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ON ENERGY

Financial instruments and models for energy production

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List of acronyms

Acronym	
CEF	Connecting Europe Facility
CfD	Contract for Difference
CfD	Cohesion Fund
DFI	Development Financial Institution
DG	Directorate General
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EE	Energy efficiency
EIB	European Investment Bank
EIC	European Innovation Council
EIF	European Investment Fund
ERDF	European Regional Development Fund
ETS	Emission Trading System
EU	European Union
FiT	Feed-in Tariff
GBER	General Block Exemption Regulation
GDP	Gross Domestic Product
GHG	Greenhouse gas
HHI	Herfindahl-Hirschman Index
ID-E	Investors Dialogue on Energy
IEA	International Energy Agency
LCOE	Levelised Cost of Energy
MF	Modernisation Fund

Acronym	
NECP	National Energy and Climate Plan
NRRP	National Recovery and Resilience Plan
NZIA	Net-Zero Industry Act
PPA	Power Purchase Agreement
PV	Photovoltaic
RDI	Research, Development, and Innovation
RES	Renewable Energy Source
RRF	Recovery and Resilience Facility
SME	Small and medium-sized enterprise
T&D	Transmission and Distribution
TRL	Technology Readiness Level
UK	United Kingdom
UoP	Use of Proceeds
US	United States
WACC	Weighted Average Cost of Capital
WG	Working Group

Executive summary

Member States will need to ramp up financing in order to meet the EU renewable energy production targets. Under the REPowerEU Plan the headline 2030 target for renewables at the EU level has increased from 40% to 45%[1] to cut Europe's energy dependency on Russian gas well before 2030.

Despite renewable energy becoming more and more cost competitive in many countries, renewable energy investments face a series of barriers. Some barriers derive from sub-optimal market conditions (e.g., access to capital, cost of capital), while others from the nature of renewable investments (e.g., availability of grid connection) and from the current framework that governs the energy market (e.g., complex and long permitting process, lack of supportive regulatory framework).

Current geopolitical rifts act as an additional barrier to investment and raise concerns about supply chains to further increase renewable energy capacities in the EU. Up to 80% of EU's energy needs are dependent on imports. This is why the focus on investment policies/ financial instruments must widen to include entire RES supply chains and, ideally, support the growth of production capacities in the EU. For this to happen, a conducive investment framework, that considers fluctuating energy prices within the EU, is essential.

Different clean energy production technologies have different financing needs, depending on their maturity and the barriers to investment they face. For emerging technologies, such as renewable hydrogen, availability and access to finance remain a key risk beside their inherent technology risks. Grants remain important for earlier stages of development. For mature and transition technologies, regulatory and policy risk as well as administrative barriers are key, next to grid, technology and infrastructure risks and demand side risks (off-takers).

Financial instruments can address some of the barriers to investment, which slow down the decarbonisation of the EU energy sector. Through a range of instruments available at the EU and Member State level, policy makers and investors can overcome some of the obstacles making clean energy projects, particularly innovative ones, too risky for the private sector alone. The presence of non-financial barriers affecting energy production investments requires additional measures beyond financial instruments to create a truly enabling environment for energy investments.

A mapping of financial instruments at the Member State level resulted in data on 468 instruments available for financing energy production in the 27 EU Member States. Among these 468, loans and grants are the most popular instruments across the EU.

Several trends in offering of instruments at the Member State level can be identified:

- Loans and grants are the most widespread across the set of 467 instruments that the mapping identified as relevant for Energy Production financing
- Most of the mapped instruments are technology neutral, meaning that they do not target a specific energy production technology, but rather select projects based on a different set of criteria.
- Most of the mapped instruments target mature and market-ready projects ("roll-out stage"), and only to a lesser extent less mature technologies are covered.
- SMEs and larger companies are the most supported recipients by financial instruments in most EU Member States.

[1] As provisionally agreed between the Council and the European Parliament, RES target is to raise in the EU's final energy consumption to 42.5% by 2030. The member states are urged to strive for a 45% share [status June 2023].

Four characteristics emerged as key for a financial instrument to be effective: broad scope of application, technology neutrality, accessibility, and long-term visibility. These characteristics do not need to all be present in each instrument for it to be effective, but rather the characteristics with the highest assessed impact on an instrument's effectiveness should be present.

The availability of a comprehensive set of financial instruments for energy production is particularly important in countries with low market maturity and a big investment gap to address RES 2030 targets. In general, in most countries the current offering of financial instruments could be improved going forward in terms of the diversity of instruments offered and the calibration of instruments towards relevant target beneficiaries.

One easy and fast way to increase the firepower of the existing instruments and to ensure the addition of EU support, would be to use EU funding / guarantees in support of existing national / regional instruments. However, the current rules, namely in the EU Financial Regulation and in respective programmes, would add a considerable amount of red tape and operational risks to the respective instruments, preventing a quick and easy procedure. A more balanced and proportionate approach, especially for the use of financial instruments, would seem warranted.

1. Introduction

The “Study on current energy sector investment instruments and schemes” in the energy production sector in the EU has been carried out as part of the Investors Dialogue on Energy – an initiative launched by the European Commission, DG Energy in 2022 as a multi-stakeholder platform bringing together experts from energy and finance sectors in all EU countries to assess and upgrade financing schemes to mobilise financing in the context of the European Green Deal.

This study focuses on the energy production sector and is part of a series covering also transmission and distribution, energy storage, heating and cooling, and services and prosumers. The study has been prepared on the basis of research carried out in 2022 and beginning of 2023 and incorporates data collected via desk research and interviews, as well as feedback from the stakeholders participating in the discussion of Working Group 1 of the Investors Dialogue for Energy which focuses on energy production.

Figure 1: Overview of main topics and data sources

	Desk research	Interviews	Working Group discussions
1 Analysis of the main barriers to investment in clean energy	✓		✓
2 Mapping and analysis of financials instruments and schemes	✓	✓	
3 Analysis of the **effectiveness** of the identified financial instruments	✓	✓	✓
4 Analysis of the **market readiness** of each country regarding different types of energy financing.	✓		

This study will set the basis for further work under the Investors Dialogue on Energy on the identification of new or upgraded solutions for financing the decarbonisation in energy production in order to support the achievement of the EU’s 2030 climate and energy targets and pave the way towards long term carbon neutrality.

2. The investment context for energy production

2.1. The new macroeconomic conditions for energy investment

Over the last couple of years, Europe has experienced a period of profound macroeconomic and geopolitical change, characterised by often unpredictable events that have made it necessary to accelerate the energy transition process and to adapt funding flows to the evolving needs. The following four macroeconomic trends have been identified which will make the coming years, and the next MFF budgeting period, fundamentally different than the past decade.

1. Tackling the climate crisis

At the end of 2019, the European Union published the European Green Deal[2], which outlined its aim to become the first climate-neutral, resource efficient, and sustainable economy by 2050. As an intermediate step towards climate neutrality, the EU strengthened its commitments to climate and energy, pledging to reduce 55% of net GHG emissions by 2030, while ensuring Europe's security of energy supply. In order to align current laws with the 2030 and 2050 ambitions, the Commission tabled the Fit for 55 package of legislative measures which, among other targets, proposed to increase the share of renewable energy sources in the overall energy mix from 32% to 40% to speed up the decarbonization of the energy system. These new and updated targets represent a major challenge and a necessary acceleration of green investments. The impact of these policy shifts is already being felt strongly in the European financial sector. Example of notable shifts include:

- The publication of the European Taxonomy, which provide companies, investors and policymakers with appropriate definitions for which economic activities can be considered environmentally sustainable, thus helping the EU to scale up sustainable investment and implement the European Green Deal.
- The transformation of the EIB into the European Climate Bank, and the ensuing commitment to gradually increasing its share of finance dedicated to green investment to over 50% by 2025 and beyond.

The urgency of the climate crisis is increasingly reshaping the investment environment for energy production, with an ever-stronger focus on low carbon technologies.

2. Ending the EU's dependence on Russian fossil fuels

The energy crisis, intensified by Russia's unprovoked aggression in Ukraine in February 2022, has had a significant impact on the EU's energy system and the European financial sector. Turbulence in energy markets, the all-time high energy prices and the risk of supply shortages across the EU have further exposed the EU's over-reliance on Russian fossil fuels, highlighting the need to accelerate the green transition under the European Green Deal and to ensure a more secure, affordable, resilient, and independent energy system[3]. To respond to these hardships, in May 2022 the European Commission presented updated energy targets in the REPowerEU plan[4] and the emergency electricity market design interventions. The REPowerEU plan, which aims to cut the EU's energy dependency on Russian gas well before

[2] The European Green Deal, *European Commission*, December 2019.

[3] Progress on competitiveness of clean energy technologies, *EU Commission,* November 2022.

[4] REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, *European Commission*, May 2022.

2030, confirms the EU's commitment to achieving the European Green Deal's long-term goal of climate neutrality by 2050 and fully implementing the Fit for 55 package, proposing to increase the headline 2030 target for renewables from 40% to 45%.

Broadly speaking, the European Green Deal as an EU growth strategy, the war and the REPowerEU are expected to reshape the direction of financial flows. In particular, investments in gas-related projects are focused mainly on projects, which serve the objectives of the energy transition, Security of Supply and diversification of gas/energy supply. Examples of such projects may include directional changes to pipeline flows (e.g., establishing north-south pipeline connections), or the repurposing of gas infrastructure for transportation and storage of hydrogen or other low-carbon gases.

3. Rising interest rates in an inflationary context

The global economy is confronting a challenging situation not witnessed for decades, with inflation persistently high amidst increased economic and geopolitical uncertainties, as well as disruptions in energy and commodity markets and supply chains bottlenecks caused by the COVID-19 pandemic and Russia's ongoing invasion of Ukraine. In years past, in the aftermath of the global financial crisis, central banks maintained low interest rates for extended periods of time, leading to a low-volatility environment and easy financial conditions that investors grew accustomed to. In the coming decade, rising interest rates mean that capital is more expensive, and harder to get to, which could prove especially daunting for nascent cleantech industries attempting to establish themselves on the market. This adverse impact of rising interest rates is likely to be compounded by the related phenomena of inflation and supply chain bottlenecks. This is why it is important to create a favourable financing environment that prevents the energy transition and the development of clean technologies from slowing down.

4. Rising global clean tech competition

Europe's partners are increasingly introducing policies and stimulus programmes to seize the net-zero industrial opportunities. The prime example of rising competition for global clean tech dominance is the US Inflation Reduction Act (US IRA), which will mobilize over USD 360bn by 2033. Japan, India, China, the UK and Canada have also put forward their own national programmes to stimulate their own clean tech leadership. While competition is beneficial to the overall global climate race to net zero, the EU is also increasingly looking to cement its own positioning in the clean tech space and prevent the outflow of its own industrial champions overseas. Therefore, to facilitate the reaching of its climate objectives and enable the necessary greening and competitiveness of the EU industry, in January 2023 the Commission put forward the Green Deal Industrial Plan[5]. This plan will enable the EU to access key technologies, products, and solutions needed for a successful transition to net-zero, which will in turn boost economic growth and generate quality jobs. The Green Deal Industrial Plan will thus attract investments in the net-zero industrial base, with a focus on innovative technologies, helping them to overcome the so-called 'valley of death' before commercialisation[6]. In line with the Green Deal Industrial Plan the European Commission has adopted a new Temporary Crisis and Transition Framework which, together with the amended General Block Exemption Regulation (GBER) will help to accelerate investment and financing for clean tech production within the European Union and allow Member States more flexibility to design and implement support measures in sectors that are key for the transition to climate neutrality[7]. In addition, a proposal for a Net Zero Industry Act (NZIA)[8] has been submitted with the aim of establishing a framework of measures directed at strengthening Europe's net-zero technology products manufacturing ecosystem and overcoming barriers to scaling up the

[5] A Green Deal Industrial Plan for the Net-Zero Age, *EU Commission,* February 2023.

[6] Questions and Answers: Green Deal Industrial Plan for the Net-Zero Age, *EU Commission,* 2023.

[7] Temporary Crisis and Transition Framework, *European Commission,* March 2023.

[8] Available at the following link.

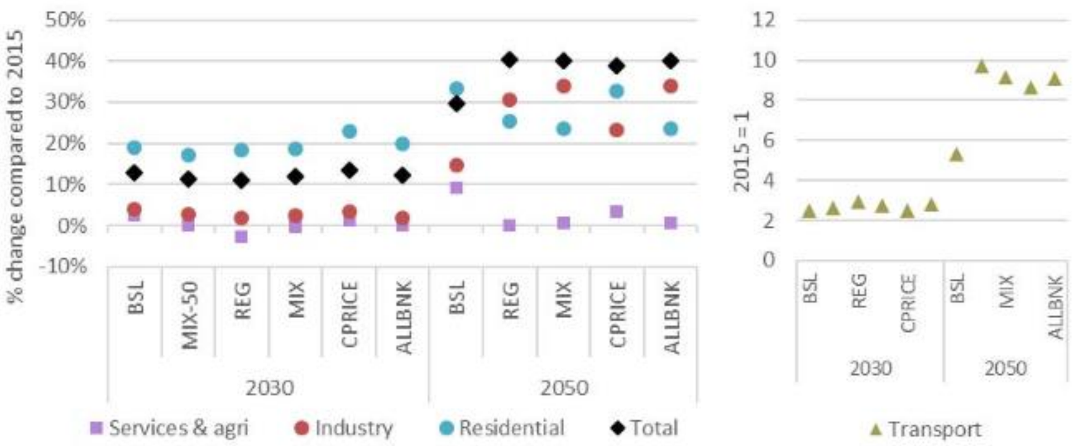
manufacturing capacity in Europe. The Regulation encompasses products, components and equipment used in manufacturing net-zero technologies and it distinguishes between net-zero technologies and strategic net-zero technologies, whereby the latter is regarded as making a significant contribution to decarbonisation by 2030.

In practice, reaching ambitious decarbonization targets and decoupling emissions from economic growth will require a fundamental transformation of the EU economy and, particularly, its energy system. The key buildings blocks of the transformation of the European energy context will consist of a range of measures, including those described in the following paragraphs.

Accelerated electrification of end-use sectors

Energy used in large economy sectors such as transport, industry and buildings, currently comes mostly from fossil fuels. Decarbonization of the end-use sectors calls for electrification: deployment of carbon-free energy sources in power generation makes electricity a carbon-free energy carrier which is suitable for most of the final energy uses. To exploit the full decarbonisation potential of electricity, the share it occupies in the energy sector must be rapidly increased. According to the EU Climate Target Plan impact assessment, all scenarios see increasing electrification of consumption in almost all sectors with the share of electricity in final energy demand increasing between 2015 and 2030, by 11% (REG) to 13% (CPRICE) and growing further by 2050[9].

Figure 2: Evolution in final electricity consumption in 2030 and 2050 compared to 2015[10]



Source: Stepping up Europe's 2030 climate ambition, Impact Assessment, SWD(2020) 176 final, Brussels 2020

Greening the existing supply of electricity

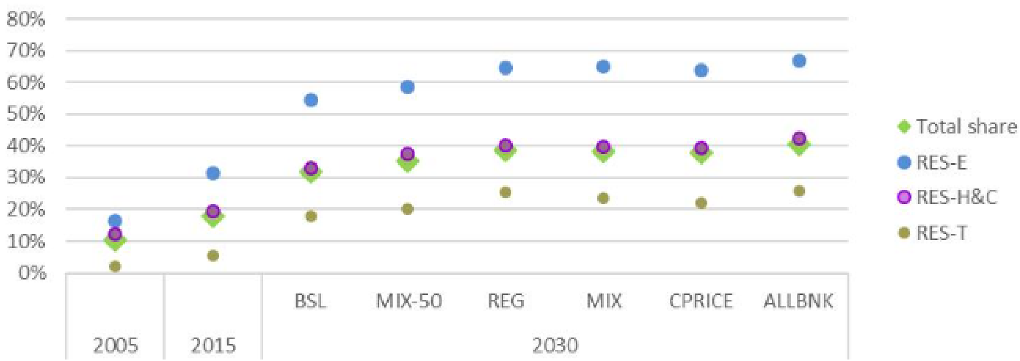
Decarbonization of the electricity sector can be achieved by replacing fossil-based generation with clean energy sources such as renewables and low-carbon fuels, including hydrogen. Major investments in renewable energy power plants are thus crucial to decarbonise the

[9] Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people, Impact Assessment, *European Commission*, SWD(2020) 176 final, Brussels 2020. Main scenarios identified are: BSL (achieving the existing 2030 GHG, RES and EE EU targets); REG (a regulatory-based measures scenario that achieves around 55% reductions); CPRICE (a carbon-pricing based scenario that achieves around 55% reductions); MIX (following a combined approach of REG and CPRICE, which achieves around 55% GHG reductions); MIX-50 (an increased ambition scenario achieving at least 50% GHG reductions); ALLBNK (the most ambitious scenario in GHG emissions reduction, based on MIX and further intensifying fuel mandates for aviation and maritime sectors).

[10] Data in Figure 1 on projected electricity consumption is not up to date but it illustrates the size of the challenge ahead. Left graph: % change compared to 2015 for total, residential, services and industry; right graph: ratio between 2030, 2050 and 2015 for transport. The x-axis represents the scenarios analysed in the SWD.

European electricity sector as a whole. This is confirmed by the EU Climate Target Plan impact assessment, which charts the path to an increasing shift toward carbon-neutral energy sources in electricity production. As shown in Figure 3 below, the energy mix of electricity production continues moving away from fossil fuels. Representing around 31% of gross electricity production in 2015, the contribution of renewables keeps increasing across all scenarios. In BSL, renewables will be responsible for 57% of electricity production in 2030, while for the policy scenarios this figure increases to 67% (REG, CPRICE) - 68% (MIX). This figure reduces to 61% for MIX-50 and further increases to 69% for ALLBNK[11].

Figure 3: Renewables shares in major demand sectors (electricity, Heating and Cooling, Transport)



Source: Stepping up Europe's 2030 climate ambition, Impact Assessment, SWD(2020) 176 final, Brussels 2020

Alternative fuels for hard-to-abate sectors

For those sectors of the economy that are difficult to electrify (notably heat and high-temperature industrial applications), reaching carbon neutrality will require recourse to alternative fuels. Power-to-X (P2X) processes and direct use of green hydrogen can be used for a range of applications.

System resilience and energy independence

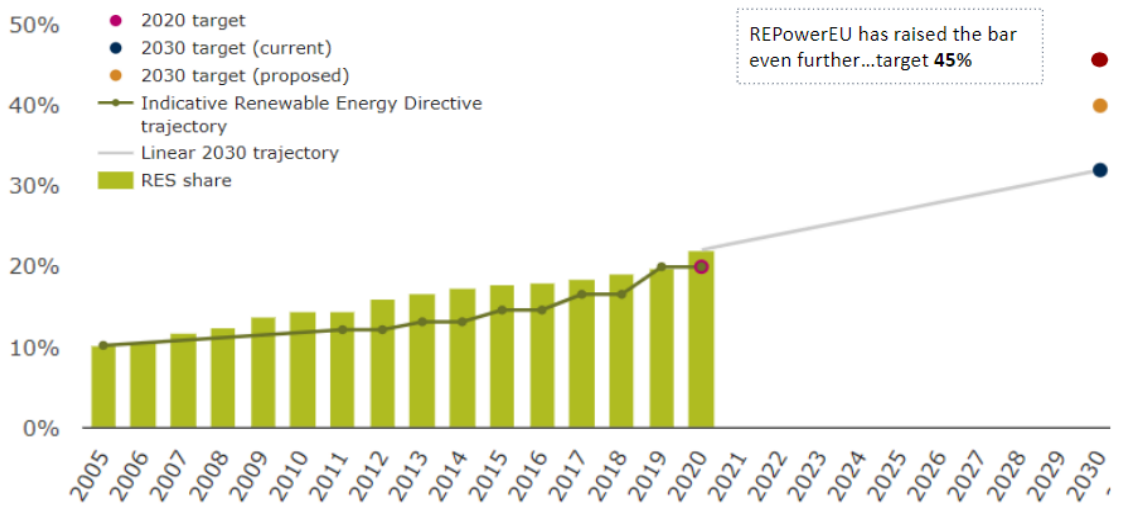
Creating an energy system which is resilient to exogenous shocks is crucial to achieve carbon neutrality and energy independence. Energy efficiency measures are the cheapest, safest, and cleanest way to reduce Europe's reliance on fossil fuel imports from Russia while helping to reach carbon neutrality objectives. Reflecting the energy efficiency first principle, the Fit for 55 package contained, among other things, a proposed target for Europe's final energy consumption to decrease by 36% by 2030 in comparison with a 2007 Reference Scenario[12] (revised from the current target of 32.5% decrease). Another way to secure energy supply and boost system resilience is by producing energy within EU borders. This will require, among other things, strengthening its industry against high inflation, labour shortages, supply chains disruptions, rising interest rates, spikes in energy costs and input prices. The EU is committed to accelerating its net-zero industrial transformation, with a focus on renewable energy, energy and transport infrastructure, fossil-free hydrogen, and clean tech cooperation with partners abroad. For instance, to ensure security of supply for critical raw materials needed for clean technologies, the EU will propose a Critical Raw Materials Act aimed at diversifying sourcing,

[11] Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people, Impact Assessment, *European Commission*, SWD(2020) 176 final, Brussels 2020.

[12] Energy efficiency targets, *European Commission.*

recycling raw materials, and reducing dependence on highly concentrated supplies from third countries.

Figure 4: European Union RES production targets



Source: EEA 2022

All of these measures imply a need to sharply increase electricity production from clean sources. The Clean Energy for all Europeans initiative ("Clean Energy Package") launched in March 2019 introduced a requirement for all EU Member States to establish integrated 10-year National Energy and Climate Plans (NECPs)[13] for 2021-2030, outlining the measures they plan to implement in order to meet the 2030 climate targets in all 5 dimensions[14] of the energy union, including for renewable energy production. The *Table* 1 below shows an overview of the 2030 RES pledges made by Member States in the NECPs submitted to the European Commission in 2019 (subject to review in the next submission of NECPs due in June 2023), in terms of the RES share in Member in Member States' gross final energy consumption.

Table 1: Member States' 2030 RES targets[15]

[13] European Commission. National energy and climate plans. https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

[14] The energy union builds five related and mutually reinforcing dimensions: Security, solidarity and trust; Fully integrated energy market; Energy efficiency; Climate action, decarbonising the economy; Research, innovation and competitiveness.

[15] Targets in Table 1 do not reflect new targets proposed with the revision of the RED II and the REPowerEU Plan.

Country	2020 RES Target	2030 RES pledge
Austria	34%	46-50%
Belgium	13%	17.53%
Bulgaria	16%	27%
Croatia	20%	36.4%
Cyprus	13%	23%
Czech Republic	13%	22%
Denmark	30%	55%
Estonia	25%	42%
Finland	38%	51%
France	23%	33%
Germany	30%	65%
Greece	18%	35%
Hungary	13%	21%
Ireland	16%	34%
Italy	17%	30%
Latvia	40%	50%
Lithuania	23%	45%
Luxembourg	11%	25%
Malta	10%	11.5%
Netherlands	14%	27-35%
Poland	15%	21-23%
Portugal	31%	47%
Romania	24%	30.7%
Slovakia	14%	19.2%
Slovenia	25%	27%
Spain	21%	42%

Country	2020 RES Target	2030 RES pledge
Sweden	49%	65%

Source: Member States' National Energy and Climate Plans

In its assessment of NECPs, the European Commission estimated that under existing and planned measures, the share of renewable energy could reach a range of 33.1 to 33.7% in 2030 at Union level, surpassing the previous REDII target of at least 32% in 2030 but falling short of the target increases proposed under Fit for 55 and REPowerEU[16]. To achieve higher greenhouse gas emissions reduction targets the EU will need a share of renewable energy of 38-40% by 2030, but only few Member States have pledged to such targets. Additional investments in renewables can have a positive impact on the economy, reducing energy bills, and improving air quality, while creating new jobs. Member States are then invited to fast track and make better use of measures such as waste heat/cold, renewable self-consumption, renewable energy communities, and electrification in transport, as well as predictability in planned tenders, streamlining permitting procedures, and power purchase agreements to stimulate investments.

Additionally, current geopolitical rifts raise concerns over supply chains for the further increase in renewable energy capacities in the EU. Indeed, the EU is heavily dependent on third countries for the supply of raw materials. More specifically, China occupies a dominant position as a supplier at various stages of the energy value chain, ranging from raw materials (e.g., electrolysers), to raw and processed materials along with components (e.g., wind turbines and magnets for electric motors) and even covering the complete value chain (e.g., solar PV). This is true for most renewable energy generation technologies. This dependence, combined with increased demand and global competition to secure access to the same pool of resources, significantly increases the risk of disruptions, stressing the need to take into account entire RES supply chains and, ideally, to build up more production capacities in the EU again[17].

2.2. The investments needed to reach European Green Deal objectives

For Member States to achieve renewable energy production targets set out in their own NECPs, a large step up in financing is needed. Table 2 below provides an overview of investments needed to reach RES production objectives in the 2021-2030 period, and the investment gap that needs to be bridged with additional resources, based on NECP and RRP documents. Data on the investment needed and the investment gap is not uniformly available; in fact, some NECPs plans still lack details on actions and measures used to identify those same investments needs and to mobilize private funds[18]. In view of compensating for this incompleteness of investment gap data, figures related to measures planned under the RRF have been added to the quantification. These figures relate to measures aimed at promoting investments in renewable energy production in each Member State in the 2021 - 2026

[16] An EU-wide assessment of National Energy and Climate Plans Driving forward the green transition and promoting economic recovery through integrated energy and climate planning, *European Commission*, Brussels 2020.

[17] Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study, Joint Research Centre (JRC), 2023

[18] Member States are expected to provide updated versions of the NECPS by mid-2023 which should perform better in terms of data estimates and quantification.

timeframe that is specific to the RRF[19]. Figures from the NECPs and the RRF are not always comparable, therefore the estimates presented in this table are to be considered with care and only for the purpose of this study.

Consequently, the Investment gap has been calculated according to the following process:

i) Firstly, investments necessary to reach targets declared within NECPs have been identified;

ii) Secondly, investments foreseen under existing policies have been identified and subtracted from investment needs identified at point i). Since information for existing investments is consistently lacking across NECPS, the result of this calculation often was equal to the investment needs;

iii) To compensate for the lack of information for investments under existing policies, investments from the RRF have been mapped for the production sector.

The calculation is as follow: i – ii – iii = investment gap.

Table 2: Member States' investment needs and investment gap to achieve 2030 RE production targets [20]

Country	Investment needs 2030 RE production targets (€ bn)	Notes on investments need	Estimated investment gap (€ bn)	Notes on investment gap
Austria	20-27		19.5-26.5	
Belgium	9.89		9.89	
Bulgaria	2.4		1.88	
Croatia	2.16		2.16	
Cyprus	1	Including storage	0.97	Refers to power production
Czech Republic	23.53		N/A	Data shows total investment support for RES
Denmark	8-12		8-12	
Estonia	N/A	€0.3bn for the energy sector	N/A	
Finland	N/A		N/A	
France	110	Estimated based on annual amount of investments needed for energy and electricity grids for 2019-2032	2.50	

[19] For several countries (Austria, Bulgaria, Cyprus, Hungary, Italy and Lithuania) some measures did not focus only on energy generation but incorporated also investments pertaining other segments of the energy value chain such as storage, energy infrastructure and heating & cooling. Lack of granular data concerning the amount that should be dedicated to each segment, has prevented to isolate the fraction of investments related only to renewable energy generation thus, such measures were included in energy generation in their entirety.

[20] Investment needs do not reflect new targets proposed with the revision of the RED II and the REPowerEU Plan.

Country	Investment needs 2030 RE production targets (€ bn)	Notes on investments need	Estimated investment gap (€ bn)	Notes on investment gap
Germany	49		49	
Greece	9		9	
Hungary	N/A		N/A	
Ireland	N/A	For the energy system (renewables and interconnectors)	N/A	
Italy	85	Data refers to “Electrical sector: power plants” not just RES production	33.13	
Latvia	1.6		1.60	
Lithuania	2.3	Data refers to “Energy: RES development”	2.16	
Luxembourg	2.14		0.60	
Malta	N/A		N/A	
Netherlands	32,2-32,8	Data refers to electricity production and green gas	32.2-32.8	
Poland	12.8	2016-2030 projected expenditure in renewables.	0.90	
Portugal	23,6-24,3	Data refers to the electricity sector as a whole for the period 2016-2030	23.33-24.03	Data refers to the electricity sector as a whole for the period 2016-2030
Romania	12	Data refers to power plants not just RES production	11.54	
Slovakia	1.26	Sum of investments under 2 policies: National Action Plan for Renewable Energy and the Decarbonisation of electricity production	1.09	
Slovenia	1.4		0.35	
Spain	91.8		88.64	
Sweden	8.9		8.9	

Source: Member States’ National Energy and Climate Plans (NECPs) and Recovery and Resilience Facility (RRF)

In its assessment of NECPs, the European Commission estimated that, in order to achieve the EU 2030 climate and energy targets,[21] annual investments related to energy production and use will need to increase by around €260 bn per year in 2021-2030 compared to the previous decade.[22]The Commission estimates that, to meet the Fit-for-55 objectives, around EUR 487 billion would need to be invested each year in the entire energy system until 2030, which include supply side (€55 billion and €93 billion for power grids and power plants respectively) and demand side (€339 bn)[23]. On top of that, meeting REPowerEU targets requires €210bn of investments between 2022 and 2027[24]. These additional investments include €113bn for renewables (€86bn) and key hydrogen infrastructure (€27bn) as well as €37bn to increase biomethane production by 2030.

Figure 5: Investment needs under the Clean Energy Package, Fit for 55, and the REPowerEU Plan

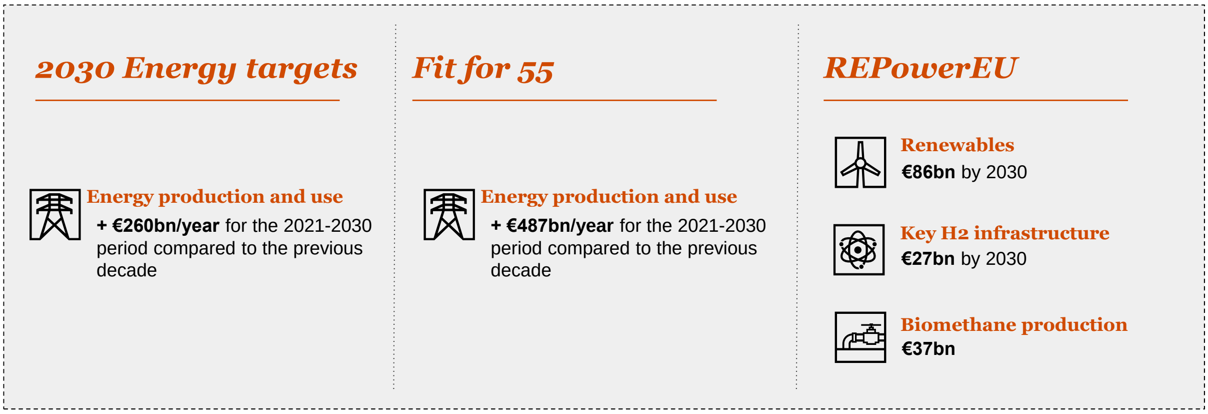
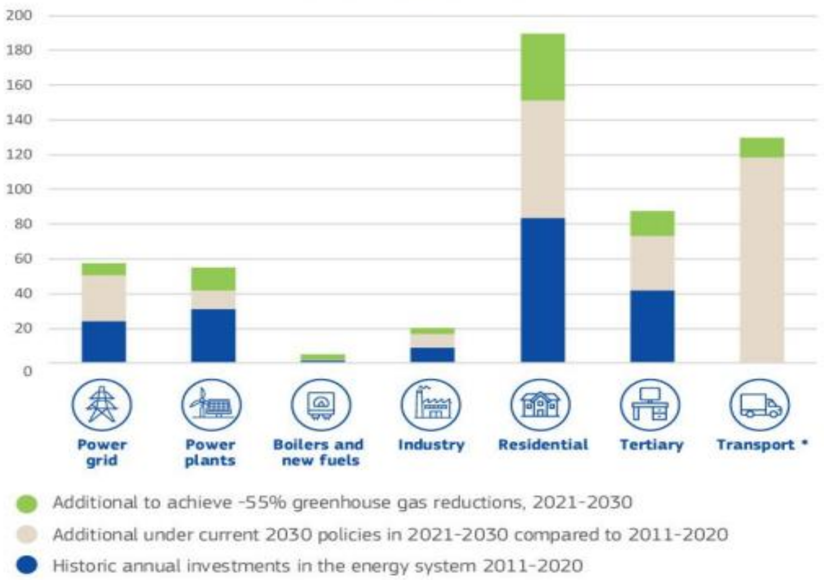


Figure 6: Average annual investments 2011-2020 and additional investments 2021-30 under existing policies and to achieve -55% GHG emission reductions (in € bn, 2015)



Source: European Commission assessment of National Energy and Climate Plans. Brussels 2020

21 Targets against which the evaluation was made do not reflect new targets proposed with the revision of the RED II and the REPowerEU Plan.

22 An EU-wide assessment of National Energy and Climate Plans Driving forward the green transition and promoting economic recovery through integrated energy and climate planning, *European Commission*, Brussels 2020.

23 SWD (2023) 68 final.

24 REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition*, European Commission*, 18 May 2022.

2.3. Economics of energy production

The mechanics by which energy production projects get financed and ultimately find their way to the market is conditioned by two factors:

- the maturity of the energy production technology, and
- the type of financing needed for different stages of technology maturity.

The section that follows looks into these two factors in an attempt to provide a high-level, hands-on understanding on the economics of energy production.

Technology Maturity

Broadly speaking, low-carbon technologies aimed at producing energy comprise those technologies that result in minimal or zero emissions of carbon dioxide (CO_2) and pollutants. For the purposes of this Study, in scope are electricity production technologies (solar, wind offshore and onshore, hydro, ocean, geothermal), production of biomass, production of decarbonised gasses incl. hydrogen, e-gas and biomethane, as well as that support the energy transition such as nuclear and gas. The differences in maturity levels of these technologies, and their sub-categories, can be explored through the following **3 dimensions**:

1. **Technology Readiness Level (TRL)**
2. **Levelized cost of Energy (LCOE) of the technology**
3. **Capital Intensity of the technology**

The Technology Readiness Level (TRL) scale provides a useful way to assess where a technology is on its journey from initial idea to commercial market deployment. The scale has originally been developed for the aerospace industry in the United States but has gained increasing traction in the EU, where its usefulness lays in providing a common framework to assess and compare the maturity of technologies across sectors. For the needs of this study, we use the TRL scale as understood by the annual IEA *Energy Technology Perspectives* publication which, compared to the traditional scale which ends when a technology can be commercially available (TRL 9), extends the scale to incorporate the need of technologies to be further developed in order to be integrated within the existing energy system, to reach scale, or to develop mature supply chains. In the European energy production sector, a range of technologies at different stages of development coexist. This is especially true if thinking at the level of sub-technologies. For example, solar PV can be thought of as a mature technology if based on crystalline silicon or concentrated PV; on the other hand, it can be considered at an early stage of development if based on, for example, Perovskite solar cell.[25]

For this study, the TRL scale provides a useful framework to think about barriers to investment and investment schemes, given that reasoning at the level of individual technologies would be unfeasible. For the sake of simplicity, we refer to two broader readiness categories, each of which comprises different ranges of the full TRL scale[26]:

- **Emerging technologies –** comprising TRLs 1 to 7
- **Mature technologies –** comprising TRLs 8 to 11

[25] Energy Technology Perspectives 2020, *International Energy Agency*, 2020.

[26] We use the TRL framework explained in The Energy Technology Perspectives — Clean Energy Technology Guide published by the IEA (2020). Link.

- ***Transition technologies***[27] – a subset of mature technologies which have the role of assuring transition towards a decarbonised energy system.

As illustrated in Figure 7, each technology and sub-technology is allocated to one of these broad categories of readiness. The concept of TRL and the grouping into two categories is a lynchpin of this study and will be picked up in several sections later on.

[27] Working Group discussions have highlighted the need to represent these technologies. Investments in these technologies will be rerouted from construction of new generation capacity to the long-term operation of existing plants with the scope of ensuring safety and stability to the energy system in the decarbonisation process.

Figure 7: TRL clusterisation of energy production and production technologies

TRL	Stage	Technology	Technologies
1	**Initial idea** Basic principles have been defined		
2	**Application formulated** Concept and application of solution have been formulated		
3	**Concepts needs validation** Solution needs to be prototyped and applied	• Hydrogen: • (production)	*Seawater electrolysis* *Chemical looping* *Thermochemical water splitting*
		• Ocean:	*Salinity gradient*
4	**Early prorotype** Prototype proven in test conditions	• Biogas: (production)	*Micro-algae and macro-algae*
		• Biomethane: (production)	*Biomass gasisication and biological methanation*
		• Ocean:	*Ocean thermal* *Ocean wave*
		• Solar:	*Perovskite solar cell*
		• Wind:	*Airborne energy system*
5	**Large prototype** Components proven in conditions to be deployed	• Geothermal:	*Enhanced geothermal system*
		• Tidal:	*Tidal stream/ocean current*
6	**Full prorotype at scale** Prototype prove at scale in conditions to be deployed	• Geothermal	*Kalina process*
		• Solar:	*Organic thin-film solar cell*
		• Hydrogen: (generation)	*Hybrid fuel cell-gas turbine system*
7	**Pre-commercial demonstration** Solution working in expected conditions	• Biomethane:	*Biomass gasisication and catalytic methanation*
		• Hydrogen: (production)	*Solid oxide electrolyser cell electrolysis*
8	**First of a kind commercial** Commercial demonstration, full scale deployment in final form	• Hydrogen: (generation)	*Hydrogen-fired gas turbine* *High-temperature fuel cell*
		• Hydrogen: (production)	*Polymer electrolyte membrane electrolysis*
		• Nuclear:	*Light water reactor-based small modular reactor*
		• Solar:	*Thin-film PV*
9	**Commercial operation in relevant environment** Solution is commercially available, needs evolutionary improvement to stay competitive	• Biogas: (production)	*Non algae feedstock*
		• Biomethane: (production)	*Biomass gasisication – small-scale* *Anaerobic digestion and catalytic methanation with hydrogen*
		• Hydrogen: (production)	*Alkaline electrolysis*
		• Solar:	*Solar tower* *Parabolic trough*
		• Tidal:	*Tidal range*
10	**Integration needed at scale** Solution is commercial and competitive but needs further integration efforts	• Wind:	*Offshore*
		• Geothermal:	*Organic rankine cycle*
		• Solar:	*Crystalline silicon* *Concentrated PV*
		• Wind:	*Onshore*
11	**Proof of stability reached** Predictable growth	• Geothermal:	*Dry system* *Flash process*
		• Hydropower	
		• Natural gas	
		• Nuclear:	*Large-scale light-water reactor*

Legend:
- Emerging technologies
- Mature technologies
- Transition technologies

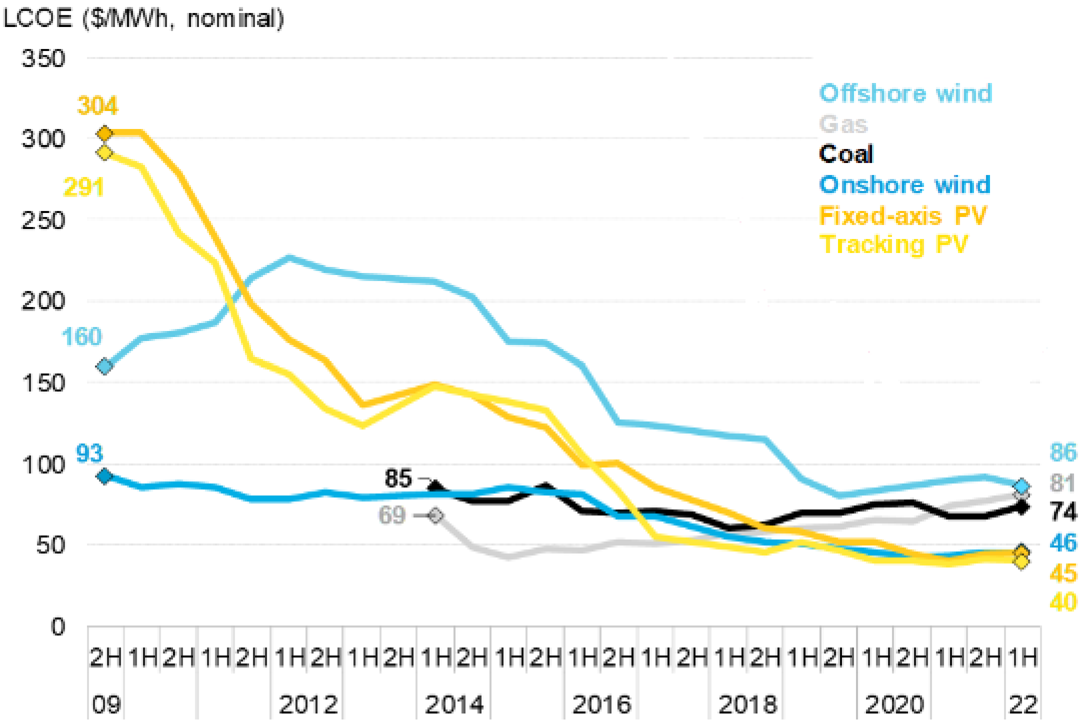
***Production**: production of decarbonised gas/fuels*
***Generation**: electricity generation*

Source: The Energy Technology Perspectives — Clean Energy Technology Guide. 2020

The Levelized Cost of Energy (LCOE) is a measure of the average cost of electricity production, in €/MWh, for a generator over its lifetime which provides a useful framework to compare the cost-competitiveness of energy production for different

technologies on a consistent basis. The LCOE is closely influenced by technological development, and thereby TRL and LCOE often move together in an inversely proportional relationship. Typically, low TRLs, associated with emerging technologies that do not possess the requirements to be commercially viable, are associated with high LCOE as low commercial viability entails high capital costs and thus high LCOE. On the other side, mature technologies with high TRLs tend to be associated with a low LCOE as they achieve a sufficient level of development to allow for commercially viable production. As seen in Figure 8, the LCOE for renewable energy generation installations has experienced **a remarkable decrease over the past decades** (LCOE for PV technologies has decreased by 86% in 2022 compared to 2009 levels) driven by a rapid industrialization of manufacturing processes and the resulting erosion of underlying capital costs.

Figure 8: Global levelized cost of electricity benchmarks, 2009-2022



Source: BloombergNEF, 2022[28]

Besides technological development, the LCOE is also influenced by regulatory and policy measures. Incentive schemes are one example of indirect influence, as non-refundable public resources have increased the TRL of renewables like wind and solar to levels where private investors perceive investments in such technologies as low risk, thus enabling even more investment to flow towards these technologies with the effect of lowering the LCOE[29]. Conversely, the application of a price on the emitted CO_2, as currently pursued

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[28] Available at the following link.

