



JRC TECHNICAL REPORT

# COMPETITIVENESS INDICATORS FOR THE LOW-CARBON ENERGY INDUSTRIES

*Definitions, indicators and data sources*

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**Contents**

Abstract .....2

1 Introduction.....3

2 What is ‘competitiveness’?.....4

3 Existing Indices - approaches to measure competitiveness.....6

4 Framework proposed by the Council of the European Union .....7

5 Framework proposed by the Clean Energy Industrial Forum.....9

6 Review of competitiveness indicators and data availability .....10

7 Conclusions – considerations for the way forward .....15

References .....16

List of abbreviations and definitions .....19

List of tables.....20

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## **Abstract**

The JRC, in the context of its support to the implementation of the Governance of the of the Energy Union, and in particular of the Research, Innovation and Competitiveness dimension and the preparation of the envisaged Competitiveness Report has been working on the identification of a set of indicators that could be used to assess the competitiveness of the EU low-carbon industry in a global context. This report presents a summary of definitions, indicators and metrics on competitiveness, and potential data sources that can be used for their quantification, based on ongoing work.

# 1 Introduction

The Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action and in particular the National Energy and Climate Plans (NECPs) call the Member states to include, where applicable, national objectives with regard to competitiveness, policies and measures related to these objectives, elements related to competitiveness (e.g. position on global market, R&D investments, patents, researchers, price elements) in the analytical basis, as well as an assessment of the impacts of the planned policies and measures on competitiveness linked to the 5 dimensions of the Energy Union.

The draft NECP submissions in 2018 revealed that the Member States had difficulty addressing the aspect of competitiveness: 21 Member States had not set any objectives. As a result they were advised to include an analysis or elaborate further and quantify in the final submission. Similarly, the evidence presented in the analytical basis was sparse. Following Commission's recommendations, the final NECPs have been improved in this aspect and now include expanded assessments on competitiveness. However, these remain very diverse in terms of the scope and context, are often generic in terms of objectives and, even when evidence is included, they do not make clear connections to their current positioning as revealed through the analytical basis.

This is not surprising, as competitiveness is a multi-dimensional concept, monitored through a number of sets of indicators including e.g. market share, investment environment, knowledge production and competence, exports, efficiency, growth, jobs, etc and often expressed in the form of rankings or indices. The assessment of the competitiveness of the EU at global level through objectives and measures in the NECPs, presents an additional challenge. Namely, it needs to take into account the impact of the collective effort of the Member States, described through their national objectives for competitiveness, to the strengths, weaknesses, synergies and knowledge sharing of the industries at EU level.

The JRC has been working on the identification of a set of indicators that can be used to measure the competitiveness of the EU low carbon industry in a global context by:

- Reviewing existing competitiveness indices and the indicators they comprise
- Assessing the relevance and data availability for application of the above indices and indicators to the low-carbon energy industries
- Selecting a number of indicators that can be included in the first instance in a competitiveness monitoring framework for the low-carbon sector
- Examining the feasibility of developing a composite indicator for the sector

The purpose of this document is to offer a summary of findings with regards to definitions, indices and metrics used to describe competitiveness, and propose potential data sources that can be used to construct selected competitiveness indicators for the low-carbon energy industries.

The Communication on the Green Deal (European Commission, 2019c) launched a strategy for a climate-neutral, resource-efficient and competitive economy. Within it, it recognises the complexity and interlinkages between sectoral policy priorities and measures taken to achieve them, and the need to exploit synergies across all areas to maintain and maximise benefits to EU competitiveness. As such, this work will support the delivery of the European Green Deal, and the New Industrial Strategy for Europe (European Commission, 2020) as the low-carbon technologies and industry will play a pivotal role in both.

## 2 What is 'competitiveness'?

There is no agreement on a universal definition of 'competitiveness'. The World Economic Forum (2004) defines competitiveness as *"the set of institutions, policies, and factors that determine the level of productivity of a country"* In this context, competitiveness does not only refer to minimising production costs and pricing, but also to the ability to innovate and stay relevant in a particular market segment within the global economy, in this instance new and sustainable energy technologies. National or industrial competitiveness traditionally refers to the ability of the nation's firms to achieve sustained success against (or compared to) foreign competitors.

