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# The Global Cleantech Innovation Index 2017

WHICH COUNTRIES LOOK SET TO PRODUCE  
THE NEXT GENERATION OF START-UPS?



# ACKNOWLEDGEMENTS

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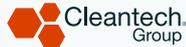
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## About the Cleantech Group



Founded in 2002, the mission of Cleantech Group (CTG) is to accelerate sustainable innovation.

Our custom research, subscriptions, events and programs are all designed to help corporates, investors, and all players in the innovation ecosystem discover and connect with the key companies, trends, and people in the market. Our coverage is global, spans the entire clean technology theme and is relevant to the future of all industries.

The company is headquartered in San Francisco, with a growing international presence in London. Learn more at [cleantech.com](http://cleantech.com). Our parent company, Enovation Partners, one of Consulting Magazine's 7 to Watch, is based in Chicago (learn more at [enovationpartners.com](http://enovationpartners.com)).

[www.cleantech.com](http://www.cleantech.com)

## About WWF



WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption. The Climate and Energy Practice (CEP) works towards an equitable and just transition that limits warming to 1.5°C degrees, protects people and biodiversity and builds a climate resilient future. A future with universal energy access by 2030, doubled energy efficiency, and a sustainable and fossil fuel free energy system. The core team is based in Berlin, Germany.

[www.panda.org/climateandenergy](http://www.panda.org/climateandenergy)

## UNIDO



UNIDO is the specialized agency of the United Nations that promotes industrial development for poverty reduction, inclusive globalization, and environmental sustainability. With the unique mandate to promote and accelerate inclusive and sustainable industrial development (ISID) in developing countries and economies in transition, UNIDO contributes to the three pillars of sustainable development, as recognized by the recently adopted 2030 Agenda for Sustainable Development and the related Sustainable Development Goals (SDGs), and in particular SDG-9 which calls to "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". Within this context UNIDO supports the transition to a sustainable energy path as a key solution to a climate resilient and economically sustainable growth. UNIDO also accords high priority to technology transfer and capacity building of industries including small and medium sized enterprises, and supports projects and programmes that leverage the power of innovation and entrepreneurship to address the energy, environmental and economic challenges of today by empowering emerging cleantech start-ups and bolstering the local entrepreneurial ecosystem and policy frameworks.

## About Tillväxtverket – The Swedish Agency for Economic and Regional Growth

Tillväxtverket, The Swedish Agency for Economic and Regional Growth, is a government agency under the Ministry of Enterprise and Innovation. We promote economic growth in Sweden by increasing the competitiveness of companies. We work to strengthen the competitiveness by facilitating entrepreneurship and creating attractive environments for companies in the regions. Our vision is more companies in Sweden that want to grow and have the capabilities and courage to do so. Knowledge, networks and funding are our main tools to achieve it. One task for the Agency is to support small and medium sized enterprises with fully developed green goods and services in their business development.

The aim of the financial support is to strengthen their competitiveness in domestic and international markets.

[www.tillvaxtverket.se](http://www.tillvaxtverket.se)



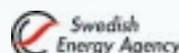
## About The Swedish Energy Agency

The Swedish Energy Agency is a national authority that works for a sustainable energy system by combining ecological sustainability, competitiveness and security of energy supply.

The Agency has a broad spectrum of roles with the aim to attain energy and climate objectives.

The Agency finances research for new and renewable energy technologies, smart grids, and vehicles and transport fuels of the future. The Agency also supports growth of the Swedish business community through realization of energy related innovations and new business ideas.

The Business development department has a special role in commercialize new energy innovations and technology. There is a more than 80% survival degree for the funded companies and an evaluation of the portfolio shows a potential, for the innovations in the portfolio, to save 750 million ton of CO2E on an annual base.



## About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to the majority of the world's poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration. Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.



# EXECUTIVE SUMMARY

The Global Cleantech Innovation Index (GCII) programme investigates where, relative to GDP, entrepreneurial clean technology companies are most likely to emerge from over the next 10 years – and why. Drawing on a wide range of factors and sources, the study seeks to answer the same question as the 2012 and 2014 GCII reports,<sup>1</sup> namely: which countries currently have the greatest potential to produce entrepreneurial cleantech start-up companies that will commercialise clean technology innovations over the next 10 years?

Based on the data contributing to 15 indicators of creation, commercialisation and growth of cleantech start-ups in 40 countries, the key trends identified in this edition of the Index are:

- Overall, and consistent with the 2014 Index, this 2017 Index demonstrates that countries will score well if they are a) addressing growing demand for renewable energy and other clean technologies; b) connecting start-ups with multiple channels to increase their success rates and; c) increasing international engagement across the cleantech ecosystem.
- The top three positions are held by Denmark, Finland and Sweden, which is not surprising based on very strong positions in the 2014 Index. All three appear to be gearing up for additional growth with increases in the numbers and amount of cleantech funds. The lowest scoring Nordic country is Norway. There are challenges for Norway but it is also the country with highest cleantech R&D budgets in 2013-15. The world would invest roughly 4 times more in cleantech R&D if it adopted the same level of cleantech R&D per GDP as Norway. The Nordic region performs strongly in 2017 Index.
- Denmark tops the 2017 Index, moving up from 5<sup>th</sup> place in 2014, based on strong scores in both *inputs to innovation* and *outputs of innovation*. The key contributing *cleantech specific drivers* include the amount of capital raised by cleantech funds and the number of cleantech organizations. Denmark also shows strong *evidence of commercialised cleantech*, including cleantech exports, the number of public cleantech companies and the number of renewable energy jobs.\*
- Poland has displayed the biggest change from the 2014 Index, as it rose thirteen places to take 24<sup>th</sup> place. This is mainly due to three notable increases in *cleantech-specific drivers*. Poland's public cleantech R&D expenditure now sits at the global average, having been in last place in the 2014 Index. The country also improved its score in the Renewable Energy Country Attractiveness Index, moving from 29<sup>th</sup> to 27<sup>th</sup> in that Index.<sup>2</sup> These factors are combining to show increasing *evidence for emerging cleantech innovation*, as Poland moved up 16 places in our measurement of cleantech patent filings.
- As expected, and consistent with the 2014 Index, there is a positive correlation between *inputs to innovation* and *outputs of innovation*. Countries that are facilitating investment in innovation, either through public R&D, cleantech-friendly policy, or any other of the *inputs* measured, tend to also reap benefits from the commercialisation of cleantech companies.
- It is becoming clear that the commercialisation efficiency varies by country, as shown by our analysis of these conversion rates (*Figure 5*). Germany, Singapore, and South Korea, show relative strength in *evidence of commercialised cleantech* innovation without having leading *inputs to innovation* scores, highlighting a strong efficiency in converting *inputs*. However, the top three overall ranked countries in the 2017 Index are less efficient at conversion; which may make their long-term position in the ranking less stable.