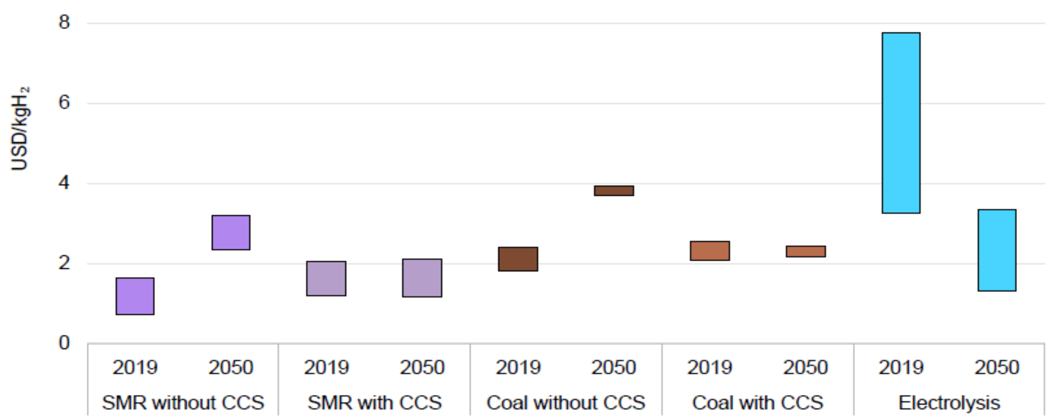
[29] Please note that to assess the direct and indirect impacts of capital-intensive investments on hydrogen technologies, the levelized cost of hydrogen (LCOH) should be considered. In its 2021 "AnalysisAnalysis of the levelized cost of hydrogen", Lazard illustrates how renewable energy can represent between 40% and 70% of the LCOH. Therefore, support schemes and capital-intensive investments that drive down the LCOE may have an indirect impact also on the LCOH. Additionally, Lazard states that the next-most significant driver of the LCOH are costs pertaining development and utilization of electrolyzers. These costs can be decreased through technological developments and industrial scale applications, which could have a direct effect on decreasing the LCOH.

by the EU ETS, is an example of increasing LCOE through a direct policy measure. As explained by the Fraunhofer Institute[30], the LCOE of conventional power plants is set to increase as the quantity of CO_2 emission allowances available on the market is reduced through policy measures thus increasing the operational costs borne by coal and gas power plants. This kind of measure encourages the phase-out of conventional power plants also from the point of view market economics, as it becomes increasingly difficult for these power production sources to remain competitive relative to renewable sources. This effect is also visible in Figure 8, as CCGT plants based on natural gas have experienced a slight but constant increase in their LCOE from 2008 to 2018.

Capital intensity of energy production projects is crucial in the implementation of energy production and production technologies as it is closely linked to the components of the LCOE formula and is also closely influenced by TRL. In fact, TRL influences LCOE through capital intensity as higher levels of TRL imply the possibility to develop technologies on a larger scale leading to the possibility of benefiting from economies of scale and standardized production processes which lower the level of capital per MW of production required to implement projects. On the contrary, technologies in pre-commercial development or in demonstration phase, associated with low to medium TRLs, require higher intensity of capital to run pilot projects and validation tests which are necessary to bring the technology to the market. For such projects, CAPEX requirements are high due to the necessity of involving innovative production processes which have yet to be optimized or rare materials that require additional R&D to be substituted with cheaper and more common materials.

The emerging green hydrogen industry provides an example of how capital intensity and TRL influence LCOE. TRLs for green hydrogen production processes are generally lower than for grey hydrogen[31], which is a mature and established technology. This is illustrated in Figure 9, where all technologies except for electrolysis are based on fossil fuels; what emerges is that as of today, the cost of producing one kg of hydrogen via SMR technology far outcompetes production via electrolysis, making electrolysis commercially unattractive as of today. [32] This is due to the fact that green (electrolysis-based) hydrogen requires higher CAPEX (as well as OPEX), and also has a steeper learning curve than grey hydrogen.

Figure 9: Hydrogen production costs by technology in the Sustainable Development Scenario, 2019 and 2050



Notes: CCS = carbon capture and storage; SMR = stream methane reforming; coal = coal gasification. Electrolysis based on dedicated renewable-based production.

30 Kost, C., Shammugam, S., Fluri, V., Peper, D., Memar, A., D., Schlegl, T., Levelized Cost of Electricity Renewable Energy Technologies, *Fraunhofer Institute*, June 2021.

31 Grey hydrogen is the most common form of hydrogen, and it is generated from natural gas, or methane, through a process called "steam reforming". This process generates Co2 in quantities just a smaller than those generated to produce black or brown hydrogen, which require black (bituminous) or brown (lignite) coal in the hydrogen-making process. Black or brown hydrogen is the most environmentally damaging as both the CO2 and carbon monoxide generated during the process are not recaptured. Link

32 Projected Costs of Generating Electricity, *IEA*, 2020.

Source: IEA Energy Technology Perspectives. 2020

Capital intensity represents a crucial factor also for nuclear energy, as capital costs concern between 60% and 85% of the total costs of nuclear power plants.[33] Such high levels of capital intensity generate high upfront costs which is one of the reasons that tend to generally discourage investors from participating in such projects. These high capital requirements are attributed to the fact that nuclear power plants are technically complex and must satisfy strict licensing and design requirements, especially following the Fukushima disaster of 2011, which resulted in increased safety requirements. The design and construction of a new nuclear power plant requires many highly qualified specialists and often spans over the course of many years, compounding financing costs, which can become significant. Design changes, spurred by increasingly demanding safety requirements, can cause delays that further increase the financing charges, which in some cases exceed the actual construction costs[34]. Increased standardization and reduced size of power plants (e.g., modular power plants) are currently seen as the most viable alternative to allow the continuation of investments in this technology.

Type of financing needed

The type of financing needed to bring to the market different energy production projects is driven in large part by the maturity of technologies. More specifically, the type of financing needed reflects the risk profile associated to a certain point in the technology's maturity: as technologies pass through each stage of the maturity scale, the level of risk associated with technology performance is reduced; at the same time more mature technologies which are deployed at large scale may face broader risks related to, for example, market access and public acceptance.

In light of this, emerging technologies with high investment risk and few viable revenue streams have a risk-reward profile which is often insufficiently attractive to secure commercial financing in the market. To bridge this commercial viability gap, early TRL projects tend to require support from public sources (via grants, loans, equity and risk capita, or subsidies, including subsidized revenue streams) and / or from investors with a high-risk appetite (typically via equity investment). On the contrary, mature technologies which have reached commercial viability and are able to tap into safe and constant future revenue streams tend to be more bankable, i.e., are better able to secure commercial-rate financing in the market without the need for a particular support scheme. Two main categories of financing instruments and schemes are identified according to the type of risks they cover and support they provide, as outlined in the following paragraphs.

Public support, Debt instruments & Risk capital for low TRL technologies

Technologies that are in the low TRL area tend to be characterised by high risk, as concepts and ideas might prove wrong or ahead of their time to be commercially feasible. Furthermore, economic returns, if they are present, are not considered sufficient to receive commercial-rate financing. The combination of these two factors generates an economic viability gap. The purpose of the major types of support for these technologies is to:

- Reduce the CAPEX requirements and technology risks (including in the research and development phase). This can be supported by:
    - Public support in the form of grants and / or loans awarded either by governments through research programmes, or by the EU funding programmes (e.g., Innovation Fund, Horizon Europe, LIFE Programme, ERDF, etc).

[33] Synthesis on the Plant-Level Cost of Nuclear: Workshop on Cost Electricity Generation, *OECD-NEA*, January 2016, Paris.
[34] Projected Costs of Generating Electricity, *IEA*, 2020.

- Reduce the risk profile of the investment. This can be supported by:
    - Public guarantees, e.g., first-loss or partial risk coverage scheme, which for the final beneficiary the guarantee translates into lower lending requirements and better financing conditions (lower interest rates, longer maturities, etc).
    - Equity investments, e.g., venture capital is particularly effective at providing support to young companies and start-ups with promising technologies that lack financial resources or track record to scale up production. Private equity is another form of support, which tends to provide greater financing amounts than venture capital with the aim of bringing businesses and developing technologies to levels of maturity that enable them to be sold on the stock market or to be taken over by other larger companies.
- Boost the future revenue stream of the project and mitigate market risks. This can be supported by:
    - Public subsidy schemes, e.g., Feed in Tariff or Contracts for Difference.[35]

[35] Global Trends in Renewable Energy Investment 2020, *Frankfurt School-UNEP Center*, 2020.

Box 1: Public subsidy schemes

Public subsidy schemes can be generally grouped into three categories: feed-in tariffs, feed-in premiums, and contracts for difference.

In a feed-in tariff (FiT), energy suppliers are offered a cost-based compensation per unit of electricity (e.g., kilowatt per hour, kWh) fed into the grid. FiT payments can be technology-specific, for example by applying different tariffs to electricity depending on how it has been generated, to ensure that a broader set of RE technologies is supported, including those that are more expensive due to lower levels of maturity and/or economies of scale. In this last case, the FIT can also decrease over time, to reflect the supposed increase in technology maturity.

Finding the right balance between cost-based tariff and good adjustment over time is crucial, as any overestimation of tariffs will lead to higher energy prices for final users and may fail to generate sufficient competition to enhance technological development and decrease unit costs. On the other hand, too low tariffs might lead to too few installations of RE, as the upfront costs are recovered over a too long period of time.

A very similar instrument is the Feed-in premium (FiP), which has a basic set-up almost identical to FiTs. Rather than receiving a fixed rate per unit of electricity supplied, RE suppliers receive a premium on top of the market price of their electricity production. The main difference to the FiT is that the electricity generated is sold to the market at market prices. The RE supplier, however, gets an additional payment in the form of a premium. This premium can be either fixed (constant regardless the market price), or sliding (varying depending on the market prices).

Contracts for difference (CfD) are long-term power purchase agreements with a determined “strike price”. The energy producer receives a premium if the market price is below the strike price. In this case, the premium is equal to the difference between both prices. If the electricity price is above the strike price, then the RE supplier has to pay the difference to the off-taker.

CfD can be applied not only on energy prices, but also on carbon prices. In this case they are called Carbon Contract for Difference (CCfD), and is a model that addresses the issue of CO2 price volatility. Similarly to a classic CfD, in a CCfD, a public administration and a project promoter sign a contract fixing a carbon price level (the strike price). On an annual basis, one party reimburses the difference between the strike price and the actual price to the other party. If the CO2 price is lower than the strike price, then the government pays the difference to the investor, like a common subsidy. If the CO2 price is higher, private companies reimburse the government. This model reduces the risk of CO2 price volatility and allows for long-term financial planning.

Commercial instruments and market-rate funding for mature technologies

Projects with mature energy production technologies and safe and constant future revenue streams tend to be bankable, i.e., have access to market-based financing provided at low interest rates. The financing can take the form of, for example:

- Public equity financing, which channels money from conventional institutional and private investors into renewable energy companies by trading their shares on the stock market, also enabling them to scale up production and commercialize their technologies.
- Financing can also come from credit and debt markets, especially for maximum-TRL technologies, where the low risk profile makes this attractive for institutional investors.

- Balance sheet financing, which refers to the use of either equity or debt instruments to attract investments into a company (including into start-ups).
- Power Purchase Agreements (PPAs), a type of contract that ensure pre-determined levels of revenues over the medium-to-long term, which in turn make a project (more) bankable.
- Debt financing with public support, under the form of concessional loans either with a guarantee or a grant combined with a loan, can foster the implementation of rooftop solar or other RES measures for residential buildings and SMEs

Box 2: Power Purchase Agreements

A Power Purchase Agreement (PPA) is a **long-term contract** under which a business agrees to purchase electricity directly from an energy generator. PPAs provide financial certainty to the energy producer (project developer) and energy consumer, thus removing a significant roadblock to energy investments (stability of long-term revenues was identified as one of the main barriers in the first WG1 meeting). A recent market study from the European Investment Bank (EIB) estimates a market size for commercial PPAs in 2030 between 140 TWh and 290 TWh, equivalent to around 10% and 23% of 2030's solar and wind production[36].

A PPA is typically between a purchaser "off-taker" (usually an electricity utility or a company that requires large amounts of energy) and a private energy producer. The structure and risk allocation regime under the PPA is central to the private sector participant's ability to raise finance for the project, recover its capital costs and earn a return on equity. A PPA provides **long-term clarity** on the roles, responsibilities, costs, revenues and risks for all actors involved[37].

PPAs can be on-site and off-site. An **on-site (or physical) PPA** is a contract for the supply of electricity from a specific production plant located on the customer's property and connected to its internal network. The energy generated is energy that the customer is no longer demanding from the grid, so the developer offers the customer this energy at a more competitive price. An **off-site (or virtual) PPA** is associated with a production plant connected to the transmission or distribution network of the country's electricity system[38].

The two main factors limiting the popularity of PPAs in Europe are the limited ability of corporates to expose themselves to **electricity market risks**, and the credit worthiness of off-takers. Large power buyers with limited risk appetite who face strong competition in their own sectors are reluctant to commit to long-term fixed-price contracts, as they fear that their competitiveness could suffer if the market price declines and their competitors enjoy lower energy costs[39,40]. **Credit worthiness** is also a major barrier for many sectors, as lenders to renewable projects typically require off-takers to have a strong investment grade credit ratings to consider a PPA-based project bankable[41].

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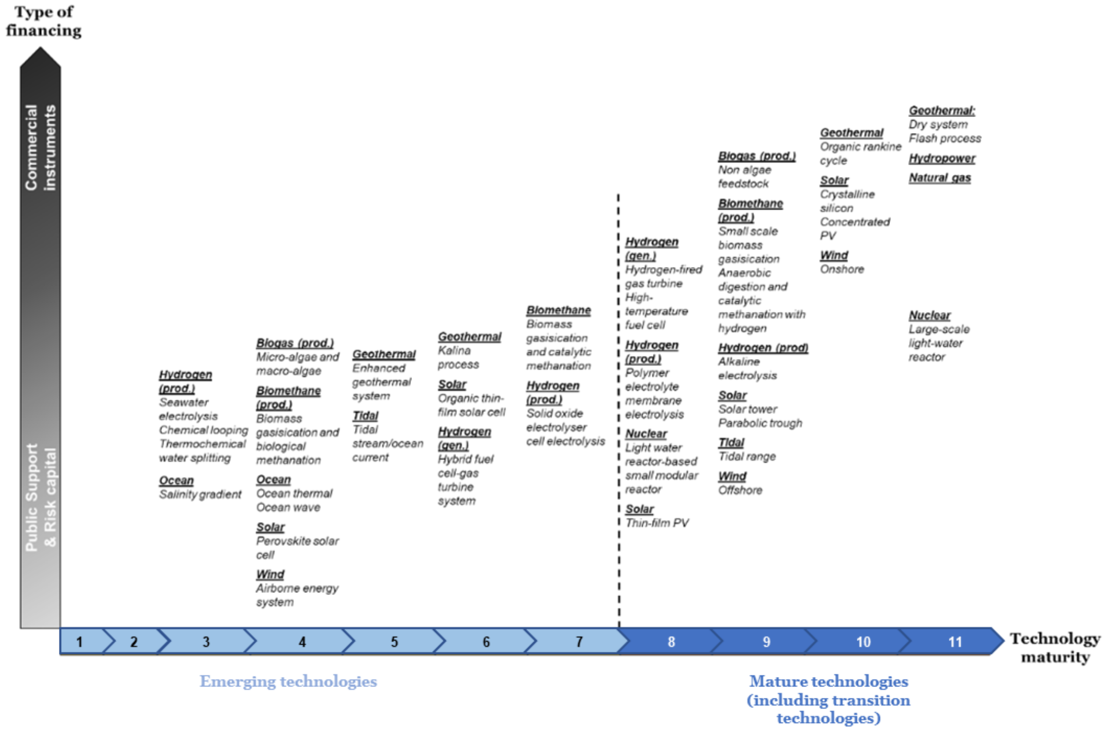
[36] European Investment Advisory Hub (2022). Commercial Power Purchase Agreements. Available on: Link
[37] IRENA (2018). Power Purchase Agreements for Variable Renewable Energy. Available on. Link
[38] Iberdrola. https://www.iberdrola.com/about-us/contracts-ppa-energy
[39] European Investment Bank. Renewable Energy Power Purchase Agreements. Available on: Link
[40] European Investment Advisory Hub (2022). Commercial Power Purchase Agreements.
[41] European Investment Bank. Renewable Energy Power Purchase Agreements.

Figure 10: Type of financing in relation to technology maturity (TRL)



This categorization serves to provide a high-level overview and is subject to numerous exceptions. Mature technologies can also benefit from public support in the form of governmental incentives, guarantees and subsidies, even though to a lesser extent in comparison to emerging technologies. An example for this would be nuclear projects receiving state guarantees to reduce risk profiles, or wind projects benefiting from Contracts for Difference to boost revenue streams and reduce market risks. Similarly, private equity and venture capital can also be provided for projects or companies with a high maturity development phase.

Figure 10 illustrates the type of financing, which is prevalent for different TRLs levels, highlighting also the areas where several categories overlap and indicating which of the technologies illustrated in Figure 7 can benefit from the different types of financing in function of their current TRLs. Chapter 2 of this study provides further detail on financing schemes and instruments for energy production technologies considered in this study.

2.4. Barriers to investment

Despite falling technology costs, making mature renewable energy commercially viable in many countries, renewable energy investments face a series of barriers deriving the nature of renewable investments and from the current framework that governs the energy market.

This chapter provides an overview of barriers affecting energy production and electricity production from RES (i.e., solar, wind offshore and onshore, hydro, ocean, geothermal), production of biomass, production of decarbonized gasses incl. hydrogen, e-gas and biomethane as well as natural gas. For the purpose of this study, the barriers have been identified following a two-step process:

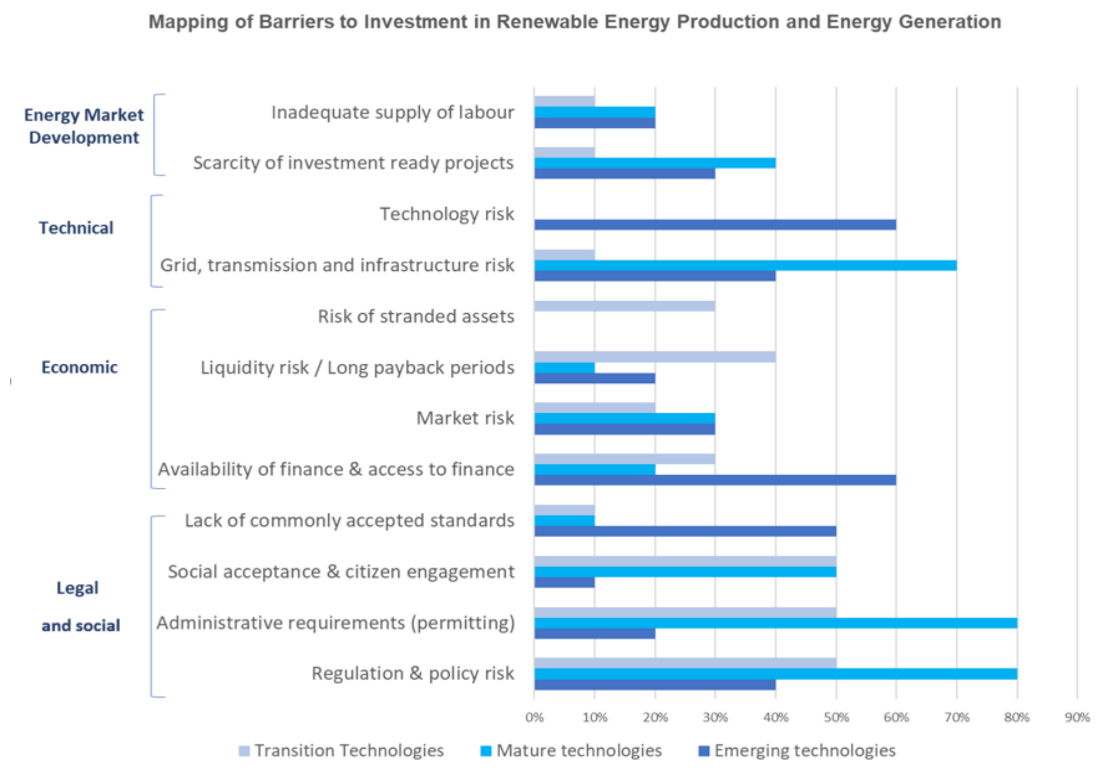
A literature review was carried out to identify a long list of barriers to energy production investments from different reliable sources (e.g., EIB, European Commission, International Energy Agency IEA, etc.). The identified barriers were grouped into four categories, namely:

- **Legal,** associated with risks and barriers concerning compliance with the regulatory and policy frameworks, the permitting framework, **as well as social acceptance** of these projects on behalf of the general population
- **Economic,** associated with risks and barriers deriving from economic factors like market dynamics and organization, access to capital, transaction costs, off-taker risks and incentive schemes
- **Technical,** associated with risks arising from technical features of projects like technology and resource availability, including supply chain risks
- **Energy market development,** barriers emerging from the immature nature of the market for emerging technologies

Following this classification, the **Technology Readiness Level framework** was proposed as an instrument to rate the acuteness of barriers in function of the maturity of production technologies. As explained in the previous section, the 11 TRLs are grouped into two main categories (see section 1.2.1 for further detail).

The Working Group (WG) on Energy Production in the Investors Dialogue on Energy was invited to identify the barriers considered most acute. Table 3 provides a view of the barriers identified as most acute, or most relevant, for each technology type. In the sections that follow, we provide more detailed information about participant's views of the barriers, as well as several examples of the effect of barriers on energy production.

Table 3: Mapping of barriers to investment in renewable energy production and energy production[42]



[42] Please note that the long-list of barriers alsobarriers also included:

- **Energy market development:** inadequate or underdeveloped supply chain and industrialization, small size of projects and high transaction costs.
- **Technical:** resource risk, weak planning and preparation capacities.
- **Economic:** counterparty/offoff taker risk, high upfront costs, unduly high borrowing costs or costscosts of capital
- **Legal and social:** compliance with EU State Aid and other competition regulation

Source: PwC own elaboration based on the results of the online survey circulated amongst WG members

Legal and Social Barriers

Regulation & policy barriers derive from changes in legal or regulatory policies that have significant adverse impacts on project development or implementation (e.g., incentive programmes, interconnection regulations, permitting process). As evidenced by the EIB, barriers to investments concerning regulation originate from two main issues[43]:

- **Regulatory uncertainty.** Certainty and predictability of the regulatory framework is essential for investments such as renewable energy production projects, which are characterized by high upfront fixed costs. In these contexts, regulation has an important role in determining the costs and benefits of investing through the implementation of incentive and support schemes. Unbalanced and unstable
- regulatory frameworks can compromise investor confidence in the credibility of those frameworks leading them to deciding not to invest.
- **Regulatory fragmentation.** Regulatory fragmentation refers to situations where different levels of government of one country (local, regional and national) are not harmonized in terms of regulation and policy. The issue can also arise from differences between regulations of different countries or EU member states which can hamper the development of renewable cross-border projects, which play an important role in the promotion of an integrated energy market at the EU level[44].

[43] Breaking Down Investment Barriers at Ground Level - Case studies and other evidence related to investment barriers under the third pillar of the Investment Plan for Europe, *European Investment Bank*, *European Investment Fund*, 2016.

[44] With Commission Delegated Regulation 2022/2202 (link), the Commission has adopted the first list of selected cross-border projects in the field of renewable energy (RES). The list comprises three projects, involving a total of seven Member States, namely:

- A hybrid offshore wind park between Estonia and Latvia
- Cross-border district heating grid based on RES between Germany and Poland
- A project to produce renewable electricity in Italy, Spain and Germany for conversion, transport and use of green hydrogen in the Netherlands and Germany.

Although few in number, such projects are an important step towards the creation of an integrated European energy market designed to promote cross-border cooperation between Member States (and between Member States and non-EU countries) in the field of planning, development and cost-effective exploitation of renewable energy sources. In addition, cross-border RES projects may facilitate RES integration through energy storage or hydrogen production facilities, among others, with the aim of contributing to the EU's long-term decarbonisation strategy. More information about the project can be consulted at the following link.

Box 3: Retroactive cuts to incentives for renewables in France, Italy and Spain

The early stages of large-scale solar deployment in Europe saw a boom of generous feed-in-tariffs (FiTi) regimes with the goal of bridging the economic viability gap for renewable energy projects. In recent years, however, some EU countries scaled back those regimes by implementing retroactive changes thus inflicting damage on those who invested based on those incentives.

One example is **France** where, on the 13th of November 2020, the French National Assembly adopted an amendment tabled by the government that led to the "retroactive" reduction of the electricity purchase tariff for large-scale PV installations (with a capacity above 250 kWp) concerning contracts signed between 2006 and 2010. The cut was set to affect 800 out of the 235,000 solar power purchase contracts that have been concluded in that period, affecting specifically medium-sized PV projects commissioned between 2007-2008 and 2011-2012[45].

Another relevant example is **Italy**, which at several instances retroactively cut down incentives to renewables following a generous incentives regime implemented between 2003 and 2011. In 2011 Italy started to pass a series of measures aimed at reducing the electricity bill of consumers, including cutting the minimum guaranteed price paid to renewable developers that applied under the incentive scheme. These regulatory changes led to foreign investors bringing several claims against Italy. The event was repeated in 2014 following the so-called “Spalma Incentivi Decree” of 2014 and associated changes to the “Conto Energia” regime dedicated to incentivising PV projects. Broadly speaking, the Decree significantly reduced the FiT levels guaranteed to grid-connected PV power plants with a nominal capacity exceeding 200 kW, subject to express stabilization agreements between PV electricity producers and the relevant state-owned entity (the Gestore dei Servizi Energetici S.p.A., or GSE). This unexpected change affected the project finance obtained by most solar PV projects in Italy and prevented numerous investors from servicing their debt.[46]

The most recent attempt of reducing incentives retroactively is represented by a 11-month retroactive incentive cut on PV systems over 20 kW, which will apply from 1st of February 2022, to 31st of December 2022, and will reduce the tariffs paid to PV system operators under the “Conto Energia” regime, depending on the zonal energy price, with the incentive reduction being proportional to the increase in energy prices. Although the Government has justified this move with the intent to help consumers and businesses reduce their energy bills (which finance directly the incentive regimes), great concern has been expressed by several Italian trade bodies with warnings that this move might undermine the credibility of the country towards investors in renewable energy[47].

Spain has also undergone retroactive cuts of incentives for renewable energy installations in the early 2010s. The pre-existing support scheme for renewables was approved in 2007 with the aim of boosting investments in renewable energy generation in view of meeting Spain’s share of renewable energy generation targets for the period 2000-2020[48]. The scheme generated larger than expected investments in PV solar plants with consequent increasing costs of supporting the scheme itself which has led the Spanish government to gradually dismantle the scheme starting from 2010, culminating in 2014 with the complete eradication of the FiT scheme in favour of a new remuneration regime[49]. The new regime consisted in a fixed remuneration on investment of 7.5% over the useful life of installations for all PV plant operators. However, plant operators and investors felt that the government broke its promises regarding stable incentives over a 20-year period and filed numerous suits against the Spanish government. In an attempt to restore stability to the incentive system, in 2019 the Spanish government proposed a plan to grant investors a 7.398% remuneration rate until 2031 for plants that have been up and running since before 2013[50].

However, the incentives will be denied to those firms that are still pursuing litigation over the FiT cuts or for those that have already obtained compensation after winning court disputes.

Similar retroactive changes to renewables support schemes have been adopted in the **Czech Republic, Romania, Bulgaria and Slovakia**. The overall concern is that this might compromise investment in renewables and slow the EU's progress towards its decarbonisation objectives. In fact, one scientific paper[51] raises the argument that “a retroactive subsidy change decreases the investment rate by approximately 45% for PV and 16% for onshore wind” and that “once the seed of mistrust is sown, it is likely to have a lasting impact”. The study further indicates “that a stable policy environment with credible policy commitments is crucial for incentivizing investments made by private firms”.

Regulation and policy were identified as the most acute barrier to investments in energy production in the WG discussions and survey. Some 80% of the WG members consider it as relevant for mature technologies, with this view converging broadly among both the supply and demand-side of stakeholders including project developers, IPPs, investors and industry associations. 50% of stakeholders consider this barrier relevant for transition technologies, while although not the main concern, it occupies a relevant position also for emerging technologies with 40% of the votes. WG members also expressed the need to have a regulatory framework that can anticipate future issues and ensure long-term stability and security, with developers in particular affirming that as long as the regulatory context can assure stability and security, access to finance is not an issue for high TRL technologies. WG members also referred to the difficulties of some Member States in transposing EU directives at the Member State level in a timely and precise manner. As a concluding remark, participants agree that regulatory sandboxes present the most effective solution against this barrier, particularly for low TRL technologies.

Unduly burdensome administrative requirements (permitting) are considered as another major barrier to investments in energy production, with 80% of the WG Members converging on the opinion that it affects mature technologies and 50% affirming that it affects also transition technologies. Stakeholders both on the demand and supply side of financing converge on manifesting concern for mature technologies, while this barrier is not seen as relevant for emerging technologies. The WG members converge on the opinion that compliance with environmental requirements and spatial planning constraints are the most acute factors slowing down or outright blocking project development and are endangering Member States’ ability to meet their renewables targets. Offshore projects were identified as particularly vulnerable to permitting issues concerning marine planning constraints. WG members also identified the lack and inadequacy of human capacities in permitting authorities as one of the main reasons behind permitting issues. One solution proposed by the WG

[45] Retroactive cuts for solar feed-in tariffs, *Dentons.com*, November 2020.

[46] Broken promises: Legal recourse for retroactive FIT cuts, *PvMagazine.com*, January 2020.

[47] Italy introduces 11-month retroactive incentive cut on PV systems over 20 kW, *PvMagazine.com*, January 2022.

[48] Directive 2009/28/EC established a common framework at the European level to promote energy from renewable sources and set compulsory national targets for 2020 in relation to the share of energy from renewable sources in final gross energy consumption. For Spain this target was set at 20% of the energy consumed in 2020 to be from renewable sources. (F. Castro-Rodriguez, D. Miles-Touya, Assessment of support schemes promoting renewable energy in Spain, *Spanish Econ. Financ. Outlook*, 2015).

[49] F. Castro-Rodríguez, D. Miles-Touya, Impact of Spanish renewable support scheme reforms on the revenues of photovoltaic power plants, Utilities Policy, February 2023.

[50] J. Rojo Martín, Spain fights litigation over retroactive FiT cuts with more subsidies, *pv-tech.org*, November 2019.

[51] Sendstad L.H., Hagspiel V., Jebsen Mikkelsen W., Ravndal R., Tveitstøl M., The impact of subsidy retraction on European renewable energy investments, *Department of Industrial Economics & Technology Management, Norwegian University of Science & Technology*, 2022.

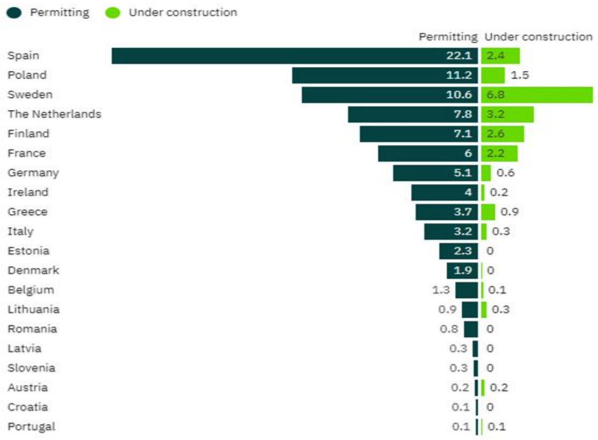
members is to perform environmental assessments of entire zones / areas where RES production projects can be implemented thereby avoiding the need to perform individual assessments for each project (a measure already proposed by the REPowerEU, the so-called *dedicated 'go-to' areas for renewables*). Other proposed solutions concern the simplification of permitting procedures and the limitation of possibility of recourse by local inhabitants.

The following boxes present some examples of permitting issues at Member State level.

Box 4: Permitting slows down the development of EU wind energy

As evidenced in an analysis by Energy Monitor and Global Data[52], the EU has **four times** more wind capacity stalled in the permitting phase than under construction. *Figure* 11 illustrates the disproportion between active wind energy projects and those still waiting for approval. This disproportion is particularly important in Spain, Poland and Sweden.

Figure 11: Top 20 EU countries by wind pipeline capacity broken down by development stage (GW)



Source: Data insight: The permitting problem for EU wind farms, Energy

A report from the consulting firm Eclareon[53] found that no EU country has effective policies in place that would ensure the necessary deployment of wind and solar farms. The most serious problems are linked to bureaucracy, the report says, "especially the high complexity, long duration and low transparency of administrative procedures".

The current situation is summed up by the following considerations by Wind Europe: "Most EU countries have ambitious national targets for the expansion of wind energy. But permitting remains the main bottleneck. Europe is not permitting anything like the volumes of new wind farms needed. And almost none of the Member States meets the deadlines for permitting procedures required in the EU Renewable Energy Directive. The permitting rules and procedures are too complex. Permitting authorities are not always adequately staffed."[54]

[52] Data insight: The permitting problem for EU wind farms, *Energy Monitor*, April 2022.

[53] Barriers and best practices for wind and solar electricity in the EU27 and UK, *eclareon GmbH*, March 2022.

[54] Europe's building only half the wind energy it needs for the Green Deal, supply chain is struggling as a result, *WindEurope*, February 2022.

Box 5: Poland's Wind Energy Challenges[55]

In June 2016 the Polish Parliament approved a law aimed at protecting the health and standard of living of citizens living in the vicinity of wind farms. The law made it illegal to construct new wind turbines near homes, schools and natural reserves. It also prohibited wind turbine construction within a distance of at least 10 times their height, which, according to experts, led to 99% of Poland's surface becoming excluded from wind farm development. The wind power industry has criticized the 10H10H rule, saying that it has halted the development of onshore wind energy in Poland. To address this issue, in March 2023, the Parliament voted an amendment of the regulation to ease the 10H rule. The new law allows local spatial development plans to define the reasonable distance between residential buildings and wind farms. In addition, an extra social consultancy shall be conveyed and local citizens have a right to buy 10% of investment share to benefit from electricity sell. A minimum distance of 700700[56] meters between residential areas and wind parks would be mandatory. The law would also affect the repowering of existing wind installations. The Parliament voted the change in attempt to fulfil the milestone for releasing RFF for Poland, as it may help to revive the development of onshore wind energy in Poland.

Box 6: Renewable energy permitting barriers in Romania[57]

The Romanian Ministry of Agriculture and Rural Development (MADR) has reportedly rejected all permits requested from the start of 2022 for PV installations on agricultural land. Permits have been rejected for projects below and above 50 hectares alike, causing those occupying more than 50 hectares to be completely halted. Projects applying for such permits are reported to be mature projects, with investment operations initiated at least one year in advance. These investments consist in either the purchase of lands or in commitments to long-term superficies agreement. This administrative setback puts these projects also at risk of losing the grid connection rights, as the grid connection permits expire if the building permit is not obtained within 18 months from the issuance thereof.

Permitting rules state that PV, wind, biomass, bioliquid, biogas, storage projects, and transformer stations are allowed to be developed directly on extra-muros land under fertility classes III, IV, and V. Prior to their introduction, development was prohibited on such sites. The new rules also state that such land can be used for projects with dual uses, including power production and agricultural activities. MADR has reportedly failed to provide a legal argumentation for these rejections, leading to believe that the Romanian government might be misinterpreting legislative changes introduced in late June 2022 to support solar on agricultural land and ease the permitting process for small projects spanning less than 50 hectares.

[55] Barriers and Best Practices for wind and solar electricity in the EU27 and UK, *Eclareon*, 2022.

[56] Increased from 500 meters to 700 meters by a last-minute amendment, as explained in a press article - "A., Ptak, Polish parliament approves law to unblock building of onshore wind farms, Notes from Poland, February 2023".

[57] Permitting issues for solar on agricultural land in Romania, *pv-magazine.com*, 2022.

Box 7: Permitting issues put Denmark's offshore ambitions at risk[58]

Most new offshore wind farms in Denmark are established following a tendering procedure, however, the Open-Door procedure is also applicable.

In the Open-Door procedure, a project developer takes the initiative to establish an offshore wind farm of a self-selected size and location. In this process, the Danish Energy Agency must grant three permits before offshore wind turbines can be installed: a feasibility study permit, an establishment permit and an energy use permit. These permits are issued as the project progresses therefore each permit is a prerequisite for the subsequent. During the authorisation process, the Danish Energy Agency consults the other relevant authorities.

In February 2023, The Danish Energy Agency suspended the Open-Door scheme with the motivation that the scheme may be in breach of EU state-aid law. The Danish Energy Agency has therefore suspended the processing of all pending cases under the Open-Door scheme until its relationship with EU law has been further investigated. The same will apply to any new applications.

The decision has received relevant criticism from developers and associations as it was unexpected, given the recent announcement of the Danish Energy Agency on 31 August last year, that 47 applications under Open Door scheme have been received since 4 April 2022.

Social acceptance & citizen engagement is analysed in the RENAISSANCE survey on renewable energy and community solutions[59] through the following dimensions:

- **Socio-political acceptance** which implies acceptance of renewable resources as viable energy resources and support to RES production development on behalf of governments through support policies.
- **Market acceptance** as the acceptance and inclusion in the market of RES by market operators such as private investors, financial institutions and consumers.
- **Community acceptance** as the acceptance of specific renewable energy projects by hosting communities (the so-called NIMBY effect).

Social acceptance & citizen engagement is seen as a relevant barrier by 50% of WG members both for mature and transition technologies, and views are broadly shared by both demand and supply-side stakeholders. For emerging technologies, this barrier is not seen as relevant. The most relevant issue highlighted by participants to WG discussions is related to the increasing proximity of RES production plants to populated centres, particularly in rural areas and in densely populated Member States. Nuclear technologies are particularly exposed to social opposition on a broad scale (i.e., going beyond NIMBY effect). Participants also highlight the high social opposition related to the use of land and the effects on biodiversity of RES projects. Some WG members highlight the high incidence of this barrier concerning offshore wind energy projects in the Nordics and in the Baltics, where social opposition to these projects is quite high – the following box provides an example.

[58] Denmark puts offshore ambitions at risk as it suspends processing of projects under the Open Door scheme, *balticwind.eu*, 2023.

[59] RENAISSANCE survey on renewable energy and community solutions, *RENAISSANCE project*, 2020.

Box 8: Public resistance to renewable wind energy projects in Germany, Sweden and Norway

German wind energy has been struggling in the last years with increasing public acceptance issues. One example of such opposition can be seen near the town of Nauen, about 50 kilometres west of Berlin, where the planned extensions of Ketzin 1 and Ketzin 2 wind farms have raised strong public opposition with a lawsuit launched against the expansion justified by the small distance between the project and the village of Falkenrehde, just 600 meters away, and by concerns concerning the impact on the local fauna. There are other examples of similar lawsuits against other wind power production projects caused by their proximity to residential areas. This has led to initiatives on behalf of German regional authorities, like the regional government of the southern German state of Bavaria, which has imposed a so-called 10H ban on new installations stipulating that the distance between a turbine and a settlement must be a minimum of 10 times the height of the turbine. Environmental concerns about the turbines' impact on wildlife also contribute to the public opposition. BWE's findings suggest that about 300 turbines with a total capacity of 1,200 MW are currently being blocked by legal objections based on alleged threats to endangered birds and bats[60].

Wind energy development has encountered social resistance also in Sweden, whose goal is to scale up its wind power capacity to 100 TWh by 2040, from the current 28 TWh generated by a fleet of 4,000 turbines[61]. Several projects have been designed to pursue these targets, among which the construction of a fleet of 30 250-meter-high wind turbines near the Swedish village of Malung. The project has received strong opposition from the local community considering that the benefits generated by such a project would be insufficient to compensate the potential damage to local people and wildlife. In details, the local community is concerned about the impacts of the project on the landscape and on the economy of the village which is situated on the main road to popular ski resorts further north. A referendum held in Malung last year in 2020 showed a slight majority (52.1 percent) against the project while about 44.6 percent were in favour.

Similarly, Norway has experienced protests against the construction of wind turbines near Fosen, in central Norway, on lands traditionally used by Indigenous Sami reindeer herders. In this particular case, it was established by the Supreme Court of Norway that the wind turbines, which are currently operational, violate Sami rights under international conventions. The debate is still ongoing, with the Norwegian government working to find a compromise between involved parties[62].

Lack of commonly accepted standards at the EU level and the necessity to meet different standards between different Member States, or even within Member States between different regional governments, leads to market fragmentation and hampers the ability of technologies to reach scale / enter new market segments. This is among the most important barriers identified for emerging technologies, with 50% of votes, while it is not perceived as relevant for mature and transition technologies. Emerging technologies are particularly exposed to this barrier as regulatory bodies are often unable to keep up with the rapid pace of technological development, leading to a fragmentation and duplication of regulatory efforts at different governance levels.

[60] German wind energy stalls amid public resistance and regulatory hurdles, *DW.com*, September 2019.

[61] C. Duxbury, Sweden's fading enthusiasm for onshore wind farms, *politico.eu*, February 2021.

[62] V., Klest, G., Fouche, Thunberg, Indigenous protesters block Norway energy ministry over wind farms, *reuters.com*, February 2023.

Economic Barriers

Availability of finance & access to finance can stem from capital market failures, whereby capital markets are not used to making certain types of investment and accurately pricing risk[63]. Such an effect may be amplified by the stringent regulation of the financial sector, which may lead to a less transparent and more complex financing environment[64]. Because of this, emerging technologies tend to depend on high levels of subsidized or no-cost finance to be set in place.

Availability and access to finance is considered by 60% of participants as relevant for emerging technologies, making it the most important barrier for this group of technologies. More specifically, concerns originate mostly on the demand side of financing, with developers affirming that low TRL technologies have more difficulty in securing finance as opposed to high TRL technologies. Some participants also argued that low TRL technologies are affected by the scarcity of public resources in R&D projects and initiatives, since this is the main source of financing at this level of maturity. These findings are consistent with the description of economics of the energy production segment illustrated in Section 2.3, where also literature sources affirm that low-TRL technologies face a commercial viability gap, typically bridged by public support.

This barrier is less relevant for transition technologies where it still gained 30% of the votes, mostly from investors, reflecting some degree of concern regarding the impact of the EU Taxonomy regulation and PR risk on investments in gas production. For mature technologies, WG participants agreed on the fact that access to finance is not a relevant issue, as long as regulatory and policy frameworks are favourable, whereas the modest Investment Rate of Return (IRR)[65] achieved by RES project relying on mature technologies may limit the investors' interest.

Market risk refers to risk deriving from two factors:

- **Input side** caused by the increase of the price of fuel, raw materials or services;
- **Output side** caused by a decrease in the price of the electricity sold.

On the input side, a typical risk is the rise in the price of gas for energy production in gas-power turbines. On the output side, the inability to hedge against fluctuations of the price of electricity sold (via e.g., a PPA contract or a financial hedge) generates difficulties in creating reliable future earnings models.

Market risk received some degree of concern across all technology types, acquiring 30% of the votes for both emerging and mature technologies and less concern for transitional technologies with 20% of votes. In fact, concern has been prevalently expressed on behalf of the supply side of financing with investors concerned that fluctuations in the price of commodities and of sold electricity might impact the bankability of both low-TRL and high-TRL projects. Some concern has also been expressed by regulation and association stakeholders. As a **potential solution** to mitigate market risk generated by price fluctuations, some WG

[63] Ex-ante assessment methodology for financial instruments in the 2014-2020 programming period, fi-compass, May 2014.

[64] As illustrated in a 2023 study carried on by the European Banking Federation (EBF) in collaboration with Oliver Wyman on the banking regulatory and supervisory framework and its impact on banks and the economy, despite the strengthening of the EU's banking regulatory framework has allowed European banks to withstand global challenges such as the COVID-19 pandemic, it has also made the system less transparent and more complex as opposed to the United States banking system. This is caused by economic factors, such as poor growth of the Eurozone, and also by political and structural factors, such as an incomplete Banking Union and an underdeveloped capital markets union.

[65] Figures provided by IRENA indicate a 8-9% range for renewable energy projects (Mobilising institutional capital for renewable energy, *International Renewable Energy Agency (IRENA),* 2020).

participants identified long-term contracts to avoid merchant/market exposure in case of volatile prices.