With the increased globalisation of the economy, the term competitiveness has become one of the most commonly used concepts in economics. In the absence of a universally accepted definition of competitiveness, Table 1 presents a range of definitions used in literature by researchers to define the concept of competitiveness.

Competitiveness should not be confused with innovation, although both concepts are closely related. Innovation has been defined as *"the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations"* (OECD/Eurostat, 2005). Therefore, innovation can have an important effect on the competitiveness of an economy/industry, decreasing costs, increasing productivity and increasing product diversity in the global market (Sener and Saridogan, 2011).

Competitiveness can be defined and measured at different levels of economic analysis:

- mega-(global),
- macro-(regions, nations),
- meso-(industries and economic sectors); and
- micro-(firms) level.

Regardless of the level of analysis, competitiveness is conceived, and evaluated, in comparison with others. At the micro level, the evaluation of the competitiveness refers to the relative market success of a firm. At the macro level, the term competitiveness refers to a wider concept, including growth, quality of life and productivity. Despite the different levels of analysis, the basic unit of analysis of competitiveness is the "industry". A nation's industrial international competitiveness can be defined as a nation's industry *"possessing competitive advantage relative to the best worldwide competitors"* (Porter, 1990).

According to existing literature, the measure of competitiveness should satisfy three basic criteria, independently of the level of analysis:

1. It should cover all the sectors exposed to competition, i.e. represent all goods traded or are tradeable that are subject to competition and only those goods;
2. it should encompass all the markets open to competition; and
3. it should be constructed from data that allow international comparison.

In practice, none of the competitiveness indicators encountered in literature fulfil these three criteria. Data availability and other limitations lead to compromises, so that any measure of competitiveness is in fact only a rough approximation of the ideal.

**Table 1 Definitions of competitiveness from selected literature**

Author	Definition
Bobba et al.,1971	Competitiveness is the ability of nations, regions and companies to generate wealth being the precondition for high wages
Scott and Lodge, 1985	National competitiveness is a country's ability to create, produce, distribute, and/or service products in international trade while earning rising returns on its resources
Buckley et al., 1988	A firm's competitiveness means its ability to produce and sell products and services of superior quality and lower costs than its domestic and international competitors. Competitiveness is a firm's long-run profit performance and its ability to compensate its employees and provide superior returns to its owners
Porter, 1990	The only meaningful concept of competitiveness at the national level is national productivity. Competitiveness is an ability of an economy to provide its residents with a rising standard of living and a high employment on a sustainable basis
Krugman, 1994	If competitiveness has any meaning, it is simply just another way to express productivity. The ability of a country to improve its living standard depends almost entirely on its ability to raise its productivity. Competitiveness is meaningless word when applied to national economies
World Economic Forum, 1996	Competitiveness is the ability of a country to achieve sustained high rates of growth in GDP per capita.
Barker and Köhler, 1998	Country's competitiveness is the degree to which it can, under free and fair market conditions, produce goods or services meeting the test of international markets, while simultaneously maintaining and expanding the real incomes of its population over the longer term
European Commission, 2001	Competitiveness of a nation is the ability of an economy to provide its population with high and rising standards of living and high rates of employment on a sustainable basis
Porter et al., 2008	The most intuitive definition of competitiveness is a country's share of world markets for its products. This makes competitiveness a zero-sum game, because one country's gain comes at the expense of others
Chao-Hung and Li-Chang, 2010	A firm's competitiveness is its economic strength against its rivals in the global marketplace where products, services, people and innovations move freely despite the geographical boundaries
World Economic Forum, 2004	Competitiveness is the set of institutions, policies, and factors that determine the level of productivity of a country
OECD, 2015	Ability of the country to, in free and equal market conditions, produce goods and services that previously pass the test of international markets, ensuring retention and long-term increase in the real income of the population
Djogo and Stanišić, 2016	Ability of the country to maintain the balance of trade in free and fair market conditions, create jobs and provide an increase in income of the population
European Commission, 2017	Ability to offer an attractive and sustainable environment for firms and residents to live and work' (Regional Competitiveness Index)
Council of the European Union, 2020	Competitiveness is a broad term that is not clearly defined. There is no single indicator that captures the essence of its meaning for an economy. Moreover, competitiveness is often best interpreted by reference to comparisons to other entities.

Source: JRC, adapted and supplemented from (Siudek and Zawosjka, 2014).

