European Commission

First Report on the Clean Energy Innovation Index

Provision of technical assistance and study to support the development of a composite indicator to track clean-energy innovation performance of EU members

Independent Expert Report

Jessica Yearwood, Trinomics
Perla Torres, Trinomics
Natalie Janzow, Trinomics
Anna Kralli, Trinomics
March 2021

Research and Innovation

First Report on the Clean Energy Innovation Index

European Commission
Directorate-General for Research and Innovation
Directorate C — Clean Planet
Unit C.1 — Clean Energy Transition
Contact Daniele Poponi
Email daniele.poponi@*ec.europa.eu*
RTD-PUBLICATIONS@ec.europa.eu
European Commission
B-1049 Brussels

Manuscript completed in March 2021.

This document has been prepared for the European Commission, however it reflects the views only of the authors, and the European Commission shall not be liable for any consequence stemming from the reuse.

More information on the European Union is available on the internet (http://europa.eu).

PDF	ISBN 978-92-76-38683-4	doi:10.2777/351069	KI-02-21-752-EN-N

Luxembourg: Publications Office of the European Union, 2021

© European Union, 2021

The reuse policy of European Commission documents is implemented by Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Unless otherwise noted, the reuse of this document is authorised under a Creative Commons Attribution 4.0 International (CC-BY 4.0) licence (https://creativecommons.org/licenses/by/4.0/). This means that reuse is allowed provided appropriate credit is given and any changes are indicated.
For any use or reproduction of elements that are not owned by the European Union, permission may need to be sought directly from the respective rightholders.

EUROPEAN COMMISSION

First Report on the Clean Energy Innovation Index

Provision of technical assistance and study to support the development of a composite indicator to track clean-energy innovation performance of EU members

Trinomics

In association with:

Science-Metrix

cambridge econometrics
clarity from complexity

2021

Directorate-General for Research and Innovation
Clean Energy Transition

EN

Table of Contents

Abbreviations

AC	Air conditioning
CCMTs	Climate change mitigation technologies
CCS	Carbon capture and storage
CCU	Carbon capture and utilisation
CCUS	Carbon capture utilisation and storage
CEII	Clean energy innovation index
CET	Clean energy technology
CO_2	Carbon dioxide
DEA	Data envelopment analysis
EC	European Commission
EU	European Union
EV	Electric vehicles
FCV	Fuel cell vehicles
GDP	Gross domestic product
GHG	Greenhouse gas
$HCP_{10\%}$	Highly cited publications (those among the 10 % most cited)
HEV	Hybrid electric vehicle
HVP/GDP	High value inventions per unit of GDP
ICE	Internal combustion engine
ICT	Information and communications technology
JRC	Joint Research Centre
JRC-COIN	Joint Research Centre - Competence Centre on Composite Indicators and Scoreboards
KA(s)	Key action(s)
LEDs	Light emitting diode
MI	Mission Innovation
MS(s)	Member State(s)
N/A	Not available
OECD	Organisation for Economic Co-operation and Development
PC	Principal components
PCA	Principal component analysis
PV	Photovoltaic
R&I	Research and innovation
SCP	Number and share of publications cited in patents
SET Plan	European Strategic Energy Technology Plan
ToR	Terms of Reference
UN	United Nations
VA	Value added
WEC	Weighted eigenvector centrality

1 Introduction

This report is a deliverable of the study to support the development of a composite indicator to track clean energy innovation performance of European Union (EU) member states and Mission Innovation (MI) members, which contributes to the overarching aim of assessing progress in clean energy innovation by analysing output-related indicators.

Aim of the Clean Energy Innovation Index

The composite indicator (also known as the 'clean energy innovation index' or CEII) covers three dimensions: scientific publications, patents and trade. The primary objectives of the CEII are three-fold:

- To **track clean energy innovation performance** of EU Member States and Mission Innovation members for the 4+2 priorities of the R&I and competitiveness dimension of the Energy Union, and identify technology-related trends relevant to the RIC pillar of the Energy Union;

- To support the following European Commission (EC) policy instruments or initiatives:
    - Accelerating Clean Energy Innovation;
    - State of the Energy Union report;
    - Strategic Energy Technology Plan.

- To contribute to the Tracking Progress work stream of the Mission Innovation initiative.

The intended audience for the CEII includes policy makers, the research community, the sustainable energy industry and the general public.

Structure of this report

This report covers the work on the methodology and calculation of the CEII and has the following objectives (as detailed in the Terms of Reference [ToR]):

1. Provide the detailed methodological approach to develop the CEII based on the data collected for scientific publications, patents and trade in previous work packages;
2. Provide an outline for updating preliminary CEII calculations, and describe the calculations that will be detailed and analysed in the final version of the report.

The report is structured according to these objectives. In chapter 2, we discuss the conceptual framework for the CEII, by introducing the policy context and describing the existing methods for measuring clean energy innovation. The distinction between the three dimensions that constitute CEII is stressed and the challenges for the construction of the composite index are also discussed.

In chapter 3, the methodological steps applied for the construction of the CEII, based on principles set out by the OECD and the EC Joint Research Centre (JRC)[1] are also detailed. Chapter 4, in the next version of the report, will provide insights on the CEII results at country level, as well as at SET Plan and technology level. Preliminary CEII calculations are not included in this version of the report, as incomplete patents data for 2017 is skewing the first round of results. Calculations will be updated when complete patents data for 2017 is made public, and CEII results will be published once more robust analyses can be developed.

---

1 OECD, 2008. Handbook on Constructing Composite Indicators: Methodology and User Guide.

2 CEII Conceptual Framework

This section provides the conceptual framework behind the index. This section begins with an introduction to the policy context and explanation of the overall framework to measure innovation related to clean energy technology (CET). We then focus on the aspects that can be measured given the current data constraints.

2.1 The policy context

The EC established the Energy Union in 2015 with the aim of providing European citizens with secure, sustainable and affordable energy, while positioning Europe at the forefront of the global renewable energy market.[2] Although the work undertaken in this project is relevant to all five pillars of the Energy Union, it focuses on the fifth pillar, that is the research, innovation and competitiveness aspects.

The SET Plan was established to help boost Europe's transition towards a climate neutral energy system with the ultimate goal of fundamentally transforming Europe's energy system in a cost-effective way.[3] In doing so, the SET Plan will deliver on the priorities of the Energy Union by identifying and implementing nine key actions. Accordingly, the CEII must depict progress along each of these nine key actions in monitoring the progress of European and Mission Innovation member countries[4] towards the SET Plan's objectives (especially those focused in R&I performance). This highlights a key limitation in selecting the indicators to be chosen in building the CEII, that is, the data sources must enable the indicators to be disaggregated by each of the SET Plan key action.

Box 1 The SET Plan

The SET Plan supports research and innovation policies that create an **open innovation** ecosystem that capitalises on the results of research and **open science**.[5] It also favours transparency and exchange of information to avoid unnecessary duplication of efforts and to stimulate **cooperation and coordination between Member States**.[6] It also wishes to build synergies between European and national programmes, especially **joint investment programmes** in order to leverage **investment from the private sector**.[7] In the final stage of innovation, regulatory measures are essential to guarantee **large scale market uptake and successful commercialisation of innovation**.[8] **The public also needs to be informed and educated** on how to transition to more efficient energy systems and on how to optimise its energy consumption. European citizens and civil society, as energy consumers, are expected to actively participate in the energy transition and to benefit from it.[9]

The SET Plan is based on the principle that researchers and companies should be supported through public action, not only to conduct basic research, but all the way through the innovation chain, including the market uptake of innovation. The **private sector**, especially energy producers and suppliers, **is expected to innovate**,[10] and is therefore **also expected to participate in funding its own**

[2] European Commission, 2015a. A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy: pp. 4–17.
[3] European Commission, 2015b. Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation: p. 2.
[4] The EU is not included in the CEII for MI (as a group) in order to avoid double counting of European countries.
[5] European Commission, 2015b: p. 3.
[6] Ibid. p. 9.
[7] Ibid. p. 4.
[8] Ibid. p. 16.
[9] Ibid. p. 11.
[10] Ibid. p. 2.

innovation, which it will ultimately benefit from, since energy efficiency is now seen as a **business opportunity** that will make Europe more competitive.[11] It also aims to reduce the **cost of energy** for European citizens and organisations.[12] The EC wishes to strengthen the financial commitment from Member States as well as the private sector. At the moment, the EC grants large sums of money to energy-related research, in collaboration with the private sector (through Public-Private Partnerships, for example).[13] In the final stage of innovation, **risk-financing** is also necessary to ensure that innovation gets successfully commercialised at a large scale.[14]

The collaboration aspect has already been mentioned in this report, but its importance should not be neglected. The EC stresses the **necessity of Member States collaborating** not only **among themselves**, but also with the EU **and with other countries** globally. The **public** and the **private** sectors are also strongly encouraged to **collaborate together**. **Collaborations should be fostered throughout the innovation chain**, from funding and conducting basic research, to adapting research to applications, all the way to commercialising the applications for large scale market uptake. The EC wishes **all stakeholders** with common interests and mutual benefits **to coordinate their research, funding and innovation activities** to avoid unnecessary duplication of efforts.[15] In its communication titled "Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation", the EC states: "The aim is to avoid working in silos."[16]

The SET Plan's documentation mentions **policy, funding and collaboration** as three essential aspects to implement the SET Plan's innovation goal. These three aspects are intertwined throughout all stages of research, innovation and commercialisation of innovation.

The dimensions highlighted in the previous paragraphs are key to the successful implementation of the SET Plan from its inputs to its longer-term social, economic, and environmental impacts.

2.2 Measuring clean energy innovation

A theoretical framework is the starting point in the construction of a composite indicator, given that theory can play a key part in guiding the choice for the multi-dimensional structure. However, measuring innovation is very complex and challenging. There are several complex models to measure innovation in academic literature. National innovation systems have, for example, been modelled on a so-called triple-helix, with innovation occurring in three different sectors (academic, governmental and private) and involving a complex set of interactions between them[17]. In essence, these more complex models emphasise that the innovation system cannot be readily understood without its complex interactions between heterogeneous actors, which can be captured through network

[11] Ibid. p. 6.
[12] European Commission, 2015a: p. 2, 11.
[13] European Commission, 2015b: p. 15.
[14] Ibid. p. 14.
[15] Ibid. p. 8.
[16] Ibid. p. 2.
[17] See, for example, Lowe (1982); Leydesdorff & Etzkowitz (1998); OECD (2010); Hekkert et al. (2017).

indicators, as well as its multiple feedback loops, which are much more difficult to grasp[18] through the simple use of indicators.

