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EU’s Global Leadership in Renewables

Final synthesis report
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Abstract

This is a study on the EU's global leadership in renewable energy (RE), covering wind energy, solar energy, bioenergy, geothermal and aerothermal, hydropower and ocean energy. It applies a value-chain based approach, covering the following segments: research, project planning, resource sourcing, manufacturing, construction and operation and end-of life management. For each of the technology and value chain segments, the study assesses the EU's current situation in terms of competitiveness and global leadership through a statistical analysis for the period 2010-2018. Future developments are illustrated through six case studies of maturing energy technologies, a brief SWOT analysis, and forward projections based on the modelling tools used by the European Commission, supplemented by an analysis of PRIMES projected future developments.

Building on this, the study proposes EU policy options that could promote the global leadership and competitiveness of the EU's RE sector. The impacts of these are quantitatively assessed based on four performance criteria: lowering costs of RE technologies, improving their efficiency, improving trade conditions for exporting RE technologies, and increasing global market. An Excel Tool delivers rough estimates of the likely impacts on direct employment and GVA. Stakeholder consultations, including four specific stakeholder workshops, expert assessment, scoping interviews, and over 40 bilateral in-depth interviews, have constituted an integral element of the study

Kurzfassung

Diese Studie beschreibt die globale Führungsrolle der EU bei den erneuerbaren Energien (EE) und behandelt die Sektoren Windkraft, Solarenergie, Bioenergie, geothermische und aerothermische Energie, Wasserkraft und Meeresenergie. Für die Studie wurden die Wertschöpfungsketten dieser Sektoren analysiert und die folgenden Segmente berücksichtigt: Forschung, Projektplanung, Ressourcenbeschaffung, Herstellung, Bau und Betrieb und Entsorgung. Im Rahmen der Studie wurde für alle Segmente in Bezug auf Technologie und Wertschöpfungskette anhand einer statistischen Analyse für den Zeitraum 2010-2018 die aktuelle Wettbewerbsfähigkeit und globale Führungsrolle der EU bewertet. Künftige Entwicklungen werden anhand von sechs Fallstudien zu Energietechnologien, die demnächst die Marktreife erreichen, einer kurzen SWOT-Analyse sowie Prognosen mit den von der Europäischen Kommission verwendeten Modellierungsinstrumenten verdeutlicht, ergänzt durch eine Analyse der von PRIMES prognostizierten künftigen Entwicklungen.

Auf dieser Grundlage wurden für die Studie politische Optionen der EU entwickelt, mit denen die EU ihre globale Führungsposition und ihre Wettbewerbsfähigkeit bei den erneuerbaren Energien ausbauen könnte. Deren Auswirkungen werden anhand von vier Leistungskriterien quantitativ bewertet, nämlich Senkung der Kosten für EE-Technologien, Erhöhung ihrer Effizienz, bessere Handelsbedingungen für den Export von EE-Technologien und Erhöhung des globalen Markts. Ein Excel-Werkzeug liefert grobe Schätzwerte zu den wahrscheinlichen Auswirkungen auf die direkte Beschäftigung und die BWS. Die Konsultation der Interessenvertreter, die unter anderem in vier Workshops für spezielle Interessenvertreter sowie durch die Einschätzung von Experten, Interviews zur Problembestimmung und über 40 ausführliche bilaterale Interviews erfolgt ist, war ein wichtiger Bestandteil der Studie.

Résumé

Le présent rapport consiste en une étude sur le leadership mondial de l’Union européenne (UE) en matière d’énergies renouvelables, couvrant l’énergie éolienne, l’énergie solaire, la bioénergie, l’énergie géothermique et aérothermique, l’énergie hydraulique et l’énergie marine. Il applique une approche basée sur la chaîne de valeur qui couvre les segments suivants : la recherche, la planification du projet, l’approvisionnement en ressources, la fabrication, la construction et l’exploitation, ainsi que la gestion en fin de vie. Pour chacune des technologies et des segments de la chaîne de valeur, l’étude évalue la situation actuelle de l’UE en matière de compétitivité et de leadership mondial au moyen d’une analyse statistique pour la période 2010-2018. Les évolutions futures sont illustrées par six études de cas de technologies énergétiques en voie de développement, une brève analyse des forces, faiblesses, opportunités et menaces, et des projections basées sur les outils de modélisation utilisés par la Commission européenne, le tout complété par une analyse des développements futurs prévus par PRIMES.

Sur cette base, l’étude propose des options stratégiques qui pourraient promouvoir le leadership mondial et la compétitivité du secteur des énergies renouvelables de l’UE. Les impacts de ces options sont évalués quantitativement sur la base de quatre critères de performance : la réduction des coûts des technologies liées aux énergies renouvelables, l’amélioration de leur efficacité, l’amélioration des conditions commerciales pour l’exportation des technologies liées aux énergies renouvelables, et l’extension du marché mondial. Un document Excel fournit des estimations approximatives des impacts probables sur l’emploi direct et la valeur ajoutée brute (VAB). Les consultations des parties prenantes, y compris quatre ateliers spécifiques, des évaluations d’experts, des entretiens de cadrage et plus de 40 entretiens bilatéraux approfondis, constituent les éléments centraux de l’étude.

Executive Summary

The study finds that **the EU holds a global leadership position** in terms of world market shares **particularly in Wind Energy (67%), Geothermal Technologies (42%) and Hydropower (39%)**[1] in 2018. EU's overall exports to the rest of the world amounted to over € 5.4 billion in 2018[2], an average annual increase of 1.6 % p.a[3]. compared to 2010. The growth in Wind Energy technologies (3.0 % p.a.) and Bioenergy (10.9 % p.a.)[4] have more than compensated the -2.2 % p.a. drop in Solar Energy technology exports. EU Solar Energy technology exports drop was even more severe including the EU intra-trade (-12.5 % p.a.). The sharp declining of -18.3 % p.a. occurred from 2010 to 2015. Since, EU Solar Energy technologies exports, including EU intra-trade, have flattened out and increased (+2.6 % p.a. 2016 to 2018). Global Solar Energy exports are dominated by countries in the Asia-Pacific region, especially by China.

Innovation is a key asset for international renewable energy competitiveness. **The EU leads the global innovation race with the highest share of high value patents**[5] (36%, 2016). Based on this assessment, the EU holds an innovation leadership position in all assessed renewable energy technologies, with a shared leadership position with Japan and South Korea in Solar energy technologies. While EU's share of high value patents marginally dropped in 2016 to 36%, the EU still holds more than twice as many high value filings than any other world region. China, by contrast, only holds a 9% global share, even though it has seen a fivefold increase compared to 2008.

In addition, **maturing energy technologies could further strengthen the EU's future global leadership**. For instance, the EU currently has a strong position within renewable hydrogen, building-integrated photovoltaics (BIPV), floating offshore wind (FOW), and ocean energy. However, non-EU countries have a stronger leadership position within EV batteries and floating solar PV. While there is increasing competition from Asia and North America, European companies are well positioned to maintain and further develop their global leadership position within renewable hydrogen. Even though still niche, the global BIPV market is currently dominated by European companies. In addition, European companies are pioneers in FOW and lead three quarters of the more than 50 projects worldwide today. The EU is also a leader in the filing of ocean energy patents in international markets, seeking protection in key markets such as the United States, South Korea, and China, as well as Canada and Australia. However, in terms of batteries, Europe is in a catch-up mode. For example, the global electrical vehicles (EV) battery market is dominated by manufacturers from three countries, all of them in Asia: China, Japan, and South Korea. China's strength within solar PV manufacturing puts the country also in a strong position in the floating solar PV segment.

[1] Based on trade data, hence concentrating on goods and not considering services. Considering the EU as one single market and trader, (i. e. excluding EU intra-trade) with data for 2018.
[2] Average annual exchange rate, source: World Bank
[3] Growth rates based on US$ across the report. Between 2010 and 2015 the US$ revaluated against the EUR, then fell slightly again.
[4] The strong growth rate in Bioenergy is mainly driven by the increase of biodiesel exports since 2015.
[5] High-value patents describe those patent families that have been filed in more than one patent office, i.e. in several countries to secure international protection.

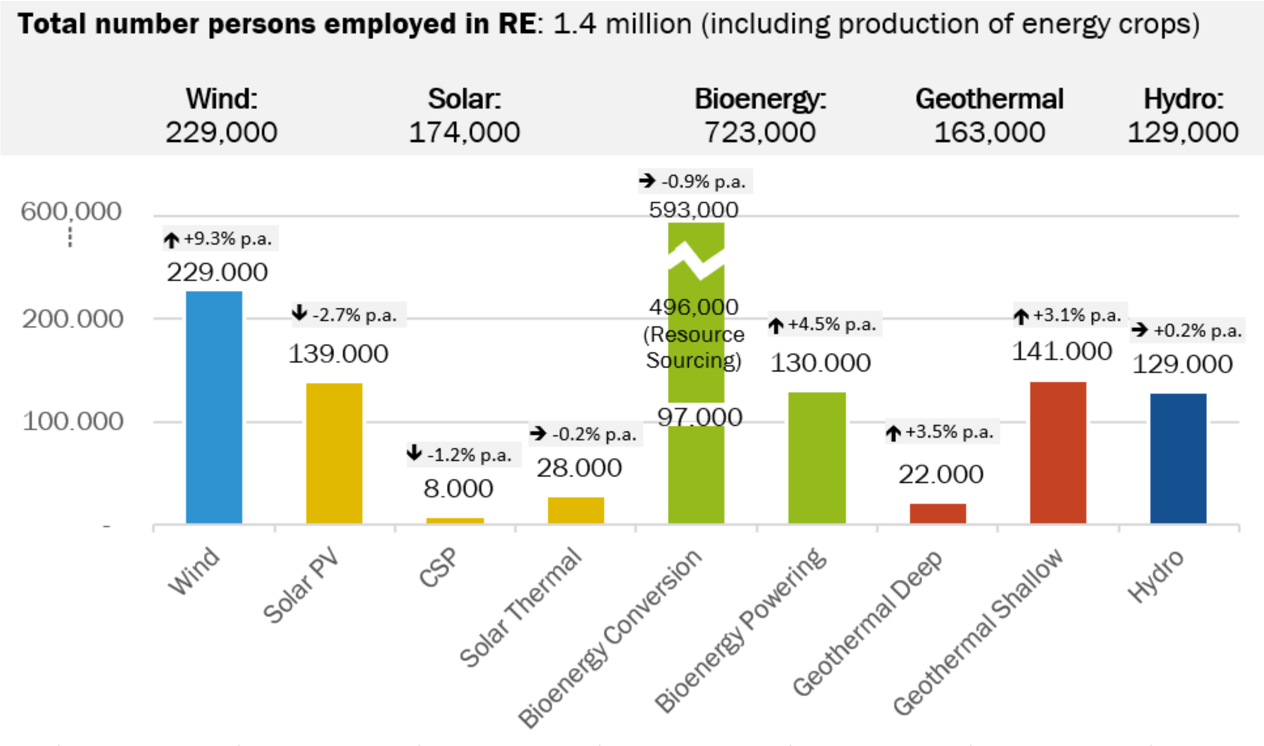
Table 1: EU global competitiveness indicators (EU compared to 12 selected non-European countries)

			Wind energy	***Bioenergy***	***Solar energy***	***Geothermal & aerothermal***	***Hydropower***
Global Exports	**World Market Share (2018)**	**EU**	**67%**	**17%**	**4%**	**42%**	**39%**
		Main* rivals	CN: 18% IN: 3% JP: 1% US: 1% TR: 1% KR: 1%	ID: 22% US: 10% MY: 7% CN: 6% KR: 1% JP: 1%	CN: 35% MY: 10% JP: 8% KR: 8% US: 6% MX: 1%	CN: 21% JP: 11% US: 9% KR: 3% MX: 2% MY: 1%	CN: 23% US: 10% IN: 6% JP: 3% TR: 1% KR: 1%
	Growth Rate (2010-18 %	**EU**	**3.0%**	**10.9%**	***-2.2%***	**1.6%**	***-2.2%***
		Main rivals	CN: 21.3% IN: *-2.3%* JP: *-0.8%* US: -21.7% TR: 1.8% KR: -4.9%	ID: *-1%* US: *-5.2%* MY: 70% CN: 23.5% KR: -4.6% JP: -9.9%	CN: *-3.5%* MY: 5.5% JP: *-5.6%* KR: 0.4% US: -2.9% MX: -2.7%	CN: 5.4% JP: 1.1% US: 5.9% KR: 3.8% MX: -11.2% MY: -6.1%	CN: *-6.4%* US: *-8.1%* IN: 6.6% JP: -4.7% TR: 22.7% KR: 11.3%
Patents	**Share of Patents (2016)**	**EU**	**63%**	**46%**	**20%**	**47%**	**46%**
		Main rivals	CN: 6% IN: 0% JP: 11% US: 11% TR: 0.2% KR: 3%	ID: 0% US: 24% MY: 0% CN: 5% KR: 2% JP: 13%	CN: 12% MY: 0% JP: 22% KR: 22% US: 12% MX: 0%	CN: 8% JP: 12% US: 15% KR: 4% MX: 0% MY: 0%	CN: 2% US: 12% IN: 0% JP: 26% TR: 0% KR: 7%
	Growth in Patent Number	**EU**	**EU: 5.4%**	**EU: *-0.7%***	**EU: *-3.8%***	**EU: *-0.4%***	**EU: 6.1%**
		Main rivals	CN: 26.1% IN: 0% JP: *-7.2%* US: -11.9% TR: 9.8% KR: 4.2%	ID: - US: *-9.4%* MY: - CN: 10.2% KR: -13.4% JP: -0.7%	CN: 29% MY: - JP: 3.9% KR: 7.9% US: -9.8% MX: -	CN: 16.2% JP: -2.6% US: 6.1% KR: -18.9% MX: - MY: -	CN: 0% US: 13.8% IN: - JP: 24.9% TR: - KR: 19.4%

**12 selected non-EU countries: CN: China; EG: Egypt; ID: Indonesia; IN: India; JP: Japan; MX: Mexico; MY: Malaysia; NO: Norway; KR: South Korea; TR: Turkey; UA: Ukraine; US: United States; not all appear in the table above.*

The EU's global renewable energy leadership is a significant generator of direct employment and GVA growth within the EU. As of 2018, there are over 1.4 million persons directly employed in the RE sector in the EU, with the largest share currently employed in the Bioenergy sector (including production of energy crops)[6]. While the Solar Energy's development has been turbulent, Wind Energy has doubled its employment compared to 2010 (with robust jobs growth of +9.3% annually). Geothermal Energy, including Heat Pumps, have also seen recent expansion (+3.1% p.a. for Shallow including Aerothermal and +3.5% p.a. for Deep Geothermal). The use of bioenergy has also seen positive employment developments. (+4.5% p.a.)

Figure 1: Employment and growth

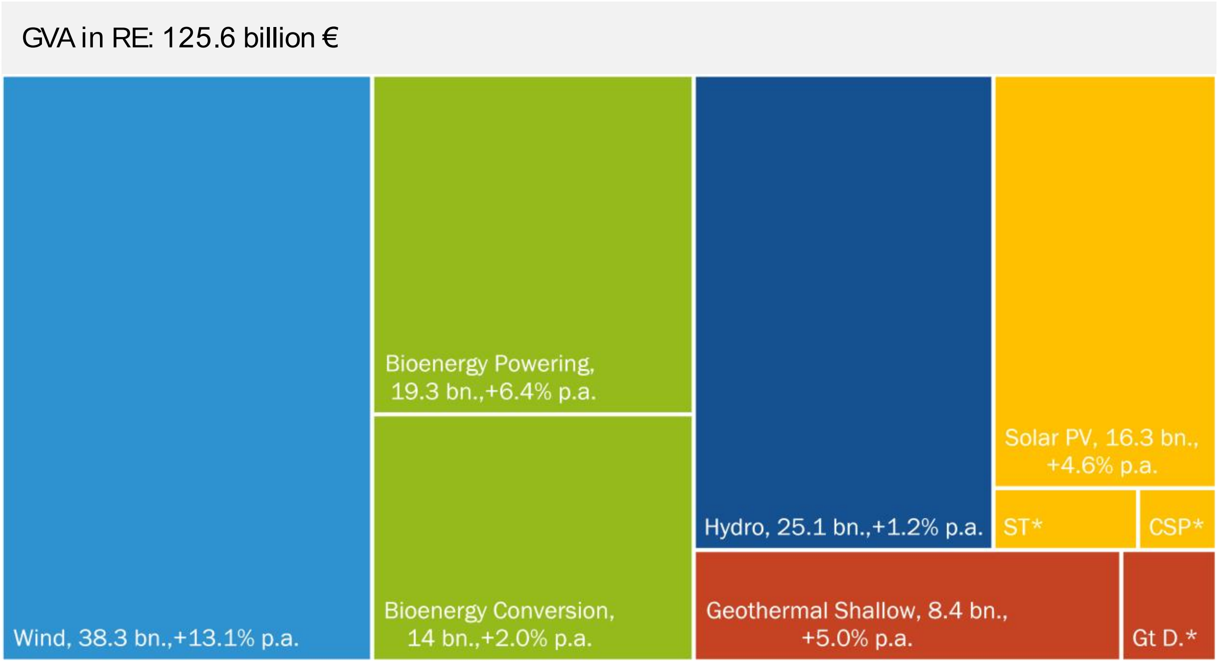


Source: own elaboration, based on Eurostat SBS

Renewable energy GVA in the EU is estimated to be € 125.6 bn (2018), with the highest contribution from the Wind Energy sector (€ 38.3 bn). The RE construction and operation value chain segment brings the largest GVA (76%, 94 bn.) with the highest growth rate in wind (above 10%) and geothermal energy (above 3%).

[6] This assessment considers all direct activities along the value chains as defined in the detailed mapping of activities and products, where these could be matched to the economic classification system. The scope of the analysis differs from other common approaches, such as input-output modelling or the analysis of bottom-up company data. As such indirect or induced effects are not included. Results presented in this study, thus, may deviate from other reports, due to the use of different methodologies, scopes, metric, and data. For example, EurObserv'ER state 1.5 million full time equivalent (FTE) persons directly or indirectly employed in the European Union renewable energy sector https://www.eurobserv-er.org/19th-annual-overview-barometer/

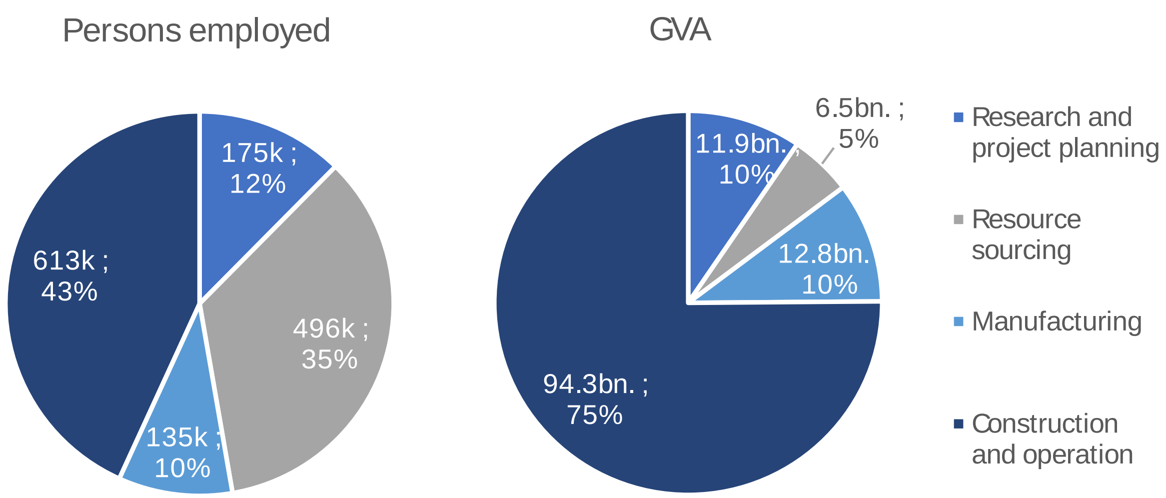
Figure 2: GVA and growth



*Gt D.=Geothermal Deep, 1.9 bn.,+3.0% p.a.; ST= Solar Thermal, 1.6 bn.,-0.4% p.a.; CSP 0.9 bn. Euro,+4.6% p.a.
Source: own elaboration, based on Eurostat SBS

Across the six value chain segments assessed under this study, **construction and operation is the segment that makes the largest impact on employment** (44%, 0.6 million jobs) **and GVA** (76%, € 94 billion) in the EU.

Figure 3: Employment and GVA by value chain segment* 2018 (in %)



*The value chain segment End-of-service-life management was not included in the economic analysis due to its difficult assessment and its current marginal economic importance.
Source: own elaboration, based on Eurostat SBS

Looking ahead, the EU has set an ambitious GHG reduction target of 55% by 2030 and climate neutrality by 2050. The path to reaching this target will imply that total installed capacity of solar power will be quadrupled, and wind power tripled before 2050 compared to 2020, contributing to further job creation and GVA growth. The expansion will impact Member States differently depending on the availability of sun and wind resources, energy systems and industrial capabilities. The development of GVA and employment in the baseline can be explored further in an Excel Tool developed as part of this assignment.

In addition, based on desk research and stakeholder consultation, the study has identified five general objectives that can be pursued to continue to improve EU global leadership in renewable energy technologies. These have been translated into specific objectives, and possible EU policies promoting the EU's leadership and competitiveness in renewable energy. The study assessed each of these as EU policy options. Furthermore, a quantitative analysis was conducted on the potential impact of these policy options on jobs and GVA.

Table 2: Overview of identified objectives and possible EU policies

General objectives	Specific objectives	Possible EU policy options
Improving access to finance for commercially ready RE projects	*Strengthening an enabling policy environment for investments in the EU during the period of 2021-2030* *Improving coordination and availability of EU financing sources across the EU, especially in MS which need them most* *Better channel to stimulate private funding by a well-functioning sustainable finance framework*	Enabling policy environment for RE investments in the EU in the period of 2021-2030 Better access to EU funding programmes Establishing and Import Project of Common Interest (IPCEI) for RE Mobilising private funding by fast adoption and progressive amendment of the EU Sustainable Finance Framework
Reducing administrative burdens of project permits	*Simplifying the permitting process for developing installations* *Shortening and providing higher certainty around the permitting timeline*	EU guidelines on transposition and implementation of relevant articles under REDII and Electricity Market Directive EU Renewables Deal: new mechanism to identify and reduce regulatory barriers affecting RE projects
Bridging the funding gap between R&D and commercialisation	*Promoting the use of EU funds for demonstration of technologies* *Mitigating the risks associated with innovative pilot and pre-commercial projects* *Better coordinating public funding to support the deployment of RE technologies*	Enhanced use of the Innovation Fund Creation of an EU Risk insurance and guarantee fund Sequencing and blending different public funding opportunities
Facilitating the export of EU RE technologies and services	*Ensuring that EU companies benefit from EU support in developing countries* *Coordinating and harmonising efforts to facilitate the export of EU RE technologies and services* *Removing trade barriers for the EU products through standardisation*	EU support for RE in developing countries Harmonising efforts of the export credit agencies across the EU Promotion of the further alignment of standards internationally
Fostering global demand for renewable H&C technologies	*Improving the policy environment in the EU and supporting third countries with best practice transfer* *Reducing barriers that consumers face when adopting RE H&C solutions*	Assessing and reforming policies affecting the RE H&C industry Assessing existing public-private initiatives to launch dedicated alliances and to identify and disseminate best practices to remove financial

	in the EU *Supporting information exchange about H&C technologies with third countries*	barriers Promoting consumers' awareness of available RE H&C products Organising information campaigns and guidance to third countries authorities to develop better RE H&C policies

Policies improving access to finance for commercially ready RE projects can generate 900,000 additional jobs and € 165 billion of GVA by 2030 (Policy objective 1). Limited access to finance impinges on the competitiveness of the EU RE industry in several Member States. The EU could intervene to improve the RE sector's access to funding, notably for commercially ready technologies.[7] An enabling policy environment for RE investments would facilitate the achievement of the EU 2030 RE target and create the conditions for fostering private investments into RE technologies by rapidly adopting and progressively amending a Sustainable Finance framework. In addition, concrete measures to improve the access to EU and national funding programmes could be considered. Special attention should also be warranted for de-risking private investment in the RE sector and for the promotion of existing instruments, such as IPCEI. These policy options are expected to decrease the financing costs for RE projects, lower the capital expenditures (CAPEX) and stimulate R&D of RE technologies. Based on information collected during the interviews, the impacts were estimated for the solar PV, solar thermal, shallow geothermal and wind power value chains. The value chain segment that would contribute the most to these impacts is construction and operation services.

Policies reducing administrative burdens of project permits could generate between 125,000 and to 413,000 jobs, and GVA between € 37 billion and € 124 billion by 2030 (Policy objective 2). Lengthy, complex and uncertain permitting process for RE projects impinge on the deployment of RE projects in several Member States. The EU should intervene to simplify the permitting process for developing RE installations, shorten and provide higher certainty around the permitting timeline. This could be done through preparation of an EU guidance to ensure the proper transposition of relevant articles under the REDII and the Electricity Market Directive on permit-granting process and grid connection. In addition, introducing the so-called 'Renewable Deals' - an *ad hoc* notification mechanism for industry stakeholders and dialogues between the Commission and national/local permitting authorities - can help identify and remove unnecessary regulatory obstacles affecting the permitting process. These policy solutions would contribute to increasing the number of RE projects realised in the EU (particularly in less mature RE sectors) and allowing RE developers to rely on the most modern technologies available. The estimates of quantitative impacts are limited to the solar PV and wind power value chains. The segment that would benefit the most from improved permitting process is construction and operation services.

Policies bridging the funding gap between R&D and commercialisation of RE technologies could generate 81,000 jobs and € 15 billion GVA by 2030 (Policy objective 3). The demonstration and deployment of RE technologies are slow and hampered by the so-called 'valley of death' - the lack of funding resources to develop innovations once the basic research has been completed. To address this, the EU should closely coordinate with Member States to promote the use of EU funds for demonstration of RE technologies, mitigate the risks associated with pilot and pre-commercial RE projects, and improve the synergies of different public funding programmes. The

[7] Policies addressing the funding challenges for new RE technologies are assessed in the third policy group below (policies bridging the funding gap between R&D and commercialisation of RE technologies).

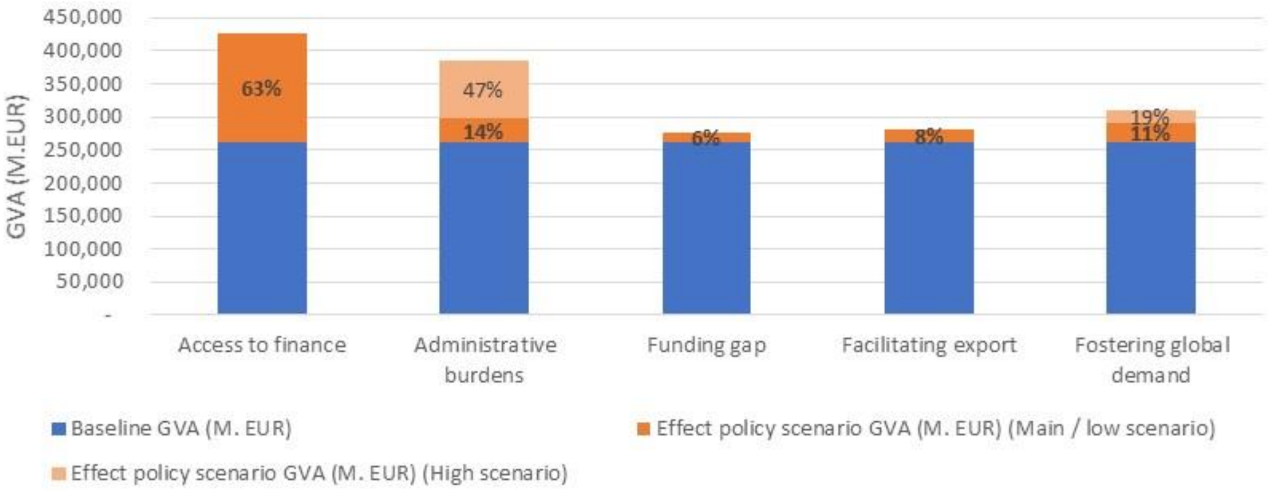
Innovation Fund is in place, so actions in this regard would aim to enhance awareness. The creation of an EU risk mitigation instrument would cover the risks associated with product testing, pilot projects or facilitating major demonstration projects. Strengthening the synergies of EU funding measures would involve a consultation process involving DG ENER and other Commission services, Member States and relevant stakeholders to improve the integration of research funds with other funding programmes that could support the demonstration and deployment of RE technologies. The most significant impacts of these options are lower CAPEX thanks to economies of scale and economies of learning, higher private R&D spending, lower financial costs and increased market potential for the EU RE industry. The impacts are quantitatively estimated for the solar PV, hydropower, wind power and geothermal value chains using inputs from the interviews. The segment that would observe highest impacts is the research segment.

Policies facilitating the export of EU RE technologies and services could generate 70,000 jobs, and € 20 billion GVA by 2030 (Policy objective 4). While export is key to securing competitiveness and global leadership in renewables, there are currently limited targeted tools facilitating the export of the EU RE technologies and services. The EU could support export activities of the RE industry in the global market through three policy options. First, the EU can support RE in developing countries to secure new export destinations for the EU RE technologies and services. Second, it can harmonise the efforts of the export credit agencies across the EU to create uniform conditions for exporting EU RE technologies across Member States. Third, the EU should promote alignment with international standards, e.g. the alignment of the ISO and the European Standards-EN. These above options could improve the competitiveness of the EU RE industry through increasing exports of EU RE technologies, decreasing financial costs and lowering CAPEX. The impacts are estimated for the bioenergy powering, hydropower, solar thermal, and ocean energy value chains. The impacts would materialise in the construction and operation services segment of these value chains.

Policies fostering global demand (including EU's demand) for renewable H&C technologies could generate between 364,000 and 631,000 jobs, and GVA between € 29 billion and € 49 billion by 2030 (Policy objective 5). Demand – in the EU and globally - for RE H&C technologies is hindered by insufficient policy support including a relatively less enabling RE H&C policy environment, low consumers' awareness of H&C solutions, and limited internal heat and energy planning capacities at local level. There is a need for timely interventions to foster demand for renewable H&C solutions. The Commission should improve the policy environment through creating a level playing field for RE H&C technologies vis-à-vis fossil-based solutions, ensuring a more enabling building codes and diffusing best practices among Member States. The EU can also assess existing public-private initiatives in certain Member States that support consumers choice for RE H&C solutions to identify and disseminate best practices and create dedicated H&C alliances. Promoting consumers' awareness of available EU RE H&C products can be done through consumer education, energy labelling and quality assurance. These solutions are expected to create a strong EU home market, which is a key prerequisite for increasing exports from the EU to third countries and enhancing global competitiveness of RE H&C manufacturers. Finally, information campaigns and guidance to third countries' authorities could develop better policies for RE H&C on a global scale. Inputs from stakeholders operating in the solar thermal, deep geothermal and shallow geothermal value chains are used to calculate the quantitative impacts. Construction and operations service is the segment that would observe highest impacts from these policy options.

Options under Policy objective 1 (access to finance) are expected to have the greatest impact on GVA, followed by objectives 2 (administrative simplification) and 5 (RE-H&C). Options under policy objectives that target a wide range of value chains typically have a greater impact, as will objectives that target high value chains. The impacts on employment follow the same pattern, although the impacts relative to the baseline are smaller. The impacts are lower for employment than for GVA because the relationship between GDP growth and employment growth is not 1:1. In the EU, a 1% increase in GDP typically leads to a 0.5% increase in employment, subject to significant differences between Member States.

Figure 4: Comparison of objectives based on GVA impact by 2030 [8]



[8] The impacts on GVA of the Objectives are summarized in the figure. The chart shows the total baseline for all value chains in blue and the impact of the objectives in orange. For Policy objectives 2 and 5, a low and a high scenario were defined. In these cases, the high scenario is shown as an additional impact in pale orange. The percentages show the increase in GVA over the baseline. It is important to keep in mind that the impacts are ultimately based on stakeholder feedback and should not be interpreted as exact values.

A. Zusammenfassung

Die Studie kommt zu dem Ergebnis, dass **die EU** bezogen auf die weltweiten Marktanteile im Jahr 2018 **eine globale Führungsposition einnimmt, insbesondere bei der Windkraft (67 %), geothermischen Technologien (42 %) und der Wasserkraft (39 %)**[1]. Die gesamten Ausfuhren der EU in Drittländer weltweit belief sich im Jahr 2018 auf über 5,4 Milliarden Euro[2], was im Vergleich zu 2010 einer durchschnittlichen jährlichen Steigerung von 1,6 %[3] entspricht. Die Zunahme der Exporte in den Bereichen Windkrafttechnologie (3,0 % pro Jahr) und Bioenergie (10,9 % pro Jahr)[4] konnte den jährlichen Rückgang von 2,2 % bei der Solarenergie mehr als ausgleichen. Wenn man den innereuropäischen Handel hinzunimmt, war der Rückgang der Exporte im Bereich Solarenergie aus der EU noch wesentlich stärker (-12,5 % pro Jahr). Der größte Einbruch um -18,3 % jährlich fand von 2010 bis 2015 statt. Seitdem haben sich die EU-Exporte bei der Solarenergietechnik, den innereuropäischen Handel eingeschlossen, stabilisiert und sind sogar wieder gestiegen (+2,6 % pro Jahr von 2016 bis 2018). Die weltweiten Solarenergieexporte werden von Ländern in der Region Asien-Pazifik und insbesondere China beherrscht.

Innovation ist ein wichtiger Aktivposten für die internationale Wettbewerbsfähigkeit bei den erneuerbaren Energien. **Die EU liegt beim globalen Innovationsrennen mit dem höchsten Anteil hochwertiger Patente an erster Stelle**[5] (36 %, 2016). Die EU ist bei allen Technologien im Bereich erneuerbare Energien, die für die Studie bewertet wurden, führend. Einzige Ausnahme ist die Solarenergie, wo China und Japan die wichtigsten Wettbewerber sind und die EU auf den dritten Platz verwiesen haben. Auch wenn der Anteil der EU an hochwertigen Patenten 2016 geringfügig auf 36 % gesunken ist, reicht sie immer noch mehr als doppelt so viele hochwertige Patentanträge ein wie jede andere Weltregion. China zum Beispiel hält einen weltweiten Anteil von nur 9 %, wobei sich dieser Wert verglichen mit 2008 schon verfünffacht hat.

Tabelle 1: Indikatoren für die globale Wettbewerbsfähigkeit der EU (EU im Vergleich zu 12 ausgewählten Nicht-EU-Ländern)

			Windenergie	*Bioenergie*	*Solarenergie*	*Geothermische & aerothermische Energie*	*Wasserkraft*
Globale Exporte	**Anteile am Weltmarkt (2018)**	**EU**	**67 %**	**17 %**	**4 %**	**42 %**	**39 %**
		Wichtigste* Wettbewerber	CN: 18 %	ID: 22 %	CN: 35 %	CN: 21 %	CN: 23 %
			IN: 1 %	US: 10 %	MY: 10 %	JP: 11 %	US: 10 %
			JP: 1 %	MY: 7 %	JP: 8 %	US: 9 %	IN: 6 %
	Wachstumsrate (2010-18 % pro Jahr)	**EU**	**3,0 %**	**10,9 %**	***-2,2 %***	**1,6 %**	***-2,2 %***
		Wichtigste Wettbewerber	CN: 21,3 %	ID: *-1 %*	CN: *-3,5 %*	CN: 5,4 %	CN: *-6,4 %*
			IN: *-2,3 %*	US: *-5,2 %*	MY: 5,5 %	JP: 1,1 %	US: *-8,1 %*
			JP: *-21,7 %*	MY: 70 %	JP: *-5,6 %*	US: 5,9 %	IN: 6,6 %
Patente	**Anteil an Patenten (2016)**	**EU**	**63 %**	**46 %**	**20 %**	**47 %**	**46 %**
		Wichtigste Wettbewerber	CN: 6 %	ID: 0 %	CN: 12 %	CN: 8 %	CN: 2 %
			IN: 0 %	US: 24 %	MY: 0 %	JP: 12 %	US: 12 %
			JP: 11 %	MY: 0 %	JP: 22 %	US: 15 %	IN: 0 %
	Zunahme der Patente (2008-	**EU**	**EU: 5,4 %**	**EU: *-0,7 %***	**EU: *-3,8 %***	**EU: *-0,4 %***	**EU: 6,1 %**

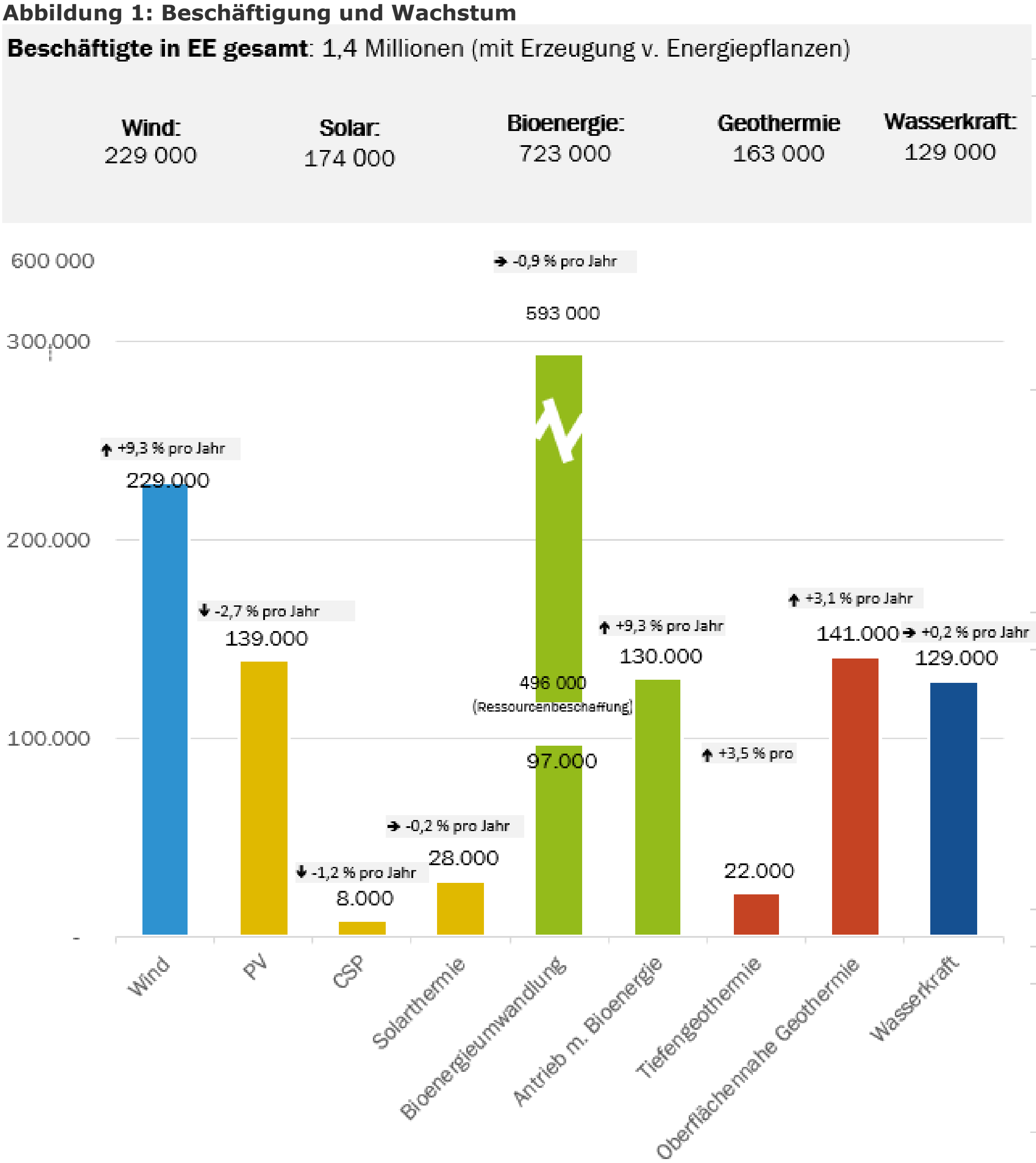
16)	**Wichtigste Wettbewerber**	CN: 26,1 % IN: 0 % JP: *-7,2 %*	ID: - US: *-9,4 %* MY: -	CN: 29 % MY: - JP: 3,9 %	CN: 16,2 % JP: -2,6 % US: 6,1 %	CN: 0 % US: 13,8 % IN: -

**12 ausgewählte Nicht-EU-Länder: CN: China; EG: Ägypten; ID: Indonesien; IN: Indien; JP: Japan; MX: Mexiko; MY: Malaysia; NO: Norwegen; KR: Südkorea; TR: Türkei; UA: Ukraine; US: Vereinigte Staaten; nicht alle kommen in der Tabelle vor.*

Außerdem könnten **Energietechnologien, die demnächst ausgereift sind, die globale Führungsposition der EU künftig noch verstärken**. So hat die EU beispielsweise eine starke Stellung in den Bereichen regenerativer Wasserstoff, gebäudeintegrierte Photovoltaikanlagen (GIPV), schwimmende Offshore-Windkraftanlagen (FOW) und Meeresenergie. Bei Batterien für Elektrofahrzeuge und schwimmenden Photovoltaikanlagen haben allerdings Nicht-EU-Länder die Nase vorn. Obwohl die Konkurrenz aus Asien und Nordamerika zunimmt, sind europäische Unternehmen in einer guten Position, um ihre globale Führungsrolle beim regenerativen Wasserstoff zu verteidigen und weiter auszubauen. GIPV ist derzeit noch ein Nischenprodukt, der globale GIPV-Markt wird jedoch von europäischen Unternehmen beherrscht. Auch im Bereich FOW spielen europäische Firmen eine Vorreiterrolle und leiten derzeit drei Viertel der über 50 Projekte weltweit. Auch bei der Anmeldung von Patenten für Meeresenergietechnologien auf internationalen Märkten ist die EU führend und schützt ihre Innovationen in wichtigen Märkten wie den Vereinigten Staaten, Südkorea, China sowie Kanada und Australien. In Bezug auf Batterien ist Europa allerdings noch im Hintertreffen. Der globale Markt für die Batterien von Elektrofahrzeugen beispielsweise wird von Herstellern aus drei Ländern beherrscht, die alle in Asien liegen: China, Japan und Südkorea. Dank seiner Stärke bei der Herstellung von Photovoltaikanlagen hat China auch bei schwimmenden Photovoltaikanlagen eine gute Ausgangslage.

Die globale Führungsrolle der EU bei den erneuerbaren Energien ist ein wichtiger Faktor für die direkte Beschäftigung und eine wachsende BWS in der EU. 2018 waren in der EU über 1,4 Millionen Arbeitnehmer direkt im EE-Sektor beschäftigt, wobei der größte Teil derzeit im Bioenergiesektor beschäftigt ist (zu dem auch die Erzeugung von Energiepflanzen gehört)[6]. Während die Entwicklung in der Solarbranche turbulent war, konnte die Windenergie die Beschäftigtenzahlen im Vergleich zu 2010 verdoppeln (mit einem robusten Beschäftigungswachstum von +9,3 % jährlich). Der Sektor geothermische Energie, zu der auch Wärmepumpen gehören, ist in letzter Zeit ebenfalls gewachsen (+3,1 % pro Jahr bei der oberflächennahen Geothermie, einschließlich aerothermische Energieerzeugung, und +3,5 % pro Jahr bei der Tiefengeothermie). Auch in der Bioenergiebranche gab es eine positive Beschäftigungsentwicklung (+4,5 % pro Jahr).

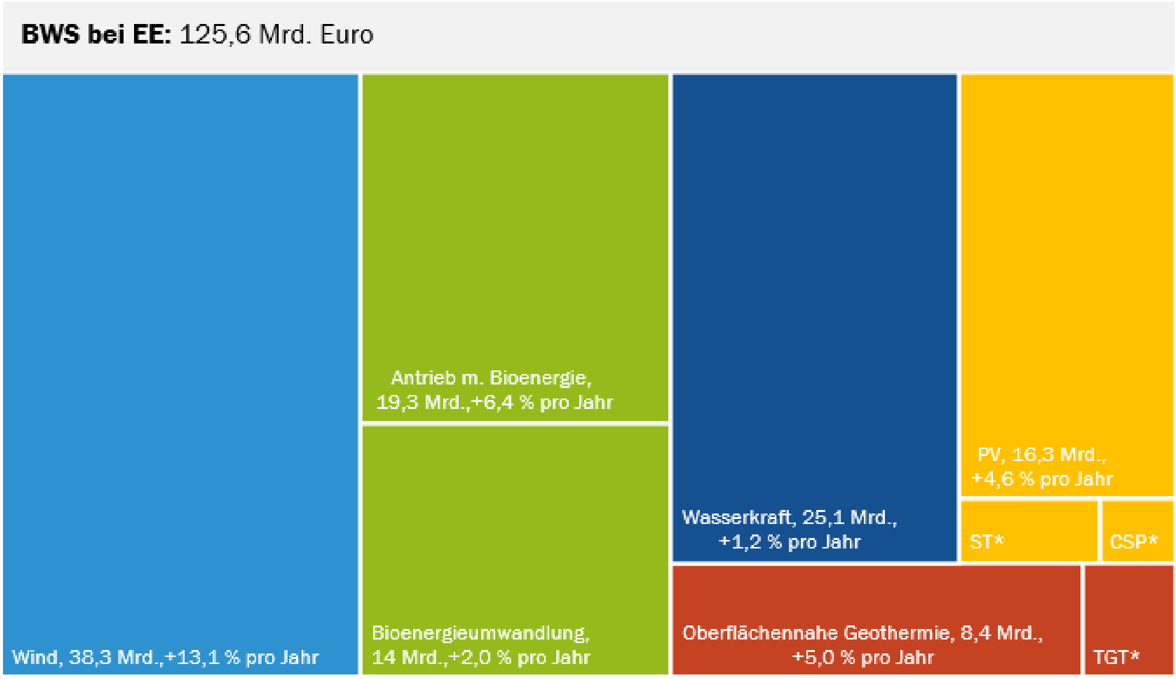
Abbildung 1: Beschäftigung und Wachstum



Quelle: eigene Berechnung auf der Grundlage von Eurostat SBS

Die BWS der erneuerbaren Energien in der EU liegt geschätzt bei 125,6 Mrd. Euro (2018), wobei die Windenergiebranche den größten Beitrag leistet (38,3 Mrd. Euro). Das Segment in der Wertschöpfungskette mit der höchsten BWS (76 %, 94 Mrd.) ist der Bau und Betrieb von EE-Anlagen, wobei die Sektoren Windenergie (über 10 %) und geothermische Energie (über 3 %) die höchsten Wachstumsraten aufweisen.

