration of renewables of any French department and among the EU ORs. This is mainly due to the ample availability of running water from the Amazonia Forest. More than 50% of its current 220 MW of hydropower comes from the dam *Petit Saut* that supplies a 116 MW power station. The region is aiming to increase its renewables penetration by leveraging on its underutilised biomass potential. The geographical location near to the equator and large landmass of 83 846 km², twelve times the size of the Canary Islands, with highly fertile soil with a net primary productivity (NPP) of 10.5 tC/ha/yr,[2] compared to the global average of ~3-4 tC/ha/yr), make it an ideal location for bioenergy usage (IRENA, 2022[28]). For example, the French renewable power producer Voltalia SA with the support of Proparco is developing a 5.1 MW biomass power plant in the region.

In Saint-Martin, the use of renewables remains limited. In this region, electricity originates mainly from thermal combustions (diesel engines), and very marginally from photovoltaic panels with a total regional capacity of 1.8 MW. The peculiarity of Saint-Martin is that the electrical networks serving the two sides of the island (Sint Maarten has the status of an overseas country and territory that is part of the Netherlands) do not regularly operate on an interconnected basis, while a single line allows energy exchange in case of an emergency. Advancing in the deployment of renewable energies in this region would require an effective and practical co-operative approach with Sint Maarten.

[2] Net primary productivity is the amount of carbon retained in an ecosystem (increase in biomass); it is equal to the difference between the amount of carbon produced through photosynthesis (GPP) and the amount of energy that is used for respiration (R). The unit of measure indicates the tons of carbon per hectare, per year that a country produces. For more information see Ashton et al. (2012[52]).

Figure 6. In the Caribbean Basin, ORs are deploying renewables more rapidly than mainland France

Change in the percentage of total primary electricity produced by technology, 2016-22



Note: Data for Saint Vincent and the Grenadines, Jamaica, Haiti, Guyana, Saint Kitts and Nevis are from 2020.
Source: Based on IRENA (2023[15]), *Energy Profiles*, https://www.irena.org/Data/Energy-Profiles; Interreg (2019[20]), *RESOR Project Joint Regional Analysis*; OREC (2022[21]), *Guadeloupe Energy Bulletin - S1-2022*, Observatoire de l'Energie et du Climat.

In the Indian Ocean

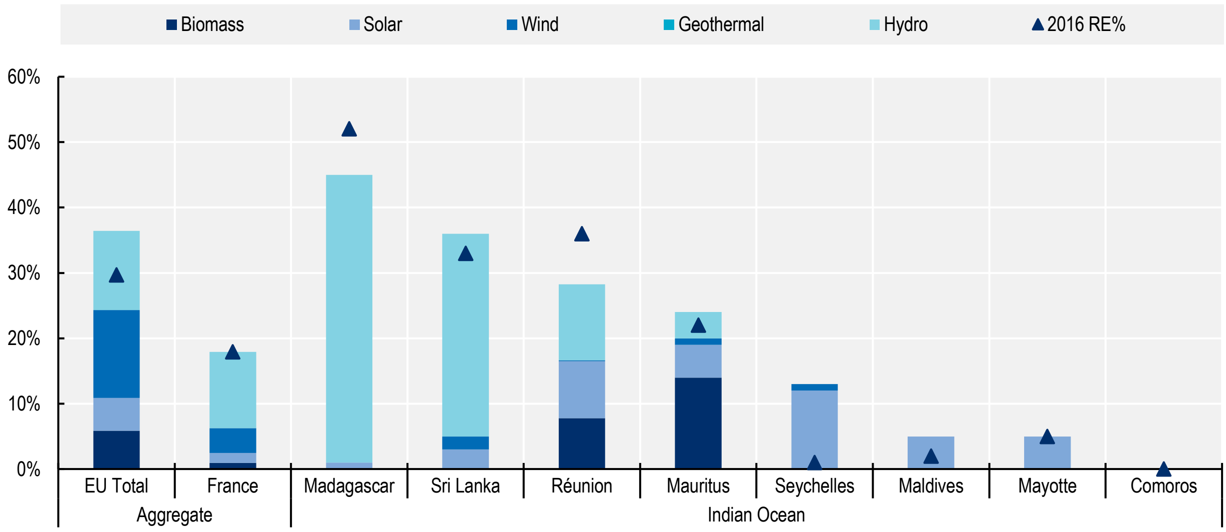
The Indian Ocean is home to two EU-ORs – Réunion and Mayotte –which have two different renewable energy profiles, due to their differences in size and physical characteristics. Mayotte, much like other small islands such as the Seychelles and Maldives, relies mostly on solar energy for its renewable electricity, contributing to 5% of total electricity generation in 2021 (Figure 7).

The limited size makes it difficult to take advantage of other renewable energy sources widely used in the area such a hydro and biomass due to the lack of sufficiently large sources of running water and limited crop land. Réunion, with a renewable energy penetration of almost 30% in 2021 (i.e. 6 percentage points larger than in 2016), relies on equal measures of hydro, solar and biomass, much like Mauritius. Other major countries and islands in the region such as Madagascar and Sri Lanka with larger landmasses and water resources mainly produce electricity through hydro while other technologies have limited penetration.