### 3 Existing Indices - approaches to measure competitiveness

As the competitiveness concept lacks a universally accepted definition, researchers have proposed a variety of approaches to measure competitiveness, as shown by the overview of literature in Table 2.

For practical purposes, the review presented in this document classifies existing competitiveness indicators in two main categories: Global competitiveness indicators and Low-Carbon Energy Technologies (LCET) (or Green) Competitiveness indicators. Competitiveness measures can also be classified into two categories: static (assessing competitiveness level at any point of time such as the UNIDO Competitive Industrial Performance), and dynamic (assessing the changes in competitiveness over time such as the Compendium of Productivity Indicators – OECD).

Competitiveness rankings serve different purposes, highlighting various aspects such as, overall business environment, physical and knowledge infrastructure, labour market indicators, and financial markets regulation. Additionally, the development stage of the countries analysed has implications on the level of detail of the evaluation.

**Table 2 Overview of literature on practical approaches to measure competitiveness**

	Reference organisation	Index
Global Competitiveness Indicator	Cornell University, INSEAD and WIPO	Global Innovation Index (GII)
	Deloitte Global & Council on Competitiveness	Global Manufacturing Competitiveness Index
	European Commission	European Innovation Scoreboard
	Organisation for Economic Co-operation and Development (OECD)	Compendium of Productivity Indicators
	International Institute for Management Development (IMD)	World Competitiveness Rankings
	United Nations Industrial Development Organisation (UNIDO)	Competitive Industrial Performance (CIP)
	World Bank	Doing Business (DB)
	World Economic Forum	Global Competitiveness Index (GCI) / Global Competitiveness Report
Green Competitiveness Indicators	ASEM SMEs Eco-Innovation Center	ASEM Eco-Innovation Index (ASEI)
	Cleantech	Global Cleantech Innovation Index
	Dual Citizen	Global Green Economy Index
	Ernst & Young	Renewable Energy Country Attractiveness Index (RECAI)
	Organisation for Economic Co-operation and Development (OECD)	Green Growth Indicators
	Vivid Economics	G20 low carbon competitiveness report and index
	Yale Centre for Environmental Law and Policy	Environmental Performance Index

Source: JRC review of various sources

## 4 Framework proposed by the Council of the European Union

The Council of the European Union (2018a) has also emphasised the need to monitor the implementation of the industrial policy objectives and the trends in the development of the EU industry through appropriate indicators. It put forward an indicator framework regarding industrial competitiveness (Council of the European Union, 2018a,b) to choose from, based on existing Eurostat data and other official data sources and incorporating the following set of principles:

- focus on the most relevant dimensions of industrial competitiveness
- high statistical quality in terms of measurement and timeliness
- as far as data is available: focus on comparing the EU to the main global partners in addition to intra-EU comparison
- highlight areas with a need to improve competitiveness
- consist of a limited number of simple and straightforward indicators.

Table 3 provides a list of indicators put forward. These were described as non-exhaustive and proposed as part of a multi-layered structure comprising:

1. Headline indicators focusing on outcomes in the industrial sector
2. Investments as a key enabling factor
3. EU/national projects that stimulate investment activities
4. Policy related indicators to capture how the EU and its Member States perform in the relevant areas

In its continuing work the Council (2018b) linked the competitiveness of the EU industry to its ability to continuously adapt and innovate by investing in new technologies, digitalising its industrial base and transitioning to safe and sustainable low-carbon and circular economy.

The Council (2020) also recognised that the concept of competitiveness remains broad, and not clearly defined; it cannot be captured by a single indicator; and it is best interpreted by reference and comparison to others.

As such, the proposal for the policy- related indicators complementing the set of headline indicators is an indicative starting point for future adaptations and amendments. Especially with regard to the policy-related indicators, the Council called on the Commission to work on indicators related to current trends, including decarbonisation, to reveal strengths and issues for the competitiveness of EU industries (Council of the European Union, 2018a).

The indicators included in the proposed framework (Table 3) reflect many of the aspects captured by the indices listed in the previous section. The work of the Council underlines the need to frame the concept of competitiveness to the industrial sector addressed and tailor the indicator framework to the aspects most relevant to that industry that can be tracked by global, robust, and transparent data.