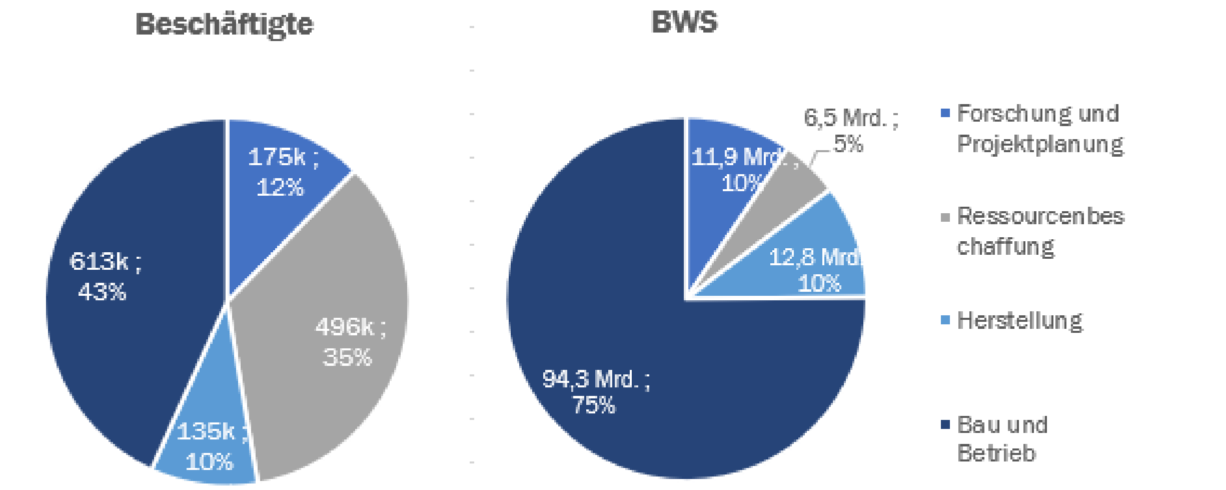
Abbildung 2: BWS und Wachstum



*TGT= Tiefengeothermie, 1,9 Mrd.,+3,0 % pro Jahr; ST = Solarthermie, 1,6 Mrd.,-0,4 % pro Jahr; CSP 0,9 Mrd. Euro,+4,6 % pro Jahr
Quelle: eigene Berechnung auf der Grundlage von Eurostat SBS

Von den sechs in der Studie untersuchten Segmenten der Wertschöpfungskette trägt das Segment „Bau und Betrieb“ in der EU **am stärksten zur Beschäftigung** (44 %, 0,6 Millionen Arbeitsplätze) **und BWS bei** (76 %, 94 Mrd. Euro).

Abbildung 3: Beschäftigung und BWS nach Segment in der Wertschöpfungskette* 2018 (in %)



*Das Segment Entsorgung in der Wertschöpfungskette wurde bei der wirtschaftlichen Analyse nicht berücksichtigt, weil es nur schwer einzuschätzen und derzeit von geringer wirtschaftlicher Bedeutung ist.
Quelle: eigene Berechnung auf der Grundlage von Eurostat SBS

Für die Zukunft hat sich die EU das ehrgeizige Ziel gesetzt, die Treibhausgasemissionen bis 2030 um 55 % zu senken und bis 2050 klimaneutral zu werden. Dieses Ziel kann nur erreicht werden, wenn sich die installierte Gesamtkapazität beim Solarstrom bis 2050 im Vergleich zu 2020 vervierfacht und bei der Windkraft verdreifacht, was zur Schaffung weiterer Arbeitsplätze und einem Wachstum der BWS beitragen wird. Diese Expansion wird sich je nach Sonnenstunden und Windressourcen, Energiesystemen und industriellen Kapazitäten unterschiedlich auf die Mitgliedstaaten auswirken. Die Entwicklung von BWS und Beschäftigung in der Basislinie kann in einem Excel-Werkzeug genauer untersucht werden, das im Rahmen dieses Auftrag entwickelt wurde.

Durch Literaturrecherche und eine Befragung der Interessenvertreter hat die Studie fünf allgemeine Ziele identifiziert, deren Verfolgung dazu beitragen können, die globale Führungsposition der EU bei Technologien für erneuerbare Energien weiter auszubauen. Diese wurden in konkrete Zielvorgaben und mögliche politische Initiativen der EU übertragen, mit denen sich die Vorreiterrolle und Wettbewerbsfähigkeit der EU bei den erneuerbaren Energien fördern lassen. Im Rahmen der Studie wurden diese politischen Optionen der EU bewertet. Außerdem wurde eine quantitative Analyse der potenziellen Auswirkungen dieser Politikoptionen auf Beschäftigung und BWS durchgeführt.

Tabelle 2: Überblick über die ermittelten Ziele und mögliche EU-Politik

Allgemeine Ziele	Konkrete Ziele	Mögliche Optionen der EU-Politik
Verbesserter Zugang zu Finanzmitteln für kommerziell ausgereifte EE-Projekte	*Stärkung eines günstigen politischen Umfelds für Investitionen in der EU im Zeitraum 2021-2030* *Bessere Koordinierung und Verfügbarkeit von EU-Finanzierungsquellen in der gesamten EU, insbesondere in MS, die sie am meisten brauchen* *Schaffung eines besseren Kanals zur Anregung privater Finanzierung durch einen gut funktionierenden Rahmen für nachhaltige Finanzierung*	Aufbau eines politischen Umfelds für EE-Investitionen in der EU im Zeitraum 2021-2030 Besserer Zugang zu Förderprogrammen der EU Schaffung eines wichtigen Vorhabens von gemeinsamem europäischen Interesse (IPCEI) für EE Mobilisierung privater Finanzierung durch die schnelle Verabschiedung und progressive Anpassung des nachhaltigen Finanzierungsrahmens der EU
Senkung des Verwaltungsaufwands für Projektgenehmigungen	*Vereinfachung des Genehmigungsverfahrens zur Entwicklung von Anlagen* *Verkürzte und verbindlichere Genehmigungsfristen*	EU-Leitlinien zur Umsetzung und Anwendung relevanter Artikel der RED II und Binnenmarktrichtlinie Elektrizität EU-Deal für EE: neuer Mechanismus, mit dem rechtliche Hürden bei EE-Projekten identifiziert und gesenkt werden
Überbrückung der Finanzierungslücke zwischen FuE und kommerzieller Nutzung	*Erleichterte Nutzung von EU-Mitteln für die Präsentation von Technologien* *Senkung der Risiken von innovativen Pilotprojekten und vorkommerziellen Projekten* *Bessere Koordinierung öffentlicher Fördermittel, mit denen die Einführung von EE-Technologien unterstützt wird*	Bessere Verwendung des Innovationsfonds Schaffung eines Risikoversicherungs- und Garantiefonds der EU Ablaufplanung und Kombination unterschiedlicher öffentlicher Finanzierungsmöglichkeiten
Vereinfachter Export von EE-Technologien und -Dienstleistungen aus der EU	*Gewährleisten, dass EU-Firmen von EU-Fördermitteln in Entwicklungsländern profitieren* *Die Maßnahmen zur Erleichterung des Exports von EE-Technologien und -Dienstleistungen aus der EU koordinieren und harmonisieren* *Handelshindernisse für EU-Erzeugnisse durch Normierung abbauen*	EU-Hilfen für EE in Entwicklungsländern Die Arbeit von Exportkreditstellen innerhalb der EU harmonisieren Die internationale Harmonisierung von Normen vorantreiben
Die globale Nachfrage nach EE-Wärme- und Kältetechnologien erhöhen	*Das politische Umfeld in der EU verbessern und Drittländer mit dem Transfer bewährter Verfahren unterstützen* *Abbau von Hindernissen für Verbraucher bei der Verwendung von EE-Wärme- und Kältetechnologien in der EU*	Politik in Bezug auf die EE-Wärme- und Kältebranche überprüfen und reformieren Bestehende öffentlich-private Initiativen zur Gründung zweckbestimmter Allianzen überprüfen und bewährte Verfahren zum Abbau finanzieller Hürden ermitteln und verbreiten Die Verbraucher über verfügbare EE-Wärme- und

	Förderung des Informationsaustausch über Wärme- und Kältetechnologien mit Drittländern	Kältetechnologien informieren Informationskampagnen und Leitlinien entwickeln, mit denen die Behörden in Drittländern ihre Politik für EE-Wärme- und Kältetechnologien verbessern können

Politische Maßnahmen, die den Zugang zu Finanzmitteln für kommerziell ausgereifte EE-Projekte verbessern, können bis 2030 900 000 zusätzliche Arbeitsplätze und eine BWS von 165 Milliarden Euro schaffen (Politikziel 1). Der begrenzte Zugang zu Finanzmitteln in mehreren Mitgliedstaaten schwächt die Wettbewerbsfähigkeit der europäischen EE-Branche. Die EU könnte Maßnahmen ergreifen, um den Zugang des EE-Sektors zu Finanzmitteln zu verbessern, insbesondere für kommerziell ausgereifte Technologien.[7] Ein günstiges politisches Umfeld für EE-Investitionen würde die Verwirklichung des EE-Ziels der EU für 2030 erleichtern und die rasche Verabschiedung und schrittweise Anpassung eines nachhaltigen Finanzierungsrahmens würde für günstige Bedingungen zur Entwicklung privater Investitionen in EE-Technologien sorgen. Zusätzlich könnten konkrete Maßnahmen erwogen werden, die den Zugang zu Förderprogrammen von EU und Mitgliedstaaten verbessern. Besondere Aufmerksamkeit sollte darauf verwendet werden, die Risiken privater Investitionen in den EE-Sektor zu mindern und IPCEI und andere bestehende Instrumente bekannter zu machen. Es ist zu erwarten, dass diese politischen Optionen die Finanzierungskosten von EE-Projekten und die Investitionsausgaben (CAPEX) senken und die FuE von EE-Technologien anregen. Ihre Auswirkungen wurden auf Grundlage der in den Interviews erhobenen Daten für die Wertschöpfungsketten der Sektoren PV, Solarthermie, oberflächennahe Geothermie und Windkraft geschätzt. Den größten Beitrag zu diesen Auswirkungen würde das Wertschöpfungssegment „Bau und Betriebsdienstleistungen" leisten.

Maßnahmen zur Senkung des Verwaltungsaufwands für Projektgenehmigungen könnten bis 2030 zwischen 125 000 und 413 000 Arbeitsplätze und eine BWS zwischen 37 Mrd. und 124 Mrd. Euro schaffen (Politikziel 2). In mehreren Mitgliedstaaten behindern langwierige, komplizierte und unsichere Genehmigungsverfahren für EE-Projekte deren Umsetzung. Die EU sollte eingreifen, um die Genehmigungsverfahren für die Entwicklung neuer EE-Anlagen zu vereinfachen und die Genehmigungsfristen zu verkürzen und verbindlicher zu machen. Dazu könnte die EU Leitlinien ausarbeiten, um die korrekte Umsetzung relevanter Artikel der RED II und der Binnenmarktrichtlinie Elektrizität zum Genehmigungsverfahren und Netzanschluss zu gewährleisten. Außerdem könnte die Einführung der so genannten „Erneuerbare Energien-Deals" – ein *Ad hoc*- Notifizierungsverfahren für Akteure der Branche und ein Dialog zwischen der Kommission und nationalen/lokalen Genehmigungsbehörden – dazu beitragen, unnötige rechtliche Hindernisse, die Genehmigungsverfahren beeinträchtigen, zu identifizieren und zu beseitigen. Diese politische Lösung würde dabei helfen, in der EU mehr EE-Projekte umzusetzen (insbesondere in EE-Sektoren, die noch nicht die volle Marktreife erreicht haben) und es EE-Entwicklern ermöglichen, die modernsten verfügbaren Technologien einzusetzen. Die Schätzung der quantitativen Auswirkungen beschränkt sich auf die Wertschöpfungsketten der Sektoren PV und Windkraft. Auch hier würde das Segment „Bau und Betriebsdienstleistungen" am stärksten von einem verbesserten Genehmigungsverfahren profitieren.

Maßnahmen zur Überbrückung der Finanzierungslücke zwischen FuE und kommerzieller Nutzung von EE-Technologien könnten bis 2030 81 000 Arbeitsplätze und eine BWS von 15 Mrd. Euro schaffen (Politikziel 3). Der Weg, bis neue EE-Technologien erprobt sind und eingesetzt werden können, ist lang und führt durch das so genannte „Tal des Todes", in dem die finanziellen Mittel fehlen, um Innovationen nach Abschluss der Grundlagenforschung weiter zu entwickeln. Um dieses Problem zu lösen, sollte die EU in enger Abstimmung mit den Mitgliedstaaten die Verwendung von EU-

Mitteln für die praktische Erprobung von EE-Technologien fördern, die mit Pilotprojekten und vorkommerziellen Projekten verbundenen Risiken senken und die Synergien zwischen unterschiedlichen öffentlichen Förderprogrammen verbessern. Da es bereits einen Innovationsfonds gibt, müssten entsprechende Maßnahmen darauf abzielen, den Fonds bekannter zu machen. Die Schaffung eines EU-Instruments zur Risikominimierung würde die Risiken bei Produkttests, Pilotprojekten oder der Umsetzung großer Testanlagen abdecken. Um die Synergien zwischen den Finanzinstrumenten der EU zu stärken, müssten auch die GD ENER und andere Dienststellen der Kommission, die Mitgliedstaaten und wichtige Interessenträger konsultiert werden, damit die Integration von Forschungsmitteln in andere Finanzierungsprogramme verbessert wird, was die Präsentation und Umsetzung von EE-Technologien fördern könnte. Die wichtigsten Auswirkungen dieser Optionen sind eine durch Skalen- und Lerneffekte ermöglichte Senkung der Investitionsausgaben, höhere private FuE-Ausgaben, niedrigere Finanzierungskosten und ein besseres Marktpotenzial für die europäische EE-Branche. Die quantitativen Schätzwerte berücksichtigen die Wertschöpfungsketten der Sektoren PV, Wasserkraft, Windkraft und Geothermie und basieren auf Informationen aus den Interviews. Die stärksten Auswirkungen würden im Wertschöpfungssegment „Forschung" auftreten.

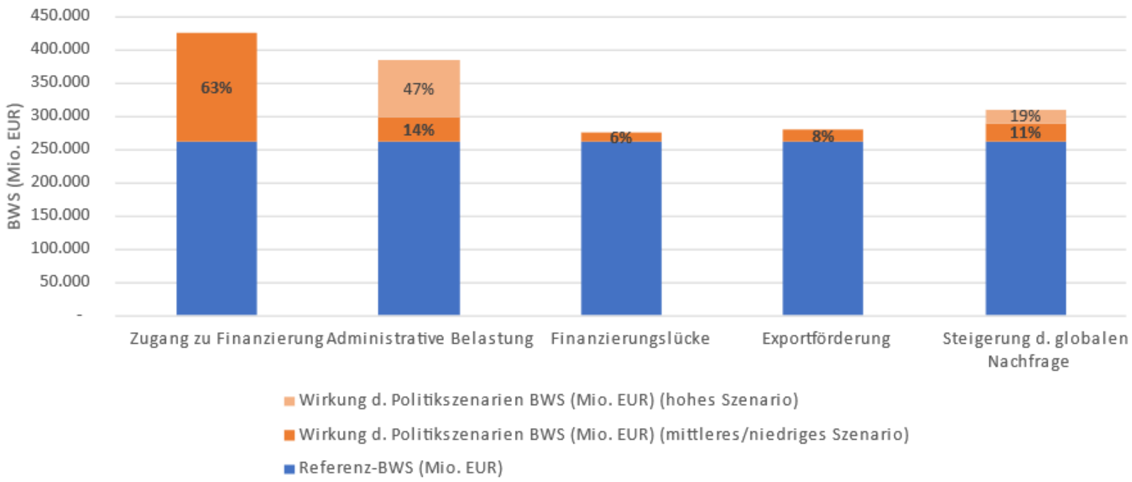
Maßnahmen, die den Export von EE-Technologien und -Dienstleistungen aus der EU vereinfachen, könnten bis 2030 70 000 Arbeitsplätze und eine BWS von 20 Mrd. Euro schaffen (Politikziel 4). Der Export trägt entscheidend dazu bei, die Wettbewerbsfähigkeit und globale Führungsrolle der EU bei den erneuerbaren Energien zu erhalten. Trotzdem gibt es zurzeit nur wenig Instrumente, die den Export von EE-Technologien und -Dienstleistungen aus der EU gezielt fördern. Die EU könnte die Exporttätigkeit der EE-Branche auf den globalen Märkten durch drei politische Optionen fördern. Erstens kann die EU die EE in Entwicklungsländern unterstützen, um neue Zielmärkte für EE-Technologien und -Dienstleistungen aus der EU zu schaffen. Zweitens kann sie die Arbeit der Exportkreditstellen innerhalb der EU harmonisieren, um in allen Mitgliedstaaten einheitliche Bedingungen für den Export von EE-Technologien zu schaffen. Drittens sollte die EU die Anpassung an internationale Normen fördern, z. B. die Angleichung der ISO und der Europäischen Normen (EN). Alle eben genannten Optionen könnten den Export von EE-Technologien aus der EU fördern, die Finanzierungskosten und Investitionsausgaben senken und so die Wettbewerbsfähigkeit der europäischen EE-Branche stärken. Die Auswirkungen werden für die Wertschöpfungsketten der Sektoren Antrieb mit Bioenergie, Wasserkraft, Solarthermie und Meeresenergie geschätzt. Sie betreffen das Segment „Bau und Betriebsdienstleistungen" dieser Wertschöpfungsketten.

Maßnahmen zur Steigerung der globalen Nachfrage (einschließlich der EU-Nachfrage) nach EE-Wärme- und Kältetechnologien könnten bis 2030 zwischen 364 000 und 631 000 Arbeitsplätze und eine BWS zwischen 29 Mrd. und 49 Mrd. Euro schaffen (Politikziel 5). Die Nachfrage (in der EU und weltweit) nach EE-Wärme- und Kältetechnologien wird politisch nicht ausreichend gefördert. Dazu gehören ein relativ schwieriges politisches Umfeld, ein geringer Bekanntheitsgrad von EE-Wärme- und Kältetechnologien bei den Verbrauchern und begrenzte Planungskapazitäten für Wärme- und Kälteanlagen auf lokaler Ebene. Es sind schnelle Maßnahmen nötig, um die Nachfrage nach erneuerbaren Wärme- und Kältelösungen zu erhöhen. Die Kommission sollte das politische Umfeld verbessern, indem sie die Wettbewerbsbedingungen der nachhaltigen Wärme- und Kältetechnik an die von Lösungen mit fossilen Energieträgern angleicht, die Bauvorschriften entsprechend überarbeitet und Mitgliedstaaten über bewährte Verfahren informiert. Außerdem kann die EU bestehende öffentlich-private Initiativen in einzelnen Mitgliedstaaten analysieren, mit denen Verbrauchern die Wahl von EE-Wärme- und Kältetechnologien erleichtert wird, um bewährte Verfahren zu ermitteln und zu verbreiten und spezielle Allianzen mit der Wärme- und Kältebranche zu schaffen. Geeignete Wege, um die Verbraucher über die in der EU verfügbaren nachhaltigen Wärme- und Kälteanlagen zu informieren, sind Verbraucheraufklärung, Energiekennzeichnung und

Qualitätssicherung. Es ist zu erwarten, dass diese Maßnahmen einen starken EU-Binnenmarkt schaffen, der eine Voraussetzung für mehr Exporte aus der EU in Drittländer und die Verbesserung der globalen Wettbewerbsfähigkeit der Hersteller von EE-Wärme- und Kälteanlagen darstellt. Schließlich könnten Informationskampagnen und Leitlinien für die Behörden in Drittländern die Politik für EE-Wärme- und Kältetechnologien weltweit verbessern. Der Berechnung der quantitativen Auswirkungen liegen die Angaben von Interessenvertretern der Sektoren Solarthermie, Tiefengeothermie und oberflächennahe Geothermie zugrunde. Das Segment „Bau und Betriebsdienstleistungen" würde am stärksten von diesen politischen Optionen profitieren.

Die Optionen zum Politikziel 1 (Zugang zu Finanzierung) dürften sich am stärksten auf die BWS auswirken, gefolgt von den Zielen 2 (vereinfachte Verwaltungsverfahren) und 5 (EE-Wärme- und Kältetechnologien). Optionen zu Politikzielen, die auf viele unterschiedliche Wertschöpfungsketten abzielen, haben in der Regel stärkere Auswirkungen. Dies gilt auch für Ziele, die sich auf Lieferketten mit hoher Wertschöpfung beziehen. Die Auswirkungen auf die Beschäftigung folgen demselben Muster, allerdings sind die Auswirkungen im Vergleich zur Basislinie geringer. Die Maßnahmen wirken sich auf die Beschäftigung weniger aus als auf die BWS, weil das Verhältnis zwischen BIP-Wachstum und Beschäftigungswachstum nicht 1:1 ist. In der EU führt eine Steigerung des BIP um 1 % im Schnitt zu einem Beschäftigungswachstum von 0,5 %, wobei sich das Verhältnis zwischen den Mitgliedstaaten deutlich unterscheidet.

Abbildung 4: Vergleich der Ziele anhand der Auswirkungen auf die BWS bis 2030 [8]



[1] Auf der Grundlage von Handelsdaten, d. h. mit einem Schwerpunkt auf Gütern, bei denen Dienstleistungen nicht berücksichtigt werden. Die EU wird als ein einheitlicher Markt und Handelspartner betrachtet (d. h. ohne den Handel auf dem Binnenmarkt); die Daten sind von 2018.

[2] Jahresdurchschnittskurse, Quelle: Weltbank

[3] Die im Bericht angegebenen Wachstumsraten basieren durchgehend auf US-Dollar. Zwischen 2010 und 2015 gewann der US-Dollar gegenüber dem Euro an Wert und fiel dann wieder leicht.

[4] Das starke Wachstum bei der Bioenergie ist vor allem auf die zunehmende Ausfuhr von Biodiesel seit 2015 zurückzuführen.

[5] Als hochwertige Patente gelten Patente, die in mehr als einem Patentamt, d. h. in mehreren Ländern angemeldet wurden, um einen internationalen Schutz zu gewährleisten.

[6] Bei dieser Bewertung werden alle direkten Aktivitäten entlang den Wertschöpfungsketten berücksichtigt, wie sie in der detaillierten Kartierung von Aktivitäten und Produkten definiert wurden, sofern diese mit dem ökonomischen Klassifizierungssystem in Einklang gebracht werden konnten. Der Gegenstand der Analyse unterscheidet sich von anderen häufig verwendeten Ansätzen, wie der Input-Output-Modellierung oder der Analyse von Bottom-up-Unternehmensdaten. Daher sind keine indirekten oder induzierten Effekte enthalten. Da andere Methoden, Untersuchungsbereiche, Kennzahlen und Daten verwendet wurden, weichen die in dieser Studie präsentierten Ergebnisse möglicherweise von anderen Berichten ab. So sind beispielsweise nach Angabe des EurObserv'ER in der Europäischen Union 1,5 Millionen Personen in Vollzeitäquivalent (VZÄ) direkt oder indirekt im Sektor der erneuerbaren Energien beschäftigt. https://www.eurobserv-er.org/19th-annual-overview-barometer/

[7] Politische Maßnahmen, die Finanzierungsprobleme für neue EE-Technologien betreffen, werden in der dritten Maßnahmengruppe bewertet (Maßnahmen, die die Finanzierungslücke zwischen FuE und kommerzieller Nutzung von EE-Technologien schließen).

[8] In der Abbildung werden die Auswirkungen der Ziele auf die BWS zusammengefasst. In der Grafik ist die Gesamtbasislinie für alle Wertschöpfungsketten blau dargestellt und die Auswirkung der Ziele orange. Für die Politikziele 2 und 5 wurden ein niedriges und ein hohes Szenario definiert. In diesen Fällen wird das hohe Szenario als zusätzliche Auswirkung in blassem Orange dargestellt. Die Prozentangaben zeigen die Steigerung der BWS über der Basislinie. Dabei ist zu beachten, dass die Auswirkungen letztlich auf den Angaben der Interessenvertreter beruhen und nicht als exakte Werte zu verstehen sind.

B. Résumé analytique

L'étude révèle que **l'UE occupe une position de premier plan au niveau mondial** en termes de parts de marché, **notamment dans le domaine de l'énergie éolienne (67 %), géothermique (42 %) et hydraulique (39 %)**[1] en 2018. Les exportations globales de l'UE vers le reste du monde se sont élevées à plus de 5,4 milliards d'euros en 2018[2], soit une augmentation annuelle moyenne de 1,6 % par an[3] par rapport à 2010. La croissance des technologies liées à l'énergie éolienne (3,0 % par an) et à la bioénergie (10,9 % par an)[4] a plus que compensé la baisse de -2,2 % par an des exportations de technologies liées à l'énergie solaire. La chute de ces exportations a été encore plus sévère dans l'UE, y compris pour le commerce intracommunautaire (-12,5 % par an). La forte baisse de -18,3 % par an s'est produite de 2010 à 2015. Depuis lors, les exportations de technologies liées à de l'énergie solaire de l'UE, y compris en termes de commerce intracommunautaire, se sont stabilisées et ont augmenté (+2,6 % par an de 2016 à 2018). Les exportations mondiales de ces technologies sont dominées par les pays de la région Asie-Pacifique, notamment par la Chine.

L'innovation est un atout essentiel pour la compétitivité internationale des énergies renouvelables. **L'UE est en tête de la course mondiale à l'innovation avec la plus grande part de brevets à haute valeur ajoutée**[5] (36 % en 2016). L'UE occupe la première place du podium en matière d'innovation pour toutes les technologies liées à l'énergie renouvelable évaluées, à l'exception de l'énergie solaire, où la Chine et le Japon sont les principaux rivaux, laissant ainsi l'UE en troisième position. Si la part de l'UE dans les brevets à haute valeur ajoutée a légèrement baissé en 2016 pour atteindre 36 %, l'UE détient toujours plus de deux fois plus de dépôts de demandes de brevet à haute valeur ajoutée que toute autre région du monde. La Chine, en comparaison, ne détient que 9 % de l'ensemble des brevets déposés dans le monde, même si elle a vu sa part multipliée par cinq par rapport à 2008.

Tableau 1 : Indicateurs de compétitivité globale de l'UE (l'UE comparée à une sélection de 12 pays non membres de l'UE)

			Énergie éolienne	***Bioénergie***	***Énergie solaire***	***Énergie géothermique et aérothermique***	***Énergie hydraulique***
Exportations mondiales	**Part du marché mondial (2018)**	**UE**	**67 %**	**17 %**	**4 %**	**42 %**	**39 %**
		Principaux* rivaux	CN : 18 %	ID : 22 %	CN : 35 %	CN : 21 %	CN : 23 %
			IN : 1 %	US : 10 %	MY : 10 %	JP : 11 %	US : 10 %
			JP : 1 %	MY : 7 %	JP : 8 %	US : 9 %	IN : 6 %
	Taux de croissance	**UE**	**3,0 %**	**10,9 %**	***-2,2 %***	**1,6 %**	***-2,2 %***
	(2010-18 % par an)	**Principaux rivaux**	CN : 21,3 %	ID : *-1 %*	CN : *-3,5 %*	CN : 5,4 %	CN : *-6,4 %*
			IN : *-2,3 %*	US : *-5,2 %*	MY : 5,5 %	JP : 1,1 %	US : *-8,1 %*
			JP : *-21,7 %*	MY : 70 %	JP : *-5,6 %*	US : 5,9 %	IN : 6,6 %
Brevets	**Part des brevets (2016)**	**UE**	**63 %**	**46 %**	**20 %**	**47 %**	**46 %**
		Principaux rivaux	CN : 6 %	ID : 0 %	CN : 12 %	CN : 8 %	CN : 2 %
			IN : 0 %	US : 24 %	MY : 0 %	JP : 12 %	US : 12 %
			JP : 11 %	MY : 0 %	JP : 22 %	US : 15 %	IN : 0 %

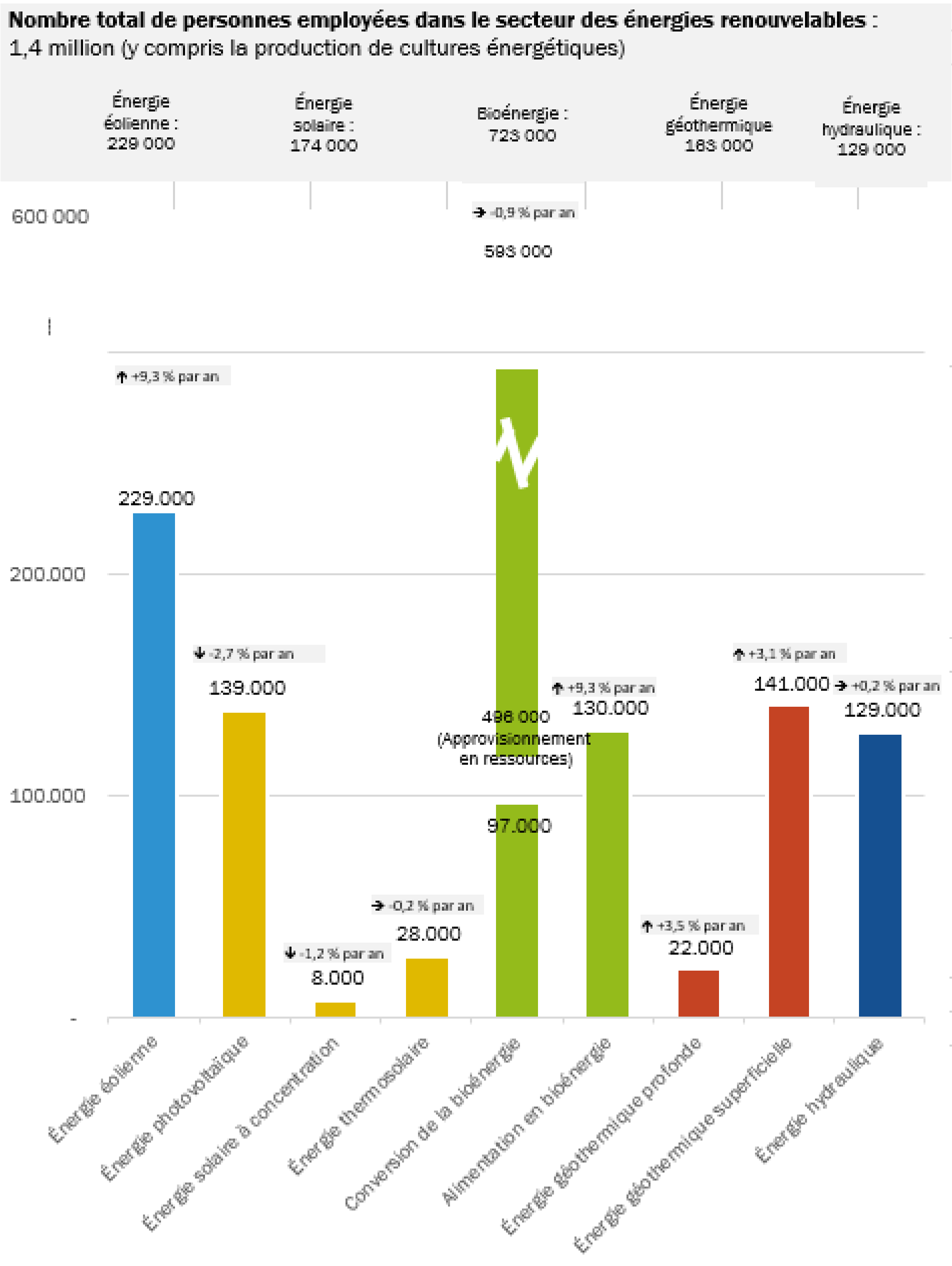
	Évolution du nombre de brevets (2008-16)	**UE**	**UE : 5,4 %**	**UE : *-0,7 %***	**UE : *-3,8 %***	**UE : *-0,4 %***	**UE : 6,1 %**
		Principaux rivaux	CN : 26,1 %	ID : -	CN : 29 %	CN : 16,2 %	CN : 0 %
			IN : 0 %	US : *-9,4 %*	MY : -	JP : -2,6 %	US : 13,8 %
			JP : *-7,2 %*	MY : -	JP : 3,9 %	US : 6,1 %	IN : -

**12 pays non membres de l’UE sélectionnés : CN : Chine ; EG : Égypte ; ID : Indonésie ; IN : Inde ; JP : Japon ; MX : Mexique ; MY : Malaisie ; NO : Norvège ; KR : Corée du Sud ; TR : Turquie ; UA : Ukraine ; US : États-Unis ; tous ces pays n’apparaissent pas dans le tableau ci-dessus.*

En outre, **le développement des technologies liées aux énergies renouvelables pourrait renforcer le futur leadership mondial de l’UE.** Par exemple, l’UE occupe actuellement une position de premier plan dans le domaine de l’hydrogène renouvelable, de l’énergie photovoltaïque intégrée aux bâtiments, de l’énergie éolienne flottante et de l’énergie marine. Toutefois, les pays non membres de l’UE ont un leadership plus fort dans le domaine des batteries pour véhicules électriques et du photovoltaïque flottant. Malgré la concurrence croissante de l’Asie et de l’Amérique du Nord, les entreprises européennes sont bien placées pour maintenir et renforcer leur leadership mondial dans le domaine de l’hydrogène renouvelable. Bien qu’il soit encore étroit, le marché mondial de l’énergie photovoltaïque intégrée aux bâtiments est actuellement dominé par les entreprises européennes. En outre, les entreprises européennes sont des pionnières en matière d’énergie éolienne flottante et sont aujourd’hui à la tête des trois quarts de la cinquantaine de projets connexes menés dans le monde. L’UE est également leader dans le dépôt de brevets en lien avec l’énergie marine sur les marchés internationaux, afin d’obtenir une protection sur des marchés clés tels que les États-Unis, la Corée du Sud et la Chine, ainsi que le Canada et l’Australie. Toutefois, en ce qui concerne les batteries, l’Europe est à la traîne. Par exemple, le marché mondial des batteries pour véhicules électriques est dominé par les fabricants de trois pays, tous situés en Asie : la Chine, la Corée du Sud et le Japon. Le poids de la Chine dans le domaine de la fabrication de panneaux photovoltaïques place également le pays en position de force en matière de panneaux photovoltaïques flottants.

Le leadership mondial de l’UE en matière d’énergies renouvelables est un générateur important d’emplois directs et de croissance de la VAB au sein de l’UE. En 2018, plus de 1,4 million de personnes étaient directement employées dans le secteur des énergies renouvelables dans l’UE, la plus grande partie travaillant dans le domaine de la bioénergie (y compris la production de cultures énergétiques)[6]. Si le développement de l’énergie solaire a été mouvementé, l’énergie éolienne, quant à elle, a doublé ses effectifs par rapport à 2010 (avec une nette croissance de l’emploi de +9,3 % par an). L’énergie géothermique, y compris les pompes à chaleur, a également connu une expansion récente (+3,1 % par an pour la géothermie superficielle, y compris l’énergie aérothermique, et +3,5 % par an pour la géothermie profonde). L’utilisation de la bioénergie a également favorisé l’emploi (+4,5 % par an).

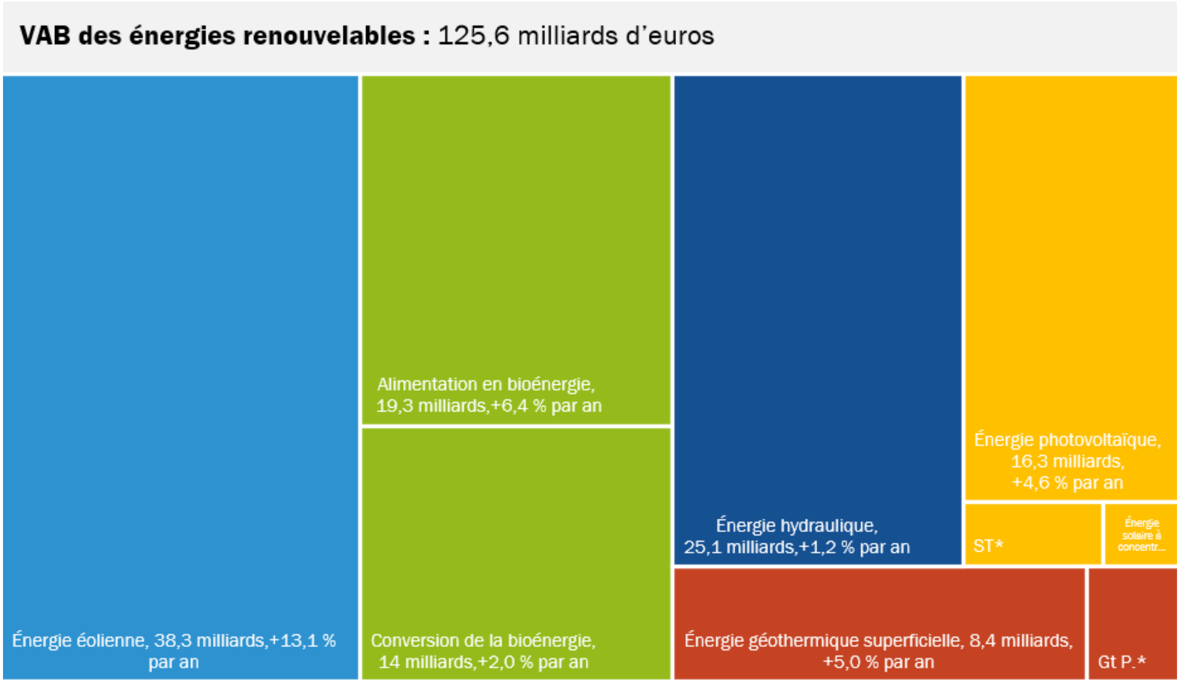
Figure 1 : Emploi et croissance



Source : élaboration propre, sur la base des statistiques structurelles sur les entreprises d'Eurostat

La VAB des énergies renouvelables dans l'UE est estimée à 125,6 milliards d'euros (2018), la contribution la plus élevée provenant du secteur de l'énergie éolienne (38,3 milliards d'euros). Le segment de la chaîne de valeur de la construction et de l'exploitation des énergies renouvelables apporte la plus grande VAB (76 %, soit 94 milliards), le taux de croissance le plus élevé provenant de l'énergie éolienne (plus de 10 %) et de la géothermie (plus de 3 %).

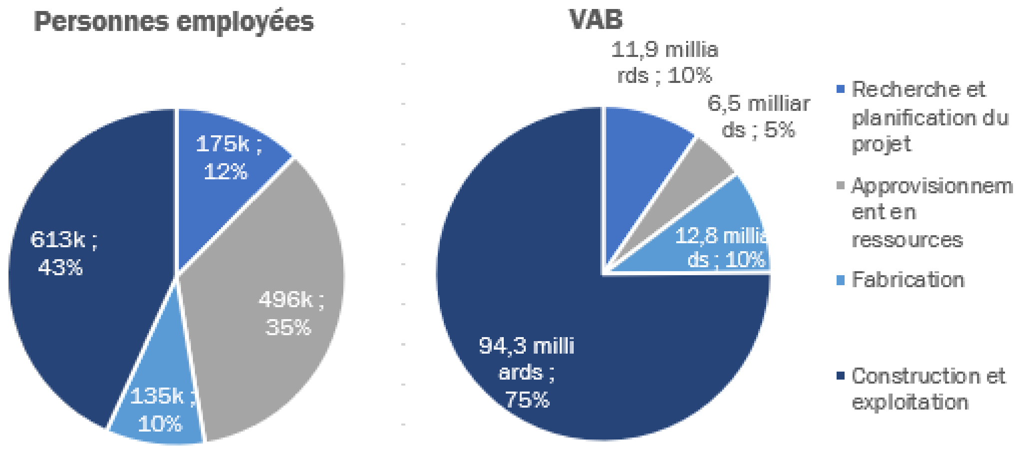
Figure 2 : VAB et croissance



*Gt P. = Géothermie profonde, 1,9 milliards, +3,0 % par an ; ST = Solaire thermique, 1,6 milliards, -0,4 % par an ; Énergie solaire à concentration 0,9 milliard d'euros, +4,6 % par an
Source : élaboration propre, sur la base des statistiques structurelles sur les entreprises d'Eurostat

Parmi les six segments de la chaîne de valeur évalués dans le cadre de cette étude, la construction et l'exploitation sont le segment qui a la plus grande incidence sur l'emploi (44 %, soit 0,6 million d'emplois) **et la VAB** (76 %, soit 94 milliards d'euros) dans l'UE.

Figure 3 : Emploi et VAB par segment de la chaîne de valeur* 2018 (en %)



*Le segment de la chaîne de valeur « Gestion en fin de vie » n'a pas été inclus dans l'analyse économique en raison de sa difficulté d'évaluation et de son importance économique marginale actuelle.
Source : élaboration propre, sur la base des statistiques structurelles sur les entreprises d'Eurostat

Pour l'avenir, l'UE s'est fixé un objectif ambitieux de réduction des gaz à effet de serre de 55 % d'ici à 2030 et de neutralité climatique d'ici à 2050. Pour atteindre cet objectif, la capacité totale installée de l'énergie solaire sera quadruplée et celle de l'énergie éolienne triplée avant 2050 par rapport à 2020, ce qui contribuera à la création d'emplois et à la croissance de la VAB. Cette augmentation aura un impact différent sur les États membres en fonction de la disponibilité des ressources solaires et éoliennes, des systèmes énergétiques et des capacités industrielles. L'évolution de la VAB et de l'emploi dans le scénario de référence peut être explorée plus en détail dans un document Excel élaboré dans le cadre de cette étude.

Sur la base de recherches documentaires et de la consultation des parties prenantes, l'étude a identifié cinq objectifs généraux qui peuvent être poursuivis afin de continuer à améliorer le leadership mondial de l'UE dans les technologies issues des énergies renouvelables. Ceux-ci ont été traduits en objectifs spécifiques et en politiques communautaires potentielles en vue de promouvoir le leadership et la compétitivité de l'UE dans le domaine des énergies renouvelables. L'étude a évalué chacun d'entre eux en tant qu'options stratégiques européennes. En outre, une analyse quantitative a été menée sur l'impact potentiel de ces options stratégiques sur les emplois et la VAB.

Tableau 2 : Aperçu des objectifs identifiés et des politiques communautaires potentielles

Objectifs généraux	Objectifs spécifiques	Options stratégiques potentielles de l'UE
Améliorer l'accès au financement pour les projets liés à l'énergie renouvelable prêts à être commercialisés	*Promouvoir un environnement politique favorable aux investissements dans l'UE au cours de la période 2021-2030* *Améliorer la coordination et la disponibilité des sources de financement européennes dans l'ensemble de l'UE, en particulier dans les États membres qui en ont le plus besoin* *Établir un meilleur canal pour stimuler le financement privé par le biais d'un cadre de financement durable performant*	Créer un environnement politique favorable aux investissements dans les énergies renouvelables dans l'UE au cours de la période 2021-2030 Meilleur accès aux programmes de financement de l'UE Élaboration d'un projet important d'intérêt européen commun en ce qui concerne les énergies renouvelables Mobilisation des fonds privés grâce à l'adoption rapide et à la modification progressive du cadre de financement durable de l'UE
Réduire les charges administratives liées aux autorisations de projets	*Simplifier la procédure d'autorisation pour les installations en développement* *Raccourcir et sécuriser le délai d'obtention des permis*	Lignes directrices de l'UE sur la transposition et la mise en œuvre des articles pertinents de RED II et de la directive sur le marché de l'électricité Accord de l'UE sur les énergies renouvelables : nouveau mécanisme pour identifier et réduire les obstacles réglementaires affectant les projets liés aux énergies renouvelables
Combler le fossé financier entre la recherche et le développement et la commercialisati on	*Promouvoir l'utilisation des fonds européens pour la démonstration des technologies* *Atténuer les risques associés aux projets pilotes et pré-commerciaux innovants* *Assurer une meilleure coordination des financements publics pour soutenir le déploiement des technologies liées aux énergies renouvelables*	Favoriser l'utilisation du Fonds pour l'innovation Créer un fonds européen d'assurance et de garantie des risques Articuler et combiner différentes possibilités de financement public
Faciliter l'exportation des technologies et services de l'UE dans le domaine des énergies renouvelables	*Veiller à ce que les entreprises européennes bénéficient du soutien de l'UE dans les pays en développement* *Coordonner et harmoniser les efforts visant à faciliter l'exportation des technologies et des services liés aux énergies renouvelables de l'UE* *Supprimer les barrières commerciales pour les produits de l'UE grâce à la normalisation*	Assurer le soutien de l'UE aux énergies renouvelables dans les pays en développement Harmoniser les efforts des agences de crédit à l'exportation dans l'UE Promouvoir la poursuite de l'alignement des normes au niveau international
Stimuler la demande mondiale de technologies de chauffage et de climatisation	*Améliorer l'environnement politique au sein de l'UE et soutenir les pays tiers en leur transmettant les bonnes pratiques* *Réduire les obstacles auxquels les consommateurs sont confrontés lorsqu'ils adoptent des solutions de chauffage et de climatisation faisant intervenir des*	Évaluer et réformer les politiques affectant l'industrie du chauffage et de la climatisation faisant intervenir des énergies renouvelables Évaluer les initiatives publiques et privées existantes afin de créer des alliances dédiées et d'identifier et de diffuser les bonnes pratiques en

utilisant les énergies renouvelables	*énergies renouvelables dans l'UE* *Soutenir l'échange d'informations sur les technologies de chauffage et de climatisation avec les pays tiers*	vue de supprimer les obstacles financiers Sensibiliser les consommateurs aux produits de chauffage et de climatisation disponibles faisant intervenir des énergies renouvelables Organiser des campagnes d'information et conseiller les autorités des pays tiers afin qu'elles élaborent de meilleures politiques en matière de chauffage et de climatisation faisant intervenir des énergies renouvelables

Les politiques améliorant l'accès au financement pour les projets d'énergie renouvelable prêts à être commercialisés peuvent générer 900 000 emplois supplémentaires et 165 milliards d'euros de VAB d'ici à 2030 (objectif stratégique n°1). L'accès limité au financement nuit à la compétitivité de l'industrie européenne de l'énergie renouvelable dans plusieurs États membres. L'UE pourrait intervenir pour améliorer l'accès du secteur des énergies renouvelables au financement, notamment en ce qui concerne les technologies prêtes à être commercialisées.[7] Un environnement politique favorable aux investissements dans les énergies renouvelables faciliterait la réalisation de l'objectif de l'UE en matière d'énergies renouvelables à l'horizon 2030 et créerait les conditions nécessaires à la génération d'investissements privés dans les technologies liées aux énergies renouvelables en adoptant rapidement et en modifiant progressivement un cadre de financement durable. De plus, il serait également envisageable d'élaborer des mesures concrètes visant à améliorer l'accès aux programmes de financement européens et nationaux. Une attention particulière doit également être accordée à la réduction des risques liés aux investissements privés dans le secteur des énergies renouvelables et à la promotion des instruments existants, tels que le projet important d'intérêt européen commun. Ces options stratégiques devraient permettre de réduire les coûts de financement des projets faisant intervenir des énergies renouvelables, de diminuer les dépenses d'investissement (CAPEX) et de stimuler la recherche et le développement des technologies liées aux énergies renouvelables. Sur la base des informations recueillies lors des entretiens, les effets ont été estimés pour les chaînes de valeur de l'énergie photovoltaïque, solaire thermique, géothermique superficielle et éolienne. Le segment de la chaîne de valeur qui contribuerait le plus à ces effets est celui des services de construction et d'exploitation.