**\* Note from the Authors:**

The indicators data is from 2013 to 2016, which means that the score of countries may not be up to date. The Index results and country profiles should therefore be interpreted as strengths and weaknesses in relation to other countries in the 2013-2016 period. For example, Denmark has since cut its cleantech R&D budget by half since measurements were taken for the 2017 Index.

<sup>1</sup> <http://www.i3connect.com/gcii>

<sup>2</sup> EY, *Renewable Energy Country Attractiveness Index*, 2016

# FOREWORD

Global biodiversity is declining at an alarming rate, putting the survival of other species and our own future at risk. Living Planet Index<sup>1</sup> reveals that we could witness a two-thirds decline in global populations of fish, birds, mammals, amphibians and reptiles in the half-century from 1970 to 2020 – unless we act now to reform our food and energy systems and meet global commitments on addressing climate change, protecting biodiversity and supporting sustainable development.

The earth's climate is changing and disrupting a number of natural systems on which we all depend. Predicted effects of a temperature increase above 2°C to include more extreme weather events, sea level rises, precipitation changes, disappearing coral reefs, ocean acidification, eroded food security, prolonged poverty traps and forced migration of thousands of species including humans. International climate change negotiations delivered a turning point in 2015 at COP21 in Paris. All the world's countries agreed for the first time the shared objective of "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change". In reality this means that the world agreed in a pace of change over coming 30 years to half greenhouse gas emissions every decade as well as reaching a sustainable and fossil fuel free energy system.

But national climate action plans are not yet delivering sufficiently to reach the globally agreed targets, which make accelerated investments in solutions by business, financial institutions, countries and cities even more crucial. Current trends of energy investments fall well short of the amount needed to avoid dangerous global warming. But there is unprecedented momentum. More than 260 of the world's largest corporates have committed to WWF, UN Global Compact, WRI and CDP to set new science based targets that relate to a trajectory of 2 degrees global warming<sup>2</sup>. More than 1000 cities from all five continents have pledged support to ambitious long-term climate goals such as a transition to 100% renewable energy in their communities, or a 80% greenhouse gas reduction by 2050. Many of these are directly involved in WWFs One Planet City Challenge now spanning 30 countries and 300 cities. And it is becoming more and more clear to investors that there is a lot of money backing up the problem that must be shifted to support the solutions instead. The Michael R. Bloomberg lead Task Force on Climate-related Financial Disclosures is the first global, industry-led effort that has now created recommendations for climate-related financial disclosures for consideration at G20 and other fora. A great flow of financial sector actors are now divesting from coal assets, trying to align their portfolios with a 2 degrees global warming trajectory, investing heavily in renewable power generation, urging countries to stick to the Paris Agreement and putting increased pressure on fossil fuel companies to diversify rather than risking to strand large parts of their assets in case of a future scenario where we do actually avoid catastrophic climate change.

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<sup>1</sup> WWF's Living Planet Report 2016

<sup>2</sup> [www.sciencebasedtargets.org](http://www.sciencebasedtargets.org)



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Solutions do exist and can be enacted with the right combination of political, social and financial will. WWF’s Energy Report showed that all of the world’s energy needs could be provided cleanly and renewably by the year 2050, in ways that can be sustained by the global economy and the planet, and that such a transition is not only possible but cost-effective. However, the major innovation challenges ahead include the acceleration of business models that take solutions to market and the continuous cost-cutting of key technologies.

**The Global Cleantech Innovation Index 2017**

In order to accelerate progress we need to look at the conditions surrounding our large and small solution providers. We will need to see a shift towards a circular economy within planetary boundaries where energy comes from renewable energy sources. A wide range of products and services, such as those honored in WWF Climate Solver<sup>3</sup> program, must scale up quickly over the next 10-30 years. Government agencies, investors, cities, business and accelerators need to proactively collaborate as forces for scaling the change that comes out our most promising born global start-ups. Understanding these innovation processes is important in order to accelerate delivery towards the Sustainable Development Goals rather than stagnating in unsustainable failure. Tracking the innovation activity of smaller cleantech disruptors that carry the hope of enabling a shift to a cleaner, better, more attractive future for all is the impetus for this Global Cleantech Innovation Index. A future we must join hands in creating. Together possible!

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Climate and Energy Practice Leader, WWF International

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3 [www.climatesolver.org](http://www.climatesolver.org)

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# INTRODUCTION

The UN 2030 Agenda for Sustainable Development outlines the challenge for humanity as a balance between maintaining nature in all of its many forms and functions, and creating an equitable home for people on a finite planet.<sup>3</sup> Put in terms more familiar with the cleantech investment theme, this means moving away from the ‘business-as-usual’ scenario, preserving our climate, and doing more with less in an increasingly resource-constrained world. These are not simple challenges, and they require multi-dimensional, innovative, and global solutions.

This Index, first produced in 2012, and repeated in 2014, remains the only study (we know of) seeking to look at why entrepreneurial companies developing sustainable solutions seem to spring up in certain geographies, and which economic, social and environmental conditions cultivate hotbeds for such innovation. The GCII investigates the results of policies, and other related factors, on producing cleantech entrepreneurs and supporting commercialisation of their companies. The hope is that the analysis of these factors can be used to identify levers that can be pulled to improve innovation and commercialization, identify where to look for sources of innovation, and highlight where entrepreneurs might go to improve their chances of commercialisation.

Sustainable financial flows that support conservation and sustainable ecosystem management are an essential enabling condition for both preserving natural capital and promoting resilient and sustainable markets. Still, many financial institutions continue to invest substantially in harmful and unsustainable activities such as coal mining, environmentally damaging agriculture and oil drilling. Long-term perspective on financial risks recognising the interdependence of human demands for food, water, energy and environment, and our reliance on the Earth’s core physical and natural systems, is a holistic and powerful vehicle for analysing business and policy problems.<sup>4</sup> There are two reasons why businesses should be interested in the food-water-energy-environment nexus. Firstly, financial stability will be improved by avoiding the cost implications of resource scarcity and environmental damage such as floods, storms and drought. Secondly, businesses want to avoid the cost burden of future regulation in markets that begin to regulate in reaction to environmental decline or to reputational disasters. Currently, financial markets focus on short-term income and reduction of immediate risk when making investment decisions. There is little private sector incentive to consider long-term risks from environmental degradation.<sup>5</sup>

Policy makers, corporations, and investors are aware of the benefits of curating clean technology start-ups. Whether it is as part of a GHG emissions target roadmap, a source of increased employment, a way of preserving freshwater & biodiversity, a method of revenue growth, or a pivot in a newly created technology sector, the investor community has an increasing list of motivations for investing in innovative clean technology companies. This has led to over \$55 billion in equity investments in cleantech start-ups over 6 years, from 2010 to 2016.<sup>6</sup> However, venture capital investment figures only go so far, and this Index endeavours to cover different forms of support and acceleration of cleantech companies, including relationships with local and international partners, to produce a measurement of cleantech innovation support and commercialisation.