Réunion has a relatively diversified renewable energy mix. Hydroelectricity is the leading renewable energy source followed by biomass (bagasse) and solar. In the region there are six hydroelectric power plants, two of which, Sainte-Rose and Takamaka account for 90% of total 133 MW hydroelectric generation. Solar capacity is also increasing since the first large plant in 2006. However, like in other ORs context, the exploitation of solar energy faces the problem of its intermittent nature and need for storage capacity. Focusing on capacity solutions is a key part of the regional government's vision of reaching 100% renewable generation in 2028. Biomass appears to be particularly important to Réunion's transition. For example, in Réunion, Albioma has converted two of their 40-60% coal-biomass hybrid plants into pure biomass powerplants (Deutsche Welle, 2022[29]). When space is highly limited, these conversion projects can save a large amount of upfront capital and help to prevent "infrastructure stranding", which would incur demolition costs in the future. This is particularly critical when considering the difficulty in mobilising large amounts of capital in these small, isolated markets. To meet this increased demand for biomass Albioma plans to import pellets from the United States, and potentially from Mozambique and South Africa in the future, which raises concerns in terms of sustainability (Deutsche Welle, 2022[29]). One promising future pathway for Réunion could be to shift to importing from Mauritius, using their established biomass industry with several active firms with experience in the production of biomass pellets, reducing transport costs. (Energy XPRT, 2023[30]).

Figure 7. Indian Ocean energy shares feature high hydroelectric and solar penetration

Change in the percentage of total primary electricity produced by technology, 2016-22



Note: All electricity profiles are from 2020 except for Mayotte which is from 2016 and Réunion which is from 2022.
Source: Based on IRENA (2023[15]), *Energy Profiles*, https://www.irena.org/Data/Energy-Profiles; Interreg (2019[20]), *RESOR Project Joint Regional Analysis*; OREC (2022[21]), *Guadeloupe Energy Bulletin - S1-2022*, Observatoire de l'Energie et du Climat.

Mayotte, like Saint-Martin in the Caribbean, only relies on photovoltaic power for its renewable electricity generation, which only accounts for 5% of total electricity production. The potential for PV development is greater than wind energy given the limited exposures to strong and persistent winds. For PV technologies land availability and poor grid connection are the main challenges for large-scale expansion. All this results in very high electricity prices which are almost four times higher than in mainland France. Mayotte, however, has strong untapped potential for geothermal energy. In 2019, after several years of exploration, the French geological survey (BRGM) started, comprised of a geophysical measurement campaign together with a fracture analysis on the feasibility of a geothermal plant on the Island of Petite Terre, though the results are not available yet (BRGM, 2021[31]).

4 The EU ORs can utilise targeted policies at the EU level to promote renewable energies

The European Green Deal (EGD) is the reference framework for boosting the use of renewables in the EU ORs. One-third of the EUR 1.8 trillion in investments from the NextGeneration EU Recovery Plan is targeted to reduce emissions by at least 55% by 2030, compared to 1990. In 2019, the EGD adopted pledges to create new investment and innovation opportunities as well as to address energy poverty, create jobs and reduce external energy dependency (European Commission, 2022[32]). The Commission in 2022 also presented the REPowerEU Plan that aims to accelerate the diversification of energy sources and the uptake of clean energy amid the new geopolitical reality. Other relevant EU initiatives and legislation that complement the framework include the Renewable Energy Directive (RED) of 2022, the amended Energy Efficiency Directive (EED) of 2018, Solar Energy Strategy of 2022 and the New Energy Solutions Optimized for Islands (NESOI). The latter supported the Industrial Energy Community in the Arinaga Industrial Area Park in Gran Canaria. La Palma has also been chosen as one of the six pilot islands of the Clean Energy for EU Islands Initiative.

National strategies use the EGD as a reference point. These include: the National energy and climate plans (NECPs), which aim to meet the EU's new energy and climate targets for 2030; other instruments such as the Recovery and Resilience Facility with the National recovery and resilience plans; and the regional programmes (OP) of the EU cohesion policy funds. For example, the regulations for the 2021-27 programming period specify that 30% of European Regional Development Fund (ERDF) and 37% of Cohesion Fund should be focused on climate objectives (European Committee of the Regions, 2022[33]).

Several EU ORs have more ambitious targets than the EGD (Table 2). Madeira and the Azores have aligned with the national Portuguese targets which go beyond those of the European Green Deal, striving for a greater share of renewables in the electricity mix as well as adding goals for energy efficiency and renewable energy penetration in transport. Madeira has also added a further goal to reduce greenhouse gas emissions by 85% (compared to 2005) by 2050, as well as a commitment to allocate 30% of their regional budget to climate action (Interreg, 2021[34]). Spain similarly has more ambitious goals than those of the European Green Deal, which the Canary Islands build upon further aiming for a 62% renewable share of their total energy capacity as well as a 29% renewable share in the total energy share through penetration in transport as well as heating (through solar heaters) (Interreg, 2021[35]). Similarly, Martinique strives to exceed the European Green Deal targets, aiming for 50% renewable penetration in the electricity mix. Réunion however has the most ambitious goals, aiming to decarbonise the energy matrix by 2028.

Table 2. Regional strategies of the ORs and the EU Green Deal

	ORs	Greenhouse gas emission reduction compared to 1990 levels (by 2030) (%)	Renewable penetration into the electricity mix by 2030 (%)	Increase energy efficiency increase by 2030 (compared to baseline scenario) (%)	Reduction in electrical interconnectedness by 2030 (%)	Zero emission transport share by 2030 (%)	Renewable energy penetration into total energy use by 2030 (%)	Carbon neutrality
EU Green Deal		55	32		32			2050
EU ORs	Guadeloupe	55	32	NA	32	NA	NA	2050
				NA		NA	NA	
	Saint-Martin			NA		NA	NA	
	French Guiana			NA		NA	NA	
	Mayotte			NA		NA	NA	
	Martinique		50	NA		NA	NA	
	Réunion	55	100	20		Reduce fossil fuels in transport by 10	100 (by 2028)	2028
	Madeira	55 (85, compared to 2005, by 2050)	47	35		20	-	2050
	Azores	55	47	35		20	-	2050
	Canary Islands	37 (compared to 2010)	62	27		16 (Specifically, only road vehicles)	29	2040

Source: Based on Interreg (2019[20]), *RESOR Project Joint Regional Analysis*; Consejería de Transición Ecológica, Lucha contra el Cambio Climático y Planificación Territoriallimático (2022[18]), *Energy Strategy Sustainable in the Canary Islands*.