**Table 3 Indicator framework proposed by the European Union Competitiveness Council**

Core Areas	Indicator
Headline Indicators	Manufacturing value added per capita
	Gross value added constant prices; annual % change
	Gross value added per person employed % change (5 year MA)
	Number of employees (domestic concept), % change
	Global Market share of exported manufactures (%)
Investments	Gross Fixed Capital Formation - total% GDP
	Gross expenditure on R&D in % of GDP
	Investment rate (investment/total value added at factor costs) in %
	Private gross investments in activities of circular economy sectors in % of GDP
Policy related areas	
Research and Innovation	Total Researchers per 1.000 employees (total employment)
	Patent Applications per billion GDP
	Share of high growth enterprises in the manufacturing sector (growth by 10% or more, measured in employment)
	SMEs innovating in-house (relative to EU in 2010)
	Intellectual property products (Investment % of total Investments)
	ICT investments (Investments in % of total Investments)
	Number of installed industrial robots per 10.000 persons (in the manufacturing industry, ISIC Rev. 4 - Section C)
Skills	Share of graduates in STEM <sup>5</sup> in % of all graduates
	Adult participation in learning (% of population aged 25 to 64)
	Employment shifts in manufacturing by education
Digital economy	Digital Transformation Enablers Index
	Human Capital/digital skills
	Integration of digital Technology
Decarbonisation and Circular economy	Air emission intensities (greenhouse gases, kilograms per euro, % change)
	Trade in recyclable raw materials (nominal % change of exports and imports)
	Energy productivity GDP per unit of TPES, % change
	Eco-innovation related patents (normalised per population)
	Electricity price for medium sized industries
Single Market	Intra-EU28 trade in goods and services (% change, imports and exports)
	Intra-EU trade in intermediate goods (% share of intra-EU imports and exports)
	Price dispersion across Member States (coefficient of variation)
International Dimension	Domestic value added in gross exports (% total value, p.p. change)
	Stock of FDI inward, % of GDP (manufacturing)
	Stock of FDI outward, % of GDP (manufacturing)

Source: adapted from Council of the European Union (2018a,b)

## 5 Framework proposed by the Clean Energy Industrial Forum

In the context of the Clean Energy Industrial Forum (CEIF) on Renewables, following the input from the High-level Meeting on the 9th January 2018, the Commission has prepared a list of concrete proposals and policy recommendations on tracking the competitiveness of the European renewable energy industry (European Commission, 2019b). Table 4 presents the proposed indicators with additional notes on data sources and availability for their construction as assessed by the JRC.

**Table 4 Proposed indicators in the context of the CEIF and indicative data sources**

Indicator	Data Sources
Energy costs	IEA World Energy Prices European Commission (2019a) - Energy Prices and Costs in Europe Eurostat energy prices (nrg_pc_202), (nrg_pc_203), (nrg_pc_204), (nrg_pc_205)
Levelised cost of energy	EurObserv'ER for renewable technologies. Low Carbon Energy Observatory <sup>1</sup> and related JRC work IRENA Global Trends in Renewable Energy Costs
Number of (new) jobs in the renewable energy sector	EurObserv'ER for employment in renewable technologies IRENA Renewable Energy Employment Eurostat employment in the environmental goods and services sector (env_ac_egss1) for renewables and energy efficiency and research Data could be provided by industry associations <sup>2</sup> .
Gross Value Added and growth rate/ year	Data could be provided by industry associations <sup>2</sup> . Eurostat value added in the environmental goods and services sector (env_ac_egss2) for renewables and energy efficiency and research The Added Value reported by companies active in the sector in their financial statements can be used as a proxy; GVA can also be estimated using metrics such as turnover, cost of goods and employees etc.
Amount and turnover of (new) companies active in the renewable energy sector	EurObserv'ER for renewable technologies. Data could be provided by industry associations <sup>2</sup> . The indicator could be constructed using information from company statements or 'aggregator' databases (public administration or commercial) containing company financial information.
EU share of global manufacturing, engineering and design	Ideally, data would be provided by the industry associations <sup>2</sup> . Low Carbon Energy Observatory Technology Market Reports <sup>1</sup>
Trade statistics as a proxy for market share and technology dependency	Data available at HS Code level from: Eurostat Comext and UN Comtrade The JRC <sup>3</sup> has developed a concordance between HS Code and Technology, used for the compilation of datasets provided by EurObserv'ER Additional codes could be explored for materials.
Deployment and share of renewable industries	IRENA Renewable Electricity Capacity and Generation Statistics Eurostat - Primary production of energy (nrg_bal_c) - Supply, transformation and consumption of electricity (nrg_105a) - RES share per sector (sdg_07_40) - Installed electrical capacity (nrg_113a)
Competitiveness of renewables globally	Ranking and Change of Ranking of Companies in each sector against global competition. (Development of global impact) Could be sourced from relevant indices and/or scoreboards based on the selected metric.