<sup>3</sup> UN, *Transforming our World: The 2030 Agenda for Sustainable Development*, 2015

<sup>4</sup> Reynolds, J. and Cranston, G., *Nexus thinking: can it slow the Great Acceleration?*, Cambridge Institute for Sustainable Leadership, 2014

<sup>5</sup> WWF, *Living Planet Report 2016*, pg. 114

<sup>6</sup> Cleantech Group data, *Seed, Series A, Series B, and growth equity investment from 2010 - 2016*

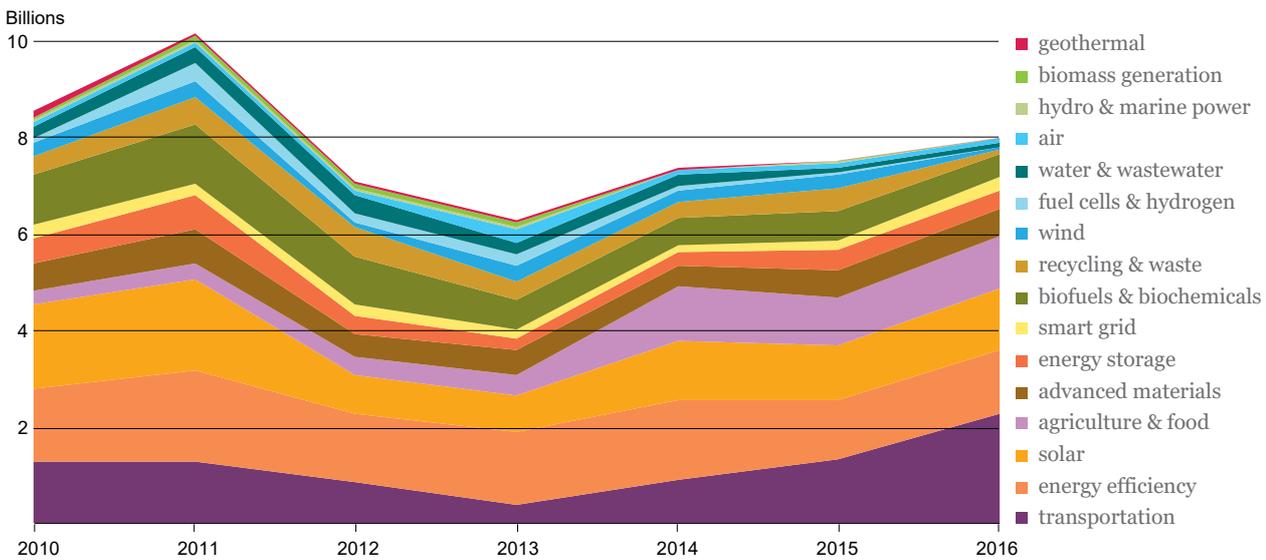
## Global Cleantech Investment: An Update

CTG is primarily focused on charting the future of all industries. It does so primarily through the lens of its sustainable innovation heritage, but it is not the only relevant lens for doing so. WWF is primarily focused on preserving wild animals through creating and maintaining nature conservation areas. With this shared heritage in sustainability, the changing landscape of innovation and cleantech is critical to meeting their goals. Over time, it has become clear that there are other innovations and technologies that will be critical to the future of some industries, but where their positive environmental benefit is what we might variously think of as tangential, indirect, or second order benefits. The core problem that most of such companies are trying to solve might be more related to convenience or cost, but they all ultimately have additional environmental benefits. In summary, the cleantech investment theme is always expanding beyond its core sectors, and is increasingly used interchangeably with terms such as ‘industrial efficiency’, ‘sustainable technology’, ‘resource innovation’, ‘circular economy’ and any other definition of doing more with less using technological innovation.

### The changing nature of cleantech investment:

In the 2014 GCII, we reported on the rise of ‘other cleantech’ sectors gaining favour in a ‘post-bubble landscape for renewables (especially solar), in which many venture capital investors have pulled out since the hype and height of stimulus spending in 2008’.<sup>7</sup> According to *Figure 1*, the update in 2017 would confirm the first assertion that there has been a proliferation of ‘other cleantech’ sectors receiving venture investment in substantial quantities, while sectors such as solar, which constituted a large part of the \$329 billion invested in renewable energy in 2015, have used venture capital investment to go mainstream, proving that the solar ‘bubble’ may have in fact led to the maturing of the solar market. The second comment on the decline of venture capital investor’s participation, at the time measured by the decline of investment from the 2011 peak to the 2013 trough, seems to have been written at a turning point. On evidence of the last four years, venture capital is steadily returning to newly-defined cleantech.

**Figure 1. Global Venture and Growth Equity Investment in cleantech companies, 2010 - 2016**



Includes seed, Series A, Series B, growth equity, excludes outliers (>\$350 million)

7 Cleantech Group, WWF, *Global Cleantech Innovation Index*, 2014

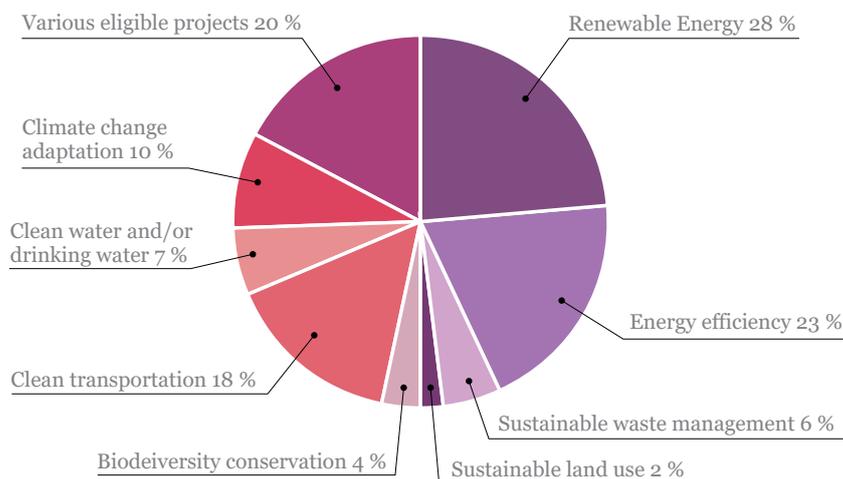
However, it is returning to a much-changed investment theme. While Renewable Energy and Energy Efficiency remains the bedrock of cleantech venture capital, there has been a significant rise in investment in Agriculture and Food, Advanced Materials, and Transportation, with the latter now a leading cleantech sector. We shall return to look at the impact of Energy Efficiency and Transportation on the cleantech investment theme later in this report.