The policy approach is similar among the EU-ORs. Most of the incentives focus on supporting renewable energy demand and providing incentives to diversify renewable energy supply, as well as increasing energy efficiency and securing affordable access to energy for all. Seven out of the nine EU ORs are prioritising improvements in the allocation of public financing. The latter reflects the cross-cutting difficulty in accessing and utilising EU funding. Due to the limited human resources and knowledge, several EU ORs struggle to design and implement effective multi-annual projects (Interreg, 2019[20]). Guadeloupe and Martinique are also prioritising infrastructure development linked to the modernisation of the electricity grid as well as the deployment of infrastructure resilient to natural disasters, given the increasingly large number of natural disasters that are affecting the Caribbean region. While French Guiana, Mayotte and Saint Martin have a limited number of policy objectives focused on improving business competitiveness such as innovation, attraction of investment and development of skilled labour, these specific objectives feature more prominently in the EU ORs in the Atlantic and in Réunion (Table 3).

Table 3. EU-ORs policy objectives linked to renewable energies

Area	Objectives	Atlantic			Caribbean				Indian	
		Madeira	Azores	Canary Islands	Martin.	Guad.	French Guiana	Saint-Martin	Mayotte	Réunion
Energy efficiency and supply	Diversification of energy matrix	✓	✓	✓	✓	✓				✓
	Electrification of energy matrix		✓	✓		✓				✓
	Increase re use	✓	✓	✓	✓	✓	✓	✓	✓	✓
Household and demand	Improve energy efficiency	✓	✓	✓		✓		✓		✓
	Reduce number of people in energy poverty	✓			✓	✓	✓	✓	✓	
	Improving awareness of renewables	✓	✓	✓		✓		✓		
Business competitiveness	Promote innovation and new industries	✓	✓	✓	✓					
	Promoting skilled labour	✓	✓	✓	✓					
	Attract and mobilise private investment		✓	✓						✓
Infrastructure development	Improve grid interconnectivity			✓		✓	✓			✓
	Increase energy storage		✓	✓	✓	✓				✓
	Resilience against natural disasters				✓	✓				
Governance	Improve public fund allocation including eu	✓	✓		✓		✓	✓	✓	
	Streamlining project approval processes	✓		✓	✓	✓				
	Demand management	✓			✓					✓

Source: Based Interreg (2019[20]), *RESOR Project Joint Regional Analysis*; Consejería de Transición Ecológica, Lucha contra el Cambio Climático y Planificación Territoriallimático (2022[18]), *Energy Strategy Sustainable in the Canary Islands*; French Regional Multiannual Energy Programming.

5 Unleashing the full potential of renewables to foster internationalisation in the EU ORs

The EU ORs have the potential to speed up the deployment of renewables while also supporting the electrification of the energy matrix. While the EU institutions and Member States are discussing new CO_2 emissions reduction targets by 2035 for cars and commercial vehicles, the EU ORs may consider the electrification of their energy matrix as a priority. The ORs can become hubs for electricity generation from off-grid renewable sources but this will require the phase out of strategies, to shift from relying on fossil fuels subsidies and eliminate market distortions. The policy actions and instruments need to be designed within the national and EU contexts, and the local authorities should consider the trade-off between subsidised fuels on the economy and energy poverty against the potential to accelerate the deployment of new renewables according to their potential (Table 4). These analyses regarding the transition should also consider non-monetary costs such as environmental, health and social aspects, while continuing to combat energy poverty among the most vulnerable population.

Table 4. Energy sources with strong potential for the EU ORs

Region	OR	Solar	Wind	Hydroelectric	Geothermal	Biomass	Marine
Atlantic	Madeira		✓	✓		✓	✓ - Wave
	Azores		✓	✓	✓		✓ - Wave
	Canaries	✓	✓				
Caribbean	Martinique	✓	✓		✓	✓	✓ - OTEC
	Guadeloupe	✓	✓		✓	✓	✓ - OTEC
	Saint-Martin	✓	✓				✓ - OTEC
	French Guiana	✓		✓		✓	
Indian Ocean	Réunion	✓		✓	✓	✓	✓ - OTEC
	Mayotte	✓			✓		✓ - OTEC

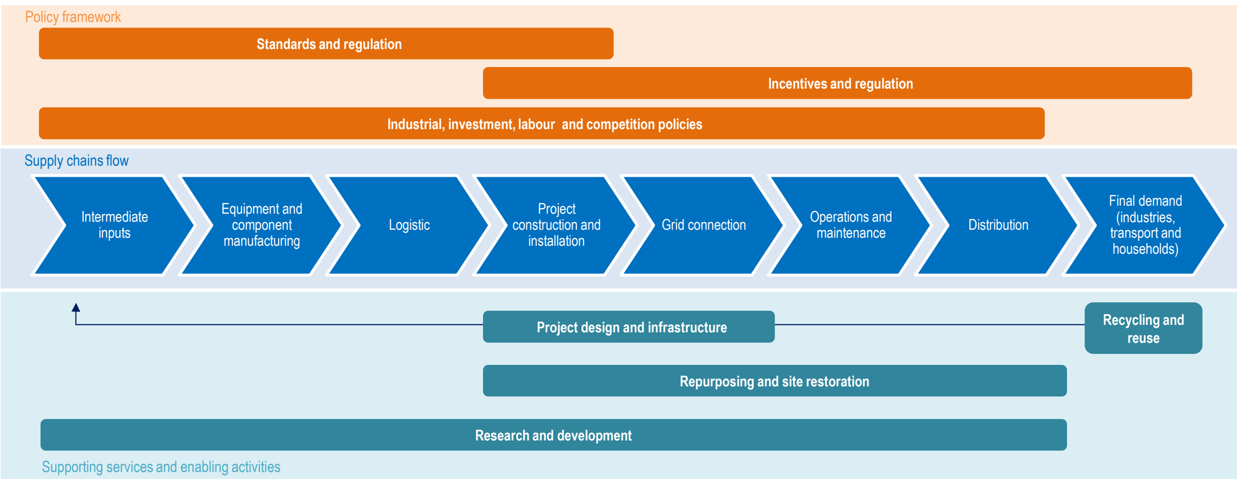
Source: Authors' elaboration.