As such, there are a number of aspects that play a role in a measurement framework for the CEII. For instance, one can make a clear distinction between the wider framework conditions that are conducive to innovation (e.g., indicators of macro-economic stability, basic scientific skills, business regulations, infrastructure and financial markets), innovation indicators per se (i.e., which are covered broadly in this study, including those part of the CEII), and the social, economic and environmental outcomes to which innovation contributes. Note that the triple-helix nature of the innovation process can also be captured through integration of network indicators (e.g., joint investment programmes, public/private co-publications) across the different stages (e.g., inputs, throughputs, and outputs) of the innovation chain.

Others have attempted to create measurement frameworks for innovation: including the conceptual models of the Innovation Output Indicator 2017[19], the European Innovation Scoreboard 2018[20] and the Global Innovation Index[21]. Existing indicators tend to follow the linear model of innovation while incorporating interactions between government, academia and industry in specific indicators in the different sections of the innovation chain. The European Innovation Scoreboard, for example, captures framework conditions, investments, innovation activities and impacts; while the Global Innovation Index is split between innovation input and output sub-indices.

The measurement framework should be informed by R&I policies specific to clean energy innovation since the purpose of the future index is to track clean energy innovation performance of EU Member States and Mission Innovation countries for each of the SET Plan key actions. The goal is to build a solid knowledge base on progress towards the 4+2 priorities of the R&I and competitiveness dimension of the Energy Union. However, many of the necessary indicators to be included in an 'ideal' measurement framework for innovation are not readily available and difficult to produce with existing data for each SET Plan key action.

This project focuses on three core output-related dimensions represented by scientific publications, patents and trade statistics to evaluate the EU's and MI countries performance in clean energy innovation.

2.3 Dimensions of the Clean Energy Innovation Index

Given that one of the key drivers for this index is the need to access complete and robust data by SET Plan key action, the CEII focusses on three dimensions for which relevant indicators and data are available by key action; several other relevant indicators are not available at the required level of disaggregation. The dimensions cover the core R&I activities from research to market innovation:

- **Scientific publications** - bibliometrics are an effective way of tracking the scientific output and impact of any entity conducting and/or funding research, particularly basic and applied research;
- **Patents** – the ability to patent an invention is a clear sign of successful innovation activity;

[18] Understanding such feedback loops require more advanced statistical modelling (for example using structural equation modelling) which cannot be summarised in a composite indicator. Such modelling is beyond scope of the CEII.
[19] Vertesy, D., 2017. The Innovation Output Indicator 2017: Methodology Report.
[20] European Commission, 2018. European Innovation Scoreboard 2018.
[21] Cornell University, INSEAD, and WIPO, 2019. Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation. Appendix I The Global Innovation Index Conceptual framework: pp. 205-212.

- **Trade** - international trade provides a useful measure of the market uptake of clean energy technologies (CET) and development of the technological sectors.

The three dimensions are grouped into the CEII (or, the scientific publications and trade dimensions into the simplified CEII[22]). Figure *1* provides the structure of the index and the indicators considered (resulting from the different Work Packages).

Disaggregation of the different dimensions

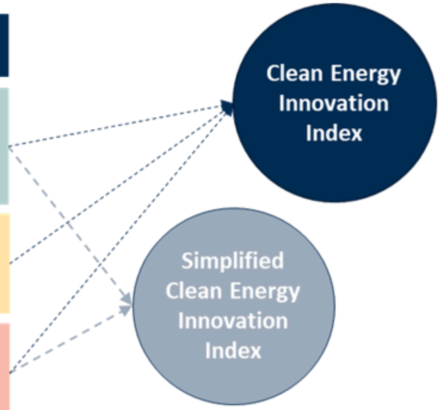
Each of the dimensions is disaggregated by sub indicator, but also according to the SET Plan key actions, and by the technologies included in the SET Plan key action "Performant renewable technologies integrated in the system- Reduce technology costs". The figure below, adapted from the EC JRC's report[23], outlines the scope of clean energy research/technologies to be covered by each of the nine SET Plan key actions for the publication, patent and trade data. Annex 1 of the JRC's report provides the more detailed definitions of the SET Plan key actions.

[22] During the construction of the CEII, we will assess the statistical coherence, robustness and sensitivity of both the CEII and simplified CEII. The aim will be to ensure that the simplified index encompasses the most relevant information to measure clean energy innovation.

[23] Fiorini et al., 2017. Monitoring R&I in low-carbon energy technologies.

Figure 1 Key dimensions of the Clean Energy Innovation Index

Source	Sub-indicators	Dimension
Scopus (Elsevier) World Bank	• Share of highly cited publications (those among the 10 % most cited) normalised (HCP10%) • Number of publications per capita (Pubs/pop)	Publications
JRC datasets based on PATSTAT	• Number of patents per unit of GDP (Pat/GDP) • Number of high value patents per unit of GDP (HVP/GDP) • Number of international patents per unit of GP (Int Pat/GDP)	Patents
Comtrade database OECD Trade in Value Added database	• CET exports vs GDP (clean energy tech exp/GDP) • Value Added vs exports (VA/exports)	Trade



Supporting dashboard of indicators		
Scopus (Elsevier) 1findr (1science) World Bank	• Number of publications in fractional counting per 1,000,000 population • Specialisation index • Share of international co-publications • Share of public/private co-publications • Share of open access publications • Share of highly cited publications at the 10% level	Publications
JRC datasets based on PATSTAT	• Inventions (abs. and per unit of GDP) • Granted inventions (abs. and per unit of GDP) • High value inventions (abs. and per unit of GDP) • International inventions (abs. and per unit of GDP)	Patents
Comtrade database (+ Comext database for EU MSs)	• CET exports vs GDP • Value Added vs exports • CET exports vs prod • High-tech export	Trade

Disaggregated by SET Plan Key Actions

01 & 02. Performant renewable technologies - Reduce costs
03. New technologies & services for consumers
04. Resilience & security of the energy system
05. New materials & technologies for buildings
06. Energy efficiency in industry
07. Competitive in global battery sector (e-mobility)
08. Renewable fuels
09. Carbon capture Utilisation and Storage (CCS/U)
10. Nuclear safety

Disaggregated by SET Plan Key Action Performant Renewable Technologies

1. Solar energy
2. Geothermal Energy
3. Hydroenergy
4. Ocean Energy
5. Wind energy

Note: Trade dimension data on Key action 6. Energy efficiency in industry, and in Performant Renewable Technology 4. Ocean was not available.

Table 1 Mapping of topics within the Energy Union R&I and Competitiveness priorities, produced by SETIS[24]

Energy Union R&I priority	SET Plan (key actions)	Publications technologies	Patents technologies	Trade technologies
Number 1 in renewables	1. Performant renewables	Solar energy	Solar energy (PV + Concentrated solar power)	Solar energy (PV+ Solar thermal)
		Wind	Wind	Wind
		Hydropower	Hydropower	Hydropower
		Geothermal	Geothermal	Geothermal
		Ocean	Ocean	N/A
Smart system – Smart EU energy system with consumers at the centre	3. New technologies & services for consumers[25]	Energy management systems (including smart meters) and ICT	Efficient end-user side electric power management and consumption & Others	Smart meters
		Heating, cooling and ventilation technologies (including AC, water heaters	Energy efficient heating, ventilation or air conditioning	N/A
		Lighting technologies and control systems (including halogen lamps, LEDs)	Energy efficient lighting technologies	N/A
		Residential and commercial building appliances and equipment (including batteries for portable devices)	Home appliances & elevators, escalators and moving walkways	N/A

[24] Table adapted from Fiorini et al. (2017), in which this allocation was applied to the extent made possible by the structure and granularity of publicly available data.

[25] Based on the JRC's mapping of CPC codes to the SET Plan key actions, KA-2 covers smart solutions for energy consumers and new technologies aimed at improving/reducing energy consumption. In this scheme, aspects of smart applications, tools and integrated energy management for consumers, as well as energy efficient technologies (LEDs/halogen lamps) are considered.

		N/A	ICT aiming at the reduction of own energy use & Market activities	N/A
		N/A	Systems supporting end-user of stationary applications & in the sector of transportation	N/A
	4. Resilience & security of the energy system[26]	Combustion technologies, coal, oil and gas	Combustion technologies with mitigation potential	Clean coal & gas
		Electric power generation	Adapting or protecting infrastructure or their operation in energy generation or distribution	N/A
		Electricity transmission and distribution	Efficient electrical power generation, transmission or distribution	
		N/A	Enabling technologies to GHG emissions mitigation and Others	
		Grid communication, control systems and integration	Systems supporting electrical power generation, transmission or distribution and ICT	
		Energy storage: non-transport applications; thermal, electromagnetic and mechanical storage; batteries and other stationary electrochemical storage (excluding vehicles and general public portable devices)	N/A	
		Energy system analysis		
	5. New materials &	Efficient heating, cooling and ventilation technologies (refers to the structure/envelope, thermodynamic and technology of the facility, and to some external equipment	N/A	Heating

[26] KA-3 covers energy efficient systems specifically in grids and cities.