Liquidity risk / Long payback periods arise from operational liquidity issues caused by revenue shortfalls or mismatches between the timing of cash receipts and payments. The main reason for this is represented by the high upfront costs that need to be sustained to implement the projects which generate negative cash flows for the first years of the projects. Thus, the issue is relevant in the first years but can still occur after the break-even has been reached. Furthermore, the issue is influenced by the energy generating technology that is considered: natural gas and nuclear projects have high upfront and operational costs and thereby a high payback periods, typically between 8.5 and 15 years for gas[66] Renewable energy projects have lower upfront costs and lower operational costs with payback periods ranging from 1 to 4 years for PV[67] and 3 to 4 years for wind turbines.[68]

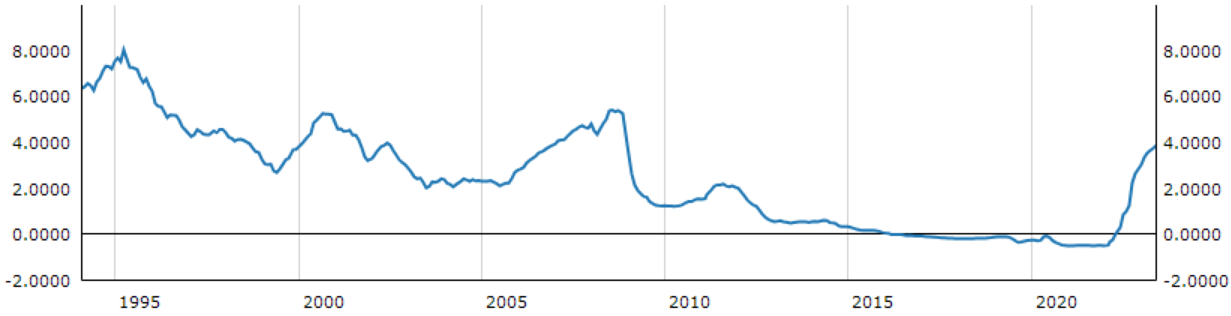
Box 9: Concern over liquidity of renewable energy projects on behalf of institutional investors

As reported by Capital Monitor,[69] institutional investors made up just 2% of total direct investment in renewables in 2018, according to the International Renewable Energy Agency (IRENA). From its study of almost 6,000 investors over the past two decades, IRENA found that although a fifth of institutional investors have invested in renewable energy funds, just 1% have invested directly in clean energy projects. Capital Monitor also highlighted that the concerns over liquidity risk are growing: a survey performed by an energy utility found that 43% of 100 institutional investors saw liquidity as the biggest challenge in 2020, compared with just 19% in 2019.

This barrier is considered relevant mostly for transition technologies, with 40% of votes, and less relevant for emerging and mature technologies. More specifically, for transition technologies like nuclear, investors are mainly concerned about liquidity risks arising from high upfront costs to construct the power plants, a problem which is accentuated also by the long time until power plants can start operating. Also, uncertainties concerning the ability of new projects to remunerate investments in a timely manner arise due to the very nature of transition technologies which are set to gradually be replaced by renewables. Although not relevant for emerging technologies, participants in the WG discussions have highlighted how lending from International Institutions like the EIB can be slow due to bureaucratic complexity and long lead times, thus generating issues in the cash flows of low-TRL projects. Attention has been drawn also on the impact that the recent rise in interest rates (+2% on EUR swap rates since 1/1/2022) can have on projects concerned by long payback period where debt costs represent an important part of the Profit & Loss during exploitation phase. Evidence of this can also be seen in the Figure below, which illustrate the rise in the Euribor 1 year rate following the recent manoeuvres in monetary policy.

[66] Carvalho, R., Hittinger, E., Williams, E., Payback of natural gas turbines: A retrospective analysis with implications for decarbonizing grids, 2021.
[67] Bhandari, K., P., Collier, J., M., Ellingson, R., J., Apul, D., S., Energy payback time (EPBT) and energy return on energy invested (EROI) of solar photovoltaic systems: A systematic review and meta-analysis, 2015.
[68] Wind Turbine Payback Period, *Enerpower*, 2011.
[69] Renewable energy: Why institutional investors are finally bullish, *Capital Monitor*, 2021.

Figure 12: Euribor 1-year – historical observations.



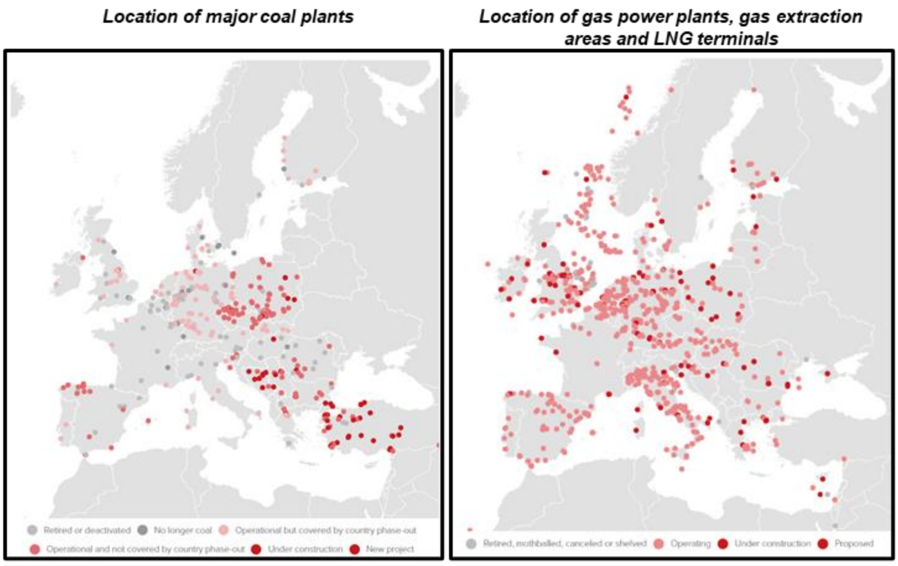
Source: European Central Bank - Statistical Data Warehouse

Stranded assets risk refers to the risk un unanticipated or premature write-downs, devaluation or conversion to liabilities of power production assets, which is set to happen to some degree in the transition to a low-carbon economy, as reported by IRENA.[70] This risk has been considered as relevant only for transitional technologies by 30% of respondents, implying relevant concern on behalf of stakeholders for conventional production assets, especially for gas power plants. Concern has been expressed mostly by the supply side (i.e., providers of capital), as investors are growing increasingly uncertain on the ability of new or recent projects to remunerate investments in a timely manner and in respect of the decarbonization goals set by the EU. Uncertainty has been added by the EU taxonomy with the labelling of gas and nuclear as “transitional technologies” implying that investments in these technologies may be less remunerative with the acceleration of the decarbonization process. Concern has been expressed also by regulatory bodies.

[70] Stranded assets and renewables: how the energy transition affects the value of energy reserves, buildings and capital stock, *International Renewable Energy Agency (IRENA)*, Abu Dhabi, 2017.

Box 10: Decarbonisation and the risk of stranded assets

The ambitious renewable energy and emission reduction targets embedded in Fit for 55 and the REPowerEU Plan are expected to put some conventional production assets at risk of becoming stranded, especially coal and gas fired power plants. As illustrated in the following maps, most Western European countries have either reconverted or placed under phase-out procedure existing coal power plants without investing into new ones. In such countries stranded assets risk is low, as opposed to eastern European countries where many coal generation power plants are under construction or planned to be constructed, despite the EU's push for decarbonisation. Concerning gas production projects, the "transition technology" label attributed by the EU taxonomy has left the door narrowly open for investments in new gas production capacity. New investments are especially expected to take place in Eastern European countries which envisage gas as the main substitute to compensate for the phasing out of coal in the circumstance of slower renewable energy development. For such investments, stranded assets risk is high, as the rush to reach climate neutrality by 2050 at the EU level may mean the decommissioning of new assets before they will be able entirely recoup the full initial investments.



Source: Oroschakoff. K., Guàrdia, A., B., Europe's stranded assets: Mapped, Politico.eu, June 2020.

Technical Barriers

Grid, transmission and infrastructure risk refers to limits on grid, pipeline or other infrastructure connection of energy production projects in a manner that hinders the project's ability to sell and / or monetize the energy produced. These problems might relate to permitting issues as slow administrative procedures concerning grid construction delays the coming online of energy projects. Problems might relate also to a lack of clarity as to which subject is in charge of developing and maintaining certain areas of the grid which can also cause delays and interruptions. Finally, some energy production projects might require grid retrofitting which is not always possible, or extremely costly, thereby putting at risk the feasibility of the project.

Box 11: The EU hydrogen strategy depends on the development of a European hydrogen infrastructure 'backbone'

A major barrier on the development of an EU green hydrogen market is the absence of a transportation infrastructure, since the existing fossil gas infrastructure is not suited to transport hydrogen, and other forms of transport are too expensive. To address this issue, a group of eleven European gas infrastructure companies presented in July 2020 a plan to create a dedicated hydrogen pipeline network of almost 23,000 km by 2040, to be used in parallel to the natural gas grid.[71] The "European hydrogen backbone" was presented in a vision paper developed by transmission system operators Enagás, Energinet, Fluxys Belgium, Gasunie, GRTgaz, NET4GAS, OGE, ONTRAS, Snam, Swedegas (Nordion Energi), Teréga, and consultancy company Guidehouse. The plan affirms "the cost of such a European Hydrogen Backbone can be very modest compared to the foreseen size of the hydrogen markets". In fact, this is partly due to the assumption that 75% of the network will consist of retrofitted natural gas pipelines – which are gradually expected to become redundant as volumes of natural gas decrease in the future. Despite this, green hydrogen production will only develop according to the pace with which the "hydrogen backbone" is developed. Delay in the retrofitting process at the localised and at the EU level has the potential of stalling also green hydrogen production projects.

Grid, transmission and infrastructure risk has been voted as relevant for mature technologies by 70% of respondents, with supply-side stakeholders expressing slightly more concern than demand-side stakeholders. More specifically, participants agreed on the lack of visibility on planning and development of the transmission grids, pointing out that, in light of the increasing pressure on developing renewable production, there is a risk of saturating grid capacity. Participants also pointed out that investments in the grid need to be compatible with RES production targets, warning that, in absence of grid connection, all the other projects are at risk of becoming temporarily stranded with grids becoming a development bottleneck. For both permitting and grid issues, participants identify **market interventions** as the most effective **solution**, although highlighting the risk of market distortions as a downside.

The barrier has been classified as relevant also for emerging technologies by 40% of respondents, as connecting low TRL production plants might require an upgrade of T&D networks or might prove difficult in function of the location of the generation plants. In this case, concern was evenly spread among investors, developers, regulatory bodies and industry associations.

Technology risk is associated with uncertain future performance of nascent technology, or inexperienced and unskilled labour deploying it. Some of the challenges may include:

- Lack of developed industry standards where parties do not know exactly how the final asset will operate.
- Heavy reliance on both: (i) scaling up demonstrator technology, where assumptions are necessarily made as to output and build cost and complexity; and (ii) feasibility studies, leaving parties unsure whether the project will meet financial projections in the long term.
- Any approval delays may lead to an owner/operator losing its 'place in the queue' with a supplier for fabrication or construction.

[71] Gas grid operators unveil plan for European hydrogen infrastructure 'backbone', *Euractiv.com*, July 2020.

Box 12: Disputes concerning renewable energy emerging from technology risk

A few examples of the disputes that can arise from technology risk concerning renewables are provided[72]:

- **Floating offshore wind**: given the novel nature of certain technology (e.g. increased blade length, specialized gearboxes, higher towers[73]), defects may appear after only completion of the works, with the owner needing to rely on warranties for design life.
- **Hydrogen**: there is a tension between the supply and demand market for hydrogen projects: developers of hydrogen projects may be reluctant to invest in building facilities where demand for the product is uncertain. By the same token, without a secure supply (and potential high prices), off-takers may be reticent to invest too. Therefore, when these projects do start, the owner will be under considerable pressure to meet the commercial operation date to ensure it can meet its offtake agreement obligations: any delays to that commercial operation date caused by technology issues could create disputes in the construction phase and at the off-taker level.

Technology risk represents the most relevant risk for emerging technologies as voted by 60% of WG participants. This is consistent with literature findings illustrated in Section 2.3, where emerging technologies entail higher risk with respect to mature technologies since they need to undergo further test and standardization in order to reduce the risk of critical flaws. As such, private investors prefer to invest in higher TRL technologies, leaving the task of guiding technologies away from the "valley of death" mostly to public support. Some participants also point out that new technology is becoming mandatory in the construction of generation plants (e.g., in Portugal, environmental legislation demands that new bioenergy plants be built with carbon capture and storage). The high investment costs and uncertainty on performance that are linked with the use of this new technology might stop projects from going forwards in the absence of strong financial incentives.

Energy market development

Scarcity of investment-ready projects is a barrier which mostly concerns the supply side: financiers willing to invest face a shortage of investment-ready or bankable projects with an attractive value proposition. IRENA notes that the origins of this barrier can be attributed to inadequate availability for project promoters of initiation and facilitation tools that signal to investors that a pipeline of deals is becoming available in the near future, making it worth their while to develop internal capacity. The technical complexity of clean energy production projects, and delays in feasibility and spatial planning, tend to further aggravate the issue of project scarcity. Technical assistance and grant funding for project development and document preparation can increase the renewable energy deal flow and improve the pipeline of projects ready for investment.

This barrier is considered relevant for mature technologies by 40% of respondents and for emerging technologies by 30% of respondents, while it is not considered relevant for transition technologies. While it would be expected to find scarcity in investment-ready projects for emerging technologies due to the high-risk profile that these technologies entail, mature technologies are likely to be more afflicted by planning complexity and delays which in the project finance cycle.

[72] Risks associated with new technology on renewable energy projects, *Freshfields Bruckhaus Deringer*, March 2022.

[73] Green energy: Insuring a renewables future, *Allianz*, July 2019.

Inadequate supply of labour is a risk driven in large part by the novel nature of emerging energy production technologies, which will require major upskilling and reskilling and educational systems may not be able to keep up. This risk is exacerbated by demographic decline and / or brain drain, whereby some MSs may face a shortage of labour at a more systemic level.

Box 13: Skills shortage threatening the EU wind industry

WindEurope reports that the total number of jobs in the wider field of energy could increase from 58 million in 2017 to 100 million globally by 2050, an almost 100% increase from current levels. Of this, today wind energy employs 1.2 million people globally and 300,000 people in Europe alone. WindEurope estimates that in order to meet the EU decarbonization targets will require approximately 450,000 workers by 2030 representing an increase of 50% from today[74].

Such rapid development carries the risk of enveloping the wind industry into a skills crunch if fast and ambitious measures are not applied. Such measures, described in an article from K2Management[75], take resources and time to overcome considerable obstacles like:

- Reskilling workers from the oil & gas industry: although representing a fix in the long term, cannot be implemented in the short term due to the high demand of fossil fuels, which has maintained an increasing trend despite decarbonization initiatives. Such a high demand implies that workers are unlikely to transition into renewable energy roles at the required rate. To add to this, the transition role attributed to natural gas in the EU decarbonisation context and the disruptions in the phase-out of coal cause by the war in Ukraine will further slow down this process.
- “Brain drain” effect of skilled workers from the EU to other parts of the world where project pipelines on fossil fuels are set to grow and skills are in demand (USA, China).
- Lack of encouragement for local production of wind turbine parts opposed to importation in order to increase the range of opportunities offered to skilled workers in the EU.
- Lack of awareness initiatives in universities and schools on behalf of the stakeholders of the EU wind industry with the aim of attracting school-leavers and graduates to the industry.

This barrier, although not critical for any of the technology clusters, has raised some degree of concern across all three clusters, especially for emerging and mature technologies with 20% of votes for each. Concern has been expressed mostly on by investors and could be linked to uncertainties generated by the changes that the fast pace of decarbonization could have on the labour market.

[74] LearnWind: WindEurope launches educational hub to tackle skills gap, *WindEurope,* September 2021.

[75] What you need to know about the skills shortage threatening the UK offshore wind industry, *K2Management*, December 2021.

3. Mapping and benchmarking of energy financing schemes and investment products

This chapter presents the financial schemes and programmes available for energy production projects in the EU. The first section comprises funding programmes at EU level, both under centralised and decentralised management that can be used to support energy production projects. The second section presents the instruments and schemes identified at Member State-level that are available for energy production based on the findings from the mapping exercise that was conducted.

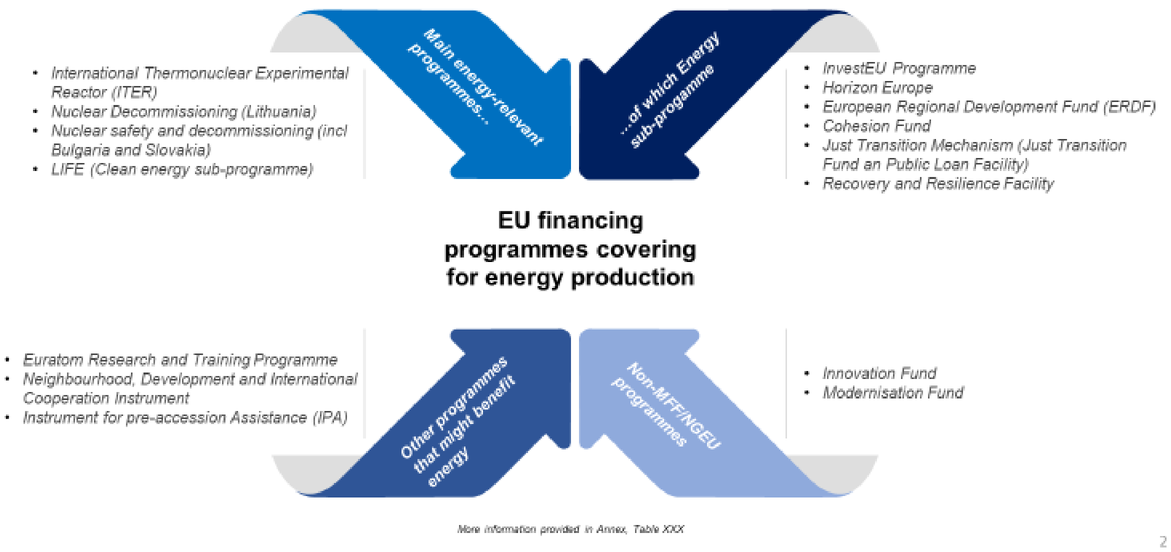
3.1. EU financing programmes for energy production

EU targets of climate neutrality and independence from Russian gas require an unprecedented level of investment. The European Commission has reported an overall investment need of €210 billion (until 2027) to reach REPowerEU targets.

To support the region's green transition, the EU has made it a priority to support the enhancement of development, construction, and operationalisation of energy production projects through several funds and programmes. Such programmes are either managed directly by the European Commission or by other EU bodies via *ad hoc* agreements. Starting from the 2014-2020 multiannual financial framework, the Commission has also adopted the **Climate Mainstreaming** approach, which requires all programmes – regardless of their policy area – to take climate issues into account. For the 2021-2027 period, the EU budget is expected to deploy €557 billion (31% of the overall budget) for climate investments across different sectors and programmes.

The purpose of this section is to provide an overview of some existing financing instruments at the EU level (Figure 13) as well as EU funds allocated to individual Member States. The focus will be placed on instruments targeting the sector of energy production to provide a view on available EU programmes and their disbursement practices.

Figure 13: Overview of the EU financing programmes covering for Energy Production



All the programmes funded by the EU budget fall under one of three types of implementation modes depending on the nature of the funding concerned:

- **Direct management**: EU funding is managed directly by the European Commission
- **Indirect management**: funding is managed by partner organisations or other authorities inside or outside the EU
- **Shared management**: the European Commission and national authorities jointly manage the funding.

In addition to these three management modes, this Study analyses programmes that are not financed from the EU budget but through the **EU Emission Trading System** (ETS)[76].

For specific sub-segments of the energy sector additional sectorial funding programmes which go beyond the scope of this Study might be available. For instance, offshore renewable energy – wind and ocean – could receive financing from both the Maritime Fisheries and Aquaculture Fund and BlueInvest. Other instruments, such as the Neighbourhood, Development and International Cooperation Instrument (NDICI) also provide resources for energy production, although not directed to EU countries. Hence, they are not part of this Study.

Direct management

In direct management, the European Commission is directly responsible for all steps in a programme's implementation. These tasks are carried out by the Commission's departments, at its headquarters, in the EU delegations or through EU executive agencies; there are no third parties. Programmes implemented in direct management account for around 20% of the EU budget 2021-2027[77].

NextGenerationEU: the Recovery and Resilience Facility

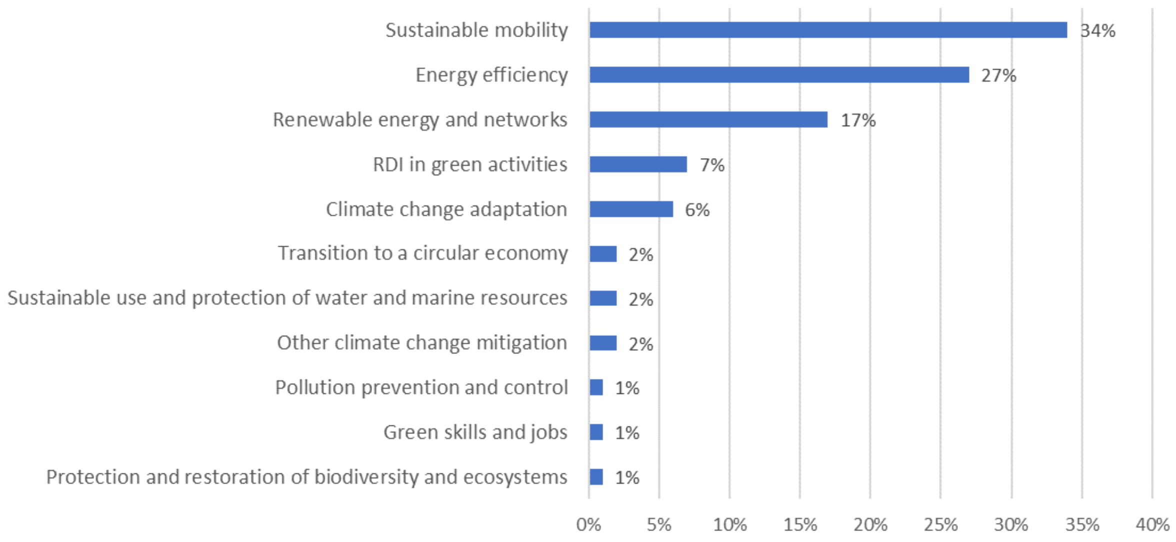
The **NextGenerationEU**, is a temporary recovery instrument with a budget of more than €800 billion aiming to support Member States in repairing the economic and social damage brought on by the Covid-19 Pandemic and build greater resilience to face incoming challenges. At its centre is the **Recovery and Resilience Facility (RRF)**, a programme providing financing to enable Member States to increase resilience and prepare for their digital and green transitions. It has a total budget of €723.8 billion, out of which €385.8 billion take the form of loans and €338 billion of grants. To access these funds, Member States prepared tailored **National Recovery and Resilience Plans** (NRRPs) reflecting the allocation of the funds in each country and detailing the investment and reforms they plan on undertaking with the RRF resources to make their economies more sustainable, resilient, and digital by end of 2026. All 27 Plans have been officially adopted.

The Facility is structured around **six pillars: green transition; digital transformation; social and territorial cohesion; health, economic, social and institutional resilience;** and **policies for the next generation**. Green transition is the pillar with the largest share of allocated RRF funds, amounting to 38.85% of the funds. Within the green transition pillar, sustainable mobility is the area with the largest share of allocated funds by the NRRPs, followed by energy efficiency and renewable energy and networks (see Figure 14).

[76] European Commission. EU Emission Trading System. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

[77] European Commission. Funding by management type. https://commission.europa.eu/funding-tenders/find-funding/funding-management-mode_en

Figure 14: Breakdown of expenditure towards climate objectives per policy area (Pillar 1)



Source: RRF Scoreboard – Green Transition

When it comes to energy production, the most relevant indicator is the **additional operational capacity installed**. More specifically, NRRPs aims at installing additional capacity of **1,067 MW from renewable energy** and **1,106 MV from green hydrogen**. To date[78], already 795.4 MW from renewables and 553 MW from hydrogen have been installed.

For the Green Transition Pillar, €10.33 billion in grants and €5.09 billion in loans have already been disbursed[79], out of a total of €96.97 billion in grants and €47.11 billion in loans disbursed[80].

[78] Based on information available on the RRF Scoreboard as of 16/02/2023.

[79] These amounts refer to the while Green Transition pillar and not to the “Renewable energy and networks” area only.

[80] Based on information available on the RRF Scoreboard as of 16/02/2023.

Box 14: Country focus: The RRF in Greece

Greece holds a large share of the RRF funds respective to its GDP. Indeed, the Member State has submitted its Recovery and Resilience Plan consisting of 106 investment measures and 68 reforms and has commenced the disbursement of the funds. The plan is expected to lift Greece's GDP by 2.1% to 3.3% by 2026 and create 62,000 jobs.

To this end, €4.8 billion have already been disbursed in the form of grants, and €3.5 billion as loans. When looking at loans, they are being disbursed through financial intermediaries and banks. Alphabank has established a co-financing structure making RRF loans available to businesses who have at least 20% of their budget investment plan related to green transition investments in line with the RRF goals. Similarly, Piraeus Bank offers co-financing programmes providing loans to up to 50% and requiring a minimum of 20% equity participation for the investment plan. The National Bank of Greece further provides access to the funds through a dedicated co-financing structure.

When considering the disbursement of RRF grants, the Greek government has established a few instruments such as the buildings renovation programme ("*EXOIKONOMΩ")* providing grants to households to improve energy efficiency of their building and the installation of energy saving heating and cooling systems. This instrument supported by the Ministry of the Environment and Energy further encourages businesses, to transform their practices.

Overall, Greece has taken important measures to disburse the RRF funds to meet EU climate targets.

The InvestEU Programme

The **InvestEU Programme** is a single programme which during the 2021-2027 period succeeds thirteen centrally managed EU financial instruments[81] and the European Fund for Strategic Investments (EFSI), which had all been operational during 2014-2020 period. The program is structured around three blocks, of which two are under direct management:

- *InvestEU Advisory Hub* (direct management) providing support and technical assistance;
- *InvestEU Portal* (direct management) brings together investors and project promoters on a single EU-wide platform, by providing an accessible and user-friendly database of investment opportunities.
- *InvestEU Fund* (indirect management) which, through an EU budget guarantee of €26.2 billion, aims at raising more than €372 billion of public and private investments. The guarantee is deployed to back investments from selected implementing partners, with the EIB Group being the main one with 75% of the whole instrument. The guarantee supports investments in four policy windows: sustainable infrastructure, research, innovation, and digitalisation, SMEs, and Social investments and skills.

Other programmes

Horizon Europe has an overall budget of €95.5 billion for the 2021-2027 period and aims to support research and innovation in the EU. Its resources are divided into four pillars and fifteen components. The two components *Climate, energy and mobility* and *Food, Bioeconomy,*

[81] *CEF Debt Instrument, CEF Equity Instrument, Loan Guarantee Facility under COSME, Equity facility for Growth under COSME, Innovfin Equity, Innovfin SME guarantee, Innovfin Loan Services for R&I Facility, Private Finance for Energy Efficiency Instrument, Natural Capital Financing Facility, EaSI Capacity Building Investments, EaSI Microfinance and Social Enterprise Guarantees, Student Loan Guarantee Facility, Cultural and creative sectors Guarantee facility*

Natural Resources, Agriculture and Environment will receive, respectively, around €15 and around €9 billion each. to the Horizon programme is complemented by the **Euratom Research and Training Programme** (ERTP), which covers only nuclear energy with a budget of €1.38 billion between 2021 and 2025.

The **LIFE Programme** was originally created in 1992 to fund environmental projects and climate action. For the 2021-2027 programming period it will receive a total budget of €5.45 billion, whereby 1 billion is dedicated to the *Clean Energy Transition* sub-programme. Funds are allocated through yearly calls for proposals managed by CINEA.

Indirect management

Some funding programmes are partly or fully implemented with the support of entities, e.g., national authorities or international organisations. The majority of the EU budget allocated to humanitarian aid and international development, for instance, is implemented under indirect management. Under this management mode, the Commission delegates budget execution tasks to different types of implementing partners.

The InvestEU Programme

The **InvestEU Programme** combines thirteen centrally managed EU financial instruments[82] and the European Fund for Strategic Investments (EFSI) into a single instrument. The program is structured around three blocks, of which, as mentioned above, only one is under indirect management:

- *InvestEU Fund* (indirect management) which, through an EU budget guarantee of €26.2 billion, aims at raising more than €372 billion of public and private investments. The guarantee is deployed to back investments from selected implementing partners, with the EIB Group being the main one with 75% of the whole instrument. The guarantee supports investments in four policy windows: sustainable infrastructure, research, innovation, and digitalisation, SMEs, and Social investments and skills.
- *InvestEU Advisory Hub* (direct management) providing support and technical assistance;
- *InvestEU Portal* (direct management) brings together investors and project promoters on a single EU-wide platform, by providing an accessible and user-friendly database of investment opportunities.

Shared programmes

In shared management, both the European Commission and national authorities in Member States, such as ministries and public institutions, are in charge of running a particular programme. Around 70% of EU programmes are run this way. For what concerns the energy production sector, the European Regional Development Fund is the main relevant shared-management programme.

European Regional Development Fund

The **European Regional Development Fund (ERDF)** aims to strengthen economic, social, and territorial cohesion in the EU and to enable investments in greener and smarter practices. It functions through financing programmes in shared responsibility between the European

[82] *CEF Debt Instrument, CEF Equity Instrument, Loan Guarantee Facility under COSME, Equity facility for Growth under COSME, Innovfin Equity, Innovfin SME guarantee, Innovfin Loan Services for R&I Facility, Private Finance for Energy Efficiency Instrument, Natural Capital Financing Facility, EaSI Capacity Building Investments, EaSI Microfinance and Social Enterprise Guarantees, Student Loan Guarantee Facility, Cultural and creative sectors Guarantee facility*

Commission and national or regional authorities of Member States. Member States receive support for investments aligned with one or more of the ERDF's five policy objectives aimed at making the EU:

1. More competitive and smarter
2. Greener, low carbon and resilient
3. More connected
4. More social
5. Closer to citizens

The total budget of the ERDF is around €212 billion, to which around €97 billion of national co-financing by Member States should be added, for a total of around €308.8 billion[83]. A particularity of the fund is that less-developed regions will benefit from co-financing rates of up to 85% of the cost of the projects, while rates for transition regions and for more-developed regions will be up to 70% and 40% respectively.

Greener Europe is the Policy Objective with the second highest share of ERDF resources, €102.9 billion, second only to Smarter Europe with €112.95 billion. Through these resources, a significant number of national programmes have been financed in different Member States. Some of these programmes have been financed in full with ERDF resources, others have combined ERDF with other public resources. The Table below presents some of these schemes at both national and Regional level and shows that the instrument is being used and thus is relevant for Member States' ability to finance their transition.

Table 4: Examples of national and regional schemes for energy production and renewable energies financed with ERDF resources, where renewable energy projects are also eligible (among others).

Member state	Programme	ERDF Funding	Total funding
Germany	Programme ERDF 2021-2027 Baden-Württemberg	278 879 836 €	697 199 591 €
Greece	Anatoliki Makedonia, Thraki	402 497 728 €	473 526 740 €
Greece	Attiki	599 388 217 €	1 198 776 434 €
Greece	Dytiki Ellada	395 789 433 €	465 634 631 €
Greece	Dytiki Makedonia	248 206 933 €	292 008 159 €
Greece	Environment and Climate Change	1 371 554 979 €	1 716 896 396 €
Greece	Ionia Nisia	181 123 976 €	213 087 033 €
Greece	Kentriki Makedonia	906 961 547 €	1 067 013 588 €
Germany	Programme ERDF 2021-2027 Thuringia	1 088 404 990 €	1 814 008 317 €
Greece	Sterea Ellada	268 331 820 €	315 684 496 €

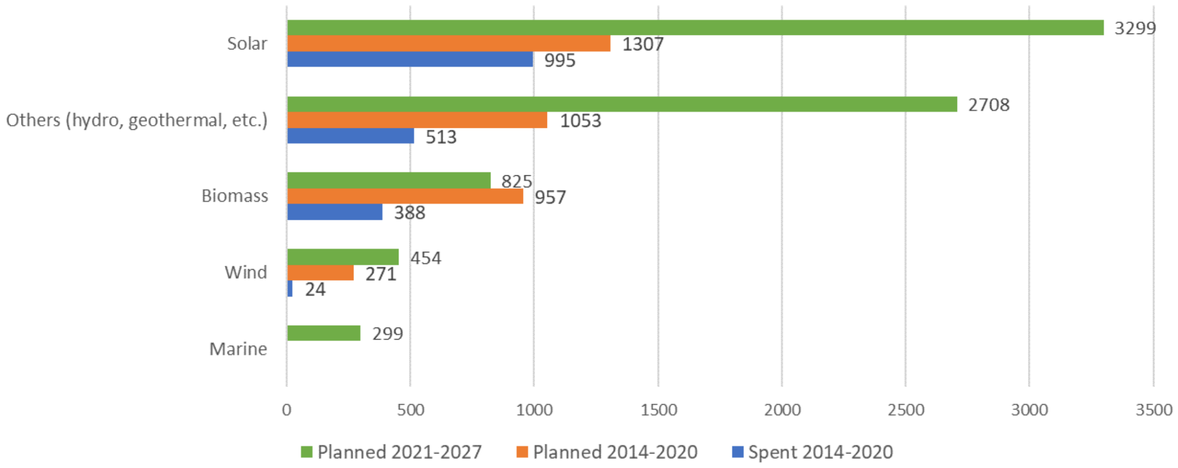
[83] European Commission. Cohesion Open Data Platform. https://cohesiondata.ec.europa.eu/funds/erdf/21-27

Member state	Programme	ERDF Funding	Total funding
Greece	Thessalia	348 831 364 €	410 389 843 €
Italy	RP Lombardia ERDF 2021-2027	800 000 000 €	2 000 000 000 €
Italy	RP Toscana ERDF 2021-2027	491 534 446 €	1 228 836 115 €
Italy	RP Valle d'Aosta ERDF 2021-2027	36 995 717 €	92 489 293 €
Sweden	European Regional Development Fund programme for Stockholm 2021-2027	33 970 886 €	84 927 215 €
Cyprus	Cohesion Policy Programme "THALIA 2021-2027"	466 925 267 €	778 208 780 €
Bulgaria	Environment	1 171 798 777 €	1 399 922 369 €

Production technologies covered[84]

When looking at EU cohesion data for the 2021-2027 financing period, solar energy has received the most planned financing commitments with approximately €3.3 billion, followed by "other renewable sources including geothermal energy" (approximately €2.7 billion). Wind energy is planned to receive €454.5 million (Figure 15 below).

Figure 15: ERDF Planned and actual spending in renewable energy sources (EU with national co-investment, programming periods 2014-2020 and 2021-2027, in € M)



[84] The amounts reported on this section are based on the data from European Commission's Cohesion Data platform as from 20/02/2023.

Furthermore, in the 2021-2027 cycle, the Member States with the largest planned commitments in total amounts for the scaling up and development of renewable energy are Spain, Poland, Italy, and Hungary.

Box 15: Country focus: Example of ERDF funding in the Netherlands[85]

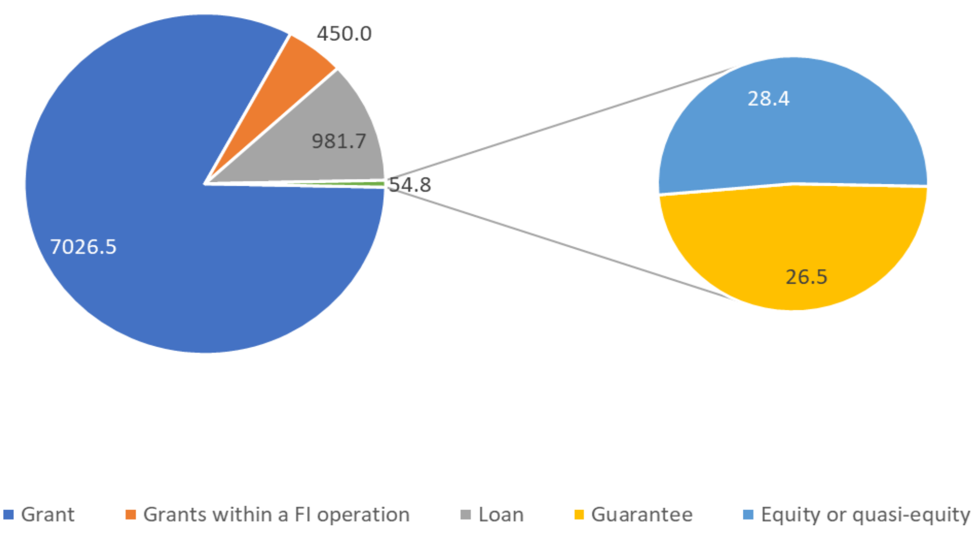
The Netherlands holds a budget of €506 million from the ERDF for the period of 2021-2027. To deploy the resources, it has created four regional ERDF programmes across the country.

“PowerNEST” is an example of a project that already successfully received ERDF funding through the regional programmes in the previous programming period 2014-2020. This project was implemented by IBISPower, a business based in Eindhoven and focused on innovative technologies combining solar and wind energies in the aim to allow for greater energy savings and increase the use of renewable energies. In total, the project received €927.892 as an EU subsidy in combination of public and private co-financing. As such, this indicated that the fund is to some extent accessible to businesses and entrepreneurs and can finance innovative energy production technologies.

Types of financing provided

ERDF resources are disbursed by Member States through different programmes and schemes, and thus through different types of financing. Figure 16 below shows how around €8.5 billion of ERDF resources in the current programming period 2021-2027 for renewable energy (RS02.2) are disbursed. Grants represent by a large margin the most used type of financing for the deployment of ERDF resources, accounting for almost €7.5 billion, of which €450 million for grant components of financial instruments operations, and over €7 billion for standalone grants. Loans account for around €980 million, whereas guarantees and equity represent the two least used types of financing, both respectively accounting for less than €30 million. Nonetheless, growing use of financial instruments is observed.

Figure 16: Amounts of ERDF financing provided by type of financing (in € M, excluding national contributions)[86]



Source: PwC analysis of cohesiondata.ec.europa.eu data

[85] European Commission. Kohesio. https://kohesio.ec.europa.eu/en/beneficiaries/Q3988599

[86] Guarantee and equity and quasi-equity presented separately on the right for readability purposes.

Just Transition Mechanism

The **Just Transition Mechanism** supports the fair transition to climate neutrality across the EU. For the 2021-2027 period it is expected to mobilise nearly €55 billion targeting industries and workers in most affected regions. The program is structured around three pillars:

- *Just Transition Fund,* which aims to raise €25.4 billion of investments starting from a budget of €19.2 billion in current prices. The Fund has clean energy among its goals but there is no direct earmarking of budget for the sector;
- *InvestEU "Just Transition" scheme*, providing – under InvestEU – a guarantee and an advisory hub with the objective of mobilising €10-15 billion, predominantly from private sector. This is going to cover energy but there is no specific allocation to it.
- *Public Sector Loan Facility,* managed by DG REGIO and CINEA, which combines resources from the EU budget (€1.5 billion) with those provided by the EIB (€10 billion). It will also provide technical assistance under the InvestEU Advisory Hub. By blending these resources, the Facility aims to raise around €18.5 billion of public investments to be used by public sector entities.

ETS-based programmes

The EU ETS works on the 'cap and trade' principle. A cap is set on the total amount of certain greenhouse gases that can be emitted by the operators covered by the system. The cap is reduced over time so that total emissions fall. Within the cap, operators buy or receive emissions allowances, which they can trade with one another as needed. The limit on the total number of allowances available ensures that they have a value.

Revenues from the sale of allowances in the EU ETS mostly feed into Member States' budgets. Allowances are also auctioned to supply the funds supporting innovation in low-carbon technologies and the energy transition: the Innovation Fund and the Modernisation Fund.

Innovation Fund

The **Innovation Fund** is expected to provide €38 billion[87] between 2020 and 2030 for the commercial demonstration of innovative low-carbon technologies. This scheme is funded by the EU Emissions Trading System, so the exact amount of resources will ultimately depend on the carbon price. The fund is managed by CINEA and resources are allocated through regular calls for proposals for both large and small-scale projects[88].

[87] Estimated assuming a carbon price of €75/tCO2

[88] For small-scale projects are intended all those with total capital costs under 7.5 million

Box 16: Innovation Fund and funded projects

The **Innovation Fund** has been successful in disbursing its resources to eligible projects. Indeed, it has provided support for **52 projects across the energy and innovation sectors** (37 in 2021 15 in 2022), which all contribute to the established EU decarbonisation and innovation targets.

Regarding energy production, the Fund has been able to support projects concerning green and sustainable hydrogen in Spain and Finland. In Spain, the project received €4 484 293,00 for the deployment of a pre-commercial plant based on photo-electrocatalytic technology for green hydrogen production which is scheduled to end in March 2028. In Finland, to the project is allocated €63 221 856,15 to produce sustainable hydrogen by 2035.

Furthermore, projects generating energy from innovative renewable energy sources have also received Innovation Fund resources. For instance, the Nose Airborne Wind Energy (AWE) project developed by a Norwegian SME has been allocated €3 350 473,00 for the construction and operation of an onshore wind farm based on the AWE technology that has move to viable commercial demonstration phase at TRL7 in the last five years. The project completion date is set for June 2028.

The Innovation Fund is also financing a significant number of projects integrating renewable energy sources to production processes across the EU, as well as efficient storage and heat technologies. Overall, the resources provided are accessible to innovative start-ups and SMEs to develop new technologies and solutions to advance the transition to greener practices.

Modernisation Fund

The **Modernisation Fund** was set up by the European Commission to support the ten lower-income Member States[89] in their transition to climate neutrality and to increase energy security. The Fund supports investments in energy production, energy efficiency, energy storage, modernisation of energy networks, and just transition in carbon-dependent regions.

The Modernisation Fund is an ETS-based instrument and not an EU budgetary programme. **It is funded from revenues from the auctioning of 2% of the total CO_2 allowances** for 2021-2030. At the price of €75/tCO_2, the total budget of the MF amounts to around €48 billion from 2021 to 2030, but this amount can change depending on carbon prices. In addition to the MF budget, beneficiary Member States can transfer additional allowances from other programmes under the ETS system. This can further increase the financial resources available to Member States to finance energy transition. To date, five Member States (Croatia, Czech Republic, Lithuania, Romania, Slovakia) have opted to do so.

Poland, Czech Republic, and Romania are the three biggest beneficiaries of the MF, with shares of 43.4%, 15.6%, and 12% of the total allowances, respectively. To date[90], a total of 38 investments have been approved for generation and use of electricity from renewable sources, either exclusively for it or together with other priority areas (e.g., energy storage, energy efficiency). The majority of these investments are in Czech Republic and in Romania, which respectively account for 13 and 12 investments. The two countries are also those with the biggest amounts of approved resources for such investments, amounting to over €2.5 billion.

[89] Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia.

[90] Based on data available on modernisationfund.eu as per the 17/08/2023.