Besides the environmental and ecological benefits, renewables can spur new business opportunities and support innovation in the EU ORs. Renewables can help the EU ORs to identify ways to preserve their unique natural ecosystems, whilst also activating mechanisms to support value chain development, attract investment, foster innovation, and create new jobs. Renewables embed transformational opportunities and synergies within traditional sectors such as agri-food and transport and in other emerging areas including the circular economy that can support a long-term sustainable and inclusive development model.

Renewable energy supply chains involve a set of complex activities. Regardless of the technology, renewable value chains include a set of complex downstream and upstream activities that require an adequate policy framework, financing, supporting services and specific technological and industrial capabilities (Figure 8). From access to raw materials for manufacturing components such as semiconductors, solar PV cells and inverters, and wind turbine blades and towers, to infrastructure development including grid connection and installation, solar energy requires a set of specific knowledge and skills that are context specific and do not accrue overnight. Manufacturing segments are largely localised where economies of scale are possible to achieve, such as China, India, the United States and the EU countries. For small regions such as the EU ORs, where economies of scale cannot be achieved there is the untapped opportunity to leverage their unique natural endowments and leverage more sophisticated supporting services and activities. These include scientific research and innovation activities adapted to specific climate or environmental contexts as well as downstream activities that involve an effective circular process and the reuse of natural resources.

The EU ORs have enormous potential to be natural test laboratories for the use and combination of diverse renewable energy production facilities and for the development of new technologies: the availability of bioresources of the Amazonia in French Guiana, the high and constant solar irradiation of the Canary Islands, the winds of the Caribbean and the geothermal resources in the Azores and the marine assets for almost all the regions. The EU ORs can in turn provide to the EU and the global scientific community the possibility to test frontier technologies. At the same time, these opportunities can promote the development of local capabilities, which would trigger a virtuous cycle of knowledge accumulation and economic growth with a strong sustainable footprint.

Figure 8. Renewable supply chains



Source: Authors' elaboration.

EU ORs are trying to unlock the potential of innovation linked to renewable energies. For example, since 1990, the Canary Islands have hosted the Technological Institute and Renewable Energies (ITER). Located on the island of Tenerife, it has conducted numerous international projects involving technology transfer and pro-development co-operation linking Europe, America, and Africa. Réunion also has established research and innovation initiatives related to renewables. The Temergie energy cluster brings together around 50 stakeholders from both the public and private sector operating in renewables, energy efficiency, smart grids, energy storage and smart mobility. The University of Réunion hosts the ENERGY lab, which focuses on research aimed at optimising solar and intermittent energy systems. Still both human and capital resources dedicated to R&D and innovation remain limited, given the small size and lack of scalable market opportunities. For example, the French ORs' R&D expenditure account for 0.4% of GDP compared to the national average of 2.3% in 2015. Likewise, in the ORs less than 1 in 10 firms are active in R&D activities compared to 6 in 10 in mainland France (IEDOM, 2020[36]). The Canary Islands, Azores and Madeira have figures similar to the levels of investment in emerging economies in Latin America.

Policies will be key in enabling the EU ORs to explore and exploit the renewable energy potential of their ecosystems. Three policy priorities emerge, as follows.

Innovate: Piloting and scaling up new technologies and existing solutions

The EU ORs can develop innovative solutions linked to all renewable energies. The diverse climate conditions, geological conformation as well as marine resources are the best endowments that the EU ORs can exploit in a sustainable way. In addition to utilising available technologies that are already in place including solar, wind, and geothermal the EU ORs can transform their energy matrices, shifting from fossil fuels to renewables, and contribute to the development of early-stage renewable technologies while integrating existing technologies, including:

- **Ocean Thermal Energy Conversion (OTEC)**. This technology makes use of the temperature differences between the surface water layer of the ocean and the deep sea. The warm water from the surface is pumped through an evaporator which contains a working fluid. The vaporised fluid then drives the turbine and is condensed, using the cold water from the deep sea. Generally operating with temperature differences of 20°C or more OTEC can be land-based or floating and can produce a steady power supply. OTEC currently faces some challenges regarding economic viability. Not only does it face high upfront costs of between USD 16 400 and 33 000 per kilowatt due to the difficulties of off-shore construction and the novelty of the technology but it also has a high levelised cost of final energy – around eight to ten times that of more conventional renewable energy sources such as PV. Its key advantages however are that it can be built both offshore and onshore, making it less space intensive. These are critical factors for the EU ORs where there is limited landmass and consistent renewable energy sources are limited, if not otherwise outright unavailable in some isolated parts of the grid. This technology is also ideal for subtropical territories, where many of the EU ORs are found, and can be combined with other specific functions such as air-conditioning and freshwater production (IRENA, 2014[37]). OTEC pilot projects have been launched in Martinique and Réunion. In Martinique a 16 MW power plant was planned to be operational in 2018, however the project was interrupted due to technical issues and lack of financing, whereas in Réunion piloting is still ongoing (Interreg, 2019[20]). As the technology matures, several countries such as China, Korea and the United Kingdom are planning to establish new projects, particularly in the Caribbean, Indian and Pacific oceans.
- **Wave and tidal energies**. The movement of the ocean and the sea can be captured and used to create energy. The amount of energy created depends on the speed, height, and frequency of the waves, as well as the water density. There are essentially three different wave energy technologies that are designed for specific environments. The simpler but lower performance oscillating water columns, the more powerful oscillating body converters (OBC) that normally are only deployed in deep waters where the depth is greater than 40 meters and overtopping converters (or terminators) which consist of a floating or bottom fixed water reservoir structure which, although based on a simple concept, require vast dimensions. The United Kingdom, Italy, Spain and Portugal are hosting several pilot projects including in the ORs. In 2022 the Norwegian company Ocean Oasis signed an agreement with the Oceanic Platform of the Canary Islands (PLOCAN) (Box 1) to test its wave energy-powered desalination plant in Gran Canaria thanks to a EUR 2.5 million grant from the European Innovation Council (EIC). At the same time however in the Azores, the Pico Wave Power Plant, built in the 1990s as a testing pilot with the support of the EU Fourth Framework Programme (European Commission, 1996[38]) was decommissioned in 2018 due to high repair