Efficient energy systems	technologies for buildings	such as heat pumps but not to the indoor equipment, such as AC systems, water heaters)		
		Design and envelope: improving thermal performance	Adapting or protecting infrastructure or their operation in buildings, dwellings, or related infrastructures	Insulation
		Integration of renewables (hybrid systems, PV, solar thermal, wind power, etc.)	Integration of renewables in buildings	N/A
		N/A	Passive houses technology & elements improving the thermal performance of buildings	N/A
		Energy efficient heat pumps and chillers	N/A	N/A
	7. Energy efficiency in industry	Industrial techniques and processes, equipment and systems for energy efficiency: process efficiency in metal, chemical, oil, minerals, agroalimentary processing (i.e., reduction of GHG emissions/waste, better storage, transport)	CCMTs for production process for final industrial or consumer products	N/A
		N/A	CCMTs for sector-wide applications & Others	
			Conservation, efficient supply or use, relating to industrial water supply	
			Food processing	
		Waste heat recovery and utilisation	Heat recovery other than air pre-heating	
		N/A	Technologies related to metal processing	
			Technologies relating to chemical industry	

			Technologies relating to oil refining and petrochemical industry	
			Technologies relating to the processing of minerals	
		Efficient energy usage, usage of renewables	N/A	
Sustainable transport	8. Renewable fuels	Biofuel production and use	Biofuels & Fuel from waste	Biofuels
		Hydrogen technology and fuel cell technology	Hydrogen technology & Application to transportation	Hydrogen technology
			Fuel cells & Application to transportation & in buildings	Fuel cells
			Hydrogen technology & Application to transportation	Hydrogen technology
		Advanced power electronics, motors and EV/HEV/FCV systems, and combustion engines	Internal combustion engine [ICE] based vehicles	Energy Storage and electric powertrains
		Waste management (reuse, recycling, recovering technologies)	N/A	
		Battery technology for transport (vehicles, railway, aeronautics, air)	Battery technology & Recycling of batteries	
		Storage for electromobility, fast charging technology	Efficient propulsion technologies & Energy recovery propulsion system in locomotives or motor railcars	
		Electric vehicle infrastructure	Road transport of goods or passengers	
			Technologies related to electric vehicle charging	

		Solid waste management, second-use, recycling	N/A	N/A
Carbon capture, utilisation and storage (CCUS)	9. CCS/U	CO2 capture, transport, utilisation, combustion and storage	CCS	Carbon capture, utilisation and storage (CCUS)
		Reduction of GHG emissions (also in KA-5)	N/A	N/A
Nuclear safety	10. Nuclear safety[27]	Safety, integrity, environmental protection	Nuclear safety	Nuclear energy
		Waste management, decommissioning, reprocessing, recycling		
		Nuclear fission/fusion (reactors, fuel cycle, fusion energy within tokamaks)		
		Efficiency, sustainability		N/A
		Innovation, development and assessment of technology, new generation reactors		

[27] KA-9 does not relate solely on nuclear safety and waste management as its label suggests. It also covers technologies for nuclear energy (fusion, reactors).

2.4 Key issues

When dealing with a composite index, there are several issues and peculiarities that need to be considered for proper interpretation of the data. In this section, we discuss the main issues and challenges, namely the choice of the different dimensions, subdimensions and indicators to be used in the composite index; their weighting; and the presentation of the results.

Structure of the index

The construction of the tool involves stages in which choices based on expert judgements have to be made including the selection of dimensions, sub-dimensions and indicators, as well as methodological choices throughout the process. In order to minimise risks, these choices should be undertaken and documented as transparently as possible. Different existing innovation indices and relevant literature on innovation has been reviewed to define the 'ideal' framework to measure innovation. Limitations regarding data availability have led to a more simplified approach for the CEII. Additional robustness and coherency checks will be performed to ensure the selected dimensions and indicators are appropriate.

Weighting

One of the main issues in the construction of a composite index is the weighting choice for each dimension and indicator. This is often a subjective choice which may lead to a similarly subjective valuation of the different dimensions of the index. As such, an unbiased and transparent choice for the weight is key. Section 3.4 provides the alternatives considered for the weight choice of the CEII, along with the testing performed and our final weighting selection. The Excel tool (Annex A) allows for the end-user to modify the weight for both the dimensions and the indicators within, according to their own preferences, showing the results in a graphic and intuitive way - using the approach adopted by the OECD's better life index.[28]

Presentation of the results

One of the main benefits of an index is the simplification of information for ease in decision making. However, the simple 'big picture' results which the index shows may create a risk of misinterpretation of the results due to aggregation and may invite decision-makers and stakeholders to draw simplistic policy conclusions. Therefore, as with any indicator, the index should be used in combination with contextual information and with granular information regarding the three dimensions as well as sub-indicators and context indicators to draw detailed policy conclusions.

28 http://www.oecdbetterlifeindex.org/

3 Methodology for the Construction of the CEII

Once the indicators to be included in the three dimensions of the CEII were selected and calculated for all relevant countries and at the required level of disaggregation, we computed the CEII following the Commission's JRC-COIN ten steps[29]. The methodology applied can be summarised as complying with the following guidelines:

- Minimise the need for use of expert judgement;
- Maximise the use of objective and scientific approaches;
- Taking into account country-specific issues, particularly data availability and indicator relevance; and
- Supporting the assessment of progress towards long-term clean energy innovation goals.

The following sections describe the steps taken in preparing the indicators for inclusion in the CEII. After each step, we went back to the data in an iterative process, to ensure that the CEII is robust and coherent, and that it includes the right data to measure clean energy innovation.

3.1 Compile the underlying data and calculate the indicators

The first steps were performed as part of the previous Work Packages per dimension, where the indicators per dimension were selected. The raw data was compiled, and indicators were calculated as described in Table 2.

Table 2 Overview of selected indicators per dimension

Dimension	Indicator name	Description & calculation	Data source
Publications	Share of highly cited publications (those among the 10 % most cited) normalised ($HCP_{10\%}$)	The number of citations received by publications is a proxy for measuring contributions to subsequent knowledge generation; however, because citation practices vary between the disciplines of science, a simple count inevitably creates biases. To correct this shortcoming, the number of citations of each publication is normalised by field, publication type and publication year. This measure is known as the relative citation (RC) score. The 10 % most cited articles are determined by their RC scores instead of their raw number of citations. The share of scientific publications among the 10 % most cited is the number of scientific publications among the 10 % most cited proportional to the total number of scientific publications. Fractional counting (across authors and KAs) is used, and self-citations are excluded. It is calculated for each Member State and country with Mission Innovation membership as follows: $$\textit{Share of pubs. among } 10\% \textit{ most cited} = \frac{X_{10\%}}{X_T}$$ Where: $X_{10\%}$ Number of publications for entity *X* (e.g. Belgium) that are among the 10 % most cited according to their RC scores X_T Total number of publications with a RC score for entity *X*	Scopus (Elsevier)

29 https://composite-indicators.jrc.ec.europa.eu/?q=10-step-guide

	Number of publications per capita (Pubs/pop)	The number of scientific publications obtained using fractional counting across authors and KAs, also referred to as output, is measured for each EU27 member and MIM. It is weighted by the population of each country.	Scopus (Elsevier), World Bank
Patents	Number of inventions per unit of GDP (Pat/GDP)	The number of patent applications weighted by the GDP of the countries.	JRC, World Bank
	Number of high value inventions per unit of GDP (HVP/GDP)	The high value inventions are inventions for which patents are filed at multiple patent offices. The indicator is weighted by the GDP of the countries. It indicates the inventions with high market value since filing patents at more than one patent office entails more effort and costs for the applicant.	JRC, World Bank
	Number of international inventions per unit of GDP (Int Pat/GDP)	International inventions are defined as those with patent applications where the country of the applicant differs from the country of the patent office. The indicator is weighted by the GDP of the countries. Filing patents in more than one country entails more effort and costs for the applicants and may be considered as an indication that the invention is valuable.	JRC, World Bank
Trade	CET export vs GDP (CET exp./GDP)	The key rationale behind this indicator is a view that clean energy technology (CET) exports are an indication of successful innovation performance in the sector. This indicator measures the export performance of a country relative to its resources available (GDP), with a special focus on CET exports (i.e., it reflects a country's ability to commercialise results of R&D and innovation in international markets).	UN Comtrade database, World Bank
	Value Added vs exports (VA/exports)	The indicator measures the domestic contribution to traded CET products, measured against the value of total CET exports.	OECD Trade in Value Added database

Additional indicators which were also considered are listed in Table 3 below. These indicators have been included as supporting indicators for the CEII. Other indicators which were not deemed adequate are further explored in the specific reports for each dimension.

Table 3 Overview of supporting indicators

Dimension	Indicator name	Description & calculation	Data source
Publications	Specialisation index	The specialisation index represents the scientific output of a given entity (e.g. a Member State) in a given research area (e.g. nuclear safety) relative to the intensity in a reference entity (e.g. the world) in the same research area. In other words, when an entity is specialised in an area, it puts more emphasis, relative to the reference entity, on that area at the expense of others. Specialisation is therefore said to be a zero-sum game: the more an entity specialises in an area, the less it does in another. Fractional counting of publications across authors and KAs is used to ensure a true zero-sum game. It is calculated as follows: $$SI = \frac{X_S/X_T}{N_S/N_T}$$ Where: X_S Number of publications in for entity X in a given research area (e.g. Belgium publications in nuclear safety)	Scopus (Elsevier)

		X_T Total number of publications for entity *X* (e.g. all Belgium publications) N_S Number of publications for reference entity *N* in a given research area (e.g. world publications in nuclear safety) N_T Total number of publications for reference entity *N* (e.g. all world publications)	
	Share of international scientific co-publications	The number of international scientific co-publications is the number of publications that include at least two authors affiliated to different countries. The share is the number of international scientific co-publications proportional to the total number of scientific publications. Publications are fractioned across KAs but not authors. It is calculated for each EU27 member and MI as follows: $$\boldsymbol{SIP} = \frac{\boldsymbol{X_I}}{\boldsymbol{X_T}}$$ Where: X_I Number of publications for entity *X* (e.g. Belgium) that include at least one author affiliated to another country X_T Total number of publications for entity *X*	Scopus (Elsevier)
	Share of open access scientific publications	The number of open access scientific publications is the number of publications that are publicly and freely available online without any barriers, either through the publisher (known as gold open access), or through a repository or a personal website (known as green open access). The share of open access scientific publications is the number of open access scientific publications proportional to the total number of scientific publications. Publications are fractioned across KAs but not authors. It is calculated for each EU27 member and MI as follows: $$\boldsymbol{SOA} = \frac{\boldsymbol{X_{OA}}}{\boldsymbol{X_T}}$$ Where: X_{OA} Number of publications for entity *X* (e.g. Belgium) that are available in open access X_T Total number of publications for entity *X*	Scopus (Elsevier), 1findr
	Share of public/private scientific co-publications	The number of public/private scientific co-publications is the number of publications that include at least one author affiliated to the public sector (academic, government) and one author affiliated to the private sector (firms, corporations). The share of public/private scientific co-publications is the number of public/private scientific co-publications proportional to the total number of scientific publications. Publications are fractioned across KAs but not authors. It is calculated for each EU27 member and MI as follows: $$\boldsymbol{SPP} = \frac{\boldsymbol{X_{PP}}}{\boldsymbol{X_T}}$$ Where: X_{PP} Number of publications for entity *X* (e.g. Belgium) that include at least one author affiliated to the public sector and one author affiliated to the private sector	Scopus (Elsevier)

		X_T Total number of publications for entity X	
Patents	Granted inventions	This indicator represents the number of inventions that have met a certain minimum quality level in terms of novelty and uniqueness and thereby eliminates several low(er) quality patent applications. It is measured for EU27 and MI countries.	JRC
	Patent specialisation	A measure of the relative specialisation of a country in a certain technology compared to the global average specialisation in terms of share of total inventions: $$Patent\ specialisation\ index = \frac{P_{d,i}/\sum_d P_{d,i}}{\sum_{di} P_{d,i}/\sum_{d,i} P_{d,i}}$$ where i is the country and d the technological field. The nominator expresses the share of patent applications of a country in a particular technological field over the total patents of the country in all technological fields. The denominator expresses the share of world patents in the specific field over the world patents of all technological fields.	JRC
Trade	High-tech export (High-tech exp)	The indicator measures the technological competitiveness of the observed countries, i.e. the ability to commercialise the results of research and development (R&D) and innovation in international markets. Creating, exploiting and commercialising new technologies are vital for the competitiveness of a country in the modern economy.	UN Comtrade database
	Clean export vs production	The indicator reflects to what extent domestic production of a specific CET is exported – in other words, how export-driven the production process of a country is, with respect to clean technologies.	UN Comext ; PRODCOM (for EU MSs)

3.2 Data treatment & normalisation

3.2.1 Unreliable and missing data points

During the work under the previous Work Packages per dimension, the data was checked for unreliable and missing data points.