Figure 17: Amount of approved MF resources for investments in "generation and use of electricity from renewable resources" by country (in € M)

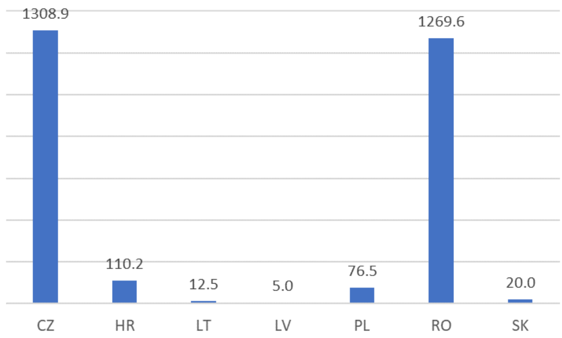
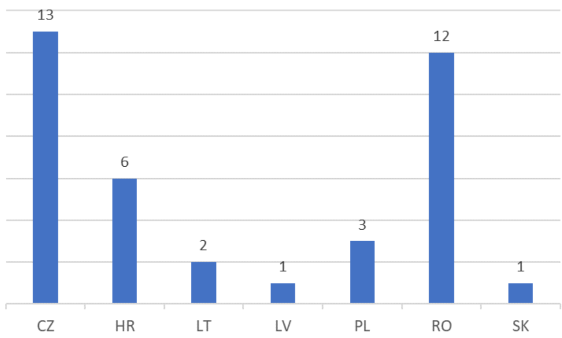


Figure 18: Number of confirmed investments in "generation and use of electricity from renewable resources" by country



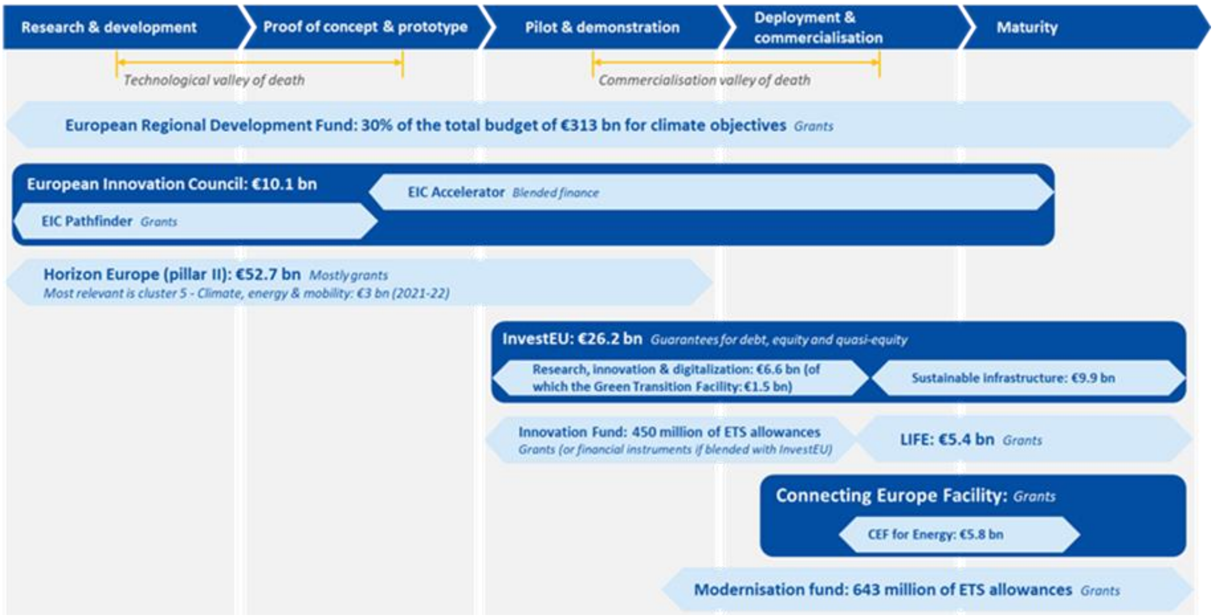
On May 2023, the revised EU ETS regulation was published in the Official journal of the EU[91]. The revised regulation strengthens the System and extends the ETS to new sectors of the economy, such as buildings, road transport and shipping, and to three additional Member States: Portugal, Greece and Slovenia. This will result in the Modernisation Fund to increase its size.

Maturity stage and technologies covered by EU programmes

EU financing programmes target beneficiaries and projects at different levels of maturity and TRLs, aiming to address their specific barriers to investment. By focusing on different TRLs, programmes can better address the barriers to investment relevant for. As can be seen from Figure 19 below, EU financing programmes provide complete coverage across different stages of maturity. For less mature technologies still in the research & development stage, Horizon Europe and the EIC Pathfinder provide support primarily in the form of grants, which tend to be the most suited type of financial support for technologies that are still far from commercial maturity. The EIC Accelerator, the Innovation Fund, and InvestEU's RDI investment window provide then support for more developed technologies, which are nonetheless still not fully mature. This support comes in the form of blended finance, grants and guarantees for debt and equity financing. Finally, InvestEU's Sustainable infrastructure window, the LIFE Programme, CEF, and the Modernisation Fund provide financial support for mature technologies, in the form of grants and guarantees.

[91] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2023:130:TOC

Figure 19: Overview of EU financing programmes and funds (also outside MFF) according to their targeted TRL levels (under direct, shared and indirect management)



Energy production is characterised by projects covering a wide variety of innovative solutions, as well as the modernisation and upgrade of mature technologies. EU programmes are nonetheless able to support projects in energy production with different TRLs through a technology neutral approach. With the exception of the Euratom Training Programme, the other programmes previously mentioned are **technology neutral**. The Innovation Fund, for instance, has supported numerous and different renewable energy technologies such as on- and offshore wind, floating and ground-based foundations, concentrated solar power, photovoltaics (PV), production facilities for PV cells and modules, tidal, wave, salinity gradient and hydro energy, deep geothermal energy and biofuels. More specifically, in the programme's first call for large-scale projects, three main technological pathways were identified: hydrogen, carbon capture use and/or storage and bio-based solutions. Small-scale projects further provided a focus on renewable energy, storage as well as hydrogen.

The European Investment Bank Group

The **European Investment Bank Group** (composed of European Investment Bank and European Investment Fund) plays a central and key role in the energy financing landscape. While the EIBG does not have specific investment programmes or schemes for energy, in its **energy lending policy**[92], one of the key areas of intervention is the **decarbonisation of the energy supply**. This consists of supporting the deployment of renewables as well as investing in new and more innovative technologies.

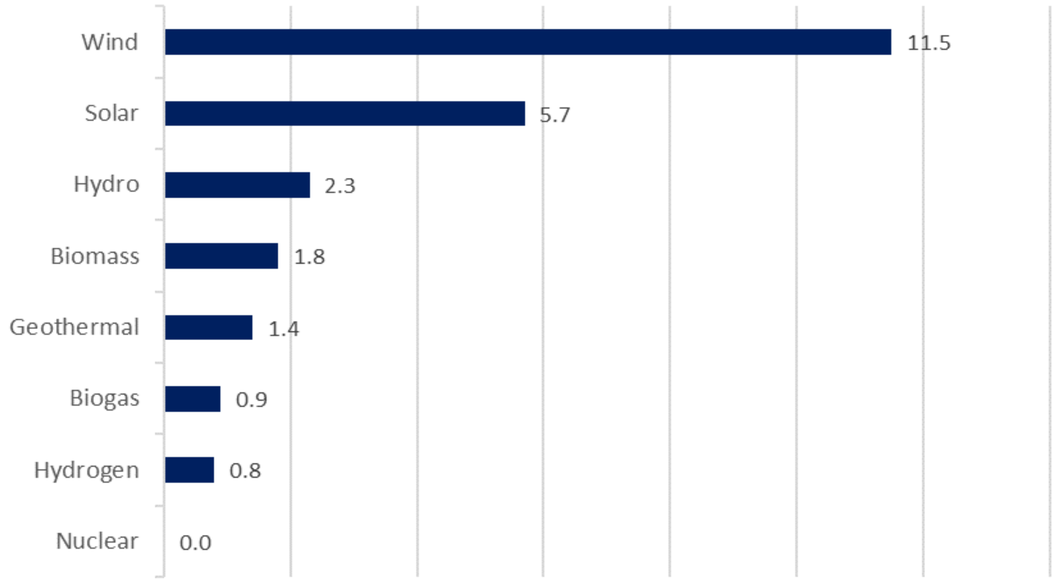
When looking at data from the energy projects financed directly by the EIB, **wind energy, both onshore and offshore, is the most supported energy production source,** followed by solar and hydro. **Hydrogen is the type of energy production with the lowest amount.** Nuclear energy did not receive any EIB contribution in these years, the last ones being back in 2016 in Finland[93]. The amounts presented below do not include any national co-

[92] EIB. Energy lending policy. https://www.eib.org/attachments/strategies/eib_energy_lending_policy_en.pdf

[93] EIB. TVO SAFETY IMPROVEMENTS. https://www.eib.org/en/projects/pipelines/all/20150675

investment/contribution and include financing in the form of **loans, equity, and quasi-equity (venture debt)**.

Figure 20: EIB contribution to energy production projects in the 2017-2022 period (in € bn)[94]



Source: PwC analysis of eib.org data on 564 financed projects in the energy sector from 2017 to 2022.

The EIF also invests in the energy sector, although not directly but thorough other funds. Under the InvestEU equity product, EIF seeks to increase the availability of risk capital across all stages of company development, accelerating growth of European scale-ups accompanying and supporting them in accessing public markets, as well as other EU policy objectives. **Under the InvestEU Climate & Infrastructure Product, the EIF provides equity investments to, or alongside, climate & infrastructure funds** investing in, among others, clean energy[95].

The Marguerite Fund is a pan-European initiative worth mentioning. Marguerite is an equity fund launched in 2010 and **backed by the EIB and the five National Promotional Banks** of Italy, Poland, Spain, Belgium, and Germany. It acts as a catalyst for key investments in energy (renewables, hydrogen, low-carbon gasses, T&D, storage) and transport. It is the first fund of its kind launched by Europe's leading public financial institutions following an initiative endorsed during the second half of 2008 by the Economic and Financial Affairs Council and the European Council as part of the European Economic Recovery Plan[96]. The first fund, the Marguerite I, gathered €710-million worth of commitments, and the Marguerite II reached €745 million.

The majority of central EU programmes provide financing in the form of grants. Horizon Europe and the LIFE Clean Energy Transition sub-programme only offer grants, while the other programmes mix grants with other types of financing. The exception is InvestEU, which is a guarantee for debt and equity financing, complemented by the technical assistance offered through the InvestEU Advisory Hub.

[94] Double counting possible. For projects investing in more than one type of energy production, the full amount of the transaction was counted for under all energy production sources, as no explicit earmarking was available.

[95] EIF. Climate & Infrastructure Funds. https://engage.eif.org/investeu/climate-infrastructure-funds

[96] EIB. Marguerite Fund. https://www.eib.org/en/products/equity/funds/marguerite-fund

Table 5: Types of support provided by central EU programmes relevant for energy

Programme	Grants	Loans	Guarantee	Equity	Project/technical assistance
Horizon Europe	✓				
LIFE Programme	✓				
Public Sector Loan Facility	✓	✓			
EIB		✓		✓	✓
InvestEU			✓		✓

3.2. Financial support schemes at Member State Level

To address the challenges faced by energy production projects and to enhance investments in energy production to achieve policy goals, the public sector can implement a series of financial support schemes. Financial instruments not only improve the financing conditions for a specific type of project (e.g., by de-risking it, increasing the financing available, improving the financing conditions, etc.), but also send a strong signal to market players about governments' and public authorities' commitment to that sector.

A mapping exercise was conducted to gather an overview on the existing financial support schemes available for energy projects, including energy production. The purpose of the mapping was to assess the current availability of instruments and schemes to support energy production projects, in order to assess to what extent they are effective in addressing barriers and mobilising additional finance. This will prove to be useful and functional for the development of future financial support schemes to support the energy transition in the EU, both new instruments or existing one being continued and improved.

Financial support schemes are not the solution for all barriers and bottleneck faced by energy projects. They are the most relevant to address barriers stemming from financial and market conditions, and less suitable for social and regulatory ones. This relevance is further explored in section 4.1 Relevance of instruments in addressing investment barriers: theory and evidence.

The mapping was conducted through a combination of **desk research and interviews** with selected stakeholders to obtain complementary information. Instruments were categorised by segments of the energy value chain they can support, eligible beneficiaries, targeted development phase, energy production sources, and type of financing provided (see Annex 1). Some instruments have been flagged as **relevant for more than one single dimension**. This is the case, for instance, of those instruments covering the installation of both PV panels and of batteries or providing both loans and grants. These instruments were categorised under all the relevant categories, so as to reflect the scope of the instrument. This note should be kept in mind when reading the data presented below as, for instance, when it is stated that 100% of mapped instruments in Cyprus target energy production, it does not mean that all the mapped instruments target only energy production, but that they target also energy production and none of the mapped instruments do not target it.

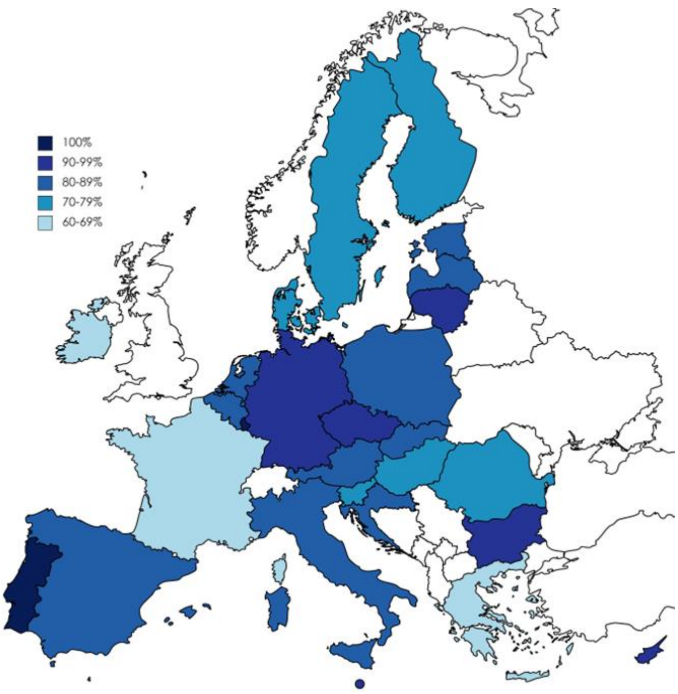
Instruments targeting solely energy efficiency (e.g., for the renovation of buildings, for industries, etc.) – albeit particularly popular – have been excluded from the analysis, as already covered by the work on the Energy Efficiency Financial Institutions Group. Energy efficiency instruments were mapped only if they included also support for energy production (e.g., covering also PV panels, batteries, and/or heating systems). For the purpose of the analysis and to identify regional trends, EU Member States have also been aggregated in four geographical areas, following the classification from EuroVoc[97]: Central and Eastern Europe[98], Northern Europe[99], Southern Europe[100], and Western Europe[101].

General overview: energy production instruments

The mapping has produced a database of 563 instruments across the 27 EU Member States. Poland (43), Italy (41), and Germany (39) are the three countries in which the highest number of identified instruments. On the contrary, Cyprus (10), Denmark (10), and Finland (8) are the countries with the lowest number of identified instruments for energy production.

On average, about 83% of the mapped instruments support energy production, 468 in total. However, out of these that have been identified as available for this category**, just 76 are targeting only energy production.** Additionally, 92 of them support energy production and another segment (T&D 10 times, Storage 7 times, H&C 25 times, Energy Services and Prosumers 50 times). Finally, 171 instruments support all the five segments. In Luxembourg and Portugal all identified instruments are partly or entirely destined for energy production. In contrast, France, Greece, and Ireland are the only countries where fewer than 70% of the identified instruments target energy production. Hence, **it is clear how the production of energy is the sector of the energy value chain that receives the most attention across all EU countries.**

Figure 21: Share of Energy Production instruments out of the total mapped



Instruments that only target energy production have been found in 22 Member States, with the only exceptions being Croatia, Denmark, Estonia, Greece, and Malta. Romania and Spain, with 9 and 8 instruments respectively, are the countries where the highest number has been mapped. Right after there is Italy with 7. The average share of energy production supporting instruments that only target this segment of the value chain is around 16%. The highest value is reached by Finland, with 67%. Indeed, while having few mapped instruments overall, Finnish instruments present a high specificity. By leaving aside those countries for which no specific energy production

[97] Available on: https://www.researchgate.net/figure/European-subregions-defined-by-EuroVoc-Blue-Northern-Europe-green-Western-Europe_fig1_321354391

[98] Bulgaria, Czech Republic, Croatia, Hungary, Poland, Romania, Slovakia, Slovenia

[99] Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden

[100] Greece, Italy, Malta, Portugal, Spain

[101] Austria, Belgium, France, Germany, Ireland, Luxembourg, the Netherlands

instruments was mapped, Czech Republic – with around 3% - is the one that displays the lower value of production specific instruments overall. 33 instruments out of the 76 which target only energy production are also aligned with ESG or the Paris Agreement.

The mapping also looked for information about the **volumes of financing** provided. Information about the total budget of the instruments as well as the amount already deployed have been collected where available, to understand what the available magnitude of financing for different target groups is and how it is channelled through different funding instruments/financial schemes. However, **the mapping was able to gather only partial information on volumes, as such data was publicly available for less than half of all instruments relevant for energy production (232 instruments of the total 468 instruments)** and information on deployment was missing in most of the cases.

Figure 22: Instruments mapped per country

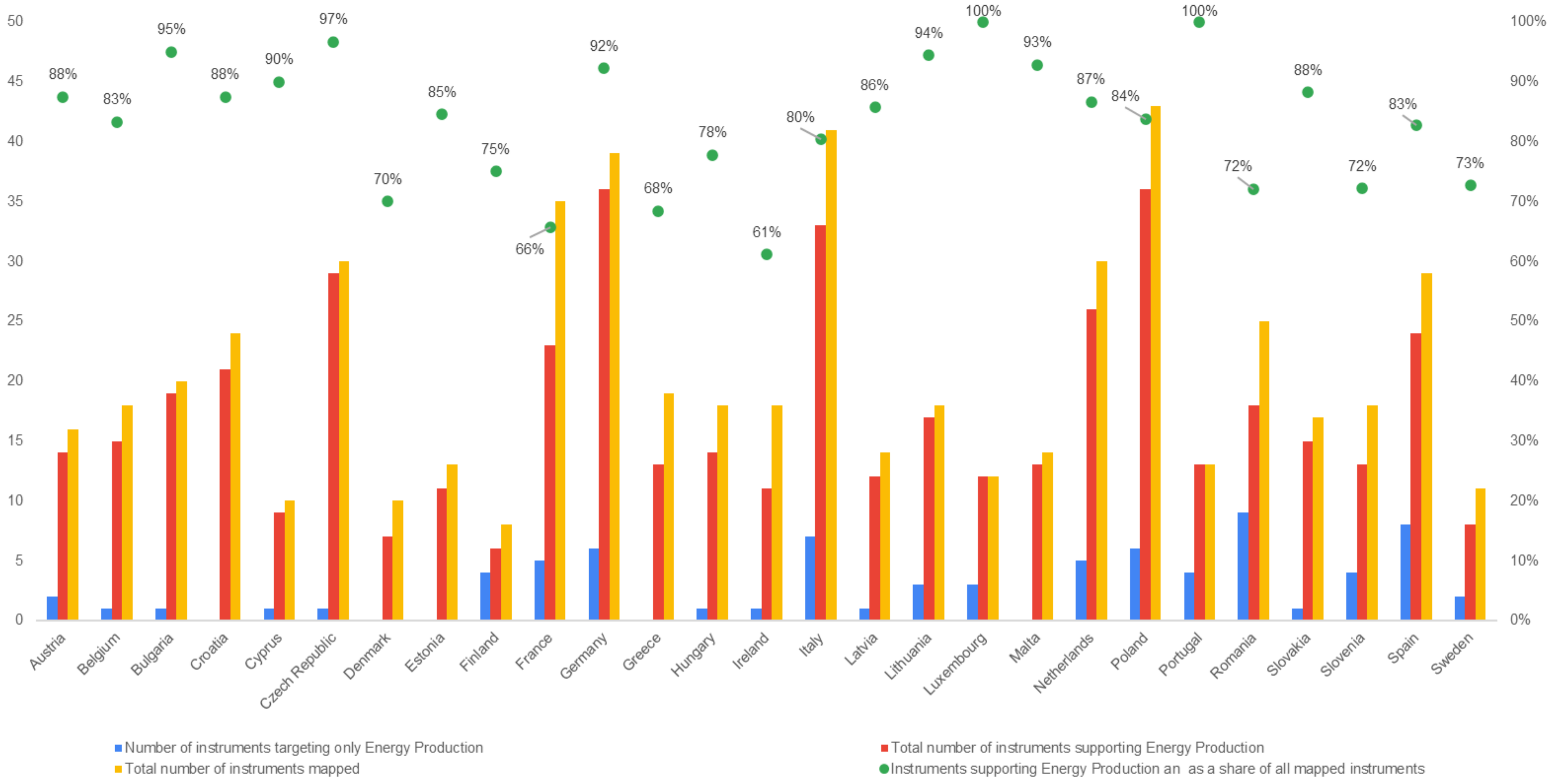
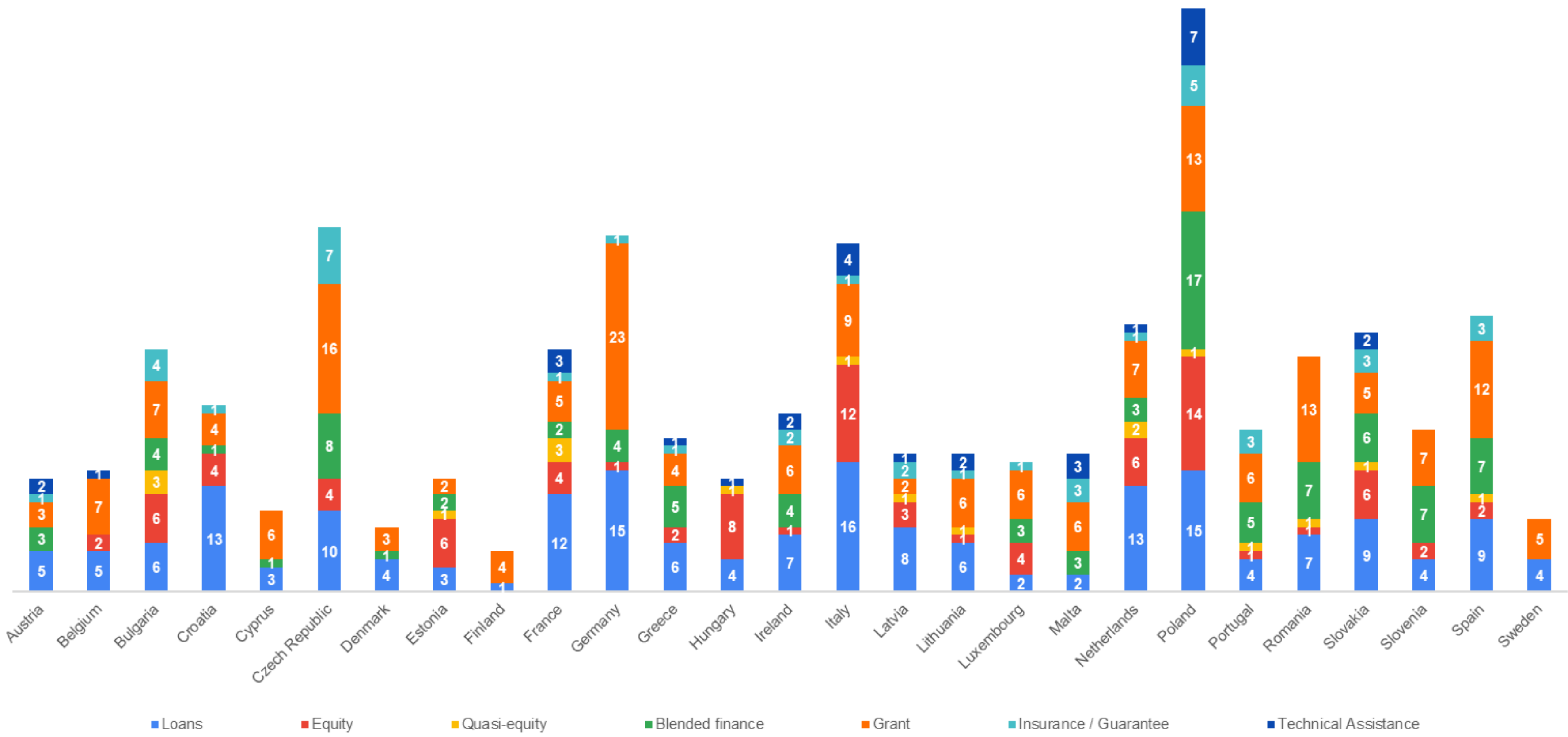
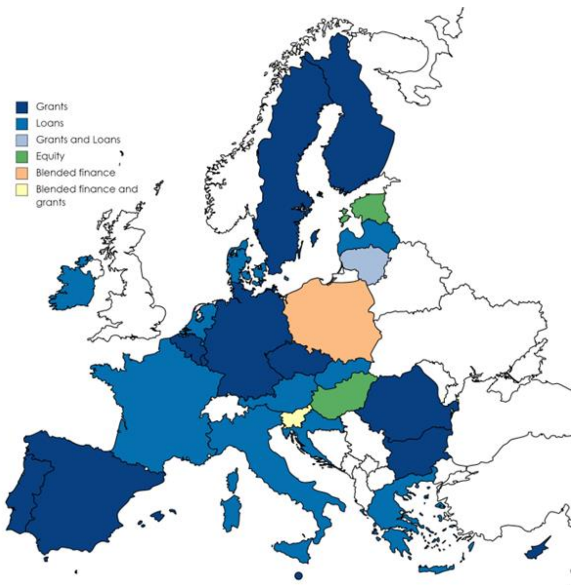


Figure 23: Number of financial instruments for energy production per type of instrument and per country



Financing Instruments by type

Figure 24: Most mapped instrument per country

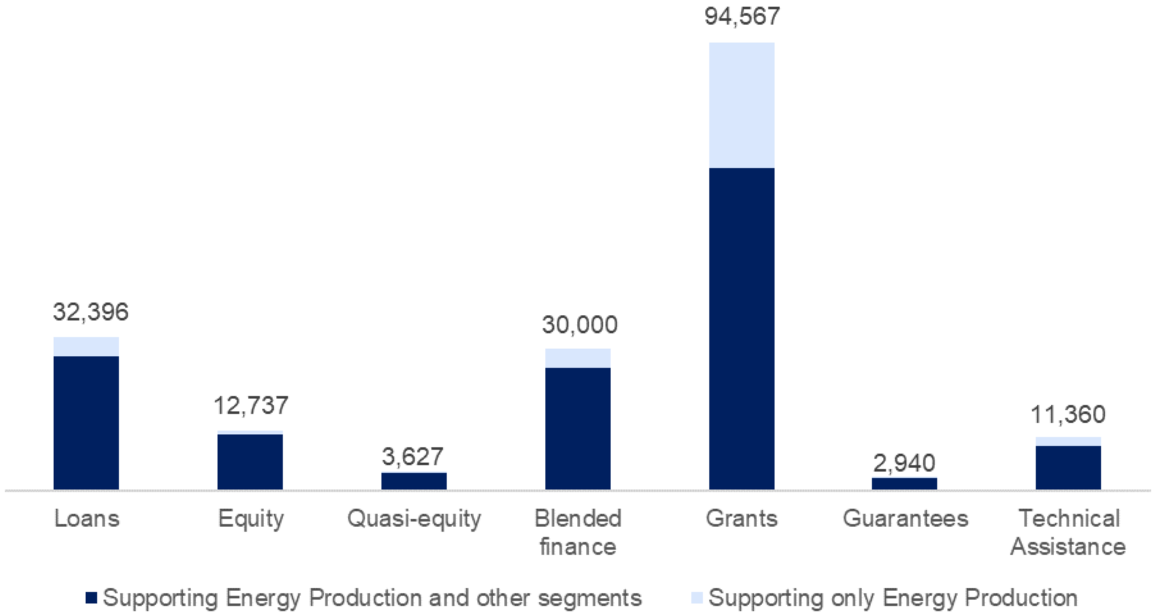


Loans and grants are the most widespread across the set of 468 instruments that the mapping identified as relevant for Energy Production financing. Only in Estonia and Hungary equity instruments are the most widely available.

A similar pattern was found also when considering only those instruments which specifically target only energy production. In this subsample indeed we found that 49% of the instruments are grants and around 37% are loans.

On aggregate, **a total amount of €165 billion has been estimated to be available inter alia for energy production projects by considering the resources coming from the EU, national public authorities, and private institutions.** As displayed in Figure 25 below, the amount allocated to grants, €94.5 billion, is over twice the size of that allocated to loans (€32 billion). For guarantees, the maximum leveraged investments due to the respective guarantee has been considered for the calculation, and not the amount of guarantees disbursed, which was not available. These estimates are based on information for 232 instruments. These volumes also include the total volume of instruments targeting also but not only energy production, and for which there is no specific pre-allocation. This means that these volumes are not guaranteed to be spent in energy production only. The fraction of these resources which is channelled through instruments targeting only energy production is about €38 billion. This data is based on 47 instruments out of the 77 identified as relevant only for energy production.

Figure 25: Volume of financing per instrument (in € M)

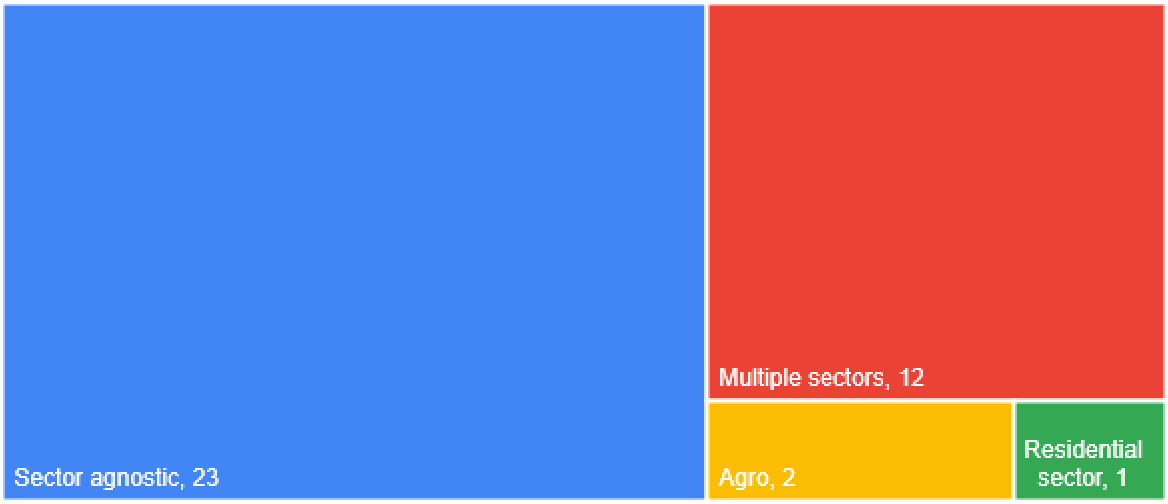


We mapped a total of 187 grants supporting energy production. **Germany is the country with the highest number of grant instruments** (23), and this data is explained by the fact that many of them come from the investment arms of the Länder, reflecting the federal governance of the country. Grants are largely used in the energy production sector, mainly to incentivise the transition towards sustainable energy production. This finding could be in part confirmed by the fact that Sweden, Finland, Latvia and Austria – which in 2020 had the highest share of gross final energy consumption coming from renewable sources[102] – are the countries with the fewest grant instruments identified, thus possibly showing a smaller need to step up clean energy production through subsidies. In general, however, grants are available across all countries and geographical regions.

37 grants target only energy production. They represent around 20% of all grants being available for this sector of the value chain and 21 of them are funded by the EU money, with a significant share given by RRF/Next Generation EU Resources which is the source for around one third of all the production-only grants registered. Understandably, the EU represents the main driver behind such interventions, all across the 27 Member States. 23 out of the total 37 grants only focusing on energy production are then sector agnostic, as we see in Figure 26. Other 12 instruments focus instead on multiple – but specific – sectors of the economy such as hard-to-abate industries. Part of the resources provided to agriculture are also designed to target *agrovoltaic* initiatives (i.e., using the same area of land to obtain both solar energy and agricultural products). All these grant instruments have a country-wide coverage and are not intended only for one or more exclusive regions.

[102] Eurostat, Romania statistics explained – Renewable energy statistics

Figure 26: Number of energy production specific grants by sectoral focus

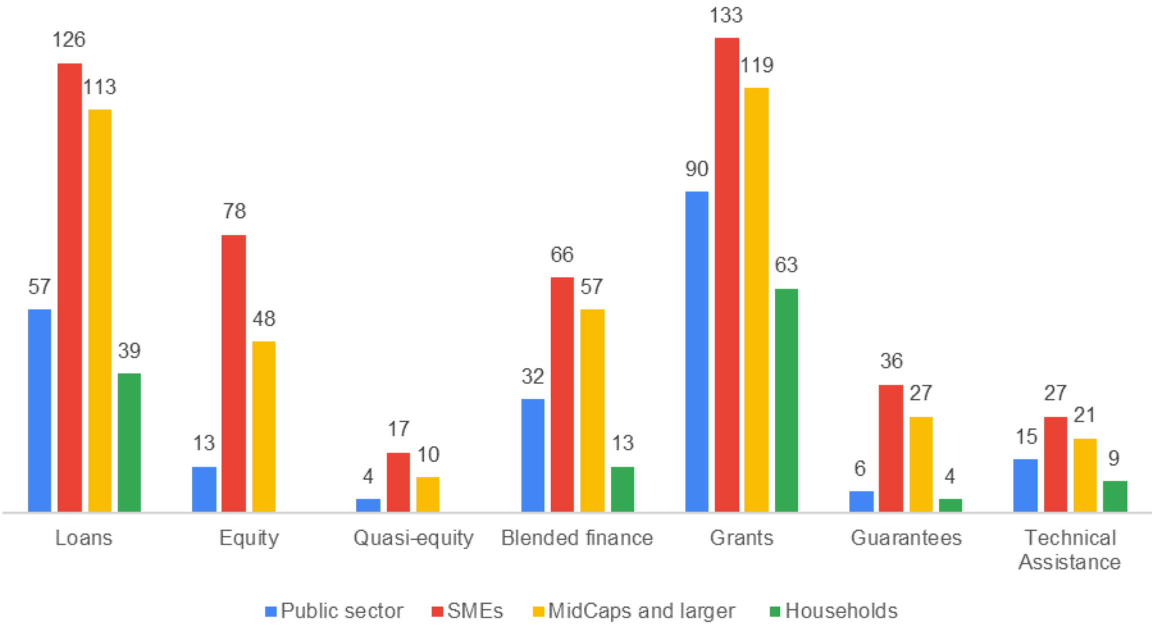


Similar considerations also apply to the overall sample of grants supporting production. The majority of these are also sector agnostic and with a wide scope of application. On the other hand, those instruments which do target selected sectors focus on hard-to-abate industries, manufacturing, agriculture, and the residential sector. In terms of geographical coverage, only 14 instruments target regional/local entities. 9 of them are in Germany – focusing on specific Länder– and the remaining 5 cover different Belgian Regions. **Grants are predominantly funded by public authorities.** This result is consistent across all countries and the source of money is usually either the EU, the national budget, or a specialised governmental agency. This reflects the non-repayable nature of the instrument.

Loans (193 in total) come mostly from market-oriented public institutions such as national promotional banks (NPBs) or the EIB Group and the mapping found them across all member states. Some products coming from private banks and funds are also present. Italy, Germany and Poland are the countries with the highest number instruments (16 and 15 instruments respectively).

The overall number of loans instruments which specifically target energy production is 28 and they represent around a 14% of all loans available for this segment of the energy sector. The EIB Group is again the most present institution in this segment, being involved in the 34% of the cases. More than 50% of the loans are sector agnostic.

Figure 27: Number of instruments by type of instrument and by final recipient



The mapping found 90 equity instruments, across 21 EU countries[103]. Poland is the country with the highest number of equity instruments identified. Only 4 (4%) of all equity instruments are exclusively targeting energy production.

Quasi-equity, which is a more complex financial instrument, is less present and was found mainly in France, Bulgaria, and the Netherlands, for a total of 18 instruments. A single quasi-equity instrument in Portugal targets only energy production – it is a joint financing tool from the Portuguese NPB and the EIF.

Blended finance schemes have been found in 20 Member States. Poland (17 instruments) is by far the Country with the largest availability of such schemes.

The ratio between the number of instruments targeting only energy production and the number of instruments which widely support this segment is considerably lower for equity than for loans, blended finance or, above all, grants. As emerged during interviews with selected stakeholders that were run in the preparation of this study, in some countries the energy market is often not deep enough for funds and financial institutions to pursue a narrow investment strategy. To get a significant pool of projects and companies, it is indeed necessary to have a horizontal approach which looks at all the segments of the value chain. A more detailed analysis of market readiness is provided in Chapter 5 of this study.

The provision of more sophisticated financial instruments such as (quasi)equity and blended finance require a high degree of cooperation between public and private providers of finance. Most of the identified instrument are provided by or in cooperation with NPBIs and the EIB Group.

One or more guarantee schemes for energy production are available in 18 EU Member States[104], for a total of 41 instruments. Czech Republic, with 7 schemes, is the Country with the highest mapped availability. In the majority of the cases, guarantees are provided by the public sector, especially through facilities financed by the EIB Group or EU funds. None of the 2 guarantees which specifically target energy production is a standalone tool. One is indeed

[103] Belgium, Bulgaria, Croatia, Czech Republic, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain

[104] Austria, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Spain

paired with loans, two are paired with loans and blending finance, and the remaining one goes together with bonds and blending finance, 3 out of these 4 guarantees comes from the Pan-European Guarantee Fund (EGF) managed by the EIF.

Finally, **30 instruments also including technical assistance have been mapped across 13 Member States**[105], **out of which 3 are inserted in programmes targeting only production**. Poland and Italy are the countries in which Technical Assistance is provided the most (7 and 4 schemes respectively). None of these instruments are offered on a standalone basis but rather combined with another instrument. In 21 occasions this instrument was paired with loans. 13 times it was offered together with a grant. Indeed, in 8 occasions (3 in Poland, 2 in Slovakia, 1 in Ireland, Latvia, and Malta) both instruments were offered together, alongside technical assistance. Overall, as showcased in Figure 25 above, the volume of money channelled through programmes, mostly loans and grants, which come together with a technical assistance part is €11 billion.

Financing instruments by targeted production technology

Most instruments available for energy production are technology neutral, i.e., they provide financing to renewable

energy production projects without specifying the technology to be used.[106]

A total of 308 technology-neutral instruments – out of the 468 mapped overall - **have been identified in all 27 EU Member States**, with Germany (29), Czech Republic (22), and France (21), being the Member States with the most technology neutral instruments, and Cyprus (3), Finland (3), Spain (3), Portugal and Sweden (4) the countries with the fewest (see Figure 36). The high share of technology-neutral instruments can be explained by the flexibility they provide by not binding resources to a specific production technology.

Based on the partially available data on volumes coming from 232 out of the total 468, there is a prevalence in volumes provided via technology neutral instruments being higher than that through instruments targeting technology specific instruments.

Box 17: Green bonds

Green Bonds are expected to be an increasingly important instrument to finance sustainable activities over the next years. In the last decade in the EU, both public and private sector entities have started tapping the green bond market, following the increasing attention to sustainable finance. Although China has been in 2022 the largest global issuer by number of issuances, the European market remained the largest in terms of issued volumes, with a supply of around $219.03 billion. Historically, European entities have been pioneers in this field, with the EIB being the first issuer of a green bond in the world back in 2007.

1,960 or around 58%, of all GSSSBs of EU issuers between January 2015 and February 2023 were relevant for renewable energy. The following figures will focus on the **use-of-proceeds bonds** (i.e., Green bonds, social Bonds, Sustainability Bonds, **1915 in total**) which had renewable energy as one of the declared uses of proceeds[107, 108]**.**

Corporate bonds

Sweden has the highest number of issued corporate UoP whose proceeds are entirely or partially earmarked for renewable energy projects among all Member States. This result is largely due to the high number of issuances from real estate companies and housing associations, which account for more than 80% of the total Swedish issuances. **Spain ranks second with 83**

105 Austria, Belgium, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Slovakia

106 Instruments that targeted, even partially, coal and natural gas have been excluded.

107 Based on data from Environmental Finance retrieved on 29 March 2023.

108 For EU companies that have operations outside the Union, as well as for DFIs, a non-quantifiable of the raised funds may have been directed towards projects in extra-EU countries

bonds in total, and it leads in terms of the number of issuances from energy sector companies (68). **Germany ranks third overall**, with a total of 70 issuances, including 48 from energy sector companies.

Corporates issued around €216 billion of UoP bonds with proceeds designated for financing renewable energy projects. German and French companies have issued just around €35 billion each, **with an average issuance of around €510 million and €662 million**, respectively. The Netherlands and Spain are next, with €28 billion each, and average issuances of €535 million

Figure 1: Number of UoP bonds relevant for renewable energy issued by companies from 2013 to 2023, per country

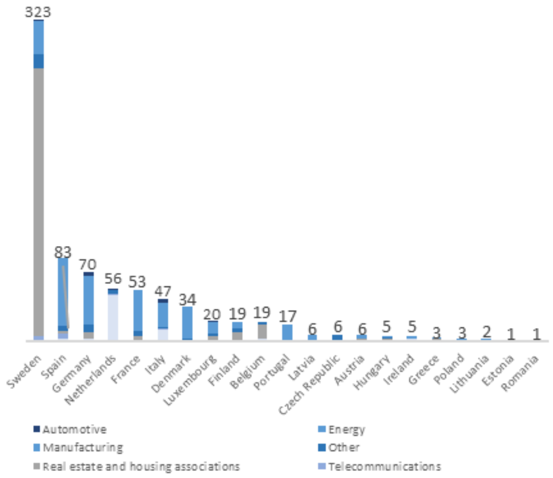
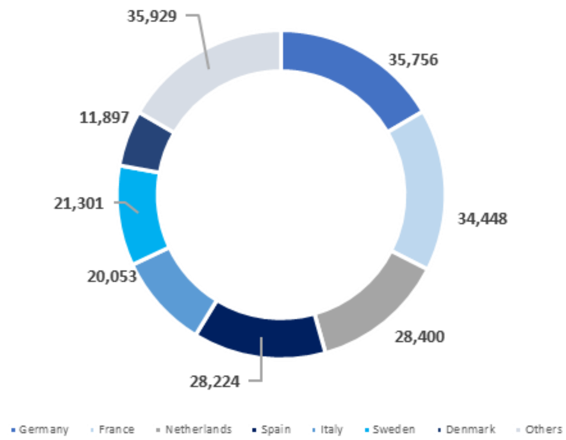


Figure 2: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by companies from 2013 to 2023 per country (In € M)



and €340 million, respectively. On the other hand, Swedish companies issued only around €21 billion, with an average issuance of just €66 million.

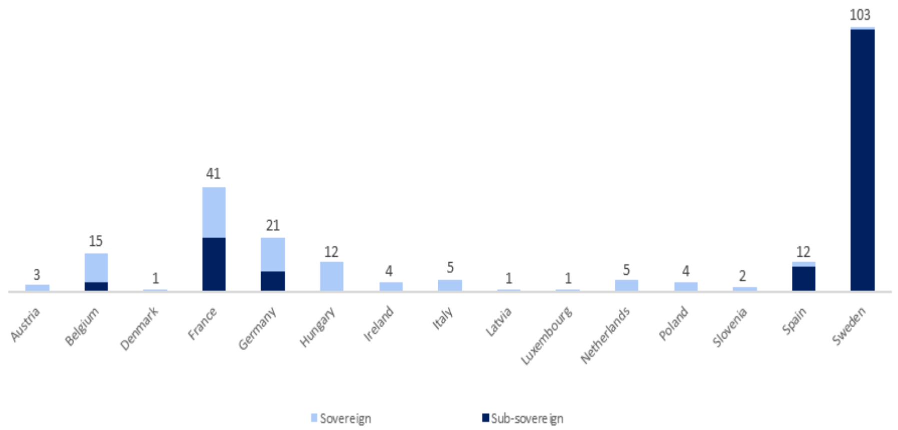
Sovereign bonds

Over the analysed period, a total of 230 UoP bonds whose proceeds are totally or partially earmarked to renewable energy projects were issued by European sovereign and sub-sovereign entities, with sub-sovereigns accounting for 145 issuances and national governments accounting for the remaining 85**.** The Stockholm Regional Council was the sub-sovereign entity with the highest number of bond issuances, while the French State was the leading issuer among sovereign entities.