costs after a partial collapse of the infrastructure. Revitalising these projects as well as piloting similar new ones could represent important future assets for the ORs.

- **Offshore renewables**. The vast maritime and ocean territories of the ORs can provide opportunities to pilot and scale up offshore renewable technologies including wind and solar. The Canary Islands and Réunion are already establishing new projects in this regard. In 2022 a floating wind prototype developed by X1 Winds, a Barcelona based start-up, was installed at the PLOCAN test site in the Canary Islands. The project benefited from H2020 funding and involves the co-operation of several partners including the Technical University of Denmark, the country in which the first multimegawatt wind turbine was built in 1978. Réunion, within the framework of the pluriannual energy programme, is planning to develop an offshore wind turbine between 5 to 10 km from the coast with a total installed capacity of 200 MW (Horizon Réunion, 2019[39]).
- **Integration of existing solutions.** Solar and wind are complementary in the Caribbean basin where winds are strongest during the evening and night, when solar is less productive, and solar is most productive around mid-day, when the winds are weakest (GEA, 2016[40]). Likewise tapping into the biomass potential of the regions could lead to further self-reliance in the energy sector and induce a virtuous circular economy effect. Guadeloupe for example has a net primary production score of 8.5 tC/ha/yr, over double the global average of ~3-4 tC/ha/yr (Interreg, 2021[41]). Biomass also has the benefit of being able to use much of the same infrastructure used for fossil fuel power plants, as demonstrated by Albioma's recent plan to convert coal or hybrid coal-biofuel plants into pure biofuel plants in Guadeloupe and Martinique, contributing a substantial 34 MW and 40 MW of renewable energy, respectively (Interreg, 2019[20]). Also, French Guiana is exploring the potential of its biomass. The Cacao biomass facility, located in the municipality of Roura, was designed and built by a French company Voltalia with the Support of the French Development Agency (AFD). The plant currently has a capacity of 5 MW and is currently undergoing tests. Once fully commissioned, it will save 28 500 tonnes of CO_2 equivalent every year (AFD, 2022[42]).

Box 1. Oceanic Platform of the Canary Islands (PLOCAN)

The Oceanic Platform of the Canary Islands (PLOCAN) is a scientific and technological infrastructure located in Gran Canaria that aims to accelerate the development of scientific technologies and capabilities associated with the sustainable use of the ocean. Co-funded by the European Regional Development Fund (ERDF) between 2007 and 2013, it is a consortium whose funding is comprised 50% of contributions from the Government of the Canary Islands and the Spanish National Government (Ministry of Science, Innovation and Universities).

PLOCAN offers both land-based and offshore infrastructures to promote multidisciplinary research. In particular the offshore marine test site located 3 nautical miles off the coast is dedicated to studying the behaviour and efficiency of different types of maritime devices and technologies, including renewable energies. It is equipped with electrical and communications infrastructure, consisting of two medium-voltage submarine cables of 5 MW each, which allow for the connection of technologies that use natural resources to generate electricity and that can be delivered to the island's electricity transmission grid.

Source: PLOCAN (2022[43]), "The circularity of the blue economy in Macaronesia. Successful projects and opportunities for economic diversification in the EU ORs, 28 April 2022", https://consulta-europa.com/wp-content/uploads/ENG_Agenda_Forward-LaPalma-3.pdf.

Connect: Sharing expertise and strengthen international partnerships

Fully exploiting the EU ORs' potential in renewable energies requires expanding and strengthening their international partnerships. In doing so, the EU ORs can leverage their strategic locations in three distinctive geographical areas as well as on the co-operation frameworks provided by their belonging to the EU single market. The following partnerships could be strengthened and further exploited.