As described in the reports on Publications, Patents, and Trade, the data sets used have some gaps, especially at the more disaggregated levels (SET Plan KA and renewable energy technologies). Some of the key data gaps are as follows:

- The HCP10% indicator is missing values for several countries and disaggregation levels. This is because by definition, the share of HCP10% includes a small share of publications, which can cause important year-to-year fluctuations at the country level that might not capture true performance. For that reason, the share of HCP10% was calculated only for countries and disaggregation levels that have published at least 30 publications (with an RC score) in any given year;

- The HCP10% indicator is not available for Malta, as a result, the CEII cannot be calculated for this country at any level of disaggregation.

- There are no values for Trade indicators for the SET KA ‘Energy efficiency in industry’ nor for the renewable technology ‘Ocean’;

- There are missing values for several countries in the three dimensions for SET KA 'Carbon Capture Utilisation and Storage (CCUS)' and 'Nuclear Safety'. As a result, the CEII can only be calculated for half of the countries (21 out of 42 countries) for these SET KAs at this disaggregation level;

- RES technologies 'Geothermal' and 'Hydroenergy' are missing values for the majority of countries, mainly in indicator HCP10%, but also in the three patent indicators. As a result the coverage of the CEII for these technologies is very limited (less than 10 out of 42 countries).

Besides the above, for **trade**, the dataset was complete for all the considered indicators, with an exception being the Value Added vs exports (VA/exports) indicator for which no data were available for the United Arab Emirates. In that case, Saudi Arabia was used as a proxy since they are countries with a similar industry structure/trade characteristics. Regarding **publication** data, no missing data were identified, while outlier and break in series tests were conducted to detect any problematic data points (these are detailed in the report on the publication dimension[30]). Also, in **patents** dimension, the dataset was complete for years up to and including 2016, and there was no need for further treatment on that data[31].

When data is not available for one country at the indicator level, the dimension sub-index and CEII have not been calculated for that country, allowing the rest of the countries to be compared using the CEII (as all the countries have the same data coverage of indicators).

3.2.2 Data transformations

As part of the verification and validation of data, we tested the distributions of each indicator to identify those with highly skewed data via graphical inspection of the data and statistical rules based on skewness and kurtosis.

As a first step we plotted histograms per indicator, followed by the use of descriptive statistics measuring skewness and kurtosis (results are presented in Annex B). As a rule of thumb, the indicators that had a skewness higher than 1 were transformed to shape their distribution closer to the normal "bell curve". Table 4 presents the overview of the transformations selected per indicator.

[30] European Commission, 2021. [Publications as a measure of innovation performance: Selection and assessment of publication indicators]().

[31] Data on patents is still incomplete for the year 2017. The calculations will be updated with the complete 2017 dataset (likely without needing extra treatment).

Table 4 Overview of transformations for highly skewed indicators

Dimension	Indicator name	Transformation
Publications	Share of highly cited publications (those among the 10 % most cited) normalised ($HCP_{10\%}$)	None
	Number of publications per capita (Pubs/pop)	Square root
Patents	Number of inventions per unit of GDP (Pat/GDP)	log(x+1)
	Number of high value inventions per unit of GDP (HVP/GDP)	log(x+1)
	Number of international inventions per unit of GDP (Int Pat/GDP)	log(x+1)
Trade	CET exports vs GDP (CET exp/GDP)	Cubic root
	Domestic value-added content of CET exports as a share of clean energy technology exports (VA/exports)	None
	High-tech export (High-tech exp)*	Square root

**This indicator was ultimately not included in the CEII.*

3.2.3 Normalisation

Once the skewed data was accounted for and transformed accordingly, the score of countries were normalised for each of the indicators using the following formula:

$$\frac{S_X - S_{min}}{S_{max} - S_{min}}$$

Where:

S_X Score for entity *X* (e.g., Belgium);

S_{min} Minimum score among the distribution of entities;

S_{max} Maximum score among the distribution of entities.

This normalisation was performed using the minimum and maximum scores across years 2015-2017 and countries to allow for the cross-comparison of countries as well as to allow the analysis of trends. As a result, all indicators are on a comparable scale (i.e., between 0, the worst performance, and 1, the best performance) prior to aggregating the countries' scores across indicators into the CEII.

3.3 Statistical coherence of individual indicators

Linear Correlation among the levels of the CEII and Multivariate analysis are used to test for the impact of each data item, to ensure that the data items that account for the widest span of clean energy innovation performance variance are selected while redundancy is controlled. This process is intended to identify the set of baseline conditions that influence clean energy innovation to the greatest extent.

After the normalisation of data we conducted correlation analysis of the indicators within each dimension, as well as across dimensions.

3.3.1 Publications

Table 5 shows the correlation coefficient between the bibliometric indicators that are included in the CEII as well as the dashboard of the supporting indicators.[32] The CEII was designed to combine a small, yet highly informative, set of innovation performance indicators for each of its three core dimensions (i.e. publications, patents and trade). For publications, this translated into the selection of the number of publications per capita as a measure of national productivity and the share of $HCP_{10\%}$ as a measure of research impact/influence, two performance indicators that are often central to assessments of scientific performance. The remaining indicators, while providing useful information on the structure and dynamics of national research systems, are perhaps less focused on raw performance. They are nevertheless kept as supporting indicators to the CEII since they are of relevance to the SET Plan's objectives (see Publications report for more details). They include the specialisation index, the share of international co-publications, the share of open access publications, and the share of public/private co-publications. Per the below correlation matrix, none of the retained indicators are strongly correlated with one another in a way that would add too much redundancy in the publication data (maximum Pearson r = 0.6).

Table 5 Correlation coefficient between the bibliometric indicators among in-scope countries

	Pubs./Pop.	SI	SIP	SPP	SOA	$HCP_{10\%}$
Pubs./Pop.	1.00	0.16	0.45	0.53	0.24	0.40
SI	0.16	1.00	-0.27	-0.33	-0.45	-0.05
SIP	0.45	-0.27	1.00	0.39	0.44	0.60
SPP	0.53	-0.33	0.39	1.00	0.44	0.24
SOA	0.24	-0.45	0.44	0.44	1.00	-0.01
$HCP_{10\%}$	0.40	-0.05	0.60	0.24	-0.01	1.00

Source: These statistics were calculated using data on publications from Scopus (Elsevier) and data on GDP from the World Bank[33]

3.3.2 Patents

The results of the correlation analysis for patent indicators show that all the patent indicators are highly correlated (Table 6). High-value inventions per GDP and International inventions per GDP share the highest correlation (0.88), followed by High-value inventions per GDP and inventions per GDP (0.84). International inventions per GDP and inventions per GDP share the lowest correlation (0.77) however this can still be considered a high correlation.

The high correlation amongst indicators might be explained by the nature of the indicators: all three indicators are subsets of the same larger set. An international invention and a high-value invention are both inventions; therefore, it wouldn't be possible that a higher number of high-value inventions coincides with a lower number of inventions. However,

[32] See the report on the publication dimension (European Commission, 2021) for the reasoning behind the exclusion of some of the initially selected indicators as well as for a more in-depth description of all indicators.
[33] See European Commission (2021) for additional details on data sources and indicator calculations.

the three of them measure somewhat different aspects within the dimension, so combining them in a sub-index for patents could provide a balanced view.

Table 6 Correlation coefficient between the patent indicators

	HVP/GDP	Int. Inv./GDP	Inv./GDP
HVP/GDP	1.00	0.88	0.84
Int. Inv./GDP	0.88	1.00	0.77
Inv./GDP	0.84	0.77	1.00

3.3.3 Trade

In the case of trade indicators, these have a low to moderate correlation (Table 7). A moderate correlation (0.41) was found between High-tech exports and CET exports per GDP, while a very low negative correlation (-0.31) was found between CET exports per GDP and VA/exports. High-tech exports is only available at SET Plan level so it is included in the dashboard supporting the CEII but not selected as one of the indicators which conform the CEII, as there is no disaggregation available per SET Plan Key Action nor Renewable energy technology.

Table 7 Correlation coefficient between the trade indicators

	High-tech exp.	CET exp./GDP	VA/exports
High-tech exp.	1.00	0.41	-0.07
CET exp./GDP	0.41	1.00	-0.31
VA/exports	-0.07	-0.31	1.00

3.3.4 Multivariate Analysis (Principal Component Analysis)

Finally, a multivariate analysis was conducted using Principal Component Analysis (PCA)[34] to test for the impact of each data item, to check how they are associated and to ensure that the data items explaining the greatest share of variance in clean energy innovation performance are selected, while redundancy is controlled.

In Principal Component Analysis a linear transformation is performed to turn multivariate data into a form where variables are uncorrelated. The new uncorrelated variables are the so-called Principal Components (PCs), and they are in descending order based on the variance explained.

Table 8 presents an overview of the results of the Principal Component analysis. The first part of the table shows the individual and cumulative variance that is explained by the PCs. The results indicate that the first 4 PCs account for 90% of the variance.

The second part of the table shows the component loadings[35] for the individual indicators pre-selected for the CEII. High and moderate loadings (>0.45) indicate how the individual indicators are related to the principal components. The results of the PCA show that the

[34] With the use of the web tool https://biit.cs.ut.ee/clustvis/ . The full methodology can be found in Metsalu and Vilo (2015).
[35] The correlation coefficients between the principal components and the variables.

high and moderate loadings are found in different principal components, indicating that the principal components are measuring different “statistical” dimensions in the data.