In terms of volumes, sovereign entities (€182 billion) raised almost seven times the amount of the sub-sovereign ones (€27 billion). This trend could reflect the different – and larger – financial needs that national governments generally have compared to sub-sovereign entities, which are responsible for a narrower range of activities.

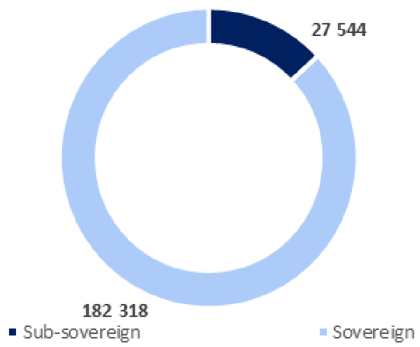
On aggregate, **sovereign green bonds accounted for nearly €177 bn.** France is the Member State that issued the most, with €56 bn, followed by Germany, and Italy. This result is not surprising considering that these are also the three largest economies in the EU.

Figure 3: Number of UoP bonds issuances relevant for renewable energy issued by sovereign and sub-sovereign entities from 2013 Q1 to 2023 Q1



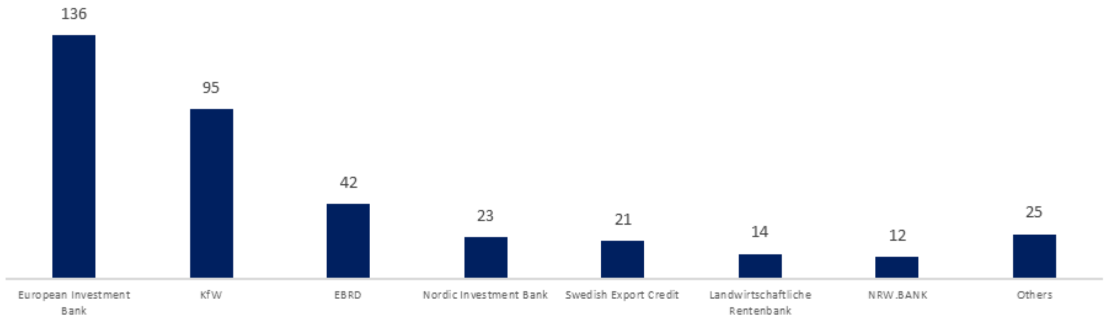
DFIs

Figure 4: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by sovereign and sub-sovereign entities from 2013 to 2023 (In € M)



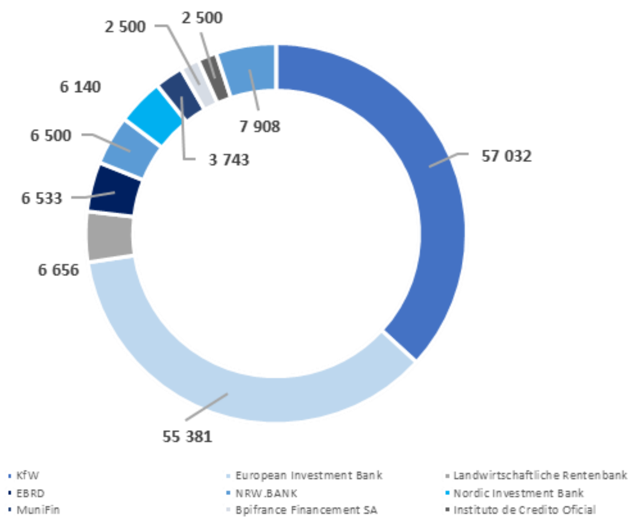
In the analysed dataset, **368 bonds whose proceeds are totally or partially earmarked to renewable energy projects were issued by DFIs, with the EIB (136) accounting for around a third of them.** The EBRD and the Nordic Investment Bank rank third and fourth, after the German NPB, KfW. This category of issuers plays an important role in financing sustainable energy projects. Typically, they issue bonds to raise funds that they can then lend out to support selected projects.

Figure 5: Number of UoP bonds issuances relevant for renewable energy issued by DFIs from 2013 Q1 to 2023 Q+



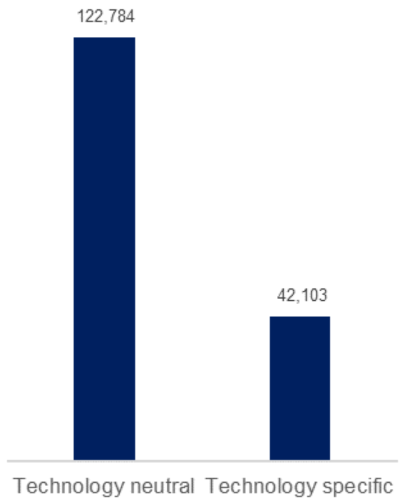
In terms of volumes of bond issuances, KfW is the largest issuer with around €57 billion worth of GBs. The bank commenced building its global portfolio in collaboration with the German Ministry for the Environment, Nature Conservation, and Nuclear Safety in 2015. The EIB comes in second place with €55 billion and the combined bond issuances of these two institutions make up over 70% of the total for this category.

Figure 6: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by DFIs from 2013 to 2023 (In € M)



Financial instruments by targeted production technology

Figure 7: Volume of financing per generating technology (In € M)



Most instruments available for energy production are technology neutral, i.e., they provide financing to renewable energy production projects without specifying the technology to be used.[109]

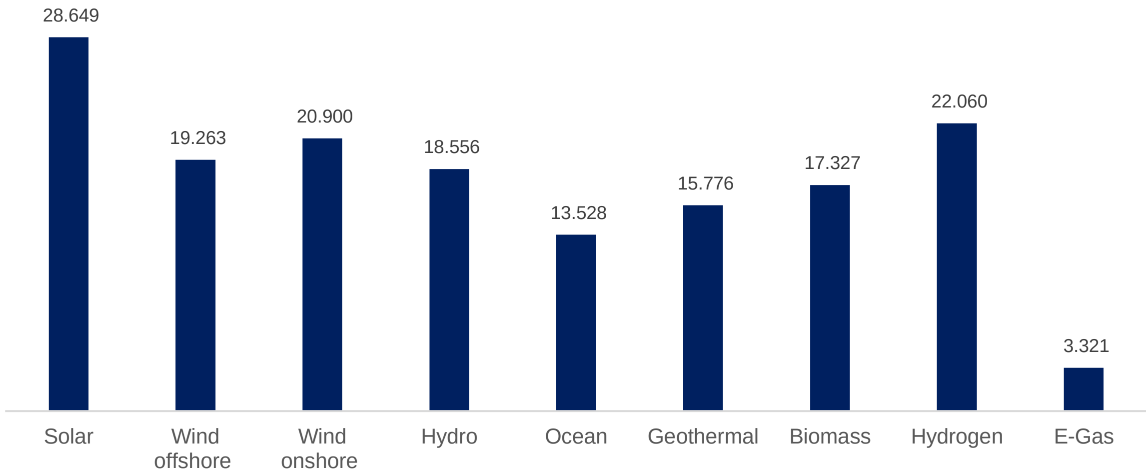
A total of 308 technology-neutral instruments – out of the 468 mapped overall - **have been identified in all 27 EU Member States**, with Germany (29), Czech Republic (22), and France (21), being the Member States with the most technology neutral instruments, and Cyprus (3), Finland (3), Spain (3), Portugal and Sweden (4) the countries with the fewest (see Figure 36). The high share of technology-neutral instruments can be explained by the flexibility they provide by not binding resources to a specific production technology.

Based on the partially available data on volumes coming from 232 out of the total 468, there is a prevalence in volumes provided via technology neutral instruments being higher than that through instruments targeting technology specific instruments.

[109] Instruments that targeted, even partially, coal and natural gas have been excluded.

Figure 35: Volume of financing targeting a specific production technology (In € M)[110]

Note: Data for 247 instruments only. Double counting possible.



Solar energy specific instruments (110 in total) mainly take the form of grants (53) and loans (48), and to a lesser extent of equity. The use of grants could be explained by its fit with households and public buildings, where grants money can help addressing the barrier of by high upfront costs. Solar is also targeted by guarantees, which then result in loans provided, and by 11 instruments which also included a technical assistance component. In terms of dedicated volume of financing, solar is – understandably – the one which receives the largest amount of money, also due to the numerous programmes which target installation of solar panels.

The same trends as above can be observed with the other energy production technologies, with loans and grants alternating as the most present type of instrument. Equity instruments are used for all production technologies, with the exception of ocean, geothermal and e-gas. **Biomass** in particular accounts for 9 equity instruments and 3 quasi-equity instruments. **Hydrogen** is targeted mostly by grant instruments (17), mainly due to the innovative and recent nature of the different technologies in the H_2 value chain, which still require high upfront costs, and only to a lesser extent by loans (3). **Hydro power** is also a technology which receives a large amount of targeted funding, together with wind. This finding reflects the fact that onshore wind and hydro were, as of 2020, the most used, and mature, renewable sources in the EU while solar one was the fastest growing[111]. Other less used sources (i.e., ocean, geothermal, biomass, e-gas, or biomethane) are indeed receiving less funding.

[110] Some methodological caveats apply to this data
- Data refers to 245 instruments out of the total 496 which have been mapped for energy production
- In the case of an instrument which was flagged under more than one specific generating technology category, the related amount is fully counted in each of them

[111] https://ember-climate.org/insights/research/eu-power-sector-2020/

Box 18: Focus on: Hydrogen financing

The mapping of instruments identified 27 instruments supporting hydrogen production. Italy and Bulgaria, with 4 instruments, are the countries with the highest mapped number. Poland and Spain have 3, and Germany, Czech Republic and Romania all have 2. Most of these instruments have a broad scope and fund a wide number of technologies that includes hydrogen. **There are 6 instruments targeting specifically hydrogen with a dedicated budget of around €3.4 bn**. These resources are all deployed in the form of grants and direct investments from the Member States to public sector entities, SMEs, or Midcaps and larger companies.

The Italian RRP features four hydrogen projects and an estimated total investment of over €3 bn. Nearly 66% (around €2 bn) of this amount is planned to favour the transition toward zero emissions green hydrogen in industries that today are ever more polluting and harder to convert (hard-to-abate), primarily steel mills and refineries.

Finally, two instruments from the Spanish government – for a total of €400m – have been mapped. They are related to innovation, research and prototype activities across the renewable hydrogen value chain and to the support to projects that combine in an integrated way the production, distribution and consumption of renewable hydrogen.

Additional resources for hydrogen will also be deployed through a special fund in the German Climate and Transformation Fund. Money will be disbursed from 2023 to 2026.

The majority of the 76 instruments targeting specifically energy production are technology specific (47) rather than technology neutral (29). This is the exact opposite of what happens in the overall sample of instruments supporting but not necessarily explicitly dedicated to energy production.

On the other hand, considerations about the amount available for each technology do not change significantly. Through technology neutral instruments are channelled about €8 bn, while the volume of financing per technology specific instruments is around €25 billion. Out of these €25 billion, €18 billion target solar projects which is by far the most targeted technology both by number and by volume.

Figure 36: Number of mapped instruments by type of instrument and production technology

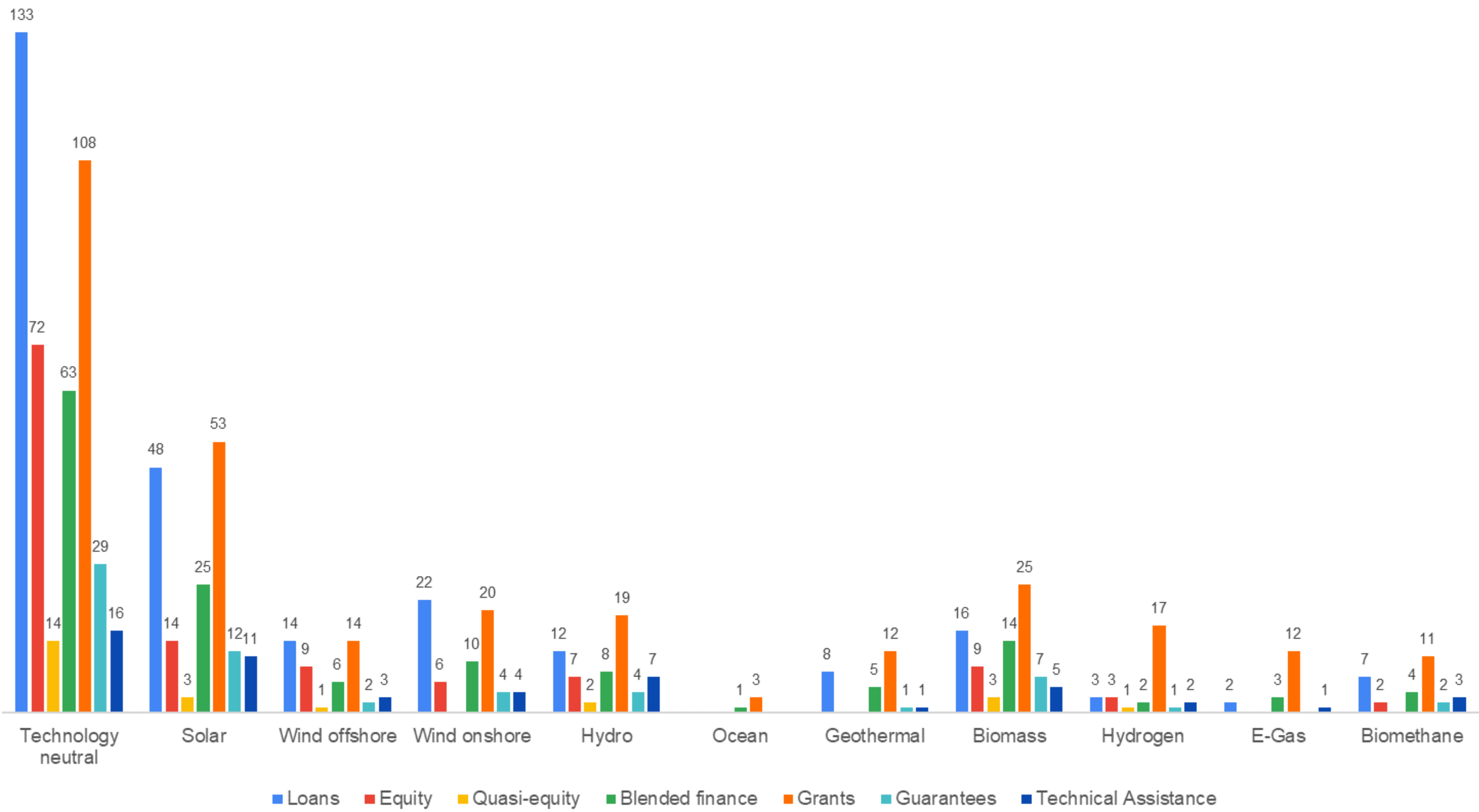
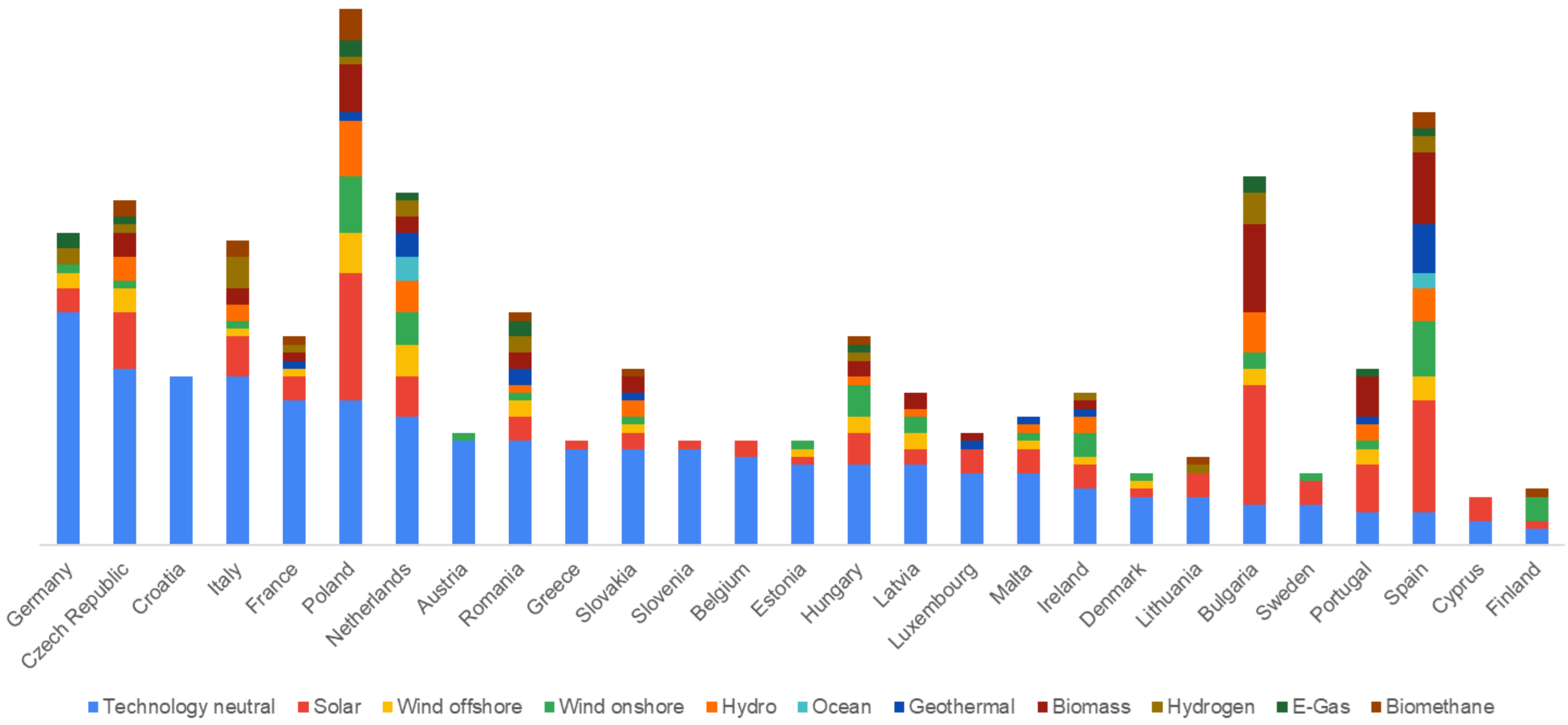


Figure 37: Instruments by type of energy production technology by country



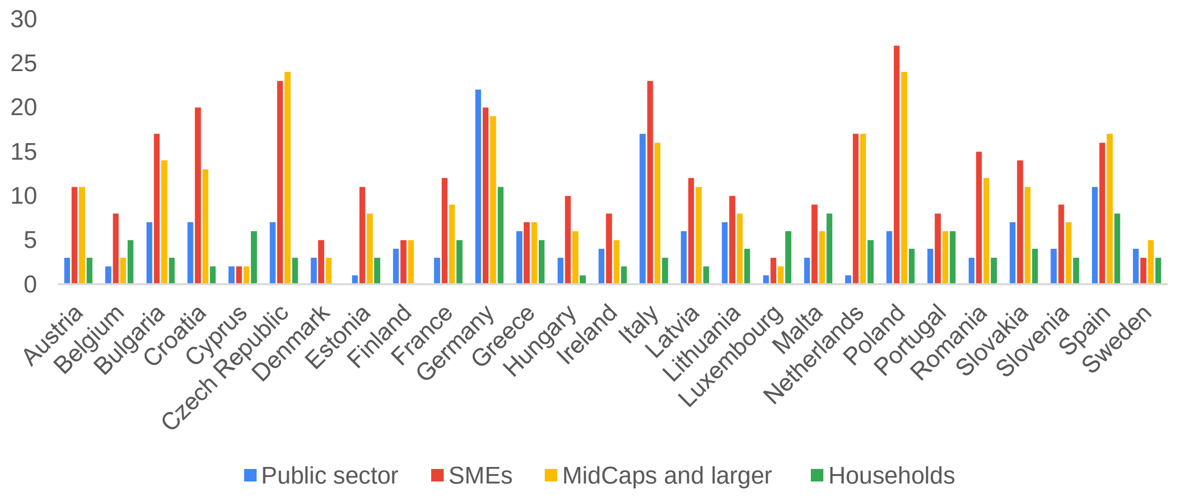
Financing instruments by beneficiary

SMEs and larger companies are the most supported recipients by financial instruments in most EU Member States. They are the most supported type of beneficiary due to their higher investment needs in general, which lead to the need for greater support. In fact, "financing costs" was indicated by both SMEs and large companies as a relevant obstacle for their green transition activities in a recent Commission report on EU SMEs[112], showing an existing need for support in the field. Croatia and Poland are the two countries which have the highest number of loan instruments towards the private sector (12) while Germany and the Czech Republic have the highest number of grants (17 and 13). Most of the equity, quasi-equity and blended finance is directed towards SMEs and larger companies. Indeed, 87% of equity instruments target SMEs and 53% for Midcaps and larger companies. The share that is dedicated to public companies and households in negligible in all the EU countries. Similar results are found also for quasi-equity, where 94% of the instruments are directed towards SMEs and more than 56% to Midcaps and large companies.

Public-owned companies and public administrations ("public sector") are supported by about a third of the mapped instruments. The lower support for public sector entities could be linked to the extent such entities receive direct budget support from the state budget and their expenditures might not need to be financed through external instruments. Only 57 loans were found towards these recipients, mostly in Italy and Germany, while grant instruments for public sector are 90, mostly in Germany (18), Spain and Italy (9 each).

Households are the least supported group by the mapped instruments, with more than 10 instruments per country identified only in Germany. This can be explained by the fact that pure energy-efficiency instruments – the ones most suited for households - were excluded from the mapping. Households also have limited energy production potential due to limited roof surface for PV panels and impracticalities in installing other types of energy production systems (e.g., wind turbines, geothermal systems). Furthermore, households tend to have relatively homogeneous needs when it comes to energy production systems (e.g., mainly only PV panels, small production capacity). Grants are also the most used tool to support households, followed by loans (63 and 39 instruments, respectively). Further details on this topic will be shared in the study about Energy Services and Prosumers.

Figure 38: Number of mapped instruments by supported beneficiary and by country



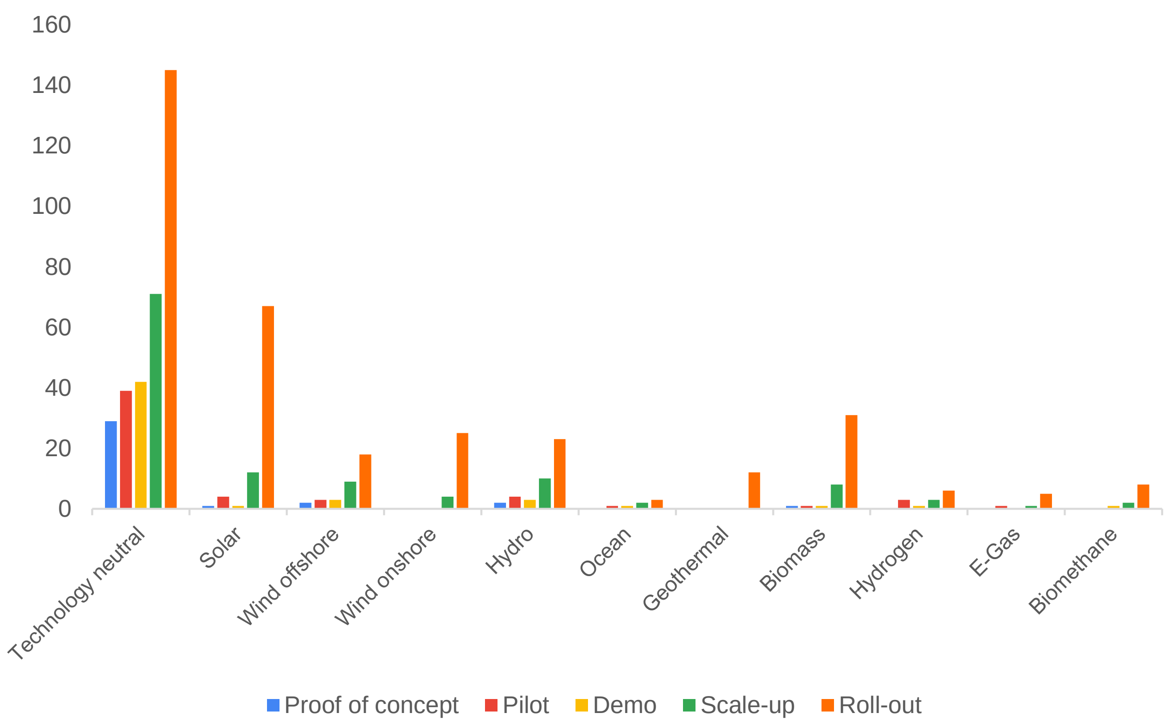
[112] European Commission (2021). Annual report on European SMEs 2021/2022. SMEs and environmental sustainability.

Financing instruments by targeted TRL

Most of the identified financial instruments target mature and market-ready technologies ("roll-out" stage). As can be seen in Figure 41, most instruments target mature technologies and roll-out stage projects/activities. The availability of instruments decreases as the maturity stage decreases for lower TRL technologies and early-stage projects. Among mapped instruments, about 49% of instruments target roll-out stage and 20% target scale-up stage projects. On the other hand, only 7% covers proof of concept and 10% - pilot and demo stage. The results suggest that **at Member State level, there is a limited number of instruments able to specifically target less mature low-TRL technologies** and/or that instruments are not calibrated/designed in a way to widely support these technologies. Despite this, even the least mature stages (Proof of concept and Pilot) still recorded some level of support, primarily in the form of grants and loans for the majority of technologies. Furthermore, it should be kept in mind that programmes at EU level like the Innovation Fund[113] and Horizon Europe[114] have been put in place exactly to provide financing for innovative but less mature technologies that would otherwise struggle to access financing opportunities in the market. Despite not being specific to energy production, these programmes can also finance such types of projects (see section 3.1).

Based on the partially available data, about €6.3 billion are available by financial instruments targeting proof of concept stage and another €5 to 6 billion for pilot and demo stage. The trend in terms of volumes of financing understandably replicates the one of absolute number of instruments. Significantly higher volumes of financing are available for scale-up and – above all – roll-out stage projects/activities. Indeed, the latest stage alone receives almost double the amount of all the other stages combined, reflecting the higher amounts of financing needed to deploy a mature technology at scale.

Figure 39: Number of instruments by targeted stage of development and energy production technology



113 European Commission. Innovation Fund. https://cinea.ec.europa.eu/programmes/innovation-fund_en

114 European Commission. Horizon Europe. Available on: Link

4. Assessing the relevance and effectiveness of instruments

As referred to in Section 2.3, energy production projects continue to face a series of barriers limiting the provision of financing and stemming from market failures, complex permitting frameworks or underdeveloped markets for emerging technologies.

This chapter focuses on the role financial support schemes can play in addressing investment barriers affecting energy production investments, and attempts to assess, based on the mapping of financial support schemes conducted, to what extent existing instruments are effective. Contractual schemes such as PPAs and FiTs, while useful in addressing market barriers faced by renewable energy projects, are not analysed under this chapter as they are contractual arrangements between two parties rather than financial products.

Section 4.1 provides more conceptual considerations and evidence from the mapping on the **capacity of different types of instruments to address barriers**. Indeed, not all barriers can be addressed through financial instruments and not all instruments address all barriers. Section 4.2 presents findings on instruments' **effectiveness** in addressing relevant barriers and reaching their objectives, drawing on evidence from the mapping and existing instrument evaluation studies.

4.1. Relevance of instruments in addressing investment barriers: theory and evidence

Theoretical considerations

This section focuses on the main types of instruments identified in the mapping. We present a conceptual analysis of their relevance for addressing different barriers to investment based on the way they function and their effects on the project's bankability. This framework will then be used in sub-section 4.2 to analyse the findings from the mapping.

Loans

A loan is an interest-bearing type of debt product requiring timely repayment of the interest and principal. While the mapping exercise did not distinguish among the different types of loans, mainly for a reason of feasibility[115], it is nonetheless useful to understand how different types of loans can help addressing investment barriers

The following paragraphs provide a description of the most relevant types of loans and the type of financing needs they address in energy production projects.

A. **Bridge loans are short-term instruments which are used by an individual or company until they are able to secure permanent (long-term) financing or pay an existing obligation. Bridge loans fill the gap between two phases of a project, such as the "ready to build" phase and the moment when the project is ready for connection to the grid.** Another example of bridge financing involves covering the financing needs that arise since a project obtains a grant until the moment the grant is disbursed. Such instrument allows the borrower to meet current expenditure or investment obligations by providing immediate cash flow. Bridge loans can be particularly helpful to accelerate the development of greenfield energy projects. Greenfield RE investments typically face high capital needs right before construction,

[115] Feasibility considerations included a) consistency of available information across loan instruments (most loan descriptions did not provide information on loans' subordination features); and b) consistency of available information across other instruments (most guarantee, equity and grant schemes did not provide detailed information as to their type).

when materials and equipment must be bought, and contractors paid although the project is not yet able to generate revenues. This can create a **financing gap/need** primarily affecting medium-sized promoters with insufficient liquidity to cover high construction costs on their own. Larger developers with large pipelines of new projects but without the capital to finance them all in parallel can also face the need for transitional capital during development and construction phases. Bridge loans (e.g., RE construction loans repaid at completion of construction or converted into long-term loans) can provide project developers with the **necessary access to finance** to advance faster towards project implementation.

B. **Long-term loans are a basic tool used for financing investments. They are suitable for improving the financing conditions for mature RE technologies with good access to commercial financing.** Established RES typically face the need for long term loans to spread the investment cost over the asset's economic life. Long term debt, particularly if combined with lower interest rates or collateral requirements improve the financing conditions for mature RE technologies, by lowering and better distributing debt service costs across the project's economic life.

C. **Subordinated loans can be a powerful instrument for less established RES with limited access to commercial lenders or for projects exposed to market risk.** Such instrument is typically offered by specialised institutions rather than commercial banks, which normally prefer to take the role of senior lenders. Subordinated loans rank below more senior debt with respect to timing of repayments or claims on assets. They can therefore **crowd in** other senior lenders and incentivise them to lower their risk premium or collateral requirements by mitigating their risk exposure to a project. Such instrument can **improve access to finance and financing conditions** for less established RES or projects with merchant risk elements. Additionally, it can leverage the investor's equity or fill the gap between the required equity for a new project and the investor's own funds.

D. **Loans (individual or loan portfolios) that facilitate the aggregation of small projects are relevant for improving access to finance for small RE investments**. Smaller scale projects such as rooftop PVs can face challenges in accessing finance due to their small ticket sizes, which can disincentivise commercial banks and private investors from investing. This is due to all the administrative and due diligence processes that must be performed before financing is provided, which in the case of smaller projects might not be worth the effort, as the revenues from the interest rates would be relatively small. There are two main levels at which loans can enable small-project aggregation: (i) at the individual loan level - by facilitating the presentation of small interventions and different RE/EE technologies under the same loan application (e.g. commercial bank home energy loans for the installation of rooftop PV and other energy-saving systems) and (ii) at portfolio level, where loan portfolios of similar small projects (e.g. solar PV installations in different housing units) can enable larger commercial banks and providers of climate finance such as EIB to participate in the financing with larger tickets. Aggregation of small projects into larger portfolios can similarly be exploited by other financial instruments such as guarantees and equity schemes to improve the accessibility of small projects to larger private investors.

Guarantees

Guarantees cover the risk of no payment to the money provider. These are relevant for improving access to finance and financing conditions for RE projects, particularly in cases involving high perceived risk. Through tailoring of their coverage conditions, guarantees can be a powerful instrument to support the deployment of both mature and less established energy production technologies.

Guarantees provided to financial intermediaries and covering mainly default risks on underlying loans or equity are particularly useful for **increasing the provision of financing** and **improving financial conditions for medium-to-high TRL projects.** Such guarantees are particularly suited for market contexts where **financing is sufficiently available**, but where it is provided with **too strict conditions due to high perceived risks**, such as in the case of young or non-investment grade companies with inadequate collateral. For more mature technologies, a partial coverage may suffice in unlocking financing. Depending on the characteristics of the guarantee, it can also provide **capital relief** for financial intermediaries, enabling **higher exposures** towards particular capital-consuming sectors or riskier client segments for which banks may be subject to exposure limits[116]. **Guarantees with high coverage rates and covering off-taker and construction risks in addition to default risks can be particularly effective for promoting low-TRL technologies.** Less mature RES with a high level of innovation and technology risk also face more pronounced risks across their supply chains (e.g., availability of manufacturers to supply key components, experienced construction, operation and maintenance companies to operate the technology). As such, guarantees with high coverage rates and offering protection against a wide set of risks can be a necessary tool to **unlock bank financing** for innovative and less mature solutions, as commercial banks might otherwise not invest due to uncertainty in the performance of the technology, long investment horizons, or underdeveloped supply chains.

The nature and structure of guarantees can also differ depending on particular barriers or investment specificities they aim to address. In addition to different coverage rates, guarantees can differ based on the nature of the guarantor (public or private), how many investments the guarantee covers (individual or portfolio) and how the risks are shared between the guarantor and the beneficiary of the guarantee (pari passu or other arrangement). The paragraphs below provide some further considerations on these elements.

Guarantees provided by public sector entities, such as sovereign or regional governments, can be particularly effective in supporting private borrowers raise sufficient debt for new investments. A public sector guarantee can be a helpful tool to **attract private investors with a risk averse profile** towards new projects, as any losses would be at least partly covered by the public sector. By issuing a guarantee rather than contributing directly to the financing of an investment, the public sector entity avoids a **crowding-out effect** because of its intervention. In addition, for the public sector budget, a guarantee constitutes an **off-balance sheet instrument** which is not considered as public sector debt as long as the revenues of the underlying project make it economically viable. This makes guarantees an **efficient tool** for governments to improve access to finance and financing conditions in target energy sectors, without the public authority having to disburse any public resources unless there is a case of default.

Guarantees can also be individual or portfolio instruments, depending on whether the guarantee covers one specific investment/project, usually a large-scale one, or multiple, often smaller ones. Portfolio guarantees are also functional at **aggregating smaller-scale projects** that would otherwise struggle to access finance due to the small amount of financing they need. In the case of portfolio guarantees, a further differentiation can be found in how the risk is split in case of default of one or more investments in the portfolio. In the case of **pari passu guarantees**, the risk is shared between the guarantor and the intermediary on all investments based on a pre-determined allocation (e.g. 50%-50% or60or%-40%9). In case of **first-loss portfolio guarantees**, the guarantor covers the risks of a first tranche of defaults within the portfolio based on a pre-determined covered rate (e.g. 80% coverage on 20% of the portfolio). First-loss portfolio guarantees are particularly useful when developing **portfolios of projects with different levels of maturity**, as the intermediary will be more protected if less mature and riskier investments default (as they are more likely to default first).

[116] See example of MIDIS – Natwest capital relief transaction in the UK enabling increased lending to the sustainable energy sector

Equity

Equity is a type of ownership instrument, where the equity provider becomes an owner or co-owner of the investment. Equity instruments are relevant for providing initial capital to new RE technologies and young companies and for closing financing gaps for mature technologies. Equity-type instruments expose equity providers to a higher degree of risk but also to potentially higher returns. They. They can be tailored to support both mature and less established energy production technologies. Equity schemes targeting utility scale renewables (e.g., infrastructure fund managed by Spain's NPB) can be effective at catalysing **mature RE technologies** such as wind or solar financed through project-finance/SPV modality, and which may **struggle in attracting enough equity investment** to cover part of the initial development costs, both CAPEX and OPEX. Publicly supported equity schemes crowding in venture capital investments can **improve access to capital for less established RES** facing a higher level of **technology risk** and/ or for **young companies** with promising technologies but not mature enough to apply for debt finance due to lack of collateral or a limited credit history.

There are various forms of equity financing, each with its own unique features, risk level and return potential. Equity is usually provided either directly or indirectly. In the first case, the financial institution makes a **direct equity participation** in the company (potentially through an SPV), thus directly acquiring a certain number of share and, therefore, of ownership. This direct participation can take the form of smaller-sized investments from VC funds or Angel investors for start-ups and younger energy companies, or of larger PE investments from investment funds or corporates for utility-scale companies. Alternatively, the investment can be done **indirectly through financial intermediaries**. The financial institution invests in another fund (investment fund, fund-of-funds, etc.), which will in turn invest in one or more companies based on its predetermined investment strategy. In the first case, that of direct investment, it is up to the financial institution to undertake all due diligence and screening processes. In the second case, it is up to the investment fund to do so, and the financial institution only needs to select the fund(s) the most aligned with its policy and investment objectives. Indirect equity schemes also allow **institutional investors** (e.g., pension funds, insurances, national and international financial institutions, etc.) to play a role in energy financing without the need to develop tailored expertise and know-how in it.

Grants

Grants are sums of money given to a project promoter conditionally or unconditionally. Grants can be relevant in addressing a number of investment barriers, depending on the types of beneficiaries targeted and cost components covered. Grants like other forms of subsidies can be used to internalize externalities, which otherwise would not have been considered in investment decisions. These externalities can be of negative (e.g., climate externality) as well as positive (e.g., positive spill over effects) nature.

There are different types of grants that public authorities use to support energy production investments. The following paragraphs provide a description of some the most common types of support and the financing needs they address.

Investment/capital grants are usually provided to cover development costs, finance viability gaps and reduce the ultimate financing costs to increase projects' competitiveness. They are well suited to address **restrictions in access to finance** affecting less established RES, where private investors may be reluctant to invest due to a high degree of novelty and technology risks, product-market fit or high investment costs. In addition, private investors may not consider the **positive spill over effects** resulting from research, development and innovation in new energy technologies, leading to sub-optimal investment outcomes. In this case grants (whether stand alone or combined with other instruments) can provide a necessary financial incentive for the development and commercialization of low TRL technologies until they are able to access commercial financing. In addition, investment grants can target **specific types of beneficiaries** with the purpose of encouraging economic investments from specific actors. Examples include grants for homeowners, energy communities or agricultural holdings for renewable energy investments. In this sense grants also have an important **awareness-raising and market-signalling function** about relatively simple investments individuals and companies can perform to support the green transition, supporting a **greater citizen engagement** and more decentralized energy production systems.

Capital rebates can be used to incentivise promoters to complete projects **in a timely fashion** or to a **certain performance level**. Rebates are lump-sum payments that cover a portion of a project's development cost and are paid to promoters **upon project completion**. Similar to capital grants, rebates lower the amount of project costs that need to be financed by private investors, thus improving the economic incentives for target energy investments.

Interest rate or guarantee fee subsidies facilitate access of individuals and companies to existing lending or guarantee schemes. By improving the financing conditions of underlying financial products (loans, guarantees), such subsidies strengthen individuals' and companies' incentives for obtaining commercial financing for energy investments. This type of support can be particularly relevant for **smaller companies** (in addition to individuals), who may lack the ability or opportunity to negotiate bilaterally with banks the financing conditions of new loans they are interested in contracting.

Indirectly, grants can also address **insufficient planning and preparation capacity** affecting promoters who lack the experience in energy production projects. This can take the form of **technical support grants** to cover part of the project preparation costs, such as energy audits conducted by externals or other studies to be conducted towards FID, but also have a great benefit in OPEX financing for SPV. Such grant funding for project and document preparation can also help to address **project pipeline scarcities** affecting the supply/financing side of RE projects, by increasing the deal flow and pipeline of investment-ready projects ready for assessment by commercial financiers.

Bonds

Bond instruments are relevant for amplifying the sources of medium to long-term capital available to the clean energy sector. **Green bonds** in particular are a common type of bond instrument used to raise capital for climate-friendly projects and can be issued by sovereigns, NPBs, commercial banks or corporates directly. **By earmarking their proceeds** towards sustainable projects, green bonds can serve as an **important bridge** between providers of capital, such as institutional investors, and clean energy production projects. This type of capital market instrument can support the development of RE projects **by improving their access to medium to long-term and more diversified sources of capital**, complementing traditional bank financing available to the sector. The support through bonds has been identified as an area for deeper investigation in the ENER ID WG.

Blended finance

Blended finance instruments are a versatile tool that can support different types of RES projects with easier access to private finance. Although the mapping did not include a large number of blended finance instruments, such instruments can help **mobilize commercial investment** towards clean energy projects, whilst limiting the use of scarce public resources only to the extent needed to crowd-in enough private finance. Blended finance interventions benefit from the possibility to be **tailored to particular sectors, technologies and barriers** (e.g., equity co-investment facilities providing growth finance to SMEs), making them a **versatile tool** to mobilize commercial financing towards priority RE sectors and types of beneficiaries.

A blended finance instrument is typically developed by a public entity together with one or more private entities, where all entities involved pool their resources. Contrary to more standard financial instruments in which public resources crowd-in private ones after the launch of the instrument, in blended finance schemes **private and public resources are combined since the creation of the instrument**.

The most common types of blended finance are **interest rate subsidies** and **capital rebates**, but also **concessional capital** and **credit enhancement** (risk insurance). Blended finance is often also combined with technical assistance grants, to provide capacity building and knowledge-sharing to the beneficiary, to strengthen its commercial viability and support in the transaction preparation.

The main investment barriers for private investors addressed by blended finance are (i) high perceived and real risk, and (ii) poor returns for the risk relative to comparable investments. Blended finance aims at creating investable opportunities in developing market sectors, as well as in sectors with under optimal returns to attract sufficient private investments.

Technical Assistance

Technical assistance is relevant for improving the planning and preparation capacity of project promoters and their ability to benefit from financial instruments. Technical assistance schemes identified through the mapping were primarily paired with loans or grants to SMEs, Midcaps or public sector entities and referred mostly to environmental impact assessments, feasibility studies or support on regulatory and policy matters.

TA can be developed to help project promoters preparing a solid business and financial plan that is ready to be submitted to investors and financial institutions, and thus **improve the investment readiness** of projects and **their ability to access external financing options**. Combining technical assistance with instruments such as loans or grants can therefore facilitate the implementation and uptake of such instruments to support well-defined and more mature project proposals.

Evidence from the mapping of instruments at Member State level

The mapping collected available evidence on the relevance of financial instruments for addressing investment barriers currently affecting energy production projects[117]. For most instruments mapped, the instrument descriptions and guidelines would typically not refer to the investment barriers targeted. Therefore, for each instrument, its relevance for addressing barriers to investment was established/assessed based on the following sources of information:

- **Instrument type**: The instrument's type (e.g., loan, equity, guarantee) and typical functioning mechanism were taken into account to identify the investment barriers that are most likely to be targeted. To reduce the risk of self-confirmation bias based on the theory of instruments' relevance in addressing barriers, inferences made from the instrument type were contrasted with other sources of information (see following points).
- **General description**: Most instruments in the mapping came with a general description summarizing the instrument's main features and eligibilities. Although usually limited in detail, some descriptions were able to provide insight on the investment barriers targeted by the respective schemes. This was mostly in the case of descriptions that explicitly referred to instruments' favourable financing terms, reduced collateral requirements or subordinated position, from which it was possible

[117] The set of barriers considered are those identified by WG participants as most relevant and presented in Section 2.3

to infer the instrument's relevance for improving the financing conditions of underlying investments.