- **Between and among the EU ORs**. Beyond the EU and Europe other forms of co-operation among EU ORs are already in place through either dedicated or more generic programmes. These include ad-hoc programmes and working groups under the umbrella of Interreg and Horizon projects such as FORWARD or RESOR. FORWARD was financed under Horizon 2020, with the aim of improving the EU ORs' research and innovation potential and encouraging their participation in international research consortia funded by the EU. Under the thematic group on climate change and energy transition, the Canary Islands, Azores and Réunion participated in this programme. RESOR, financed under Interreg, aims to promote best practices to support energy efficiency and renewable energy use in businesses. While the knowledge sharing process was conducted over 2018-20, the implementation phase is currently underway. RESOR also included other non-OR EU island regions, such as Epirus (Greece). One tangible success of the project is that it lent a hand in developing a biomass plant in Martinique, based on its previous experience in Madeira. Similarly, Martinique, along with the Azores, adopted energy production and efficiency subsidy solutions based on the experience of Réunion (Interreg, 2021[41]). Going forward, strengthening such exchanges and extending them to other EU ORs such as French Guiana, Mayotte and Saint Martin, which face similar challenges, would be advisable.
- **Together with other EU partners**. The increasing attention on sustainable energy development from the EU Member States and the frameworks provided withing the European Green Deal are powerful allies for enhanced co-operation. This is the case of the European Energy Research Alliance (EERA), the largest energy research community in Europe. It is a membership-based, non-profit association that brings together 250 universities and public research centres across 30 countries. Currently only the Oceanic Platform of the Canary Islands (PLOCAN) is a participating member. Regular and/or project-based affiliation could be explored through several options including direct participation or through an already established national membership like the French Alternative Energies and Atomic Energy Commission (CEA), the Spanish National Research Council (CSIC) or the Portuguese National Laboratory for Energy and Geology (LNEG). EERA has in place 18 joint programmes that range from solar, geothermal and ocean energies as well as fuel cells and hydrogen. Other possible options include technology and specific partnerships such as the Green Hysland initiative for the deployment of green hydrogen in islands that include both public and private stakeholders. The initiative is supporting piloting projects in several EU islands and beyond. The first pilot, launched in Mallorca (Spain) in 2021, includes an electrolyser that produces green hydrogen, using electricity generated by a PV plant for a cement facility. Mallorca will serve as a replication model for other island territories including Aran (Ireland), Ameland (Netherlands) but also Madeira, the Canary Islands as well as the Island of Chiloe (Chile).
- **Connecting with geographically and historically close neighbours**. The EU ORs already have in place some forms of cross national and intra-regional partnerships that include energy-related activities and workstreams, such as the Interreg Caribbean, Amazonia, MAC (Madeira, Azores, Canary Islands) and Indian Ocean. While the MAC has set up clear expenditure and project lines related to renewables for both 2014-20 and 2021-27, the other Interreg programmes involving the EU ORs lack specific lines of action. Going forward, it would be important to pool expertise and establish concrete knowledge and scientific transfer mechanisms not only within the Caribbean and Indian basin but also Africa. These could include for example participating in the Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy (LEAP-RE) – a facility of

EUR 15 million financed through Horizon Europe that aims to promote a renewable energy shift in Africa with the support of the EU (LEAP-RE, 2023[44]). Another important option to scale up the diffusion of renewables could be fostering integrated regional grids through inter-connections. This is particularly evident in the eastern Caribbean in which Martinique, Guadeloupe and Saint-Martin could be important partners of OECS countries in their energy transition if some important reforms were to be implemented (Box 3).

The EU ORs are also leveraging established bilateral business, technological and co-operation partnerships. These include Iceland-Azores technical and business co-operation in geothermal (Box 2) or the Technological Institute of the Canary Islands (ITC), which in 2022 signed a co-operation agreement to install two solar power plants in a rural community in Senegal with the support of Interreg MAC. The project will develop a microgrid that will have an installed capacity of 50 kW and is connected to 500 households. These types of projects increase the possibility to generate positive spillover effects such as increasing the skilled labour pool and creating market opportunities for both inward and outward investments. Other potential intra-regional renewable opportunities are associated with infrastructure development to expand market size. This is the case of the planned undersea cable between Dominica, Guadeloupe and Martinique which serves to pool together their electricity grids with the specific aim of stimulate demand to the point where it is large enough for the cost-effective development of geothermal energy (OECD, 2022[27]). Cross-regional and cross-country integration could also be interesting for French Guiana with its neighbouring countries such as Guyana that has an estimated hydroelectric potential of between 7 200 MW and 7 600 MW, and also strong biomass potential. Biomass solutions could involve sugar cane waste (bagasse) but also the 18 million hectares of standing forest, which can be farmed sustainably to produce biofuel (GEA, 2016[40]).

Box 2. Iceland and the Azores cross-border business and knowledge partnership in geothermal

Both located on the Mid-Atlantic Ridge, Iceland and the Azores have established strategic partnerships in the development of geothermal technologies. Iceland's National Energy Authority as well as the private sector are sharing their know-how on geothermal, which dates back to the late 1960s. Some examples of the partnership include:

- **Grants and knowledge transfer.** In 2016, the electricity distributor of the Azores together with Iceland's National Energy Authority and with grants from the European Economic Area (EEA) established a pilot geothermal power plant in the Pico Alto Geothermal Field on Terceira Island. The plant currently provides more than 10% of the island's total energy production. The grants have also played an active role in training Portuguese geothermal professionals and in establishing bilateral relationships between Portugal and Iceland. Two Azorean professionals had the opportunity to improve their scientific and technological skills by attending a six-month postgraduate geothermal training programme at the United Nations University (UNU-GTP) in Iceland that offers multiple short courses to professionals and students.
- **Business through competitive tenders.** In 2020 the Iceland Drilling Company secured a drilling contract to drill nine wells to expand geothermal capacity in both Sao Miguel and Terceira. The project involves drilling for 9 geothermal wells, with an estimated depth of 1 000 to 2 300 meters. The value of the contract is about EUR 18.6 million.

Box 3. Towards regional energy integration in the Eastern Caribbean

Renewables are becoming cost-competitive in the eastern Caribbean region. For wind, solar PV, and geothermal the combined costs of operation, maintenance and capital are lower than the combination of operation, maintenance and fuel costs for generators running on non-renewables. However. deployment of renewables still remains limited despite their strong potential in the region. The majority of these countries continue to rely on imported energy products, which account on average for 93% of electricity generation, similar to the EU ORs in the region.

Regional energy integration in the eastern Caribbean is an option to scale up the potential of renewables. To do so, countries and territories need to work together on several fronts backed by strong political and long-term sustainable financial resources. In this respect, intra-Caribbean connections working to integrate electricity systems could help to increase the size of the market and make renewables more profitable. At present, the small individual size of the countries of the Eastern Caribbean, including the EU ORs, leads to low levels of demand for energy and fragmented electricity grids. This prevents many renewable projects from realising the economies of scale needed to be economically feasible. This is particularly true of geothermal energy. Regional inter-connections via undersea cables could create an integrated regional electricity system, allowing for electricity imports and exports, and for the pooling of financial resources and land, as well as of other resources such as expertise. Looking to the future, some important steps that the OECS countries, along with the EU ORs in the region, should consider to help foster this regional integration are as follows.