Within the patent dimension, the individual indicator HVP/GDP (high-value inventions/GDP) is almost entirely accounted for by one principal component alone (PC7), similarly to Inventions per GDP (PC6). Both indicators are also moderately correlated to PC1. International inventions/GDP is moderately correlated to three PCs: PC1, PC6 and PC7. The two Publications indicators are strongly related to two principal components (PC3 and PC5). For the two Trade indicators, CET exp/GDP is moderately correlated to three PCs: PC2, PC4 and PC5. While CET exp/VA also has a strong correlation to PC2, the indicator has a very high correlation with PC4 and as a very low correlation with PC5. No indicators are excluded from the composite index calculations based on the results of the PCA.

Component loadings were used to calculate test statistical indicator weightings based on principal component eigenvalues and eigenvectors. It was determined that statistical weightings led to balanced aggregations. PCA-based weightings were therefore not considered along with other weighting options.

Table 8 Summary of variance explained by principal components, and principal component loadings for individual indicators selected for CEII

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Individual	0.46	0.22	0.14	0.08	0.06	0.03	0.01
Cumulative	0.46	0.68	0.82	0.90	0.96	0.99	1.00

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
HVP/GDP	-0.52	0.01	-0.24	0.11	0.00	0.20	-0.79
Int. Inv./GDP	-0.50	-0.11	-0.22	0.25	0.02	0.55	0.57
Inv./GDP	-0.48	0.03	-0.34	-0.05	0.07	-0.77	0.22
Pubs/cap	-0.34	0.18	0.65	-0.11	0.65	0.00	0.01
HCP10	-0.27	-0.39	0.58	0.26	-0.58	-0.18	-0.01
CET exp./GDP	-0.23	0.60	0.11	-0.55	-0.49	0.14	0.09
VA/exports	-0.09	-0.66	-0.06	-0.73	0.07	0.11	-0.01

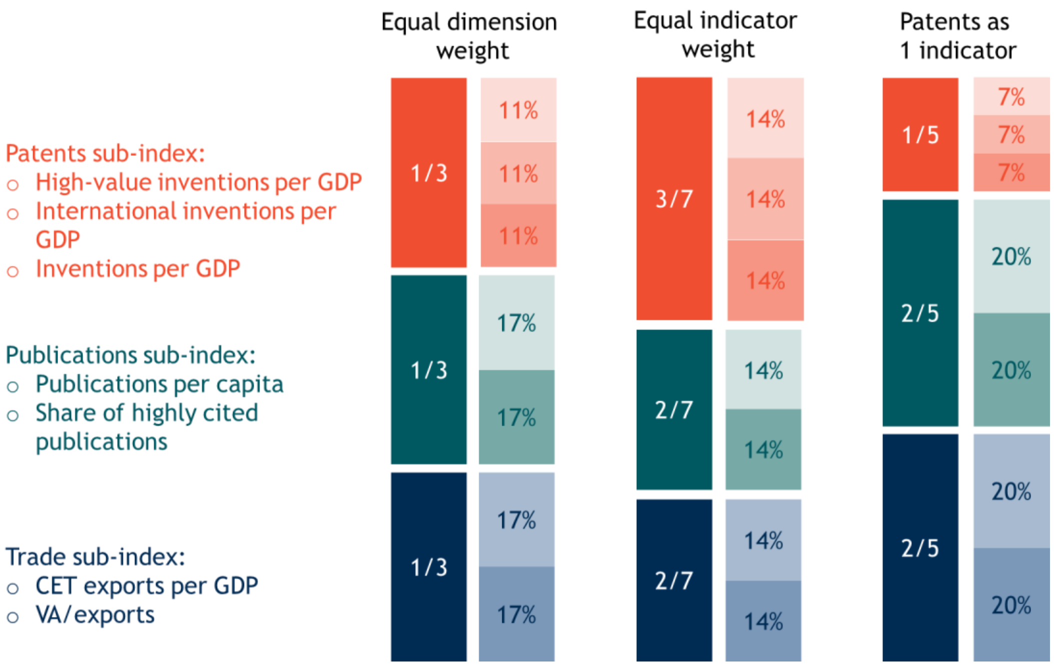
Note: loadings higher equal or higher than 0.45 are highlighted.

3.4 Weighting & aggregation

3.4.1 Weighting options

A number of weighting approaches have been tested (see Figure 2). The different weighting approaches have been combined with the aggregation using weighted arithmetic mean (or average) of the normalised indicators.

Figure 2 Weighting options



The testing approaches considered can be explained as follows:

- **Equal dimension weight –** This was the starting point, applying equal weighting across the three dimensions, and equally across all indicators within a dimension. This assumes that each dimension is equally important to clean energy innovation performance.

- **Equal indicator weight –** Applying the same weight for each indicator. However, this leads to a slight over-representation of the patents dimension, as it has three indicators compared to the two in the publications and trade dimensions.

- **Limiting the weight of patent indicators –** This option aims to account for the high correlation among the three patent indicators by giving them a lower weight (i.e. considering them all together as one indicator).

3.4.2 Simplified benefit-of-the doubt calculations

Exploratory data envelopment analysis (DEA) was conducted to test how composite index values might change if country-level performances were weighted endogenously. Specifically, a 'benefit-of-the-doubt' (BoD) approach in line with recent work on composite indicators[36] was applied using normalised indicator values calculated per country. Under the BoD approach, country-specific performances are compared to performance benchmarks and weighted in the composite index accordingly.[37]

Simplified benefit-of-the-doubt composite indices were calculated according to:[38]

[36] E.g., Cristobal et al. (2016); Agasisti et al. (2019) and Montalto (2017).
[37] OECD (2008).
38 Simplified calculation adapted from equations (19) and subsequent equations (20), (21), and (22) in OECD (2008: p.93).

$$CEII_c = \frac{\sum_i^I w_i X_{c,i}}{\sum_i^I w_i \, X_{Max,i}}$$

Where

$w_i = nominal\ weighting\ per\ indicator$, where nominal weightings were bounded according to selected weighting approach, as outlined in the section above;

$X_{c,i} = calculated\ indicator\ value\ per\ country$; and

$X_{Max,i} = maximum\ value\ across\ all\ countries\ per\ indicator$.

At the highest level of aggregation, where calculated indicator values pertain to all CET per country, BoD composite indices do not differ significantly from the conventional composite indices, as shown in the table below. Applying the BoD approach increases the overall CEII of all countries considered except Croatia, where the score slightly decreases. The BoD approach also results in several CEII ranking differences between countries; countries with increased rankings under the BoD approach are highlighted in green in the table, while countries with decreased rankings under the BoD approach are highlighted in orange. Austria and Slovakia fare particularly well under the BoD approach, both increasing two ranking levels.

Table 9 Example of core CEIIs compared with benefit-of-the-doubt CEIIs per country or country group[39]

Country	Ranking (BoD CEII)	BoD CEII	Ranking (Core CEII)	Core CEII	% change
Denmark	1	0.89	1	0.86	3%
United States	2	0.75	2	0.74	3%
Germany	3	0.71	3	0.68	4%
South Korea	4	0.71	5	0.66	6%
Sweden	5	0.70	4	0.67	4%
Netherlands	6	0.69	6	0.66	4%
Finland	7	0.68	7	0.65	5%
Belgium	8	0.66	8	0.64	3%
Japan	9	0.66	9	0.62	6%
Norway	10	0.63	10	0.61	2%
Austria	11	0.62	13	0.59	5%
Italy	12	0.61	11	0.60	3%
Australia	13	0.61	12	0.59	2%
Ireland	14	0.59	14	0.57	4%
China	15	0.59	15	0.56	5%
Canada	16	0.58	16	0.56	4%

[39] Example figures shown are calculated at the highest level of SET plan key action aggregation for the year 2015, with the "Patents as 1 indicator" weighting method to calculate the core CEII, and also used to set bounds for nominal weightings in the BoD approach. It should be noted that ranking (whether with conventional or BoD index) may change as a result of future inclusion of the 2017 complete patent dataset.

United Kingdom	17	0.58	17	0.56	4%
Mission Innovation	18	0.58	19	0.55	5%
EU27	19	0.58	18	0.56	4%
France	20	0.56	21	0.54	5%
Spain	21	0.56	20	0.54	3%
Portugal	22	0.56	22	0.54	4%
Slovenia	23	0.55	23	0.53	3%
Estonia	24	0.53	24	0.51	4%
Latvia	25	0.47	25	0.45	6%
Luxembourg	26	0.47	28	0.44	8%
Saudi Arabia	27	0.46	27	0.44	5%
Czech Republic	28	0.45	29	0.43	4%
Greece	29	0.44	26	0.44	0%
Lithuania	30	0.42	30	0.40	4%
Poland	31	0.41	31	0.39	6%
Chile	32	0.41	33	0.39	5%
United Arab Emirates	33	0.39	32	0.39	1%
Slovakia	34	0.39	36	0.37	5%
Romania	35	0.38	34	0.37	2%
Brazil	36	0.38	35	0.37	3%
Cyprus	37	0.36	38	0.34	6%
Hungary	38	0.35	39	0.33	5%
India	39	0.35	40	0.33	6%
Croatia	40	0.34	37	0.34	-1%
Bulgaria	41	0.30	41	0.27	10%
Mexico	42	0.27	42	0.25	6%
Indonesia	43	0.21	43	0.21	0%
Malta	44	N/A	44	0.86	N/A

At more granular levels of aggregation – i.e., at key action levels, the values of core CEIIs and BoD CEIIs diverge more significantly. For example, at the highest level of aggregation (depicted in the figures above), the BoD approach increased CEIIs by 4% on average, while at the “KA 1 – Performant Renewables” level of aggregation, the BoD approach increased CEIIs by 15% on average.[40] However, even at KA levels of aggregation, country rankings differ by only one or two places.

While it is interesting to assess how the BoD approach results in differently weighted CEIIs, its complexity obscures some of the insights that can be derived when core weighting methodologies are applied. And because the BoD approach does not significantly shift rankings between countries, even at more granular levels of aggregation, it is not applied in the final CEII calculations.