- **Instrument-specific characteristics**: In the case of instruments accompanied by more detailed guidelines, their relevance for addressing investment barriers was inferred from instrument-specific features that signalled relevance towards particular barriers. Some examples of such characteristics include:
  - **Targeted beneficiaries**: For instruments targeting beneficiaries who have not traditionally been key actors in energy production e.g., energy communities or beneficiaries in rural areas it was generally possible to infer the instrument was promoting greater citizen engagement in local clean energy solutions.
  - **Targeted technology and innovation level**: For instruments targeting mainly newer technologies and innovative projects it was generally possible to infer instruments' relevance for addressing restrictions in availability of finance, which typically affect less-established technologies.
  - **Eligible investments and project costs**: For instruments considering project and document preparation costs as eligible expenses covered by the instrument it was generally possible to infer instruments' relevance for addressing limitations in promoters' planning and preparation capacity.

However, some methodological caveats should be taken into consideration when reading the results presented below. The information presented in the graphs below should be interpreted as general trends rather than exact matches between instruments and specific barriers.

This is because of two main reasons: (i) **Most instruments do not only target energy production** projects, so the barriers identified as relevant may also be in relation to other segments of the energy value chain. (ii) Most **barriers are correlated**, meaning that they are caused by intertwined conditions that might also lead to other barriers. For instance, a new, innovative, and not-yet-tested technology might face heavy administrative requirements due to such technology not yet being regulated. At the same time, it might also be subject to worse financing conditions compared to other more mature technologies due to its perceived technology or market risk. Furthermore, the company might struggle to hire workforce with the right qualifications to operate such a new technology. These four barriers all stem from the fact that the project is based on a new and innovative technology but are counted as different as they affect different aspects of the project. This of course poses challenges in the identification of barriers addressed by different instruments, as, from a theoretical perspective, addressing one barrier might also, indirectly and partially, address other barriers (e.g., reducing the technology risk exposure of an investor might increase the overall availability of financing, as the investor has to bear less risk and can thus invest more if willing to do so).

Financial instruments for energy production investments target mostly investment barriers related to availability of finance, financing conditions and market risk of energy investments. The results of the mapping confirmed the expected relevance of instruments for the first two types of barriers, across all types of instruments considered (see Figure 40 below). Around 90% of mapped instruments across the main instrument categories (loans, grants, equities and guarantees) address restrictions in the availability of finance and approximately 50% address restrictions in financing conditions.

Figure 40: Number of times investment barriers were identified as being "addressed" or "partially addressed" by the mapped financial instruments - by type of barrier

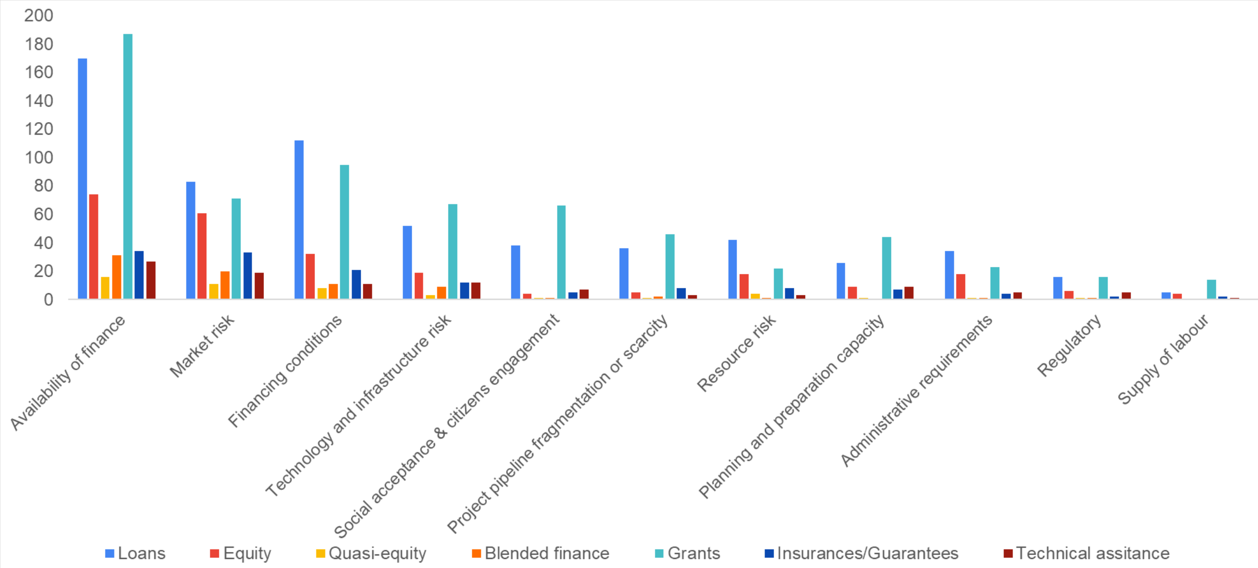


Table 6: Percentage of instruments mapped and identified as "addressing" or "partially addressing" particular barriers

	Availability of finance	Market risk	Financi-ng conditions	Techno-ogy and infrastructure risk	Social acceptance & citizen	Project pipeline fragmentation or	Resource risk	Planning and preparation	Administrative requirements	Regulatory risk	Supply of labour
Loans	86%	42%	57%	26%	19%	18%	21%	13%	17%	8%	3%
Equity	90%	74%	39%	23%	5%	6%	22%	11%	22%	7%	5%
Quasi-equity	94%	65%	47%	18%	6%	6%	24%	6%	6%	6%	0%
Blended finance	89%	57%	31%	26%	3%	6%	3%	0%	3%	3%	0%
Grants	99%	38%	50%	35%	35%	24%	12%	23%	12%	8%	7%
Insurances& Guarantees	89%	87%	55%	32%	13%	21%	21%	18%	11%	5%	5%
Technical assistance	84%	59%	34%	38%	22%	9%	9%	28%	16%	16%	3%

Source: Mapping

Bottlenecks in the financing conditions were found to be mostly targeted by loans and guarantees, followed by grants and quasi-equity. Loans (57%) and guarantees (55%) can address this barrier through the reduction of risk exposure that the financial intermediary is subject to. By covering part of the credit risk that, for instance, a bank takes when providing a loan to a renewable energy company, loans and guarantees **reduce the amount of risk that the bank needs to cover through interest rates and collateral**. Because of this, financing conditions applied to the loan financing improve. Guarantees can improve financing conditions also from a project promoter point of view. In the case of an energy production plant, selling the electricity produced at certain prices is essential for the long-term financial viability of the plant, which is a main element analysed by banks when deciding whether to provide financing and at what conditions. This viability can be achieved through long-term PPAs, which are, however, not often used due to varying energy prices. A guarantee on such PPAs would reduce risk exposure for those providing the PPAs, thus allowing a greater use of long-term PPAs which, in turn, improve the attractiveness of a renewable energy production plant for banks, who will provide financing at better financing conditions. Other instruments such as **blended schemes and grants** can also tackle financing conditions by reducing the amount of private capital needed, and thus reducing the amount of financing that the project promoter would need to seek.

Market risk is also identified as one of the most relevant barriers in the mapping[118]. In the case of **subsidised loans and grants**, their relevance in addressing market risk stems from the financial incentive these instruments provide to beneficiaries for **bearing the upfront cost** that will translate in **future energy savings** (e.g., investments in residential RE installations). The mapping provides some evidence in favour of this hypothesis, as around 70% of instruments found relevant in addressing market risk covered energy services and prosumers in addition to energy production. In relation to the mapped **equity** instruments addressing market risk, these could reflect the role of **public equity schemes in de-risking new technologies and innovative demonstration projects**. While investors may have some visibility on the future revenue stream of new technologies, unstable energy prices may still pose a risk to future revenues and raise the risk profile of investments in new clean energy innovations. Publicly supported schemes, such as EIB's InnovFin Energy Demonstration projects[119], could therefore be necessary to crowd in private investors and mobilise equity financing for innovative projects in the field of renewable energy technologies.

Technology and infrastructure risk was mostly being targeted by grants, guarantees, **and technical assistance** schemes, with c. 35% of such mapped instruments addressing this barrier. A detailed assessment at the level of individual technologies was not possible due to the extreme variety of solutions using the same technology[120]. That being said, the mapping identified a limited number of instruments which were identified as targeting technology and infrastructure risks in ocean technologies (whether exclusively or combined with other technologies). All such three instruments were grants, which supports the relevance of this type of support scheme for promoting **low-TRL** energy production technologies. According to the mapping, out of the 108 instruments mapped as being available for energy production and targeting technology and infrastructure risks, most of them (79) are **technology neutral**, which could reflect the intention of entities implementing financial instruments to keep instruments' eligibilities as broad as possible and let the market pick the winners, while still allowing for technology risks to be addressed when relevant on a project-by-project basis.

Social acceptance and citizen engagement is partially targeted through grants and loans, but in general financial instruments are not the most relevant way of addressing them. The identified examples were mainly in relation to schemes for companies and households promoting building upgrades and RE installations. Particularly for grants, this finding is in line with theoretical predictions that they can improve citizen engagement for investments outside the household/company's core needs. This is the case, for instance, when citizens are potentially interested in installing PV panels in their households or companies, but such an investment is not a priority if there are not sufficiently strong economic incentives. If they need to bear the upfront costs on their own, citizens might refrain from investing. However, if part of

[118] Market risk is typically thought of with utility scale renewables in mind, where FiTs and PPAs (rather than financial support schemes) are effective in reducing this type of risk. As the mapping did not consider PPAs, results obtained can be reconciled if one considers how market risk affects target beneficiaries in our sample, primarily SMEs, public entities and households. For these beneficiaries, market risk can manifest in uncertain future electricity prices making it difficult to plan for RE investments involving self-consumption. Fluctuating energy prices reduce the incentive to install RE equipment, as the benefit this would bring is uncertain and periods of low energy prices might not make it worth from a financial perspective. Similarly, for utility companies, unstable energy prices mean unstable revenues and without certainty on future prices, banks and investors might be reluctant to provide financing to utilities.

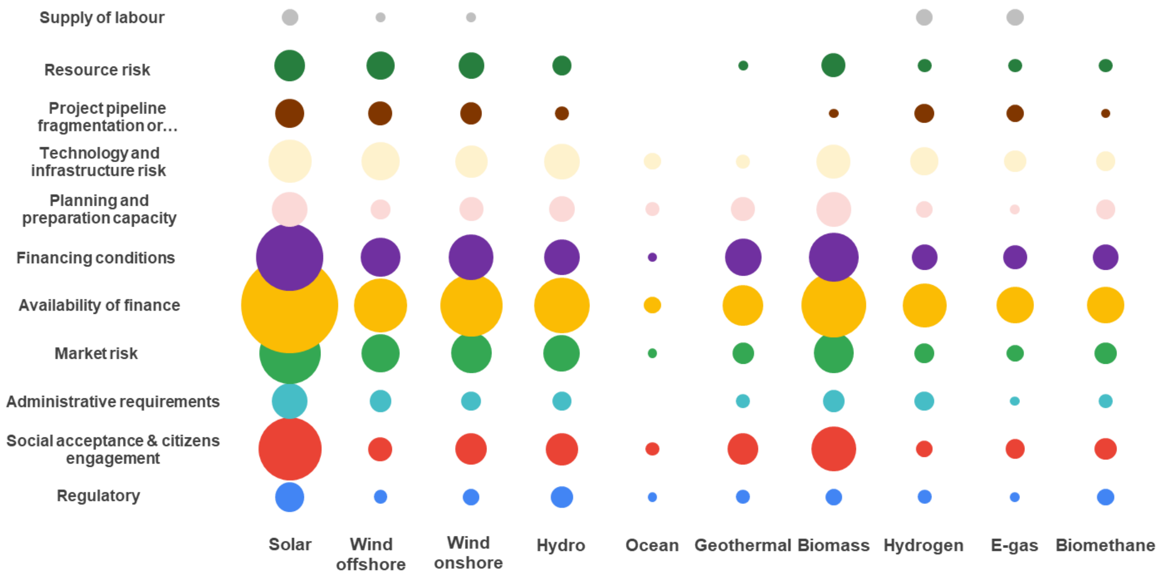
[119] European Investment Bank. InnovFin Energy Demo Projects. https://www.eib.org/en/products/mandates-partnerships/innovfin/products/energy-demo-projects.htm

[120] The mapping only considers broad technology categories such as Solar, whereas TRL differences are mostly evident at sub-category level e.g. concentrated PV (considered mature) vs. perovskite solar cell (considered emerging).

the cost is either directly covered or reimbursed by a subsidy, then they might opt to undertake the investment, thus contributing to the achievement of EU's climate objectives and goal.

The above findings obtained from the entire sample of mapped instruments are also largely reflected in the sub-sample of **technology-specific** instruments. Financial instruments for specific energy production technologies target mostly investment barriers related to availability of finance, financing conditions and market risk of energy investments (see Figure 41 below). Social acceptance and citizen engagement and technology and infrastructure risk are also relevant barriers. Financial instruments for solar and biomass energy investments are particularly relevant for targeting social barriers related to citizen engagement. This is likely to reflect the ability of financial instruments to **improve individuals' economic incentives** for undertaking such type of relatively simple/ smaller scale RE investments.

Figure 41: Number of instruments targeting barriers by energy production technology



As expected, financial instruments were not found relevant for addressing regulatory barriers or those related to supply of labour. Subsidies or private sector investments would not do much to address the shortage of skilled and qualified labour. This barrier would be best addressed through a wider upskilling programme that includes relevant courses. Similarly, regulatory barriers cannot effectively or efficiently be addressed through financial schemes, as they require regulatory and/or legislative changes to the framework governing that sector and can also be influenced by political decisions. Working Group members noted that the huge expansion of renewable energy needed to meet 2030 targets will only be possible if Europe has the right **energy market design** in place, which should seek **to avoid market distortions** as governments take measures to support vulnerable consumers in the current energy crisis.

A similar situation applies to the barriers related to administrative requirements and resource risks, which are caused by elements outside the financial market landscape, despite affecting it. Although these barriers found more relevance in the mapping compared to regulatory and labour-related risks, financial instruments are still an insufficient tool to tackle such barriers effectively. Responding to risks in the supply of key raw materials needed for the construction of RE projects will require a more holistic policy response, where better access to finance for strategic supply chain projects is likely to be one of several measures needed to build more resilient supply chains[121]. The concept of regulatory sandboxes could serve the purpose as well, with clear direction to national/regional permitting bodies to decrease permitting time by factor X.

The findings indicate there is further need for (i) instruments that at design level facilitate the aggregation of small projects and (ii) instruments combining technical assistance support with financial support. Barriers related to **project pipeline fragmentation or scarcity**, and to **planning and preparation capacity** were identified in a minority of cases as being at least partially addressed by the mapped instruments. Recent studies have also highlighted the need for aggregation of small-scale RE projects[122] and for enhanced technical assistance to local authorities, particularly when it comes to understanding and using available resources for decarbonising their building stock[123]. The fragmentation and small size of projects is something that could be better targeted through new or revised financial support schemes. This would be addressed not through the provision of financing per se, but rather through instruments' design and capacity to aggregate small projects under common eligibilities, allowing private investors to co-finance such schemes with meaningful ticket sizes. Issues related to planning and preparation could be addressed through additional technical assistance programmes coupled with existing financial support schemes.

4.2. Evidence on the effectiveness of financial instruments: Findings from the mapping

Effectiveness of a financial support scheme can be defined as the instrument's capacity to achieve its objectives and targets, intended as addressing barriers and market failures, make a project bankable, mobilising additional financing, and contributing to the achievement of energy and climate objectives.

However, this type of assessment can be done only once the scheme has been fully deployed and when the projects that have received financing are completed. Since the mapping exercise covered only ongoing and recently closed financial schemes, only in very few cases was there an available analysis on instruments' effectiveness so far. Quantitative and qualitative metrics on the deployment and impacts of the schemes are not yet available. Data on resources disbursed, financing crowded-in, GW of new capacity installed and jobs created will likely be public only once mid-term and ex-post evaluations are conducted. This is not the case for the large majority of instruments mapped.

Given these limitations in data availability, the analysis of effectiveness has been structured around the factors supporting effectiveness, that is the characteristics and features that a financial support scheme can have that are functional to its effectiveness. These factors were defined based on consultations with WG members and other stakeholders from different Member States. **The three main factors identified as key for effectiveness are: broad and flexible scope of application, long-term stability and visibility, and accessibility**, intended as having an easy, periodic, and rapid application process. Based on the findings from the mapping, it was possible to assess to what extent some of these factors

[121] Critical_Raw_Materials_Act__securing_the_new_gas_oil_at_the_heart_of_our_economy_I_Blog_of_Commissioner_Thierry_Breton.pdf

[122] Malhotra, A., Schmidt, T.S., Haelg, L., Waissbein, O., 2017. Scaling up finance for off-grid renewable energy: The role of aggregation and spatial diversification in derisking investments in mini-grids for rural electrification in India. Energy Policy 108, 657–672.
Manasseh Obi, Tylor Slay, Robert Bass, Distributed energy resource aggregation using customer-owned equipment: A review of literature and standards, Energy Reports, Volume 6, 2020. https://www.sciencedirect.com/science/article/pii/S2352484720312853
ENTSO-E. Aggregation of small-scale demand. https://www.entsoe.eu/Technopedia/techsheets/aggregation-of-small-scale-demand
Combination of financial instruments and grants, fi-compass Factsheet, May 2021

[123] Technical assistance: Local authorities needs and upcoming policy, BuildUpon, November 2021

are present in existing financial support schemes, and provide examples of effectiveness in addressing barriers to investment and in mobilising additional financing.

Enabling factors for instruments' effectiveness

Broad and flexible scope

A technology neutral and sector agnostic instrument profile was generally pointed as useful to support the effectiveness of instruments. WG members agreed that a **broad and flexible scope**, understood as an instrument's capacity to finance different types of technologies, sectors, projects, and projects sizes are important for the instrument's effectiveness. Technology and sector neutrality help simplifying a financial instrument and broaden its scope and eligibilities for underlying projects and final recipients. As such, simpler specifications can support instrument deployment in broad sectors like energy investments, by facilitating the integration of different RES technologies financing in existing standard instruments (e.g., standard loans to SME with RE component) or by enabling combinations of interventions (e.g., RE and EE refurbishments) under the same project, such as in the case of residential energy efficiency instrument in Lithuania, which combine solar, geothermal and heat pumps in multi-apartment dwellings[124].

Long-term stability and visibility

The stability of the instrument over long-term, intended as both the regular provision of financing, and the lack of unforeseen changes occurring during the instrument's lifetime helps creating trust among investors, thus incentivising them to invest. Sudden and unforeseen changes would negatively affect investors' trust and confidence in the instrument, reducing their engagement with the instrument.

Furthermore, the process for ideating, developing and structuring a project is long and complex, and requires **project promoters to have visibility on the long-term conditions on which the project will be implemented**, so as to adequately plan their business and financial models. Even smaller changes in application requirements, eligibility criteria, or instrument functioning can derail the project preparation.

Long-term stability and visibility can however only be assessed in the long-term. Since the mapping covered ongoing and new instruments, it was not able to capture this aspect. Nonetheless, this feature should be taken into consideration for the development of future new financial support schemes, as pointed out in discussions in the Working Group on Energy Production.

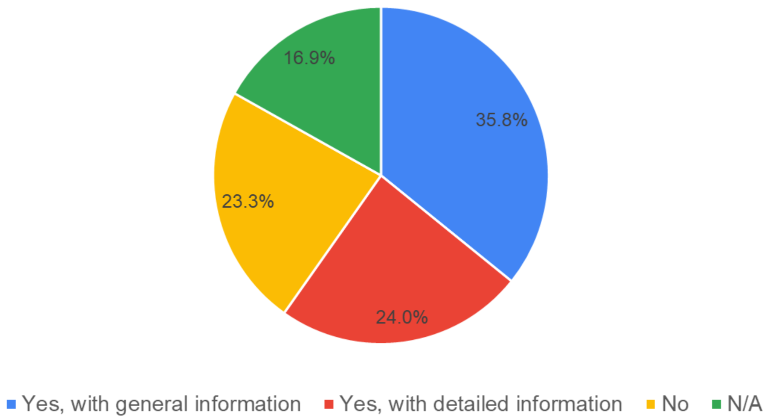
Easy, periodic, and rapid application process (Accessibility)

A key element of an instrument's effectiveness is the ability of a potential project promoter to apply for it, understood as an **instrument's accessibility**. This was confirmed by multiple discussions with WG members. Regardless of the scope, financing conditions, and type of financing provided, the instrument will not be able to achieve its objectives and contribute to the decarbonisation of the energy sector if potential project promoters are not interested in applying to it, or do not qualify for financing because they submitted an incomplete or wrong application.

A potential project promoter would apply to get financing from a financial instrument only if the effort required to submit such an application is acceptable in relation to the

[124] Fi-compass. Residential energy efficiency financial instrument in Lithuania. https://www.fi-compass.eu/sites/default/files/publications/Residential%20energy%20efficiency%20financial%20instruments%20in%20Lithuania_2.pdf

Figure 42: Share of instruments with and without an application manual



amount of financing to be received, and the likelihood of success. For each individual project promoter and project there is going to be a "breakeven" point from which the amount and/or type of financing to be received is not worth the effort necessary to comply with the application requirements. Indeed, application processes with too many requirements or instruments with burdensome monitoring and reporting requirements will likely be perceived as less interesting from potential project promoters. This phenomenon is even more relevant for SMEs and start-ups, as they can often rely on a smaller pool of personnel, often without dedicated figure(s), to take care of different administrative requirements and commitments compared to larger companies. For this reason, an instrument's effectiveness is also affected by its accessibility to all types of project promoters. In this context, an instrument's accessibility is assessed against four criteria: the availability of an application manual, the application periodicity, the length of the application in terms of number of pages that needs to be submitted in the application, and the possibility to contact the implementing authority to ask questions and clarifications.

Out of the 468 financial support schemes mapped as available for energy production, only 278 of them have an application manual available to potential applicants. Most of the instruments with an application manual are either grants (121) or loans (115), followed by equity (57), and guarantees (27)[125]. Of these 278, 111 (40%) had an application manual with detailed information on the application process and requirements, and 167 (60%) had an application manual with more general information on the process, but without going into details on the different steps, leaving to the applicants to understand the requirements. Finally, for 190 of them (23.3%) no application manual was identified.

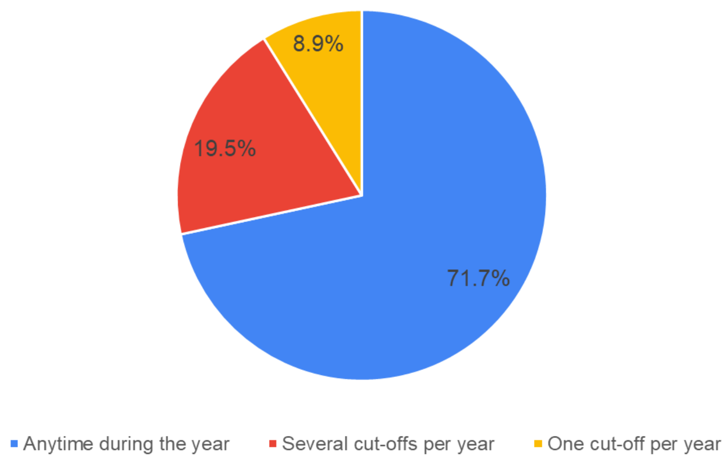
While the availability of an application manual is not a guarantee of effectiveness, it does nonetheless contribute to reducing errors in applications and helps making the instrument application process clearer and easier to follow. These characteristics were highlighted by WG members as important for instruments to be attractive. The application manual may also include aspects of investor strategy, which help potential beneficiaries to understand the ambition and investment rationale and thereby establish, whether they are a fit to the investments targeted. As mentioned above, the manual does not affect the effectiveness of the instrument per se, but it rather reduces the possibilities that smaller project promoters (often without dedicated staff for these administrative processes) do not receive financing because of administrative or bureaucratic mistakes committed during the application process.

The second factor analysed when it comes to accessibility is the **periodicity of the application window**. The assumption made in this case is that an instrument for which promoters can apply at any given moment in time (i.e., on a rolling basis) is more accessible compared to one that has limited cut-off windows. This is because projects might follow timelines that are not aligned with an application's timeframes. Because of this, project promoters might not be eligible for it or might not decide to apply for it, thus negatively affecting

[125] Double counting possible.

the absorption of that instrument and, consequently, its effectiveness. For the majority of instruments for energy production (293) it was possible to identify the timing of the application period. For most instruments (210), applications are also possible anytime during the year. This gives greater flexibility to applicants, as they are less restricted in terms of when they can apply. For 57 instruments there are several application windows per year, but it is not possible to apply anytime, and for 26 instruments there is only one application window per year[126]. This latter figure includes instruments for which only one application period was/is envisaged.

Figure 43: Energy production instruments by application period[127]



A large majority of the mapped instruments can receive applications throughout the whole year. This should be interpreted as a positive fact in terms of accessibility, as project promoters can prepare their applications without specific concerns and restrictions in terms of timing. Furthermore, as remarked by some WG members during the third batch of meetings, the possibility to apply throughout the whole year makes it easier to plan and implement a company's business and technology roadmap.

The third element analysed in terms of accessibility is the **length of applications**, measured in number of pages of documentation, in paper or digital format, that an applicant has to submit in order to comply with the instrument's requirements. Like for the previous two elements analysed in this section, the length of an application is not a synonym of the effectiveness of an instrument. However, **shorter applications can be generally linked to fewer administrative and bureaucratic requirements**, as less documents, extracts, certificates, and so on are required to be submitted. This would thus make the application process easier and faster for the applicants, reducing the chances that the applicant gives up on applying due to the excessive administrative requirements. Furthermore, a faster preparation of the application could also decrease the time-to-market[128], and thus increase the investment return.

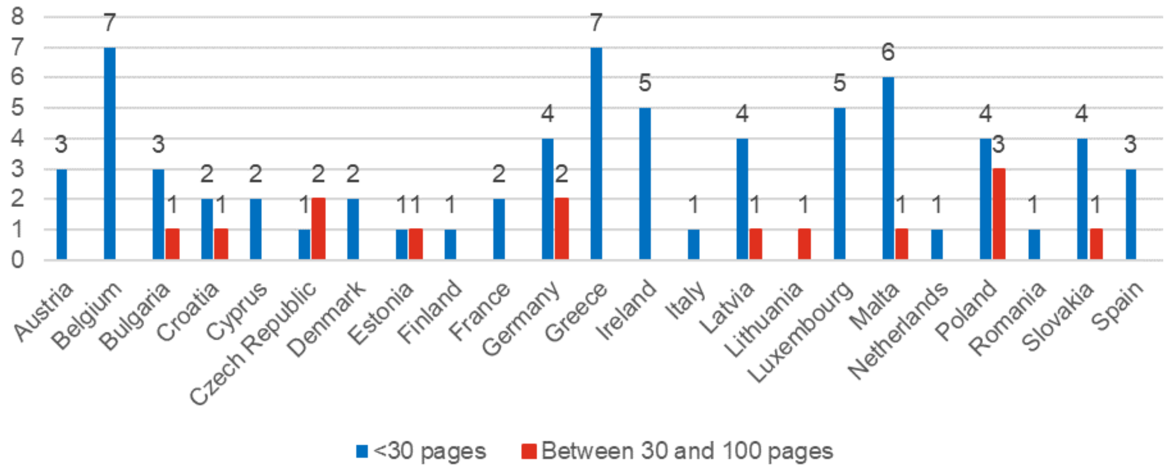
During the mapping exercise, it was possible to gather information on the average length of an application for only 83 instruments available for energy production. This does not come as a surprise, as applications are usually not made available to the public and is thus difficult to obtain information on this. Out of the 83 instruments, the large majority of them (69) usually require applications up to 30 page-long. Following, 14 instruments generally require between 30 and 100 pages of application. For none of the mapped instruments applications longer than 100 pages were identified.

[126] It should be noted that application windows might differ significantly in terms of duration. This difference is not reflected in the mapping and, consequently, in this analysis.

[127] Methodological note: Data on application period available for 304 instruments.

[128] The time-to-market is influenced by numerous other factors other than the time necessary to prepare the application.

Figure 44: Number of schemes for which it was possible to assess the application length, per member State



Finally, the last element considered under the accessibility analysis is the **possibility to contact the implementing entity** to ask questions and clarifications. Ideally, there should be the possibility to interact with the investor before submitting an application. This would serve especially the beneficiaries which could confirm fit to investment strategy before engaging in the potentially effort-heavy application process. This was considered important as different project promoters might face very different situations and have very different questions and conditions, which might not all be clearly addressed in the instrument's website or application manual. For this reason, having the possibility to reach out to the implementing entity to ask for clarifications is important and particularly useful for potential applicants, but also for the investors, which thereby avoid screening of applications which do not match the investments targeted. Information on whether or not it is possible to contact the implementing entity with questions on the instrument was found for 108 instruments at Member State level available for energy production projects. For 104 of these it is possible, and only for 4 of them it is not. However, it should be noted that for the large majority of the instruments mapped it was not possible to clearly determine whether contact channels were established.

It was possible to identify three instruments having all the "ideal" characteristics for an instrument effectiveness from the accessibility point of view[129], by doing a cross analysis of all the financial support schemes available for energy production. These three instruments come with an application manual with detailed information, offer the possibility to contact the implementing authority with questions and inquiries, have on average applications below 30 pages, and it is possible to apply to them anytime during the year. Two of these instruments are in Croatia, both implemented by the Croatian Bank for Reconstruction and Development, and one in Latvia, implemented by Swedbank. All three instruments are loans, the two in Croatia funded by the NRRP resources, and the one in Latvia by Swedbank's own resources. Two out of the three instruments, one in Croatia and one in Latvia, are available for the whole energy value chain, thus potentially financing projects also in transmission and distribution, storage, heating and cooling, and prosumers. Neither of them targets households, and one of them targets only public sector entities, whereas only the instrument in Latvia is available also for mid-caps and larger companies.

All the other instruments mapped present are characterised by different combinations of these features (e.g., short applications but only one cut-off per year, etc.). While this does not mean that those instruments are less effective than the three mentioned above, from a beneficiary/applicant perspective they represent a bigger effort to apply to. Ideally, according to consulted WG members, instruments should keep bureaucratic and administrative

[129] This does not mean that these are the only instruments having these characteristics, but rather that these are the only instruments for which it was possible to map these characteristics.

requirements at a minimum necessary, so as to avoid burdening beneficiaries, particularly start-ups and SMEs. This should also result in faster and easier application processes that smaller companies and households can complete without having to rely on external support and help.

The **visibility of available instruments** was also pointed out by WG members as a challenge to instruments' accessibility and, therefore, effectiveness. While not specific to any individual scheme, WG members noted that the number of financial support schemes in some countries make it difficult for project promoters and investors to have complete visibility on the options available to support investments. On this matter, **one-stop-shops** were valued positively by WG members as a possible solution to the fragmentation and low visibility that financial support scheme can have.

Examples of effectiveness

Effectiveness in addressing barriers: evidence from the mapping and case studies

The mapping identified a number of financial support schemes with evidence on their effectiveness in addressing barriers, summarized in the table below. As the mapping concentrated on ongoing instruments for which there are no formal evaluations yet, evidence was primarily collected from available news and press releases reporting on instruments' results and impacts achieved so far, as well as feedback from stakeholders consulted in the process of data collection and the views of WG members shared in the context of the Investor Dialogue on Energy.

Grant schemes found to be effective have attracted a high number of applications and supported many projects. This suggests the schemes are effective in **improving access to finance for target beneficiaries** and in **strengthening the economic incentives** for RE investments. Examples include Spain's CE Implementa, a scheme for pilot projects of energy communities which already selected 45 projects for grant financing[130] and Luxembourg's PRIMe House initiative which provided €11 M of subsidies to more than 200 energy renovation and construction projects in a period of nine months. These examples also show the role grants can play in raising awareness and **stimulating greater citizen engagement** for local energy projects.

In relation to **loan instruments**, the RRP Greek Loan Facility is an example of an instrument with a large budget **making use of different distribution channels to improve access to finance** for Greek businesses (including in the RE sector). RRF loans are managed by the EBRD (up to €500 M), the EIB (€5bn) and six commercial banks in Greece. The scheme has thus far been effective in **catalysing important projects in Greece's energy sector**, including investments in transmission and distribution and large energy efficiency projects in industry. The instrument's relevance has been recognised in a recent study by the European Commission[131], which pointed out that the compartments managed by the EBRD have received active interest from the private sector.

In relation to **equity instruments**, the mapping identified three schemes with evidence of targeting barriers across different types of investments:

- Italy's IEFF II equity scheme specializes in **energy efficiency and small-scale RES projects** and has been effective in **amplifying the available sources of capital** for sectors that have traditionally struggled to attract investment. The scheme's effectiveness can be seen through the Fund's raising of around €130 million at first close, above the initial target of €100 million. Supported by the EIB, the Fund has

[130] The results achieved by the programme as of June 2022 exceed the implementing entity's initial target of selecting 40 projects.

[131] Study providing analytical support for the financial instruments and programmes to facilitate investment in the energy sector: the Recovery and Resilience Facility, European Commission, December 2022

successfully mobilised capital from institutional investors and family offices for investments in the residential, energy community and heating & cooling sectors.

- Estonia's Green Fund scheme targets **green technology companies** and seeks to address the **shortage in capital** for innovative green products, services and technologies. Benefiting from a contribution of €100m in RRF funds, this instrument aims to mobilise additional resources from venture capital funds for innovative companies. The scheme's effectiveness so far can be seen through the **interest it has generated among private fund managers**, who showed good responsiveness to the scheme's recent fund call[132].
- The Eiffel Transition Infrastructure fund specializes in **larger RES infrastructure projects** and provides a pioneering solution to **financing gaps during the RES project development phase.** The Fund provides equity or quasi equity bridge facilities to finance project development activities (e.g., securing the land designing the project engineering) which can take years and are capital intensive. The provision of this type of innovative financial product is expected to **accelerate the development** of RE assets and the deployment of clean energy in Europe. The scheme's effectiveness so far can be seen through the commitments secured by several top tier institutional investors including the EIF (as sponsor of the initiative), Allianz, Abeille Assurances, and others. In addition, the scheme has already concluded its first inaugural investments, supporting the construction of solar assets in Ireland and Italy.

In relation to **guarantees**, the portfolio guarantee agreement signed recently between Mano Bankas, a Lithuanian bank, and the EIF under InvestEU is an example of an instrument with **good potential to increase commercial financing available to RE projects.** The guarantee covers loans to SMEs under two key policy areas – sustainability and competitiveness. The establishment of two broad areas of eligible investments suggests the instrument strikes a good balance between incentivising particular types of projects and remaining broad enough to accommodate investments across different sectors. Although the scheme is too recent to observe its results, Mano Bankas expects that it will be able to start financing new RE projects **earlier during their construction and development phase.** This suggests the guarantee is important in de-risking phases of the RE project cycle that were perceived too risky for the bank to invest in.

Effective bond instruments identified through desk research include recent green bond issuances by UBI Banca, a commercial bank in Italy (now Intesa Sanpaolo) and Instituto de Crédito Oficial (ICO), an NPB in Spain. In both cases, green bonds were effective in **improving the availability of diverse and medium to long-term capital sources** for renewable energy investments. This could be seen through investors' **high demand for the bond** (order book exceeding x2 times nominal bond value) allowing a narrowing of the initial spread, as well as from the varied geographic or thematic profile of interested investors (55% of ICO's latest green bond emission was subscribed by sustainable investors).

[132] SmartCap's recent call to select up to two private fund managers for establishing and managing green technology investment funds received six applications.

Table 7: Examples of mapped instruments[133] considered effective in addressing barriers

Instrument name	Instrument type	Instrument description	Country	Barriers addressed	Evidence of Effectiveness
Energy Technology Development and Demonstration Programme (EUDP)	Grant	Grant scheme to support work by enterprises and universities on demonstration of new green energy technologies.	Denmark	Bridging initial financing gap for innovative projects	Applications for funding as of March 2022 more than three times the size of the grant pool.
Programa CE-IMPLEMENTA	Grant	Grant scheme to support pilot projects of energy communities.	Spain	Availability of finance for energy communities Limitations in citizen engagement	Number of applications received and projects selected as of June 2022, compared to initial estimates by implementing entity.
PRIMe House Initiative	Grant	Grant scheme for residential energy renovations	Luxembourg	Lack of sufficiently strong incentives for residential RE investments	Volume of financing and number of subsidies granted during the first nine months of the programme
RRP Greek Loan Facility	Loan	Broad loan instrument with eligibilities that include energy efficiency in industry; Renewable energy production; Energy infrastructure	Greece	Availability of finance at advantageous conditions for energy investments	Active interest from the private sector in RRF projects co-financed by EBRD
IEEF II – Italian Energy Efficiency Fund II	Equity	Closed-end alternative investment fund focused on energy transition projects.	Italy	Availability of equity financing for small RE projects	Fund achieved first close in Aug 2020 1.3 times above the initial minimum target.
Smartcap green technology investment fund	Equity	Investment programme for green technology companies, offering direct investments and investments in private venture capital funds	Estonia	Availability of private capital for innovative green technology companies	Number of applications received by private fund managers to the scheme's recent fund call

133 Bond instruments included in this table were identified through press releases issued by UBI Banca and ICO and are not included in the mapping.

Instrument name	Instrument type	Instrument description	Country	Barriers addressed	Evidence of Effectiveness
Eiffel Transition Infrastructure Fund	Equity	Innovative fund providing equity bridge financing for RE infrastructure assets in Europe	France & EU	Availability of bridge capital for RE projects	Participation of top tier institutional investors to fund's first close and successful execution of inaugural investment
Mano Bankas & EIF InvestEU agreement	Guarantee	Portfolio guarantee for loans to SMEs (focus on sustainability and recovery from Covid19)	Lithuania	Availability of finance during development stage of RE projects	Expectation that bank will begin to finance RE projects during earlier stages of development and construction
Intesa Sanpaolo (ex-UBI Banca) April 2019 green bond issuance	Bond	5-year green bond whose proceeds are allocated to refinance a selected RE project finance portfolio	Italy	Availability of medium/long-term financing for RE projects	Size of the demand expressed by the market, geographical distribution of investors and final pricing achieved.
ICO May 2022 green bond issuance	Bond	4.5-year green bond to finance sustainable projects of Spanish companies.	Spain	Availability of medium/long-term financing for RE projects	Size of the demand expressed by the market, geographical distribution of investors and final pricing achieved.

Further insight on the role financial instruments can play in addressing investment barriers for clean energy projects can be gained from two additional case studies shown below. The first scheme concerns Denmark's EUDP programme included in the table above and for which additional information was obtained from an interview with an EUDP representative. The second scheme concerns support for energy efficiency and renewable energy investments in multi-apartment buildings in Latvia, identified through desk research.

Box 19: Case study on EUDP by the Danish Energy Agency

The Energy Technology Development and Demonstration Program, run by the Danish Energy Agency, is a structured funding program that each year provides technology-neutral grants to projects in the energy field. Since its establishment in 2007, it has supported **more than 1,000 innovative projects** with about DKK 5.7 billion (€765.6 million) on aggregate. Every year, there are **several cut-off dates for presenting projects**.

During an interview with an EUDP representative, it has been stated how the rationale behind this project and its longstanding success is to **help innovative projects in crowding in initial resources to accelerate the business** after selecting them based on nine criteria such as innovation height, climate-policy targets, and commercialization potential. Given its success, **the programme has not seen many changes during the 15 years it has been operational**, proving the benefits of long-term stability and consistency in the public financing offer. The EUDP representative confirmed that the programme seeks to provide applicants with good predictability on the scope, financing model and next application deadlines candidates can expect, to ensure a good visibility of the instrument for interested projects.

Over the time dedicated to the collaboration with EUDP, projects are expected to find a self-financed amount of money that is the same size of public funding. When the collaboration with EUDP is over, there is still the possibility to receive support from another public entity, namely the Danish Green Investment Fund, which however does co-financing through loans. Reaching the completion of EUDP, it is expected that **projects can seek more and different types of funding** to get ready for the market. Those which have been in the program then perform better than their peers which have not in attracting further resources.

Source: PwC

The example from EUDP shows how a broad scope (evidenced through technology neutrality) and long-term stability and visibility can support a financing scheme in reaching its objectives. Indeed, the programme has been successful in **bridging the initial financing gap** affecting innovative energy projects during their demonstration and early development phases, where market failures (e.g., imperfect information about the performance and risks of new innovations) are likely to be most acute. The case study is also a good example of how different publicly supported financing schemes, in this case grants and loans, can be complemented to assist a business through its different development phases until it is ready to access commercial finance from the market. The scheme's effectiveness can be seen through the high number of innovative projects supported to date and from the observation that, by the end of the program, beneficiaries tend to perform better in attracting additional financing resources compared to projects that did not benefit from EUDP.

The second case study provides additional evidence on the role of a broad and flexible scope and good accessibility in supporting an instrument's effectiveness. The requirement for **a single application** to benefit for loan and grant support suggests the instrument offered by ALTUM **simplified administrative requirements and improved accessibility** for applicants interested in benefiting from the program. With a **broad and flexible scope**, the instrument was able to cover EE and RE investments and to offer loans for applicants who were rejected by commercial banks. The evidence suggests the instrument was effective in **addressing restrictions in access to finance** for the EE/RE residential sector in Latvia, including for riskier clients who may struggle in securing commercial financing regardless of investments having positive externalities. This can be seen through the instrument's **high leverage effect** and from the **high number of contracts signed** with final recipients, including during the crisis year of 2020.

Box 20: Case Study on Financial instruments by ALTUM: Energy Efficiency and Renewable Energies in Multi-Apartment Residential Buildings in Latvia

This Latvian *DME finanšu instruments* supports energy efficiency improvement, smart energy management as well as the use of renewable energy resources at multiapartment residential buildings. The FI is implemented by ALTUM, the national promotional bank of Latvia, and consists of a loan and a guarantee product supported by the ERDF funds. The total commitments from the programme resources to the financial instrument amount to€25 million. In addition, ALTUM manages a separate ERDF grant scheme from which grants cover up to 50% of the eligible costs of the investment. Homeowner associations need to file one single application with their commercial banks to apply for loan and grant support.

ALTUM provides individual guarantees for loans provided by a commercial bank or an alternative investment fund of up to 80% of the principal, for a **period of up to 20 years**. By the end of 2020, there were 172 guaranteed loans signed with final recipients. The total leverage of this guarantee product hit 9.05, meaning that every euro set aside for the ERDF guarantee triggered additional 8 euro of additional investment in Latvia.

Under the same FI, ALTUM also offers **loans for the applicants whose loan application was rejected by their commercial bank**. ALTUM offers a promotional loan covering up to 50% of eligible costs with a repayment term of up to 20 years. Targeting mostly **small projects or houses in less developed areas**, this product tripled the number of contract signed with final recipients from 21 to 61 in the course of the crisis year 2020. Moreover, the ALTUM loans achieved a total leverage effect of 3.74, demonstrating their ability to mobilise significant private investment.

Given the small size of the Latvian market and the relatively large size of the projects supported, DME finanšu instruments proved to be an exemplary delivery mechanism for achieving Union’s climate objectives, while saving energy costs of Latvian households.

Source: Financial instruments under the European Structural and Investment Funds – Situation as of 31 December 2020

Altum’s new EE/RE instrument included in the mapping shows similar characteristics to the instrument identified in the literature. In addition to a loan, grant, and guarantee component, the instrument launched in 2022 includes a technical assistance element. The new instrument has been identified at tackling a number of investment barriers, including **easing administrative requirements** and supporting to close gaps in apartment owners’ **project planning** and **preparation capacities**.

Effectiveness in mobilising private finance

An important element of an instrument’s effectiveness is its multiplier effect, that is the instrument’s capacity to attract additional private financing compared to the instrument’s initial public budget, and channel funds to the targeted projects. By crowding in and unlocking private financing, financial instruments aim to **increase the overall capital available** to achieve EU policy goals more efficiently[134].