- **Increase access to finance for long-term renewables projects**. Currently in most countries, energy ministries have a one-year budget cycle, forcing them to focus mainly on the short term.
- **Adopt regulatory frameworks to channel private investment**. The majority of electrical utilities in the region are integrated monopolies in power generation, transmission and distribution and the regulatory frameworks do not include provisions for private investment in the electricity sector.
- **Reduce red-tape to fast-track operations**. Even where third-party power producers are allowed there are significant restrictions on their operations, such as onerous, long, and opaque application procedures. Furthermore, access and exploitation rights for geothermal resources are not clearly delineated in most OECS countries.
- **Improve incentive schemes for renewable energy**. In most of the countries, there are either tax credits, reductions, or exemptions for renewables. However, net metering or billing schemes are not sufficiently diffused.
- **Harmonise standards and norms.** Renewable portfolio standards, which are regulatory mandates that require utility companies to increase electricity generation from renewables, are also absent in Eastern Caribbean states while several countries lack interconnection standards,

Source: (OECD, 2022[27]), *Development Strategy Assessment of the Eastern Caribbean*, https://doi.org/10.1787/f1566c7a-en.

Invest: Exploit synergies of different financing options and prioritise game-changers projects

Several available financing options could support the deployment of renewable energies in the EU ORs. For the ORs, small market size, remoteness, and lack of connection to the main grid result in suboptimal private investment, thus making public funding projects essential. Several studies show that cohesion funding in many EU regions has been instrumental in overcoming the major barriers to renewable utilisation particularly related to the cost of the initial investment (Florkowski and Rakowska, 2022[46]). With the multiannual financial framework (MFF) 2021-27 and under the aegis of the European Green Deal (not to mention various cohesion policy funds, such as the Cohesion Fund (CF) and European Regional Development Fund (ERDF) that provide grants and loans to support energy-related projects with social, competitiveness and environmental benefits) other options to scale up and match public and private investment are available. These include among others:

- **Invest EU programme**. Operational since 2022, it aims to leverage EUR 279 billion in private and public climate and environment related investments over the period 2021-30. The programme is structured in three blocks. A fund backed by the European Investment Bank (EIB) aims to mobilise EUR 370 billion through guarantee and equity products to invest in higher-risk project and crowding in private investment - at least 30% of the resources are channelled to green energy projects. An advisory hub provides technical support to project developers regarding project preparation and implementation. A single window platform matches investors and project promoters (European Union, 2021[47]).
- **Connecting Europe Facility (CEF).** A funding instrument for boosting cross-country energy, transport, and digital infrastructure launched in 2013. The CEF for 2021-27 has a specific line for energy of EUR 8.7 billion. The facility allows for projects with a cross-border dimension, network integration and territorial accessibility, including for European islands and outermost regions with third countries (European Union, 2021[48]).
- **Renewable Energy Financing Mechanism (RENEWFM).** Launched in 2021, it is a flexible financing mechanism that facilitates the matching of investors and projects for a more cost-effective and quicker roll-out of renewables across the EU. The mechanism consists of competitive tenders for grants and aims to connect countries aiming to finance renewable energy projects elsewhere with countries ready to host new projects. The key element of the mechanism's collective nature is that all countries that take part will share the statistical benefits of the produced renewable energy. The private sector can participate by providing resources to the mechanism, forming part of the sustainability and decarbonisation portfolio of the company. They can also participate as a project developer and compete for support in the tender process (European Commission, 2020[49]).
- **LIFE Clean Energy Transition sub-programme.** Building on the Intelligent Energy Europe (2003-13) and Horizon 2020 Energy Efficiency (2014-20) programmes, the LIFE Clean Energy Transition supports the development and scale-up of renewables. With a budget of EUR 1 billion over 2021-27 it aims to support the energy transition in five areas of intervention: i) building regional and local policy frameworks to support the clean energy transition; ii) accelerating technology roll-out, digitalisation, new services and business models and the enhancement of related professional skills on the market; iii) attracting private finance for sustainable energy; iv) supporting the development of local and regional investment projects and v) involving and empowering citizens in the clean energy transition.

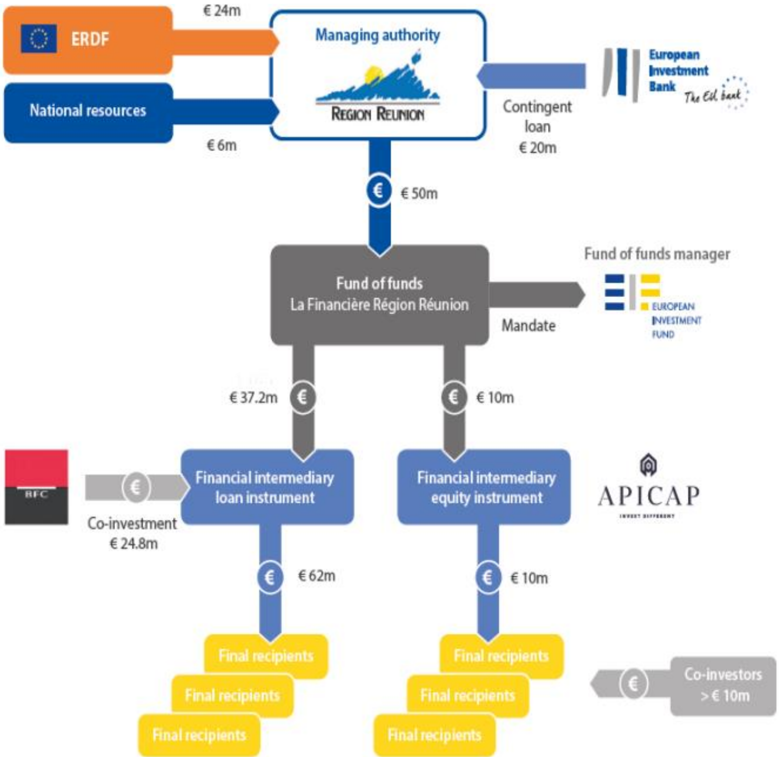
Innovative financing mechanisms such as funds of funds[3] or blending can scale-up public support and facilitate long-term financing. Co-ordination between EU investment instruments and funds or programmes as well as blending operations could be used to induce a multiplier effect and enable new investment in renewable energy projects. The ORs can provide good examples that go in this direction. An example of such a mechanism is *La Financière Région Réunion (FRR)*, a fund of funds that supports projects aimed at small and medium-sized enterprises (SMEs) that pool resources from the ERDF EIB and private investors from Mainland France. The FRR has also supported several SMEs in the energy sector. Portugal is also using a similar approach with the *Financial instruments for urban development in Portugal (IFRRU)*