1. Reports prepared by the Joint Research Centre (JRC) are available at the JRC Science Hub and SETIS websites

2. See for example (WindEurope 2017). Local impact, global leadership - The impact of wind energy on jobs and the EU economy; and (Solar Power Europe 2017). Solar PV Jobs & Value Added in Europe

3. (JRC, 2017). EU energy technology trade: Import and export

Source: JRC adapted from European Commission (2019b)

## 6 Review of competitiveness indicators and data availability

Table 5 presents an overview of indicators currently under consideration by the JRC for the definition and evaluation of the competitiveness of the low-carbon energy industries. Data availability remains the major limitation for the analytical evaluation of competitiveness and its quantification through a set of indicators. Existing data classifications often do not differentiate between low-carbon or conventional energy activities. In addition the definition of what 'low-carbon' or 'clean energy' entails differs across literature and data sources, and thus the group of actors covered, and underlying estimation methods also differ. The table lists indicative data sources and proxies for the indicators, the available granularity of the data, and the geographical coverage. It also lists the level of disaggregation of data per technology as available in the different data sources:

- 0 – No breakdown,
- 1 – Energy,
- 2 – Low-carbon energy,
- 3 – Renewables (aggregated),
- 4 – Renewables disaggregated for wind and solar technologies,
- 5 – Renewables disaggregated for all the technologies.

The indicators are preliminarily further classified under 12 pillars (indicated in the first column of Table 5) describing the different aspects of competitiveness broadly grouped under six headings:

- Factor conditions:
  - 1. National Competitive Environment
  - 2. National Competitive Conditions
  - 3. National LCET conditions
- Demand conditions:
  - 4. Market Conditions LCET/Technology
  - 5. R&I conditions LCET/Technology
- Related & supporting industries:
  - 6. Market and production conditions in related and supporting industries
  - 7. R&I conditions related and supporting industries
- Firm strategy, structure and rivalry:
  - 8. Firm strategy, structure and rivalry LCET/Technology
  - 9. Investment environment LCET/Technology
- Environmental awareness:
  - 10. Environmental concern
- Governmental support:
  - 11. Public Investment per LCET
  - 12. Governmental supportive environment

**Table 5 Extended overview of indicators on the competitiveness of low-carbon energy technology industries, indicative data sources and availability (non-exhaustive)**

	<b>Indicator / Index</b>	<b>Indicative source</b>	<b>Description</b>	<b>All Countries</b>	<b>EU</b>	<b>EU Countries</b>	<b>Technology</b>
<b>National Competitive Environment</b>	Labour productivity and unit labour costs	EUROSTAT	Average cost of labour per unit of output produced.	NO	YES	YES	1
	Labour productivity and unit labour costs	OECD	Average cost of labour per unit of output produced.	YES	NO	YES	1
	GDP per hour worked	OECD	GDP per hour worked (labour productivity)	YES	NO	YES	1
	GDP per capita	EUROSTAT	Ratio of real GDP to the average population.	NO	YES	YES	0
	GDP per capita	OECD	Ratio of real GDP to the average population.	YES	YES	YES	0
	Labour productivity per Unit Labour	OECD	Labour per unit of output produced.	YES	NO	YES	1
	Employment in high- and medium-high technology sectors.	EUROSTAT	Employment in high- and medium-high technology sectors.	NO	YES	YES	1
	Regional economic growth	EUROSTAT	Regional economic growth	NO	YES	YES	0
	Regional economic growth	OECD	Regional economic growth	YES	NO	YES	0
	Energy costs	EUROSTAT	Electricity prices for industrial consumers.	NO	YES	YES	0
	Energy costs	IEA	Electricity prices for industrial consumers.	YES	NO	YES	0
	Competitive Industrial Performance (selection)	CIP	Macroeconomic Indicator - Global Competitiveness Index (selection)	YES	NO	YES	0
	Global Innovation Index	GII	Macroeconomic Indicator - Global Innovation Index (selection)	YES	NO	YES	0
	Global Manufacturing Competitiveness Index (selection)	GMCI	Macroeconomic Indicator - Ranking of nations in terms of current and future manufacturing competitiveness.	YES	NO	YES	0
EU Regional Competitiveness Index	EU	EU Regional Competitiveness Index (selection)	NO	NO	YES	0	
<b>National Competitive Conditions</b>	Global Competitiveness Index (selection)	GCI	Macroeconomic Indicator - Global Competitiveness Index (selection)	YES	NO	YES	0
	Global Innovation Index	GII	Macroeconomic Indicator - Global Innovation Index (selection)	YES	NO	YES	0
	Global Manufacturing Competitiveness Index (selection)	GMCI	Macroeconomic Indicator - Ranking of nations in terms of current and future manufacturing competitiveness.	YES	NO	YES	0
	EU Regional Competitiveness Index	EU	EU Regional Competitiveness Index (selection)	NO	NO	YES	0