[134] In addition to the multiplier effect, impact indicators (e.g., tons of CO2 avoided, jobs created) are also important to assess the effectiveness of financial instruments. This section focuses exclusively on the multiplier effect as the mapping did not provide information on the impact generated by ongoing financial schemes. As such, this section should not be interpreted as a complete evaluation of the effectiveness of instruments in the mapping but rather as a presentation of findings related to their crowd-in potential. Crowding in of private funds in turn remains an important feature of financial instruments, as the initial public budget

Because an instrument's multiplier is usually only calculated as part of evaluations conducted at the end of the instrument's life, the mapping was able to provide very limited information on the achieved multiplier effects or amount of additional investment crowded in. Information on the current multiplier effect was available for two mapped loan instruments implemented by the Croatian Bank for Reconstruction and Development

allocated to an instrument is typically not enough to cover all the investment costs and to ensure a timely deployment of the underlying target investment(s).

(HBOR)[135]. The first instrument, launched in 2021 and targeting micro enterprises and SMEs, achieved a current multiplier effect of 1.18x. The second loan scheme has a broader eligibility of final recipients including SMEs, public sector companies and midcaps and achieved a current multiplier of 3.33x.

Multiplier information on HBOR's active loan schemes can be compared, even if only indicatively, with the multiplier or leverage effect achieved by previous ERDF/CF and EIB loan instruments implemented at EU level[136]. It should be noted that this comparison does not focus on instruments being energy-specific but rather being of the same type, in this case loan instruments. In addition, as calculation methods on the multiplier and leverage effect can vary across the literature, it is not possible to verify that the HBOR instruments and the examples identified in the literature all follow the same multiplier or leverage calculation methodology.

The achieved multiplier effect of the HBOR loan schemes (average multiplier of 2.3x) compares well with the leverage or multiplier of previous ERDF/CF and EIB Covid 19 MBIL loan schemes (leverage or multiplier effect below 2x). EIB's ABS programme loan was a higher-leverage instrument through which capital released from intermediaries' securitised portfolios could be used to generate new lending.

For what concerns the **target multiplier** of instruments in the sample, the table below compares the target multiplier for the main types of instruments in the mapping against the achieved leverage effect for similar types of instruments implemented under ERDF and CF in the 2014-2020 programming period. It should be noted that, in most cases, the mapping considered the target multiplier as the ratio of target private finance attracted based on the amount of public financing. On the other hand, the achieved leverage effect for the instruments included below considers the total amount of finance reaching final recipients divided by the public (ESIF) support. As a result, target multipliers from the mapping are likely to have lower values compared to achieved leverage figures. The information presented below should therefore be used for general observations rather than for making exact comparisons on the effectiveness of current and past instruments. Grants have been excluded from this analysis as the intention behind grant support is not typically to generate simultaneous private co-investment but rather to cover part of the costs of the project and support early-stage projects so that they can access private investment at a later stage.

Table 8: Average target multiplier by type of instrument in the mapping[137]

Type of financial instrument from mapping	Average target multiplier from mapping	Median achieved leverage as at 31 Dec 2020 – financial instruments under ERDF/CF
Loans	1.57x[138] (based on 29 instruments with available target multiplier)	1.3x (based on 451 instruments)

[135] It was not possible to verify the calculation of these multipliers.

[136] ERDF and CF loan instruments implemented from 2014-2020 (aggregate information across 451 instruments) achieved a median leverage of 1.3x as at 31 December 2020. An evaluation of the EIB L4SMEs intermediated lending product for the period 2005-2011 highlighted that loan products like L4SMEs generally provide for limited leverage potential and that leverage can be better achieved through higher risk products (such as equity fund investments), or guarantee/risk sharing products (with higher risk and capital consumption). More recent EIB loan instruments implemented as a response to the Covid-19 crisis achieved multipliers (at mid-2021) of 1.89x (EIB Covid 19 programme loan for MBILs) and 6.81x (EIB Covid 19 programme loan for asset backed securities).

[137] European Commission (2021). Financial instruments under the European Structural and Investment Funds – Summaries of the data on the progress made in financing and implementing the financial instruments for the programming period 2014-2020.

[138] In the case of instruments presenting a numerical range for their targeted multiplier e.g., 1.4-2x, the calculation of the average considered midpoint values (1.7x in given example). Combined loan/guarantee instruments were taken into account both for the calculation of the average target multiplier for loans and separately for guarantees.

Equity	1.17x (based on 3 instruments with available target multiplier)	1.8x (based on 211 instruments)
Guarantees	1.79x(based on 12 instruments with available target multiplier)	4.8x (based on 87 instruments)

Loan instruments in the mapping[139] show on average a multiplier target that is slightly higher than the median leverage achieved by ERDF/CF loan instruments until 2020. This could signal a good potential for current active loan schemes to mobilise private capital for energy projects. Alternatively, results could also be influenced by the fact that many instruments in the mapping were developed during or right after the pandemic, which was characterised by increased bank lending to businesses[140] and a successful avoidance of a credit crunch. These observations may have positively influenced the expected crowd-in potential of new loan instruments.

The average target multiplier observed for the three mapped equity schemes with data on this is slightly lower than the leverage effect achieved by ERDF/CF equity schemes. This could be due to the differences in the multiplier vs. leverage calculation methodology referred to above or due to differences in market conditions and technologies targeted by the schemes in the mapping. Comparing the *Portugal Blue* equity scheme included in the mapping with EIB's Climate Action Fund investments[141] suggests that differences in the maturity of target sectors could be a relevant factor affecting the crowd-in potential of different equity schemes. *Portugal Blue* targets equity investments in the blue economy, which is still a new sector for many investors. This could be a relevant factor behind the scheme's target multiplier of around 1.5x compared to the catalytic effect of 6.5x achieved by EIB's Climate Action Funds, which focused predominantly on wind and solar investments.

Finally, guarantee schemes in the mapping show target multipliers lower than those achieved by ERDF/CF guarantee instruments in recent years. In addition to differences coming from multiplier and leverage calculation methodologies, this could signal some remaining constraints in the current use of guarantees to mobilize large volumes of private capital.

Summary findings on instrument relevance and effectiveness

- **Evidence from the mapping on the relevance of financial instruments for addressing investment barriers** affecting energy production projects indicates that**:**
    1. **Financial instruments for energy production investments are primarily relevant for targeting investment barriers related to the availability of finance, financing conditions and market risk of energy production projects**.
    2. **Financial instruments are not relevant for addressing regulatory barriers or those related to supply of labour**. A similar situation can be said to apply to the barriers related to **administrative requirements** or **resource risks**,

[139] Those with available data on their target multiplier.

[140] At the euro area level, outstanding loans to the non-financial private sector stood at €12.6 trillion before the pandemic crisis, and they increased by approximately 7% by the end of 2021 (European Stability Mechanism, 2022).

[141] https://www.eib.org/attachments/ev/ev_climate_action_eu_2010-2014_en.pdf. The EIB's Climate Action Fund investments are not part of the mapping as this scheme ended in 2014

which are caused by elements outside the financial market landscape, despite affecting it.

3. **The mapping seems to suggest that there is further need for (i) schemes that at design level facilitate the aggregation of smaller projects, and (ii) schemes combining the provision of finance with technical assistance support.** This should support in further tackling barriers related to **project pipeline fragmentation or scarcity**, and to limitations in promoters' **planning and preparation capacity.**

- **Examples of mapped instruments found to be effective in addressing barriers include grants, low-interest loans, equity schemes, a portfolio guarantee instrument and green bonds**[142] **in a number of EU Member States.** In general, evidence of the schemes' effectiveness could be seen from the **interest shown by the private sector** (final beneficiaries, banks, potential equity co-investors) in the different schemes. More specifically, and considering the different types of instruments mapped:

  1. For grant schemes, evidence of their effectiveness in improving availability of finance and the economic incentives for target recipients was seen through a **high number of applications**[143] **and/or a high number of projects supported** under such schemes. However, it should also be noted that the effectiveness of grants might be detrimental for the effectiveness of other schemes due to potential crowding out effect, WG members noted.
  2. Effective loan schemes similarly financed a **large number of projects**, or, in the case of more recent instruments, received **active interest from project promoters and already achieved inaugural investments**.
  3. For equity schemes, evidence of their effectiveness in improving the availability of equity financing for renewable energies and innovative technologies was seen through the schemes' **successful fundraising activities**, or, in the case of more recent schemes, from the **active interest shown by private investors** to co-invest in the schemes.
  4. In the case of the portfolio guarantee agreement concluded recently between EIF and a commercial bank in Lithuania, evidence of the instrument's good potential to de-risk and catalyse RES investments could be seen from the bank's expectation/intention to use the guarantee in order to finance new RES **projects earlier during their construction and development phase.**
  5. In the case of green bond issuances, evidence of their effectiveness in amplifying medium/long-term finance for RES projects was seen through **strong and diverse investor demand for the issued bonds.**

- **The mapping provided limited information on the multiplier effect (current or target) of currently active financial instruments.** Loan instruments from the mapping show on average a slightly higher target multiplier than comparisons from the literature, which could signal a good potential for current active loan schemes to mobilise private capital for energy projects. Equity schemes showed slightly lower results than examples from the literature, while guarantee schemes showed the highest deviation (i.e., lower target multiplier results) compared to examples from the literature. This could be due to differences in multiplier/leverage calculation methodologies as well as due to some remaining constraints in the current use of guarantees to mobilise large volumes of private capital. In addition to the multiplier

[142] As referred in Section 4.2.2., bond instruments were identified through separate desk research and are not included in the mapping.

[143] While the number of applications alone is not sufficient to define the effectiveness of a grant, it is nonetheless essential to define its uptake, attractiveness and visibility in the market, which are key elements of effectiveness

effect, impact indicators (e.g., tons of CO_2 avoided, jobs created) are also important to assess the effectiveness of financial instruments.

Additional financing solutions that were not covered in this Study can be used to invest in energy production. Most notably, **crowdfunding** is gaining increasing traction as means to finance smaller-scale RES plants and leverage ore on local actors to raise financing[144]. Future WG meetings could also deal with this topic, so as to gather WG members' inputs on it.

[144] Renewablesnow. Spanish firm Fundeen starts crowdfunding for 9.6 MWp of Mallorca solar. https://renewablesnow.com/news/spanish-firm-fundeen-starts-crowdfunding-for-96-mwp-of-mallorca-solar-777773/

5. Level of maturity of EU clean energy finance markets

This section analyses the level of maturity of clean energy finance market of EU Member States. The aim is to assess to what extent each State has an energy finance market and overall enabling environment that is fit for delivering the ambitious goals of the EU energy transition agenda. The section is organised as follows:

- Section 5.1 provides an overview of the approach adopted to assess clean energy finance maturity
- Section 5.2 shows the analysis that has been performed to assess the maturity of each Member State

5.1. Approach to assessing market maturity

Financial markets and regulatory systems that are able to efficiently allocate capital to clean energy projects and offer appropriate risk-adjusted returns, are a necessary precondition for clean energy finance mobilisation. Financing the energy transition will also require a large-scale mobilization of private capital, and an enhanced role for international and public finance institutions[145]. This means that the public sector and the private financial sector must be able to jointly provide financing that is (i) adequate in terms of volume (ii) with appropriate and relatively cheap[146] terms and (iii) diversified and covering a broad range of market readiness levels, needs and target beneficiaries/clients.

With these considerations in mind, we have developed a framework to assess the maturity of clean energy finance markets, based on three dimensions. The table below summarises the framework, as well as which indicators and metrics we have selected to assess the three dimensions.

Table 9: Characteristics of mature clean energy finance markets, and how our analysis will assess them

[145] IEA (2021), *Financing clean energy transitions in emerging and developing economies*, available on link

[146] Relatively to specific risk-return conditions and the macroeconomic landscape

Market maturity characteristics	**Description** *Why we have chosen this characteristic*	**Key metric/indicators** *How we will measure it*

Abundant supply of energy finance, primarily from the private sector, with the public sector intervening in underserved markets	• The deployment of renewable power production technologies to mitigate carbon emissions typically requires high upfront investment[147,148]
	• Best (2017)[149] finds that across countries, the availability of financial capital contributes to investments in more capital-intensive energy technologies. For high-income countries, financial capital supports transitions towards more capital-intensive energy technologies such as wind energy.
	• In terms for sources of funding, while it is clear that both public and private clean energy finance are needed, they should play very different roles in financing the energy transition. Public sector financing should be directed to underserved markets, emerging technologies, addressing market failures and investing in riskier areas. Private sector finance, on the other hand, should be able to provide the supply of debt and equity finance needed in the market, covering a wide range of levels of technology maturity with a diverse offer of instruments
		To evaluate the supply of finance, we will use the following indicators:
		• The availability of private finance in each Member State, measured through:
		    ○ Banking debt of corporates
		    ○ Stock market capitalisation
		    ○ Green bond market
		• The availability of public finance to finance renewable energy investments in each Member State.

Low cost of capital - WACC	• The weighted average cost of capital (WACC)[150] is one of the most important financial variables for low-carbon infrastructure, given their capital-intensive nature and high upfront costs (Dukan et al., 2019)[151]. • The WACC incorporates the level of interest rates and several country risks, such as regulatory, economic, political and legal. Furthermore, WACC can also reflect technological advancements and increased experience in the energy financing sector, signalling a high level of maturity. • For these reasons, low values of WACC signal mature energy finance markets and a low country risk.	To evaluate the cost of capital, we have calculated the WACC for renewable energy projects in each Member State.
	• Renewable energy projects are financed mainly with project-level conventional (i.e., non-concessional) debt, which accounted for 32% of the total RE investment in 2017-2018, on average[152].	Comprehensive data on the instruments used for investments in renewable energy is not available. To evaluate the diversity and

Presence of a diverse set of financial instruments, including the use of 'sophisticated' financial instruments, such as bonds and equity, and a low use of grants for mature technologies	• The availability of grants can signal the presence of many early-stage technologies in the market. However, an excessive use of grants signals low maturity of the energy finance market, which is too dependent on free public support. This is especially concerning if grants are deployed for mature technologies that are already capable of accessing private financial markets. • Considering the above, we consider as mature those markets that have a balanced mix of financial instruments, including 'sophisticated' instruments such as bonds and equity. On the other hand, markets that rely solely or mainly on grants and loans can be considered less mature.	comprehensiveness of financial instruments available in each country, we will use the following indicators: • Diversity of financing instruments for renewable energy, measured through a repurposed use of the Herfindahl-Hirschman Index (HHI) • Number of categories of 'sophisticated' financial instruments offered in the Member State. • Grants for rollout stage projects as a % of grant instruments To compute the indicators above we have used the data of the mapping of financial instruments presented in Section 3 of this study.

5.2. Trends on market maturity identified

This section provides an assessment of the maturity of the clean energy finance markets of each Member State, based on the three dimensions presented in the previous section.

Supply of clean energy finance

The availability of private finance indicates a healthy financial system, while public financing should serve specific policy goals and address market failures. Comprehensive data on private and public RES investments broke down for each EU Member State, are currently not easily accessible. We can however extrapolate the supply of clean energy finance from a series of data points. In the rest of this section, we analyse the indicators chosen to assess the supply of finance for clean energy investments, as described in Section 5.1.

[147] Steckel JC, Jakob M, Flachsland C et al (2017) From climate finance toward sustainable development finance. Wiley Interdiscip Rev Clim Chang 8:e437. https://doi.org/10.1002/wcc.437

[148] Tietjen O, Pahle M, Fuss S (2016) Investment risks in power generation: a comparison of fossil fuel and renewable energy dominated markets. Energy Econ 58:174–185. https://doi.org/10.1016/j.eneco.2016.07.005

[149] Best R (2017) Switching towards coal or renewable energy? The effects of financial capital on energy transitions. Energy Econ 63:75–83. https://doi.org/10.1016/j.eneco.2017.01.019

[150] The formula to calculate the WACC is presented below:

WACC=DD+E*Cd*1-t+ ED+E*Ce

- *D* is the market value of a firm's debt
- *E* is the market value of a firm's equity
- *Cd* is the cost of debt
- *t* is the corporate tax rate
- *Ce* is the cost of equity

[151] Dukan, M., Kitzing, L., Brückmann, R., Jimeno, M., Wigand, F., Kielichowska, I., Klessmann, C., & Breitschopf, B. (2019). *Effect of auctions on financing conditions for renewable energy* (Issue May).

[152] Source: IRENA (2020), *GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2020*, available at: Link

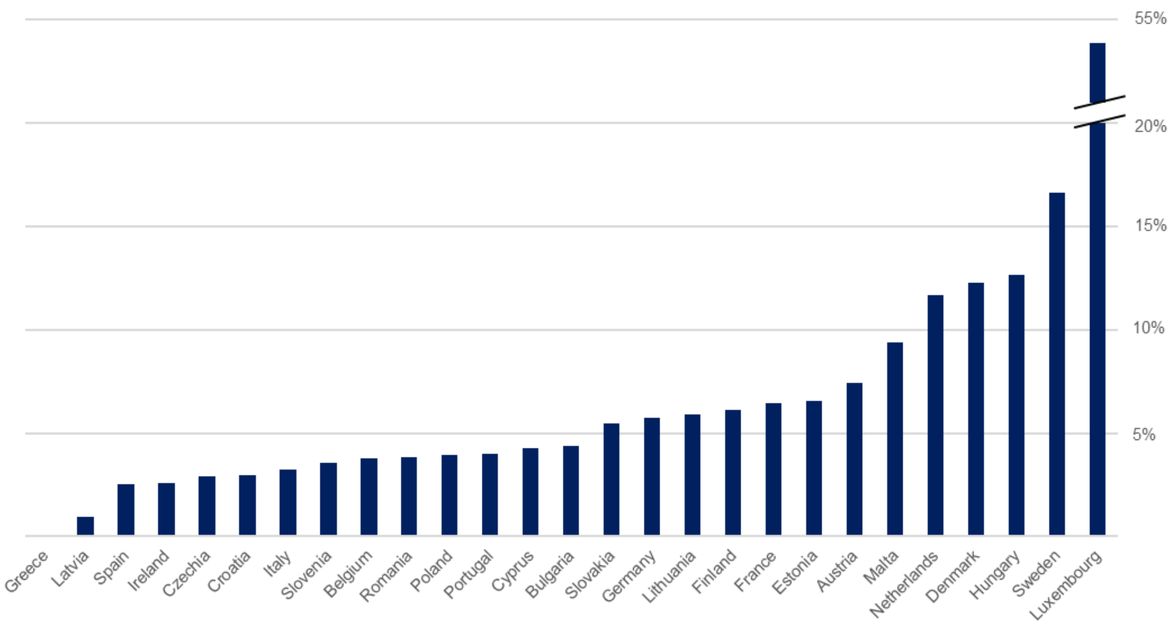
Availability of private finance: bank financing and capital markets

Below we present the three key metrics that will be used to measure the availability of private finance in each Member State, although none of this metric is specific to the energy sector. These metrics reflect criteria on private market financing used in the IMF Financial Development index.

Bank financing

Bank financing is the main source of external finance for firms of all sizes in the European Union. Data from EIBIS 2021 shows that, on average, bank loans represented 59% of external funding for companies in the EU. An adequately high, but sustainable, stock of debt to non-financial corporates can be an indicator of a well-functioning banking system. In countries where the banking system is in distress or constrained by high cost of financing or high ratios of non-performing loans, financial institutions will limit their lending to corporates and households. The banking indicator reported by the European Central Bank, can be used as aa proxy of the amount of credit and debt financing that firms can access in each Member State.

Figure 45: Debt securities and loans of the private non-financial sector as a ratio of GDP, 2021



Source: European Central Bank[153]

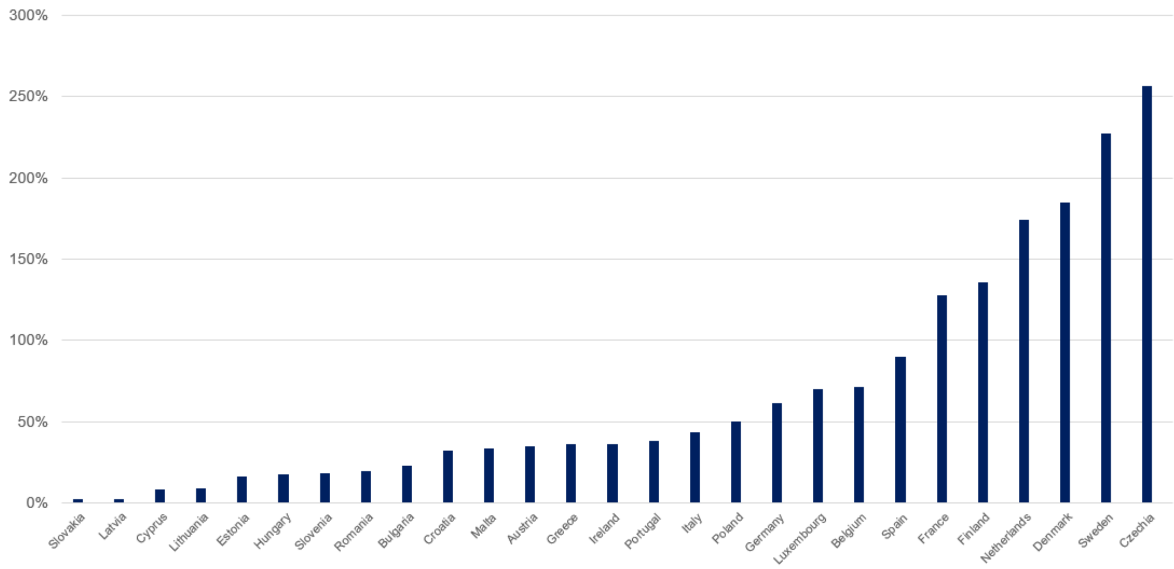
Stock market

The following stock indicator is generally used as a measure of under – or – over-valuation of a country's stock market[154]. For the purposes of our analysis, it is used as an indicator of access to equity capital markets.

[153] Available at: [Link]

[154] Stock Market Capitalization-to-GDP Ratio: Definition and Formula, available at: [Link]

Figure 46: Stock market capitalization as % of GDP (2021)



Source: CEIC[155]

Green bonds

The green bonds indicator can help understanding the extent the level of access to capital markets for financing the energy transition. According to data from the Climate Bonds Initiative[156], energy represents on average 44% of the use of the proceeds of Green Bonds issued in Europe, between 2014 and the first half of 2022, equivalent to over USD 32 billion. This is a proxy of at least part of the RES investments financed via bond issuance, as the energy investments financed by Green Bonds are by definition in clean energy, otherwise the bond could not be labelled as 'Green' according to international standards[157].

The Figure below shows the stock of green bonds (in USD millions) in 23 EU countries[158] issued as of the first half of 2022 as share of their GDP[159]. This analysis allows to compare bond issuance to the relative size of a country's economy. Larger Member States have issued more Green bonds than smaller ones, but such larger issued amounts sometimes represent a smaller share of that country's GDP. For instance, Germany and France are the two countries with the highest issued amounts, but rank 7th and 4th, respectively, in terms of issuances as share of their GDP. Italy has issued in total the 6th highest amount, but ranks only 14th if the issued amount is assessed proportionally to Italy's GDP. Luxembourg is the country with the highest Green bond issuance if assessed in relation to its GDP, despite being 11th in terms of absolute amounts.

155 Available at: https://www.ceicdata.com/en/indicator/market-capitalization--nominal-gdp

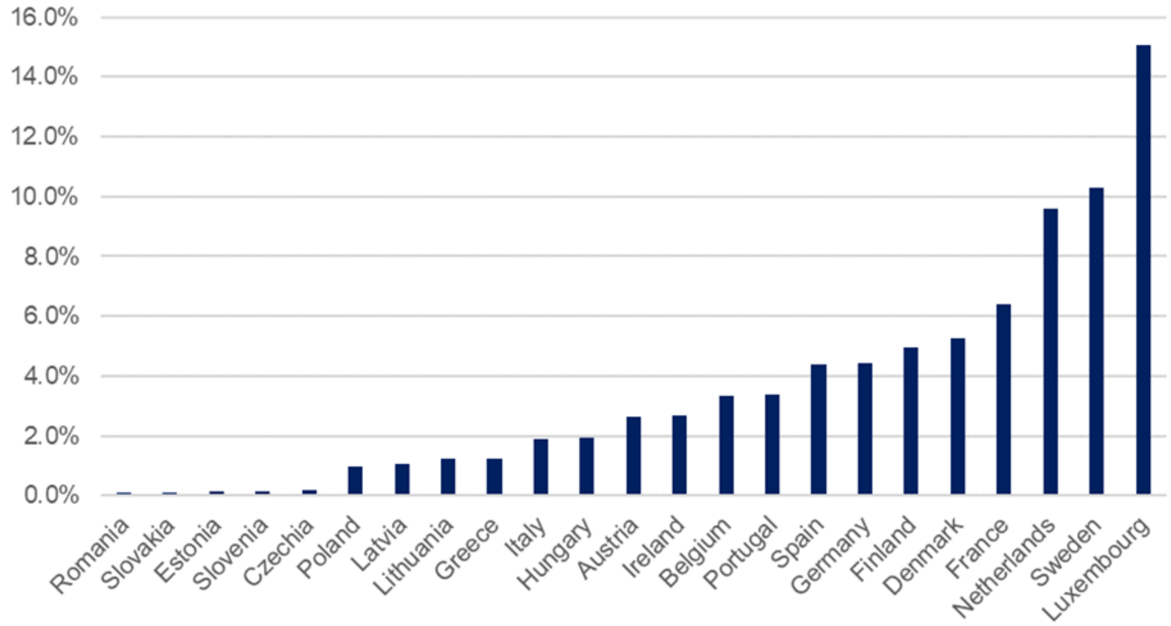
156 Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

157 International Capital Markets Association (ICMA), 2021 Green Bond Principles, available at: Link

158 Green Bonds data have been extracted by the Climate Bonds Initiative database, which did not include all EU-27 countries. Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

159 World Bank data on GDP per capita data (USD current, 2021). Available at: Link

Figure 47: Ratio between Green Bond market size (USD M, as of H12022) and GDP (USD, 2022)



Source: Climate Bonds Initiative[160], The World Bank[161]

Further information on the green bond market in EU countries can be found in the box "*Focus on: Bonds financing for energy and sustainable activities"* in Section 3.

Availability of public finance

When it comes to the energy sector, public finance represented on average 14% of total investments in renewables between 2013-2018[162]. The role of the public sector, and public financial institutions in particular, is to address market failures and intervene in underserved markets, achieving additionality and providing financial resources where they are scarce and/or unaffordable. Public financing resources, although limited, can be crucial to reduce risks, overcome initial barriers, attract private investors and bring new markets to maturity[163].

Data on public investment in RES collected by IRENA[164] provides a relevant indicator of the volumes of financing channelled through the European Investment Bank (EIB). Public RES investments collected by IRENA are largely financed by the EIB (74.2% of the total) via standard loans (98% of the total). Therefore, the analysis of this data should be interpreted with the limitation that it does not capture the full spectrum of RES public financing. Aggregated data for 24 EU Member States[165], between 2000 and 2020, has been adjusted for the size of the economy of each Member State.

160 Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

161 Source of GDP (USD current, 2021): https://data.worldbank.org/indicator/NY.GDP.MKTP.CD

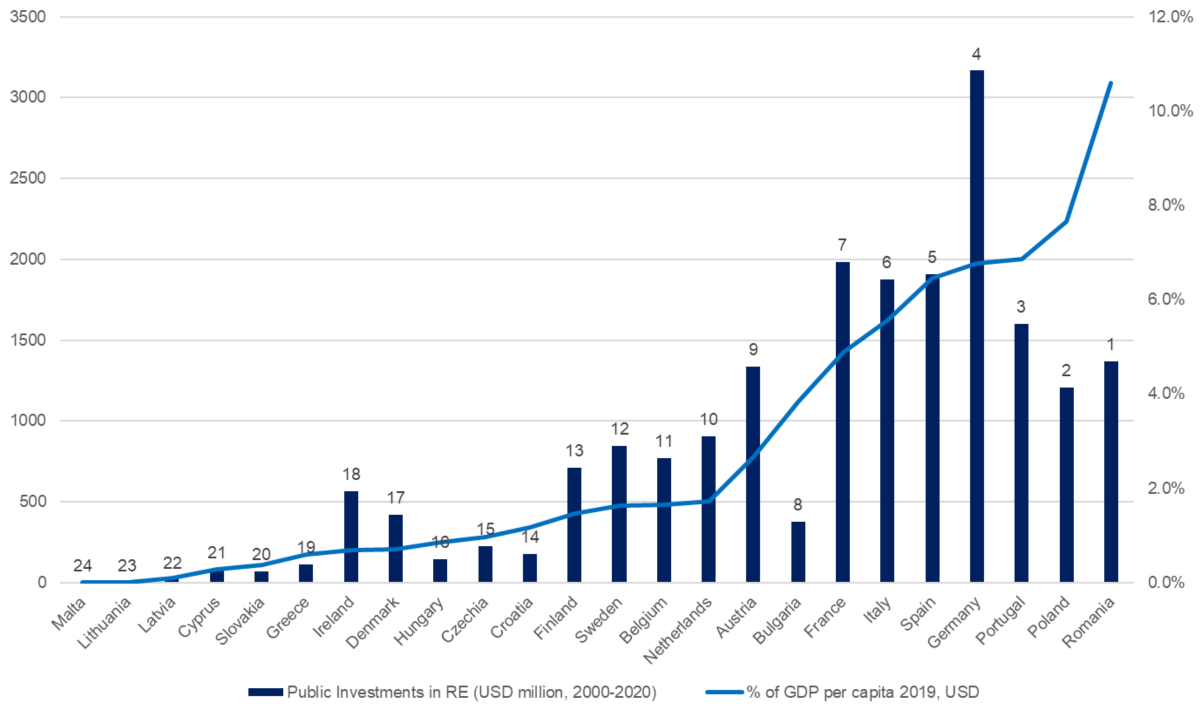
162 IRENA (2020), *GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2020*, available at: https://www.irena.org/publications/2020/Nov/Global-Landscape-of-Renewable-Energy-Finance-2020

163 Ibid

164 Available at: https://www.irena.org/Data/View-data-by-topic/Finance-and-Investment/Renewable-Energy-Finance-Flows

165 Data on Slovenia, Estonia and Luxembourg are not available

Figure 48: Public investments in renewable energy in the EU



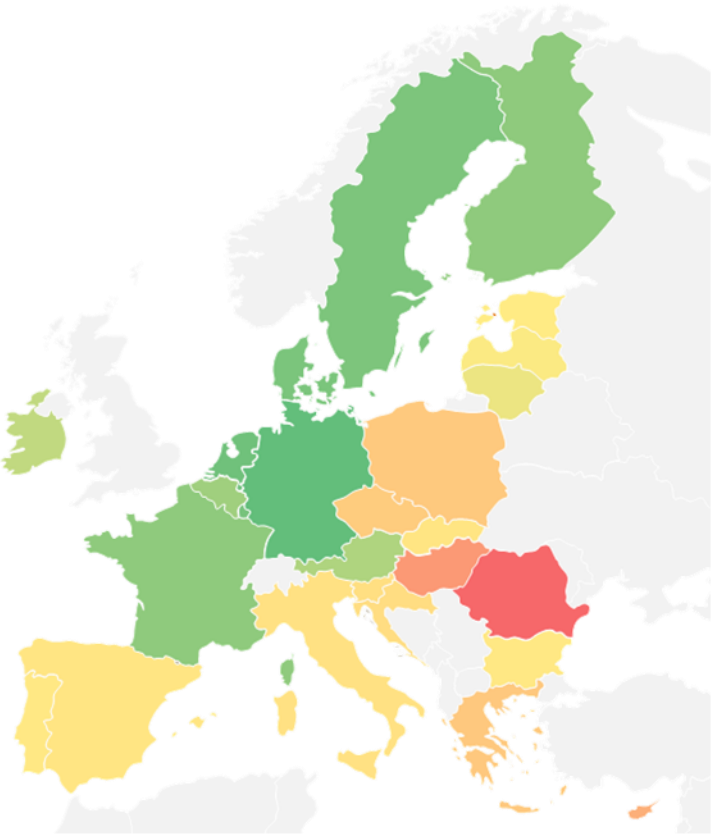
Source: IRENA, The World Bank

Cost of financing – Weighted Average Cost of Capital (WACC)

A low WACC of renewable energy (RES) projects can be considered an indicator of maturity of the clean energy finance market. Indeed, it reflects abundance of capital at relatively low cost and a low country risk, thanks to a regulatory and economic environment that enables RES investments. The Figure below shows that WACC of RES projects in the EU, calculated by PwC for the purposes of this study based on the latest data available[166]. It should be noted that the WACC values are influenced by national/ European monetary policies and Central Banking. In particular, countries with higher free interest rate correspond to higher WACC values. As a result, the comparison of countries based on their WACC is especially valid among the 20 countries of the Eurozone. Details on the calculation and data sources are available in Annex 3: WACC Calculation.

[166] As of February 2023.

Figure 49: WACC of RES projects across the EU



Country	WACC RE 2022
Romania	12.30%
Hungary	10.26%
Cyprus	9.31%
Greece	8.24%
Poland	8.20%
Czechia	8.09%
Croatia	7.36%
Slovenia	7.25%
Italy	7.17%
Spain	7.01%
Slovakia	7.00%
Portugal	6.90%
Bulgaria	6.87%
Estonia	6.73%
Latvia	6.69%
Lithuania	6.51%
Malta	6.12%
Ireland	5.99%
Austria	5.77%
Belgium	5.59%
Finland	5.50%
France	5.39%
Sweden	5.17%
Denmark	5.15%
Luxembourg	5.10%
Netherlands	5.01%
Germany	4.85%

Source: Statista, Aswath Damodaran (Stern, New York University), IRENA

Comprehensiveness and diversity of financial instruments for renewable energy

Analysis of the data from the mapping of energy financial instruments conducted as part of the present study sheds further light on the availability and relevance of financial instruments for clean energy production at Member State level and how the complement the analysis of market maturity.

Diversity of financing instruments for renewable energy

A first proxy of the diversity of mapped financing instruments available for each Member States can be obtained through a repurposed use of the Herfindahl-Hirschman Index (HHI)[167]. In the current case, the HHI shows the concentration of identified financing instruments among different types of instruments. In other words, countries with a high HHI (up to 10,000, in the case of one single type of instruments) offer a low variety of financing instrument types, whereas countries with a low HHI (nearing 0) provide a more diverse set of instruments that come with specific answers to different investment barriers.

For the scope of this Study, the HHI based on the share of each type of instrument over the total number of instruments mapped for a given country. The value of the HHI was then obtained by squaring the share of each type of instrument and then summing the resulting numbers. It should be noted that some of the mapped financing schemes combine different kinds of instruments. In the mapping, those were consistently tagged in several categories of

[167] Investopedia 2022, Herfindahl-Hirschman Index (HHI) Definition, Formula, and Example, available on: https://www.investopedia.com/terms/h/hhi.asp

financing instruments. Nevertheless, this does not change the interpretation that can be made for financing instruments.

The obtained HHI values for each Member-State are available in the summary table at the end of this section.

‘Sophistication’ of the current offering of financial instruments

In general, we consider mature those markets that have a balanced mix of financial instruments, including ‘sophisticated’ instruments such as equity, quasi-equity, bonds, guarantees and blended finance. On the other hand, markets that rely solely or mainly on grants and loans can be considered less mature.

Notably, recourse to equity, bonds or guarantees is not preferable to that of grants and loans *per se*. Further, it should be taken into account that bank loans represent the main source of external finance for firms in the EU, while equity and bonds are rarely used, as reported by EIBIS[168]. However, the availability of only grants and loans is not likely to address the range of investment barriers faced by clean energy production companies and technologies at different stages of development. The presence of more ‘sophisticated’ instruments such as equity, guarantees, blended finance and bonds can indicate a higher maturity of the market in terms of its ability to finance the full range of activities required for reaching renewable energy targets.

In this sense, the presence of several types of ‘sophisticated’ financial instruments has been considered a proxy of market maturity. On the other hand, relying mostly on grants and loans has not been penalised. To capture this, we have defined as ‘sophisticated’ financial instruments the following ones: equity, quasi-equity, blended finance, guarantees and bonds[169]. We have then scored the Member States from 0 to 5, where 5 means that the Member State features all of the ‘sophisticated’ financial instruments, 4 means that it features 4 out of 5 of the instruments, and so on. The results are reported in the summary table at the end of this section.

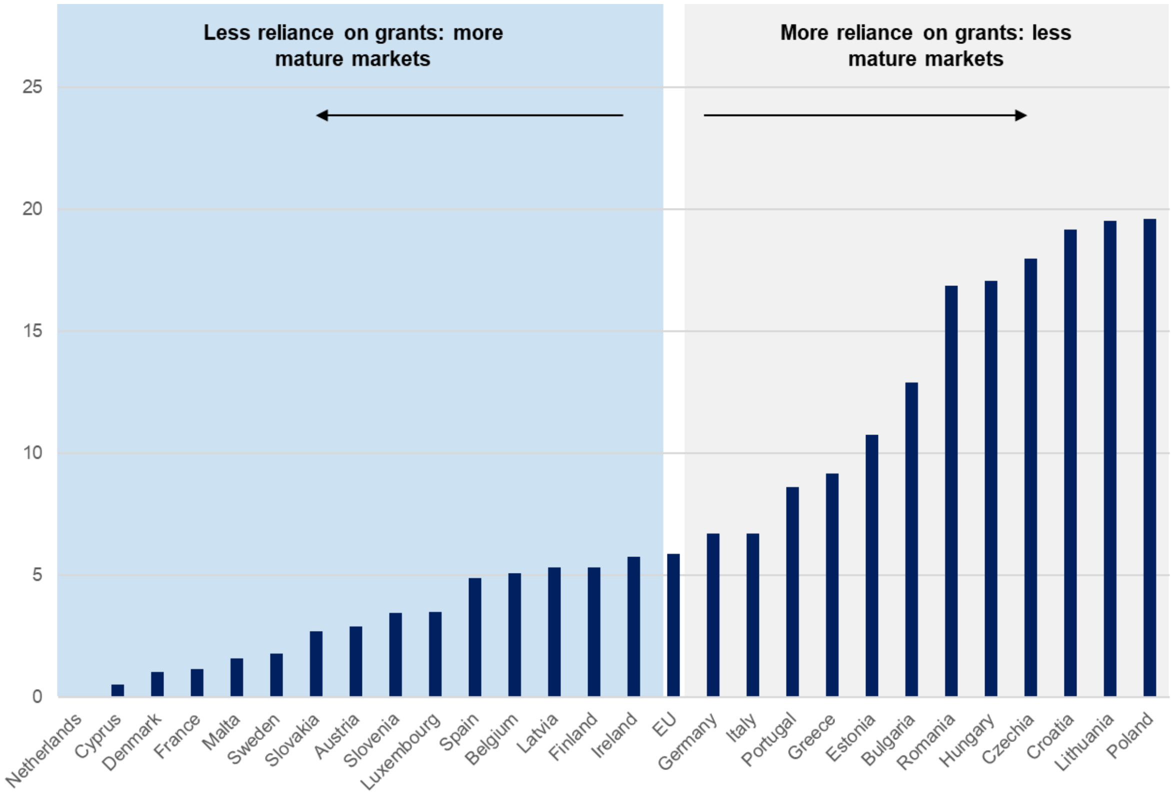
Strategic use of grants

Of all the types of financing instruments considered, grants represent the strongest public intervention in the market and as such should be prioritised for risky innovative investment projects the market would not be able to finance through other instruments. As can be seen from the following figure, a number of countries, in Eastern Europe in particular, rely significantly on grants, instead of using the full spectrum of financing instruments.

[168] European Investment Bank Investment Survey, 2021, available at: https://data.eib.org/eibis/index;jsessionid=58E533D642F2ED07C87B1E9F150ACF75

[169] Sovereign green bonds have been considered a financial instruments for RE. However, it must be noted that proceeds from sovereign green bonds could be used to finance a wide array of environmental projects, and not exclusively RE. Please refer to the box “*Focus on: Bonds financing for energy and sustainable activities”.*

Figure 50: Share of grants in EU firms' financing mix (all sectors, all sizes)



Source: EIBIS

For the purpose of this study, we have calculated the **percentage of grant instruments for ready to build projects** (rollout-stage technologies such as PV panels) for each Member State. A high value for this indicator can be interpreted as a sign of low market maturity.

The results for the RES sector are broadly consistent with those for the economy as a whole, with a number of countries such as Poland, Croatia, Estonia, Portugal and Czechia ranking high in both.

Summary table on comprehensiveness and diversity of financial instruments

The following table provides a summary of all the indicators introduced in this section:

- HHI as a measure of diversity ranging from 0 (perfect diversity) to 10,000 (one single type of instruments)
- Sophisticated instruments score ranging from 0 (no sophisticated instruments) to 5 (high sophistication)
- Percentage of grants for rollout-rollout-stage technologies ranging from 0% (no presence of grants for mature technologies) to 100% (all mapped grants target mature technologies)

Table 10: Comprehensiveness and diversity of financial instruments for renewable energy

Country	Concentration Index (HHI)	Level of 'sophistication' of financial instruments	Grants for rollout as a % of grant instruments
Austria	2449	3	33%
Belgium	3511	2	29%
Bulgaria	4488	4	29%
Croatia	4603	3	75%
Cyprus (Republic of)	5679	1	N/A
Czechia	5767	4	31%
Denmark	5306	2	100%
Estonia	4463	4	50%
Finland	4722	1	0%
France	3932	5	0%
Germany	5957	4	22%
Greece	4911	4	75%
Hungary	4184	3	N/A
Ireland	9091	4	50%
Italy	4582	4	N/A
Latvia	5764	4	100%
Lithuania	2734	4	17%
Luxembourg	4583	4	50%
Malta	3964	2	50%
Netherlands	3979	5	0%
Poland	7361	5	69%
Portugal	5207	5	50%
Romania	8302	4	0%
Slovakia	8533	5	40%
Slovenia	6982	3	0%
Spain	5000	5	67%
Sweden	6406	1	0%

How to read the data – examples of countries:

- **Finland** exhibits a limited diversity of financing instruments for RES, with only one type of sophisticated instruments. Moreover, no grant-based instruments were identified.
- On the other hand, **Poland** shows a wide variety of financing instruments, including different kinds of sophisticated instruments. However, a significant share of grant-based instruments is still available for rollout-stage technologies.
- When it comes to **Germany**, the diversity of instruments is rather limited, with a good variety of sophisticated instruments. The third indicator shows a rather adequate use of grants.

Summary of findings on market maturity

The following table combines all the indicators presented in the previous sections with information about the RES (investment) gaps for each Member State based on the information presented in Section 2. The values included in the column “Investment needs in RES” are based on an assessment conducted by Member States in 2018/2019. This means that such needs are likely to be an underestimation in light of the recent REPowerEU targets. The updated NECPs, expected to be approved in mid-2024, will included more realistic appraisals of countries’ investment needs. The “% RES target gap” is the difference between the country’s current share of RES and it 2030 target. A higher gap is to be linked to a higher effort needed by that country in terms of stepping up its investments in clean energy. However, it should be noted that countries in red are those whose 2030 RES targets are below the estimated requirement of 38-40% of RES under FitFor55 and RePowerEU. The updated NECPs will likely include also updated RES targets.

For the other columns, Member States have been ranked from 1 to 27 for each indictor, where 1 is the best and 27 is the worst (for some indicators, not all Member States have data. Therefore, the ranking does not go up to 27). The only exception is the indicator “Level of ‘sophistication’ of financial instruments”, where the numbers 1 to 5 indicate the level of sophistication of the financial instruments in each Member State based on the types of financial support schemes available, 1 being the least sophisticated and 5 the most sophisticated.