Les politiques réduisant les charges administratives liées aux autorisations de projets pourraient générer entre 125 000 et 413 000 emplois, et une VAB comprise entre 37 et 124 milliards d'euros d'ici à 2030 (objectif stratégique n°2). Le processus d'autorisation long, complexe et incertain des projets liés aux énergies renouvelables entrave leur déploiement dans plusieurs États membres. L'UE doit intervenir pour simplifier le processus d'octroi de permis en vue du développement d'installations d'énergie renouvelable, et raccourcir le délai d'obtention des permis et fournir une plus grande certitude en la matière. Ces objectifs pourraient être réalisés en préparant des orientations européennes visant à garantir la transposition correcte des articles pertinents de la directive RED II et de la directive sur le marché de l'électricité concernant le processus d'octroi de permis et la connexion au réseau. En outre, l'introduction de ce que l'on appelle les « Renewable Deals » – un mécanisme de notification *ad hoc* pour les parties prenantes du secteur et des dialogues entre la Commission européenne et les autorités nationales/locales chargées de l'octroi des permis – peut contribuer à identifier et à supprimer les obstacles réglementaires inutiles affectant le processus d'octroi des permis. Ces solutions stratégiques contribueraient à augmenter le nombre de projets liés aux énergies renouvelables réalisés dans l'UE (notamment dans les secteurs moins matures) et permettraient aux développeurs d'énergies renouvelables de s'appuyer sur les technologies les plus modernes disponibles. Les estimations des impacts quantitatifs sont limitées aux chaînes de valeur de l'énergie photovoltaïque et éolienne. Le segment qui bénéficierait le plus d'un processus de délivrance de permis amélioré est celui des services de construction et d'exploitation.

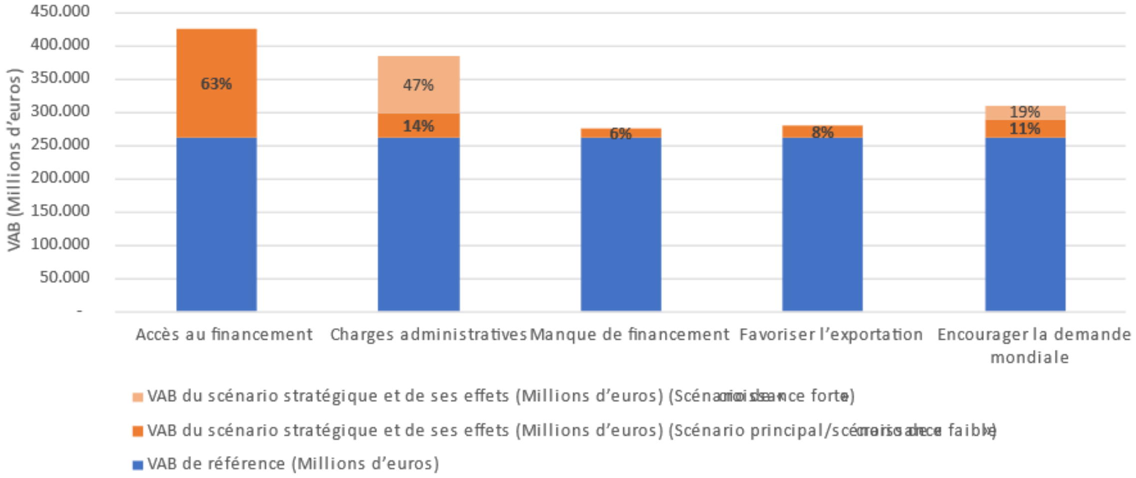
Les politiques visant à combler le déficit de financement entre la recherche et le développement et la commercialisation des technologies liées aux énergies renouvelables pourraient générer 81 000 emplois et 15 milliards d'euros de VAB d'ici à 2030 (objectif stratégique n°3). La démonstration et le déploiement des technologies liées aux énergies renouvelables sont lents et entravés par la « vallée de la mort », c'est-à-dire le manque de ressources financières pour développer les innovations une fois la recherche initiale terminée. Pour y remédier, l'UE doit se concerter étroitement avec les États membres afin de promouvoir l'utilisation des fonds européens pour la démonstration des technologies liées aux énergies renouvelables, d'atténuer les risques associés aux projets pilotes et pré-commerciaux connexes et d'améliorer les synergies des différents programmes de financement public. Le Fonds pour l'innovation est en place, les actions à cet égard viseraient donc à renforcer la sensibilisation. La création d'un instrument européen d'atténuation des risques permettrait de couvrir les risques liés aux essais de produits, aux projets pilotes ou à la facilitation de grands projets de démonstration. Le renforcement des synergies des mesures de financement de l'UE se traduirait par un processus de consultation impliquant la Direction générale de l'énergie et d'autres services de la Commission, les États membres et les parties prenantes concernées afin d'améliorer l'intégration des fonds de recherche à d'autres programmes de financement susceptibles de soutenir la démonstration et le déploiement des technologies liées aux énergies renouvelables. Les effets les plus significatifs de ces options sont la réduction des dépenses d'investissement grâce aux économies d'échelle et d'apprentissage, l'augmentation des dépenses privées liées à la recherche et au développement, la diminution des coûts financiers et l'augmentation du potentiel offert par le marché pour l'industrie européenne des énergies renouvelables. Les impacts sont estimés quantitativement pour les chaînes de valeur de l'énergie photovoltaïque, hydraulique, éolienne et géothermique en utilisant les données des entretiens. Le segment qui observerait les impacts les plus importants est celui de la recherche.

Les politiques facilitant l'exportation de technologies et de services liés aux énergies renouvelables dans l'UE pourraient générer 70 000 emplois et 20 milliards d'euros de VAB d'ici à 2030 (objectif stratégique n°4). Alors que l'exportation est essentielle pour garantir la compétitivité et le leadership mondial dans le domaine des énergies renouvelables, il existe actuellement peu d'outils ciblés facilitant l'exportation des technologies et services de l'UE dans ce domaine. L'UE pourrait soutenir les activités d'exportation de l'industrie des énergies renouvelables sur le marché mondial grâce à trois options stratégiques. Premièrement, l'UE peut soutenir les énergies renouvelables dans les pays en développement afin d'assurer de nouvelles destinations d'exportation pour les technologies et les services de l'UE dans ce domaine. Deuxièmement, elle peut harmoniser les efforts des agences de crédit à l'exportation dans l'UE afin d'instaurer des conditions uniformes pour l'exportation des technologies liées aux énergies renouvelables de l'UE dans les États membres. Troisièmement, l'UE doit promouvoir l'alignement sur les normes internationales, par exemple l'alignement des normes ISO et des normes européennes EN. Ces options pourraient améliorer la compétitivité de l'industrie européenne des énergies renouvelables en augmentant les exportations de ces technologies, en diminuant les coûts financiers et en réduisant les dépenses d'investissement. Les impacts sont estimés pour les chaînes de valeur de la bioénergie et de l'énergie hydraulique, solaire thermique et marine. Ils se matérialiseraient dans le segment des services de construction et d'exploitation de ces chaînes de valeur.

Les politiques favorisant la demande mondiale (y compris celle de l'UE) de technologies de chauffage et de climatisation utilisant les énergies renouvelables pourraient générer entre 364 000 et 631 000 emplois et une VAB comprise entre 29 et 49 milliards d'euros d'ici à 2030 (objectif stratégique n°5). La demande – dans l'UE et dans le monde – de technologies de chauffage et de climatisation utilisant les énergies renouvelables est entravée par un manque de soutien politique, notamment un environnement politique relativement peu favorable aux technologies de chauffage et de climatisation utilisant les énergies renouvelables, une faible sensibilisation des consommateurs aux solutions de chauffage et de climatisation, et des capacités limitées en matière de planification interne de l'utilisation du chauffage et de l'énergie au niveau local. Il est nécessaire d'intervenir sans tarder pour stimuler la demande de solutions de chauffage et de climatisation utilisant les énergies renouvelables. La Commission doit améliorer l'environnement politique en créant des conditions de concurrence équitables pour les technologies de chauffage et de climatisation utilisant les énergies renouvelables par rapport aux solutions utilisant les énergies fossiles, en garantissant un code plus favorable en matière de construction et en diffusant les bonnes pratiques connexes parmi les États membres. L'UE peut également évaluer les initiatives publiques et privées existantes dans certains États membres qui favorisent le choix des consommateurs en matière de solutions de chauffage et de climatisation utilisant les énergies renouvelables, afin d'identifier et de diffuser les bonnes pratiques connexes et de créer des alliances dédiées au chauffage et à la climatisation. L'éducation des consommateurs, l'étiquetage énergétique et l'assurance qualité peuvent contribuer à sensibiliser les consommateurs aux produits de chauffage et de climatisation utilisant les énergies renouvelables disponibles dans l'UE. Ces solutions devraient permettre de créer un marché intérieur européen solide, une condition essentielle pour accroître les exportations de l'UE vers les pays tiers et renforcer la compétitivité mondiale des fabricants de solutions de chauffage et de climatisation utilisant les énergies renouvelables. Enfin, des campagnes d'information et des orientations destinées aux autorités des pays tiers pourraient permettre d'élaborer de meilleures politiques à l'échelle mondiale en matière de chauffage et de climatisation utilisant les énergies renouvelables. Les données fournies par les parties prenantes opérant dans les chaînes de valeur de l'énergie solaire thermique, géothermique profonde et géothermique superficielle sont utilisées pour calculer les impacts quantitatifs. Parmi ces options stratégiques, le service de construction et d'exploitation est le segment qui observerait l'impact le plus important.

Les options relevant de l'objectif stratégique n°1 (accès au financement) devraient avoir le plus grand impact sur la VAB, suivies des objectifs n°2 (simplification administrative) et n°5 (solutions de chauffage et de climatisation faisant intervenir des énergies renouvelables). Les options relevant d'objectifs stratégiques qui ciblent un large éventail de chaînes de valeur ont généralement un impact plus important, tout comme les objectifs qui ciblent les chaînes de valeur élevée. Les impacts sur l'emploi suivent le même schéma, bien que les impacts par rapport au scénario de base soient moins significatifs. Les impacts sont plus faibles pour l'emploi que pour la VAB, car la relation entre la croissance du PIB et la croissance de l'emploi n'est pas égale. Au sein de l'UE, une augmentation de 1 % du PIB entraîne généralement une augmentation de 0,5 % de l'emploi, sous réserve de différences importantes entre les États membres.

Figure 4 : Comparaison des objectifs sur la base de l'impact de la VAB d'ici à 2030 [8]



[1] Ces chiffres sont basés sur des données commerciales ; ils se concentrent donc sur les biens et ne prennent pas en considération les services. En considérant l'UE comme un marché et un commerçant uniques (c'est-à-dire en excluant le commerce intracommunautaire) ; les données datent de 2018.

[2] Taux de change annuel moyen. Source : Banque mondiale

[3] Taux de croissance basés sur le dollar des États-Unis dans l'ensemble du rapport. Entre 2010 et 2015, le dollar des États-Unis a été réévalué par rapport à l'euro, puis a de nouveau légèrement baissé.

[4] Le fort taux de croissance de la bioénergie est principalement dû à l'augmentation des exportations de biodiesel depuis 2015.

[5] Les brevets à haute valeur ajoutée représentent les familles de brevets qui ont été déposés auprès de plusieurs offices de brevets, c'est-à-dire dans plusieurs pays, afin d'obtenir une protection internationale.

[6] Cette évaluation prend en compte toutes les activités directes le long des chaînes de valeur, telles que définies dans la cartographie détaillée des activités et des produits, lorsque celles-ci peuvent être mises en correspondance avec le système de classification économique. La portée de l'analyse diffère des autres approches courantes, telles que la modélisation entrées-sorties ou l'analyse des données des entreprises collectées de manière ascendante. Ainsi, les effets indirects ou induits ne sont pas pris en considération. Les résultats présentés dans cette étude peuvent donc s'écarter des autres rapports, en raison de l'utilisation de méthodologies, de champs d'application, de mesures et de données différents. Par exemple, EurObserv'ER indique que 1,5 million d'équivalents temps plein (ETP) sont directement ou indirectement employés dans le secteur des énergies renouvelables de l'UE. https://www.eurobserv-er.org/etat-des-energies-renouvelables-en-europe-2019/

[7] Les politiques visant à relever les défis du financement des nouvelles technologies liées aux énergies renouvelables sont évaluées dans le troisième groupe de politiques ci-dessous (politiques visant à combler le déficit de financement entre la recherche et de développement et la commercialisation des technologies liées aux énergies renouvelables).

[8] L'impact des objectifs sur la VAB est résumé dans la figure. Le graphique montre les valeurs de référence totales pour tous les segments de la chaîne de valeur (en bleu) et l'impact des objectifs (en orange). Un scénario de « croissance faible » et un scénario de « croissance forte » ont été définis pour les objectifs stratégiques n°2 et n°5. Dans ces cas, le scénario de « croissance forte » est représenté comme un impact supplémentaire (en orange pâle). Les pourcentages montrent l'augmentation de la VAB par rapport aux valeurs de référence. Il est important de garder à l'esprit que les impacts sont en fin de compte basés sur les commentaires des parties prenantes et ne doivent pas être interprétés comme des valeurs exactes.

Table of Contents

1 Introduction

This report synthesises the findings from the study on 'EU's Global Leadership in Renewables'. The study commenced in late 2019 and will finish in summer 2021.

The study has been carried by COWI in collaboration with Prognos and CEPS and with the support of CapGemini.

1.1 Scope and objectives of the study

The objectives of the study are the following:

- To develop a methodology and to apply the methodology to analyse, evaluate, rank and track key countries, key markets, key activities in the global renewable supply chain that have the highest value-added for EU socio-economic development
- To test and evaluate the results of this analysis with key stakeholders in the European renewable energy industry
- To identify and evaluate policy options to support the industrial competitiveness of the European renewable energy industry, and its added value to the EU economy and society

To that end, the study has been implemented in three separate, yet coordinated and related workstreams each addressing one of the three objectives listed above.

In developing the study, three stakeholder workshops have been conducted, experts have been consulted and more than 40 individual stakeholder interviews have been held.

Detailed study reports have been elaborated on the first and the third of the above objectives:

- Final study report, EU's Global Leadership in Renewables, Work Package 1, Measuring the Economic Impact of RE value chains and the EU's global competitiveness, March 2021
- Final study report, EU's Global Leadership in Renewables, Work Package 3, Identification and assessment of existing and new policy options to support the industrial competitiveness of the European renewable energy industry, and its added value to the EU economy and society, March 2021

The outcomes of the consultations with stakeholders and experts are integrated into these two study reports. Another output of the study is:

- An Excel tool to assess the impacts on GVA and employment from policies to improve competitiveness and/or increase the RE market
- Separate brochures presenting specific case studies on new and innovative technologies

1.2 Structure of this report

This report is structured as follows:

Chapter 2 on the global market and EUs competitiveness provides first an overview of the methodology applied. This includes a description of the defined value chains and value chain segments. Details on the statistical methods and data consulted are found in the above Study report on Work Package 1. This is followed by a closer look at the economic impacts of RE value chains in Europe considering both employment and GVA contributions. Also, the impacts are described from a Member State perspective. Thereafter, the global RE market is mapped and the competitiveness of the EU is assessed. Last, an analysis is provided that looks into future trends. This includes also a summary of the specific case studies that have been carried out as part of the implementation of this contract.

Chapter 3 on the identification and assessment of possible EU initiatives to promote the EU RE industry provides first an overview of the methodology applied. In this regard it should be emphasising that the contents of this chapter, and of the underlying Study Report should not be seen as a full impact assessment study. Rather, it may be considered as a 'screening exercise'. This section also sets the five key objectives that have been identified, i.e. the objectives to pursue in order to promote the EU RE industry. These objectives have set the frame for identifying specific possible policy options and for assessing those. The Study Report on Work Package 3 provides five in-depth policy briefs that analyse the five objectives individually. Chapter 3 of this report provides a summary of the five policy briefs. Thereafter, they are summarised and the impacts compared.

Chapter 4 on the Excel Tol for assessing impacts explains in brief the approach and overall logic of the tool that has been developed. It sets out how the tool has been used to quantitatively assess the impacts on GVA and employment in the EU from addressing each of the five objectives by means of EU policies. A more elaborate description of the tool and its use is found in the Study Report on Work Package 3.

2 The global market and EUs competitiveness

This chapter provides a data-based account on the development and current economic situation of Renewable Energy (RE) value chains in the EU as well as the EU's role in the global market. It summarises the findings of the economic analysis conducted in Work Package 1. A more detailed account can be found in the separate report on the Work Package.

2.1 Methodology

The analysis takes a value chain-oriented approach to analyse the economic output of Renewable Energies (RE) and the EU's international competitiveness. Ten RE value chains are considered (**Error! Reference source not found.**).

Table 1 Considered RE Value Chains

Wind	Wind Energy
Solar	Solar Photovoltaic (PV) Energy
	Solar Thermal Energy
	Concentrated Solar Power (CSP)
Bioenergy	Bioenergy Conversion[1]
	Bioenergy Generation
Geothermal & Aerothermal	Deep Geothermal Energy
	Shallow Geothermal & Aerothermal Energy
Hydro	Hydropower
Ocean	Ocean Energy (not included in the economic data analysis due to its current marginal market)

[1] The value chains have been separated to provide more detail on the various activities related to Bioenergy. While the Bioenergy Conversion value chain leads to the production of biobased energy carriers (such as biofuels or wood pellets), the Bioenergy Generation value chain uses these carriers as inputs and culminates in the production of power and heat. The results of both value chains can be summed up to consider Bioenergy as a whole.

The approach builds upon a bottom-up mapping of the economic activities and products connected to renewable energy value chains. On this foundation, a statistical model was developed that uses official data sets from Eurostat and UN sources to analyse various economic indicators. Due to the cross-cutting and emerging nature of renewable energy technologies and services sector, respective (socio-) economic outputs cannot simply be taken from standard data presentations offered by the statistical offices. Hence, a detailed delineation model was required, which identifies related goods and activities from the renewable energy value chain mappings within the official classification systems (NACE, PRODCOM, and HS).

The scope of the analysis differs from other common approaches, such as input-output modelling or the analysis of bottom-up company data[9]. The assessment considers all *direct activities along the value chains defined* in the detailed mapping of activities and products, where these could be matched to the economic classification system. Further indirect or induced effects were not included.

The results of the analysis cover the following indicators:

- Persons employed
- Gross Value Added (GVA)
- Production output
- Export & Import (inversion of export) volumes
- Patent filings
- RE Capacities installed

2.2 The economic impact of RE value chains in Europe

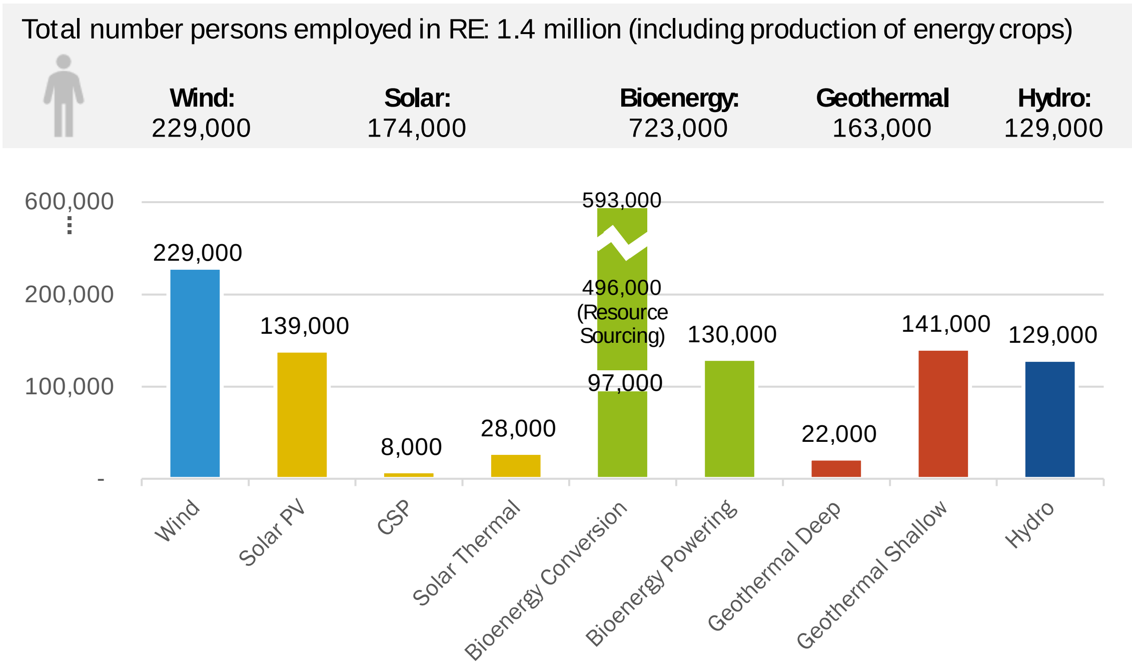
2.2.1 Employment and GVA in the EU

Renewable Energy in the European Union has evolved to be a significant employment and economic growth factor. In 2018 the Renewable Energies accounted for over 1.4 million jobs (persons employed) in the EU28[10], i.e. almost 1 % of the total economy. The Renewable Energy sector grew by 2.4 % p.a. (2010-2018) compared to 0.8 % p.a. of the total economy[11]. Across the three market segments (R&D, manufacturing, and construction and operation) Renewable Energies generate almost EUR 120 billion GVA.

Error! Reference source not found. shows the number of people employed in the different RE value chains[12] in Europe. As seen, the intensity of employment differs significantly among the RE value chains. By far the most persons are employed in the Bioenergy Conversion value chain, which is particularly characterised by labour intensive agricultural activities. In sum, Bioenergy Conversion and Powering provide employment for over 700,000 people, about 50 % of the Renewable Energy in total. Almost 80 % of the value chain Bioenergy Conversion is comprised by the segment resource sourcing i.e. agricultural

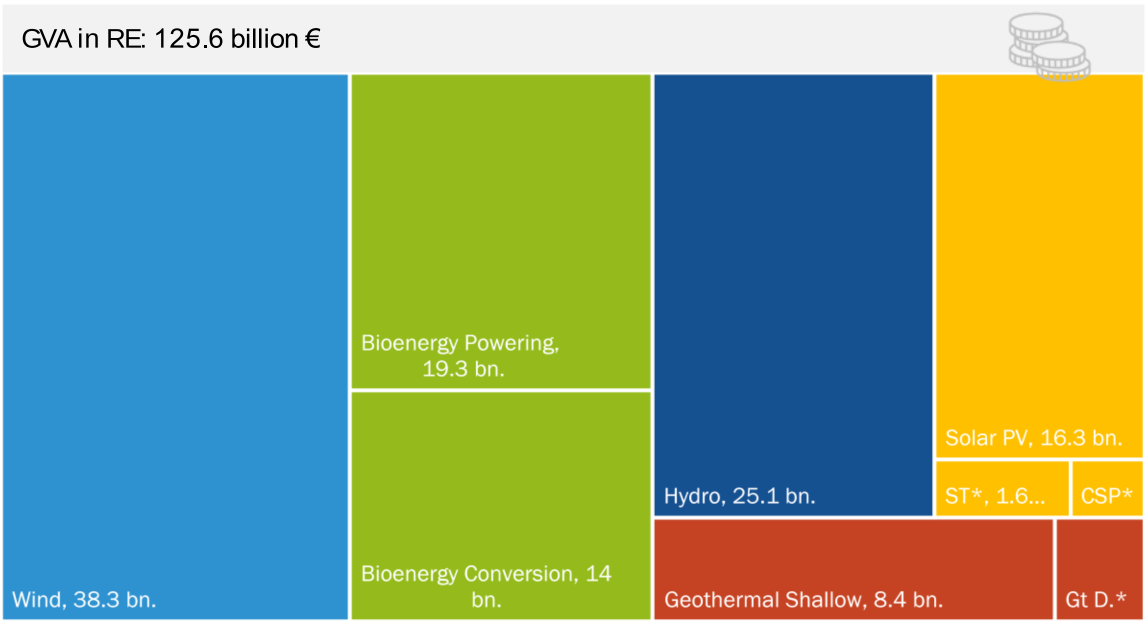
9 Results presented in this study may deviate from other reports, due to the use of different methodologies, scopes, and data. For example, EurObserv'ER, upon which IRENA draws on for results on most EU Member States, apply a methodology and scope, which accounts for direct and indirect employment associated with renewable energy (i.e. including the effect of renewable energy deployment on jobs in selected conventional sectors) and apply a "'follow-the-money' approach" using input-output (I/O) tables. There again, industry-based statistics may deviate from official data as a result from a different data collection procedure and/or metrics used.
10 EU members not included due to data limitations are: Cyprus, Latvia, Luxembourg, Malta.
11 Based on NAMA, Eurostat, excluding and countries Cyprus, Latvia, Luxembourg, Malta; A comparable data set would suggest 1.3 % p.a. using NAMA for sectors 01-02, and SBS for the remainder and excluding sectors 03, K, O, P, Q, R, 94, 96, T, U (not covered by SBS).
12 The data analysis has been conducted for nine of the ten value chains listed. Ocean Energy is not included in the economic data analysis due to its current marginal market.

Figure 3: Persons employed in Renewable Energy value chains in the EU, 2018



Source: own elaboration, based on Eurostat SBS

Figure 4: GVA in Renewable Energy value chains in the EU, 2018



*Gt D.=Geothermal Deep, 1.9 bn.; ST= Solar Thermal, 1.6 bn.; CSP 0.9 bn. Euro.

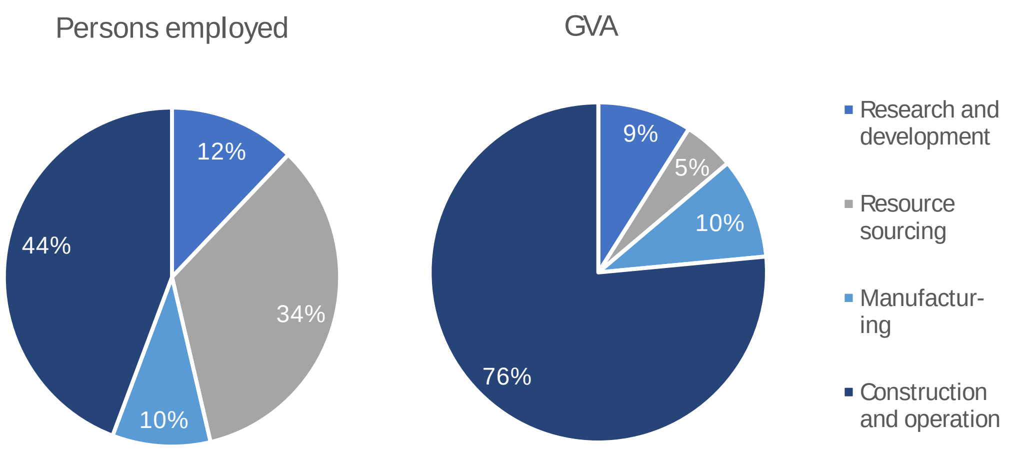
Source: own elaboration, based on Eurostat SBS

activities to obtain biomass for bio-energy (and a minor part in forestry activities). Wind Energy stimulates almost 230,000 jobs or 16 % of RE employment. This value chain is characterised by construction and operation activities (62 % of the jobs) and by its manufacturing segment (22 %). The Shallow Geothermal value chain ranks third (141,000 persons employed), followed by solar PV (139,000). For the majority of value chains, most of the jobs are related to construction and operation: in Solar PV 59 %, Wind Energy 62 % and Shallow Geothermal 74 %. In Hydropower, even 94 % of the 129,000 persons are employed in this segment.

The picture changes when considering the economic output in terms of the Gross Value Added (GVA; Figure 4). When considering GVA instead of employment, Wind Energy is the most important value chain and accounts for more than EUR 38 billion. This represents 31% of the EUR 125 billion total GVA generated by Renewable Energy in the EU – twice the share Wind Energy holds with regards to employment. Hydropower ranks second, with a value added of 25 billion Euro. Likewise, the share of Hydropower is twice as high as with employment. Bioenergy Conversion, in contrast, has a much lower share in GVA than in persons employed. Agricultural activities are relative to economic output significantly more labor intensive. If the resource sourcing segment is excluded (see box above) the GVA of Bioenergy Conversion would fall from EUR 14 billion to 8.2, and the overall GVA to EUR 119.8 billion from EUR 125.6 billion.

These differences can be explained by the varying structures of the value chains. Resource sourcing – which has only been included for Bioenergy Conversion in this analysis – is very labour intensive with 34 % of all persons employed in Renewable Energy in the EU, but accounts for only 5 % of the GVA. Construction and Operation is the most relevant segment both in terms of persons employed and GVA, which includes the electric power generation, transmission and distribution of renewable energy. While this segment accounts for less than half of the employment (44 %), its share of GVA is more than three quarters (76 %). The main reason for the high GVA output of this segment relates to energy generation itself, which generates a high GVA with comparably few persons employed. Research and development stimulated 12 % of the jobs in Renewable Energy. Next to research positions this also includes planning activities. Although the manufacturing of RE technologies can be considered the core of Renewable Energy value chains, it accounts for only 10 % of the persons employed and GVA. Compared to 2010, the manufacturing has dropped from 14% primarily due to the growing role of Construction and Operation.

Figure 5: Employment and GVA by value chain segment 2018 (in %)

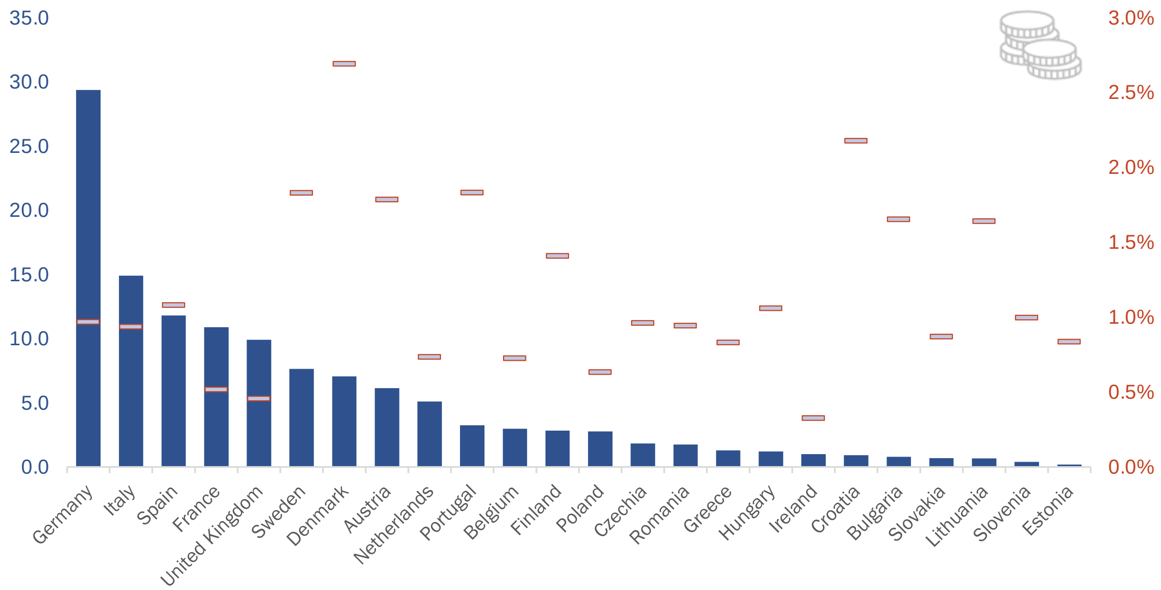


Source: own elaboration, based on Eurostat SBS

2.2.2 The Situation in Member States

Figure 6 illustrates the contribution of Member States to the GVA generated by Renewables across the EU. Germany ranks first with a gross value added of close to EUR 30 billion in Renewable Energy. Italy ranks second with a GVA only half as high. Spain, France, and UK follow closely. In Sweden and Denmark, Renewables take up a considerably high share of total GVA generation, which reflects their higher overall share of RE in gross final energy consumption.

Figure 6: GVA in RE by Member State, 2018 (columns, in billion Euro) and share of total GVA (bars, in %)



Source: own elaboration, based on Eurostat SBS

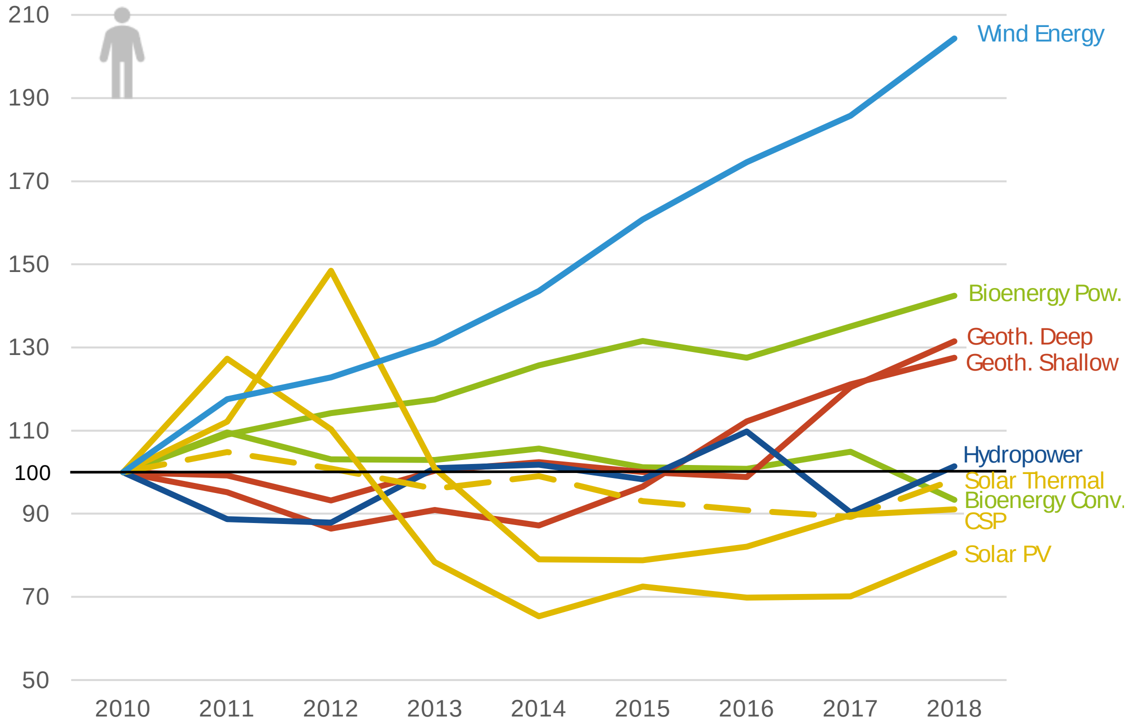
The economic development of Renewable Energies in the EU has been marked by ups and downs. On average, the number of persons employed has increased annually by 1.1 % from 2010 to 2018. Excluding Resource Sourcing even 2.4 % p.a. GVA growth was much higher with 5.5 % p.a. in the same period. Both indicators show Renewable Energies as a driver for growth in the EU. The annual growth rate of persons employed was 0.3 percentage points higher than in the total economy[13] (0.8 % p.a.) and the growth rate of GVA even 2.9 percentage points higher (total economy: 2.7 % p.a.).

However, there are significant variations in the economic development of the different value chains. Figure 7 illustrates the development of the persons employed until 2018 compared to 2010 as a base year (index 2010 = 100). Wind Energy has seen the highest growth with a steep and steady increase. In 2018 more than twice as many persons were employed compared to 2010. A very positive development can also be observed for Bioenergy Powering. Both Deep and Shallow Geothermal & Aerothermal Energy have experienced a strong growth dynamic in recent years. The number of persons employed in 2018 in the Hydropower and Bioenergy Powering value chains are largely the same as in

13 Excluding: Cyprus, Latvia, Luxembourg, Malta; based on National accounts employment data (NAMA), Eurostat.

2010. All three Solar-related value chains can be found at the bottom. While Solar Thermal shows a modest, slightly negative development, both Solar PV and CSP have experienced a steep rise in the beginning of the observed period, followed by a collapse. For Solar PV, this was caused primarily by the significant price decrease for modules following the boost of PV production in China and a global oversupply.[14] The peak of the development for PV was in 2011, one year later also for CSP. After 2014 both value chains have started to slowly recover, following EU anti-dumping and anti-subsidy policies, which significantly reduced the flooding of supply from China. This provided for a more stable PV environment for EU PV companies, backed by a simultaneously increase of internal demand.[15]

Figure 7: Development of persons employed in RE in the EU, by value chain



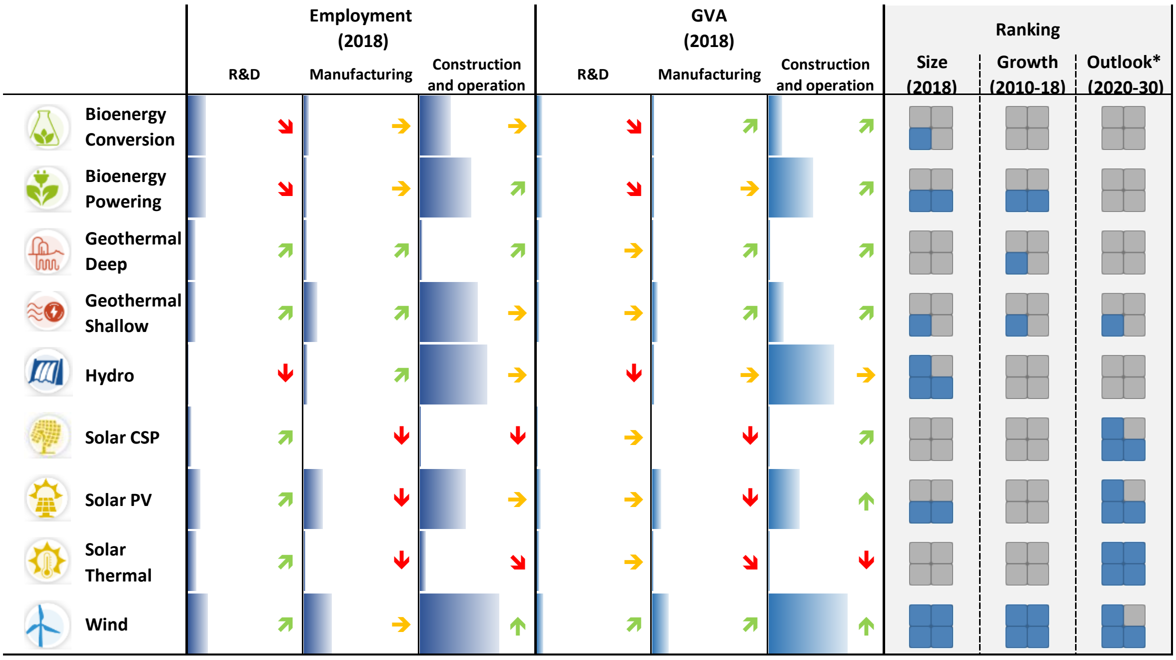
Source: own elaboration, based on Eurostat SBS

14 F. Pasimeni (2017), EU energy technology trade, p.45, JRC, citing Cao and Groba, (2013); Lv et al. (2013); Zhang et al. (2014)
15 ibid.

2.2.3 Synthesis on Value Chains and Key activities

The development of the Renewable Energy sector has occurred very differently across the technologies and value chain segments. Figure 8 summarizes the main activities' indicators and ranks these.

Figure 8 Summary and Ranking of EU's Renewable Energy Activities by Value Chain and Segment



<u>**Legend:**</u>

Indicator values: Share of segment in value chain, segment size relative to all value chains.

Growth rates: ≥10%p.a. ≥3% ≥0% ≥-5% <-5%

Ranking low high

Basis for Ranking: Size = average share in total RE size 2018; Growth = average relative growth to total RE growth (2010-2018); Outlook= future trend growth (2020-2030); values divided by quintiles.

*Outlook is based on the EU 2020 reference scenario, see chapter 2.4.1. This is also used as the baseline for the impact assessment tool developed under Work Package 3 of the project (see chapter 4).

The following overall conclusions on key activities can be drawn with regards to the different value chains:

- Across all value chains, Construction and Operation is the most relevant segment both in terms of persons employed and GVA.
- Wind Energy has been a robust and thriving economic asset for the European Union. The development of commercially competitive offshore wind parks and the extensive expansion of onshore wind energy deployment have driven employment growth. The value chain performs well across all segments, with the largest overall size, growth, and promising outlook.
- Solar PV: With most of the manufacturing sector confronted with intense global price competition from Asia, the employment in the EU in Solar PV has experienced downward pressures. However, the continued expansion and cumulative installed

capacity have contributed to employment growth and value added in the remaining value chain segments. The outlook for Solar PV is very promising.

- Solar CSP and Solar Thermal are connected to a promising outlook, while historically less large and comparably underperforming dynamic growth. As for CSP, manufacturing output and employment has sunk during the last decade, given the stagnating capacity expansions, especially in Spain. In Solar Thermal, the manufacturing segment has been hit by increased competition similar to Solar PV. Overall, there are signs of recovery following a strong increase in installed capacities. The decentralised installation activities are an important employment factor.
- Hydro has achieved a seeming sizable plateau and continues to be an important RE value chain in Europe. Due to the limited technological progress and very modest expansion rates, development and outlook stagnate. Around 94 %, of persons employed in Hydropower are working in construction and operation, particularly in operation. Nonetheless, the manufacturing output is almost as high as in Wind Energy, underlining the economic importance of exports of Hydropower's key components.
- Geothermal Energy, including heat pumps, show a dynamic development and moderately well outlook especially in the shallow geothermal and aerothermal technology. Manufacturing has benefited from the increasing sales in heat pumps, heat exchangers and other components. The construction and installation has benefited from the range of decentralised, especially household level, installation activities.
- Bioenergy Conversion and Powering, especially the application of biofuels and related energy technologies, have seen a dynamic development and have reached a sizable part of the RE economy. Its further outlook is, however, relative to the other technologies less dynamic. The important role of Resource Sourcing in the Bioenergy Conversion value chain is not reflected in the figure for reasons of comparability. This segment induces high employment due to labour intensive agricultural activities with great differences across Member States in underlying agricultural production and their efficiencies. With regards to Bioenergy Powering, the economic impact is largest in the Construction and Operation segment, especially in the operation and maintenance of electricity and heat generation plants. Given that the life cycle of Bioenergy systems, power plants and their components can be several decades, the role of manufacturing of components is limited. Also, many components are mature technologies.

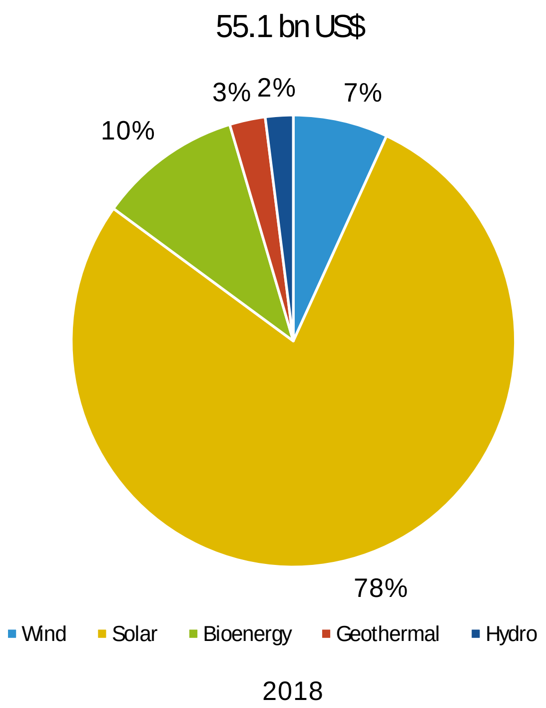
2.3 The global RE market and competitiveness of the EU

2.3.1 Global market

An international outlook is a key ingredient to the economic success of renewable energy technologies. The rapid growth in the global uptake of Renewable Energy, to meet the growing energy need and at the same time tackle climate change by substituting fossil fuel-based energy sources, has provided and continues to provide new market opportunities. Many companies have expanded their international activities, not just in Europe but around the world.

Global trade volume in Renewable Energy manufactured technologies was US$ 55.1 billion in 2018 (Figure 9). Including Renewable Energy technologies traded amongst European Union Member States, global trade volume accounts for US$ 75.5 billion. While the overall Renewable Energy trade volume has fallen from US$ 60 billion in 2010 (exc. intra-trade), the fall is mainly driven by the sharp decline in the monetary trade volume of Solar Energy technologies (US$ -7.6 billion).

Figure 9 Global Renewable Energy Trade Volume (Exports) by Value Chain in 2018 (not including trade between EU Member States)



Source: own elaboration based on UN Comtrade

China leads the overall international trade of renewable energy technologies, largely due to large Solar Energy technology exports. Still, several European countries feature prominently among the top 10 Renewable Energy technology exporting countries. Comparing the European Union (28), as a common market (i. e., excluding EU intra-trade) that exports to the world market and competes globally, against the five largest Renewable Energy technology exporting countries, China, Malaysia, Japan, Korea, and USA, reveals stark differences in the global trade shares (see synthesis figures for each value chain at the end of chapter 2.3). A heterogenous picture emerges, in which the EU holds a leading position particularly in Wind Energy, Hydropower and Geothermal technologies, while Solar Energy exports remain dominated by countries in the Asia-Pacific region, especially by China.