<b>National LCET conditions</b>	Employment in the renewable energy sector by technology.	IRENA EurObserv'ER EUROSTAT	Renewable Energy Employment for employment in renewable technologies (env_ac_egss1) for RES energy efficiency and research Data could be provided by industry associations	YES	YES	YES	3
	LCET/Technology Installed capacity	IRENA, IEA	Renewable energy installed capacity and electricity generation.	YES	YES	YES	5
	Availability of the resource	EMHIRES	Wind and PV	NO	YES	YES	4
<b>Market Conditions LCET/Technology</b>	LCET/Technology Investment by region	IRENA	Renewable energy investment across regions.	YES	YES	YES	5
	LCoE per technology by country	IRENA	LCoE per technology across regions.	YES	YES	YES	5
	Carbon and energy intensity of electricity/energy/industry	IEA EC, EEA	CO2 intensity of energy mix (CO2/TPES) EU energy statistical pocketbook and country datasheets	YES	YES	YES	0
	Price of conventional fuel sources	EUROSTAT IEA EC	Energy prices IEA Energy Prices and Taxes Statistics Energy prices and costs in Europe				
	Industrialisation Intensity	CIP	Macroeconomic Indicator - Industrialisation Intensity	YES	NO	YES	0
	Share of medium and high-value LCET manufactured value added	UNComtrade	Share of medium and high-value LCET manufactured value added in total manufacturing value added	YES	YES	YES	5
	Share of medium and high-value LCET manufactured value added	COMEXT	Share of medium and high-value LCET manufactured value added in total manufacturing value added	YES	YES	YES	5
	Share of medium and high-value LCET exports	UNComtrade	Share of medium and high-value manufactured exports share in total manufactured exports in LCET	YES	YES	YES	5
	Share of medium and high-value LCET trade	COMEXT	Share of medium high-value LCET trade share in total manufactured trade	YES	YES	YES	5
	Turnover LCET/Technology	EurObserv'ER for RES	Data could be provided by industry associations. Information from company statements or 'aggregator' databases containing company financial information.	YES	YES	YES	5
	Gross Value Added (GVA) LCET/Technology	EUROSTAT	(env_ac_egss2) for RES, energy efficiency and research Data could be provided by industry associations. Added Value from financial statements can be used as a proxy	YES	YES	YES	5
	LCET finance flow	IRENA	Finance flows linked to renewable energy project assets	YES	YES	YES	3
	Imports/Exports LCET/Technology per GDP	COMEXT	Imports/Exports LCET/Technology	YES	YES	YES	5
Imports/Exports LCET/Technology per GDP	UNComtrade	Imports/Exports LCET/Technology	YES	YES	YES	5	
<b>R&amp;I conditions LCET/Technology</b>	Patent in LCET/Technology (per GDP)	JRC SETIS	Patent per Technology based on Patstat data.	YES	YES	YES	5
	The EU Industrial R&D Investment Scoreboard	JRC	Top corporate R&D investors per sector.	YES	YES	YES	1/2
	R&D personnel by sector	EUROSTAT	Share of R&D personnel by: business enterprise; government; higher education; and private non-profit.	NO	YES	YES	0
	R&I expenditure in LCET (per GDP)	JRC SETIS	R&I in LCET from resident companies	NO	YES	YES	5