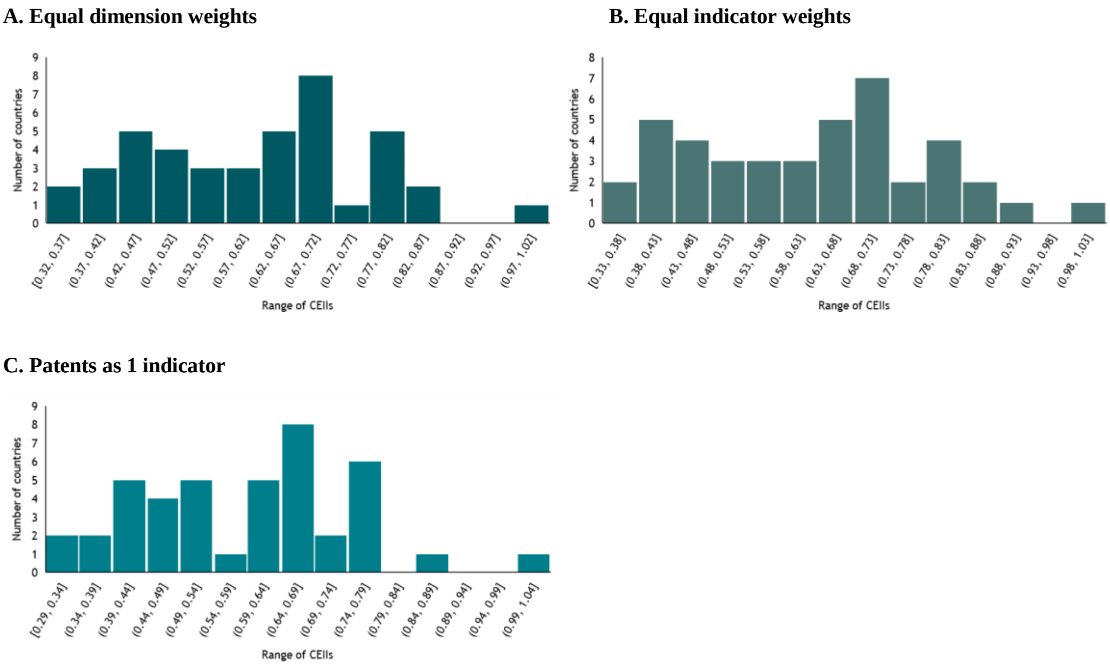
3.4.3 Final selection of the weighting approach

To select the best weighting approach, we used data envelopment analysis benchmarking and performed additional sensitivity analyses to assess the effect of weighting options in the CEII country rankings. Both are presented in detail below. Based on the results, the weighting approach which considers three patents as one indicator has been selected.

Simplified data envelopment analysis and performance distributions per weighting option

DEA benchmarking methods were used to analyse the distributional attributes of scaled CEIIs under different weighting methods. Under each weighting method, a benchmark composite index was identified as the maximum value across all 42 in-scope countries and two country groups (MI and EU27). CEIIs for each country and country group were then normalised to a performance scale where the benchmark CEII value represented a 100% performance level. The resulting performance distributions for each weighting method were then mapped and are presented in the figure below.

Figure 3 Performance distributions of benchmarked CEIIs under tested weighting options



The mapped performance distributions for the patents as one indicator weighting correspond most closely to a standard normal distribution. The distributions for equal

[40] Given figures from the year 2015 and the application of the "Patents as 1 indicator" weighting method.

dimension weights and equal indicator weighting are more skewed toward lower-than-average values, and the distribution for equal indicator weighting is flatter than the others.

These benchmarked analyses indicate that patents as one indicator weighting or equal dimension weighting would likely result in sets of CEIIs that more closely conform to normal distributions. However, the results are not distinctive enough to exclude any ranking methods on this basis.

Effect of weighting options on the CEII country rankings

In this section we present a comparison of the country rankings in the CEII when different CEII weighting options are used. The aim of this comparison is to observe the extent to which the use of different weighting options for the CEII change the ranking of a given country.

Figure 4 shows the results per country for the weighting options:

- Equal dimension weight (CEII-EDW)
- Equal indicator weight (CEII-EIW)
- Patents as one indicator (CEII-P1I)

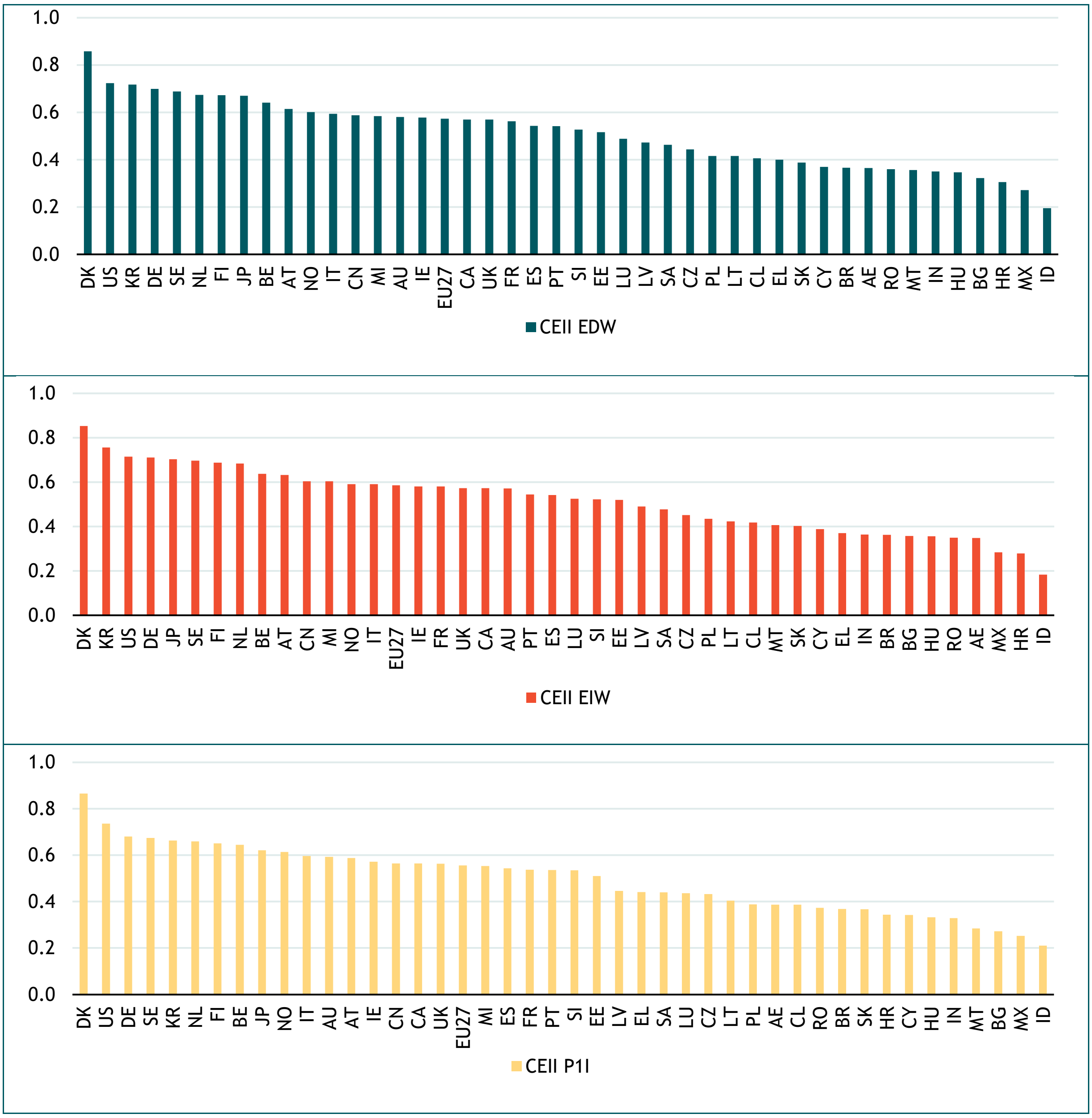
The analysis shows that there is a slight variation in the order countries rank when using the different weights; however both the frontrunners and laggards remain more or less constant disregarding the weighting approach applied.

Regardless of the weighting option the **top 10 scoring countries remain more or less constant**, with limited changes in their ranking within the top 10:

- Denmark is the frontrunner in all the weighting options.
- US and South Korea rank in the top five countries in for all weighting options, along with Germany. Sweden also usually ranks in the top five, either in fourth or fifth place, with the exception of CEII-EIW (where its place is taken by Japan).
- Japan is the country that varies the most within the top 10: in CEII-EDW it ranks eighth, while as previously mentioned in CEII-EIW it is the fifth. In CEII P1I is ranked ninth.
- Other countries following in the top 10 include the Netherlands (alternating between sixth and eighth place), Finland is usually at seventh place, while Belgium is usually in ninth place. Austria is typically in the top 10, except in the CEII-P1I option, where it is part of the second tier (12^{th} place).

In the second tier (top 10-20), eight of the ten countries remain constant across all weighting options: Norway, China, Canada, Australia, UK, Italy, France, Ireland. Both Mission Innovation and EU27 averages are always in this second tier ranking. Whereas, in the third tier (places 30-44), both Croatia and Mexico are usually in the last three, while Indonesia always comes in last place.

Figure 4 Comparison of country rankings using the different weighting options for the CEII.



3.5 Statistical coherence across dimensions

To validate the composite index, we have analysed the patterns of **correlation** between the individual indicators and the sub-indicators and CEII.

3.5.1 Linear correlation analysis - Equal dimension weight

The results of a correlation analysis between the CEII calculated using equal dimension weighting (CEII-EDW), the dimensions sub-indexes and the indicators used to calculate those are presented in **Error! Not a valid bookmark self-reference.**.

Table 10 Correlation coefficient between CEII-EDW, dimensions sub-index and dimensions indicators for the EU27 Member States and MIs

	CEII	Patents sub-index	Publications sub-index	Trade sub-index	HVP/GDP	Int. Inv./GDP	Inv./GDP	Pubs/cap	HCP10	CET exp./GDP	VA/exports
CEII EDW	1.00	0.82	0.80	0.66	0.81	0.78	0.73	0.67	0.66	0.41	0.36
Patents sub-index	0.82	1.00	0.43	0.37	0.97	0.94	0.91	0.41	0.35	0.30	0.14
Publications sub-index	0.80	0.43	1.00	0.34	0.43	0.45	0.31	0.80	0.87	0.17	0.22
Trade sub-index	0.66	0.37	0.34	1.00	0.37	0.30	0.40	0.29	0.22	0.58	0.59
HVP/GDP	0.81	0.97	0.43	0.37	1.00	0.88	0.84	0.42	0.34	0.33	0.11
Int. Inv./GDP	0.78	0.94	0.45	0.30	0.88	1.00	0.77	0.37	0.41	0.18	0.17
Inv./GDP	0.73	0.91	0.31	0.40	0.84	0.77	1.00	0.35	0.22	0.34	0.13
Pubs/cap	0.67	0.41	0.80	0.29	0.42	0.37	0.35	1.00	0.40	0.39	-0.05
HCP10	0.66	0.35	0.87	0.22	0.34	0.41	0.22	0.40	1.00	-0.08	0.32
CET exp./GDP	0.41	0.30	0.17	0.58	0.33	0.18	0.34	0.39	-0.08	1.00	-0.32
VA/exports	0.36	0.14	0.22	0.59	0.11	0.17	0.13	-0.05	0.32	-0.32	1.00

The results show that there is a very high correlation between the CEII and the sub-indexes. The patents sub-index has the highest correlation with the CEII (0.82), followed closely by the publications sub-index (0.80). The trade sub-index has the lowest correlation (0.66), although it can still be considered high. The lower score for trade (0.66) in comparison to publications and patents (0.80 and 0.82 respectively) could represent an issue, most likely due to the lower correlation observed among the elements of trade sub-Index. This could be corrected (as a last resource) with more weight.