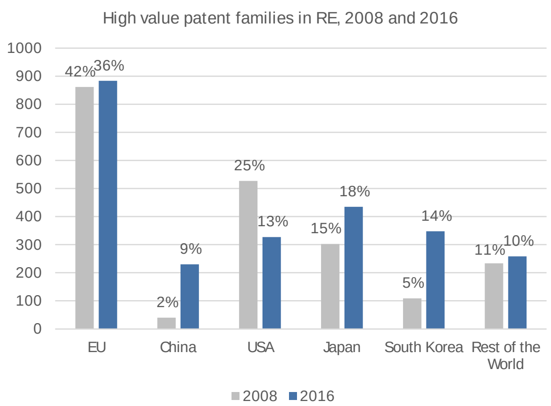
While the global trade share of the European Union has remained remarkably stable compared to 2010, with increases in Bioenergy and Hydropower technology exports, China's trade shares have increased substantially in the Wind Energy value chain (+13 %-points) and lesser so in Geothermal & Aerothermal (+5 %-points). In contrast, the United States has lost global trade shares, particularly in Wind technologies. Meanwhile, Malaysia has managed to increase its trade share in Solar Energy by increasing it from 6 % to 10 % in 2018 and overtaking in the process Japan's export volume.

2.3.2 Innovation

In high-technology domains such as RE technology, innovation is a key asset for international competitiveness.

By analysing patents, the position of the EU in global innovation can be examined. The analysis considers so called "high-value patent families". Patent families group all filings relevant to a distinct invention, thus preventing multiple counting. Those patent families that have been filed in more than one patent office, i.e. in several countries to secure international protection are considered as high value patent families.

Figure 10: Patent filings in RE technologies by world players, 2008 and 2016



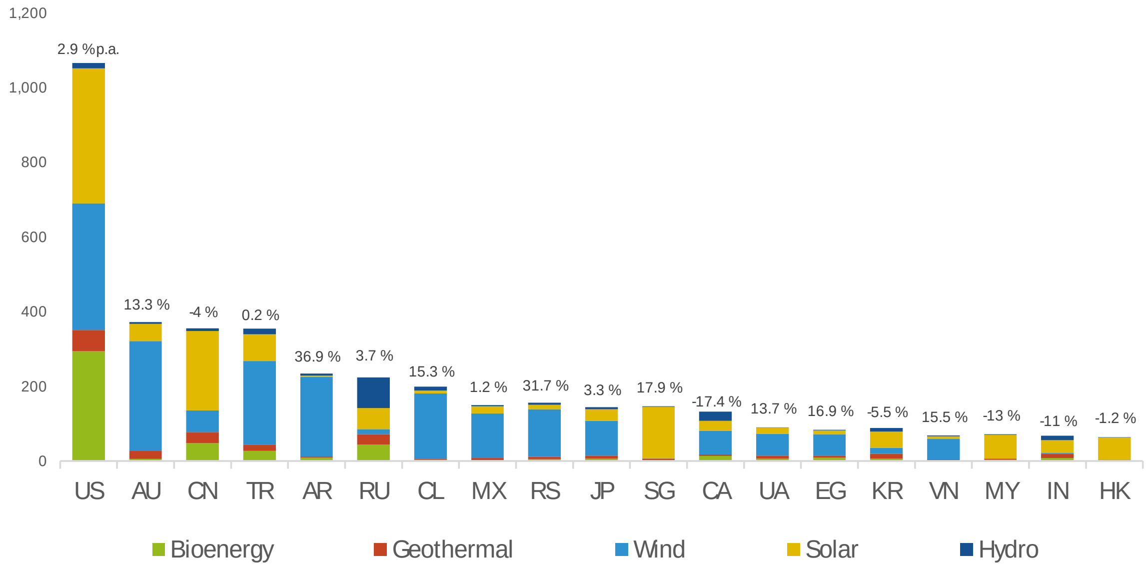
Source: own elaboration; data source: Joint Research Centre based on data from the European Patent Office/PATSTAT 2008 and 2016

Figure 10 compares the filings of high value patent families by inventors (companies, universities, or private persons) from leading world regions in RE technologies. The EU is leading the global innovation race. While its share dropped in 2016 to 36 % of global high value patents, the EU still holds more than twice as many high value filings as any other region. Looking at the country level, four Member States (Germany, Denmark, France and Italy) as well as the UK are among the top 10 innovation nations. China, by contrast, only holds a 9 % share of the global high-value patents, even though it has seen a fivefold increase compared to 2008. Japan and South Korea also strongly increased their patent activities and became leading nations of RE innovation. Both surpassed the USA, which strongly lost ground in RE patenting.

2.3.3 Key markets

Apart from vivid intra-EU trade between Member States, Asia and North America as well as the remainder of Europe (non-EU) are important sales markets for European Renewable Energy technology exports (Figure 11). Outside of the EU, the United States is by far the largest export destination. Furthermore, Australia, China, but also Turkey, Argentina, and Russia are amongst the 20 largest destinations for European Renewable Energy exports. Strikingly, Solar Energy manufactured components exports also occur to China, underscoring the role of European companies in providing specialised Solar Energy technologies to the Asian markets (China, Singapore, Korea, Malaysia, India, and Hong Kong). Singapore and Hong Kong are known regional trading hubs. The EU exports also reflect national particularities. For instance Russia's relatively large reliance on Hydropower (~18% of Russia's electricity generation stems from Hydropower), with many aged sites requiring maintenance. This may explain the large amount of exports of parts of hydraulic turbines and water wheels to Russia.

Figure 11 Top 20 non-EU markets for EU's Renewable Energy technology exports in billion US$, 2018, and % p.a. compared to 2010, by recipient country (excl. EFTA)



Source: own elaboration based on UN Comtrade; AU: Australia; CN: China; TR: Turkey; AR: Argentina; RU: Russian Federation; CL: Chile; MX: Mexico; RS: Serbia; JP: Japan; SG: Singapore; CA: Canada; UA: Ukraine; EG: Egypt; KR: Republic Korea; VN: Viet Nam; MY: Malaysia; IN: India; HK: Hong Kong; TH: Thailand.

2.3.4 Synthesis on EU competitiveness and key markets

The following charts provide for each value chain a concise summary of the EU's position and performance in the global market and in global innovation. There are two charts for each value chain. The left side provide a summary on the global market and in global innovation. The right side shows the key markets for EU exports. The key markets are identified on the basis of three criteria: First, the value of EU exports (current demand); second, the markets where EU exports have increased the most over the period 2010-18; and third: markets for which missed opportunities are identified. The 'missed opportunity' is defined as the observed difference, for specific export destinations between the growth of non-EU exports and the respective growth of EU exports; the higher the difference, the more non-EU exports to that particular destination have increased compared to EU exports.

Wind Energy

EU Global Competitiveness

	EU	Main rivals[1] CN	IN	JP
Word market share 2018	67 %	18 %	3 %	1 %
Exports in 2018	2.6 bn US$	0.7 bn US$	0.1 bn US$	0.1 bn US$
Export development 2010 – 2018	+3.0 %p.a. ↗	+21.3 %p.a. ↑	-2.3 % p.a. ↘	-0.8 % p.a. ↘
Global share of patents[2] 2016	63 %	6 %	0 %	11 %
No. patents[2] in 2016	378	36	1	65
Difference 2008 - 2016	+5.4 %p.a. ↗	+26.1 %p.a. ↑	0 % p.a. →	-7.2 % p.a. ↓

[1] Based on the 12 focus countries considered in the study, see ch. 2.3 of the detailed report
[2] High value patent families (i.e. that have been filed in more than one patent office)
[3] based on 33 EU destination countries (non-EU, non-EFTA);
[4] Export growth from non-EU to indicated destination county includes [1] and rest of world.

Key Markets

Current Demand		EU exports 2018	Growth 2010-18
1.	USA	339m US$	-3 %p.a.
2.	Australia	293m US$	+27 %p.a.
3.	Turkey	225m US$	+2 %p.a.
Growing Demand[3]		**EU exports 2018**	**Growth 2010-18**
1.	Serbia	127m US$	+81 %p.a.
2.	Egypt	58m US$	+69 %p.a.
3.	Morocco	27m US$	+56 %p.a.
Missed opportunities[4]		**EU exports 2018**	**Growth Gap** (Non-EU – EU growth, to country)
1.	Turkey	224m US$	+36 %points
2.	Brazil	3m US$	+30 %points

Bioenergy

EU Global Competitiveness

	EU	Main rivals[1] ID	US	MY
Word market share 2018	17 %	22 %	10 %	7 %
Exports in 2018	1 bn US$	1.3 bn US$	0.6 bn US$	0.4 bn US$
Export development 2010 – 2018	+10.9 %p.a. ↑	-1 % p.a. ↘	-5.2 %p.a. ↓	+70 % p.a. ↑
Global share of patents[2] 2016	46 %	0 %	24 %	0 %
No. patents[2] in 2016	108	0	56	0
Difference 2008 - 2016	-0.7 %p.a. ↘	-	-9.4 %p.a. ↓	-

[1] Based on the 12 focus countries considered in the study, see ch. 2.3 of the detailed report
[2] High value patent families (i.e. that have been filed in more than one patent office)
[3] based on 33 EU destination countries (non-EU, non-EFTA);
[4] Export growth from non-EU to indicated destination county includes [1] and rest of world.

Key Markets

Current Demand		EU exports 2018	Growth 2010-18
1.	USA	294m US$	+29 %p.a.
2.	China	48m US$	+12 %p.a.
3.	Russia	44m US$	+1 %p.a.
Growing Demand		**EU exports 2018**	**Growth 2010-18**
1.	USA	294m US$	+29 %p.a.
2.	Argentina	9m US$	+16 %p.a.
3.	Serbia	5m US$	+14 %p.a.
Missed opportunities		**EU exports 2018**	**Growth Gap** (Non-EU – EU growth)
1.	China	48m US$	+18 %points
2.	Morocco	1m US$	+17 %points

Solar Energy

EU Global Competitiveness

	EU	Main rivals[1] CN	MY	JP
Word market share 2018	4 %	35 %	10 %	8 %
Exports in 2018	1.8 bn US$	15.2 bn US$	4.3 bn US$	3.4 bn US$
Export development 2010 – 2018	-2.2 %p.a. ↘	-3.5 %p.a. ↘	+5.5 %p.a. ↗	-5.6 %p.a. ↓
Global share of patents[2] 2016	20 %	12 %	0 %	22 %
No. patents[2] in 2016	273	166	0	301
Difference 2008 - 2016	-3.8 %p.a. ↘	+29 % p.a. ↑	-	+3.9 %p.a. ↗

[1] Based on the 12 focus countries considered in the study, see ch. 2.3 of the detailed report
[2] High value patent families (i.e. that have been filed in more than one patent office)
[3] based on 33 EU destination countries (non-EU, non-EFTA);
[4] Export growth from non-EU to indicated destination county includes [1] and rest of world.

Key Markets

Current Demand			EU exports 2018	Growth 2010-18
1.		USA	362m US$	+2 %p.a.
2.		China	213m US$	-6 %p.a.
3.		Singapore	138m US$	+23 %p.a.
Growing Demand			**EU exports 2018**	**Growth 2010-18**
1.		Singapore	138 m US$	+23 %p.a.
2.		Serbia	12m US$	+15 %p.a.
3.		Pakistan	4m US$	+11 %p.a.
Missed opportunities			**EU exports 2018**	**Growth Gap (Non-EU – EU growth)**
1.		Egypt	11m US$	58 %points
2.		Argentina	3m US$	37 %points

Geothermal & Aerothermal Energy

EU Global Competitiveness

	EU	Main rivals[1] CN	JP	US
Word market share 2018	42 %	21 %	11 %	9 %
Exports in 2018	0.6 bn US$	0.3 bn US$	0.15 bn US$	0.13 bn US$
Export development 2010 – 2018	+1.6 %p.a. →	+5.4 % p.a. ↗	+1.1 %p.a. →	+5.9 %p.a. ↗
Global share of patents[2] 2016	47 %	8 %	12 %	15 %
No. patents[2] in 2016	43	7	11	14
Difference 2008 - 2016	-0.4 %p.a. ↘	+16.2 %p.a. ↑	-2.6 % p.a. ↘	+6.1 %p.a. ↗

Key Markets

Current Demand			EU exports 2018	Growth 2010-18
1.		USA	57 US$	+7 %p.a.
2.		China	29m US$	-6 %p.a.
3.		Russia	28m US$	-1 %p.a.
Growing Demand			**EU exports 2018**	**Growth 2010-18**
1.		Iran	11m US$	+33 %p.a.
2.		Nigeria	3m US$	+20 %p.a.
3.		Ghana	0.9m US$	+14 %p.a.
Missed opportunities			**EU exports 2018**	**Growth Gap (Non-EU – EU growth)**
1.		Turkey	16m US$	23 %points
2.		Serbia	7m US$	20 %points

Hydropower

EU Global Competitiveness

		Main rivals[1]		
	EU	CN	US	IN
Word market share 2018	39 %	23 %	10 %	6 %
Exports in 2018	0.44 bn US$	0.26bn US$	0.11 bn US$	0.07 bn US$
Export development 2010 – 2018	-2.2 %p.a. ↘	-6.4 %p.a. ↓	-8.1 %p.a. ↓	+6.6 %p.a. ↗
Global share of patents[2] 2016	46 %	2 %	12 %	0 %
No. patents[2] in 2016	26	1	7	0
Difference 2008 - 2016	+6.1 %p.a. ↗	0 % p.a. →	+13.8 %p.a. ↑	-

[1] Based on the 12 focus countries considered in the study, see ch. 2.3 of the detailed report
[2] High value patent families (i.e. that have been filed in more than one patent office)
[3] based on 33 EU destination countries (non-EU, non-EFTA);
[4] Export growth from non-EU to indicated destination county includes [1] and rest of world.

Key Markets

Current Demand		EU exports 2018	Growth 2010-18
1.	Russia	83m US$	+18 %p.a.
2.	Canada	24m US$	+6 %p.a.
3.	Turkey	15m US$	-18 %p.a.
Growing Demand		**EU exports 2018**	**Growth 2010-18**
1.	Japan	5m US$	+31 %p.a.
2.	Philippines	11m US$	+24 %p.a.
3.	Israel	5m US$	+21 %p.a.
Missed opportunities		**EU exports 2018**	**Growth Gap** (Non-EU – EU growth)
1.	Nigeria	0.5m US$	37 %points
2.	Thailand	1m US$	33 %points

2.4 Future trends in the EU market

This section provides a look at the main expected trends within renewable energy technologies over the next 30 years. Any attempt to look into the future is highly uncertain, but some key drivers can be identified such as the ambitions for greenhouse gas emissions reductions in EU. These ambitions require fast and immediate action which again puts emphasis on known technologies. It is these ambitions and the actions that they require that is at the core of the trends described below.

2.4.1 EU Energy Outlook 2050

In the High Ambition Summit of November 2020[16], the EU Heads of State or Government approved a new and more ambitious net greenhouse gas emissions reduction target of at least 55% for 2030 compared to 1990 levels. The Commission had proposed this new target in September 2020, to put the EU on a balanced path towards climate neutrality by 2050. This 55% reduction scenario has been analysed using the PRIMES energy system modelling tool and forms the basis for the EU 2020 reference scenario[17].

The EU 2020 reference scenario is also used as the baseline for the impact assessment tool developed under Work Package 3 of the project (see chapter 4). Figure 12 below summarizes the development within installed capacities for the technological value chains defined in this project as they are presented in the 2020 reference scenario[18].

16 Daily News 11 / 12 / 2020 (europa.eu).
17 National Technical University of Athens (E3MLab). Preliminary results were provided by DG-ENER to be used solely for the purposes of this study. This data underpins the analysis.
18 It is these trends that will be applied to the baseline in the tool.

Figure 12: EU Reference scenario 2020 (index 2020=1)

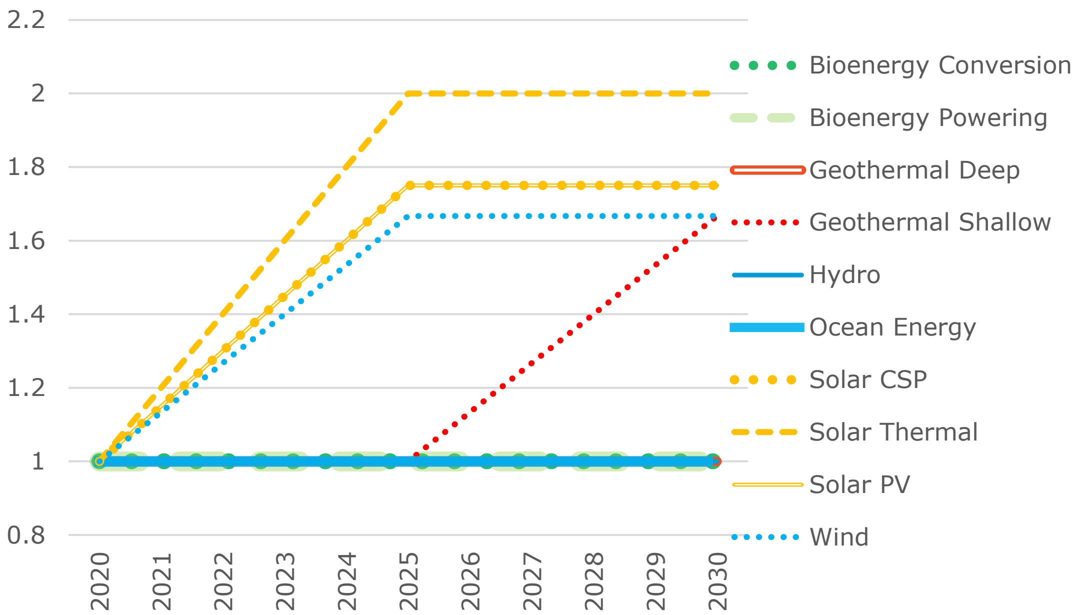
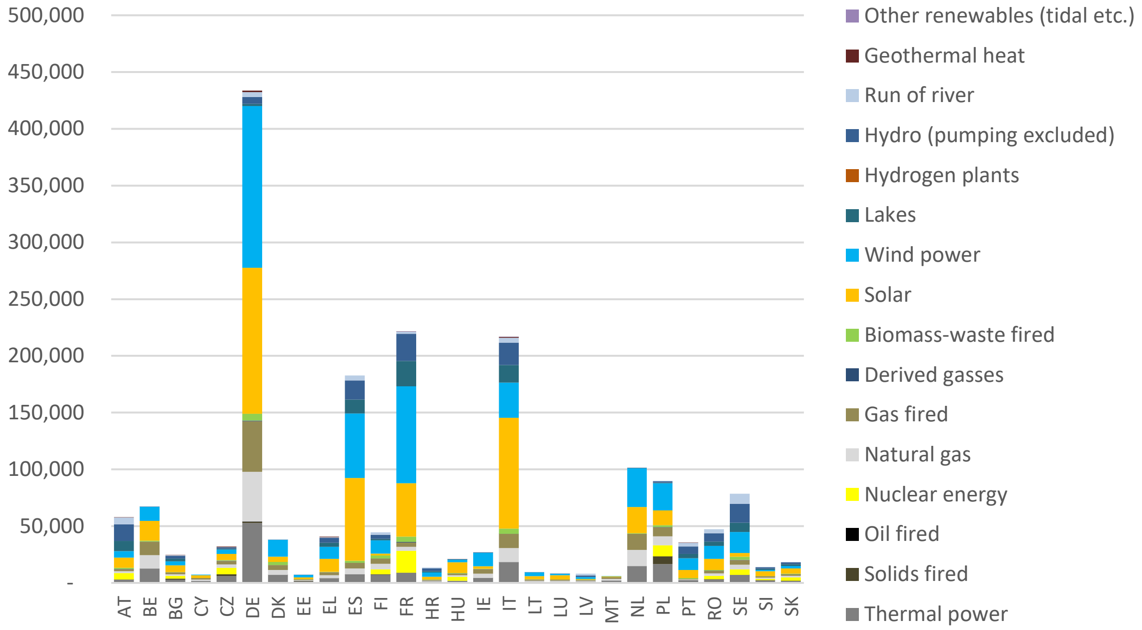


Figure 12 clearly demonstrates that four technologies are expected to deliver the vast majority of the GHG emissions reductions over the next 10 years. Solar[19] and Wind will provide most of the renewable energy needed. In the years following 2025 shallow geothermal power is expected to play an increasingly important role – Shallow Geothermal includes heat pump technologies. By 2050 solar power will constitute 14% of the total installed generating capacity in EU (5.7% today). Wind power will constitute 29% of total installed generating capacity by 2050 (15.7% today). Ocean energy is expected to gain traction only in the very last years towards 2050 but will remain very small (0.2% of total capacity in 2050).

Figure 13 shows the net installed generating capacity by 2050 for each EU Member State. It is clear, that solar and wind power will play a key role in the future EU energy system. Differences in installed capacity of solar and wind power are not only a consequence of the total energy demand in the Member State. Just as important is the availability of energy resources – wind and sun - and the specifics of the path set out in the individual NDC of each EU Member State[20]. Even considering these differences in potential for uptake, the next 30 years will bring almost exponential growth rates in installed RE capacity[21] in most EU Member States. This means that the growth potential from green investments is not limited to a lucky few Member States.

19 For lack of disaggregated data on installed solar capacities, the trends for Solar CSP and Solar PV are assumed to be identical.
20 Both considerations are integrated in the data that forms the basis for these trends.
21 This is difficult to show in a chart, as some growth rates are very high due to very low installed capacity today.

Figure 13: Net installed power capacity in 2050



Source: PRIMES; AT: Austria; BE: Belgium; BG: Bulgaria; CY: Cyprus; CZ: Czechia; DE: Germany; DK: Denmark; EE: Estonia; EL: Greece; ES: Spain; FI: Finland; FR: France; HR: Croatia; HU: Hungary; IE: Ireland; IT: Italy; LT: Lithuania; LU: Luxembourg; LV: Latvia; MT: Malta; NL: Netherlands; PL: Poland; PT: Portugal; RO: Romania; SE: Sweden; SI: Slovenia; SK: Slovakia.

Planning, manufacturing, installing and operating the expected future large capacities is a major catalyst for growth – also potentially in Member States with little installed capacity today. In addition, technologies will be needed also to support the power system and to establish the sectoral links that are necessary to ensure the penetration of renewable energy into other sectors, e.g. transport and heating. The projected increases in direct and indirect activities related to the transition to renewables thus carry immense growth potentials. In the following, some of the main supporting technologies are listed.

2.4.2 Supporting technologies

For the coming 20 years and likely even further, the majority of renewable energy generation will be based on non-dispatchable[22] energy sources such as wind and solar. This puts a premium on supporting technologies that can either store the wind and solar energy or provide flexibility in the consumption of energy. These technologies include batteries, thermal storage, Power to X, smart appliances, and aggregators.

Batteries constitute the most versatile approach to energy storage. Batteries simply store electricity and deliver it back again when needed. Batteries are also a very efficient way of storing electricity, both in terms of energy intensity and energy loss. That makes batteries ideal for use when mobility and weight is an issue. However, batteries are expensive, and rely on scarce resources such as cobalt, lithium and graphite.

Thermal storage converts electricity to heat and stores it in a medium that is designed to efficiently retain heat. Some of the common solutions in use already are insulated water tanks, bedrock and ceramics. This type of storage converts electricity to heat and are

22 Energy that cannot be planned.

rarely used to convert heat back into electricity. Thus, thermal storage is reliant on a demand for the heat produced. This could be in a district heating network or even on a household level.

Power to X is a shared denominator for energy conversions centred around the production of hydrogen using electrolysis. The hydrogen can be further refined by combining it with a source of carbon, e.g. CO_2, to create methane or other fuels. In this way, excess renewable energy can be converted to energy sources that are also relevant outside the power sector. Power to X is under rapid development and may be the best bid for a bulk electricity storage option. As an example, a consortium of Danish companies spanning sectors such as power generation, infrastructure, land-, sea- and air transport have recently engaged in a Power to X project in Copenhagen[23]. Likewise, the Danish Government in 2020 announced plans for energy islands in the North Sea and Baltic Seas with the potential for combining wind power and Power to X[24].

On the demand side, high speed internet and digitally transferred price signals open up the possibilities for providing the consumers with real time price signals as well as for third party agents (aggregators) to monitor and control the consumption in households. This again opens market opportunities for appliances that canto react to these price signals or to provide access to control for aggregators. Providing flexibility on the demand side of the electricity market is another cornerstone of a power system with a high penetration of renewable energy.

A point of commonality for all these supporting technologies is that they are most profitable when they can combine their immediate benefits - e.g. electrification of transport, heating, green fuels – with the added benefits of supporting a power system with a high share of renewable energy. Such support to the power system has a value that can be monetized, further enhancing the economic feasibility of the technologies. As EU commits to ambitious GHG reduction goals, the outlook for the supporting technologies looks bright.

2.4.3 Case studies

Six case studies (presented separately from this report) provide an overview of renewable energy generation and integration technologies. They provide insight into the future for these technologies and how EU is positioned to take advantage of the potential market growth. The following provides a summary of the main findings of each case study, and then a synthesis per value chain segment. The case studies are based on document review, expert judgement, and interviews with key players from the discussed technologies.

Renewable hydrogen

Europe is currently competitive in clean hydrogen technologies manufacturing and would be in a good position to benefit from an increasing global demand of clean hydrogen. Europe has demonstrated global leadership in high temperature Solid Oxide (SO) electrolysis and low temperature Proton exchange Membrane (PEM) and has published twice as many publications as the US on this. Europe has the pole position in electrolyser technology[25]. However, Asian competitors have recently issued many more hydrogen and fuel cell patents each year than European countries. In fact, while China, South Korea, and

23 Ministry of Foreign Affairs of Denmark
24 Danish Energy Agency
25 FCH - Making an impact on the clean energy transition (2019)

Japan hold more that 55% of fuel cells patent and 65% of all hydrogen-related patent Europe only holds 16% of total patents[26.]

Even though there is strong competition from Asia and North America, European companies are well positioned to maintain and further develop their global leadership position within renewable hydrogen. Europe will also profit from its extensive pre-existing natural gas network: A key asset in the upscaling of the technology. The current gas network can store up to 4,400 TWh of energy.

Building-integrated photovoltaics (BIPV)

With continuous cost reduction, innovation and nearly zero-energy buildings (nZEB) requirements, BIPV is increasingly becoming an attractive technology. The global BIPV market (accounting for approximately only 1% of the total PV market) is currently dominated by European companies[27]. The EU is leading not only in terms of deployment, but also in terms of technology development.

Even though the EU is currently a global market leader, it is worth noting that the market is niche and some of the main competitors are not fully committed in this sector yet (e.g. China and US[28]). China has capacity and industrial power needed for a quick upscale of their BIPV production due to their strength in solar PV manufacturing, thus also for potentially entering the EU market[29]. Therefore, there is a need for continuous development of the sector in order to maintain the EU's BIPV competitive advantage.

Floating offshore wind

Even though not yet at a commercial stage, the floating offshore wind is a rapidly maturing technology with the potential to strengthen Europe's leadership in renewables globally. Today, the 62 MW capacity of floating wind deployed in Europe represent a small fraction of the total offshore installations. Nonetheless, floating wind technology increases the potential for electricity generation from offshore wind farms. While bottom-fixed installations are limited to coastlines with low water depths and favourable sea-bed conditions, floating offshore wind has a much wider global growth potential.

The FOW technology is expected to need five more years with focus on research and innovation, and another five to be commercial. European companies such as; Siemens Gamesa, Vestas, EDP and Principle Power are pioneers and they lead three quarters of the more than 50 projects worldwide today.

Battery energy storage systems and electric vehicle batteries

Batteries are a key enabling technology for the green transition. This case study addresses two popular applications of battery technology – electric vehicles (EV) and battery energy storage systems (BESS). For BESS, under optimal conditions, Europe's prosumers could operate a battery fleet as large as 9 GWh by the end of 2024, compared to 5.6 GWh in the Low Scenario. The main driver of battery manufacturing in the EU is expected to be EVs. Currently, the global electrical vehicles (EV) battery market is dominated by manufacturers from only three countries, all of them in Asia: China, Japan, and South Korea. In 2018, approximately one percent was supplied by European manufacturers. Recent years have seen a growth in European battery manufacturers. From a global perspective, Europe is in a catch-up mode. A lack of regulatory support and a weak European supply chain has led to some of Europe's battery manufacturers to set up in

26 FCH - Hydrogen Roadmap Europe (2019)
27 As opposed to the traditional PV modules manufacturing where China currently has a dominance.
28 In the US, a main competitor is Tesla, which is most popular with it electric vehicles. In 2019, they launched Solar Roof V3 product, which was 40% cheaper than the previous version of the product.
29 Interviews with Akuo Energy, Armor Group and Solar Power Europe

China. To address these issues and promote an "innovative, sustainable and competitive battery 'ecosystem' in Europe the European Battery Alliance was launched in October 2017.

There is a significant market opportunity as almost a quarter of all cars produced globally are manufactured in Europe. As car manufacturers transition to electric vehicles, the demand for batteries grows rapidly. Car manufacturers, especially those in Europe, have high expectations to the transparency (e.g. proof of origin, human rights), sustainability and stability in the supply of batteries, which can serve as their advantage in the global markets.

Floating solar photovoltaics

Floating solar photovoltaic (FPV) are relatively new to the market and thus not yet fully mature. Therefore, they carry an important cost burden that can be partly surmounted by some of the advantageous features they offer[30]. Even though the EU is lagging compared to the rest of the world, FPV manufacturing, management and instalment has a high potential for a European global leadership. Some EU companies are leaders in floating PV, providing their solutions all over the world, maintaining a well-established track record of floating PV plants. The EU has a leadership expertise for optimizing hybrid sites in both hardware and software. [31] However, European companies are mostly operating abroad, specifically on the Asian continent.

Despite the growing energy needs of EU countries and the scientific efforts put in developing technological breakthroughs to generate energy in a sustainable way, floating solar is one of the examples of RE technologies which are characterised by increased risks and capital requirements[32] and fail to reach commercial deployment. While many countries have struggled to develop utility-scale solar PV power plants, obstacles in other fields such as floating solar are much bigger, with the first power facility being created in Germany just in 2019.[33] Industry stakeholders in the floating solar industry call for comprehensive support from concept development phase to market deployment.

Ocean Energy

The market for ocean energy is still nascent, the different technologies require first to mature before reaching a competitive level[34]. Currently, no specific ocean technology prevails and the sector struggles to create an EU market despite progress in development and demonstration. The EU is a leader in the filing of patents in international markets, seeking protection in all key markets such as the United States, South Korea, and China as well as Canada and Australia. Nevertheless, the EU receives only a small number of incoming patents applications from outside, primarily from the United States. The patent filings indicate that the EU is a net exporter of ocean energy technology and innovation,

30 Javier Farfan et al. / Energy Procedia 155 (2018) 403-411

31 Other types of technology where EU is investing a lot in can be found in XFLEX: a €18m energy innovation project demonstrating how more flexible hydro assets can help countries and regions to meet their renewable energy targets. The four-year, EU-funded project involves seven demonstration projects and 19 organisations, and will conclude in 2023. Furthermore, there is a lack of standards on floating PV (hybrid) projects worldwide. The Norwegian company DNV GL has gathered together big energy players, floating PV specialists and project developers into a consortium that will aim to define recommended practices for the floating solar business. Among the 14 participants are some big players in the field including EDP, EDF and Equinor, as well as French floating technology provider Ciel & Terre. The final report will be done by March 2021.

32 Dedecca, J.G., Hakvoort, R.A., Ortt, J.R., (2016). Market strategies for offshore wind in Europe: A development and diffusion perspective. Renew. Sustain. Energy Rev. 66: 286–296.

33 Clean Technica (29 Sep 2019)

34 JRC, Supply chain of renewable energy technologies in Europe (2017)

and that European wave and tidal energy developers are well positioned to exploit growth in the sector globally[35].

Currently, while a significant reduction in cost would be needed for tidal and wave energy technologies to reach their potential in the energy mix, the sector has already cut costs by 40% since 2015, faster than anticipated. A crucial but feasible step to reach commercial size by 2030 would be implementing the existing pipeline of 100 MW pilot-farms projects by 2025[36]. Ensuring access to the required rare earth metals and, for wave energy, OEM involvement, will be the most important challenges.

Value chain segments

Each of the six case studies describes the value chain segments in more detail, and elaborates on potential strengths, weaknesses, opportunities, and threats. A high-level overview of the current EU global leadership position for each value chain segment based on the qualitative analysis conducted under the six case studies is presented in the table below. The text following the table presents a discussion per value chain segment. More detail and elaboration on the points mentioned can be found in the case studies.

The table presents an overview, broken down by value chain segments, of:

- *Strengths*: This focusses on the technologies where EU currently has a global leadership position. This indicates where EU is already strong and should stay pro-active in order to maintain this position.
- *Weaknesses*: This lists the technologies where non-EU countries currently have a global leadership position. These are technologies where the EU should invest more strongly in order to strengthen their position and try to gain market share.
- *Key opportunities*: Looking at all case studies, this is a non-extensive list on some key opportunities where the EU could focus in order to catch up with competition, or to further strengthen EU's position with respect to the six technologies.
- *Key threats*: Looking at all case studies, this non extensive list mentions some key threats the EU could address in order to catch up, or to prevent weakening EU's position with respect to the six technologies.

- *Research* – the EU is leading on R&D in renewable hydrogen, BIPV, floating offshore, and ocean energy, but lagging in batteries and FPV, where Asia is leading. In general, the focus of research is on achieving cost reductions, and making the technologies more efficient, and more reliable. For batteries, there is also a more specific focus on the reduction of rare materials. This is also of relevance for the other technologies. There is an increasing competition for sourcing rare resources

35 European Commission - The Blue economy Report 2020 (2020)
36 European Commission - An EU Strategy to harness the potential of offshore renewable energy for a climate (2020)

between the different technologies, which makes research on alternative materials even more important.

- *Project planning* – Even though EU is leading on four of the six technologies, there is an increasing competition from third countries: for example, from the US for BIPV and Asia regarding FOW. There can be project planning synergies from cooperation between EU stakeholders, specifically for BIPV and floating offshore wind. Renewable hydrogen is expected to rise significantly over the next 5-10 years, with half of this expected capacity to be planned in Europe.
- *Resource sourcing* – A common issue for all technologies is the sourcing of raw materials (for example the platinum group materials, cobalt, lithium, silicon, indium, gallium, dysprosium, gadolinium, neodymium, praseodymium, and terbium). The EU is heavily dependent on China and the US (for batteries) for most of these. For floating offshore wind, steel is preferred over concrete since these elements can be prefabricated.
- *Manufacturing* - Regarding renewable hydrogen, even though the EU is global leader in manufacturing, China is a strong upcoming competitor with a focus on scale and low costs. For BIPV, one of the main challenges will be the upscaling of the production due to a lack of standardisation. For batteries, Asia is the global leader in manufacturing. However, there is a potential growth in a link with EU car manufacturers: almost a quarter of all cars globally are produced in the EU.
- *Construction and operation services* – The EU has a well-developed infrastructure for renewable hydrogen which will help in maintaining a leadership position. It does have a relatively high construction costs due to the high safety standards that apply. There are some opportunities in strengthening opportunities for batteries at utility scale, which requires specialized installation by a licensed crew. Designing and operating the software needed can be a substantial activity.
- *End-of-service-life management* – A common focus is the recycling of rare earth materials. Some sectors are relatively new, which means there is not a lot of experience in end-of-service-life management yet, but this brings opportunities for employment in the future and the EU has the legislative framework in place to ensure a sustainable end-of-service-life management. However, restrictions on transport of waste across borders could lead to inefficiencies in recycling.

2.5 Conclusions

Renewable Energy in the European Union has evolved to be a significant employment and economic growth factor. In 2018 the Renewable Energies accounted for over 1.4 million jobs (persons employed). Across the market segments they generate almost 126 billion Euro gross value added. The intensity of employment differs significantly among the RE value chains. These differences can be explained by the varying structures of the value chains across the Member States and over time. While solar energy's development has been turbulent, wind energy has seen dynamic growth. Geothermal energy, including heat pumps, have seen more recent dynamic expansion. The use of bioenergy has also seen positive employment developments. Across all value chains, Construction and Operation is the most relevant segment. Wind Energy, Solar Energy and Geothermal Shallow & Aerothermal (incl. heat pumps) show the most promising economic outlook for the EU.

An international outlook is a key ingredient to the economic success of renewable energy technologies. The growing importance of Renewable Energy is also reflected in global trade, even when trade volume has fallen from 60 billion US$ in 2010 to 55 billion US$ in 2018. Monetary trade volume does not reflect Watt capacity traded. The fall is chiefly driven by the sharp decline in the monetary trade volume of Solar Energy technologies (-

7.6 billion US$), not least due to the increasing competitive pricing and changed trade policies. While China leads the overall international trade of renewable energy technologies, at the country level, chiefly due to large Solar Energy technology exports, several European countries feature prominently among the top 10 Renewable Energy technology exporting countries. Comparing the European Union (28), as a common market (i. e., excluding EU intra-trade) that exports to the world market and competes globally a more heterogenous picture emerges, in which the EU holds a leading position particularly in Wind Energy, Hydropower and Geothermal technologies, while Solar Energy exports remain dominated by countries in the Asia-Pacific region, especially by China.

In high-technology domains such as RE technology, innovation is a key asset for international competitiveness. The EU is leading the global innovation (innovative activity) race. While its share marginally dropped in 2016 to 36 % of global high value patents, the EU still holds more than twice as many high value filings as any other region. China, by contrast, only holds a 9 % of the global share, even though it has seen a fivefold increase compared to 2008. Japan and South Korea could also strengthen their roles as leading nations of RE innovation, as both surpassed the US, which strongly lost ground in RE patenting.

Increasing innovative activity and global exports, especially in wind energy, are indicators for growing competition also in other value chains next to solar energy. The EU can further build on its solid RE foundations and achieve further socio-economic benefits looking ahead.

The EU has set an ambitious GHG reduction target of 55 % by 2050. The path to reaching this target will imply that installed capacity of solar power will be quadrupled, and wind power tripled before 2050. The expansion will impact MSs differently, as the availability of sun and wind varies, power systems vary, and the industrial capabilities vary. However, the scale of the expansion and the need for increased RE capacity in all MSs will provide the basis for an EU-wide economic growth.

Along with the expansion in solar and wind power comes growth in supporting technologies that will enable a much higher uptake of variable renewable energy generation. These technologies include batteries, Power to X, thermal storage, and demand response.

Through 6 cases, this study has put spotlight on just a few of the technologies where EU is already or is striving to become a global leader. Each of those face unique challenges, but a common denominator is the focus on cutting edge technological development and the advantages of building on a sound regulatory framework in the EU.

3 Identification and assessment of possible EU initiatives to promote the EU RE industry

This chapter investigates and assesses opportunities for EU action (policy options) to further support the competitiveness and growth of the EU RE sector. This chapter thus identifies possible EU level interventions (policy options) and provides a brief assessment of their impacts.

This chapter first presents the methodology applied to identify and assess relevant policy options. Thereafter, the identified general objectives and specific objectives are listed, i.e. the objectives to pursue in order to promote the EU Renewable Energy sector. Five general objectives are defined, and the following subchapters set out for each of those objectives, the following:

- Obstacles (i.e. the key relevant problems)
- Drivers (i.e. what are the main reasons why these obstacles occur)
- Policy solutions (possible options) providing the resulting intervention logic and explaining how the specific options would contribute to addressing the objectives

Based thereupon, the final sections of the chapter provide first a summary of the options distinguishing between five different intervention areas. This is followed by a summary of their identified impacts, and last a multi-criteria analysis table allows for a comparison of the impacts of the seventeen possible options that have been identified.

3.1 Methodology

Prior to defining the options and assessing the impacts, the key objectives to pursue were first identified thus ensuring that options would be relevant and viable. The key objectives were identified via desk research and stakeholder consultations. The selection process of relevant objectives aimed at identifying the key priorities that would be essential to consider at EU level in order to improve the competitiveness of the EU RE industry, both internally and at the global level. Five objectives were selected and analysed in five policy briefs. The policy briefs thus also present the identified possible options and the assessment of their possible impacts. Thus, the five policy briefs that are presented in full in a separate study report propose policy solutions to:

1. Improve **access to finance** for commercially ready RE projects;
2. Reduce **administrative burdens** of project permits;
3. Bridge the **funding gap** between research and development (R&D) and commercialisation;
4. Facilitate the **export** of EU RE technologies and services;
5. Foster global **demand for renewable heating and cooling** (H&C) technologies.

The possible policy options to address these objectives were identified with a mix of methodologies. This includes: extensive desk research, consultation activities with key stakeholders, a validation workshops with the main relevant associations representing the EU RE industry, written feedback from the participants in the workshop and comments from, and dialogue the EC including comments on Reports prepared in the context of this project. Overall, forty-three interviews with relevant stakeholders have been conducted in the process of preparing the five policy briefs. The briefs have a standard format: They first present the main obstacles to be addressed and their underlying drivers, thus constituting the background for setting out the objectives of possible new policy intervention, the identified possible policy solutions and the interviewees' opinions about the expected impacts from those options. Each brief also provides a preliminary quantitative assessment of the expected impacts of the identified possible policy solutions on growth and jobs.[37] In determining this, the impact from the individual policy option on the following three main dimensions of industrial competitiveness were assessed:[38]

- **cost and price competitiveness**
- **capacity to innovate**
- **international competitiveness**

In addition, solutions aiming to **increase EU and global demand** for RE technologies and projects were also considered thus assuming that the creation of new markets would generate new opportunities for the EU RE industry, especially in those value chains and segments where the EU has a competitive advantage.[39]

The impacts presented in the briefs were assessed on the basis of the Better Regulation guidelines and toolbox. It has to be noted that in each brief the impacts were assessed for all the options together, except if the interviewee mentioned the impacts of one specific option only. Interviews mostly covered qualitative impacts. Quantitative impacts were estimated on the basis of interviewees' best estimates for the above three core dimensions, and must be interpreted with this limitation. Besides the quantitative assessment of impacts on GVA and employment, the policy briefs also provide a qualitative assessment along the dimensions of effectiveness, efficiency, feasibility and coherence of the policy options.

This exercise has some obvious limitations. First of all, quantitative impacts are based on expert assessment and assumptions. This serves to establish the necessary input data for calculating the impacts on GVA and employment. A full impact assessment would demand more thorough analyses to establish the input data for the calculations. Secondly, the quantitative impacts presented in the policy briefs are not directly cumulable across policy briefs. The assessment of impacts in each policy brief is performed by relying on a *ceteris paribus* assumption. While most of the solutions presented in the different briefs are non-alternative and could be implemented in parallel to improve the competitiveness of the EU RE industry, their cumulative impact will be lower than the sum of the impacts presented in each brief. Finally, while the impact of investments in the RE sector will go well beyond the manufacturing of equipment, with massive implications for the service sector (e.g. maintenance and installation), the expert assessment exercise is limited and cannot take into consideration each sector, technology, type of institution or business. Therefore, the policy briefs can be seen to provide a general overview of the key problems hampering competitiveness and of the 'real-world' relevant possible policy solutions, in the sense that they are widely shared among interviewees and other sources consulted in the process of developing the policy briefs.

The full policy briefs are found in the Study Report on Work Package 3. The above five key policy objectives were articulated in thirteen specific objectives. These objectives have different scopes, ranging from creating a better business environment, promoting investments, to optimising and coordinating existing policy support measures.

Table 2 Objectives of a new policy intervention

37 Such impacts are computed by relying on the Excel Tool to estimate quantitative impacts of EU policies, prepared by COWI in the context of this study (see Annexes A, B and C for further details).
38 For further details, please see Tool #20 of the Better Regulation Toolbox on sectoral competitiveness, available at: https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-20_en_0.pdf .
39 For further details on competitive value chains and segments thereof, please see the final study report for Work Package 1 of this study on "measuring the economic impact of RE value chains and the EU's global competitiveness".

General Objectives	Specific Objectives
1. Improve access to finance for commercially ready RE projects	*1. Strengthen an enabling policy environment for investments in the EU during the period of 2021-2030*
	2. Improve coordination and availability of EU financing sources across the EU, especially in MS which need them most
	3. Better channel to stimulate private funding by a well-functioning sustainable finance framework
2. Reduce administrative burdens of project permits	*4. Simplify the permitting process for developing installations*
	5. Shorten and provide higher certainty around the permitting timeline
3. Bridge the funding gap between R&D and commercialisation	*6. Promote the use of EU funds for demonstration of technologies*
	7. Mitigate the risks associated with innovative pilot and pre-commercial projects
	8. Improve the coordination of public funding programmes supporting the deployment of RE technologies
4. Facilitate the export of EU RE technologies and services	*9. Ensure that EU companies benefit from EU support in developing countries*
	10. Coordinate and harmonise efforts to facilitate the export of EU RE technologies and services
	11. Remove trade barriers for the EU products through standardisation
5. Foster global demand for renewable H&C technologies	*12. Improve the policy environment in the EU and support third countries with best practice transfer*
	13. Reduce the awareness, financing and complexity handling barriers that consumers face when adopting RE H&C solutions in the EU and support information exchange about H&C technologies with third countries

3.2 Objective 1: Improved access to finance for commercially ready RE projects

3.2.1 Obstacles to be addressed

Upscaling RE technologies largely depends upon conditions and costs for financing. This is because most RE technologies are capital intensive with high front-load costs that require long-term funding.[40] Access to long-term funding represents a major challenge for the clean energy transition[41] and to steer investments into the RE direction.[42] However, RE projects still face limited access to competitive financing. While private financing is expected to play a key role in the upscaling of RE technologies,[43] most RE technologies still need public support to push them into the market. Public funding is thus crucial not only to support the early stages of technology innovation, but also to incentivise private funding and speed up investments from various private sources.[44] Risk and return are the fundamental determinants for private investors. Thus, policy instruments can play an

40 European Parliament (2017), 'European Energy Industry Investments. Study for the ITRE Committee', February, p. 50.
41 EC (2017), 'Assessing the European clean energy finance landscape, with implications for improved macro-energy modelling', March, p. 3.
42 Mazzucato, M., G. Semieniuk (2018), 'Financing renewable energy: Who is financing what and why it matters', Technological Forecasting& Social Change, Vol. 127, pp. 8-22.
43 IRENA (2016), 'Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance,' International Renewable Energy Agency, Abu Dhabi, p. 24.
On average, 86% of total investment for RE during 2013–2018 was private finances. IRENA (2020), 'Global Landscape of Renewable Energy Finance', International Renewable Energy Agency, Abu Dhabi, p.14.
44 EC (2017), 'Assessing the European clean energy finance landscape, with implications for improved macro-energy modelling', March, p. 7.

essential role in affecting investors behaviour by either reducing the risk of a RE project or increasing the return, or both.[45]

3.2.2 Underlying drivers

The following key drivers have been identified:

The slowdown in funding may be first explained by **retroactive changes in and a gradual phasing out of government subsidies and support schemes** for RE. The dynamics of national support schemes have been largely affected by EU legislation.[46] In several EU Member States, RE support schemes are perceived as rather unstable, even with retroactive changes impinging on renewable projects already in place. All industry stakeholders mentioned the retroactive changes as a crucial impeding factor creating even more uncertainty, in addition to uncertain energy prices and demand. Moreover, the current EU state aid guidelines[47] require that EU Member States move away from administratively determined feed-in tariffs (FiTs) to feed-in premiums (FiPs) determined by competitive bidding procedures, leaning profit margins for RE project developers and exposing them the volatility of electricity prices.[48]

No legally binding national targets as from 2021. The absence of binding national RE targets as from 2021 may disincentivise Member States to allocate more funds to national support schemes. A number of them have currently put their RE support schemes on hold.