One recent example of the growing strength of cleantech investment was announced at COP21 in Paris. A new Breakthrough Energy Coalition for early stage cleantech investment was launched. This new investment group committed to provide patient capital for clean energy innovation, starting with a \$2 billion pledge that is expected to reach \$20 billion by 2025. To follow this announcement, in December 2016 Breakthrough Energy Ventures was launched with \$1 billion, with the remaining 50% expected to be announced soon. This represents a welcome 12% addition to the \$8 billion in global venture and growth equity investment in cleantech companies.

**Green bonds boom**

The proliferation of green bonds is a telling sign for cleantech and renewable energy investment. It is encouraging to note that energy efficiency, transportation and renewable energy accounted for 70% of the rapidly growing Green Bonds market that reached \$95bn in 2016<sup>8</sup>. The same three areas represented around 62% of venture and growth equity investment in 2016. These are the three priority areas to grow in order to be able to fully decarbonise the global economy in line with reaching the agreed climate objective of staying well below 2 degrees in Paris 2015.

**Figure 2. Distribution of the \$95bn in Green bond issuance by sector and share, 2016**



<sup>8</sup> The Green Bond, Q1 2017, SEB and Moody's (2017)

## Research Context & Methodology

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The overall score for each country is based on the average between *inputs to innovation*, and *outputs of innovation*. By definition, inputs correspond to the creation of innovation (the development of technology supply) and outputs relate to the country's ability to commercialise innovation. Each of these inputs and outputs are determined by four equally weighted sets of indicators. The four pillars are built from a total of 21 metrics, condensed into 15 indicators, drawn from both third party research and Cleantech Group's proprietary data. The raw data for each indicator was normalised using a max-min scaling method to allow for comparisons on a common scale. Outliers were identified as those data points outside the upper and lower bounds, and then were attributed the value of the upper bound pre-normalisation of the data set. Where relevant, indicators were analysed from a 'per GDP purchase power parity' basis to account for relative accomplishment by size of economy, with the exception of renewable energy consumption (which we calculated as a percent of countries' primary energy consumption) and employment (which is measured on a per total labour force basis). The indicators span from 2013 to 2016 data, which means that the performance score of countries is not fully up to date. The Index results and its country profiles should therefore be interpreted as strengths and weaknesses in relation to other countries in the 2013-2016 period. More recent positive or negative changes are not captured in the Index score. The limitation of data updates is also the main reason the Global Cleantech Innovation Index has been updated less frequently than every year.

The scope of the study covered 40 countries, including all of the G20. In order to maintain comparability with the 2014 GCII, this report will not expand this selection in the 2017 Index. However, two additions have been made to the Global Cleantech Innovation Index programme generally. Firstly, a supplemental study of a number of Asian countries was conducted. In this report, data availability restricted a complete indexing of all of the Asian countries targeted, but their general position was determined relative to Asian countries that already appear in the GCII (Japan, India, Singapore, South Korea, and China). Secondly, using the GCII methodology as a guide, a cleantech innovation ecosystems assessment was conducted for partner countries of UNIDO's Global Cleantech Innovation Programme (GCIP), which includes Armenia, India, Malaysia, Morocco, Pakistan, South Africa, Thailand, and Turkey. Once again, data restrictions and comparability prevented five of these countries being added to the main GCII, however for certain dimensions of the ecosystem in-depth analyses were possible for many of the countries, which will be captured in the supplement report. For the first time we are also launching a micro-site for the Index where you can click through country profiles and other data, see [www.i3connect.com/gcii](http://www.i3connect.com/gcii) for more information.

The aim of this Index is to re-create the 2014 GCII to the greatest extent possible. To achieve this, the exact same datasets used in the 2014 Index were updated. However, this was not possible in for one 2014 Index indicator, Revenue of Cleantech Companies.<sup>9</sup> This has been replaced with a measurement of export and import of a number of selected cleantech-related commodities (including photosensitive/ photovoltaic/LED semiconductor devices, wind-powered generating units, recycling machinery, water purification machinery, and more). Export figures show the size of the national cleantech manufacturing sector and its international competitiveness. Import figures show the demand for clean commodities, balanced with a potential lack of domestic cleantech manufacturing. We consider the combination of these a

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<sup>9</sup> A measure of value-added from cleantech manufacturing as a proportion of GDP and revenue of Low Carbon and Environmental Services companies as a proportion of GDP, based on 2 reports: WWF/Roland Berger *Clean Energy, Living Planet*, and UK Department for Business Innovation & Skills, *Low Carbon and Environmental Goods and Services Report*.

valuable substitute indicator as it similarly provides a measurement of the strength of a nation's 'green economy', and is based on publicly available commodity trade data that will be accessible for all future editions of the Index.

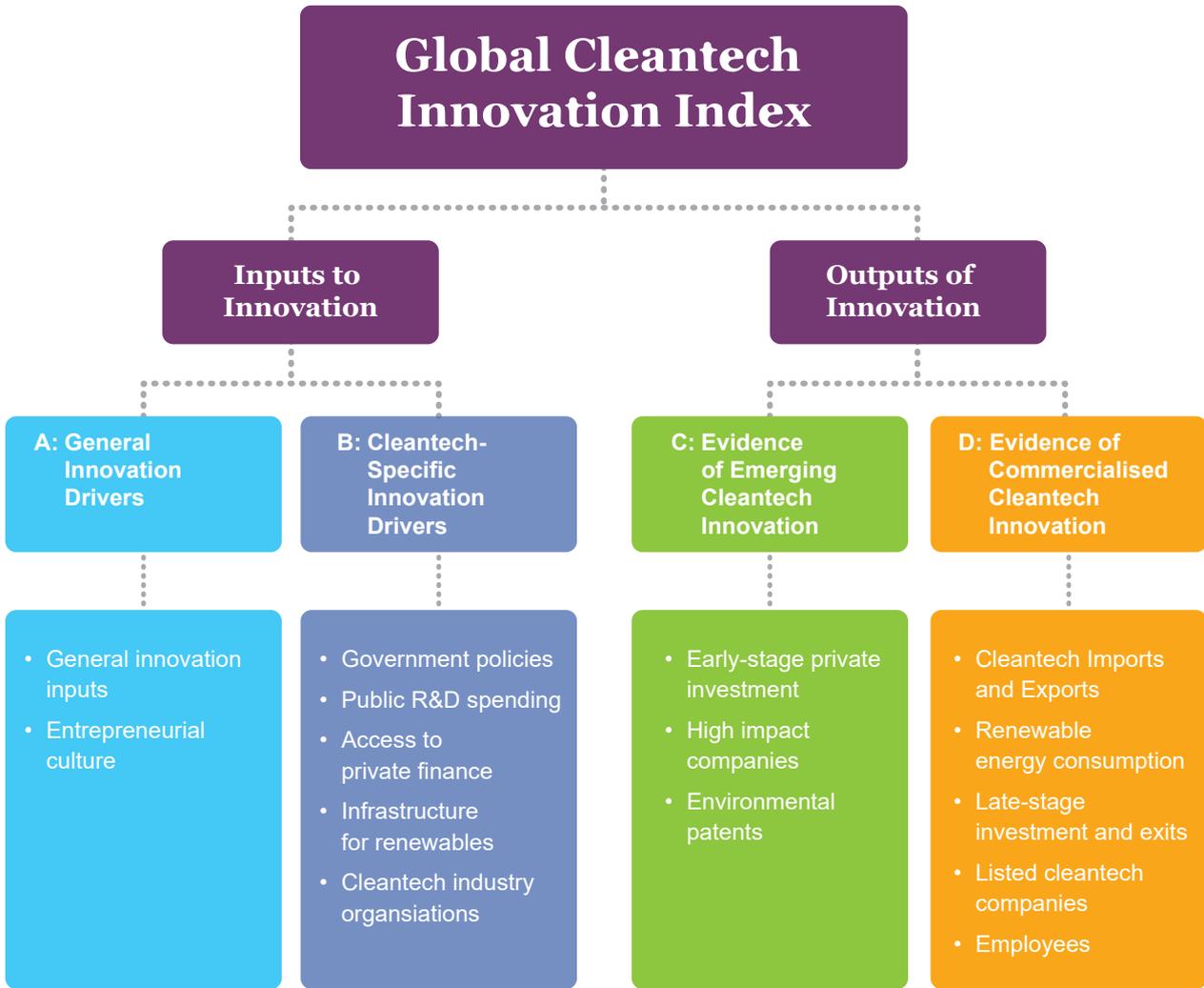
The GCII does not reflect how well country targets are set in relation to what is expected to meet a scientific need. For example, this Index does not reflect emission reduction targets, or the amount of Research & Development required within a certain time frame, in order to stay below 1.5 degrees global warming.