Table 11: Summary of findings and rankings on market maturity per country

Member State	Investment needs in RES (€ bn)	% RES target gap	Debt and loans of corporates	Stock market capitalisation	Green Bonds Market	Public investments in RES	WACC	Concentration Index (HHI)	Level of 'sophistication' of financial instruments	Grants for rollout as a % of grant instruments
Austria	20-27	12%	7	16	12	9	9	1	3	6
Belgium	9.89	27%	19	8	10	11	8	3	2	4
Bulgaria	2.4	10%	14	19	N/A	8	15	9	4	4
Croatia	2.16	5%	22	18	N/A	14	21	12	3	11
Cyprus	1	5%	15	25	N/A	21	25	18	1	N/A
Czechia	23.53	4%	23	1	19	15	22	20	4	5
Denmark	8-12	20%	4	3	5	17	4	17	2	12
Estonia	N/A	4%	8	23	21	N/A	14	8	4	8
Finland	N/A	11%	10	5	6	13	7	13	1	1
France	110	14%	9	6	4	7	6	4	5	1
Germany	49	61%	12	10	7	4	1	21	4	3
Greece	9	13%	27	15	15	19	24	14	4	11
Hungary	N/A	7%	3	22	13	16	26	7	3	N/A
Ireland	N/A	67%	24	14	11	18	10	27	4	8
Italy	85	11%	21	12	14	6	19	10	4	N/A
Latvia	1.6	8%	26	26	17	22	13	19	4	12
Lithuania	2.3	17%	11	24	16	23	12	2	4	2
Luxembourg	2.14	13%	1	9	1	N/A	3	11	4	8
Malta	N/A	0%	6	17	N/A	24	11	5	2	8
Netherlands	32.2-32.8	15%	5	4	3	10	2	6	5	1
Poland	12.8	7%	17	11	18	2	23	24	5	10
Portugal	23.6-24.3	13%	16	13	9	3	16	16	5	8

Member State	Investment needs in RES (€ bn)	% RES target gap	Debt and loans of corporates	Stock market capitalisation	Green Bonds Market	Public investments in RES	WACC	Concentration Index (HHI)	Level of 'sophistication' of financial instruments	Grants for rollout as a % of grant instruments
Romania	12	7%	18	20	23	1	27	25	4	1
Slovakia	1.26	2%	13	27	22	20	17	26	5	7
Slovenia	1.4	10%	20	21	20	N/A	20	23	3	1
Spain	91.8	21%	25	7	8	5	18	15	5	9
Sweden	8.9	2%	2	2	2	12	5	22	1	1

Note: Countries in red are those whose 2030 RES targets are below the estimated requirement of 38-40% of RES under FitFor55 and RePowerEU.

Note: WACC depends on central bank policy which determines risk free rate. It relates to the countries with no EUR. Central bank policy is to decrease inflation so countries with high inflation have higher WACC.

Interpretation of the results at Member State level

The complex picture of indicators presented in Table 11 does not always present a clear-cut conclusion regarding the state of market maturity for the financing of clean energy production, but nevertheless can lay the ground for some general findings at country level.

As can be seen from the following table, it is possible to group the EU Member States based on the size of their RES gap[170], the degree of market maturity[171] and the extent to which the current offering of financial instruments is relevant given the criteria considered above. The interpretation is provided per group in the following paragraphs.

Table 12: Grouping of countries by market maturity and RES gaps

	High market maturity	Medium maturity	Low market maturity
Low RES gap	Sweden	Hungary, Estonia, Malta	Czechia, Romania, Slovakia, Croatia, Cyprus, Latvia, Poland
Medium RES gap	Luxembourg, France, Netherlands, Finland, Austria	Portugal, Italy, Lithuania, Bulgaria	Greece, Slovenia
High RES gap	Germany, Belgium, Denmark	Spain	Ireland

Note: Countries coloured in green are considered to have a relevant offering of financial instruments (4 or 5), whereas those in red have some room for improvement (1, 2, or 3).

Countries with high market maturity and:

- **Low RES Gap – Sweden** is the only country in this category. While its RES 2030 targets are ambitious, the country's past levels of investment in clean energy put in a good place to reach them. Nevertheless, the high degree of market maturity could be further strengthened by a more diversified offering of financial instruments.
- **Medium RES gap –** Countries in this category enjoy an overall good level of market maturity, which in principle allows them to raise and provide financing adequately, thanks to their medium-to-low WACC, diversified offer of financial instruments and strong private financing dynamics. Based on this **Luxembourg** should be able to achieve both its current and potentially increased RES target under the new NECP. Similarly, **France** and **the Netherlands** have RES targets that are lower than the recommended 38-40%. Nevertheless, the current offering of instruments appears to be well structured to address the diverse financing needs in the sector, especially given the favourable market maturity context (e.g., low WACC). **Finland** has set an ambitious RES target of 54% and benefits from a mature market to achieve such target. The offering of diverse instruments could however be improved. **Austria** has set out ambitious 2030 pledges for RES usage and seems well on track to achieve them. Nevertheless, closing the gap could be supported

170 The grouping was done based on the following ranges: "Low RES gap" 0-9%; "Medium RES gap" 10-19%, "High RES gap" 20+%.

171 For each Member State, the average value of all indicators was calculated. Based on this value, countries were then dividing in three groups "High market maturity", "medium market maturity", and "low market maturity".

by an improved offering of financial instruments, including equity and blended finance solutions that can address the financing needs of different actors in the sector.

- **High RES gap -** Amongst the countries with a high market maturity and RES Gap, **Germany** stands out as the one where the current offering of financial instruments appears to be heavily concentrated around the use of grants, with limited recourse to equity, guarantee or blended finance instruments. Given that the WACC for renewable energy is low and private market solutions may be able to fill the gaps, there appears to be room for reducing the use of grants for roll-out stage technologies. **Denmark** has set out ambitious 2030 pledges for RES usage and seems well on track to achieve them. Nevertheless, closing the gap could be supported by an improved offering of financial instruments, including equity and blended finance solutions that can address the financing needs of different actors in the sector. As for **Belgium**, the overall situation seems to be favourable for the country to be able to mobilise sufficient financing to achieve its ambitious RES targets.

Countries with medium market maturity and:

- **Low RES gap – Malta** technically has no RES gap, since its 2030 target of 12% RES share has already been achieved. Nonetheless, the target is well below the REPowerEU objectives. **Hungary** has also set a rather low RES target (21%), which is the main reason why the country falls under the "low RES gap" category. In contrast, **Estonia** has a low RES gap despite having already set more ambitious target than many other countries. All three countries could benefit from a more diversified offering of financial instruments, and Estonia - from a more cautious use of grants for mature technologies.
- **Medium RES gap** - in **Portugal** there is a relatively balanced offering of different instruments, but also cases where grants are available for the financing of roll-out stage technologies, which should be capable of obtaining market financing. In **Italy,** there are numerous financial instruments available, but limited examples with guarantees, quasi-equity and guarantee schemes which can support relevant segments of the market. **Lithuania** has a balanced offering of financial instruments and shows a strategic use of grants, but past levels of public investments and a low stock market capitalisation might hinder the achievement of its 2030 targets. **Bulgaria** is in a similar situation and suffers from a relatively high cost of capital.
- **High RES gap – Spain** displays a high WACC, but also a high degree of sophistication of the offering of financial instruments, with a medium share of grants for rollout.

Countries with low market maturity and:

- **Low RES gap** - **Poland** is in the low RES gap because its current 2030 RES target is 15%, significantly below the recommended 38-40%. The country has a relatively balanced offering of different instruments, but also cases where grants are available for the financing of roll-out stage technologies, which should be capable of obtaining market financing. Despite having a good variety of financial instruments, Poland suffers from a high WACC and weak Green bond market. **Croatia** has a low RES gap, however, the low market maturity (especially the high WACC) combined with the limited offering of sophisticated instruments as well as use of grants for roll-out stage technologies signal that there is room for improvement going forward, especially when it comes to ensuring there is relevant support for innovative renewable energy projects. Both needs and market maturity of **Latvia** are similar, but there is one big difference in these two neighbouring countries and that is the high share of grant instruments in Latvia which are available for roll-out stage technologies. Finally, in **Cyprus**, there are limited financial instruments available and high reliance on grants. In **Slovakia,** there is a relatively broad offering of financial instruments, but some cases of using grants for roll-out stage technologies. In the **Czech Republic** there is a relatively broad offering of financial instruments, but some cases of using grants for roll-out stage technologies and a high WACC might hinder investments. In **Romania,** there is a notable absence of guarantees.

- **Medium RES gap –** In the case of **Greece**, there seems to be a broad range of financial instruments available, however, also a number of cases where grants are available for the financing of roll-out stage technologies which should also be able to obtain financing on market terms. **Slovenia** is characterized by a low level of sophistication, with also low WACC.
- **High RES gap** – **Ireland** displays a very ambitious RES target, the highest together with Germany, and has a good variety of financial instruments. However, it also presents a high concentration index and ranks rather low in terms of debt and loans of corporates.

One trend that should additionally be highlighted is that countries with low market maturity are also those whose current 2030 RES targets are significantly lower than the 38-40% average target for the EU set by Fit for 55 and REPowerEU. While updated RES targets under the upcoming NECPs may reveal increased ambitions amongst many of the countries in this group, it is clear that they could benefit from a more diversified offering of financial instruments in order to mobilise the necessary investments in renewable energy production.

6. Findings and recommendations

6.1. Summary of findings

A large step up in financing will be needed for Member States to achieve the EU renewable energy production targets. Under the REPowerEU Plan the headline 2030 target for renewables has increased from 40% to 45%[172] to cut the EU's energy dependency on Russian gas well before 2030.

Financial instruments can address some of the barriers to investment for clean energy production. Different clean energy production technologies have different financing needs, depending on their maturity, financial instruments offering, market maturity and the barriers to investment faced. For emerging technologies, availability and access to finance remain a key risk next to the inherent technology risks. For mature and transmission technologies, regulatory and policy risk as well as administrative barriers are key, next to grid, transmission and infrastructure risks.

A mapping of financial instruments at Member State level resulted in data on 468 instruments available for financing energy production in the 27 EU Member States. Among these 468, loans and grants are the most popular instruments across the EU. All instruments together provide an estimated cumulative financing for up to €165 billion (mostly in grants and loans, but also guarantees, which may trigger additional financing). However, most of the resources are not exclusively for energy production.

Most of the mapped instruments are technology neutral, meaning that they do not target a specific energy production technology, but rather select projects based on a different set of criteria. Excluding technology neutrality, the most targeted production technologies are solar and wind (both onshore and offshore). SMEs and larger companies are the most supported recipients by financial instruments in the EU in all EU Member States with very few exceptions. Households are the least supported group by the mapped instruments.

Most of the mapped instruments target mature and market-ready projects ("roll-out stage"), and only to a lesser extent less mature technologies are covered. While this finding might lead to conclude that there is a shortage of lower-TRL financing, further assessment should be done, as innovative solutions tend to have different financing needs compared to mature ones, and EU-level programmes like the Innovation Fund and Horizon Europe, not included in the country-level mapping, provide significant funding in this matter.

Availability of finance, financing conditions and market risk were found to be the most targeted barriers by mapped instruments. On the contrary, supply of labour, regulatory, administrative, and resource risks are the least targeted barriers. These findings are in line with the broader theoretical context on the relevance and capacity of some instruments in addressing certain types of barriers over others. Indeed, some barriers to investment are caused by factors and conditions that are not possible to solve through financing schemes, despite affecting the financing environment. The presence of non-financial barriers affecting energy production investments requires additional measures beyond financial instruments to create a truly enabling environment for energy investments.

Four characteristics emerged as key for a financial instrument to be effective: broad scope of application, technology neutrality, accessibility (in terms of having a manual of application to support applicants, established communication channels with the implementing authority, and limited administrative requirements), and long-term visibility (intended as both provision of long-term financing, so that the beneficiary can plan long-term, but also

[172] As provisionally agreed between the Council and the European Parliament, RES target is to raise in the EU's final energy consumption to 42.5% by 2030. The member states are urged to strive for a 45% share [status June 2023].

consistency of the instrument throughout the years, without sudden changes of conditions). These characteristics do not need to always be present in each instrument for it to be effective, but are those with the highest assessed impact on an instrument's effectiveness. Effective financial instruments have the ability to mobilise private resources in magnitudes that would not otherwise be possible and increase the overall capital available to achieve EU policy goals more efficiently.

In terms of market maturity, the analysis has shown very diverse situations. Countries with a high degree of market maturity are likely to have at their disposal more options for addressing the investments needs for closing their 2030 RES gaps, compared to countries with lower maturity. The need for improving the offering of financial instruments is the highest for countries with the highest RES gaps and low maturity markets. Nevertheless, in most countries the current offering of financial instruments could be improved going forward in terms of the diversity of instruments offered and the calibration of instruments towards relevant target beneficiaries.

6.2. Recommendations and next steps

Based on the analysis conducted, it was possible to broadly identify the focus on the next production of financial support schemes for energy production.

- Countries with low availability of diverse financial instruments and less mature financial markets would benefit from targeted efforts on developing and expanding the offering of financial instruments for clean energy production. Technical assistance facilities should also be deployed, to foster capacity building and increase the effectiveness and impact of instruments.
- In countries with more developed financial markets, the use of guarantees, equity and bonds should be prioritised to meet the investment needs for closing their renewable energy production gaps, reserving grant financing for less mature technologies only.
- The mapping covered mainly instruments targeting mature technologies. Further input from stakeholders will be needed to assess whether lower-TRL solutions are in need of new financial instruments, or if EU-level instruments like the Innovation Fund and Horizon Europe are sufficient to address their financing needs.
- The design of new financial instruments should take into account the features found to support effectiveness, such as broad scope, accessibility, long-term stability. However, some of these features might not be always needed (e.g. technology neutrality is to be preferred, but in some cases, specific technologies may need to be targeted).
- Technical assistance is needed to improve planning capacity of both local authorities and companies. Furthermore, new financial instruments should be designed in a way to have application costs as low as possible for potential beneficiaries. A means to do so could be favouring the aggregation of smaller projects, so as to simplify application procedures and help smaller projects access financing opportunities that would be otherwise difficult to get, but other best practices merit further investigation, too.
- Tailored advisory support could be provided for large-scale hydrogen projects, which require long-term planning and coordination and might struggle more than other renewable technologies to access such advisory support[173].
- Overall, solar and wind seem to be sufficiently mature to raise finance on their own, without the need for additional financing support schemes. Nonetheless, they could still benefit from financial instruments in two cases: (i) from broader non-disbursed

[173] EIB. Unlocking the hydrogen economy — stimulating investment across the hydrogen value chain. https://www.eib.org/en/publications/unlocking-the-hydrogen-economy

technology-neutral instruments to speed up deployment without committing too many public resources; and (ii) for lower-income households and other specific cases. Innovation in solar and wind should still be supported and incentivised through financial support schemes, if necessary, as well as for the development of renewables collocated with storage solutions.

- Additional support is required for production technologies like Ocean energy and for the production of Green Hydrogen. These technologies are characterised by high CAPEX costs and high perceived risks, but could nonetheless play a key part in the EU's future energy supply.

A guiding principle when developing new financial instruments is to pay attention to the complementarities and coordination with other initiatives (e.g., ongoing programmes for hydrogen). This is to avoid redundancies and overlapping, but also to streamline the provision of financing and of support. Indeed, consulted stakeholders often pointed out that too many instruments fail to be visible, and are thus underutilised and less effective.

Bibliography

A Clean Planet for all A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy*, European Commission*, Brussels 2018

https://ec.europa.eu/clima/system/files/2018-11/com_2018_733_analysis_in_support_en.pdf

An EU-wide assessment of National Energy and Climate Plans Driving forward the green transition and promoting economic recovery through integrated energy and climate planning, *European Commission*, Brussels 2020

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0564&from=EN

Barriers and best practices for wind and solar electricity in the EU27 and UK, *eclareon GmbH*, March 2022

https://www.eclareon.com/sites/default/files/res_policy_monitoring_database_final_report_01_0.pdf

Bhandari, K., P., Collier, J., M., Ellingson, R., J., Apul, D., S., Energy payback time (EPBT) and energy return on energy invested (EROI) of solar photovoltaic systems: A systematic review and meta-analysis, 2015

https://www.sciencedirect.com/science/article/abs/pii/S136403211500146X

Breaking Down Investment Barriers at Ground Level - Case studies and other evidence related to investment barriers under the third pillar of the Investment Plan for Europe, *European Investment Bank*, *European Investment Fund*, 2016

https://www.eib.org/en/publications/breaking-down-investment-barriers-at-ground-level

Broken promises: Legal recourse for retroactive FIT cuts, *PvMagazine.com*, January 2020

https://www.pv-magazine.com/2020/01/23/broken-promises-legal-recourse-for-retroactive-fit-cuts/

Carvalho, R., Hittinger, E., Williams, E., Payback of natural gas turbines: A retrospective analysis with implications for decarbonizing grids, 2021

https://www.sciencedirect.com/science/article/abs/pii/S0957178721001417#:~:text=Using%20historical%20data%2C%20we%20find,types%20of%20fossil%20fuel%20infrastructure.

Combination of financial instruments and grants under shared management funds in the 2021-2027 programming period, *fi-compass factsheet,* May 2021 Combination of financial instruments and grants (fi-compass.eu)

Data insight: The permitting problem for EU wind farms, *Energy Monitor*, April 2022

https://www.energymonitor.ai/policy/data-insight-the-permitting-problem-for-eu-wind-farms Developing an Effective State Clean Energy Program: Renewable Energy Incentives, *Clean Energy States Alliance,* 2009
https://www.cesa.org/wp-content/uploads/CESA-renewable-energy-incentives-mar09.pdf

El ICO lanza al mercado su cuarto bono verde por importe de 500 millones de euros para financiar proyectos sostenibles de compañías españolas, *ICO*, May 2022

https://www.ico.es/el-ico-lanza-al-mercado-su-cuarto-bono-verde-por-importe-de-500-millones-de-euros-para-financiar-proyectos-sostenibles-de-compa%C3%B1%C3%ADas-espa%C3%B1olas

El MITECO apoya 45 proyectos de comunidades energéticas impulsados por más de 2.600 personas, pymes y entidades locales, *IDAE*, June 2022

https://www.idae.es/noticias/el-miteco-apoya-45-proyectos-de-comunidades-energeticas-impulsados-por-mas-de-2600

Energy efficiency targets, *European Commission*

https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-targets_en

Energy Technology Perspectives 2020, *International Energy Agency*, 2020

https://iea.blob.core.windows.net/assets/7f8aed40-89af-4348-be19-c8a67df0b9ea/Energy_Technology_Perspectives_2020_PDF.pdf

EU electricity market rules must support renewables investments, *WindEurope*, April 2022

https://windeurope.org/newsroom/press-releases/eu-electricity-market-rules-must-support-renewables-investments/

Europe's building only half the wind energy it needs for the Green Deal, supply chain is struggling as a result, *WindEurope*, February 2022

https://windeurope.org/newsroom/press-releases/europes-building-only-half-the-wind-energy-it-needs-for-the-green-deal-supply-chain-is-struggling-as-a-result/

Ex-ante assessment methodology for financial instruments in the 2014-2020 programming period, *fi-compass*, May 2014 https://ec.europa.eu/regional_policy/sources/thefunds/fin_inst/pdf/ex_ante_vol5.pdf

Ex post evaluation of EIB Intermediated lending to SMEs in the EU, 2005-2011 https://www.eib.org/attachments/ev/ev_synthesis_report_smes_en.pdf

Final Report – Cost of Energy (LCOE): Energy costs, taxes and the impact of government interventions on

Investments, *Publications Office of the European Union*, Luxembourg 2020

https://op.europa.eu/en/publication-detail/-/publication/76c57f2f-174c-11eb-b57e-01aa75ed71a1/language-en

Financial instruments under the European Structural and Investment Funds: Summaries of the data on the progress made in financing and implementing the financial instruments for the programming period 2014-2020 in accordance with Article 46 of Regulation (EU) No 1303/2013 of the European Parliament and of the Council Situation as at 31 December 2020

https://ec.europa.eu/regional_policy/sources/thefunds/fin_inst/pdf/summary_data_fi_1420_2020.pdf

Gas grid operators unveil plan for European hydrogen infrastructure 'backbone', *Euractiv.com*, July 2020

https://www.euractiv.com/section/energy/news/gas-grid-operators-unveil-plan-for-european-hydrogen-infrastructure-backbone/

General Block Exemption Regulation (GBER)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02014R0651-20210801&from=EN

German wind energy stalls amid public resistance and regulatory hurdles, *DW.com*, September 2019

https://www.dw.com/en/german-wind-energy-stalls-amid-public-resistance-and-regulatory-hurdles/a-50280676

Global Trends in Renewable Energy Investment 2020, *Frankfurt School-UNEP Center*, 2020

https://wedocs.unep.org/handle/20.500.11822/32700?show=full

Guidelines on State aid for climate, Environmental protection and energy (CEEAG)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022XC0218(03)&from=EN

Greece: EIB first Recovery and Resilience Facility transaction backs a €524million landmark project with Greece's Independent Power Transmission Operator to connect the Western and Southern Cyclades islands to mainland electrical grid, *EIB,* 2023

Green energy: Insuring a renewables future, *Allianz*, July 2019

https://www.agcs.allianz.com/news-and-insights/expert-risk-articles/green-energy-Insuring-a-renewables-future.html

Italy: FIEE SGR gets EU backing to close its second fund dedicated to energy efficiency, *EIB*, August 2020

https://www.eib.org/en/press/all/2020-219-fiee-sgr-gets-eu-backing-to-close-its-second-fund-dedicated-to-energy-efficiency

Italy introduces 11-month retroactive incentive cut on PV systems over 20 kW, *PvMagazine.com*, January 2022

https://www.pv-magazine.com/2022/01/28/italy-introduces-11-month-retroactive-incentive-cut-on-pv-systems-over-20-kw/

Ireland: €240 million financing facility secured by solar developer Power Capital Renewable Energy from an Eiffel Investment Group led set of investors to construct over 1.2 GW of solar assets and expand internationally, *EIB,* 2023 https://www.eib.org/en/press/all/2023-006-eur240000000-financing-facility-secured-by-irish-solar-developer-power-capital-renewable-energy-from-an-eiffel-investment-group-led-set-of-investors-to-construct-over-1-2-gw-of-solar-assets-in-ireland-and-expand-internationally

KfW domestic promotional programmes for energy efficiency: Key elements and success factors*, KfW,* 2020 http://jaspersnetwork.org/download/attachments/26411157/Dominik%20Bach.pdf?version=1&modificationDate=1600072079000&api=v2

Kost, C., Shammugam, S., Fluri, V., Peper, D., Memar, A., D., Schlegl, T., Levelized Cost of Electricity Renewable Energy Technologies, *Fraunhofer Institute*, June 2021

LearnWind: WindEurope launches educational hub to tackle skills gap, *WindEurope,* September 2021

https://windeurope.org/newsroom/press-releases/learnwind-windeurope-launches-educational-hub-to-tackle-skills-gap/

Only three successful applicants for zero-interest climate loans since 2017, *RTL Today,* 2021 RTL Today - Energy efficiency programme: Only three successful applicants for zero-interest climate loans since 2017

Oroschakoff. K., Guàrdia, A., B., Europe's stranded assets: Mapped, Politico.eu, June 2020

https://www.politico.eu/article/stranded-assets-europe-mapped-energy-climate/

Pacifico Energy Partners and Eiffel Investment Group join forces to develop photovoltaic plants and battery energy storage systems in Europe, *Pacifico Energy,* 2022 https://www.pacifico-energy.com/pacifico-energy-partners-pacifico-and-eiffel-investment-groupeiffel-join-forces-to-develop-photovoltaic-plants-and-battery-energy-storage-systems-in-europe/

Projected Costs of Generating Electricity, *IEA*, 2020

https://www.iea.org/reports/projected-costs-of-generating-electricity-2020

Press Release UBI Banca closes the first Green Bond issue on the wholesale market Orders close to €1.5 billion, 3 times the amount of the issue

https://group.intesasanpaolo.com/content/dam/portalgroup/repository-documenti/sostenibilt%C3%A0/inglese/green-bond-ubi/UBI%20Banca_3%20april%202019%20def_press%20release.pdf

Rapid assessment of the EIB Group's operational response to the COVID-19 crisis https://www.eib.org/attachments/publications/rapid_assessment_covid_reponse_en.pdf

RENAISSANCE survey on renewable energy and community solutions, *RENAISSANCE project*, 2020

https://www.renaissance-h2020.eu/renaissance-survey-on-renewable-energies-and-community-solutions/

Renewable energy: Why institutional investors are finally bullish, *Capital Monitor*, 2021

https://capitalmonitor.ai/institution/asset-owners/renewable-energy-why-institutional-investors-are-finally-bullish/

REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, *European Commission*, May 2022

https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

Retroactive cuts for solar feed-in tariffs, *Dentons.com*, November 2020

https://www.dentons.com/en/insights/alerts/2020/november/26/retroactive-cuts-for-solar-feed-in-tariffs

Risks associated with new technology on renewable energy projects, *Freshfields Bruckhaus Deringer*, March 2022

https://sustainability.freshfields.com/post/102hjty/risks-associated-with-new-technology-on-renewable-energy-projects

Synthesis on the Plant-Level Cost of Nuclear: Workshop on Cost Electricity Generation, *OECD-NEA*, January 2016, Paris

https://www.oecd-nea.org/upload/docs/application/pdf/2020-07/fulll_cost_workshop_5._synthesis_on_the_plant-level_cost_of_nuclear.pdf

Sendstad L.H., Hagspiel V., Jebsen Mikkelsen W., Ravndal R., Tveitstøl M., The impact of subsidy retraction on European renewable energy investments, *Department of Industrial Economics & Technology Management, Norwegian University of Science & Technology*, 2022

https://www.sciencedirect.com/science/article/pii/S0301421521005401#:~:text=In%20the%20same%20line%20of,also%20impacted%20by%20policy%20changes.

Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people*, European Commission*, SWD (176), Brussels 2020

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0176

Still great interest in funding for green energy projects, *EUDP*, March 2022

https://www.eudp.dk/en/nyheder/stadig-stor-interesse-stoette-til-groenne-energiprojekter

Stranded assets and renewables: how the energy transition affects the value of energy reserves, buildings and capital stock, International Renewable Energy Agency (IRENA), Abu Dhabi, 2017

file:///C:/Users/rlupascu00/Downloads/IRENA_REmap_Stranded_assets_and_renewables_2017.pdf

Study providing analytical support for the financial instruments and programmes to facilitate investment in the energy sector: the Recovery and Resilience Facility, *European Commission*, 2022

Technical assistance: Local authorities needs and upcoming policy, *Build Upon,* 2021

https://www.bpie.eu/wp-content/uploads/2021/12/BU_TA_0112.pdf

The Greentech Fund Call 2022/09 received a total of six applications, *SmartCap,* 2023

The Greentech Fund Call 2022/09 received a total of six applications - SmartCap

Treaty on the Functioning of the European Union (TEFU)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:12012E/TXT&from=EN

UK energy titan SSE says low wind, driest conditions in 70 years hit renewable generation, *CNBC.com*, September 2021

https://www.cnbc.com/2021/09/29/sse-says-low-wind-dry-conditions-hit-renewable-energy-generation.html

Unlocking banks' capacity to fund the recovery, *European Stability Mechanism,* 2022

https://www.esm.europa.eu/blog/unlocking-banks-capacity-fund-recovery

Wind Turbine Payback Period, *Enerpower*, 2011

https://enerpower.ie/2011/03/30/wind-turbine-payback-period/

What you need to know about the skills shortage threatening the UK offshore wind industry, *K2Management*, December 2021 https://www.k2management.com/news/skills-challenges-offshore

Why extreme weather is putting renewable systems in the spotlight, *Energy Monitor*, 2021

https://www.energymonitor.ai/policy/market-design/why-extreme-weather-is-putting-renewable-systems-in-the-spotlight

Annexes

Annex 1: Definitions of instruments used for the mapping

Loan

A loan is an agreement which obliges the lender to make available to the borrower an agreed sum of money for an agreed period of time and under which the borrower is obliged to repay that amount within the agreed time[174]. In case of a loan provided or guaranteed by a public authority, directly or indirectly, it can help addressing a shortage of finance available where commercial banks are unwilling to lend on acceptable terms to the borrower. Nonetheless, commercial banks can also provide loans at better conditions than normal market ones as part of their lending strategy without public support (e.g., as in the case of loans for solar panels installation for which a strong pipeline is foreseen).

A financial instrument in the form of loan can be either provided directly by commercial banks at better conditions than what they would apply in a standard commercial loan (following the market interest rate), or directly by a public (regional, national, or European) body. In the case, for instance, of a guaranteed loan, the bank usually shares the risks it takes with a public authority, which functions as guarantor and financer, and allows the bank to take a greater degree of risk exposure and provide higher amounts of financing than it would be able to do in normal conditions. In the second case, the public authority directly provides the loan and acts as financial institution.

In the case of a public authority, the repayments of the loan allow the so-called revolving effect, that is the situation where the flows of money coming from the repayment of the loan is invested in another loan.

Loans play an important role in the European economy, constituting on average over 50% (56.2%) of the external finance of European companies[175].

Equity

An equity investment is the provision of capital to a company, invested directly or indirectly in return for total or partial ownership of that firm and where the equity investor may assume some management control of the firm and may share the firm's profits. In the case of equity, the financial return depends on the growth and profitability of the company and is earnt through dividends and/or the sale of the shares to another investor[176].

Equity constitutes around 0.5% of EU companies' external finance[177].

Quasi-equity

A type of financing that ranks between equity and debt, having a higher risk than senior debt and a lower risk than common equity. Quasi-equity investments can be structured as debt, typically unsecured and subordinated and in some cases convertible into equity, or as preferred equity.

Grants

Direct financial contributions provided to third-party beneficiaries (i.e. companies and households). This contribution does not need to be paid back, and is usually aimed at covering part of the upfront costs (CAPEX) or of the operating costs (OPEX) of a project. Grants can also be used to cover the costs of technical assistance to companies to conduct energy audits, develop bankable projects, etc.

[174] European Commission (2015). Guidance for Member States on Financial instruments – Glossary.

[175] EIB Investment Survey 2021.

[176] Fi-compass.

[177] EIB Investment Survey 2021.

On average, grants represent 9.16% of EU companies' external financing[178].

Bonds

Bonds are a fixed-income instrument that represents a loan made by an investor to a borrower. In return for the loan, the bond issuer will pay interest to the bondholder at fixed intervals until the bond matures and the money is paid back. Bonds can be issued by companies or by public entities.

According to the EIB Investment Survey 2021, bonds account for around 1% of EU companies' external financing composition[179].

Blended finance

Blended finance is the combination of finance from public and private resources to finance projects. Blended finance can be distinguished from other types of financial instruments by the fact that it requires a combination of public and private resources to implement a certain project jointly by the public and private sector.

Like financial instruments, blended finance is used to achieve public policy objectives that, in the existing market conditions, cannot be achieved through pure market dynamics and/or legislation.

Guarantees

A guarantee is a written commitment to assume the responsibility for all or part of a third party's debt, usually a commercial bank's, if an event such as a loan default occurs[180]. The guarantor, which can be a public institution, disburses resources only if the guaranteed fails to comply with its commitments.

For final beneficiaries (i.e. companies and households), guarantees take the form of a loan, as the guarantee is always provided to a financial intermediary, a bank or a fund, for instance, which then provides financing at better conditions.

Technical assistance

TA refers to different types of services provided to final beneficiaries and/or financial intermediaries to improve their capacities/skills to, for instance, perform business modelling, financial planning, risk assessment, report, etc.

Technical assistance (TA) is essential for the successful deployment of financial support instruments and for the achievement of their objectives and goals. Know-how transfer and capacity building can provide benefits to all stakeholders involved in an energy generation project. On the one hand, TA can be developed to help project promoters preparing a solid business and financial plan that is ready to be submitted to investors and financial institutions, and thus **improve the investment readiness** of projects and **their ability to access external financing options**. Combining technical assistance with instruments such as loans or grants can therefore facilitate the implementation and uptake of such instruments to support well-defined and more mature project proposals.

TA can also help project promoters comply with the different requirements, for instance, in terms of reporting. This can be particularly helpful for start-ups and SMEs, which might lack dedicated personnel to comply with the requirements or might simply not have the knowledge/expertise to do so. On the other hand, TA can also be useful for investors, banks, and other financial institutions to adequately understand how some sectors and types of project work, how they are structured, and how revenues are generated. This type of TA is sometimes used in market development programmes for new emerging sectors (e.g. blue economy, cybersecurity, etc.). Investors are usually not familiar with emerging sectors and tend to refrain from investing in them due to their lack of awareness of potential revenues, and to the lack of know-how on how to screen opportunities and identify and quantify risks. Finally, TA can also help policymakers, regulatory, and local authorities to better grasp the technicalities and specificities of a given market sector so as to be able to write informed and tailored legislation, regulation, and public procurement.

178 EIB Investment Survey 2021.

179 EIB Investment Survey 2021.

180 European Commission (2015). Guidance for Member States on Financial instruments – Glossary.

Annex 2: Overview of EU financing programmes for Energy Production

Energy in the MFF and NGEU	Aim	Specific Funding sectors (if any)	Total Budget
	Main energy-relevant programmes		
Connecting Europe Facility - Energy (CEF Energy)	Supports investments in building new cross-border energy infrastructure in Europe or rehabilitating and upgrading the existing one.	**(1)** Energy Infrastructure projects (PCIs) **(2)** Cross border Renewable Energy projects	€ 5.84 billion
International Thermonuclear Experimental Reactor (ITER)	Large-scale experiment designed to prove the scientific and technical viability of fusion as a new energy source, and to take fusion energy to the threshold of industrial exploitation	Focus on nuclear energy	€ 5.61 billion
Nuclear Decommissioning (Lithuania)	The programme for decommissioning and waste management, to support knowledge sharing and to deliver a safer Union.	Focus on decommissioning and nuclear waste management	€ 552 million
Nuclear safety and decommissioning (incl Bulgaria and Slovakia)	The programme provides funding for the decommissioning of nuclear facilities and the management of radioactive waste, in line with the needs identified in the respective decommissioning plan.	Focus on decommissioning and nuclear waste management	€ 466.00 million
LIFE Programme	The LIFE Programme is the EU's funding instrument for the environment and climate action.	**(1)** Nature and biodiversity **(2)** Circular Economy and Quality of Life **(3)** Climate Change Mitigation and Adaptation **(4)** Clean Energy Transition	€ 5.43 billion
	of which Clean Energy sub-programme		
InvestEU Programme	The InvestEU Programme supports sustainable investment, innovation and job creation in Europe. It aims to trigger more than €372 billion in additional investment over the period 2021-27.	**(1)** Sustainable Infrastructure **(2)** Research, Innovation and Digitalisation **(3)** SMEs **(4)** Social Investment and Skills	€26.2 billion
Horizon Europe	Horizon Europe is the EU's key funding programme for research and innovation which tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth.	Focus on research and innovation.	€ 95.5 billion

Energy in the MFF and NGEU	Aim	Specific Funding sectors (if any)	Total Budget
European Regional Development Fund (ERDF)	The European Regional Development Fund (ERDF) aims to strengthen economic, social and territorial cohesion in the European Union by correcting imbalances between its regions.	**(1)** Competitiveness **(2)** Low carbon resilience **(3)** connected: enhancing mobility **(4)** inclusive employment and skills **(5)** locally led development and sustainable urban development	€ 370 billion
Cohesion Fund	The Cohesion Fund provides support to Member States with a gross national income (GNI) per capita below 90% EU-27 average to strengthen the economic, social and territorial cohesion of the EU.	The Cohesion Fund supports investments in the field of environment and trans-European networks in the area if transport infrastructure (TEN-T).	
Just Transition Mechanism (Just Transition Fund and Public Loan Facility)	**The Just Transition Fund** supports the economic diversification and reconversion of the territories concerned. It focuses on: investments in Small and Medium-sized Enterprises, creation of new firms, research and innovation, environmental rehabilitation, clean energy, up- and reskilling of workers, job-search assistance, transformation of existing carbon-intensive installations **The Public Sector Loan Facility (PSLF)** is the third pillar of the Just Transition Mechanism. It supports projects addressing the challenges deriving from the transition to the European Union's climate target objectives in the territories most negatively affected by the climate transition as identified in the previously approved Territorial Just Transition Plans.		**Just Transition Fund:** € 19.32 billion, of which € 10.87 is under NextgenerationEU **PSLF**: €1.525 billion
Recovery and Resilience Facility (RRF)	The aim of the Recovery and Resilience Facility is to mitigate the economic and social impact of the coronavirus pandemic and make European economies and societies more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transitions.		€ 723.8 billion
Other programmes that might benefit energy			
Euratom Research and Training Programme	The Euratom Research and Training Programme (2021-2025) pursues the following key research activities through direct and indirect actions: nuclear safety, security, radioactive waste, spent fuel management, radiation protection, fusion energy.The programme also expands research into non-power applications of ionising radiation.	Focus on nuclear energy	€ 1.38 billion

Energy in the MFF and NGEU	Aim	Specific Funding sectors (if any)	Total Budget
Neighbourhood, Development and International Cooperation Instrument	The new Global Europe will cover the EU cooperation with all third countries, except for the pre-accession beneficiaries and the overseas countries and territories from the geographic programmes. It will particularly support countries most in need to overcome long-term developmental challenges and will contribute to achieving the international commitments.		€ 79.5 billion
Instrument for pre-accession Assistance (IPA)	The IPA acts on 5 components ● Assistance for transition and institution building; ● Cross-border cooperation (with EU Member States and other countries eligible for IPA); ● Regional development (transport, environment, regional and economic development); ● Human resources (strengthening human capital and combating exclusion); ● Rural development.		€ 14.162 billion
non-MFF/NGEU programmes			
Innovation Fund	The Innovation Fund will contribute to greenhouse gas reduction. It is designed to take into account the lessons learned from its predecessor, the NER300 programme. It focuses on highly innovative technologies and big flagship projects with European value added that can bring significant emission reductions.	Focus on Innovative technologies	€ 25 billion
Modernisation Fund	The Modernisation Fund is a dedicated funding programme to support 10 lower-income EU Member States in their transition to climate neutrality by helping to modernise their energy systems and improve energy efficiency.	**(1)** Generation and use of energy from renewable sources **(2)** Energy efficiency **(3)** Energy storage **(4)** Modernisation of energy networks, including district heating, pipelines and grids **(5)** Just transition in carbon-dependent regions	€ 48 billion (depending on carbon price)

Annex 3: Methodology for WACC Calculation

The Weighted Average Cost of Capital (WACC) for Renewable Energy projects in Europe was calculated by PwC for this study using the following formula:

$$WACC = \frac{D}{D+E} * CoD * (1-t) + \frac{E}{D+E} * CoE$$

Where:

- *D* is the market value of a firm's debt
- *E* is the market value of a firm's equity
- *t* is the corporate tax rate
- *CoD* is the cost of debt after tax, calculated as follows: $CoD = (risk\ free\ rate + sector\ specific\ spread) * (1-t)$
  We have applied a +2% assumption for lenders' margins to risk free rate and the sector specific spread, based on the literature on energy finance[181]. We have selected the country specific risk-free rate to reflect country risks[182].
- *CoE* is the cost of equity, calculated as follows: $CoE = risk\ free + \beta * ERP$, where ERP is the equity risk premium of every country and β is a measure of the volatility — or systematic risk — of a security or portfolio (or a specific sector/transaction) compared to the market as a whole. ERP is country-specific and β is specific to the renewable energy sector. Both data are extracted from Aswath Damodaran (Stern, New York University)[183].

One note on $\frac{D}{D+E}$ and $\frac{E}{D+E}$. They are specific to the renewable energy sector, reflecting the levels of debt and equity normally used for renewable energy projects. However, in absence of country-specific data, we have assumed that these variables are the same across the whole EU. This is of course an important caveat, as differences in $\frac{D}{D+E}$ and $\frac{E}{D+E}$ across countries might exist and they would significantly affect the WACC.

The table below shows the calculation of the WACC for each country.

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Green & Renewable Energy	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Austria	6.57%	0.56%	0.87	1.80%	7.51%	25%	67.48%	32.52%	2.85%	5.77%
Belgium	6.85%	0.84%	0.87	1.40%	7.36%	25%	67.48%	32.52%	2.55%	5.59%
Bulgaria	8.24%	2.23%	0.87	1.60%	8.77%	10%	67.48%	32.52%	3.24%	6.87%
Croatia	9.51%	3.50%	0.87	1.50%	9.77%	18%	67.48%	32.52%	2.87%	7.36%
Cyprus	9.51%	3.50%	0.87	3.50%	11.77%	13%	67.48%	32.52%	4.81%	9.31%
Czechia	6.85%	0.84%	0.87	4.10%	10.06%	19%	67.48%	32.52%	4.94%	8.09%

[181] Source: IRENA, RENEWABLE POWER GENERATION COSTS IN 2021, available at: https://www.irena.org/publications/2022/Jul/Renewable-Power-Generation-Costs-in-2021#:~:text=The%20global%20weighted%20average%20levelised,%25%20to%20USD%200.075%2FkWh.

[182] Source: Statista, available at: https://www.statista.com/statistics/885915/average-risk-free-rate-europe/

[183] Available at: https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datacurrent.html

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Green & Renewable Energy	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Denmark	6.01%	0.00%	0.87	1.40%	6.63%	22%	67.48%	32.52%	2.65%	5.15%
Estonia	7.00%	0.99%	0.87	2.50%	8.59%	20%	67.48%	32.52%	3.60%	6.73%
Finland	6.57%	0.56%	0.87	1.40%	7.11%	20%	67.48%	32.52%	2.72%	5.51%
France	6.70%	0.69%	0.87	1.30%	7.13%	27%	67.48%	32.52%	2.43%	5.39%
Germany	6.01%	0.00%	0.87	1.20%	6.43%	30%	67.48%	32.52%	2.24%	4.85%
Greece	11.04%	5.03%	0.87	1.60%	11.20%	24%	67.48%	32.52%	2.74%	8.24%
Hungary	8.67%	2.66%	0.87	4.90%	12.44%	9%	67.48%	32.52%	6.28%	10.26%
Ireland	7.00%	0.99%	0.87	1.50%	7.59%	13%	67.48%	32.52%	3.06%	5.99%
Italy	9.08%	3.07%	0.87	1.70%	9.60%	24%	67.48%	32.52%	2.81%	7.17%
Latvia	7.69%	1.68%	0.87	2.00%	8.69%	20%	67.48%	32.52%	3.20%	6.69%
Lithuania	7.19%	1.18%	0.87	2.00%	8.26%	15%	67.48%	32.52%	3.40%	6.51%
Luxembourg	6.01%	0.00%	0.87	1.40%	6.63%	25%	67.48%	32.52%	2.55%	5.10%
Malta	7.19%	1.18%	0.87	2.00%	8.26%	35%	67.48%	32.52%	2.60%	6.12%
Netherlands	6.01%	0.00%	0.87	1.30%	6.53%	25%	67.48%	32.52%	2.48%	5.01%
Poland	7.19%	1.18%	0.87	4.00%	10.26%	19%	67.48%	32.52%	4.86%	8.20%
Portugal	8.67%	2.66%	0.87	1.60%	9.14%	21%	67.48%	32.52%	2.84%	6.90%
Romania	9.08%	3.07%	0.87	7.20%	15.10%	16%	67.48%	32.52%	7.73%	12.30%
Slovakia	7.19%	1.18%	0.87	2.70%	8.96%	21%	67.48%	32.52%	3.71%	7.00%
Slovenia	7.69%	1.68%	0.87	2.60%	9.29%	19%	67.48%	32.52%	3.73%	7.25%
Spain	8.24%	2.23%	0.87	2.10%	9.27%	25%	67.48%	32.52%	3.08%	7.01%
Sweden	6.01%	0.00%	0.87	1.40%	6.63%	21%	67.48%	32.52%	2.70%	5.17%

Source: PwC calculation

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