[3] A Fund of Funds is a unique financial vehicle that is created to promote investment in venture capital as well as support the development of energy and infrastructure and competitiveness of SMEs.

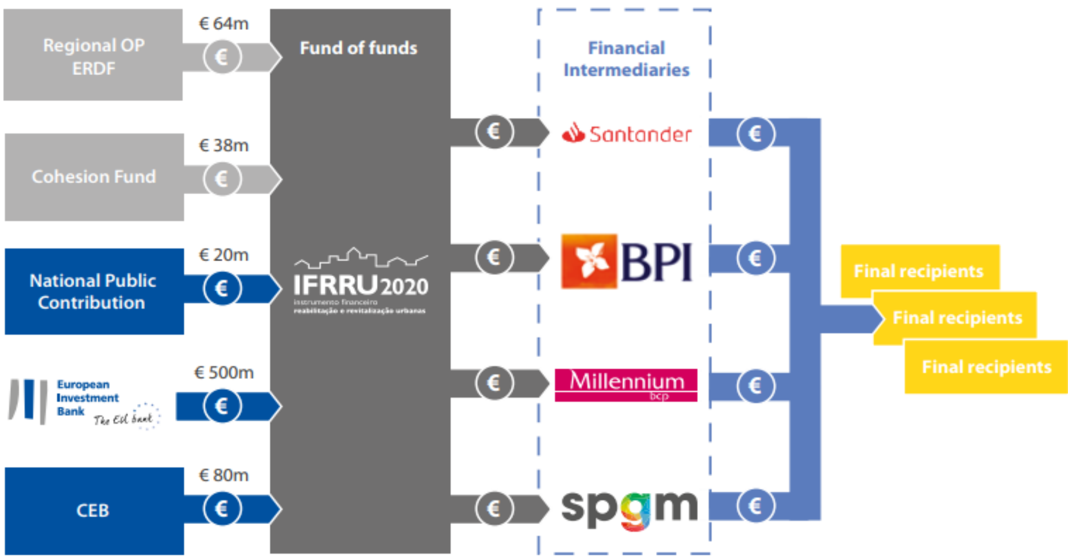
that brings together the resources from cohesion policy funds and EIB (Fi Compass, 2022[50]). In 2020, IFRRU invested EUR 307 million in building rehabilitation including converting the old fish market of Câmara de Lobos and a Council office into a high-quality hotel in Madeira with energy efficiency measures that reduced primary energy consumption by 60% (Figure 9).

Figure 9. Innovative mechanisms to support long-term investment in renewables

Panel A. Financière Région Réunion (FRR), fund of funds



Panel B. Financial Instrument for Urban Rehabilitation and Renewal (IFRRU)



Source: European Commission (2022[51]), *fi-compass*, https://www.fi-compass.eu.

6 Conclusions

The nine EU ORs (Guadeloupe, French Guiana, Martinique, Mayotte, Réunion, and Saint-Martin (France); the Azores and Madeira (Portugal); and the Canary Islands (Spain) have considerable potential in renewable energies. Renewable energies can be important drivers of transformation for the regional economies, contributing to a shift towards net zero, making all economic activities more environmentally sustainable and creating new investment and job opportunities.

The EU ORs are well positioned, thanks to their natural resources to advance in making renewable energies a key industry for local economies. They can pilot new solutions tailored to their specific needs and energy assets to strengthen their international ties. Backed by multiannual financial resources, dedicated programmes and strong political will at regional, national and EU level, the EU ORs can utilise renewable energies as the main catalysts of a renewed development model that can unleash their scientific and innovative potential by connecting local stakeholders with global industries and innovators.

Fully unlocking the renewable energy potential in the EU ORs necessitates a focused approach on three crucial pillars: innovation, connectivity, and investment.

Innovation stands as the linchpin of this endeavour, driving the development and deployment of cutting-edge renewable technologies. By establishing robust innovation ecosystems, the EU ORs can not only enhance their participation in high-value supply chains but also align with essential sustainability objectives. This demands collaborative efforts with multilateral organisations and global industries, ensuring access to the required capital and expertise to harness their abundant natural resources effectively.

Realising these goals hinges on updating financing and legal frameworks, which must actively encourage investments in renewable energy. By doing so, positive ripple effects can extend into other sectors and activities, fostering sustainable growth and development.

Developing new infrastructure projects and securing diverse funding sources will play a pivotal role in leveraging synergies among different renewable sources, supporting the natural environment, and promoting cross-sectoral benefits. Such endeavours require close co-operation between national institutions of France, Spain, and Portugal, the European Commission, as well as territories and countries in the Caribbean, South America, Atlantic Ocean, and Indian Ocean.

By embracing these key actions - innovate, invest, and connect - the EU ORs can pave the way for a prosperous, sustainable, and interconnected renewable energy future. This is not only significant for the regions themselves but also contributes to global efforts in combating climate change and building a cleaner, greener planet for generations to come.

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