For a more detailed description of each indicator, please see *Appendix A*.



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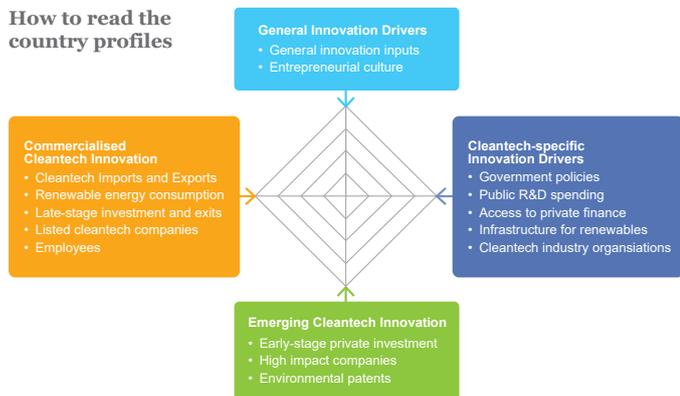
# Framework



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**How to read the country profiles**



## Factor Table

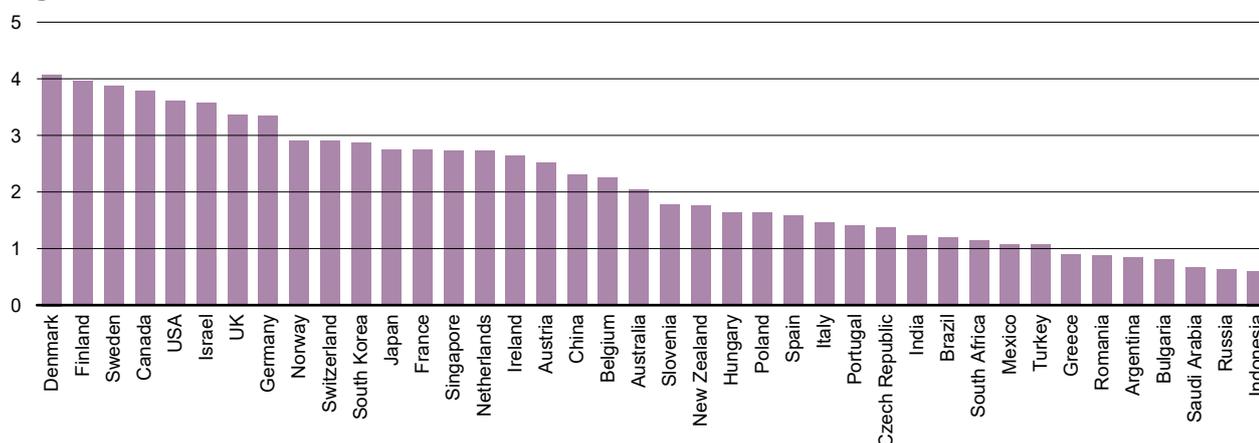
2017 Rank	Country	2017 Score	Inputs to Innovation	Outputs of Innovation	General Innovation Drivers	Cleantech-Specific Innovation Drivers	Emerging Cleantech Innovation	Commercialised Cleantech Innovation
1	Denmark	4,07	3,80	4,34	3,04	4,55	3,49	5,19
2	Finland	3,96	3,25	4,66	2,80	3,69	6,19	3,13
3	Sweden	3,86	3,36	4,35	3,69	3,03	4,73	3,98
4	Canada	3,76	3,30	4,23	3,29	3,30	5,13	3,33
5	USA	3,59	3,30	3,88	3,43	3,18	5,46	2,31
6	Israel	3,56	2,94	4,19	2,70	3,18	5,96	2,41
7	UK	3,37	2,97	3,77	2,92	3,02	4,97	2,58
8	Germany	3,33	2,47	4,18	2,31	2,64	4,58	3,78
9	Norway	2,90	3,23	2,58	2,63	3,82	2,21	2,95
10	Switzerland	2,89	3,04	2,74	3,14	2,94	2,68	2,79
11	South Korea	2,86	2,19	3,54	2,35	2,03	3,55	3,53
12	Japan	2,75	2,51	3,00	2,49	2,53	3,50	2,49
13	France	2,75	2,30	3,20	1,93	2,67	4,64	1,75
14	Singapore	2,71	2,04	3,39	2,78	1,30	2,43	4,34
15	Netherlands	2,71	2,71	2,70	3,07	2,35	2,58	2,82
16	Ireland	2,64	2,63	2,64	2,92	2,35	3,41	1,87
17	Austria	2,52	2,56	2,49	2,39	2,73	1,81	3,17
18	China	2,31	2,44	2,18	2,20	2,68	2,25	2,11
19	Belgium	2,26	2,29	2,23	2,12	2,45	1,94	2,53
20	Australia	2,04	2,77	1,31	2,86	2,68	1,51	1,11
21	Slovenia	1,78	1,64	1,93	1,53	1,75	1,43	2,43
22	New Zealand	1,74	1,87	1,61	2,59	1,15	0,70	2,52
23	Hungary	1,65	2,07	1,22	1,54	2,61	0,78	1,65
24	Poland	1,63	1,92	1,33	1,62	2,22	0,99	1,68
25	Spain	1,59	1,48	1,70	1,56	1,39	1,28	2,12
26	Italy	1,47	1,84	1,11	1,45	2,23	0,68	1,54
27	Portugal	1,41	1,74	1,08	1,65	1,84	0,34	1,82
28	Czech Republic	1,37	1,38	1,36	1,74	1,01	0,64	2,08
29	India	1,22	1,76	0,68	1,30	2,21	0,83	0,54
30	Brazil	1,20	1,52	0,88	1,74	1,29	0,24	1,51
31	South Africa	1,13	1,32	0,94	1,02	1,61	1,00	0,87
32	Mexico	1,08	1,12	1,04	1,20	1,03	0,12	1,96
33	Turkey	1,07	1,53	0,61	2,08	0,98	0,10	1,12
34	Greece	0,90	0,85	0,94	0,75	0,95	0,62	1,26
35	Romania	0,87	0,91	0,83	1,02	0,80	0,50	1,16
36	Argentina	0,84	1,32	0,36	1,33	1,31	0,09	0,63
37	Bulgaria	0,83	1,10	0,55	0,96	1,24	0,24	0,87
38	Saudi Arabia	0,67	1,24	0,10	2,37	0,11	0,14	0,06
39	Russia	0,65	0,73	0,57	0,80	0,66	0,78	0,37
40	Indonesia	0,60	1,11	0,09	1,21	1,02	0,00	0,18