Investors' confidence has been undermined, also by uncertainty in the wake of the Covid-19 crisis. Investors feel insecure about prospective project revenues, given expectations of limited or no government price support, as well as retroactive changes. As a result, they increasingly depend on private sector power purchase agreements (PPAs) or even just on merchant power prices.[49] Although auctions become ever more present and more competitive, competitive bidding procedures (tenders, auctions) make for leaner profit margins.[50] More emphasis on technology-neutral support hinders market deployment of less mature RE technologies.[51] As a result, many RE technologies are still viewed as highly risky by investors.[52]

Uncertainty on energy demand and prices, also due to the lingering financial crisis, has affected the inclinations to invest. Low and even negative electricity prices in the EU contributed to the overall slowdown in investments. The global economic growth is likely to be further hindered by looming uncertainties arising from COVID-19 and international trade wars, in particular.[53]

Differences in subsidies, energy costs, technology costs persist across MS. No single market exists in this regards and differences rely on national legal, policy and political frameworks. This further fragments RE markets within the EU and makes costs of financing in some Member States much higher than in others. As a result, the costs of

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45 Polzin, F., Egli, F., Steffen, B., and T. Schmidt (2019), 'How do policies mobilize private finance for renewable energy?' Applied Energy, Vol. 236, pp. 1249-68.
46 CEER (2017), 'Status Review of Renewable Support Schemes in Europe', C16-SDE-56-03, 11 April, Council of European Energy Regulators, Brussels.
47 EC (2014), Guidelines on State aid for environmental protection and energy 2014-2020, 2014/C 200/01.
48 Polzin et al, op.cit., p. 1255.
49 Frankfurt School (2018), 'Global Trends in Renewable Energy Investment 2018', pp. 18, 38-45, http://www.iberglobal.com/files/2018/renewable_trends.pdf
50 Kitzling, L. et al. (2019), 'Auctions for Renewable Energy Support: Lessons Learned in the AURES Project', The Energy Journal, IAEE, 3d Quarter, pp. 11-14. See also AURES II Project, http://aures2project.eu/
51 Martin, H. et al. (2020), 'Renewable Energy Auction Prices: Near Subsidy-Free?' Energies, Vol. 13
52 Geddes, A., Schmidt, T., Steffen, B. (2018), 'The multiple roles of state investment banks in low-carbon energy finance: An analysis of Australia, the UK and Germany', Energy Policy, Vol. 115, pp. 158-170. P. 158.
53 IEA (2020), 'Renewables 2020. Analysis and forecast to 2025', Report, International Energy Agency, Paris, November, https://www.iea.org/reports/renewables-2020/covid-19-and-the-resilience-of-renewables

capital for RE vary widely between Member States primarily because of policy and regulatory uncertainty and bank loans at concessionary terms in some countries.

Limited transparency on availability of the multitude of funding tools and limited coherence between them have a negative impact on their combined effectiveness.[54] Adoption of the EU Sustainable Finance taxonomy may, to some extent mitigate this problem.

3.2.3 Intervention logic and identified possible policy solutions

The below provides the intervention logic that follows from the above analysis of objectives and obstacles, and it presents the identified policy options and sets out the expected impacts and outcomes. Following the figure, the identified possible options are discussed in more detail.

Ensuring an enabling policy environment for RE investments: This policy option aims to promote the achievement of the EU 2030 RE target by ensuring an enabling policy environment for RE investments. Developers of RE projects can be encouraged by this policy environment within the EU. Although no binding national RE targets are envisaged in the upcoming decade, the Governance Regulation[55] offers a slate of procedures and instruments at the disposal of the EC to improve the prospects that the EU target will be met or even exceeded. A central instrument is the biennial updating procedure of the NECPs. Within a multi-level dialogue framework, these updates offer ample opportunities for the EC to monitor the ambition level of Member States against pre-set Commission's benchmarks and to nudge Member States to increase their ambition levels, when needed. The EU's newly established Renewable Energy Financing Mechanism[56] can also help Member States to tap into the best potential for RE generation across Europe and reduce the cost of support, as well as incentivise them to achieve or even exceed their national targets for 2020 and the EU's 2030 target. The Governance Regulation alludes at the option to use harder "gap filler" instruments such as imposing increasing minimum renewable quota upon suppliers of district heating services or transport fuel suppliers.[57] This would require amending previous Council conclusions on energy policy and governance.[58] It will be very important for the investment climate in renewables in the EU that policymakers *de facto* assure investors that the energy and climate governance framework will work in practice.

54 SolarPower Europe (2019), 'EU Market Outlook for Solar Power 2019-2023', https://www.solarpowereurope.org/wp-content/uploads/2019/12/SolarPower-Europe_EU-Market-Outlook-for-Solar-Power-2019-2023_.pdf?cf_id=11834

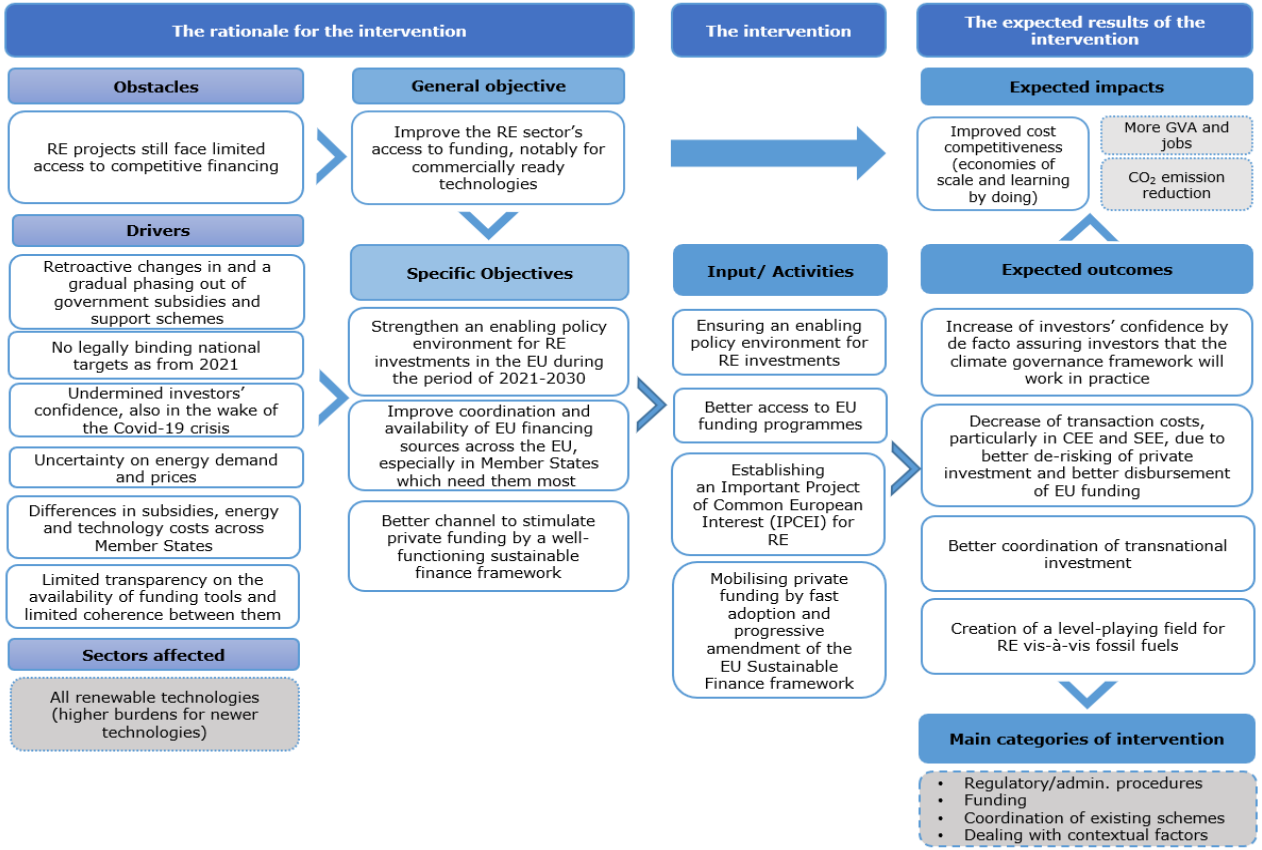
55 Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, PE/55/2018/REV/1.

56 Commission Implementing Regulation (EU) 2020/1294 of 15 September 2020 on the Union renewable energy financing mechanism, C/2020/6123.

57 Regulation (EU) 2018/1999, Art. 32(2).

58 Veum, K. and Bauknecht, D. (2019), 'How to reach the EU renewables target by 2030? An analysis of the governance framework', Energy Policy Vol. 127, pp. 299-307.

Figure 14 Intervention logic - Improved access to finance for commercially ready RE projects



Source: CEPS (2021)

Better access to EU funding programmes: Better use and coordination of EU funding schemes such as the Connecting Europe Facility (CEF), the Cohesion Fund and the Modernisation Fund, InvestEU and the European Regional Development Fund (ERDF) could enhance the support for RE projects. Within the 2021-2027 multiannual financial framework of EU budget and the NextGenerationEU recovery fund,[59] many budget items can in principle support investment projects in the EU RE sector. Special attention should be warranted to better coordination and de-risking private investment in the RE sector through access to public guarantee funds and direct participation by European (EIB, EBRD) and (sub-)national development banks.

Establishing an Important Project of Common European Interest (IPCEI) for RE. This instrument could allow some RE technologies/projects that entail significant risks and require coordination and transnational investments to receive direct funding from several MS.

Mobilising private funding by fast adoption and progressive amendment of the EU Sustainable Finance framework. The EU's sustainable finance framework should help mobilise private sector in sustainable investments and reorient capital flows towards sustainable activities and investments, such as investment in RE projects (i.e. Taxonomy, Green Bonds).

3.2.4 Impacts

The cost impacts from the measures in isolation *vis-à-vis* the overall RE project costs are claimed by stakeholders to be difficult to predict, but would most likely be small. However, the improved access to finance would contribute to accelerating the path towards economics-of-scale and hence a long-termed decline in costs. The implementation of the suggested policy solutions will not likely lead to significant reduction of OPEX, while CAPEX will decrease with time thanks to upscale of production.

Also, the improved access to finance could also play a role in growing the RE sector to the extent that access to finance is a key constraint to developing sound projects. Further, R&D would most likely also increase, improving technologies and providing a better business case for the first phases. This would most likely be most observable for the specific option that aims to provide better access to EU funding programmes. Competitiveness would also be improved as a result of the enlarged market and the accelerated path towards economies-of-scale. Analyses point to that in solar thermal and heat pumps the market growth within the EU could be quite substantial, followed by offshore wind, solar PV and onshore wind. As regards the latter, a key external factor is however the role played by 'local acceptance' issues.

Table 3 below is a summary of the stakeholder feedback on the impacts of the policy options on the competitiveness indicators. Most feedback has been related to the Objective as a whole, while the splits on policy options are based on more fragmented feedback. As a consequence, all impacts on GVA and employment were calculated for the Objective as a whole.The Total row at the bottom of the table shows the cumulative impact of the Objective on the competitiveness indicators, and will be recognizable from the majority of the stakeholder feedback.

Table 3 Objective 1: Effects from policies on competitiveness indicators

59 https://ec.europa.eu/info/strategy/eu-budget/long-term-eu-budget/eu-budget-2021-2027_en

Policy option	Lower costs	Improved technologies	Improved trade conditions	Increased global market
1 (Enabling environment)	4.7%	-	-	48 - 96%
2 (Access to EU finance)	1.6%	-	-	16 - 32%
3 (IPCEI)	0.8%	-	-	8%
4 (Mobilisation of private funding)	0.8%	-	-	32 - 80%
Total	**7.9%**	**-**	**-**	**80-160%**

Source: COWI (2020)

The percentages shown in the table above refer to a change in the respective competitiveness indicator. For the indicator "Lower costs", a positive percentage value refers to a decrease in the total operating costs of the value chain or segment. For "Increased global market", a positive percentage value refers to an increase in total global demand within a value chain or segment. The percentages are all based on stakeholder feedback, and should not be interpreted as exact values.

Further discussion of impacts and estimates of the quantified impacts on GVA and employment are provided in sections 0.

3.3 Objective 2: Reducing administrative burdens of project permits

3.3.1 Obstacles to be addressed

Developers of RE projects face major administrative burdens stemming from permitting processes in several EU MS. More specifically, the permitting rules and licensing process for new and repowered RE installations can be lengthy, complex and uncertain.[60] Most of the stakeholders interviewed confirmed that permitting procedures are one of the main bottlenecks hindering the deployment of new renewable electricity capacity in the EU.[61]

3.3.2 Underlying drivers

The following key drivers have been identified:

The administrative hurdles can be first explained by the **number of authorities** involved in the permitting process.

The **lack or the unsuccessful introduction of binding time limits** in permitting procedures result in a long and uncertain pathway for the development of RE projects.[62] In some MS, timeframes do not distinguish between the different characteristics of RE technologies and scales of projects (e.g. offshore wind vs rooftop

60 European renewable energy group (2020), Getting permitting of renewable investments right is critical to deliver the Green Deal, p1, https://windeurope.org/wp-content/uploads/files/policy/position-papers/20200513-RES-industry-letter-on-permitting-of-new-renewables-investments.pdf

61 Other bottlenecks include, by way of example, access to long-term funding, uncertainty about future electricity prices, obstacles to entering power purchase agreements, etc.

62 Trinomics (2018), Evaluation of the TEN-E Regulation and Assessing the Impacts of Alternative Policy Scenarios, p4, https://trinomics.eu/wp-content/uploads/2018/08/Evaluation-of-the-TEN-E-Regulation.pdf

PV), thus some technologies are subject to lengthy processes when they may be suitable for fast-track approval.[63]

The **ineffective transposition of relevant articles under the Recast Renewable Energy Directive** (REDII)[64] and the **Electricity Market Directive**[65] contributes to the persistence of the above Drivers 1 and 2. REDII requires Member States to create a one-stop-shop to authorise renewable power installations and ensure a maximum duration to complete the permit-granting process.[66] The Electricity Market Directive ensures that the authorisation procedure for new capacity relies on objective, transparent and non-discriminatory criteria.[67] These provisions aim to simplify and shorten the permitting process. However, this simplification effort has not yet led to expected results in practice.[68] The EC recognised this issue while assessing MS' 2030 National Energy and Climate Plans (NECPs) in September 2020.

Even when national legal frameworks comply with EU rules, **interpretation of permitting procedures** still impinges on the operation of the process. Local administrations may have a different understanding of the framework, potentially creating additional hurdles for project developers. Where permitting/consenting authorities understand and are knowledgeable about a certain technology, this can make a difference to the outcome of the permitting process: less mature RE technologies tend to face higher barriers, as permitting authorities often do not know how to apply existing rules to new cases. Decision-making authorities may also deem new activities to be riskier, which does not sit easily with procedures that require certainty. In addition, in most of the MS, there is no legal framework in place when it comes to repowering. In fact, repowering existing plants is not perceived as an urgent issue, and this perception leaves administrations operating at the local level with **very limited guidance on how to streamline permitting for installations to be repowered**.

Other **Member State-specific factors** contribute to increasing the administrative burdens stemming from permitting procedures (e.g. national rules on access to the power grid or taxation and social acceptance). Most of these factors cannot be directly addressed via an EU policy intervention, as they fall to a large extent within national competences. However, they contribute to explaining the complexity of the permitting process and the multiple obstacles faced by RE project developers.

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63 CEPS (2019), Competitiveness of corporate sourcing of renewable energy, Part 2 of the Study on the competitiveness of the renewable energy sector, p31, https://www.ceps.eu/ceps-publications/competitiveness-of-corporate-sourcing-of-renewable-energy/, p31.

64 Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (Text with EEA relevance), PE/48/2018/REV/1, OJ L 328, 21.12.2018, p82–209 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603114764011&uri=CELEX:32018L2001

65 Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (Text with EEA relevance), PE/10/2019/REV/1, OJ L 158, 14.6.2019, p125–199, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019L0944

66 Article 15 REDII aims to ensure that any national rules concerning the authorisation, certification and licensing procedures applied to RE installations are proportionate and necessary. Article 15 also calls for predictable timeframes for administrative procedures. Article 16 REDII requires MS to ensure that permit-granting process for RE installations will be handled by one single contact point in their administration (one-stop-shop) and sets a maximum duration for the permit-granting process equal to two years for large-scale plants and one year for small-scale plants and repowering. Finally, Article 17 REDII introduces a simplified notification procedure for the connection to the grid of small-scale installations (below 10.8kW and, under certain conditions, below 50kW).

67 Article 8 of the new Electricity Market Directive also calls for simplified and streamlined authorisation procedures for small decentralised and/or distributed generation.

68 European renewable energy group (2020; Note 60), p1.

3.3.3 Intervention logic and identified possible policy solutions

The below provides the intervention logic that follows from the above analysis of objectives and obstacles, and it presents the identified policy options and sets out the expected impacts and outcomes. Following the figure, the identified possible options are discussed in more detail.

Draft EU guidance to ensure the proper transposition and implementation of Articles 15 and 16 REDII on administrative procedures and organisation of permit-granting process for new and repowered RE projects as well as of Article 17 REDII and Article 8 of the Electricity Market Directive on authorisation of new capacity generation and grid connections. Guidance should be targeted to central governments and any relevant national/local authority involved in administrative procedures for RE installations.

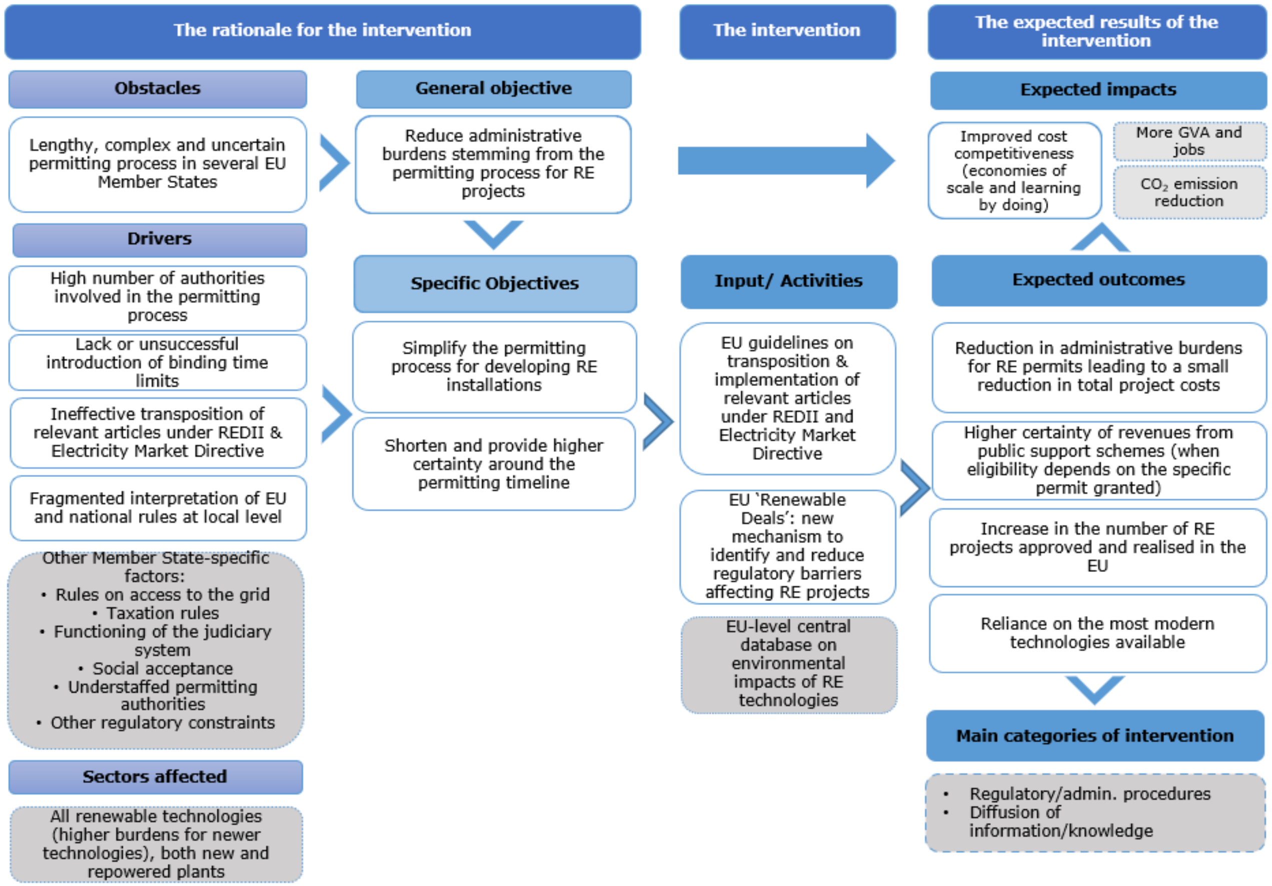
Introduce a new mechanism to reduce regulatory barriers affecting RE projects. EU institutions, national and local authorities should cooperate with project developers and/or other stakeholders of the RE industry to identify and lift regulatory barriers stemming from misinterpretation or inadequate implementation of EU legislation. The mechanism could be modelled on the Dutch Green Deal[69] or the EU Innovation Deals[70] and aim to improve the understanding of how EU rules in the field of RE work in practice and stimulate stakeholders' cooperation to solve problems together. Businesses facing issues with permitting procedures could be allowed to report such problems to the Commission via an *ad hoc* notification mechanism.[71]

69 For further details, please see: https://www.greendeals.nl/english

70 For further details, please see Simonelli F. and Renda A. (2019), Study supporting the interim evaluation of the Innovation Principle, https://www.ceps.eu/ceps-publications/study-supporting-the-interim-evaluation-of-the-innovation-principle/ ; and https://ec.europa.eu/info/research-and-innovation/law-and-regulations/innovation-friendly-legislation/identifying-barriers_en

71 The Commission has already established a general mechanism to simplify existing legislation and reduce regulatory burdens. The so-called 'Have your say: Simplify!' (formerly, 'lighten the load') initiative allows EU citizens to identify existing EU rules that could be made more effective and efficient. Suggestions are reviewed by the 'Fit for Future' platform (formerly, the REFIT platform) and may be included in the opinions of the platform to the Commission. For further details, please see: https://ec.europa.eu/info/law/better-regulation/have-your-say-simplify

Figure 15 Intervention logic - Reducing administrative burdens of project permits



Source: CEPS (2021)

Create a central database on the environmental impacts of RE technologies. This database, managed by the EC, should feature scientific evidence in the form of studies, research papers, environmental impact assessments and datasets on different RE technologies. The purpose of this database would be to allow national and especially local authorities involved in permitting procedures to rely on up-to-date, reputable sources to inform their decision-making process.

3.3.4 Impacts

Reduced administrative burdens is not expected to substaintially lower total costs of RE projects because administrative costs are a small share of total project costs. The impacts of the proposed solutions on the financial costs depends on whether the finance is provided before or after the permitting decision. In the former case, financial costs can be reduced, while in the latter case, there is no significant impacts as the risks of delays in permitting do not affect the cost of capital.

More importantly, improved permitting procedures can contribute to promoting more RE projects, thus expanding the volume of RE projects realised in the EU. Both mature and new RE technologies can benefit from improved permit-granting process, with the increase in demand for less mature RE sectors being relatively higher. A shorter and more effective process would imply that less administrative resources would be invested in projects that are eventually not approved, and that more approved projects would be implemented as the risk of the technology having become obsolete is reduced -due to a reduced time span. The effect in terms of promoting the most modern technology could also help to reduce energy generation costs.

Table 4 below is a summary of the stakeholder feedback on the impacts of the policy options on the competitiveness indicators. Most feedback has been related to the Objective as a whole, while the splits on policy options are based on more fragmented feedback. As a consequence, all impacts on GVA and employment were calculated for the Objective as a whole. The Total row at the bottom of the table shows the cumulative impact of the Objective on the competitiveness indicators, and will be recognizable from the majority of the stakeholder feedback.

Table 4 Objective 2: Effect from policies on competitiveness indicators

Policy option	Lower costs	Improved technologies	Improved trade conditions	Increased global market
1 (EU guidelines)	0.5 - 1%	-	-	12 - 40%
2 (EU 'Renewables Deal')	0.5 - 1%	-	-	12 - 40%
Total	**1 - 2%**	**-**	**-**	**24 - 80%**

Source: COWI (2020)

The percentages shown in the table above refer to a change in the respective competitiveness indicator. For the indicator "Lower costs", a positive percentage value refers to a decrease in the total operating costs of the value chain or segment. For "Increased global market", a positive percentage value refers to an increase in total global demand within a value chain or segment. The percentages are all based on stakeholder feedback, and should not be interpreted as exact values.

Further discussion of impacts and estimates of the quantified impacts on GVA and employment are provided in sections 0.

3.4 Objective 3: Bridging the funding gap between R&D and commercialisation

3.4.1 Obstacles to be addressed

While the European RE industry develops first-class equipment in fields such as ocean energy, wind, geothermal and solar, many innovative RE technologies fail to reach the market or take a long time to be deployed because of the high costs of demonstration and installations in early-stage commercialisation. The 'valley of death' in the innovation process cripples research efforts and affects negatively the EU economy and its green transition. The valley of death defines the lack of resources destined to technology development in the phase that immediately follows the basic research phase.[72] However, if these innovations make it through this valley of death, proving to be commercially viable, they can benefit once again from resources supporting their marketability. The problem of the valley of death is especially clear in the case of demonstration projects, which sit in the middle stage of the innovation process.[73] Therefore, innovators face considerable barriers in raising investment funds; such barriers prevent promising new RE technologies from attaining commercial viability.[74] More public support is needed in bridging the existing gap between the research phase and the market.

3.4.2 Underlying drivers

The following drivers have been identified:

Innovative RE concepts face a funding gap between R&D and market commercialisation, explained by either i) the lack of funding for development at high technology readiness levels (TRLs) (i.e. technologies that are close to commercialisation), or ii) difficulties in sequencing different funding opportunities going from low to high TRLs. The limited public support to address the aforementioned valley of death issues undermines the impact of the large amount of public investments in the previous research stages (with low TRLs) such as basic research, where typically the involvement of public research organisations is larger. Second, while increasing R&D funding is seen by many stakeholders as a necessary step to promote innovation in the RE sector, some call for a more efficient and effective generation of synergies between different sources of public funding such as Horizon 2020 and the European Structural and Investment Funds (ESIF).[75] More should be done to create concrete linkages between programmes in order to ensure real coherence and complementarity.[76]

Several key risks and barriers can threaten investment in RE projects and thus prevent rapid uptake of desirable technologies, such as the exploration risk in the geothermal industry or prototypical/technology risks in tidal and wave technologies. Unlike mature RE technologies e.g. solar PV and onshore wind,[77-78] risk insurance and

72 Markham, S.K., Ward, S.J., Aiman-Smith, L., Kingon, A.I., (2010), The Valley of Death as Context for Role Theory in Product Innovation. Journal of Product Innovation Management 27: 402–417.
73 Nemet, Zipperer, Kraus (2018), The valley of death, the technology pork barrel, and public support for large demonstration projects. Energy Policy 119: 154–167.
74 Hartley, Medlock (2017), The valley of death for new energy technologies. Energy J. 38: 33–61.
75 JIIP, (2017). Synergies between Framework Programmes for Research and Innovation and European Structural and Investment Funds: Contributing to the Interim Evaluation of Horizon 2020 Final Report, EC.
76 European Parliament, (2019). Mainstreaming Innovation Funding in the EU Budget. Policy Department D: Budgetary affairs.
77 Egli (2020). Renewable energy investment risk: An investigation of changes over time and the underlying drivers. Energy Policy 140: 111428.
78 Angelopoulos, Doukas, Psarras, Stamtsis (2017). Risk-based analysis and policy implications for renewable energy investments in Greece. Energy Policy 105, 512–523.

guarantee services for RE projects relying on new technologies are not available or charged at high premia to investors, especially in MS with unstable regulatory environments. Typically, these instruments allow investors to transfer part of the risk (e.g., natural hazards or technical failure) to a third party that is better able to bear it.

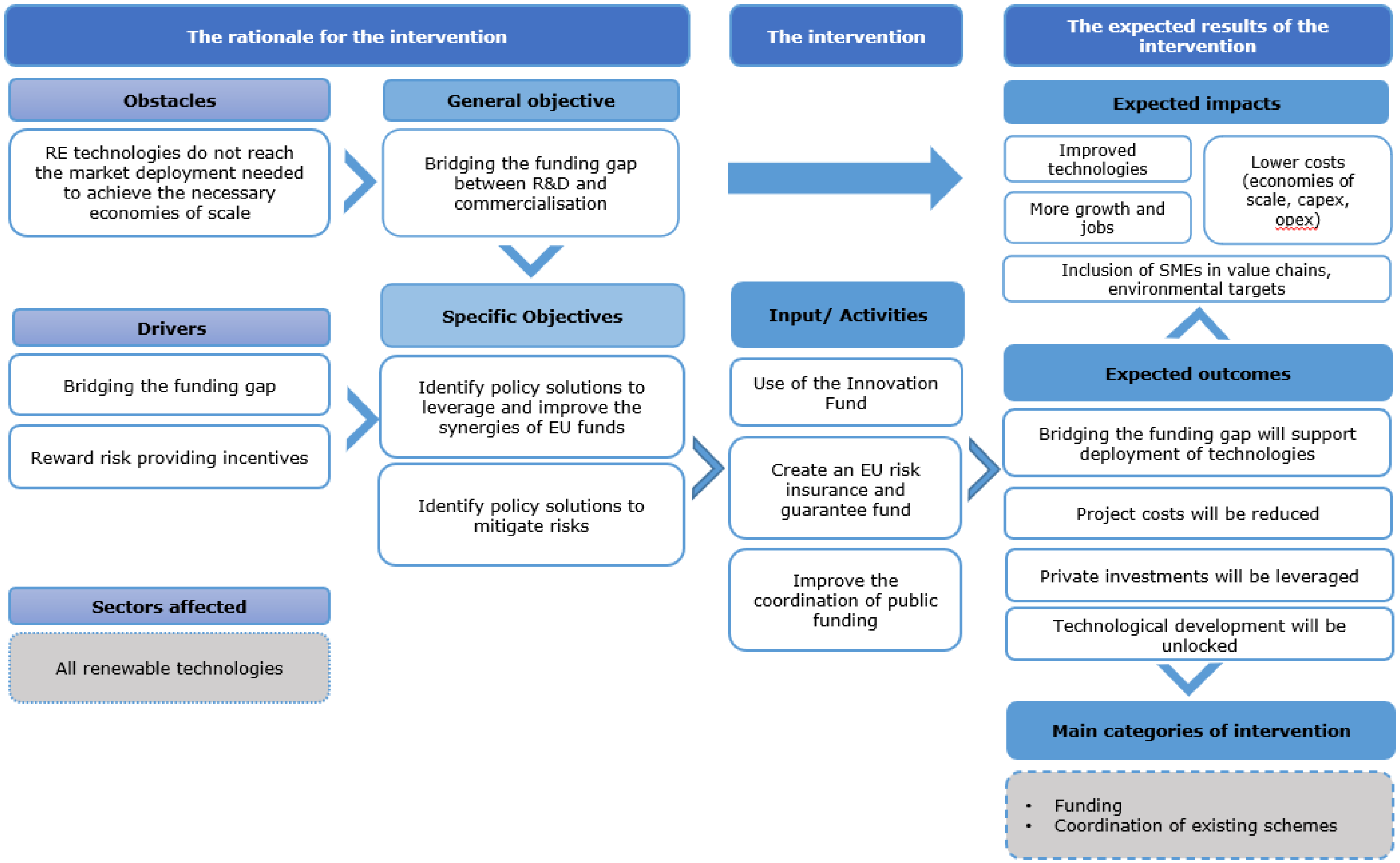
Due to the lack of risk insurance and guarantee services for innovative RE projects, there are less incentives to innovate in new RE technologies - investments are attracted by less risky sectors. Small-scale RE projects are often not considered by commercial financiers because of less favourable risk/return ratios. In the offshore wind energy sector, delays or damage during fabrication, transport, installation, testing and commissioning can affect the revenue profile of a project; consequently, the construction stage of a wind farm is the key area of concern for investors.[79]

3.4.3 Intervention logic and identified possible policy solutions

The below provides the intervention logic that follows from the above analysis of objectives and obstacles, and it presents the identified policy options and sets out the expected impacts and outcomes. Following the figure, the identified possible options are discussed in more detail.

79 UNEP, (2004). Financial Risk Management Instruments for Renewable Energy Projects: Summary document. Paris.

Figure 16 Intervention logic – Bridging the funding gap between R&D and commercialisation



Source: CEPS (2021)

The **use of the Innovation Fund**[80] should be promoted for RE technologies at demonstration phase, in cooperation with MS. The high capital-intensity of some energy projects requires investment support schemes to include a strong component of upfront finance, to help projects leverage private finance and reach financial close. The Innovation Fund should be properly harnessed to allow EU RE technologies to survive the 'valley of death', contributing to the emersion of global leaders. This fund should provide finance flexibly (grant, debt or equity) to suit the diverse profiles of projects while requesting a strong due diligence, reducing risks for the Fund itself and providing a seal of approval helping to access further private finance at reduced cost. Frontloading funding would also help especially in the case of demonstration projects, which would benefit more from immediate financial support funding than later (e.g. closer to the 2030 target).

An **EU risk insurance and guarantee fund** could be established to hedge risks associated with innovative pilot and pre-commercial RE projects. *Governments would have a particularly central and wide-ranging role to play in RE innovation that goes far beyond the provision of funds for R&D.*[81] While the commercial insurance market is cautious in backing the development of complex technological innovations, the support of the public sector could be usefully extended to cover the risks associated with product testing, pilot projects or *facilitating major demonstration projects.*

For the entire innovation value chain (from research to commercialisation), in cooperation with MSs, the **coordination of public funding** need improvement to support the deployment of RE technologies.

3.4.4 Impacts

The proposed solutions are expected to improve the competitiveness of the EU RE industry by promoting investments, improving technologies and lowering costs, thus allowing the EU RE industry to grow faster and improve its competitive position on a global scale. R&D spending can be increased if more funding on CAPEX or an EU risk insurance and guarantee scheme is available. The proposed policy solutions would lower costs of RE technologies through affecting their economies of scale, allowing projects to reach minimum scale levels which are necessary to offer technologies at more affordable prices. The impacts on CAPEX could be remarkable, while those on OPEX are more limited since OPEX in RE plants are relatively low *vis-à-vis* conventional energy. Reduction in direct costs of developing innovations towards commercialisation and the inherence risk (costs), and higher incentive to invest in R&I would also translate into an increased market in the EU and globally.

Table 5 below is a summary of the stakeholder feedback on the impacts of the policy options on the competitiveness indicators. Most feedback has been related to the Objective as a whole, while the splits on policy options are based on more fragmented feedback. As a consequence, all impacts on GVA and employment were calculated for the Objective as a whole. The Total row at the bottom of the table shows the cumulative impact of the Objective on the competitiveness indicators, and will be recognizable from the majority of the stakeholder feedback.

Table 5 Objective 3: Effects from policies on competitiveness indicators

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80 https://ec.europa.eu/clima/policies/innovation-fund_en
81 https://www.iea.org/topics/innovation

Policy option	Lower costs	Improved technologies	Improved trade conditions	Increased global market
1 (Use of Innovation Fund)	3.33%	-	-	-
2 (EU risk insurance & guarantee fund)	3.33%	500%	-	-
3 (Coordination of public funding)	3.33%	-	-	-
Total	**10%**	**500%**	**-**	**-**

Source: COWI (2020)

The percentages shown in the table above refer to a change in the respective competitiveness indicator. For the indicator "Lower costs", a positive percentage value refers to a decrease in the total operating costs of the value chain or segment. For "Improved technologies", a positive percentage value refers to an increase in total R&D budget within a value chain or segment. Stakeholders estimated that Policy Option 2 (EU risk insurance and guarantee fund) would allow companies to increase R&D spending from originally 1-2% to 5-10% of total turnover after the fourth or fifth year of project implementation, i.e. an expected 5-fold increase. The percentages are all based on feedback from stakeholder from the geothermal energy sector, and should not be interpreted as exact values.

Further discussion of impacts and estimates of the quantified impacts on GVA and employment are provided in sections 0.

3.5 Objective 4: Facilitating the export of RE technologies and services

3.5.1 Obstacles to be addressed

There are limited targeted tools facilitating the export of the EU RES technologies and services. Up until now, EU Member States focused their efforts to promote the uptake of the RE mainly on their national markets, with an aim to increase their share of RE and to achieve their national targets set in the Renewable Energy Directive. While a strong national market is a strong foothold, it will not in itself necessarily provide for a strong position in other markets. To play an important role on the international market, international cooperation is needed[82]. The EC assessed that a harmonised approach to RE support across the EU could bring significant benefits in terms of efficiency and cost reduction.

3.5.2 Underlying drivers

The following drives have been identified:

MS design their support schemes in order to reach their national RE targets[83]. The support mechanisms[84] for RE projects in place focus on **national development** of RE

82 A.Jadukiewicz and B.Pera (2020), International Trade Disputes over Renewable Energy – the Case of the Solar Photovoltaic Sector, https://www.mdpi.com/1996-1073/13/2/500
83 This has been set in Article 4 of the REDII.
84 RES-legal, database on regulation of renewable energy generation in the EU MS, see: http://www.res-legal.eu/

industries and do not provide incentives to internationalise the activities and operate in the global market.

National export credit agencies (ECAs) in some Member States facilitate export of RE technologies. These agencies have different structures across Member States. Some are governmental departments, others constitute separate agencies and, in some Member States the public mandate is given to insurance companies to undertake the work related to export credits. Additionally, the form[85] in which export credit is provided follows different requirements and depends on the characteristics of the national economy and the capacities of the financial sector[86]. While the same product may be guaranteed by multiple ECAs, the terms and conditions attached to this vary[87]. This can cause for example administrative and reporting burden for the export credit receivers. Thus, the existing export credits for the RE technologies and services are carried out in an uncoordinated manner by ECAs at Member State level.

The use of international and well-written **standards** facilitates international trade, improves communication, enhances resource efficiency and confidence in products[88]. At the global level there are currently four levels of standards bodies, including international (e.g. ISO – International Organisation for Standardisation, and IEC – International Electrotechnical Commission), regional (e.g. CEN – European Committee for Standardisation, CENELEC – European Committee for Electrotechnical Standardisation), national and standards developing organisation (e.g. ASMT – American Society for Testing and Materials). The EU standards are voluntary, and it is up to each user to use the respective standard. By comparison, the EU technical requirements are mandatory, thus ensuring an aligned high quality of the EU products. Different requirements in different countries can be perceived as an obstacle for exports by RE companies. In addition, not all the RE technologies and the segments of value chain are currently covered by the standards[89].

3.5.3 Intervention logic and identified possible policy solutions

The below provides the intervention logic that follows from the above analysis of objectives and obstacles, and it presents the identified policy options and sets out the expected impacts and outcomes. Following the figure, the identified possible options are discussed in more detail. Following the figure, the identified possible options are discussed in more detail.

EU support to RE in developing countries to secure new export destinations for the EU RE technologies and services. While environmental concerns (including mitigation of greenhouse gas emissions) is the main driver for encouraging RE in developed countries (for example by the EU), for developing countries the main driver

85 For example: financing by a commercial bank with a guarantee or insurance from ECA; financing provided directly by ECA; the use of interest rate support schemes; re-financing, etc.
86 EC (2015), Annual review by the Commission of MS´ Annual Activity Reports on Export Credits in the sense of Regulation (EU)No 1233/2011, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0130&from=en
87EC (2018), Annual review by the Commission of MS´ Annual Activity Reports on Export Credits in the sense of Regulation (EU)No 1233/2011, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0305&from=EN
88 IRENA, 2013, International Standardisation in the Field of Renewable Energy: https://www.irena.org/publications/2013/Mar/International-Standardisation-in-the-Field-of-Renewable-Energy
89 IRENA, 2013, International Standardisation in the Field of Renewable Energy: https://www.irena.org/publications/2013/Mar/International-Standardisation-in-the-Field-of-Renewable-Energy

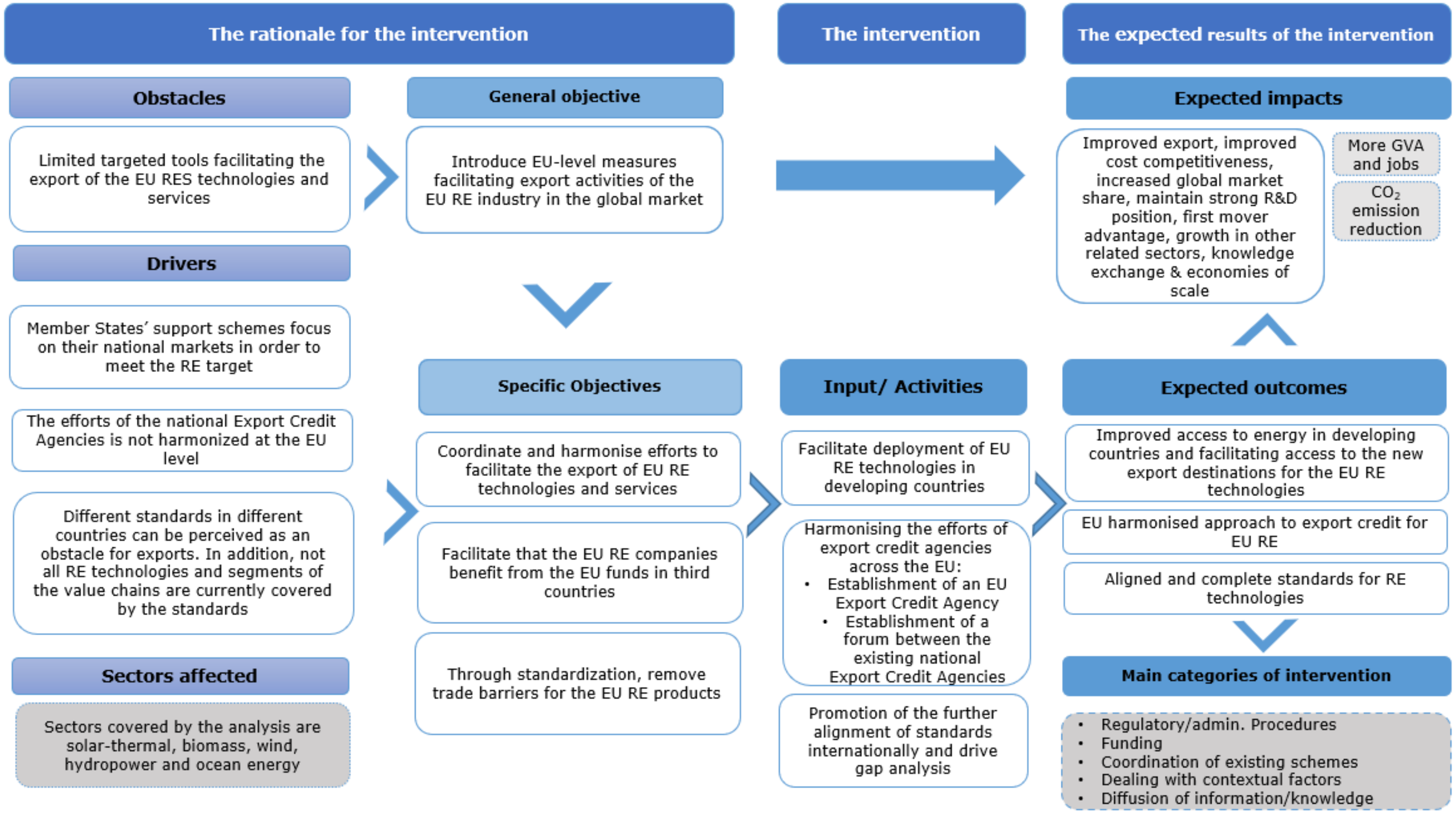
is often limited access to energy[90]. Facilitating access to energy in developing countries and at the same time improving climate and environmental concerns worldwide, combined with an effort to promote the use of EU RE technologies, could be one of the possible ways to facilitate the export of EU RE technologies.

Harmonising the efforts of the export credit agencies (ECAs) across the EU and thereby creating uniform conditions for export of the EU RE technologies across Member States would contribute to the uptake of EU RE technologies on the global market. Sharing knowledge about local circumstances, regulations, and networks, and operating under a common strategy to promote utilization of the EU RE technologies would result in increased opportunities for the EU companies to operate on the non-EU markets. It would also contribute to increased investor certainty and de-risking finances. Export credit for green technologies at the EU level could be set as part of an industrial strategy to secure new export opportunities for EU RE companies. Two alternative approaches for pursuing this solution are:

- Establishment of an **EU export credit agency for green technologies/services.** Harmonised approach to export credit is used in other export countries that are active on the global RE market. The agency could set a framework under which national ECAs would operate together and under a common strategy, collect and develop market studies, provide political support and opportunities for capacity building and networking.
- An alternative option would be the creation of a **coordination forum between the existing national export credit agencies focusing on the RE technologies**. At present, national export agencies act independently. In an EU-wide forum, national export credit agency representatives would meet, share knowledge, best practices and to the extent feasible, align their approach to export credit for the EU RE technologies.