Within the patents dimension, the three patent indicators have a very high correlation with the dimension sub-index, ranging from 0.91 to 0.97. High-value inventions per GDP stand out as the indicator with the highest correlation with its sub-index (0.97) as well as the indicator with the highest correlation to the CEII (0.81).

In the case of the Publications sub-index, HCP10 has the highest correlation with the sub-index (0.87), followed by publications per capita (0.80). However, when compared to the CEII, both indicators share similar correlation coefficients (0.66 and 0.67 respectively).

The two indicators of the Trade dimension have a strong correlation with the Trade sub-index (0.58 and 0.59) while both have a weak (though still acceptable) correlation with the CEII. CET exports per GDP shares a higher correlation with the CEII (0.41) when compared to VA/exports (0.36), which is the lowest across all dimensions.

3.5.2 Linear correlation analysis – Equal indicator weight

Compared to the CEII-EDW, when calculating the CEII using Equal indicator weights (CEII-EIW) the Patents sub-index has an even higher correlation (0.88) to the CEII than the Publications sub-index (0.75) and the Trade sub-index (0.62) (see Table 11).

Table 11 Correlation coefficient between CEII-EIW, dimensions sub-index and dimensions indicators for the EU27 Member States and MIs

	CEII	Patents sub-index	Publications sub-index	Trade sub-index	HVP/GDP	Int. Inv./GDP	Inv./GDP	Pubs/cap	HCP10	CET exp./GDP	VA/exports
CEII EIW	1.00	0.88	0.75	0.62	0.86	0.84	0.79	0.64	0.61	0.40	0.33
Patents sub-index	0.88	1.00	0.43	0.37	0.97	0.94	0.91	0.41	0.35	0.30	0.14
Publications sub-index	0.75	0.43	1.00	0.34	0.43	0.45	0.31	0.80	0.87	0.17	0.22
Trade sub-index	0.62	0.37	0.34	1.00	0.37	0.30	0.40	0.29	0.22	0.58	0.59
HVP/GDP	0.86	0.97	0.43	0.37	1.00	0.88	0.84	0.42	0.34	0.33	0.11
Int. Inv./GDP	0.84	0.94	0.45	0.30	0.88	1.00	0.77	0.37	0.41	0.18	0.17
Inv./GDP	0.79	0.91	0.31	0.40	0.84	0.77	1.00	0.35	0.22	0.34	0.13
Pubs/cap	0.64	0.41	0.80	0.29	0.42	0.37	0.35	1.00	0.40	0.39	-0.05
HCP10	0.61	0.35	0.87	0.22	0.34	0.41	0.22	0.40	1.00	-0.08	0.32
CET exp./GDP	0.40	0.30	0.17	0.58	0.33	0.18	0.34	0.39	-0.08	1.00	-0.32
VA/exports	0.33	0.14	0.22	0.59	0.11	0.17	0.13	-0.05	0.32	-0.32	1.00

3.5.3 Linear correlation analysis – Patents as one indicator

Table 12 below show the results of the correlation analysis of the calculated CEII weighting the three Patent indicators as one indicator (CEII-P1I). As expected, the Patents sub-index has a lower correlation to the FCEII P1I (0.71) than all the tested weighting options. For both Publications and Trade sub-indexes, their correlation to the CEII-P1I are the highest in this option than in all the weighting options (0.86 and 0.70 respectively).

The correlation of individual indicators with the CEII-P1I is one of the most balanced across weighting options:

- The correlation of the indicators in the inventions dimension with the CEII-P1I range between 0.68 and 0.70
- Both indicators in the publications dimension have a correlation of 0.71 with the CEII-P1I
- Trade indicators, although smaller than the other dimensions, show a higher correlation to the CEIIP1I than in all the other tested options (0.40 to 0.42).

Table 12 Correlation coefficient between CEII-P1I, dimensions sub-index and dimensions indicators for the EU27 Member States and MIs

	CEII	Patents sub-index	Publications sub-index	Trade sub-index	HVP/GDP	Int. Inv./GDP	Inv./GDP	Pubs/cap	HCP10	CET exp./GDP	VA/exports
CEII P1I	1.00	0.71	0.86	0.70	0.70	0.68	0.62	0.71	0.71	0.42	0.40
Patents sub-index	0.71	1.00	0.43	0.37	0.97	0.94	0.91	0.41	0.35	0.30	0.14
Publications sub-index	0.86	0.43	1.00	0.34	0.43	0.45	0.31	0.80	0.87	0.17	0.22
Trade sub-index	0.70	0.37	0.34	1.00	0.37	0.30	0.40	0.29	0.22	0.58	0.59
HVP/GDP	0.70	0.97	0.43	0.37	1.00	0.88	0.84	0.42	0.34	0.33	0.11
Int. Inv./GDP	0.68	0.94	0.45	0.30	0.88	1.00	0.77	0.37	0.41	0.18	0.17
Inv./GDP	0.62	0.91	0.31	0.40	0.84	0.77	1.00	0.35	0.22	0.34	0.13
Pubs/cap	0.71	0.41	0.80	0.29	0.42	0.37	0.35	1.00	0.40	0.39	-0.05
HCP10	0.71	0.35	0.87	0.22	0.34	0.41	0.22	0.40	1.00	-0.08	0.32
CET exp./GDP	0.42	0.30	0.17	0.58	0.33	0.18	0.34	0.39	-0.08	1.00	-0.32
VA/exports	0.40	0.14	0.22	0.59	0.11	0.17	0.13	-0.05	0.32	-0.32	1.00

Considering the results of the linear correlation analysis, the preferred weighting option for the CEII is to limit the weight of Inventions indicators and threat them as one (CEII-P1I). This option has the most balanced correlations amongst the three sub-indexes and the CEII, and it is the option where Trade indicators have the highest correlations with the CEII.

3.6 Robustness & sensitivity

A sensitivity analysis was undertaken to assess the robustness of the composite indicator scores/ranks to the underlying assumptions and to identify which assumptions are more crucial in determining the final CEII construction. This increases the transparency and validity of the process and can significantly contribute to building a consensus on the usefulness and the reliability of the results.

Throughout the process, in an iterative way, the following approaches have been used to assess uncertainties:

- **Inclusion and exclusion of individual indicators** – Several of the supporting indicators were included as part of the CEII for testing purposes.

- **Using alternative data transformation schemes** – Different transformation approaches were tested including log, ln and square root to reduce data skewness and their potential implications for the CEII (e.g. one indicator or dimension sub-index being close to zero for most of the countries). For details on the final selection see section 3.2 and Annex B

- **Using different weighting–** A number of weighting approaches and weights, based both on statistical analysis as well as on expert opinion, were tested and assessed as presented in section 3.4.

3.7 Details and links to other variables

Linking and comparing the composite indicator to other related indicators can help to understand and interpret the results. Below we present a preliminary list of variables against which we have tested the CEII results to assess whether they reflect the changes in the behaviour of those factors[41]. In the case of the Clean Energy Innovation Index (CEII), several relevant variables, as listed in the table below, have been considered.

Table 12 Variables to link and compare to CEII results

Variable	Description	Source
GDP **GDP/capita**	Innovation drives economic growth, since it contributes to higher productivity. Therefore, countries with a high CEII are expected to have high values of GDP or GDP per capita, which represents their economic growth.	World Bank
Gross domestic spending on R&D as % of GDP	An increase of investments in the R&D of CET will likely result in a rise in innovation outputs and outcomes, including the development of new technologies, which will contribute positively in the overall innovation performance of a country. Therefore, countries with high values of CEII are expected to have strong R&D investments.	OECD[42]

[41] OECD (2008).
[42] https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

Innovation Index	A high innovation index will likely be correlated to a high performance in clean energy innovation as well. It is important to note that the Innovation Index covers many more aspects of the R&I system than the CEII.	European Innovation Scoreboard[43]
Innovation Output Indicator	A high innovation output indicator will likely be correlated to a high performance in clean energy innovation as well. This indicator is targeted to output and uses similar dimensions to the CEII.	Innovation Output Indicator[44]

[43] https://ec.europa.eu/growth/industry/policy/innovation/scoreboards_en
[44] https://ec.europa.eu/jrc/en/publication/innovation-output-indicator-2019

4 CEII Results and Analysis

In the next version of this report, this chapter will present the most important CEII results, using visual aids and tables. We will present the CEII as one individual number and the sub-indices for each of its dimensions along with the necessary analysis. By presenting the disaggregated results along with the CEII value, we will limit the potential concerns regarding subjective weighting of both the dimensions and the sub-indicators within each index dimension. Finally, we will also contrast the results against some key variables including GDP and other innovation indices.

This version of the report does not present the initial results of the CEII analysis, as the results are still not finalised due to insufficient data on patents for the year 2017. Incomplete patent data is skewing calculations related to composite indicators. Data on patents will be updated as soon as complete results for 2017 are published, and the next version of this report will include robust, consistent calculations on the CEII. The final version of this report will also include an Excel tool in the annex, which will provide detailed CEII data and calculations, disaggregated by sub-indicator, SET Plan Key Actions and renewable energy technologies within each dimension.

4.1 Considerations for the update of the CEII

This section provides several considerations that will be taken into account when revising the CEII and preparing the next report, beyond updating the patents dataset so that consistent results can be fully presented.

4.2 Update on trade indicator selection

The current indicators for trade have an overlap, where CET Exports is the numerator of "CET exports vs GDP" and the denominator of "VA/exports vs GDP", both included in the trade sub-index. This implicitly makes the aggregation in the trade sub-index "weak" – as the same indicator is acting on two opposite directions. The negative correlation confirmed the doubts about the construction of these two indicators which are implicitly conflicting. Therefore, for the upcoming update of the CEII, we propose to test two options:

- **Option 1:** Design an alternative indicator to replace VA/export by changing the denominator, avoiding the interpretation of CET exports as a negative factor;
- **Option 2:** To exclude one of the two conflicting indicators. If this is the case, the choice of indicator will take into account its correlation with the indicators of the other dimensions (i.e. patents and scientific publications).