For comparison, the Index and Indicators have a mean score of 2.12.

## Results and Analysis

The 2017 Index top performer is **Denmark**. **Finland** and **Sweden** take the 2<sup>nd</sup> and 3<sup>rd</sup> places respectively. **Canada** and the **United States** complete the top five. Denmark stands out through its top scores for *cleantech-specific drivers* and *evidence of commercialised cleantech*. In *commercialised cleantech*, the country is far ahead of the other countries on the list. However, Denmark cut its cleantech R&D budget by half since measurements were taken for this 2017 Index, the effect of which would lower their overall score, and move the country out of 1st place. At the same time, Denmark has pledged to double their average public funding to the Danish Energy Technology Development and Demonstration Programme (EUDP) of the fiscal years 2015-2016 (\$45 million) to \$90 million by 2020. The interplay of these changes will be reflected in the next edition of the Index.

Figure 3: Cleantech Countries Innovation Index



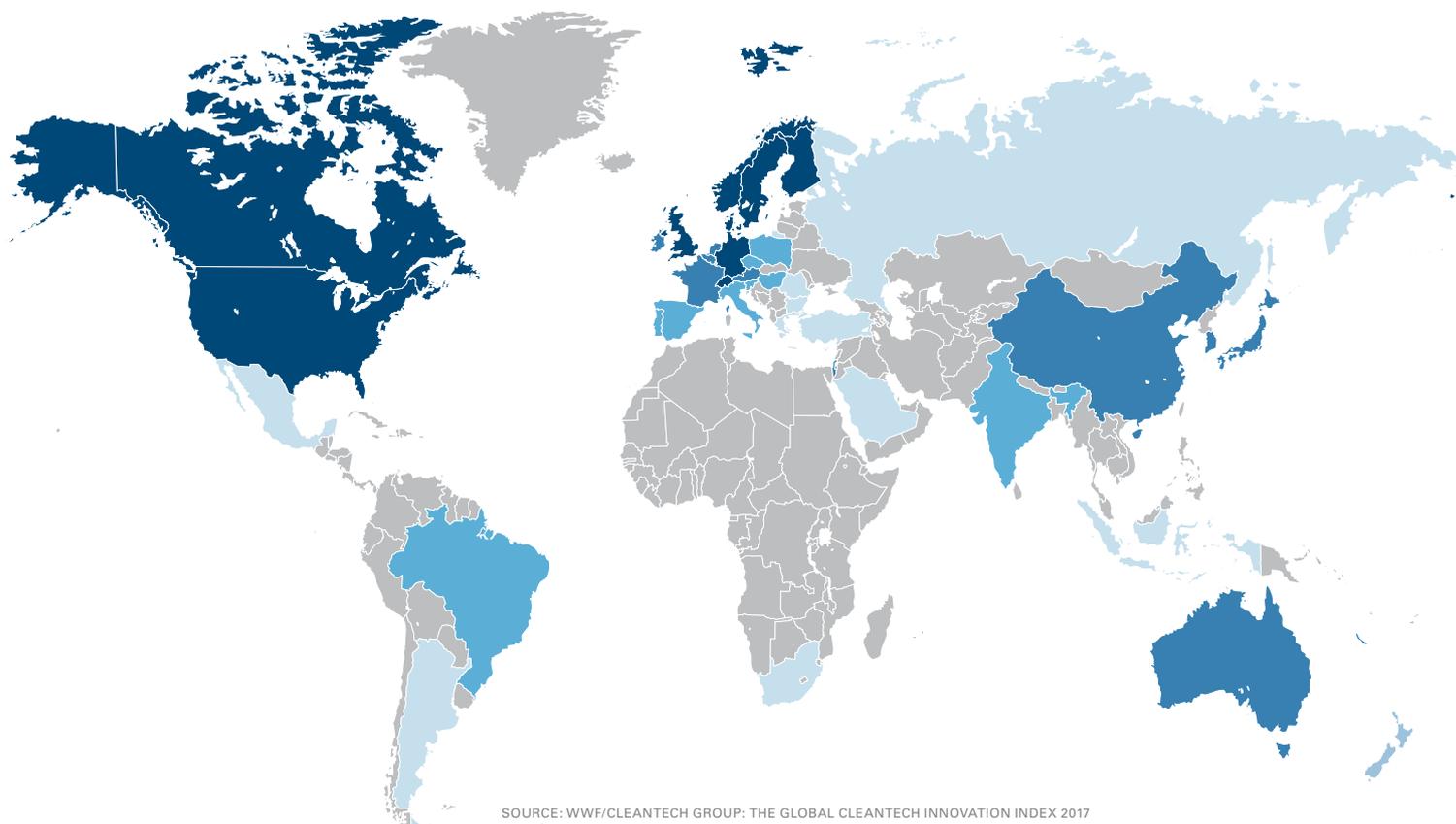
Overall, Finland holds on to 2<sup>nd</sup> place in the 2017 Index. Notable changes include increases in several key indicators including: number and amount of cleantech funds, M&A related activity, number of cleantech organizations and clusters, relative number of publicly listed cleantech companies, renewable energy consumption, and renewable energy jobs.