90 ECOTEC Research and Consulting Limited, Renewable Energy Sector in the EU its Employment and Export Potential, https://ec.europa.eu/environment/enveco/eco_industry/pdf/ecotec_renewable_energy.pdf

Figure 17 Intervention logic - Facilitating the export of RE technologies and services



Source: COWI (2021)

The use of standards in the field of RE technologies provides a number of advantages for traders and economic operators, including interoperability, resource efficiency and the allowance for dissemination of best practices[91], as well as facilitation of trade and contractual agreements and ensuring compliance with minimum environmental requirements[92]. Therefore, **promotion of further alignment of standards internationally** (i.e. alignment of the ISO and European Standards-EN) can facilitate access to the global markets for EU companies, enhance international competitiveness of the EU RE industry and remove trade barriers for EU RE products. This could be done also by continuous use of international standards when feasible, while not jeopardizing EU product quality.

3.5.4 Impacts

Stakeholders confirmed widely that options to facilitate the export of RE technologies and services would positively contribute to increasing the global demand and promoting EU exports. Guarantee of investments would trigger additional local business, while a joint approach and a strategy at the EU level are also expected to contribute significantly to improving trade conditions and increasing exports of EU RE technologies. The policy options are also expected to significantly lower RE technology cost, either through lower financial costs (thanks to the guarantee of investments) or lower technology-related capital expenditures (thanks to the increased export of RE technologies and services). The CAPEX reduction would be more remarkable for new RE technologies than mature ones. In addition, increased exports would also trigger additional investments in research and development.

Table 6 below is a summary of the stakeholder feedback on the impacts of the policy options on the competitiveness indicators. Most feedback has been related to the Objective as a whole, while the splits on policy options are based on more fragmented feedback. As a consequence, all impacts on GVA and employment were calculated for the Objective as a whole. The Total row at the bottom of the table shows the cumulative impact of the Objective on the competitiveness indicators, and will be recognizable from the majority of the stakeholder feedback.

Table 6 Objective 4: Effects from policies on competitiveness indicators

Policy option	Lower costs	Improved technologies	Improved trade conditions	Increased global market
1 (Support for RE in developping countries)	1.2%	3.33 – 10.8%	80%	-
2 (Harmonising efforts of export credit agencies)	1.2%	3.33 – 10.8%	80%	-
3 (Further alignment of standards)	1.2%	3.33 – 10.8%	40%	-
Total	**3.6%**	**10 – 32.4%**	**200%**	**-**

Source: COWI (2020)

The percentages shown in the table above refer to a change in the respective competitiveness indicator. For the indicator "Lower costs", a positive percentage value

91European Committee for Standardization (CEN), 2020, Renewable energy sources, see: https://www.cen.eu/work/areas/energy/Renewables/Pages/default.aspx

92 IRENA, 2013, International Standardisation in the Field of Renewable Energy: https://www.irena.org/publications/2013/Mar/International-Standardisation-in-the-Field-of-Renewable-Energy

refers to a decrease in the total operating costs of the value chain or segment. For "Improved technologies", a positive percentage value refers to an increase in total R&D budget within a value chain or segment. For "Improved trade conditions", a positive percentage value refers to an increase in EU market share of the global market within a value chain or segment, i.e. an 80% increase in a market share of say 10% would result in a market share of 18%. The percentages are all based on stakeholder feedback, and should not be interpreted as exact values.

Further discussion of impacts and estimates of the quantified impacts on GVA and employment are provided in sections 0.

3.6 Objective 5: Fostering global demand for renewable heating and cooling technologies

3.6.1 Obstacles to be addressed

The H&C sector is responsible for more than 50% of the EU and global energy consumption, accounting for 40% of global energy-related CO_2 emissions.[93] However, in 2018, almost 80% of energy sources used in the heating sector both in the EU and globally still came from fossil fuels.[94] Incremental growth of the residential sector, both at EU and global level, opens new opportunities to upscale RE H&C technologies. District heating systems (DHS), mostly used in EU Member States with relatively cooler climate, are deemed to be one of the most effective ways to introduce RE technologies into the H&C sector because these systems enable to integrate different fuels without requiring buildings to collect or generate RE individually.[95] Individual H&C systems, more widespread in southern MS, largely depend on household's individual decisions.

High demand growth in the EU is a prerequisite for the upscale of RE H&C production to the levels needed to allow EU companies withstanding non-EU competitors at the global level. European companies have already reached the scale and ambition to create and boost demand for their commercial offerings in third countries.[96] In order to allow them gaining a stronger competitive advantage, an extensive application of RE H&C technologies needs to be ensured both at home and abroad. However, EU demand for RE H&C technologies is hindered by insufficient policy support.

93 IRENA, OECD/IEA and REN21 (2020), 'Renewable Energy Policies in a Time of Transition: Heating and Cooling', International Renewable Energy Agency: Abu Dhabi, pp. 11, 19-20, 24, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_IEA_REN21_Policies_Heating_Cooling_2020.pdf
IEA. (2020), 'Renewables 2020 - Analysis and forecast to 2025', International Energy Agency, Paris, p. 127 https://webstore.iea.org/download/direct/4234

94 In 2019, renewables accounted for 22.1% of total energy use for H&C in the EU, of which only around 3% were from modern renewable energy sources. In global H&C demand, RE reached 22.3% in 2019, of which 10.4% of modern renewable energy sources excluding traditional use of biomass.
RE reached more than half in the H&C sector in Sweden (66.1%), Latvia (57.8%), Finland (57.5%) and Estonia (52.3%) in 2019.
IRENA, OECD/IEA and REN21 (2020), op.cit., p. 22; Eurostat (2020), 'Just over 20% of energy used for heating and cooling is renewable', 29 December, https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/ddn-20201229-1

95 IRENA (2017), 'Renewable Energy in District Heating and Cooling. A sector roadmap for REMAP', International Renewable Energy Agency: Abu Dhabi, March, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Mar/IRENA_REmap_DHC_Report_2017.pdf

96 Companies specialising in RE H&C technologies and associated equipment need to successfully pass through three sequential technology development stages: i) development of the technology from proof of concept up to a technically reliable product to be tested on the home market for receiving consumers' feedback; ii) product adjustment and scale-up of production for early market adoption, initially domestically and later in other MS; iii) unlocking latent demand in third countries in order to expand on a global scale.

Particularly, obstacles on the demand side include a relatively less enabling RE H&C policy environment, low consumers' awareness of RE H&C solutions, both within the EU and in third-country markets,[97] and limited internal heat and energy planning capacities at local (municipal) level.

3.6.2 Underlying drivers

The following drivers are identified:

Less enabling policy environment. In national policy and regulatory frameworks, RE H&C technologies are often disadvantaged vis-à-vis conventional technologies, still rely on limited public support and face several limitations linked to the poor knowledge and understanding of such technologies by regional and local public administrations. Currently, uncertainties about the level-playing field in the H&C sector persist and slow down an expansion of the EU domestic market for RE H&C technologies. Moreover, in several Member States RE H&C technologies are disadvantaged and exposed to unequal competition with subsidised fossil fuels. In spite of their cost competitiveness and minimal negative externalities compared to conventional heat sources, these technologies have gained only marginal market shares in the EU. In several MS, as well as in many third countries, support instruments for RE H&C are rather weak or even lacking. Obstacles for greater penetration of RE in buildings also persist, discouraging the construction industry to consider RE technologies for heating systems. To date, this has not been properly addressed in the national building codes in several MS.

High hurdles faced by consumers to adopt RE H&C solutions. Consumers still face the awareness barrier, the financing barrier and the expected complex handling barrier. Often, even when H&C industries offer cost-effective solutions, their implementation can be hindered by barriers for end-users, such as awareness and consumer inertia, financing, finding the best system design, equipment brands as well as installers.98 Lack of awareness of RE solutions for H&C is particularly relevant in countries with decentralised heating supplies, where individual households can choose their heat supply solutions individually. Even if consumers opt for RE H&C solutions, they often face lack access to maintenance and repair services to manage the pre-conceived complex practicalities of handing RE H&C equipment.[99]

Internal **heat and energy planning capacities at local (municipal) level** remain limited across the EU, whilst mapping local heat resources and matching them with H&C demand are crucial for successful realisation of RE HC projects. Development of public private partnerships allows delivering well-insulated new buildings and renovating the existing building stock.

97 IRENA, OECD/IEA and REN21 (2020), 'Renewable Energy Policies in a Time of Transition: Heating and Cooling', International Renewable Energy Agency: Abu Dhabi, pp. 25-27, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_IEA_REN21_Policies_Heating_Cooling_2020.pdf
98 EC (2019), 'Final report on the analysis of the heating and cooling consumers and recommendations in terms of new business models and regulatory framework', Renewable Heating and Cooling, Contract number PP-2041/2014, https://www.rhc-platform.org/content/uploads/2019/12/Final-report-on-the-analysis-of-the-heating-and-cooling-consumers.pdf
99 Valkering, P. et al. (2019), 'Final report on the analysis of the heating and cooling consumers and recommendations in terms of new business models and regulatory framework, Contract number PP-2041/2014, RH&C, September, pp. 38, 41-43, https://www.rhc-platform.org/content/uploads/2019/12/Final-report-on-the-analysis-of-the-heating-and-cooling-consumers.pdf

3.6.3 Intervention logic and identified possible policy solutions

The below provides the intervention logic that follows from the above analysis of objectives and obstacles, and it presents the identified policy options and sets out the expected impacts and outcomes. Following the figure, the identified possible options are discussed in more detail.

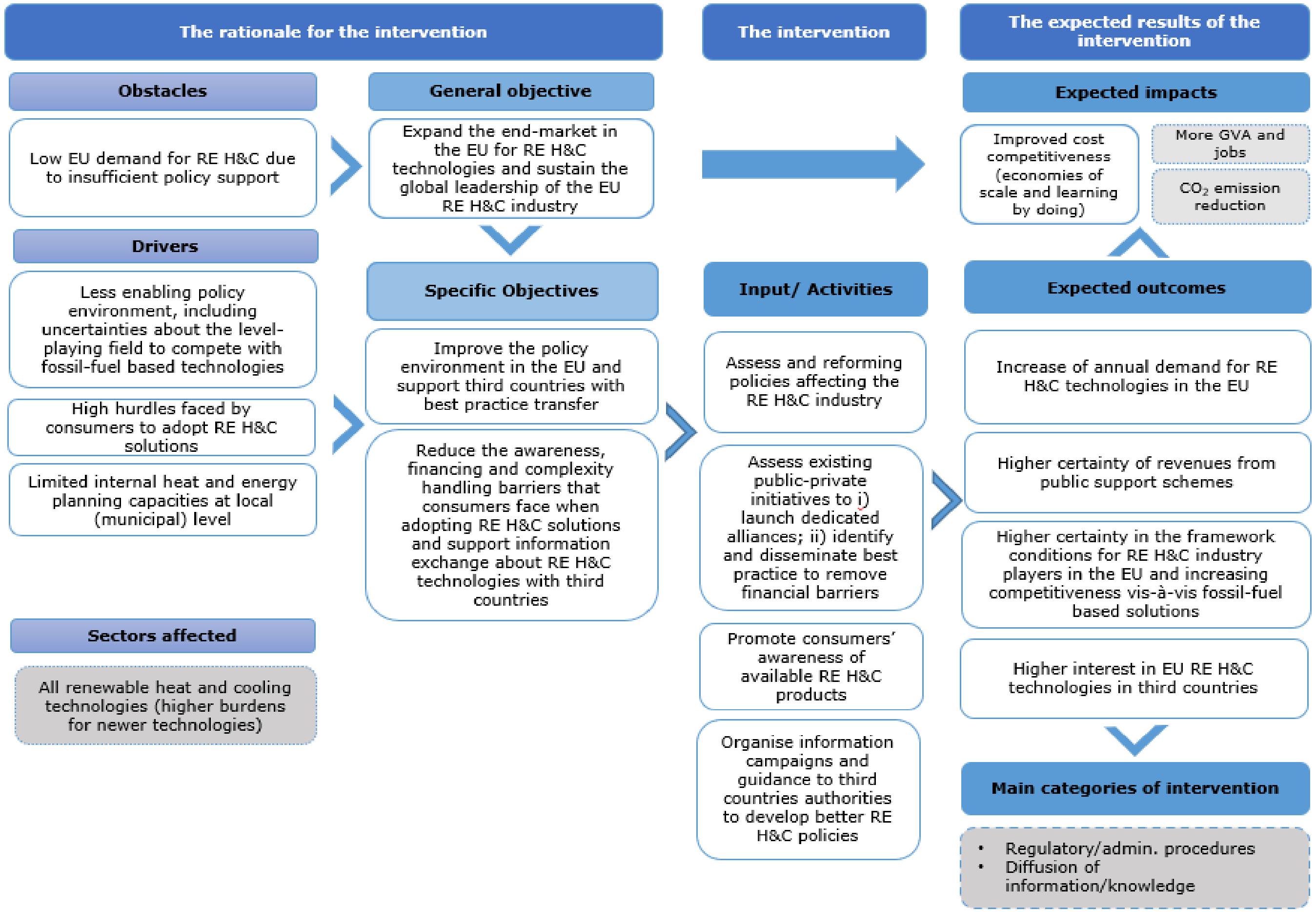
Assessing and reforming policies affecting the EU RE H&C industry would help implement effective support policies and enable a smooth ramp up of the supply chain of RE H&C equipment. This requires providing clear regulatory and market signals to allow RE H&C industries competing at least on equal basis with fossil-fuel solutions. In this respect, possible solutions include:

- Creating a level-playing field through properly reflecting environmental externalities in fossil-fuel prices.
- Introducing more enabling building codes for RE H&C technologies, with due allowance for country-specific conditions on e.g. minimum share of RE H&C in new public buildings.[100]
- In overviewing the process of updating the National Energy and Climate Plans (NECPs) in light of the 2030 EU targets, special attention should be paid to the diffusion of best practices regarding national support schemes for RE H&C across MS.
- Other instruments can include subsidies, renewable heating quota schemes, targeting e.g. district heating systems and manufacturing industry[101], derisking schemes and government procurement programmes.
- Finally, financing instruments should be easily accessible to consumers via a one-stop-shop where consumer can get advice on planning of heating system together with proper financing solutions, which can also include support measures.

These measures will be in line with the objectives stipulated by the EU Strategy for Energy System Integration to achieve a more circular system, which puts the "Energy Efficiency First" principle at the center of system integration.[102]

100 For example, minimising the water temperature in district heating and cooling systems to 400C where feasible and limiting the maximum temperature of in-house hydronic heating systems to 550C would allow several RE H&C technologies to compete with incumbent fossil-based H&C.
101 A major part of heating needs of manufacturing industry is for low- and medium-temperature heat and steam. Even a very low initial quota triggers manufacturing companies to start seriously considering utilisation of RE H&C technologies for part of their heating requirements.
102 European Commission (2020), 'Powering a climate-neutral economy: An EU Strategy for Energy System Integration', Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels, 8.7.2020 COM(2020) 299 final, p.5, 8

Figure 18 Intervention logic - Fostering global demand for renewable heating and cooling technologies



Source: CEPS (2021)

Assessing existing **public-private initiatives** in certain Member States that support consumers choice for RE H&C solutions in order to: i) launch dedicated alliances (e.g. Geothermal, Heat Pumps, and Solar Thermal Alliances) at EU level for wider replication in the EU and beyond; ii) identify and disseminate best practice to remove the financial barriers in installing RE H&C products and reduce the complexity in handling the RE H&C technologies for potential consumers at local level. Examples of such public-private initiatives include renewables-based district heating in Nordic countries, biorefineries that are self-sufficient in energy and provide electricity and heat to local industry and municipality,[103] and social housing renovation developing programmes, such as the Energiesprong.[104] The dissemination of the experience of relevant public-private initiatives could be in the form of a guiding document and/or a study on the topic to identify mechanisms that work well and could be replicated in several MS. Creating dedicated alliances, such as EU Renewable Heat Alliance (including heat pumps, solar thermal, geothermal heat) and EU District Heating and Cooling Alliance would be important to bring together various stakeholders and enhance H&C value chains. In this regard, the experience of European Battery Alliance[105] and recently established European Clean Hydrogen Alliance[106] are interesting examples.

Promoting consumers' awareness of available EU RE H&C products. In the EU, this measure could include consumer education (targeted education and training campaigns, knowledge proliferation platforms), energy labelling and quality assurance (standardisation and certification for H&C equipment and systems) to unlock the full potential of the EU domestic RE H&C market. This could help raise (perceptions of) the performance and reliability of emerging RE H&C technologies. In addition, consumers' awareness could be indirectly increased by providing specific training for installers, as they have a direct interaction and often a trust relation with consumers. Most of the RE H&C sectors face a scarcity of quality installers,[107] thus making the case for publicly supported training.

Organising information campaigns and guidance to third countries authorities to develop better policies for RE H&C on a global scale. The EU could share large experience in RE stimulation policies and measures with third countries, many of which are also facing the challenge to decarbonise their H&C sector and, therefore, can be interested in gaining insights on successful EU policy instruments. Regular exchanges between EU institutions, such as DG ENER of the EC, Member State RE policy implementation agencies, and counterpart public agencies in third countries could be organised to discuss the design and implementation of effective and cost-efficient instruments for the uptake of RE H&C, including EU experience in public-private initiatives. To foster global demand for RE H&C, EU-supported information

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103 Äänekoski bioproduct mill, Https://www.metsafibre.com/en/about-us/Production-units/Bioproduct-mill/Pages/default.aspx

104 These initiatives seek to speed up the phase-out of natural gas space heating in the existing building stock by using mass-produced prefab components. There are also initiatives in southern MS to support, among others, solar thermal heating and RE service companies (ESCOs). Among others, larger cooperation is also needed between municipalities and stakeholders (including local utilities, ESCOs, co-operatives) in DHS to ensure the implementation of integrated solutions between the source of heat supply, power supply and automated energy efficiency mechanisms in district heating networks.
Energiesprong projects are implemented in the Netherlands, France, Germany, Italy, and the UK. For further details, please see: https://www.energiesprong.uk/about

105 https://ec.europa.eu/growth/industry/policy/european-battery-alliance_en

106 https://ec.europa.eu/growth/industry/policy/european-clean-hydrogen-alliance_en

107 For example, lack of qualified technicians was stressed as one of the key barriers for wider installation of geothermal heat pumps by a representative of the geothermal association.

campaigns[108] could also promote EU RE H&C solutions in third countries. These campaigns could follow the good practice of the EU agriculture sector, where the Consumers, Health, Agriculture and Food Executive Agency (CHAFEA) arranges information campaigns on EU agricultural products worldwide.[109]

3.6.4 Impacts

The proposed solutions are expected to significantly improve the trade conditions and lower costs of EU RE technologies. However, the impact of the proposed solutions on increasing global market for EU companies will vary depending on several factors and RE H&C technologies. The impacts could be more significant for emerging RE H&C technologies that currently have a small share of the EU H&C market (such as the solar thermal heat, heat pumps and geothermal energy industries), while affecting to a lesser extend well-established RE H&C industries (i.e., bioenergy-based H&C systems). Overall, creating **a strong EU home market** is a key prerequisite for enhancing global competitiveness of RE H&C manufacturers.

Table 7 below is a summary of the stakeholder feedback on the impacts of the policy options on the competitiveness indicators. Most feedback has been related to the Objective as a whole, while the splits on policy options are based on more fragmented feedback. As a consequence, all impacts on GVA and employment were calculated for the Objective as a whole. The Total row at the bottom of the table shows the cumulative impact of the Objective on the competitiveness indicators, and will be recognizable from the majority of the stakeholder feedback.

Table 7 Objective 5: Effects from policies on competitiveness indicators

Policy option	Lower costs	Improved technologies	Improved trade conditions	Increased global market
1 (Assess and reform policies on RE H&C)	-	-	200%	43.2 - 96%
2 (Asses existing public-private innitiative)	-	-	-	14.4 - 32%
3 (Promote consumers' awareness)	-	-	-	14.4 - 32%
4 (Information campaign and guidance for third countries)	-	-	50%	-
Total	**-**	**-**	**250%**	**72 - 160%**

Source: COWI (2021)

The percentages shown in the table above refer to a change in the respective competitiveness indicator. For the indicator "Improved trade conditions", a positive percentage value refers to an increase in EU market share of the global market within a value chain or segment, i.e. a 50% increase in a market share of say 10% would result in a market share of 15%. For "Increased global market", a positive percentage value refers to an increase in the global demand within a value chain or segment. The

108 Such campaigns could be coordinated by a new dedicated EU export agency for RE technologies and services. The broader impacts of the creation of such an agency are analysed in another policy brief on "Supporting the export of RE technologies and services" that is part of the same EU's Global Leadership in Renewables project.

109 Similar campaigns for the H&C sector could include such tools as advertisement, social media promotion, press, online platforms, trade fairs, exhibitions, and events. For further details, please see: https://ec.europa.eu/chafea/agri/en/campaigns

percentages are all based on stakeholder feedback, and should not be interpreted as exact values.

Further discussion of impacts and estimates of the quantified impacts on GVA and employment are provided in sections 0.

3.7 Overall summary of policy options

The below table summarises the key areas of intervention of the seventeen policy options identified in this report. The 'areas of intervention' refer to the path through which the option in question takes effect. While few options focus on funding, the areas of intervention focus on the simplification or reform of regulations/administrative procedures or better diffusion of information and knowledge. In few cases policy options focus on better coordination of existing schemes or dealing with contextual factors.

Table 8 Main intervention areas of the identified possible policy options

Objective	Policy solution	Regulatory / admin. procedures	Funding	Coordination of existing schemes	Dealing with contextual factors	Diffusion of information/ knowledge
Improve access to finance for commercially ready RE projects	*Ensuring achievement of the EU 2030 RE target*	√			√	
	Better access to EU funding programmes		√	√		
	Establishing an IPCEI		√	√		
	Mobilising private funding	√				
Reduce administrative burdens of project permits	*EU guidance*	√				
	Cooperation mechanisms to reduce regulatory burdens	√				
	Central databases on impacts of RE	√				√
Bridge the funding gap between R&D and commercialisati on	*Innovation Fund*		√			
	EU risk insurance and guarantee fund		√			
	Sequencing and blending of different public funding			√		
Facilitate the export of EU RE technologies and services	*Facilitate deployment of RE technologies in third countries*		√		√	
	EU ECA	√	√		√	√
	Forum of national ECAs	√		√	√	√
	Standardisation	√			√	
Foster global demand for renewable H&C technologies	*Effective market stimulation policies in EU Member States*	√				√
	Foster public-private initiatives					√
	Promote consumer awareness					√
	Ensure regular exchanges with non-EU public RE agencies					√

Source: CEPS (2021)

3.8 Overview of impacts

Below, overviews are provided of the estimated impacts from addressing each of the five objectives. Further, in the last section a multi-criteria analysis considers the resulting impacts from all of the specific possible options that have been identified. Attention should be paid to the fact that while many options and objectives areas will be mutually supportive if combined, one cannot and should not add their individual impacts.

3.8.1 Impacts assessed qualitatively

Table 2 summarises the qualitative impact of the proposed solutions. Almost all the options have been ranked positively or very positively and no option was rated negatively in any of the proposed dimensions. All policy solutions will have significant impacts on the competitiveness of the EU RE industry in the four areas of competitiveness: lower costs, improved technologies, increased trade conditions and increased global market. In this context, project costs are primarily intended in terms of CAPEX (including financial costs) and OPEX.

Some areas of interventions will impact cost reduction more than others. Improving access to finance for commercially ready RE projects and reducing administrative burdens of project permits will have a negligible first order impact in terms of cost reduction or technology improvement. However, initiatives in these two areas can pave the way for more RE projects, thus allowing the EU RE industry to grow faster. As a second order effect, more projects would also help the EU RE industry reduce costs via both economies of scale and learning economies and better compete on a global scale. The impact on the economies of scale and costs in general was specifically indicated in the other three areas of intervention: bridging the funding gap between R&D and commercialisation, facilitating the export of EU RE technologies and services, and fostering global demand for renewable H&C technologies. In particular, improving trade conditions is expected to reduce costs and improve the competitiveness of the EU RE industry significantly. Direct impacts on improved technologies are obviously more evident for the area of bridging the funding gap between R&D and commercialisation.

The majority of areas will affect positively trade conditions and promote demand for RE solutions. Several stakeholders also mentioned that the policy solutions would affect positively the value chain, favouring the integration of sub-contractors. In particular, bridging the funding gap will contribute to the integration and development of SMEs, especially those promoting directly or indirectly innovation processes, and service providers (i.e. maintenance, etc.), with tangible impacts on local economies, even in countries that are not primarily involved in the manufacturing of the aforementioned technologies.

Table 9 Main types of impact

Policy objectives	Lower costs	Improved technologies	Improved trade conditions	Increased global market
Improve access to finance for commercially ready RE projects	++	+	+	++
Reduce administrative burdens of project permits	+	0	0	++
Bridge the funding gap between R&D and commercialisation	++	++	0	+
Facilitate the export of EU RE technologies and services	++	+	++	++
Foster global demand for renewable H&C technologies	++	+	++	++

Note: - - very negative; - negative; 0 neutral; + positive; ++ very positive.

Source: CEPS (2021)

While all the proposed policy solutions can contribute to fostering the competitiveness of the European RE industry, their impacts are expected to vary when it comes to effectiveness, efficiency, feasibility and coherence with existing EU and national rules.

Table 10 summarises the effectiveness, efficiency, feasibility and coherence of the policy options that have emerged during the interviews and desk research. Almost all the options have been ranked positively or very positively and no option was rated negatively in any of the proposed dimensions.

Table 10 Multi-criteria analysis of the proposed policy solutions

Objective	Policy solution	Effectiveness	Efficiency	Feasibility	Coherence
Improve access to finance for commercially ready RE projects	*Ensuring achievement of the EU 2030 RE target*	++	+	++	++
	Better access to EU funding programmes	+/++	++	0/+	+
	Establishing an IPCEI	+	0	+	+
	Mobilising private funding	+	+	+	+/++
Reduce administrative burdens of project permits	*EU guidance*	+	++	++	++
	Cooperation mechanisms to reduce regulatory burdens	++	+	+	++
	Central databases on impacts of RE	0	+	++	++
Bridge the funding gap between R&D and commercialisation	*Innovation Fund*	++	++	++	++
	EU risk insurance and guarantee fund	++	+	++	++
	Sequencing and blending of different public funding	+	+	++	+
Facilitate the export of EU RE technologies and services	*Facilitate deployment of RE technologies in third countries*	++	+	++	++
	EU ECA	++	+	0	++
	Forum of national ECAs	+	++	+	++
	Standardisation	+	++	+	++
Foster global demand for renewable H&C technologies	*Effective market stimulation policies in EU Member States*	++	+	+/0	+
	Foster public-private initiatives	+	++	++	+
	Promote consumer awareness	+	+	+	+
	Ensure regular exchanges with non-EU public RE agencies	+/0	++	++	+

Note: - - very negative; - negative; 0 neutral; + positive; ++ very positive.

Source: CEPS (2021)

3.8.2 Quantified impacts of options

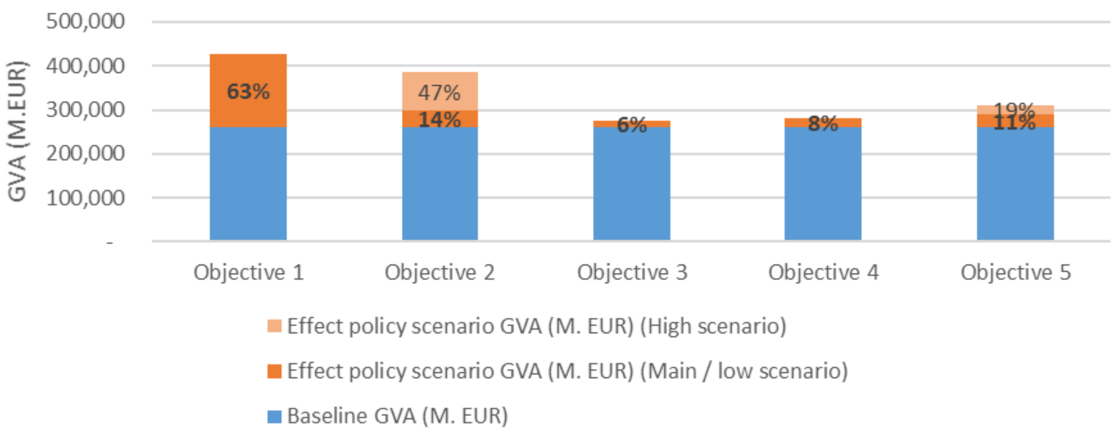
The proposed policy solutions are expected to have a substantial impact on jobs and GVA. An estimate of such impacts would help perform a more accurate cost-benefit analysis of any EU policy action in the field by allowing the proper measurement of societal benefits, beyond improvements in the competitiveness of the EU RE industry and the achievement of the EU 2030 climate and energy targets. Against this background, in the context of this project, an Excel Tool has been developed that allows for a rough estimation of impacts on growth and jobs of EU policies in the field of RE. For further details on this Excel Tool, see Chapter 4.

The results of these estimations are as follows:

- The proposed policy solutions to grant **better access to finance** is expected to generate substantial impacts on growth and jobs in the EU. Between 2021 and 2030, the proposed policy solutions to improve access to finance are expected to generate 900,000 additional jobs and EUR 165 billion gross value added.
- The proposed policy solutions to **improve the permitting process** are expected to generate 125,000 (lower-bound estimate) to 413,000 jobs (upper-bound estimate), and EUR 37 billion (lower-bound estimate) to EUR 124 billion (upper-bound estimate) GVA.
- The proposed policy solutions to **bridge the funding gaps between R&D and commercialization** of RE technologies are expected to generate 81,000 jobs and EUR 15 billion GVA.
- The proposed policy solutions to **facilitate the export of EU RE technologies** are expected to generate 70,000 jobs, and EUR 20 billion GVA.
- The proposed policy solutions to **foster EU demand for RE H&C** are expected to 364,000 (lower-bound estimate) to 631,000 jobs (upper-bound estimate), and EUR 29 billion (lower-bound estimate) to EUR 49 billion (upper-bound estimate) gross value added.

The impacts on GVA of the Objectives are summarized in Figure 19. The chart shows the total baseline for all the value chains in blue and the impact of the Objectives in orange. For Objectives 2 and 5, a low and a high scenario were defined. In these cases, the high scenario is shown as an additional impact in pale orange. The percentages show the increase in GVA over the baseline. Objective 1 is expected to have the greatest impact on GVA, followed by Objectives 2 and 5. Objectives that target a wide range of value chains will typically have a greater impact, as will Objectives that target high value value chains.

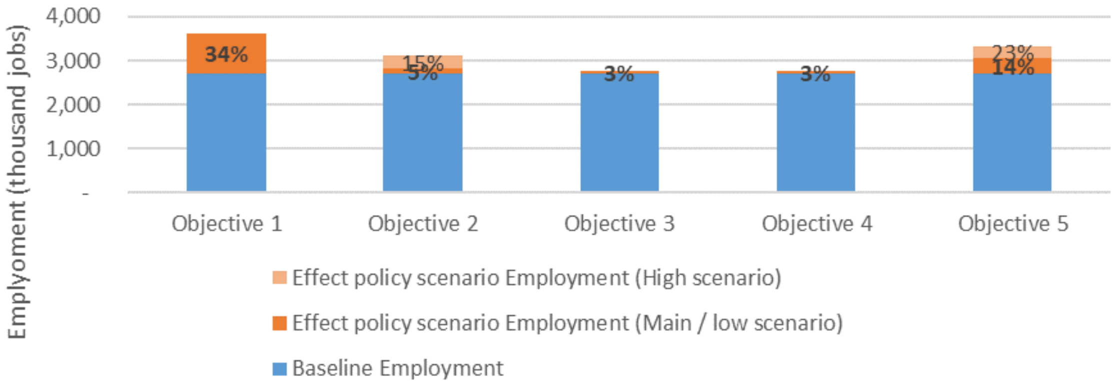
Figure 19 Comparison of Objectives based on GVA impact in 2030 (label indicates added effect of Objective in % of baseline value)



The impacts on employment of the Objectives are summarized in Figure 20. The chart is set up in the same manner as the previous on GVA. The impacts on employment relative to the baseline are lower than for GVA, but they follow the same pattern.

Objectives 1 and 5 are expected to have the greatest impact on employment, followed by Objective 2. The impacts are lower for employment than for GVA because the relationship between GDP growth and employment growth is not 1:1. In EU, a 1% increase in GDP typically leads to a 0.5% increase in employment, subject to significant differences between Member States.

Figure 20 Comparison of Objectives based on employment impact in 2030 (label indicates added effect of Obejctive in % of baseline value)



3.9 Conclusions

The five policy briefs present useful indications on policy design to improve the global competitiveness of the European RE industry. The extensive desk research exercise and consultation process allowed the identification of viable policy options, generally praised and shared by stakeholders. Industry representatives, associations and policy-makers estimate that the impact of the proposed measures would be major, sustaining the competitiveness of the whole industry and promoting jobs.

Policy intervention should go in several directions and cover different objectives. In this report, we identified five primary objectives. Most of the solutions presented in the different briefs and addressing these objectives are non-alternative and complement each other. The adoption of these policy solutions will have a tangible impact on the RE industry. However, as indicated in the Introduction, their cumulative impact will be lower than the sum of the impacts presented in each brief.

First of all, complicated, differentiated and often unpredictable access to finance impinge on the competitiveness of the EU RE industry in several MS. In this context, the EU should **timely intervene to reduce the existing barriers to accessing finance.** The EC should consider employing the available instruments for creating an enabling policy environment for RE investments and ensure the achievement of the EU 2030 RE target. It should create conditions for fostering private investments into RE technologies by rapidly adopting and progressively amending a Sustainable Finance framework. In addition, concrete measures to improving access to EU and national funding programmes should be considered. Special attention should be warranted for de-risking private investment in the RE sector and to the promotion of existing instruments, such as IPCEI.

Secondly, **Costly, slow and unpredictable permitting procedures for RE projects** impinge on the competitiveness of the EU RE industry in several MS. In this context, the EU should intervene to reduce the administrative burdens from project permits. The Commission should coordinate the **preparation of EU guidance** ensuring the proper transposition of certain articles under REDII and the Electricity Market Directive that affect the permit-granting process and grid connection. In addition, it should also experiment and introduce the so-called **'Renewable Deals'** allowing industry stakeholders, national and local permitting authorities, and the EC to cooperate in order to identify and remove unnecessary regulatory obstacles affecting the permitting process.

Thirdly, the **deployment of RE technologies is slow and hampered by the so-called 'valley of death'**. In this context, a better use of the Innovation Fund, the introduction of an EU risk mitigation instrument and improved public support would go in the right direction, alleviating the difficulties that new RE technologies face in the deployment stage and promoting diffusion. While the use of the Innovation Fund would just need better promotion, and eventually resources, the creation of a risk mitigation instrument should rely on a consultation process involving all relevant parties, including industry associations and the financial sector. Finally, the synergies of EU funding measures would require a consultation process involving DG ENER and other Commission services, Member States and relevant stakeholders to better integrate research funds with other funding programmes supporting the demonstration and deployment of RE technologies.

Fourthly, **export is key to securing global leadership in renewables an improving further RE competitiveness**. In this context, three main policy recommendations for the EC emerged. The Commission should investigate options to facilitate export of EU RE technologies to developing countries and investigate feasibility of harmonisation of the work of the national ECAs within the EU. Moreover, the Commission shall continue to promote further alignment of the standards internationally, initiate gap analysis, and keep the standards up with technological developments, and investigate further how to increase the EU RE export while mitigating market access barriers in third countries.

Finally, the EU should timely intervene to **foster demand for renewable solutions in H&C.** The Commission should improve the policy environment adopting measures to ensure a level playing field that would allow RE H&C technologies to compete with incumbent fossil-based solutions in line with with the objectives stipulated by the EU Strategy for Energy System Integration. The Commission could also conduct a study about public-private intakes to ensure a proper dissemination of the existing experience in renovation of the residential sector. A creation of several dedicated European Alliances similar to those created for batteries and hydrogen can provide additional steering capacities for stakeholders across the EU in order to strengthen RE H&C value chains. In addition, the Commission could also launch information campaigns about available RE H&C solutions to increase consumers' awareness, as well as facilitate the best practice transfer to third countries in order to disseminate advantages of RE H&C solutions.

4 An Excel Tool for assessing impacts on GVA and employment

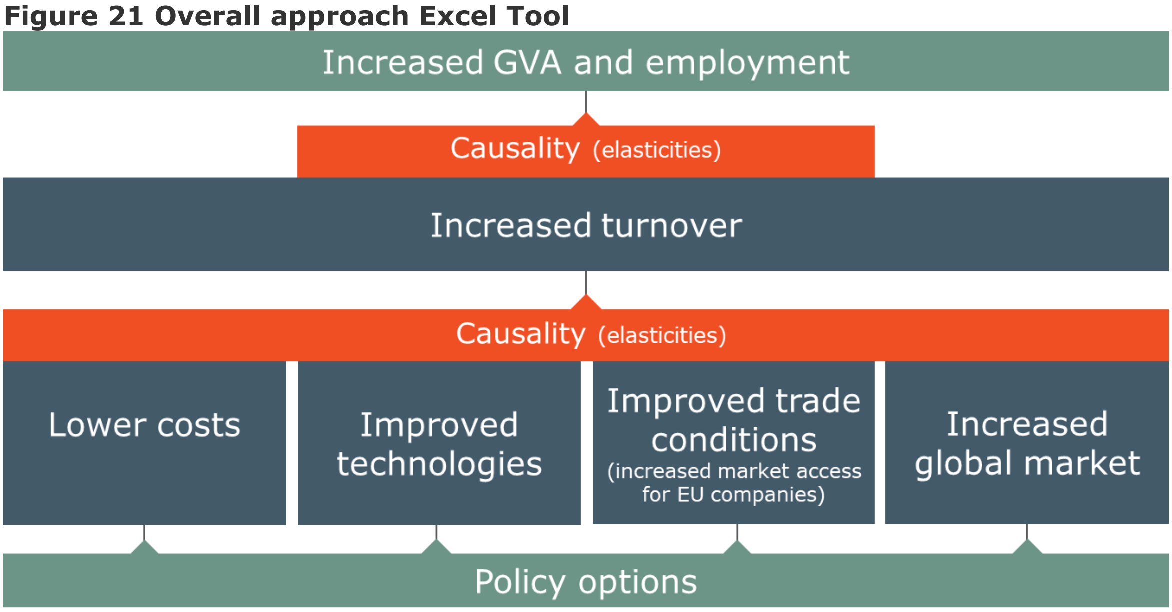
In the context of this study, an excel tool has been developed. The tool can be used to provide rough assessments of the impact of certain policies on EU GVA and EU employment. The tool has been used to produce the estimates presented in section 3.8.2. For further details on the methodology behind the tool and documentation of the assumptions made in the tool please refer to the Study Report on Work Package 3, Annex A.

The tool aims to facilitate quick and rough assessments of policies related to strengthening the EU leadership in renewable energy, specifically within the value chains defined in 2.1.

The Excel tool is built has a user-friendly interface in order for it to be relatively easy to insert new policies and calculate the effects on GVA and employment. Its primary aspiration is to enable a quick and rough estimation of long termed effects of policies to strengthen EUs leadership in renewable energy. The overall approach is illustrated below.

The model applies elasticities to identify the percentage change in GVA and employment that result from a percentage change in selected indicators. The resulting percentage change in GVA or employment is then applied to the baseline GVA and employment to derive the level of the change.

Figure 21 Overall approach Excel Tool



Source: *COWI (2020)*

GVA and employment has been determined for renewable energy value chains and segments in the value chain at a Member State level through the analytical work summarised in Chapter 2. Hence impact can be specified for a specific Member State, a specific value chain or even a specific value chain segment. The impact can also be summarized across all these dimensions for an estimate of the total impact to the EU economy.

Returning to the illustration in Figure 22, inputs flow from the bottom towards the top. First, the impacts of a specific policy on one or several of the bottom dark blue indicators are specified. These impacts are external to the model, and need therefore to be defined outside of it, e.g. informed by evidence from interviews of relevant stakeholders and/or consultations of sources. The four dark blue indicators in the bottom dark blue row are basic indicators of competitiveness (simply dubbed Competitiveness Indicators). The logic of the tool is such that an improvement in any one of these indicators will increase the competitiveness the industry.

- Lower costs will allow a company to gain market shares, increase earnings or both.
- Improved technologies will allow the company to differentiate their product, change higher prices or gain market shares.
- Improved trade conditions will improve EU exports and thereby strengthen EU market shares.
- An increased global market will increase the turnover of EU companies, given constant market shares

Inherent in the analysis of policy options outside of the model is thus a specification of the expected percentage changes in one or more of the four competitiveness indicators.

Having established the expected relative changes for the above four competitiveness indicators, the tool can multiply those by the elasticities thus converting the change in competition indicator into a percentage change of turnover. These *intermediate elasticities* are differentiated by segments only (e.g. manufacturing, R&D etc..). Thus, they do not differentiate between Member States or value chains. The tool does not make use of absolute numbers of indicators or of turnover; it only considers the relative changes.

Figure 22 Intermediate elasticities

Source: COWI (2020)

The next step is then to transform the percentage change in turnover into a percentage change in GVA and employment. To that end, another set of *final elasticities* is applied (Figure 23). These elasticities a differentiated by Member State based on a coherent source of estimates for the employment elasticity of economic growth.

Figure 23 Final elasticities

Source: COWI (2020)

The result of applying the final elasticities is an estimate of the percentage change in GVA and employment within each value chain; each value chain segment; and for each Member State.

Based on consultations of stakeholders and experts, the impact from the policy options on each of the four indicators of competitiveness were assessed. In the impacts section for each policy objective (section 3.2.4, 3.3.4, 3.4.4, 3.5.4 and 3.6.4) a table is provided that summarises the estimated effects on the competitiveness indicators. These estimates constitute a key input to the model. All policy options within a specific Objective are analysed together as the feedback from stakeholders was often not granular enough to fully distinguish each policy option within an Objective.

1.1 ANNEX A

EU's Global Leadership in Renewables

Case study on green hydrogen

March 2021

Table of Contents

1 Introduction

Green hydrogen is a fuel produced with the electrolysis of water through an electrolyser powered by electricity stemming from renewable sources. Hydrogen can be used as a feedstock, a fuel, or an energy carrier and storage, and has many applications across industry, transport, power and buildings sectors.

The production of hydrogen via electrolysis with direct connection to a renewable energy source avoids a number of electricity cost items such as network costs and taxes. However, it also limits the electrolyser capacity to the capacity of the renewable energy source. Another path to the lower costs is to build hydrogen close to the renewable resources (e.g. for southern European countries to focus on synergies with solar PV and for the northern European countries to focus on onshore and offshore wind[1]).

In July 2020, the European Commission published its hydrogen strategy for a climate-neutral Europe. The strategy highlights clean hydrogen and its value chain as one of the essential areas to unlock investment to foster sustainable growth and jobs[2]. The EU hydrogen strategy sets the objectives to install at least 6 GW of renewable hydrogen electrolysers by 2024 and at least 40 GW of green hydrogen electrolysers by 2030.

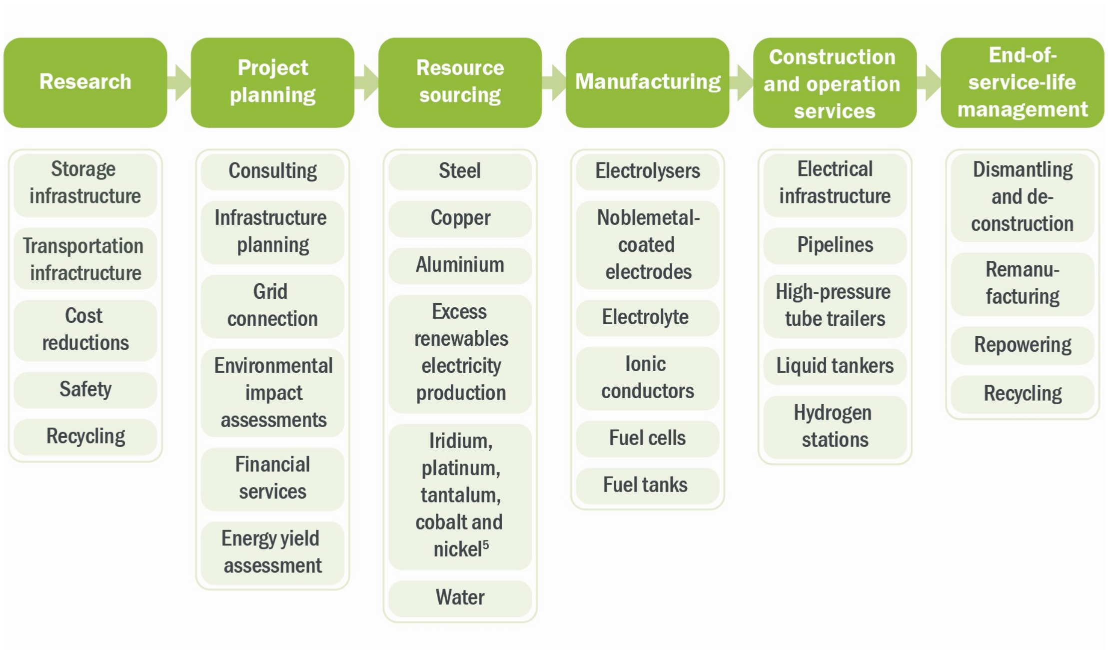
Today about 1GW of electrolysers are deployed in the EU. Hydrogen could provide up to 24% of total energy demand (or up to ~2,250 TWh) in the EU by 2050, thus enabling large-scale renewables integration and decarbonization of end uses. However, it needs to achieve a larger scale and its production must become fully decarbonised. In areas where renewable electricity is low-priced, electrolysers are anticipated to compete with fossil-based hydrogen by 2030[3].

Projects wise, the total planned capacity of green hydrogen in Europe is 20,011 MW of electrolyser deployed power by 2040 (106 projects) with an additional 1,278 MW (45 projects) with no specified start date. For 2030, the number of clean hydrogen projects with a defined start date amounts to 101, which together amount to 9,101 MW by 2030. In the medium term, there are 79 planned projects amounting to 2,131 MW by 2024[4].

[1] HydrogenEurope - Clean Hydrogen Monitor (2020)
[2] European commission - A hydrogen strategy for a climate-neutral Europe (2020)
[3] European Commission - A Hydrogen Strategy (2020)
[4] HydrogenEurope - Clean Hydrogen Monitor (2020)

2 Value chain

An overview of the green hydrogen value chain is presented below.