Table 14 Revised list of trade indicators to be considered

Indicator	Description	Suggestion
High-tech export (High-tech exp)	The indicator measures the technological competitiveness of the observed countries, i.e. the ability to commercialise the results of research and development (R&D) and innovation in international markets. Creating, developing and commercialising new technologies are vital for the competitiveness of a country in the modern economy.	Keep indicator for supporting dashboard only
CET exports/ GDP	The key rationale behind this indicator is a view that CET exports may be the result (amongst other factors) of successful innovation performance in the sector. This indicator measures the export performance of a country relative to the volume of economic activity), with a special focus on CET exports (i.e., it reflects a country's ability to commercialise results of R&D and innovation in international markets).	Keep indicator for supporting dashboard (test vs alternatives)

CET export Value Added vs CET exports (CET export VA/CET exports)	The indicator measures the domestic contribution to traded CET products, measured against the value of total CET exports.	Remove
CET export VA/GDP	The indicator measures the domestic contribution to traded CET products, measured against the value of GDP. The indicator shows the domestic contribution in CET exports relative to all the resources available in the country (GDP).	Test

If a new trade indicator is designed, we will first proceed with data treatment and normalisation (as in Chapter 3.2), and we will run correlation tests between the trade indicators as well as between the new trade indicator(s) and the indicators from other dimensions (Chapter 3.3 tests).

It should be noted that if an indicator is ultimately removed or replaced, the changes in the final selection of trade indicators also triggers a review of the CEII weighting.

Box 2 Preliminary findings and suggestions

Correlation test with other trade indicators: The proposed new indicator (CET VA vs. GDP) is very highly correlated to CET exports/GDP (0.98), showing that only one of these should be included as part of the CEII.

Table 13 Preliminary correlation across trade indicators

	CET exports vs GDP	High-tech exports	CET VA vs GDP (new)
CET exports vs GDP	1.00	0.17	0.98
High-tech exports	0.17	1.00	0.18
CET VA vs GDP (new)	0.98	0.18	1.00

Correlation with indicators from other dimensions: A preliminary correlation test was run against indicators from other dimensions (noting that these other indicators have already been transformed and normalised while trade indicators were raw). This analysis showed that the new CET VA/GDP would be the preferred choice, as the latter has higher correlation values than CET Exports/GDP which shows a negative correlation with HCP10 (from Publications).

Table 14 Preliminary correlation across indicators from all dimensions

	HVP/GDP	Int. Inv./GDP	Inv./GDP	Pubs/cap	HCP10	CET/GDP	CET VA vs GDP
HVP/GDP	1.00	0.88	0.84	0.42	0.34	0.27	0.33
Int. Pat./GDP	0.88	1.00	0.77	0.37	0.41	0.14	0.21
Pat./GDP	0.84	0.77	1.00	0.35	0.22	0.22	0.29
Pubs/cap	0.42	0.37	0.35	1.00	0.40	0.39	0.43
HCP10	0.34	0.41	0.22	0.40	1.00	-0.01	0.08
CET/GDP	0.27	0.14	0.22	0.39	-0.01	1.00	0.98
CET VA/GDP	0.33	0.21	0.29	0.43	0.08	0.98	1.00

Our **preliminary proposal** is to include only the new suggested indicator (CET export VA/GDP) in the CEII while keeping the CET export/GDP indicator in the supporting dashboard and removing CET export VA/CET exports.

Besides the update in the indicator selection, it is also expected that the workshop to be held around the HS codes revision will change the indicator(s) to a certain extent. Therefore, we suggest to revise the inclusion of the CET export / GDP indicator once second year calculations are carried out (expected timing: late-May).

4.2.1 Update data transformation of trade indicators

For consistency, we will change the transformation approach for trade indicators (currently cubic and square root) to log(x+1). The new criteria we will use to decide whether or not an indicator requires transformation will follow the JRC's suggestion: an indicator will be transformed if its skewness is higher than 2, and if its kurtosis is higher than 3.5.

Following these criteria, a test to trade indicators shows that the indicators High-tech exports and CET exports vs GDP would not require transformations. In the case of the new indicator CET VA/GDP, skewness is below 2 during the years tested, while kurtosis exceeds the threshold of 3.5 in two years (see Table 15).

We propose that in these cases the focus of the tests remains on skewness and as a consequence the indicators are kept without transformations. The distribution of each indicator will be tested again once an update of the dataset is produced.

Table 15 Descriptive statistics for Trade indicators (existing and new)

Indicator	Criteria	*2015*	*2016*	*2017*	*2018*
High tech exports	Kurtosis	0.795	0.962	1.837	2.036
	Skewness	0.955	1.072	1.279	1.395
CET exp./GDP	Kurtosis	2.062	3.102	2.329	1.846
	Skewness	1.346	1.599	1.451	1.345
CET VA/ GDP	Kurtosis	3.623	4.742	3.164	2.110
	Skewness	1.584	1.782	1.519	1.320

4.2.2 Update averages for all in-scope countries

For consistency, we will calculate the average CEII and sub-indexes for all in-scope countries in addition to calculating average CEII and sub-indexes for the EU27 and MI country groups values.

4.2.3 More in-depth analysis of the CEII trends and results

Where possible, we will aim to provide an in-depth analysis with regards to the trends and results as well as with regards to the comparison with key countries.

5 References

Agasisti, T., Munda, G., Hippe, R. 2019. Measuring the efficiency of European education systems by combining Data Envelopment Analysis and Multiple-Criteria Evaluation. Journal of Productivity Analysis, 51(2): 105-124. https://ideas.repec.org/a/kap/jproda/v51y2019i2d10.1007_s11123-019-00549-6.html

Cornell University, INSEAD, and WIPO, 2019. The Global Innovation Index 2019: Creating Healthy Lives—The Future of Medical Innovation. Ithaca, Fontainebleau, and Geneva. https://www.globalinnovationindex.org/userfiles/file/reportpdf/gii-full-report-2019.pdf

Cristóbal, J., Limleamthong, P., Manfredi, S., Guillén-Gosálbez, G., 2016. Methodology for combined use of data envelopment analysis and life cycle assessment applied to food waste management. Journal of Cleaner Production, 135: 158-168. https://doi.org/10.1016/j.jclepro.2016.06.085.

Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smits, R.E.H.M., 2007. Functions of Innovation Systems: A New Approach for Analysing Technological Change. Technological Forecasting and Social Change 74(4):413–432. DOI:10.1016/j.techfore.2006.03.002.
https://www.researchgate.net/publication/46712493_Functions_of_Innovation_Systems_A_New_Approach_for_Analysing_Technological_Change

European Commission, 2015a. A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. https://eur-lex.europa.eu/resource.html?uri=cellar:1bd46c90-bdd4-11e4-bbe1-1aa75ed71a1.0001.03/DOC_1&format=PDF

European Commission, 2015b. Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation. Communication from the Commission. C(2015) 6317 final 15.9.2015.
https://ec.europa.eu/energy/sites/ener/files/publication/Complete-A4-setplan.pdf

European Commission, 2018. European Innovation Scoreboard 2018. Publications Office of the European Union.
https://ec.europa.eu/docsroom/documents/33147/attachments/1/translations/en/renditions/native

European Commission, 2021. Publications as a measure of innovation performance: Selection and assessment of publication indicators. Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/9f1af3e9-e2ba-11eb-895a-01aa75ed71a1

Etzkowitz, H., and Leydesdorff, L., 1995. The Triple Helix -- University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development. EASST Review, Vol. 14 (1): 14-19. https://ssrn.com/abstract=2480085

Fiorini, A., Georgakaki, A., Pasimeni, F., Tzimas, E., 2017. Monitoring R&I in low-carbon energy technologies. doi: 10.2760/447418. Publications Office of the European Union.
https://publications.jrc.ec.europa.eu/ repository/bitstream/ JRC105642/ methodology_jrc_final_identifiers_pdf.pdf

Lowe, C.U., 1982. The triple helix -- NIH, industry, and the academic world. The Yale Journal of Biology and Medicine. 55(3-4): 239–246. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2596451/

Metsalu, T., and Vilo, J., 2015. Clustvis: a web tool for visualizing clustering of multivariate data using Principal Component Analysis and heatmap. Nucleic Acids Research, 43(W1):W566–W570. doi: 10.1093/nar/gkv468.

Montalto, V., 2017. Step 5: Weighting Methods (I) Data Development Analysis (DEA). European Commission Joint Research Centre, COIN 2017 - 15th JRC Annual Training on Composite Indicators & Scoreboards. 06-08/11/2017. https://composite-indicators.jrc.ec.europa.eu/sites/default/files/COIN%202017%20Step%205%20-%20Weighting%20methods%20%28I%29%20DEA_0.pdf

OECD, 2008. Handbook on Constructing Composite Indicators: Methodology and User Guide. ISBN 978-92-64-04345-9. OECD Publishing. https://www.oecd.org/sdd/42495745.pdf

OECD, 2010. Measuring Innovation – A new perspective. OECD Publishing. https://www.oecd-ilibrary.org/science-and-technology/measuring-innovation_9789264059474-en?_ga=2.196064812.141002435.1627394018-256415801.1627394018

Vertesy, D., 2017. The Innovation Output Indicator 2017: Methodology Report. Publications Office of the European Union. http://publications.jrc.ec.europa.eu/repository/ bitstream/JRC108942/jrc108942_ioi_2017_report_final.pdf

Getting in touch with the EU

IN PERSON
All over the European Union there are hundreds of Europe Direct information centres.
You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

ON THE PHONE OR BY EMAIL
Europe Direct is a service that answers your questions about the European Union.
You can contact this service:
– by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
– at the following standard number: +32 22999696, or
– by email via: https://europa.eu/european-union/contact_en

Finding information about the EU

ONLINE
Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU PUBLICATIONS
You can download or order free and priced EU publications from: https://op.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en)

EU LAW AND RELATED DOCUMENTS
For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu

OPEN DATA FROM THE EU
The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

The Clean Energy Innovation Index (CEII) is a composite indicator designed to track progress in achieving the SET Plan key actions, as measured through the lens of scientific publications, patents and trade. This report focuses on the methodology applied to the construction of the CEII, which is used in turn to monitor and assess the progress of European and Mission Innovation member countries towards SET Plan key actions (KA), focusing on R&I performance.

Studies and reports

Publications Office
of the European Union