<b>Market and production conditions in related and supporting industries</b>	Share of medium and high-value related and supporting industries manufactured value added	UNComtrade	Share of medium and high-value related and supporting industries manufactured value added in total manufacturing value added	YES	YES	YES	5
	Share of medium and high-value related and supporting industries manufactured value added	COMEXT	Share of medium and high-value related and supporting industries manufactured value added in total manufacturing value added	YES	YES	YES	5
	Share of medium and high-value related and supporting industries exports share	UNComtrade	Share of medium and high-value manufactured related and supporting industries exports share in total manufactured exports	YES	YES	YES	5
	Share of medium and high-value related and supporting industries manufactured trade	COMEXT	Share of medium and high-value related and supporting industries trade share in total manufactured trade	YES	YES	YES	5
<b>R&amp;I conditions related and supporting industries</b>	R&I Investment in related/supporting technologies	JRC SETIS	Top corporate R&D investors per related/supporting sector.	YES	YES	YES	
	R&I Investment in related/supporting technologies	JRC SETIS	R&I in related/ supporting LCET from resident companies	YES	YES	YES	
	R&D personnel by sector	EUROSTAT	Share of R&D by: business enterprise; government; higher education; and private non-profit.	NO	YES	YES	0
	Patent related and supportive technology	JRC SETIS	Patent in supporting technologies, based on Patstat.	YES	YES	YES	0
<b>Firm strategy, structure and rivalry LCET/Technology</b>	Number of firms in the value chain	various	Data could be provided by industry associations. Information from company statements or 'aggregator' databases containing company financial information.	YES		YES	0
	Firm's size / employees	various	Data could be provided by industry associations. Information from company statements or 'aggregator' databases containing company financial information.	YES		YES	0
	LCET/Technology market size	UNComtrade	Demand for LCET/Technology for own consumption and export	YES	YES	YES	5
	LCET/Technology market size	COMEXT	Demand for LCET/Technology for own consumption and export	YES	YES	YES	5
	Number of innovative companies in LCET/Technology	CIS	The Community Innovation Survey (CIS) provides information on the innovativeness of sectors by type of enterprises.	NO	YES	YES	0
<b>Investment environment LCET/Technology</b>	Corporate greenfield FDI	various	Aggregators / databases of cross-border greenfield FDI	YES	YES	YES	5
	Corporate brownfield FDI	various	Aggregators / databases of cross-border brownfield FDI in LCET	YES	YES	YES	5
	Green bonds (over total security assets)	various	Aggregators / databases of Green Bonds investments in LCET	YES	YES	YES	5
	Sovereign Wealth Funds	various	Aggregators / databases of Sovereign Wealth Funds worldwide	YES	YES	YES	5
	Doing Business	World Bank	Easiness of doing business in a country	YES	YES	YES	5

<b>Environmental concern</b>	Environmental Performance Index	Yale	Environmental Performance indicators across ten categories.	YES	YES	YES	0
	Percent of population perceiving climate change as a priority	EC	Eurobarometer public opinion surveys on Climate change	YES	YES	YES	0
	Global Green Economy Index -Perception Rank	DUAL CITIZEN	Indicators on climate change, efficiency sectors, markets & investment and the environment.	YES	YES	YES	0
	Global Green Economy Index - Performance Rank	DUAL CITIZEN	Indicators on climate change, efficiency sectors, markets & investment and the environment	YES	YES	YES	0
<b>Public Investment per LCET</b>	Public R&I investment in LCET/Technology	IEA	IEA Members report public investments on energy RD&D	YES	YES	YES	4
	Public R&I investment in LCET/Technology	JRC SETIS	JRC is collecting IEA and additional information for the State of the Energy Union reports.	YES	YES	YES	5
<b>Governmental supportive environment</b>	Environmentally related taxation/support mechanisms (FIT, FIP,..)	RES LEGAL EU website various	Information on all EU Member States, the EFTA Countries and some EU Accession Countries. e.g. feed-in tariffs for solar, wind, geothermal etc.	NO	YES	YES	5
	Governmental commitment towards LCET/Technology	IRENA	Information on the adoption of renewable energy targets worldwide. It covers targets by country and type.	YES	YES	YES	5
	Renewable Energy Auctions	IRENA	Renewable Energy Auctions report with updates on this mechanism for price discovery and market development.	YES	YES	YES	5
	European Quality of Government Index	Quality of Government Institute	Institutional quality available at the regional level in the European Union	NO	YES	YES	0