Source: COWI's elaboration based on desk research

- **Research** has a particularly important role to play in contributing to further cost reductions. For example, the high cost of platinum catalysts used in hydrogen fuel cells limits the commercialization of fuel cell electric vehicles. Scientists therefore look into alternative catalysts to increase cost-effectiveness and maintain the efficiency of hydrogen fuel cells. Another relevant research area lowering the levels of hazards and risks compared to conventional fuel technologies[5]. The EU has a strong research community supported also by Hydrogen Europe, which comprises of over 92 companies and conducts research within road transport and energy.
- In terms of **project planning** activities with the hydrogen economy set to boom in the next few years across the globe, Europe is emerging as the clear leader in planned installations and government policy supporting the sector. Europe represents about half of the global planned capacity for electrolysis hydrogen production with significant planned investments in the Netherlands, France, Germany, Italy, Portugal, Spain, Denmark, and Sweden.
- **Resource souring** for hydrogen manufacturing is a challenge for Europe. Expanding the technology renders Europe dependent on the availability of 19 (out of 29) rare raw materials required for fuel cells and electrolyser technologies (as the platinum group metals) and is also dependent on several critical raw materials for various renewable power generation technologies.
- In terms of **manufacturing**, Europe could be considered a global leader due to its technology advantage based on strong research foundations. For example, there are over 100 European companies which plan to expand their production capacities for water electrolysis to make green hydrogen. However, competition from China is increasing in a similar way as with Solar PV in the 2000s. While European

[5] JRC, State of the art and research priorities in hydrogen safety (2014)

manufacturers clearly lead the way when it comes to efficiency, scalability and flexibility, Chinese competitors use simpler technologies leading to cost advantages. Chinese electrolyser manufacturers have not significantly entered European competition as they mostly sell domestically and to markets other than Western Europe, Australia, and the U.S.

- **Construction and operation** services relate to the construction of hydrogen production, storage, and distribution assets. The production is done via an electrolysis, renewable liquid (e.g. ethanol reacted with high-temperature steam), or reforming or fermentation (e.g. of biomass converted to sugar rich feed stocks). The distribution and storage assets include pipelines, high pressure tubes, and liquefied hydrogen tankers. The European industry has built up significant experience with already more than 1500 km of dedicated hydrogen pipelines in place ensuring the safe operation of hydrogen production, transport, and storage.
- In terms of **end-of-service-life management** there are very few examples of viable and upscaled technologies for the recovery and recycling of critical raw materials from fuel cells and electrolysers. European companies are currently conducting EU financed research on recycling of proton exchange membrane fuel cells (PEMFCs) and solid oxide fuel cells (SOFCs). Polymers and platinum group metals are among the materials in PEMFCs, while SOFCs can contain rare earth metals, such as lanthanum and strontium, plus zirconia and some nickel.

3 Impacts

Cumulative investments in green hydrogen in Europe could be up to €180-470 billion by 2050, and in the range of €3-18 billion for low-carbon fossil-based hydrogen. Combined with EU's leadership in renewables technologies, the emergence of a hydrogen value chain serving a multitude of industrial sectors and other end uses could employ up to 1 million people, directly and indirectly. Clean hydrogen could meet 24% of world energy demand by 2050, with annual sales in the range of €630 billion[6].

4 Funding

In terms of investments, in the period between November 2019 and March 2020, the number of planned global investments in electrolysers by 2030 doubled, and 57% of those are European. The investments required to reach the European 2030 target of 40GW target amount to between EUR 80 and 90 billion[7]. These investment needs relate to production and to infrastructure and storage, as well as to hydrogen applications. Investments of this scale could kick start the EU manufacturing industry in clean hydrogen.

The European Commission has committed to follow up on the recommendations identified in a report by the Strategic Forum for Important Projects of Common European Interest (IPCEI) to promote well-coordinated or joint investments and actions across several Member States aimed at supporting a hydrogen supply chain. Furthermore, as part of Next Generation EU, the InvestEU programme will support the deployment of hydrogen by incentivising private investment. In addition, the European Regional Development Fund, the Cohesion Fund, as well as the Just Transition Mechanism will continue to be available for green hydrogen projects.

Dedicated infrastructure for hydrogen, repurposing of gas networks, carbon capture projects, and hydrogen refuelling stations can be financed via the Connecting Europe Facility for Energy and the Connecting Europe Facility for Transport. Finally, EU ETS Innovation Fund can facilitate first-of-a-kind demonstration of innovative hydrogen-based technologies.

[6] Questions and answers: A Hydrogen Strategy for a climate neutral Europe (2020)
[7] Hydrogen Europe - Green Hydrogen Recovery Report (2020)

5 SWOT

An overview of the key strengths, weaknesses, opportunities, and threats related to the EU's global leadership within green hydrogen value chains is presented below.

Source: COWI's elaboration based on desk research and interviews with Hydrogen Europe, Ørsted

6 EU's Global Leadership

Europe currently has a strong global position in clean hydrogen technologies manufacturing and could benefit from the increasing global demand of clean hydrogen. This leadership position was established through a first-mover advantage, technology knowledge and ownership of patents, abundance of renewable energy generation, as well as transmission system capacity able to integrate large quantities of renewables. However, if the EU fails to act now to capitalize on its unique advantages and strong international brands, it could fall behind Asian competition, putting at risk considerable market potential and future jobs.

The EU along with other public and private actors have, for many years supported research and innovation in hydrogen, thus contributing to establishing an EU leadership position for technologies such as electrolysers, large fuel cells and hydrogen refuelling stations. Europe has demonstrated global leadership in high temperature Solid Oxide (SO) electrolysis and low temperature Proton exchange Membrane (PEM) and has published twice as many publications compared as the US. However, Asian competitors have issued more hydrogen and fuel cell patents than European countries. China, South Korea, and Japan thus hold more that 55% of fuel cells patent and 65% of all hydrogen-related patent. By comparison, Europe holds 16% of total patents.

European companies are well positioned to maintain and further develop their global leadership position within green hydrogen, although there is strong competition from Asia and North America. For example, European companies and researchers are today world class in many of the technologies that are needed for fuel cell and hydrogen applications.

In the future, Europe will also benefit from its extensive natural gas infrastructure: A key asset in the up scaling of the technology. The current gas network can store up to 4,400 TWh of energy. Additionally, the EU has a well-established gas sector that employs more than 500,000 people which can support the hydrogen transition.

1.2 ANNEX A

EU's Global Leadership in Renewables

Case study on Renewable Building Integrated Photovoltaics (BIPV)

March 2021

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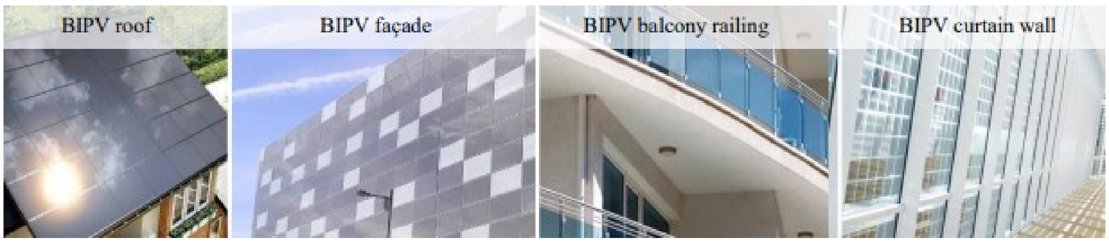
1 Introduction

Building-integrated photovoltaics (BIPV) are electricity generating materials that are used to replace conventional building materials[1]. BIPV form an integral part of a building design and structure. As a building material, BIPV provides several buildings envelop functions, such as water proofing, sun protection, thermal insulation, noise protection, daylight illumination, and/or safety. It has three main applications: roofs (including for example tiles, skylights); facades (e.g. curtain walls, windows); and externally integrates systems (e.g. balcony railings, shading systems)[2].



Source: CanmetENERGY, Natural Resources Canada, Factsheet: Building-Integrated Photovoltaics (BIPV)

The two main PV technologies used in BIPV are crystalline silicon (cSi) and thin film. Most of the roof applications use crystalline silicon technology. There are several reasons for the dominance of cSi in the roof applications. CSi technologies tend to be cheaper, more efficient, and easier to use when the BIPV system is coupled with regular PV modules (which are also typically based on cSi). In general, the performance (in terms of power production) of BIPV technologies varies depending on the design. As the roof is not that visible and because the area that can be covered is smaller than in the case of a façade, the design of technology does not play an important role to architects, and performance is the primary concern of project developers[3].

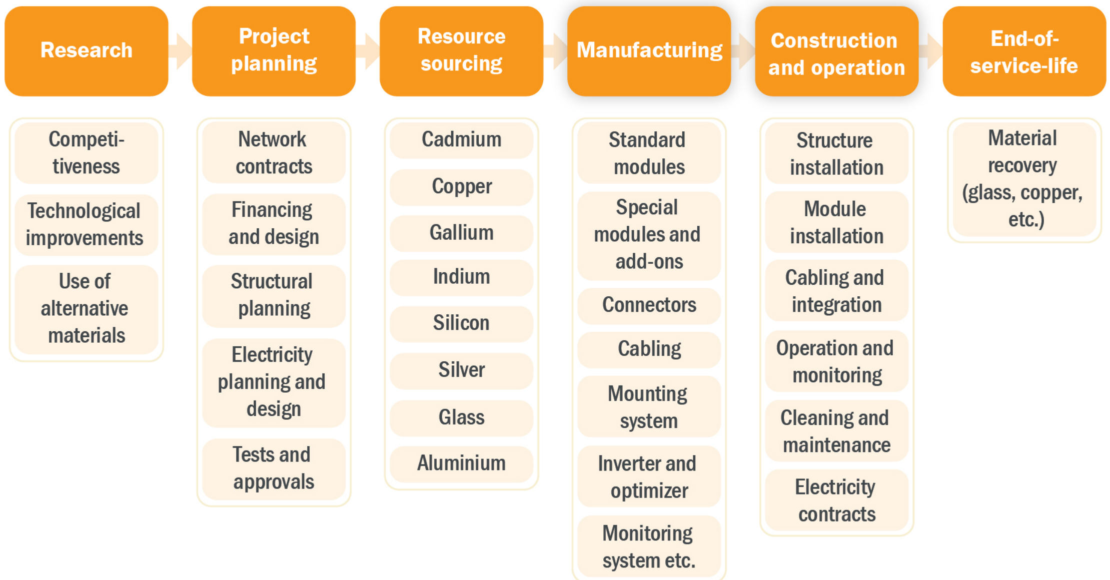
In façade applications however the use of both technologies (cSi and thin film) is more evenly distributed (44% crystalline silicon and 56% thin film technologies). The advantages of thin film technologies include aesthetics, transparency, flexibility in shape and size, and lower sensitivity to non-optimal orientation. In addition, thin film applications tend to be lighter than cSi systems, and they are more efficient in cases where there is no possibility to install ventilation (e.g. in the case of curtain walls)[4]. As a facade is more visible compared to a roof, the design is the main concern of architects, while performance tends to be a secondary concern when opting for thin film technology. Furthermore, as facade typically covers a larger area than the roof, part of the efficiency losses can be covered by the larger volume.

While PV price reduction[5], increased efficiency, improved aesthetics, and the increased policy focus on renewable energy contributed to the deployment of the BIPV technologies, there are still number of challenges to overcome for further roll out of the BIPV technologies. These challenges relate to: lack of harmonised and BIPV specific standardisation, complex installation process, the risk perception and awareness of BIPV among the public and construction sector, customized demand, a lack of collaboration between stakeholders, an inappropriate and unstable regulatory framework. Overcoming those challenges would contribute significantly to the further market uptake of BIPV.

2 Value chain

An overview of the BIPV value chain is presented below[6].

[2] CanmetENERGY, Natural Resources Canada, Factsheet: Building-Integrated Photovoltaics (BIPV)
[3] BPIVboost, Update on BIPV market and stakeholders analysis, 2018
[4] BPIVboost, Update on BIPV market and stakeholders analysis, 2018
[5] CSi cell prices halved from 2015 to 2019.
[6] BPIVboost, Update on BIPV market and stakeholders analysis, 2018 and



Source: COWI's elaboration based on desk research

The BIPV value chain is different from the Solar PV value chain. The core BIPV value chain is complex, with high number of stakeholders providing partial solutions. Stakeholders that are part of the BIPV sector can be grouped into three categories: primary stakeholders (core businesses), secondary stakeholders (extended enterprises) and tertiary stakeholders (business ecosystem).

- The primary stakeholders are active in the main activities of the BIPV sector. This group thus includes BIPV suppliers and manufacturers (for example Akuo Energy, Armor Group, ONYX), end users (housing associations, private homeowners, business rental, facility managers, recycling companies). To some extent, the group also includes contractors and architects (decisive power and responsibilities of contractors and architects vary across countries).
- Among secondary stakeholders belong key partners, without whom the operations would not be possible. This group includes suppliers of building materials, PV module instalment, wholesale (for example 4BestSolar, Photovoltaique Grossiste, Energetik Solartechno-logie Vertriebs) and to some extend consultancy (such as German Sustainable Building Council).
- The tertiary stakeholders are all other stakeholders, such as governmental and research institutions. Each of the tertiary stakeholders have their own role to play in the value chain. Universities (such as Utrecht University) and research institutes, for example, have a good technical knowledge, conduct independent research, and provide education to the future BIPV professionals.

The value chain segments are further described below:

- **Research** – BIPV is an innovative technology that receives increased attention in the EU in recent years. However, BIPV research and innovation projects as well as BIPV regulation could be observed in EU Member States already in the years 2010-2015: in Italy and France[7]. Italy and France are now among largest BIPV markets in terms of

H. Gholami at al, Lifecycle cost analysis (LCCA) of tailor-made building integrated photovoltaics (BIPV) façade: Solsmaragden case study in Norway, 2020

[7] BPIVboost, Update on BIPV market and stakeholders analysis, 2018

installed capacity. The EU dedicated significant amount of research funds to BIPV, namely analysing the competitiveness of the technology.

- **Resource sourcing** – In terms of raw materials, there is large variety of materials needed for the different BIPV solutions. Each material has its own advantages and disadvantages. For example, Cadmium is highly hazardous and rather scarce. However, it has transparency potential and good aesthetics. BIPV thin film technologies rely on scarce raw materials (for example Indium, Gallium), which are not extracted in the EU. Similarly, technologies using cSi (such as Auko´s solar tile[8]) rely on imports of the PV component from China. However, in parallel, new technologies using alternative sources are being developed. For example, organic BIPV (highly innovative thin-film technology) is based on polymers. These are not produced industrially but are made in labs. According to an interview with Armor Group (a manufacturer of organic BIPV), 98% of the raw materials come from the EU.
- **Project planning** – Project planning starts with project design, network contracts and project financing. This phase involves distribution system operators (DSO), investors and banks, and architects. The next phase is the system planning. This phase includes structural planning, electricity planning, design, and tests and approvals. These activities involve construction engineers, architects, certification companies and experts on BIPV and construction aspects.
- **Manufacturing** – Once the planning phase is completed, product configuration starts. The product configuration is performed by BIPV module manufacturers, mounting system providers and balance of system (BoS) providers. The EU companies are among global leaders in automatization for industrialisation. This knowhow could facilitate possible mass production of BIPV, should the demand become more unified. Next to the challenges related to the upscaling of the production, the manufacturing segment also faces the risk of IP theft.
- **Construction and operation** – The system installation can be grouped around three areas: structure installation, module installation and cabling. This is usually performed by BIPV installers and electricians. System management and maintenance is performed by dedicated companies. Electricity contracts are managed by DSO and utilities.
- **End of service life** – Recovering cell materials (i.e. silicon, glass, aluminium, silver) is complex and requires various methods, including mechanical, thermal, and chemical[9]. Toxicity of some of the raw materials (i.e. Cadmium, Indium) could cause obstacle to the recycling processes[10].

Development of integrator companies (companies who would be able to provide a full solution), and upscaling of BIPV technology production would have the highest potential in terms of socio-economic benefits, including job creation and GVA generation[11]. Even though there are examples of companies that already started a large-scale production in the EU, most existing installations were customised to the client's requirements thus adding to the costs.

3 Impacts

Overall, BIPV is a niche and innovative market with different technologies and applications. There is not one common definition of BIPV or one common methodology for calculating its energy production. Estimating the market size is therefore not an easy exercise. Literature reviews[12] and interviews[13] conducted revealed different numbers related to the market size. The

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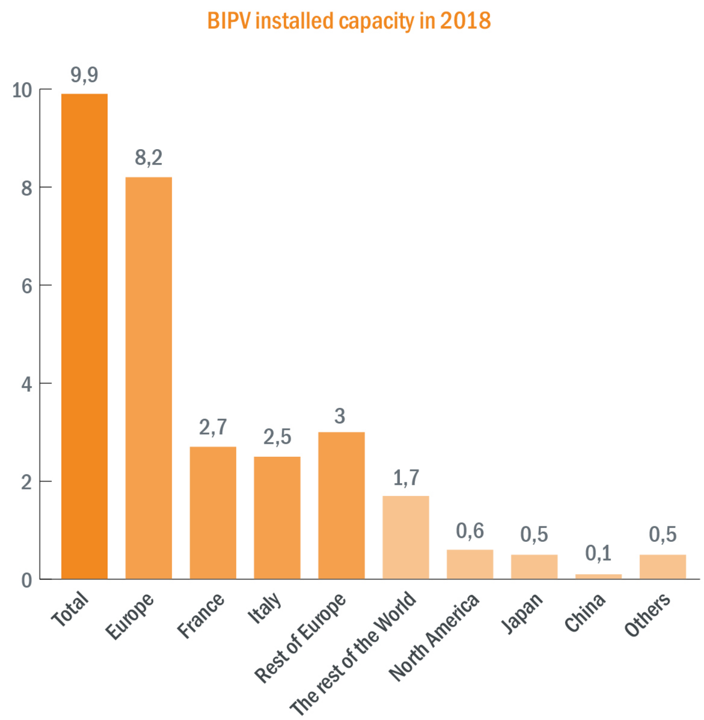
[8] Interview with Akuo energy, its BIPV product is called Sunstyle
[9] Recycling-And-Recovery-Of-Building-Integrated-Solar-Pv-And-Thermal-Energy-Systems.pdf (ijstr.org)
[10] BPIVboost, Update on BIPV market and stakeholders analysis, 2018
[11] Interviews with Solar Power Europe and Armor group.
[12] Including: BPIVboost, Update on BIPV market and stakeholders analysis, 2018 and Report Linker, Global Building Integrated Photovoltaics, 2020
[13] Solar Power Europe, Akuo Energy and Armor Group

numbers presented in the recent EU funded BIPVboost study[14] are presented in the figure below.



Source: BIPVboost

Recent predictions[15] suggest that the global BPIV market will grow by 17.8% annually in period 2020-2027. The increase is expected in all key BIPV markets, including EU, US, and China. In Europe, the most conservative estimates[16] suggest that estimated cumulative potential of Belgium, France, Germany, Italy, Netherlands, Spain, and Switzerland is approximately 290 GW. In Germany alone, the potential is up to 81 GW.

4 Funding

EU public funding has been made available to number of BIPV related research projects (see the table below). As seen, a number of interesting projects are still ongoing. This includes projects directly targeting improvements of competitiveness of the BIPV technologies (for example BIPVboost).

[14] BPIVboost, Update on BIPV market and stakeholders analysis, 2018
[15] Report Linker, Global Building Integrated Photovoltaics, 2020
[16] BPIVboost, Update on BIPV market and stakeholders analysis, 2018

Name	Description	Status	Fund	Link
BIPVBoost	The main aim of the project is cost competitiveness of the BIPV systems by implementation of cost reduction roadmaps and development of highly efficiency and multifunctional energy producing construction materials	Ongoing	Horizon 2020	Home – BIVP Boost
Tech4Win	Development of a highly innovative transparent photovoltaic window	Ongoing	Horizon 2020	About – Tech 4 Win
COMCO	Development of a new lightweight, aesthetic, and flexible shape design product, based on transparent fibre composite material, cSi and functional coating.	Ongoing	Eurostar, European Commission	Comco (onyxsolar.com)
ESPResSO	The project will bring forward technological solutions targeting cell efficiency, stability, and module process upscaling.	Ongoing	Horizon 2020	HOME (espresso-h2020.eu)
PVSITES	The aim is to trigger greater market mobilization of BIPV trough demonstration of portfolio of different technologies.	Ongoing	Horizon 2020	Onyx Solar
ADVANCED BIPV	The aim is to increase the competitiveness of the BIPV by developing new generation of PV glazing	Completed	Horizon 2020	ADVANCEDBIPV – New Generation pf BIPV glass with advanced integration properties

Source: Onyx Solar[17]

Interviews[18] with stakeholders identified several funding challenges that BIPV companies experience, including:

- Calls tend to be too large and not targeted to BIPV. For SMEs that operate in the BIPV market, engaging into such calls is perceived to be too risky due to the costs involved, and the risk of an unsuccessful outcome.
- There is lack of funding available for small-medium scale demonstration projects.

When it comes to the national support schemes, there are not many EU Member States that provide targeted support for BIPV. Currently only Austria offers BIPV specific subsidies[19].

[17] Onyx Solar: Research Projects
[18] Solar Power Europe, Akuo Energy and Armor Group
[19] € 375 per kWp for building integrated installations for maximally 5 kWp, RES legal

5 SWOT

An overview of the key strengths, weaknesses, opportunities, and threats related to the EU's global leadership within BIPV value chains is presented below.

Source: COWI based on desk research and interviews[20]

6 EU's Global Leadership

With continuous cost reduction, innovation and nearly zero energy buildings (nZEB) requirements, BIPV is increasingly becoming an attractive technology. The global BIPV market (accounting for approximately only 1% of the total PV market) is currently dominated by European companies[21]. The EU is leading not only in terms of deployment, but also in terms of technology development.

BIPV is a building material with return on investment, as it produces onsite energy. Due to its features (such as energy generation and aesthetics) it is also of relevance in densely populated areas. However, BIPV is more expensive than other non-active building materials. For example, the end user price of BIPV in roof applications is in the range of 50-250 EUR/m², whereas in case of non-active building components (such as tiles or metal sheets) the price range is 12-100 EUR/m². When examining competitiveness from a holistic point of view, thus taking into consideration the entire lifetime of the investment and the energy generated, there are cases in

[20] SWOT analysis is mainly based on the analysis done under BIPVboost project. The study findings were complemented interview with European Association (Solar Power Europe), who provided answers on behalf of their members , Akuo Energy and Armour Group. BPIVboost, Update on BIPV market and stakeholders analysis, 2018

[21] As opposed to the traditional PV modules manufacturing where China currently has a dominance.

which BIPV is cost competitive: this would depend on the retail electricity prices and existing support schemes[22] in the specific case.

The EU is strong in several areas of the BIPV value chain, including research and innovation, construction material for building envelope, and industrial equipment. However, there are also several challenges to the further deployment of BIPV that need further attention. These challenges relate to the BIPV technology itself (such as technical issues, flexible choice of substrate materials, aesthetics of some solutions) and aspects related to the market (for example collaboration in the value chain, cross-sectoral collaboration, unifying demand)[23]. One notable challenge is that building codes are different in different countries (also within the EU): if a product is certified in one EU Member State, it does not necessarily imply that the same product can be used in another EU Member States. In that case, compliance with another, local, certification would be needed. The fragmentation of the requirements and related building codes across the EU thus constitute a challenge for BIPV producers to upscale their production and access a larger market within the EU

Even though the EU is currently a global market leader, it is worth noting that the market is niche and some of the main competitors are not fully invested in this sector yet (e.g. China and US[24]). China has the capacity and the industrial power to quickly upscale their BIPV production. This is not least due to their strength in solar PV manufacturing[25]. Therefore, there is a need for a continued development of the sector to maintain and to build on the EU's current BIPV competitive advantage.

[22] BIPVboost, Cost competitiveness status of BIPV solutions, 2018, see: cost-competitiveness-status-of-bipv-solutions-in-e.pdf

[23] F. Osseweijer at al., A comparative review of building integrated photovoltaics ecosystems in selected European countries, 2018

[24] In the US, a main competitor is Tesla, which is most popular with it electic vehicles. In 2019, they launched Solar Roof V3 product, which was 40% cheaper than the previous version of the product . In 2020, they announced intention to enter with this product to the EU market . However, it is worth noting that even year later, the product did not enter the EU market. As compared to its main competing product in the EU, Sunstyle, Tesla´s tiles are smaller. This means that there are more connections needed to install the product. More connections imply higher installation, maintenance and insurance costs, therefore the Sunstyle would be in this case still cost competitive

[25] Interviews with Akuo Energy, Armor Group and Solar Power Europe

1.3 ANNEX A

EU’s Global Leadership in Renewables

Case study on floating offshore wind

March 2021

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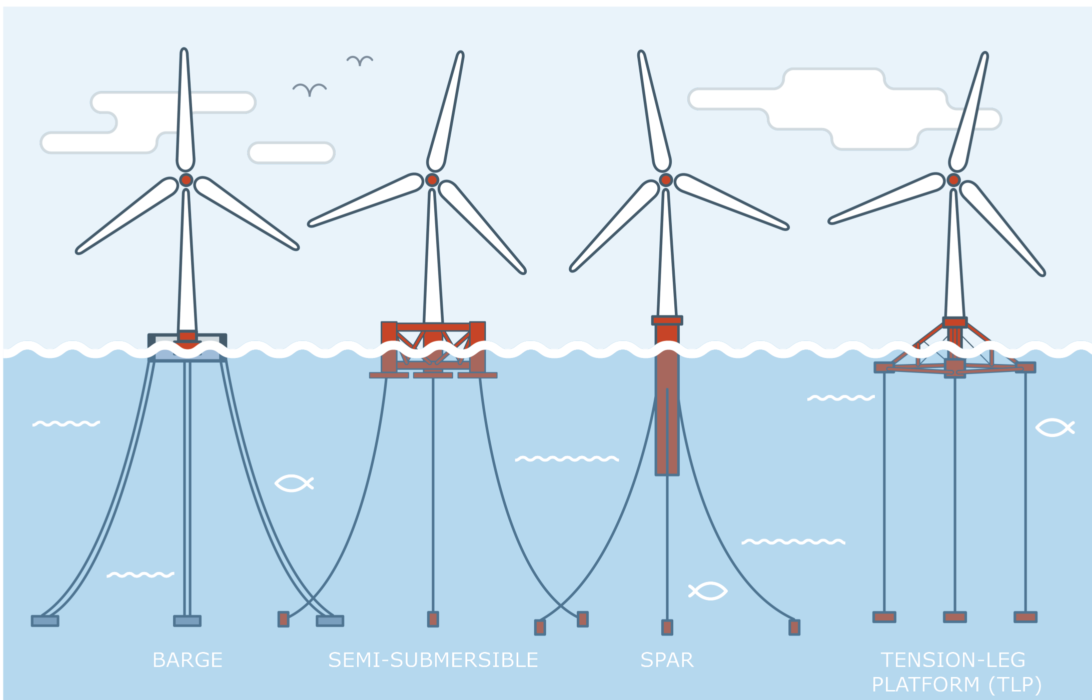
1 Introduction

Europe has up to 7 GW potential by 2030, and up to 150 GW by 2050, for deploying floating offshore wind (FOW) sites in the Northern Seas, the Atlantic, the Mediterranean and Black Sea. Up to a third of all offshore wind installations could be floating by 2050[1] [2]. As of 2020, the 62 MW of installed floating wind capacity in Europe still represent a small share in total offshore installations.

FOW is an alternative to classical ground or shallow water wind turbines. Thanks to floating devices, the wind turbines can be mounted on water freeing land or near shore space and take advantage of deep-sea areas with higher wind speed resources. With over 60 meters of depth, all wind turbines are typically floating. There four main types of floating devices including barges, semi-submersible, spar buoy, and tension-leg platforms.

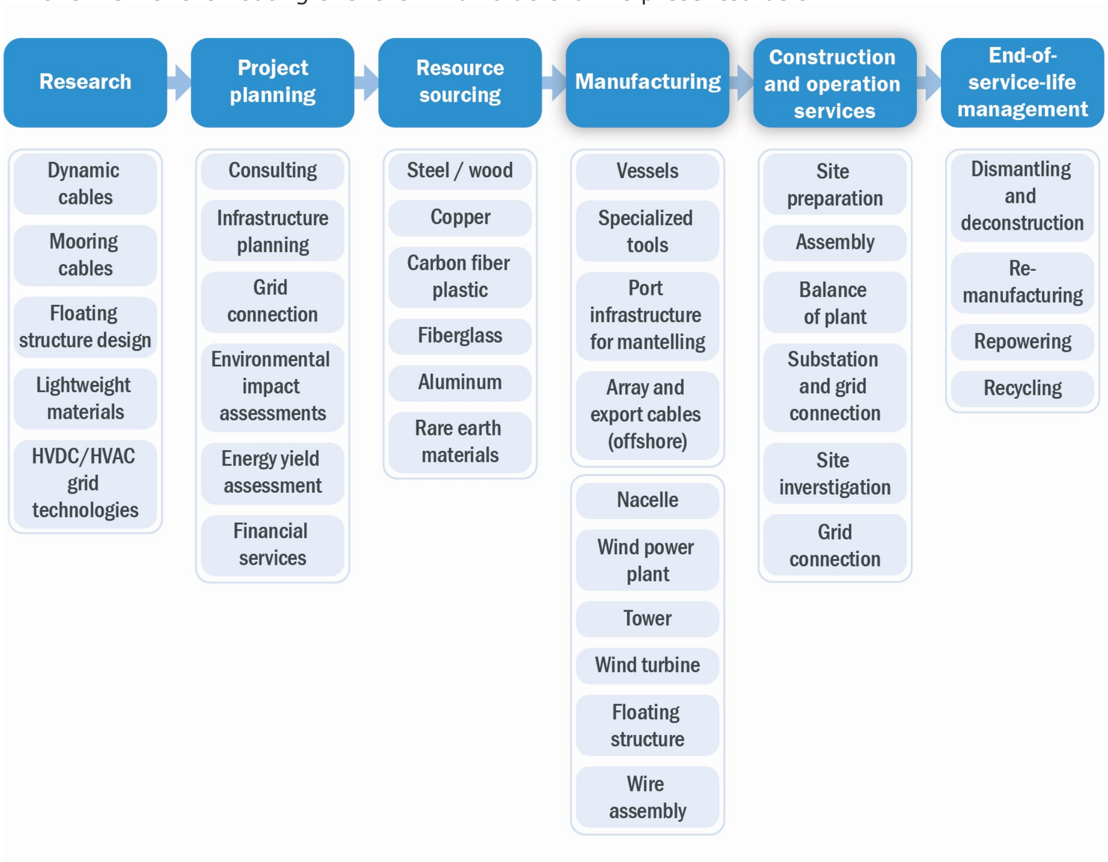


Source : COWI (2021)

[1] Wind Europe - Floating offshore wind is gearing up for take-off (2020)
[2] Wind Europe - Floating offshore wind energy (2020)

2 Value chain

An overview of the floating offshore wind value chain is presented below.



Source: COWI's elaboration, based desk research

Two-thirds of the bottom-fixed offshore wind value chain can be shared with the FOW. This applies for example to manufacturing of turbines, array and export cables, regulations, ports and infrastructures and operations & maintenance. Floating turbines are often assembled at the ports and towed out into the sea afterwards. The technology differs from bottom fixed wind turbines mainly in the components related to the floating structure. Since the turbines and the floating structures are assembled at port, more infrastructure is needed.

- The **research activities** are different from the bottom fixed technology and often cover the type of floating wind turbines e.g. spar-buoy type, tension-leg platform (TLP) type, semi-submersible type (column stabilised), pontoon-type (barge-type). In addition, research is conducted around end-of-service life management, as well as alternative lightweight materials to help lower tower weight. While today FOW only represents less than 1% of all offshore wind in Europe, the region is a global leader in the technology owning 34 out of 50 designs globally and accounting for 62MW of the current 74MW installed globally. EU research and innovation aims to lower costs and increase the performance and reliability of floating offshore wind energy technology.

- The **project planning** activities are similar to the bottom fixed segment and include site screening, wind speed measurement, geotechnical analysis, environmental impact assessment and others which are similar to the offshore wind sector. One difference is that the technology does not have the same limitations in terms of sea level depth.

- The **resource sourcing** requires the highest quality materials, as the technology lifetime is expected to be 20-25 years. Most manufacturers prefer steel (80%) over concrete, as steel offers faster assembly options with the ability to pre-fabricate certain components. Rare earth materials used for the permanent magnet-based wind turbines are for example dysprosium, neodymium, praseodymium, and terbium and often imported from China.

- The **manufacturing** of offshore wind turbines to a large extent takes place in Europe. However, there is a tendency to move manufacturing facilities of the largest components (towers, blades, and substructures) closer to, or inside the relevant port to minimise the cost of logistics. EU countries with well-established manufacturing include Germany, Spain, Italy, Denmark, and France.

- The **construction and operation** activities benefit from a well-developed port infrastructure, including heavy lift cranes, high capacity wharfs and vessels, contributing to the assembly, installation, fabrication, and quick reaction of FOW.

- In terms of **end-of-service-life management**, even though most offshore farms have submitted decommissioning plans before the farm was built, the sector has little experience as only a few farms have already been decommissioned. This is mainly because no economically and environmentally viable solution has been found yet. Considering the amount of raw materials required, the end of life treatment needs additional research to supporting sustainable decommissioning.

3 Impacts

The European wind industry has an annual turnover of €60bn with around 21% (€13bn) coming from offshore activities: 65% of this adds value to the EU economy, including €5bn in taxes and other payments benefiting local communities. Direct job creation related to offshore wind turbines is approximately 17.3 jobs[3] per MW produced. This is defined as one year of full-time employment for one person over the 25-year lifetime of an offshore wind project. On the other hand, the CO_2 emissions avoided by the offshore wind technology is considered to exceed 3.5 MT CO_2 per GW produced. This is a more than for onshore wind, solar, hydro, or efficient gas power. These figures represent the offshore wind technology in general and are thus not considered for the floating wind sector in isolation. In addition, wind farms activate the local economy and pay €2.3/MWh in local taxes on average.

By 2030, the global energy production from FOW is forecasted to amount to around 13.6 GW[4]. This translates into about 47.6 MT of CO2 emissions avoided from energy production from fossil fuels. In terms of jobs it would create 235,280 direct jobs across the globe. Within the EU, 7 GW[5] is forecasted to be produced by 2030 meaning that 24.5 MT of CO_2 emissions will be saved, and 121,100 direct jobs created. These forecasts imply that the EU will be account for 51.4% of floating offshore wind energy production in 2030.

4 Funding

EU funding opportunities for floating offshore wind include[6]:

- **Horizon 2020 calls** - Calls for proposal related to energy themes in Horizon 2020. On this page you can find more information, the work programme and a link to the energy related calls.

- **Horizon 2020 access to risk finance** - Gain easier access to debt and equity financing, such as InnovFin, managed by the European Investment Bank Group and European Investment Fund

[3] GWEC - Offshore wind (2020)
[4] GWEC - Offshore wind (2020)
[5] Interview with Wind Europe
[6] European Commission Website

- **Connecting Europe Facility energy** - CEF energy funds and finances energy infrastructure projects

- **NER 300 programme** - Funding for innovative low-carbon technology research with focus on environmentally safe Carbon Capture and Storage (CCS) and innovative renewable energy technologies

- **LIFE+ Climate Action** - Co-financing for climate change mitigation and climate change adaptation research, supporting the transition to a low-carbon and climate-resilient economy

- **European structural and investment funds (ESIF)** - Energy research related calls may be found in these funds

- **COSME** - EU Programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME) aims to make it easier for SMEs to access finance in all phases of their lifecycle

- **Prize for renewable energy islands** - Prize rewarding achievements in local renewable energy production for electricity, heating, cooling and transport on islands.

To reach large-scale deployment of commercial FOW projects, a combination of public and private investment is needed, and it is essential that the technology can access low cost financing and de-risking. It is crucial that the floating offshore wind technology is not considered a mature technology yet, as it is currently less competitive comparted to bottom fixed and onshore wind.

Europe's current lead position cannot be taken for granted. The global competition, in particular from Asia, is increasing. Continuous funding towards R&I can play a role in maintaining the leadership position. For example, projects such as "Corewind"[7] are crucial to develop and spread technology advancements. such projects create partnerships and build synergies between countries and organisations.

[7] A program funded by H2020 with the goal to achieve cost reductions and enhance performance of floating wind technology through the research and optimization of mooring and anchoring systems and dynamic cables.

5 SWOT

An overview of the key strengths, weaknesses, opportunities, and threats related to the EU’s global leadership within FOW value chains is presented below.

Source: COWI's elaboration based research and interviews with Siemens Gamesa and WindEurope

6 EU's Global Leadership

Europe is a leader in FOW research, project planning, manufacturing, and construction and operation activities. However, Europe depends on importing raw materials, and faces an increasing international competition.

Even though not yet commercial, floating offshore wind is a rapidly maturing technology with the potential to consolidate Europe's leadership in wind globally. Today, the 62 MW capacity of floating wind deployed in Europe represent a small fraction of the total offshore installations in Europe and globally. Nonetheless, floating wind technology increases the potential for electricity generation from offshore wind farms. While bottom-fixed installations are limited to coastlines with low water depths and favourable sea-bed conditions, floating offshore wind has a much wider global growth potential.

The European FOW market has not matured yet. The FOW technology is expected to need five more years with focus on research and innovation, and another five to be commercial[8]. European companies such as Siemens Gamesa, Vestas, EDP and Principle Power are floating pioneers and are leading three quarters of the more than 50 projects worldwide today.

Europe holds the possibility to capitalise on its first-mover advantage and take its leadership into the decade to come. This is an opportunity to maximise the local economic benefits in Europe of what is today a nascent floating offshore wind supply chain. EU's support could be tailored to the planning of projects and to promoting the collaboration between EU countries to enable continuous cost reductions and technology leadership. The sector needs economies of scale (volumes), consequent low financing costs as well as research and innovation funding[9]. This will further strengthen Europe's position as manufacturer, a crucial step in gaining long-term leadership

Of the 11 projects with a total capacity of 74 MW, 62 MW are located in Europe making Europe the global technology leader for FOW. At least seven countries have concrete plans to install floating wind in the coming years and others, such as Italy and Greece for the next decade. New concrete projects are planned in France (111MW), UK (49.5MW), Norway (91.6), Portugal (25MW), Spain (2MW) and Ireland (6MW). Further increasing the pipeline for floating wind projects will be key to exploit the floating wind's cost reduction potential[10] and thus maturing the technology.

The EU and its Member States must remain pro-active. Asian countries are strengthening their position globally. The South Korean government for example has committed to having 12GW of installed offshore wind capacity by 2030 of which 6GW have been announced to be floating wind turbines installed by 2023[11]. This offers international growth opportunities for the European wind industry.

[8] Interview with Siemens Gamesa
[9] ETIPWind- Roadmap Floating offshore wind (2020)
[10] Windeurope - Floating offshore wind is gearing up for take off (2020)
[11] Offshore wind - South Koreans Form Floating Wind Alliance (2020)

1.4 ANNEX A

EU's Global Leadership in Renewables

Case study Battery Energy Storage Systems and EV Batteries

March 2021

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1 Introduction

Batteries are a key enabling technology for the green transition. They facilitate the consumption of electricity to take place at a different time than the production. This is vital, when an increasing share of the electricity is produced by variable renewable energy sources (VRES) such as via wind and solar power. This case study addresses two popular applications of battery technology – electric vehicles (EV) and battery energy storage systems (BESS).

Electric vehicles are rapidly becoming the key to unlocking a green transition in the transport sector – especially when it comes to passenger transport. Most major car manufacturers now offer electric vehicles as part of their vehicle fleet. Consequently, the market for EV batteries has seen consistently high growth rates over the past few years. In 2017, for instance, global EV-battery manufacturers produced an estimated 30 gigawatt-hours of storage capacity, almost 60 percent more than in the previous year. This market represents a substantial—but so far untapped—potential opportunity for European battery makers and car makers, as well as for the European economy in general.

Currently, the global EV-battery market is dominated by manufacturers from only three countries, all of them in Asia: China, Japan, and Korea. In 2018, less than 3 percent of the total global demand for EV batteries was supplied by manufacturers outside these three countries, and only approximately 1 percent was supplied by European manufacturers[1].

When looking at the energy transition and the decarbonisation of the EU economy, BESS can play a key role in a renewable-based power system. By providing flexibility and fast balancing services, BESS technologies provide all the conditions that are vital for maximising the integration of high shares of VRES, as well as the grid integration of electric transport. From a power system perspective, BESS technologies bring significant benefits, including[2].

- Injecting and absorbing electricity extremely fast (<50ms), with higher accuracy than conventional generators, to provide power system reliability services;
- Improving short-term variability, fostering the penetration of higher shares of renewables in the power system;
- Eliminating production and load peaks, reducing network costs and investments needs;
- Making solar fully dispatchable, optimising the supply of solar energy in line with the power system needs;
- Storing solar electricity when prices are low, using it when prices are high, allowing energy prices to stabilise;
- Rebooting grid operations in the event of power outage[2].

In a 100% renewable energy system supported exclusively by BESS, batteries could deliver as much as 24% of European electricity demand. In order to do so, distributed BESS installed capacity needs to reach 900 GWh by 2030 and 1,600 GWh by 2050, an immense growth from the level installed today[2]. Most likely, batteries will not be the only type of energy storage employed – Power to X, compressed air, power to heat, pumped storage amongst others will also find uses.

Currently the most common battery type is the liquid lithium ion (Li-Ion) battery. Within this category there is a large variation in terms of charging time, safety, longevity, power, temperature etc. R&D across the world is now concentrating on building solid state batteries that should cover a large part of the current issues emanating from other types of batteries[3]. Further, the EU battery alliance has made it one of their priorities to research this technology further[4].

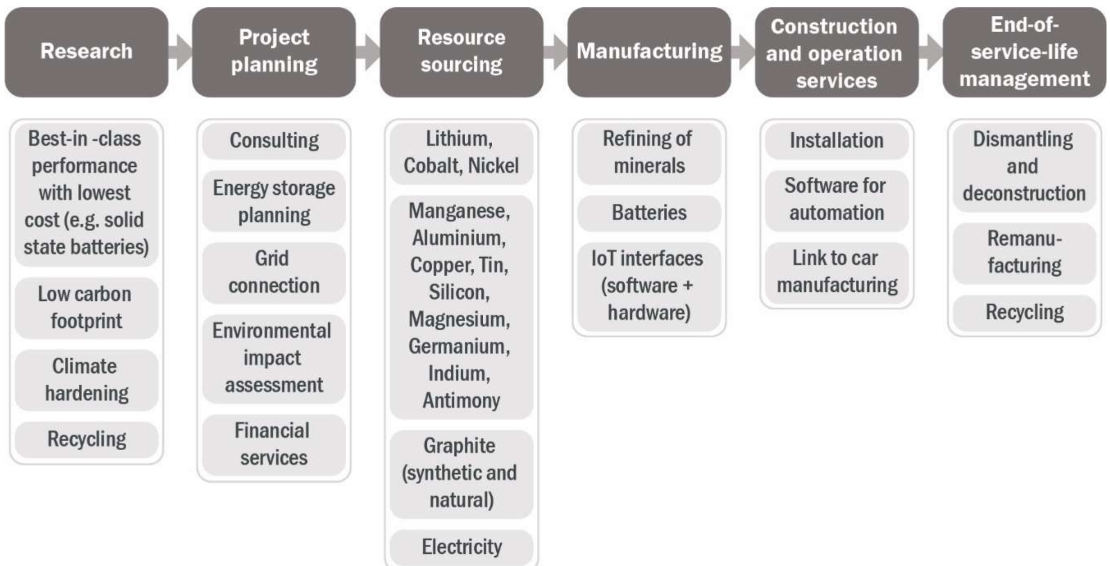
One example of a European battery manufacturer is Northvolt, which was founded in 2016 with the mission to build the world's greenest battery to support the European transition to

[1] McKinsey 2019
[2] Solar Power Europe
[3] IDTechEX, EP Newswire 2020
[4] European Commission 2019, Evaluation of Batteries Directive

renewable energy. In 2017, the company initiated a recycling program with Chalmers University, with the aim to industrialize the recycling process of lithium-ion batteries. During the same year, the company confirmed its Gigafactory and research facility in Sweden. In 2018, Northvolt commenced the development of a battery systems facility in Poland, designed for industrialization and assembly of battery modules and solutions. In 2019, Northvolt and Volkswagen Group established a join venture for a 20 GWh gigafactory in Germany, and in 2020 Hydrovolt electric vehicle battery recycling facility was launched in Norway, as a joint venture between Northvolt and Hydro.

2 Value chain

An overview of the battery value chain is presented below.



Source: COWI's elaboration based on desk research

The battery value chain currently is dominated by Asian manufacturers. Raw materials are often sourced in developing countries such as Chile, Congo, and Mongolia. On the other hand, many car manufacturers in EU are launching electric and hybrid vehicle models which rely on a steady supply of batteries and preferably with guarantees of use of ethical and sustainable raw materials. This section describes how EU can play a role in the major elements in the value chain.

- **Research** - battery technology is constantly evolving. Some of the main avenues of research include resource efficiency, solid state batteries and climate hardening. Resource efficiency relates to minimizing the use of rare materials. Solid state batteries are supposedly the next generation of batteries promising higher efficiency, lower cost and lower environmental impact. Climate hardening focuses on reducing batteries' vulnerability to extreme cold and heat. According the European Technology and Innovation platform, R&I is needed to provide the European industry with the required technological advances along the value chain:
    - to achieve to achieve best-in -class performance with lowest cost
    - to offer sustainable product solution with a differentiating low carbon footprint, enabling manufacturing of cells batteries and systems in high-volume, high efficiency, automated, digitalized industrial processes

  - enabling manufacturing and recycling industries to scale up to the needed volumes
  - to create and develop fit for purpose battery technology to enable new applications
  - to create a workforce with the necessary skills along the full battery value chain as well as excellent scientists[5]

- **Project planning** - this segment is primarily relevant for BESS, as batteries for electric vehicles feed into the automobile manufacturing value chain. BESS can be applied at many levels from off grid households to utility scale grid connected delivery of system services. Depending on the level and scale of the BESS many standard project planning services can come into play, such as consulting, energy storage planning, grid connection planning, environmental impact assessments and financing.