Sweden moved up one place to 3<sup>rd</sup>, supported by increases in number of funds, public cleantech R&D expenditure, renewable energy consumption and jobs. Other key indicators retained already high scores in areas such as *general innovation drivers* of innovation and early-stage venture capital investment.

In the 2014 report, we remarked that there appears to be a correlation between the GDP of a country and its capability for creating a well-functioning cleantech innovation ecosystem. If anything, this trend has become more visible in this year's edition of the GCII. Of the BRICS countries, only **Russia** and **China** have moved up in the ranking compared to the 2014 report, with **India**, **Brazil** and **South Africa** losing eight, five and two spots respectively. Other emerging economies like **Indonesia** and **Turkey** also lose places.

The Nordic countries continue to dominate the ranking, and do so in an even more convincing way than in the 2014 report, as shown in the full podium of Scandinavian countries (Denmark, Finland, and Sweden). **Norway** comes in 9<sup>th</sup> place, further down the ranking. The country is a less efficient innovator than the other Scandinavian

Higher index score (the darker blue it gets) means GDP related support for cleantech innovations is better (2013-2016 data).



countries, and mainly lags behind due to lower scores in *evidence of emerging innovation*. This may be attributed to the oil wealth the country is enjoying.<sup>10</sup>

As mentioned in the Executive Summary, the most improved country performance from the 2014 Index in this report is **Poland**, which rose thirteen places to take 24<sup>th</sup> place. This is mainly due to two notable increases in *cleantech-specific drivers*. Poland's public cleantech R&D expenditure now sits at the global average, having been in last place in the 2014 Index. The country also improved its score in the Renewable Energy Country Attractiveness Index, moving from 29<sup>th</sup> to 27<sup>th</sup> in that Index.<sup>11</sup> These factors are combining to show increasing *evidence for emerging cleantech innovation*, as Poland moved up 16 places in our measurement of cleantech patent filings. **Slovenia** and **Singapore** are 2<sup>nd</sup> and 3<sup>rd</sup> most improved, and rise seven and six places respectively.

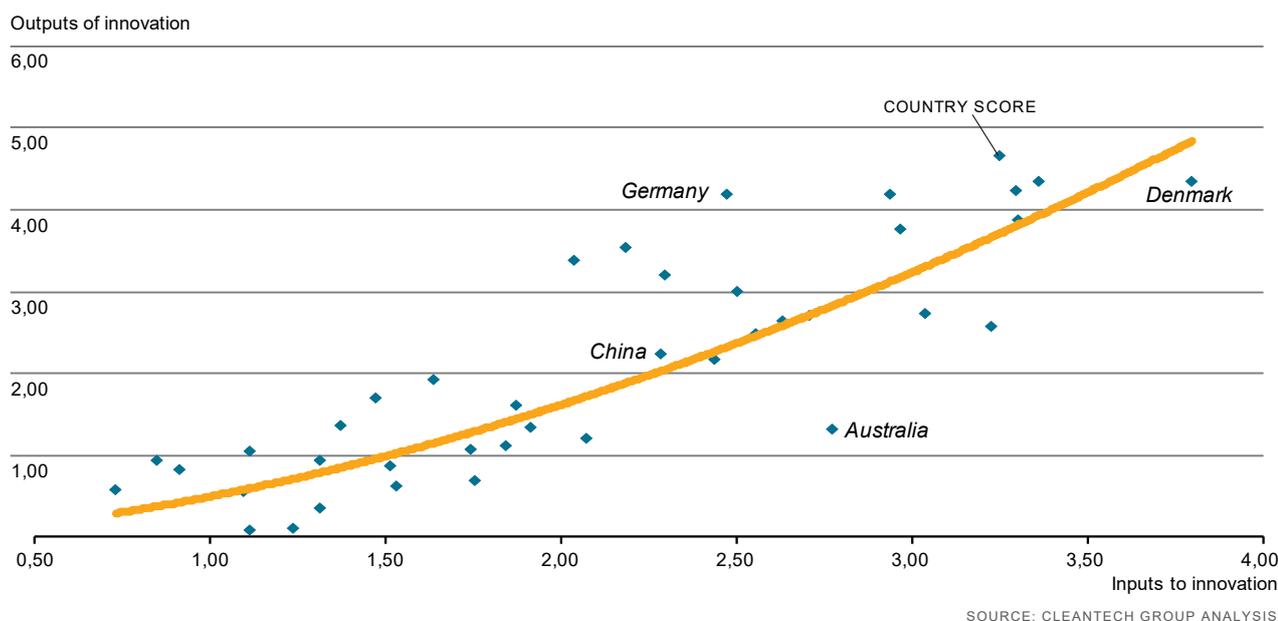
<sup>10</sup> J. Gapper, *Norway's oil wealth swamps innovation*, Financial Times, 19 October 2016, <https://www.ft.com/content/792eba76-95e0-11e6-a1dc-bdf38d484582>

<sup>11</sup> EY, *Renewable Energy Country Attractiveness Index*, 2016

### Innovation Efficiency

Figure 4 shows the comparison of a country’s score in *inputs to innovation* against its score for *outputs of innovation*. Using this graph we can see there is a correlation between *inputs to* and *outputs of* innovation, and that inputs and outputs scores tend to increase at a similar rate. **Germany** therefore registers as an efficient innovator. The country demonstrates that despite lower early-stage entrepreneurial activity, and low evidence of cleantech investment community (relative to GDP) it is still able to achieve high levels of innovation outputs through a strong established industry and manufacturing sector. Additionally, Germany is a leader for environmental patents and is also highly ranked for renewable energy jobs. **Australia**, on the other hand, is an inefficient innovator. While the country has a very strong entrepreneurial culture, which is strengthened by a well-developed early investment landscape, this is not translated into strong outputs to innovation. The country is lagging in *commercialised cleantech*, mainly due to low export revenue generated by cleantech-related companies and the low number of renewable energy jobs as a percentage of the total labour force.