Source: JRC review of various sources

## 7 Conclusions – considerations for the way forward

- Competitiveness is a multi-dimensional concept with no universal definition; it can be applied and measured at different levels of economic analysis.
- Regardless of the adopted definition and level of analysis, competitiveness is conceived, and evaluated, in comparison to the performance of others.
- National or industrial competitiveness traditionally refers to the ability of the nation's firms to achieve sustained success against (or compared to) foreign competitors.
- As such it is necessary to clarify whether the EU is examined vs other leading economies, the performance of individual Member States is regarded in the global context, or Member State performance is compared vs others and the EU average to reveal specialisation and opportunities for collaborations and best practice or knowledge transfer. Alternatively, the competitiveness of technologies/industries operating in the same market can be assessed.
- The majority of existing competitiveness indices are composite indicators built on a number of variables. They address countries or geographical areas (i.e. Europe) rather than the EU as one entity and cover the entire economy and not specific sectors (i.e. low-carbon industry).
- Not all of the indices or underlying datasets are available at the desired level of granularity. In addition many may not be consistently updated.
- Given the review of indicators and data availability the following headings and indicators could initially be considered within a framework evaluating the competitiveness of the low-carbon industries
  - Market (installed capacity, generation, global shares)
  - Price elements (LCoE, energy costs and prices, taxes, subsidies)
  - Sector turnover and GVA (growth)
  - Trade (imports, exports, global shares, dependency)
  - Efficiency (energy, carbon or resource intensity)
  - R&I investment (public and private)
  - Patenting trends (specialisation)
  - Number of (new) jobs
  - Knowledge and competence (publications, researchers, training)
  - Investment environment (investments, FDI, financing measures)
  - Number of (new) companies
- Further work is needed on the selection and construction of indicators, the quality, coverage and consistency of data sources and the grouping of the indicators so as to focus on specific aspects of competitiveness.
- The construction of an index may be helpful in monitoring the progress and position of various low-carbon industries with regards to competitiveness through a single metric.

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## List of abbreviations and definitions

ASEI	ASEM Eco-Innovation Index
ASEM	SMEs Eco-Innovation Center
CIP	Competitive Industrial Performance
CIS	Community Innovation Survey
COMEXT	Eurostat's reference database for detailed statistics on international trade in goods
DB	Doing Business
EC	European Commission
EEA	European Environmental Agency
EFTA	European Free Trade Association: Iceland, Liechtenstein, Norway and Switzerland
EPI	Environmental Performance Index
EU	European Union
EurObserv'ER	EurObserv'ER project, by Observ'ER / ECN / Renac / Frankfurt School / Fraunhofer ISI for the European Commission
EUROSTAT	Statistical Office of the European Communities
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GII	Global Innovation Index ( )
GMCI	Global Manufacturing Competitiveness Index
ICT	Information and communication technology
IEA	International Energy Agency
IMD	International Institute for Management Development (IMD)
IRENA	International Renewable Energy Agency
LCEO	Low Carbon Energy Observatory
LCET	Low Carbon Energy Technologies
OECD	Organisation for Economic Co-operation and Development
PRODCOM	"PRODUCTION COMMUNAUTAIRE" statistics on the production of manufactured goods
RECAI	Renewable Energy Country Attractiveness Index
STEM	Science, technology, engineering and mathematics
SWD	Staff Working Document
UNComtrade	United Nations Comtrade database
UNIDO	United Nations Industrial Development Organisation
WEF	World Economic Forum

**List of tables**

**Table 1** Definitions of competitiveness from selected literature ..... 5

**Table 2** Overview of literature on practical approaches to measure competitiveness ..... 6

**Table 3** Indicator framework proposed by the European Union Competitiveness Council ..... 8

**Table 4** Proposed indicators in the context of the CEIF and indicative data sources ..... 9

**Table 5** Extended overview of indicators on the competitiveness of low-carbon energy technology industries, indicative data sources and availability (non-exhaustive) .....11

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