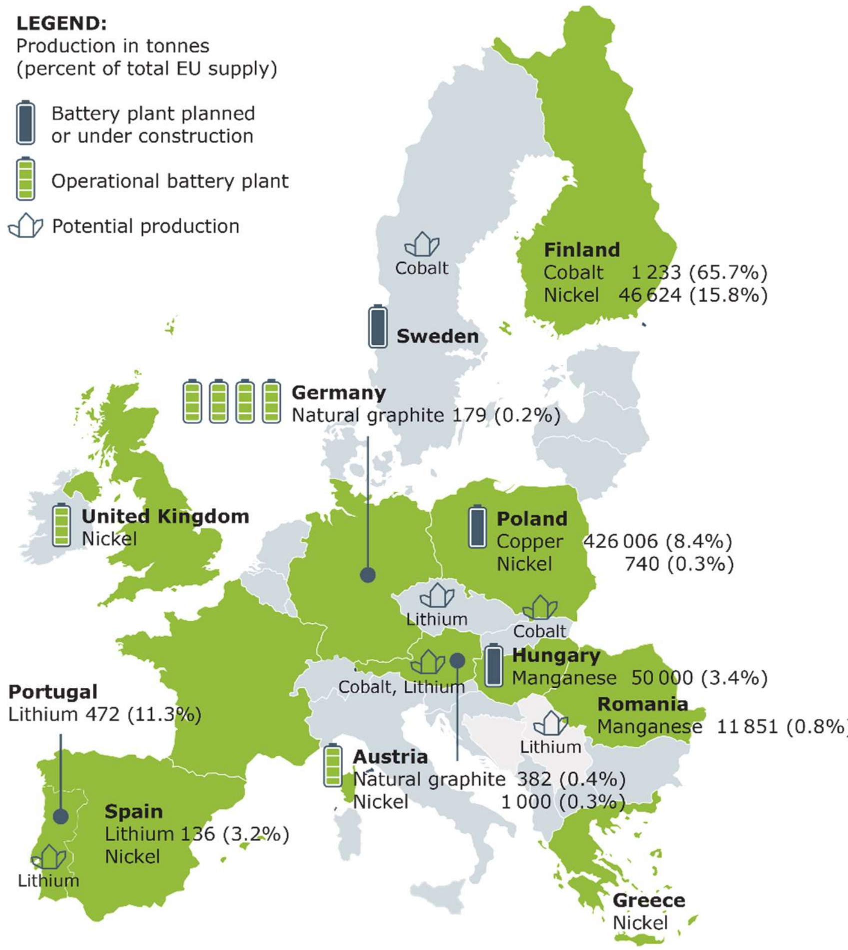
- **Resource sourcing** - The EU, thanks to the EU raw materials strategy and the launch of the European Innovation Partnership on Raw Materials back in 2012, addresses the resource sourcing challenges by: sustainable sourcing of raw materials from global markets, sustainable domestic raw materials production, and resource efficiency and supply of secondary raw materials .

  There are four essential raw materials for battery production namely: cobalt, lithium, graphite (synthetic and natural), and nickel. Other important raw materials for battery applications are; manganese, aluminium, copper, tin, silicon, magnesium, germanium, indium, antimony and rare earth elements (REEs). Some of these materials have a high economic importance while at the same time have a high supply-risk. Among the materials used in Li-ion cells, three are listed as critical raw materials (CRMs) by the European Commission namely, cobalt, natural graphite and silicon (metal). Lithium is not a CRM, but has an increasing relevancy for the Li-ion battery industry.

  The EU is sourcing primary raw materials supply mostly from non-EU countries. Usually, the global market of these materials is concentrated and vulnerable to supply disruptions. For example, globally DRC (64% of 135,500 tonnes) is the biggest producer of cobalt ore and China (42% of 83,430 tonnes) is the biggest producer of refined cobalt. Another example is lithium, almost 83% of the actual global supply of lithium is being sourced from four major producers: Albemarle (USA), SQM (Chile), FMC (USA) and Sichuan Tianqi (China) with main fields located in Chile, Australia, Argentina and China, while there is no similar global level producer based in the EU.

  The graphic below illustrates the existing battery manufacturers and raw materials extraction in EU as of 2017. With the exception of Cobalt from Finland, EU raw materials extraction only supplies a fraction of the demand in EU.

[5] European Technology Platform 2020



Source: European Commission - Report on Raw Materials for Battery Applications (2018)

- **Manufacturing** - According to Northvolt, there is a potential in bringing the refining of the raw materials to Europe. The refining process is energy intensive and would benefit from the high renewable energy penetration in the European energy system. Internalising this step of the value chain within EU would also contribute to increased transparency in terms of procurement of raw materials. As there is a lack of refining capacity in Europe, raw materials are today often transported from the mining regions to the EU via refineries located in third countries such as Asia, making the value chain more vulnerable.

  The EU as a global battery manufacturer is in a catch-up mode. Today, manufacturing of batteries is dominated by China, Korea and Japan. Manufacturing does not cover only the manufacturing of the batteries, but also the manufacturing of the equipment needed for battery production. According to Northvolt there are only a limited amount of European manufacturers that can supply such equipment. Building an industry from scratch takes time and commitment. The battery value chain in the EU needs to be built up in terms of sub-suppliers, know how, skilled labour and industrial culture.

  The market outlook and expected growth rates in battery use are in favour of growing an EU based manufacturing industry. The EU Green Deal and the Paris agreement underline the importance of electrification – not only in transport, but also in industry and in the energy system. The biggest threat to the European battery industry is falling even further behind. As the European automotive industry is increasing its focus on electric vehicles, the European suppliers of batteries need to be able to keep up. Otherwise the car manufacturers will turn to battery suppliers outside EU. The EU can play a big role in supporting the scale up of European battery manufacturing by keeping focus on electrification. A predictable and high volume of demand for batteries will provide a positive investment climate for battery manufacturers.

Manufacturing of batteries within the EU is of high strategic importance for a number of industries. Batteries are a substantial cost component of an electric vehicle, and a cost competitive secure supply of batteries is essential for a well-functioning automotive industry. Security of supply is a major concern when the majority of the value chain is located outside of EU. According to Northvolt there is also a considerable interest by the EU automotive industry for ethical and green sourcing of batteries. This illustrates the potential for establishing battery manufacturing in EU.

- **Construction and operation services** - Utility scale grid connected BESS require specialized installation likely by licensed crew. Operating BSS is typically an automated process designed to optimize the stability of the power system as well as the revenue from the services the BESS provides. Designing and operating the software needed can be a substantial activity.

- **End of service life management** - The supply of raw materials for battery manufacturing is potentially vulnerable to disruption. In view of the large quantities needed in the future, the sustainable extraction and use of these resources is fundamental. Recycling of materials will increasingly become important for reducing the EU's dependency on foreign markets and should be encouraged in the framework of the transition to a circular economy[Error! Bookmark not defined.]. In 2018, recycling of the battery materials still has not reached its full potential in Europe. Nickel is recycled to a large extent and currently covers around 34% of the EU consumption. Global end-of-life recycling rate for cobalt is also high (68%), but it covers only minor part of the growing demand. Today the recovery of lithium and graphite from batteries is technically feasible but is not economically viable. The 2019 evaluation of the Battery directive (EC 2006/66/EC) also pointed to limitations in particular when it comes to recycling[4]. Restrictions on transport of waste across borders could lead to inefficiencies in recycling. The battery manufacturers would prefer to be able to recycle the batteries themselves. This requires collection of used batteries and transporting them back to the manufacturer.

3 Impacts

Recent forecasts indicate that the demand for batteries both in the EU and globally will grow exponentially in the next years. If the full EV-battery-production capacity were to be installed in Europe, it would bring considerable advantages for Europe's economic, industrial, and sustainability efforts. with 1,200 gigawatt-hours per year of demand in 2040, the value of the cell market alone would be around €90 billion per year, with the potential to create about a quarter of a million jobs in battery-cell manufacturing and R&D. Bringing gigafactories to Europe also has the potential to create jobs upstream in the value chain and downstream in areas such as reverse logistics, recycling, and reuse. Furthermore, many components of European vehicles are manufactured elsewhere today; securing battery manufacturing in Europe could help locate much of the automotive industry's value-creation efforts in Europe[1].

Locating cell manufacturers close to Original Equipment Manufacturers (OEM) in Europe allows for the creation of a research and innovation ecosystem, fostering co-development among players in EV production, cell manufacturing, and upstream materials development and production (including cathodes, anodes, and electrolytes), along with recycling, research, and innovation networks. Battery-cell technology is also developing rapidly. Next-generation technologies, such as all-solid-state batteries, are already appearing on the horizon, and constant R&D is required to keep up[3].

For BESS, Solar Power Europe has forecasted that capacities will likely be 7.2 GWh in 2024 (in a medium scenario). But under optimal conditions, Europe's prosumers could operate a battery fleet as large as 9 GWh by the end of 2024, compared to 5.6 GWh in the Low Scenario.

The main driver of battery manufacturing in the EU is expected to be EVs. In 2019, the EU produced 24% of the total global motor vehicle production[6]. If the battery manufacturing industry in EU is able to secure a proportional share of the EV battery market, this amounts to € 22 billion per year by 2040.

4 Funding

Solar power Europe has evaluated 6 funding possibilities that have been implemented around Europe with their significant storage potential and ease of implementation. This serves for great examples of funding possibilities for each MS. They are[2];

1. direct financial incentives for end consumers,
2. tax depreciation for storage installations,
3. integrated building renovations and efficiency standards,
4. solar mandates coupled with storage,
5. tax exemptions to prosumers,
6. time-of-use tariffs.

On the EV side, the market is evolving at a rapid pace. Most car manufacturers offer electric and hybrid versions of one or several of their existing model. Prices on EVs are dropping to levels where they are commercially viable. Support schemes for electrification of mobility include:

1. Tax incentives
2. Direct financial incentives for end consumers

[6] European Automobile Manufacturers Association

3. EU regulation to:

    a. Improve energy efficiency in transport

    b. Develop sustainable fuels

    c. Scale up renewable electricity generation

    d. remove barriers to electrification of transport

From the perspective of battery manufacturers, Northvolt points to EU regulation on transparency and quality of batteries and the entire value chain as critical for supporting the EU battery industry. One suggestion is "Battery passports" that track the battery over its entire life cycle, from raw materials to manufacturing over use to end life. Another suggestion is a standardized methodology for the quantification and registration of the carbon footprint of a battery.

5 SWOT

An overview of the key strengths, weaknesses, opportunities, and threats related to the EU's global leadership within battery value chains is presented below.

Source: COWI's elaboration on desk research and interviews with Northvolt

6 EU’s Global Leadership

Almost a quarter of all cars produced globally are produced in Europe. As car manufacturers transition to electric vehicles, the demand for batteries grows rapidly. The European car manufacturers in particular have high expectations for transparency, sustainability and stability in the supply of batteries. This should position a growing European battery industry ideally to serve this growing demand.

However, from a global perspective, Europe is in a catch-up mode. From 70 announced gigafactories globally, 46 are based in China. A lack of regulatory support and a weak EU value chain have led to some of Europe’s battery manufacturers to set up in China. For example, the Dutch Lithium Werks, which already has two plants in China, announced plans in September for another. The company says it prefers to build plants in China because the infrastructure is better, and it is easier to get the permits needed to build a factory. To address these issues and promote an " innovative, sustainable and competitive battery 'ecosystem' in Europe"[7] the European Battery Alliance was launched in October 2017.

In terms of R&D, Asian manufacturers are currently more advanced. European OEMs and cell manufacturers will have to decide whether to partner with them, try to catch up to them, or attempt to leapfrog to the next technological cycle. Reputation will also play a role, as European top-tier OEMs are unlikely to source from suppliers without proven track records. With regard to sustainability, sourcing cells in European countries would allow manufacturers to benefit from Europe’s rapidly decarbonizing power systems and reduce the overall carbon footprint of EVs in line with European targets for vehicle-life cycle decarbonization.

[7] European Battery Alliance

1.5 ANNEX A

EU's Global Leadership in Renewables

Case study on Floating Solar PV with Hydropower

March 2021

Table of Contents

1 Introduction

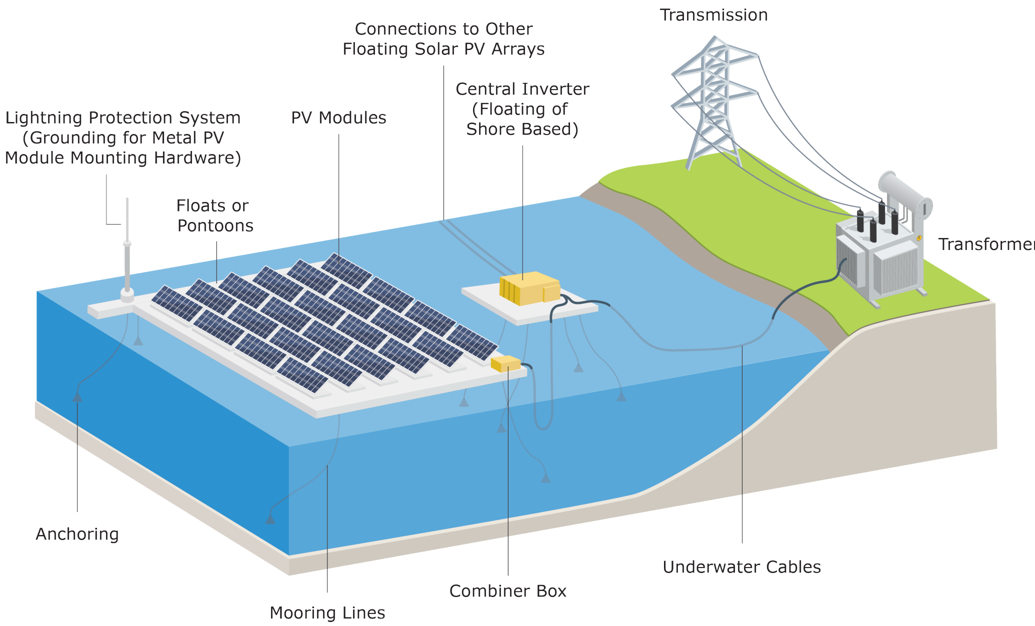
Floating solar photovoltaic (FPV) installations are a variation of typical ground photovoltaic installations. They vary by their instalment type. They are mounted on floating devices thus offering new locations like dead water spaces for the scaling up of solar renewables. In addition to being able to harvest more energy thanks to the cooling properties of the surrounding water, FPVs can be coupled with hydropower plants whereby they can contribute to the further optimization of the hydropower plants. In this case they are called hybrid FPV-hydropower systems. FPVs are relatively new to the market and thus not yet fully mature. Therefore, they carry an important cost burden that can be partly surmounted by some of the advantageous features they offer[1].

For example, the French company Ciel et Terre constructed the world's first combined hybrid FPV-Hydropower system in Portugal in 2017. It was a pilot project in the dam of Portugal's River Rabagão. With 220 kW this was a small installation, but it was the first time the two technologies were used in tandem. The advantages of the FPV systems in combination with hydropower plants include:

- Reduced evaporation from water reservoirs, as the solar panels provide shade and limit the evaporative effects (average reduction around 6.3%)
- Improvements in water quality, through decreased algae growth
- Reduction or elimination of the shading of panels by their surroundings
- Elimination of the need for major site preparation, such as levelling or the laying of foundations
- Easy installation and deployment in sites with low anchoring, and mooring requirements with a high degree of modularity, leading to faster installations.
- Cooling provided by the water leads to an increase of the panels' efficiency. Theoretically around 7%, whereas Energias de Portugal[2] estimated the efficiency increase to be around 3-4% since the effect is partly offset by to the lower tilt of the PV cells, and the use of more expensive technical solutions
- More efficient use of land and savings on grid connection costs, by installing FPV at an existing hydropower site [2]

Today, a floating solar project by itself costs significantly more than a solar plant on the ground, but this higher cost can potentially be overcome by an increased efficiency gain. The cost for large projects is in the order of 630 EUR/kWp all included (mooring, cable, inverters, electric cabinet), while the final kWh price is in the range of 60-70 EUR/MWh (compared to 30 EUR/MWh for PV), depending on the local radiation contentions[2&3].

[1] Javier Farfan et al. / Energy Procedia 155 (2018) 403-411
[2] Interview Alex Campbell (International Hydropower Association) and Miguel Patena (Energias de Portugal)
[3] Solar Power World (28 May 2020)



Source: COWI's recreation based on N. Lee et al. / Renewable Energy 162 (2020) 1415-1427

The combination of FPV and Hydropower can be called hybrid if the coupling of the two technologies result in an expected net economic benefits relative to the benefits associated with comparable independent, stand-alone technologies.

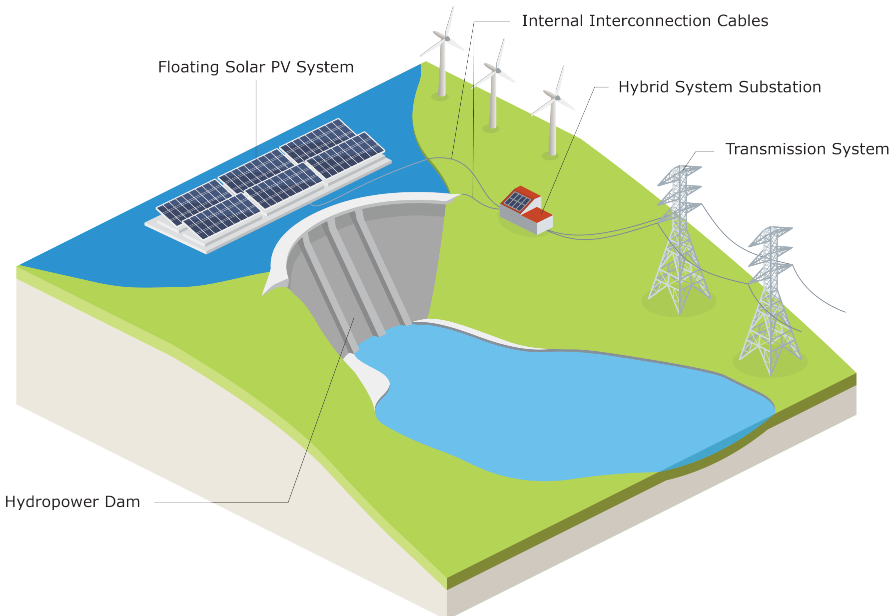
There are 3 typical hybridisations configurations[4];

1. **Co-location hybrid systems** (deliver cost improvements): two or more technologies sited together to achieve cost savings, but operations are separately optimized.

2. **Virtual hybrid systems** (deliver performance improvements): two or more technologies are sited separately, with operations linked through bilateral agreements and some co-optimized operation.

3. **Full hybrid systems** (deliver cost and performance improvements): both cost and performance improvements are achieved through optimized planning and operation. Such systems often consist of at least one dispatchable technology paired with one or more variable renewable energy technology, which, when paired, offer operational benefits.

[4] N. Lee et al. / Renewable Energy 162 (2020) 1415-1427



Source: COWI's recreation based on N. Lee et al. / Renewable Energy 162 (2020) 1415-1427

Hybrid HPV-Hydropower generates synergies through two characteristics of the functioning of the hybrid system. The solar PV generation is variable and less predictable due to weather conditions, spatial resource qualities, and daily patterns. In contrast, hydropower systems (with sufficient resources) can offer a high degrees of generation control and can cover for shortfalls to balance intermittent solar PV generation. This implies that the two sources of the hybrid system can compensate for each other by either saving water storage capacity or by producing electricity during low shining moments (seasonal changes, nights, covered skies). This significantly enhances the system's response to electricity demands. Additionally, the system can be used as a battery: one can use the extra solar power to pump water into an upper reservoir to store for later hydropower. Put simply, the hybrid system is considered to be a virtual battery: Plant operators can decide to shift the production to solar and save water for later use, at peak hours for example.

There are also potential issues to FPV installations. Insulation failures can lead to frequent unplanned downtime. Furthermore, long-term exposure to humidity may lead to the degradation of PV modules, corrosion of floating structures, waterbody contamination, and possibly material fatigue of joints may result in debris that interferes with the local ecosystem or hydropower systems. Operation and maintenance costs are typically also higher than land-based systems: specific technologies needed for instalment of FPV in hydro plants are floaters system, anchoring system, and waterproofing of electronics. The technology also needs more complex structures for safety reason and to reduce tear and wear. Other potential challenges include environmental impacts, such as temperature fluctuations that could affect local ecosystems.[5] In informal conversations with environmental NGOs, the International Hydropower Association has found that these NGO's look favourably on PV/ hydro hybrids when using existing infrastructure as it is maximizing the benefit of existing hydropower.[6]

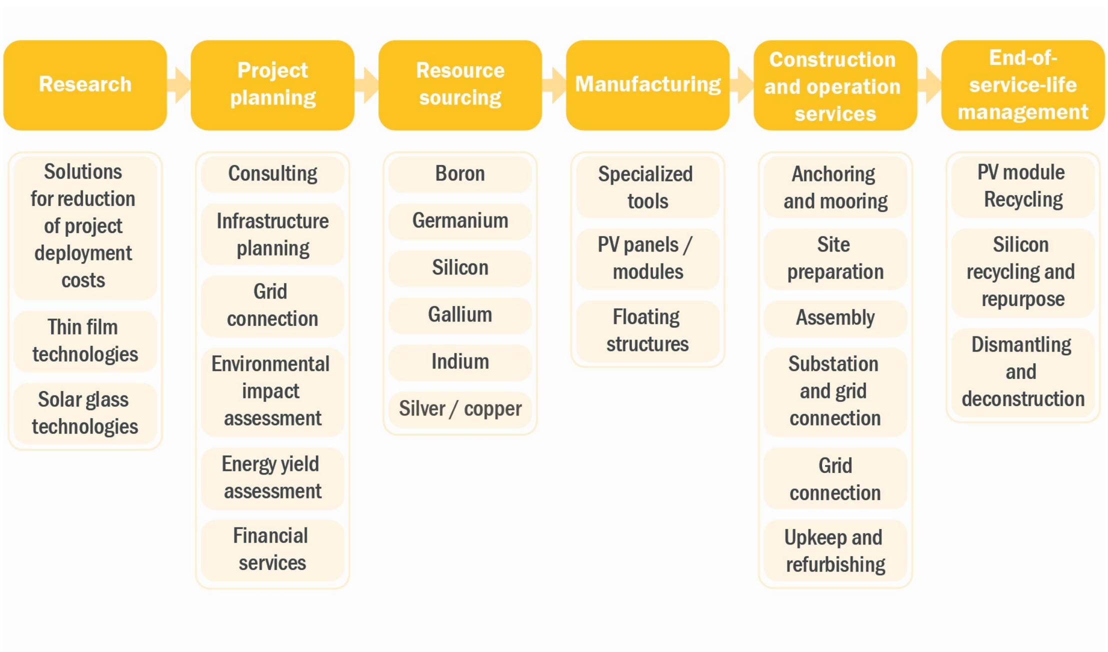
Several projects have been initiated that also demonstrate the potentials of this technology, For example, Sembcorp Industries (Singapore) has initiated work on a 60 MW floating solar power plant at the Tengeh reservoir. [7] Today, the most active market in Europe is the Netherlands, a densely populated country where space for ground-mounted installations is scarce. The 27.4

[5] *N. Lee et al. / Renewable Energy 162 (2020) 1415-1427*
[6] Interview Alex Campbell (International Hydropwer Association)
[7] PV Magazine (18 Aug 2020)

MW Bomhofsplas project in Zwolle is thus the largest floating solar project in Europe.[8] Floating solar projects are still mostly done by specialized solar developers. Among the few utilities dipping their toes into the market with pilot projects are Norway's Statkraft and Portugal's EDP. Both are operators of hydropower plants where floating solar projects can be co-located with existing generation capacity. An example is the planned Banja reservoir in Albania: a 2MW FPV that uses the technology of fish farming. The PV project proposal is a contemporary technological solution, which will enable saving of land for other purposes, and exploitation of the water surface of the Banja reservoir. While the concept of floating solar is not new, Statkraft plans to explore the feasibility of large-scale application of solar panels attached directly on a floating membrane, allowing for efficient cooling of panels and efficient utilization of land area.[9]

2 Value chain

An overview of the floating solar PV value chain is presented below.



Source: COWI's elaboration based on desk research

- **Research** – the examples mentioned in the above overview of the value chain segments are the three most recent R&D focus areas. Focussing on PV, the EU's Strategic Energy Technology plan identifies six main areas: PV for BIPV, technologies for silicon solar cells with higher quality, new technologies and materials, operation and diagnosis of PV plants, manufacturing technologies, and cross-sectoral research at lower technology readiness level.[10] There is currently a lack of incentives to develop smart and flexible solar installations in public tenders. Thus, the number of patents globally applied for are higher, than in the EU-27 (Over the last decade, 29% high value patent applications were from the EU-28).[11]
- **Project planning** – Currently, there are not many projects in the EU with the combination of Hydropower and FPV. China and India have an advantage in experience here. But looking at the PV market, the EU market size is around 13-14% of the global value. Since the EU was involved from the early start of the large-scale PV market,

[8] SP Global (5 Aug 2020)
[9] Statkraft (18 Dec 2018)
[10] REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on progress of clean energy competitiveness SWD(2020) 953 final
[11] ICF, 2020

European companies have a strong presence in the market. As a result, all services related to project planning and implementation are available within the EU. [8] Another topic concerns market design: different market designs within Europe add much complexity. There is a need for clear uniform rules.

- **Resource sourcing** – the materials mentioned are the EU's list of critical PV relevant raw materials. Silicon metal is included due to the current dependence on China. R&D efforts on raw materials are focusing on efforts to reduce silver use as a connection material, or to replace this with copper.[8]
- **Manufacturing** – compared to the regular PV modules, floating PV structures also include extra elements, like a lightning protection system. The EU currently hosts one of the leading manufacturers on polysilicon. However, a significant part of this production is exported to China. EU's share of the production of polysilicon and PV cells and modules is around 12.8% of the global value, and the top 10 companies of leading PV module manufacturers are all located outside of the EU.[8]
- **Construction and operation services** - the load factor[12] of FPV is around 20-30%. This means there is quite some capacity left for energy transportation on the power lines. In Portugal (and in other EU countries as well) there is a shortage of transmission capacity and access points. Hybrid FPV makes use of existing power lines which allows for transmitting more energy and thereby increasing the value of plants (more energy to be sold on access points). Europe has an advantage compared to third countries in combining resources with existing networks.
- **End-of-service-life management** – PV cells will have an expected lifetime of 30 years. The growing PV market will bring recycling opportunities. By 2050, the recoverable global value of PV panels will exceed EUR 12.5 billion.[13]

3 Impacts

Globally, the total FPV potential elevates itself at 404 GW for an annual energy generation of 521,109 GWh/year. This estimate is conservative in the sense that it assumes that 1% of the total surface is utilised. Europe today has realised 0.05% (20 out of 404 GW) of that conservative potential. Europe is thus the continent with the second lowest potential for energy production through FPV systems. A less conservative estimate that increases the percentage of total surface area used in Europe to 5% or 10% while keeping others constant would bring Europe's 'potential to 102 and 204 GW respectively, potentially making it the continent with the highest production[14].

In terms of hybrid systems, estimates suggest a potential global capacity of 5,333 GW and an EU capacity of 729 GW, i.e. 13% of the global capacity. This translates into 7,470 TWh/year for a 14% reservoir coverage[15]. The combination of the two technologies can thus potentially deliver a significant part of the future energy demand. Adding floating solar panels to bodies of water that already host hydropower stations could produce as much as 7.6 TW of capacity a year from the solar photovoltaic (PV) systems alone corresponding to about 10,600 TWh of potential annual electricity generation. The quoted estimates do not include the amount generated from hydropower. By comparison, according to the International Energy Agency the global final electricity consumption was just over 22,300 TWh in 2018.

Looking at employment, there is an expected growth in jobs due to an additional expected PV capacity in EU by 2030. This PV sector will likely add 150-225 thousand jobs by 2030. Currently, the FPV sector is marginal compared to PV, but by 2030, this is expected to grow exponentially. At an expected share of 10% by 2030[16], this might add around 15-22 thousand jobs in the FPV sector by 2030.

[12] Load factor is defined as the average energy load of a system divided by the peak load in a specified time period.
[13] IRENA (2016) End-of-Life Management: Solar Photovoltaic Panels
[14] Worldbank (2019)
[15] N. Lee et al. / Renewable Energy 162 (2020) 1415-1427
[16] R. Cazzaniga & M. Rosa-Clot, The booming of floating PV (2020)

4 Funding

Funding for hybrid FPV-Hydropower systems mainly comes through the European Maritime and Fisheries Fund (EMFF). The individual Member States also offer incentives, however there is not a centralized approach to this throughout the EU. For example, Portugal offers ex post R&D tax incentives. The Bomhofsplas project in the Netherlands is an example of how project financing can be organised. The Netherlands' project pipeline is underpinned by a subsidy program, which resulted in the country's active position in Europe. In recent renewables tenders, floating solar developers were able to obtain support for 500 MW of capacity, in a process where floaters were competing directly with ground-mounted solar projects.[17]

The recent Communication on an EU Strategy to Harness the Potential of Offshore Renewable Energy for a Climate Neutral Future, makes a further step in the direction of organizing funding, by emphasizing the role of research and innovation. The Communication mentions that floating PV has experienced industrial-scale deployment in natural and artificial inland waterbodies and may have promising potential in coastal and near-shore areas. The Horizon 2020 European Green Deal – a €1 billion call for research and innovation projects that respond to the climate crisis and help protect Europe's unique ecosystems and biodiversity - might give more opportunities for FPV and hybrid projects as well.

[17] SP Global (5 Aug 2020)

5 SWOT

An overview of the key strengths, weaknesses, opportunities, and threats related to the EU’s global leadership within floating solar PV value chains is presented below.

Source: COWI's elaboration based on desk research and interviews with Energias de Portugal and International Hydropower Association

6 EU’s Global Leadership

Even though it is the combination of FPV with hydropower that makes this technology potentially very efficient, FPV is one of the main elements. Solar PV has become the world’s fastest-growing energy technology, with demand for solar PV spreading and expanding as it becomes the most competitive option for electricity generation in a growing number of markets and applications. This growth is supported by the decreasing cost of PV systems (EUR/MW) and increasingly competing cost of electricity generated (EUR/MWh). The EU cumulative PV installed capacity amounted to 134 GW in 2019, and it is projected to grow to 370 GW in 2030, and to 1051 GW in 2050[18]. Given the significant projected growth of FPV capacity in the EU and globally (FPV is projected to have a share of 10% of the total PV installed capacity by 2030),

[18] European Commission (2020)

Europe could have a sizeable role in the whole value chain. This will also bring more opportunities for the combination with hydropower.

Globally, Asian countries are leading in the combination of FPV with hydropower. Countries like China, South Korea, Taiwan, India, and Japan are being pushed by land scarcity. Japan was leading on floating PV, but they stopped and are ramping up in offshore wind. Chinese developers are looking to invest in Europe now. There is thus a risk that – in the absence of further EU action to invest – the market lead, even in Europe will be non-European. The EU position right now is not that strong: while the EU RE industry develops first-class equipment to exploit many different sources such as ocean energy, wind and geothermal, a lot of innovative RE technologies fail to reach the market or take a long time to be deployed because of the high costs of demonstration and installations in early-stage commercialisation. The valley of death in the innovation process cripples research efforts and affects negatively the EU economy and its green transition.

Even though the EU is lagging compared to the rest of the world, FPV manufacturing, management and instalment has a high potential for a European global leadership. Some EU companies are leaders in floating PV, providing their solutions all over the world, maintaining a well-established track record of floating PV plants. The EU has a leadership expertise for optimizing hybrid sites in both hardware and software. [19] However, European companies are mostly operating abroad, specifically on the Asian continent. As of December 2018, 8 of the 22 biggest FPV installations in the world were French and the rest were operated by Chinese companies[20]. It is worth noting as well that by that date, 73% of all projects were done in China assigning China the title of global market leader in production. As China currently has a leadership position in solar PV manufacturing, they are also better positioned for FPV. The strong knowledge position of the EU research institutes, the skilled labour force and the existing and emerging industry players are the basis to establish a strong European (floating) PV value chain[21].

Despite the growing energy needs of EU countries and the scientific efforts put in developing technological breakthroughs to generate energy in a sustainable way, floating solar is one of the examples of RE technologies which are characterised by increased risks and capital requirements[22] and which fails to reach commercial deployment. While many countries have struggled to develop utility-scale solar PV power plants, obstacles in other fields such as floating solar are much bigger, with the first power facility being created in Germany just in 2019.[23]

[19] Other types of technology where EU is investing a lot in can be found in XFLEX: a €18m energy innovation project demonstrating how more flexible hydro assets can help countries and regions to meet their renewable energy targets. The four-year, EU-funded project involves seven demonstration projects and 19 organisations, and will conclude in 2023. Furthermore, there is a lack of standards on floating PV (hybrid) projects worldwide. The Norwegian company DNV GL has gathered together big energy players, floating PV specialists and project developers into a consortium that will aim to define recommended practices for the floating solar business. Among the 14 participants are some big players in the field including EDP, EDF and Equinor, as well as French floating technology provider Ciel & Terre. The final report will be done by March 2021.

[20] Interview Alex Campbell (International Hydropwer Association) and Miguel Patena (Energias de Portugal)

[21] REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on progress of clean energy competitiveness SWD(2020) 953 final

[22] Dedecca, J.G., Hakvoort, R.A., Ortt, J.R., (2016). Market strategies for offshore wind in Europe: A development and diffusion perspective. Renew. Sustain. Energy Rev. 66: 286–296.

[23] Clean Technica (29 Sep 2019)

1.6 ANNEX A

EU's Global Leadership in Renewables

Case study on Ocean Energy – Wave energy

March 2021

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1 Introduction

Ocean energy technology converts the ocean resources into electricity. Examples of ocean energy resources are ocean surface waves, tidal currents, tidal range, deep ocean currents, thermal gradients, and changes in salinity[1]. The *theoretical* resource potential of ocean energy ranges from 20,000 TWh to 80,000 TWh of electricity generation per year, representing 100% to 400% of the current global demand for electricity[2].

The two most important technologies revolve around tidal and wave energy. On a global scale, the theoretical potential of tidal energy is significantly smaller than the potential of wave energy, with around 1,200 terawatt-hours (TWh) per year due to geographical limitations. The theoretical potential for wave energy is at about 29,500 TWh per year. This source alone could thus theoretically meet the current global energy demand. The ideal location for wave energy is between 30 and 60 degrees of latitude and below a depth of 40 meters[3]. Tidal energy is captured at precise geographic locations in two different manners; by creating dam-like structures where turbines are deployed, or by installing underwater turbines. In wave energy, the two most common technologies are floating devices attached to the sea floor that operate as pistons when the waves carry them up, or the waves are used to push air in and out of turbines on the coast.

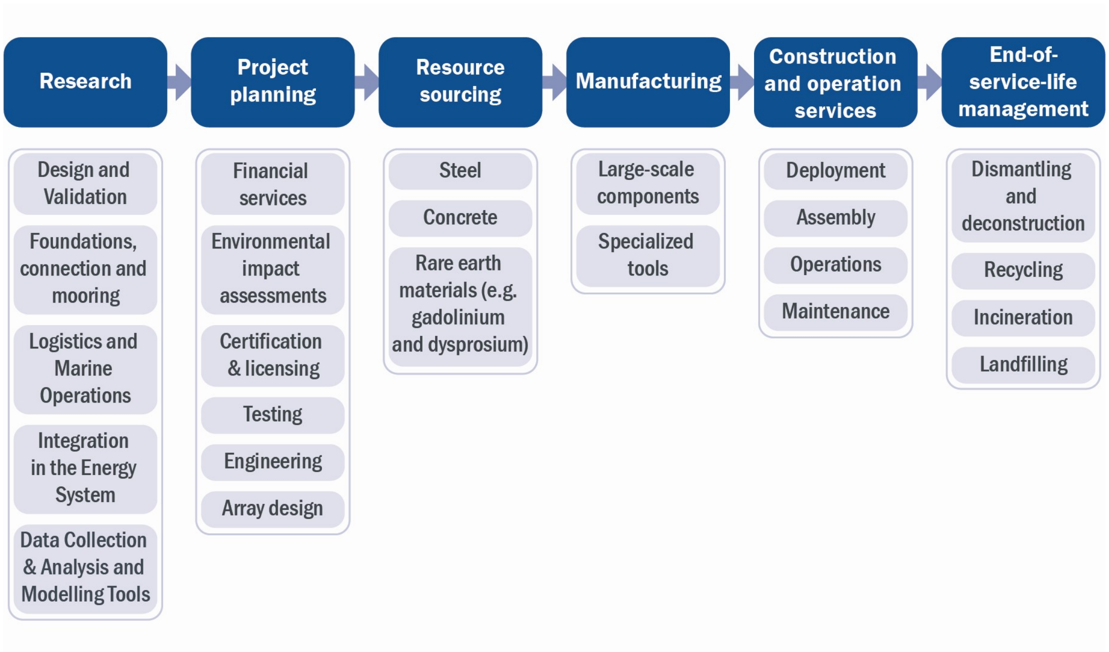
In the ocean energy market today, more than 98% of the total ocean energy installed capacity – 512.5 MW – is *tidal* and concentrates around 2 large projects: a 254 MW plant in the Republic of Korea and a 240 MW plant in France. In 2019, the added global capacity of ocean energy installed was 55.8 megawatts (MW), with most of it located in EU waters (39.5 MW). When it comes to *wave energy*, there is only an installed capacity of 2.3 MW globally. There are currently 33 energy converters with a combined capacity of 2.3 MW deployed in 9 projects across 8 countries on 3 continents. The only active project with a capacity above 1 MW is located in Hawaii. Other locations with active projects include Gibraltar, Spain, Greece, Italy, Portugal, France, and Israel[4].

The theoretical potential is large, but the development of ocean energy is faced with a number of challenges that relate to: research support and framework conditions, technological innovation, critical mass, project finance, and exogenous factors[5]. Barriers related to project finance mainly revolve around the high-risk levels of ocean energy projects. The high risk levels are in turn related to revenue (for example, retroactive cuts to the feed-in tariffs), operations (for example, uncertainty in estimating the full cost of installation, maintenance, and decommissioning), and lack of insurance or warranties (resulting from the lack of understanding of total costs of operations and technological reliability).

[1] IRENA - Ocean Energy: Technologies, Patents, Deployment Status and Outlook (2014)
[2] F. Boshell, R. Roesch, A. Salgado, J. Hecke - Unlocking the potential of Ocean Energy: from megawatts to gigawatts (2020)
[3] Euractive, IRENA chief: Europe is 'the frontrunner' on tidal and wave energy (2020)
[4] Euractive, IRENA chief: Europe is 'the frontrunner' on tidal and wave energy (2020)
[5] Ecorys/Fraunhofer - Study on lessons for ocean energy development (2017)

2 Value chain

An overview of the ocean energy value chain is presented below.



Source: COWI's elaboration based on desk research

Europe has a stable position regarding the number of companies servicing the value chain of ocean technology. In 2017, most companies in each segment of the value chain were thus in European ownership.

- **Research** – key areas for research and innovation in ocean energy are design and validation; foundations, connection, and mooring; logistics and marine operations; integration in the energy system; data collection & analysis and modelling tools. In research, over 50% of global RD&D investments in ocean energy are within the EU. Today R&D activity in ocean energy in the EU involves over 838 EU companies and research institutions in 26 Member States. In the EU, 51% of the ocean energy inventions patented are for wave energy technology, 43 % for tidal energy.[6]
- **Project planning** – services include finance, environmental monitoring & impact assessment, certification, licensing, and testing, engineering, and array design[7]. The EU has implemented support mechanisms to aid the development of ocean energy[8].
- **Resource sourcing** – ocean-based renewable energy technology requires mainly steel and concrete. However, some also rely on metals such as lithium, cobalt, copper, and rare earth elements with several of them included in the 2014 EU critical materials list. The use of magnets, in turbines for example, heavily rely on using rare earth metals as gadolinium and dysprosium. The reliance on such rare earth metals could become a critical issue when seeking to upscale the technology in competition with other renewable energy sources[9]. The key challenge in regard to resource sourcing lies with the rare earth metals. Additionally, and more specifically, for tidal energy, additional challenges arise around the availability and development of sufficient sites.

[6] ETIP-Ocean, Strategic Research and Innovation Agenda for Ocean Energy (2020)
[7] Ocean energy Europe - 2030 Ocean Energy Vision (2020)
[8] Ibid.
[9] A. Uihlein, D. Magagna - Wave and tidal current energy: A review of the current state of research beyond technology (2016)

- **Manufacturing** – large-scale components for ocean energy devices need to be fit for harsh sea environments[10]. Typical components include wave device hulls, floating platforms, and turbine nacelles. Specialised manufacturing refers to precision and high-skill design and manufacture of components and sub-systems, such as power take-offs, drivetrains, seals, bearings, gearboxes, control systems, blades. Worldwide, there are a total of 103 companies along the full value chain that are from the EU, and 82 are from the rest of the world[11]. For wave energy, identified barriers are lack of original equipment manufacturer (OEM) involvement, and lack of knowledge sharing and open source research.
- **Construction and operation services** - key elements of services include the deployment, assembly, operations & maintenance of ocean energy devices on site. Stronger areas of EU companies are on installations vessels, and wave converters among others. Weaker areas are mostly in ocean thermal convertors and in resource forecasting.
- **End-of-service-life management** – End-of-life routes for materials used include recycling, incineration, and landfilling[12].

3 Impacts

Market scenario assessments indicate that depending on the cost-reductions achieved and the realised policy design, by 2030, the total European wave and tidal energy installed capacity could range between 0.5 GW and 2.6 GW (average 1.6 GW) by 2030[13].

At the end of 2019, over 430 companies in the EU are involved in different stages of the ocean energy value chain, with an estimate of 2 250 jobs currently active in the sector across Europe[14]. For future growth of this sector, scenario analysis shows that up to 25 000 FTE a year will be created, for a total between 50 000 and 200 000 distributed in the next decade (until 2030), of which 36 500 to 146 000 direct and 13 500 – 54 000 indirect[15].

According to the same scenario analysis, the cumulative Global Value Added (GVA) generated from deployed wave and tidal energy would, by 2030 range between EUR 0.5 and 5.8 billion. [16].

Worldwide, a positive forecast is to develop, by 2050 300 GW of wave and tidal current energy. This estimate is according to forecasts by the International Energy Agency collaboration programme for Ocean Energy Systems (IEA OES). The benefits promise to be substantial, with 500 million tonnes of carbon savings.[17]

4 Funding

Between 2007 and 2019, total EU R&D expenditure on wave and tidal energy amounted to a total of EUR 3.84 billion with the majority (EUR 2.74 billion) coming from private sources[18]. In the same period, national R&D programmes have contributed EUR 463 million to the development of wave and tidal energy. EU funds, including ERDF and Interreg projects provided financing in the order of EUR 493 million. A further EUR 148 million have been made available

[10] Ocean energy Europe - 2030 Ocean Energy Vision (2020)
[11] JRC, Supply chain of renewable energy technologies in Europe (2017)
[12] A. Uihlein, Life cycle assessment of ocean energy technologies. The International Journal of Life Cycle Assessment (2016)
[13] IEA - World Energy Outlook (2019)
[14] European Commission - The Blue economy Report 2020 (2020)
[15] Breakdown based on ratio between direct and indirect jobs as identified by JRC in the 2018 Annual Economic Report on Blue Economy (EC 2018), which gives a total of 1 350 direct jobs (73%) and a range of 500 FTE in indirect jobs (27%).
[16] European Commission - The Blue economy Report 2020 (2020)
[17] SETIS , An international vision for ocean energy: decarbonisation and economic benefits (2019)
[18] European Commission - The Blue economy Report 2020 (2020)

through the NER300 Programme. On average, for the reporting period each single Euro of public funding (EU and National) has leveraged EUR 2.9 of private investments.

In the pessimistic case, it would demand an investment of EUR 2 to install 750 MW of wave and tidal energy capacity. In the optimistic case, the investments needed to deploy 2.6 GW of ocean energy capacity amount to EUR 7 billion[19]. As economies of scale and large-scale deployment will occur when volumes increase, the needed EU funding is expected to – at most - amount to, of the funding currently provided, i.e. maximum EUR 1.1 billion[20].

5 SWOT

An overview of the key strengths, weaknesses, opportunities, and threats related to the EU's global leadership within ocean energy value chains is presented below.

Source: Desk research and interviews

6 EU's Global Leadership

The market for ocean energy is still nascent, the different technologies require first to mature before reaching a competitive level[21]. Currently, no specific ocean technology prevails and the sector struggles to create an EU market despite progress in development and demonstration.

Currently, the EU can be considered a global leader with 58% of the number of tidal energy technology developers being European and 61 % of the wave energy developers[22]. In addition, Europe hosts 52% of tidal and 60% of all wave energy developers and currently maintains a technological leadership position. In addition, Europe can still benefit from a first mover advantage with tidal energy: of the 16 tidal projects deployed, 15 employ European technology.

The EU is forecasted to have 93% (2,220 MW) of total tidal energy and 87.5% (432 MW) of global wave energy[23] in 2030. National and international policymakers need to focus on the successful establishment of a marine energy marketplace that includes provisions for incentives

[19] European Commission - The Blue economy Report 2020 (2020)
[20] Current share estimate at 16.5% (EUR 640 million on eUR 3.85 billion).
[21] JRC, Supply chain of renewable energy technologies in Europe (2017)
[22] European Commission - The Blue economy Report 2020 (2020)
[23] Oceanenergy Europe - 2030 Ocean Energy Vision (2020)

that will encourage the utilisation of tidal energy and help implement strategies to enhance the level of research and technology[24].

The EU is a leader in the filing of patents in international markets, seeking protection in all key markets such as the United States, South Korea, and China as well as Canada and Australia. Nevertheless, the EU receives only a small number of incoming patents applications from outside, primarily from the United States. The patent filings indicate that the EU is a net exporter of ocean energy technology and innovation, and that European wave and tidal energy developers are well positioned to exploit growth in the sector globally[25].

Currently, while a significant reduction in cost would be needed for tidal and wave energy technologies to reach their potential in the energy mix, the sector has already cut costs by 40% since 2015, faster than anticipated. A crucial but feasible step to reach commercial size by 2030 would be implementing the existing pipeline of 100 MW pilot-farms projects by 2025[26].

Ensuring access to the required rare earth metals and, for wave energy, OEM involvement, will be the most important challenges.

[24] Crowdhury ea - Current trends and prospects of tidal energy technology (2020)
[25] European Commission - The Blue economy Report 2020 (2020)
[26] European Commission - An EU Strategy to harness the potential of offshore renewable energy for a climate (2020)

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