Figure 4: Cleantech Innovation Efficiency

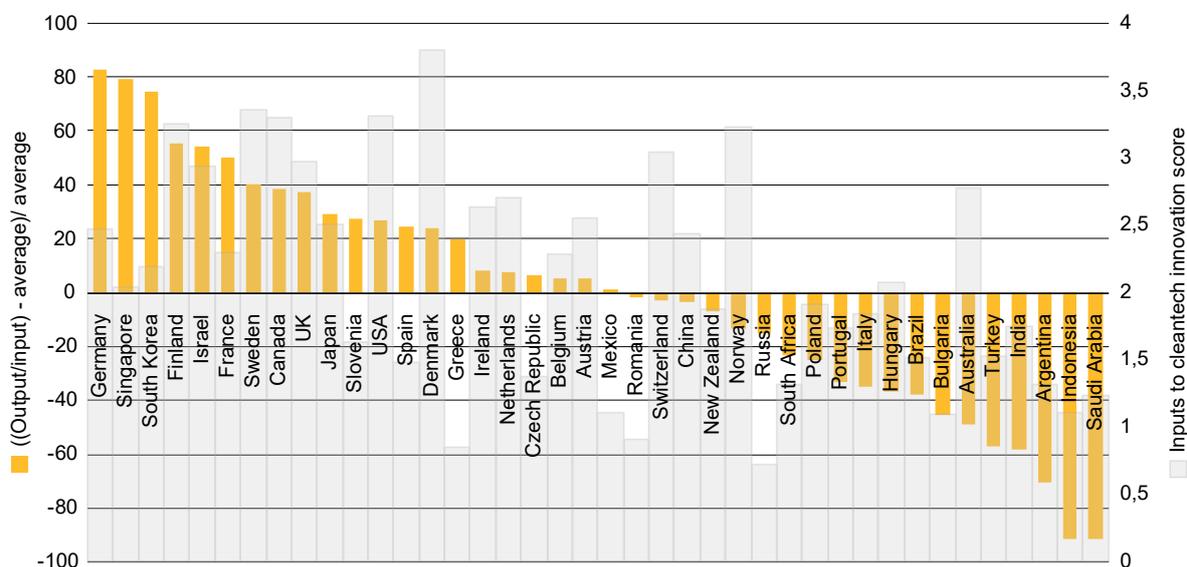


### Innovation Conversion

However, Figure 4 only gives us part of the picture. While we can see variations away from an average cleantech ‘efficiency’, it is also useful to look at cleantech conversion rates. Figure 5 measures a country’s conversion of a unit of cleantech *input* into cleantech *output*. On the secondary axis, we have added the country’s overall score for *inputs to innovation* (the combined score of *general innovation drivers* and *cleantech-specific drivers*). Using this graph we can more accurately measure a country’s innovation conversion rate, compared to the global average.

Countries that have low cleantech innovation *inputs* tend to have a low conversion rate. Conversely, countries with above average scores for *inputs to innovation* tend to have above average conversion rates. This is a reflection of Innovation Efficiency, outlined in Figure 4. However, this graph offers the insight that countries such as **Germany**, **Singapore**, and **South Korea**, are the most efficient producers of *outputs* from their measure of *inputs*. Conversely, Denmark is seen as a relatively inefficient cleantech

Figure 5. Cleantech innovation conversion rates



innovation converter, signalling that the country either; 1) requires high levels of *input* to achieve its level of *outputs*, or; 2) the country has more cleantech commercialisation potential to realise in the coming years.

The low *inputs to innovation* scores for Germany and South Korea should change in the next edition of the Index, in line with their Mission Innovation pledge.<sup>12</sup> Germany’s baseline is calculated by averaging the budget for project funding within the 6th Federal Energy Research Programme on renewable energy and energy efficiency technologies for Fiscal years 2012 to 2015. On average €450 million was spent in respective research areas within this period. The Mission Innovation pledge is double that amount to €900 million by 2020 with annual increases. South Korea’s base line year is 2016 with a funding of \$490 million, by 2020 this will double to \$980 million. However, the South Korea definition includes nuclear power, carbon capture, as well as “clean thermal power” in addition to renewables, energy storage and energy efficiency.

**Denmark**, despite being the 2017 Index top scorer, is actually a relatively inefficient innovator. This is mainly due to its relatively low score for *emerging cleantech innovation*, where the country only ranks 11<sup>th</sup> of the countries analysed. On the contrary, **Finland** and **Sweden**, the next countries in this year’s ranking, are more efficient, and take 4<sup>th</sup> and 7<sup>th</sup> places for innovation conversion efficiency.

**Switzerland**, which is regarded as one of the most innovative countries in the world,<sup>13</sup> is not an efficient cleantech innovator. This is mainly due to relatively low *emerging cleantech innovation*. Switzerland only takes 10<sup>th</sup> place in the overall ranking, down two places from its 2014 ranking.

**Saudi Arabia** is the most inefficient innovator. The country has strong *general innovation drivers*, mainly because of the great perceived opportunities for entrepreneurship, which translate into relatively high levels of early entrepreneurship. However, the country does not encourage *cleantech-specific innovation*, and there is no evidence of cleantech company success to speak of, whether *emerging* or *commercialised*.

12 Mission Innovation

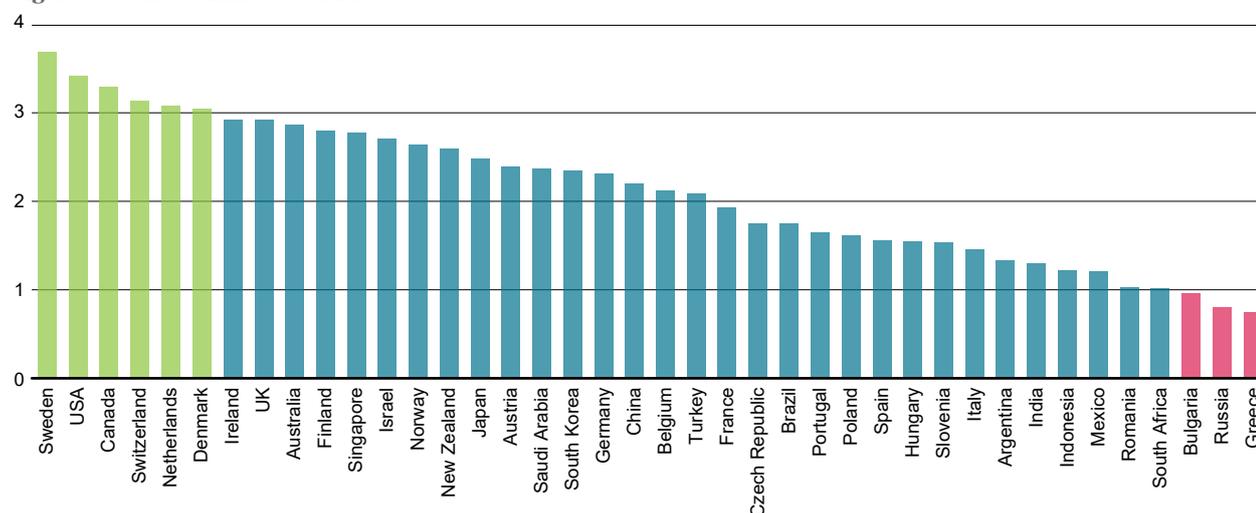
13 Switzerland ranked 1<sup>st</sup> in the INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016 Global Innovation Index.

## Inputs

### A: General innovation drivers

*General innovation drivers* are a measure of the conditions which facilitate the development of entrepreneurial activity and innovation in a country. This set of indicators are a guide to understanding whether conditions for starting a business, whether it be related to clean technology or not, are present in a country. Additionally, the culture and psychology of individuals play a large role in determining the likelihood of entrepreneurial success. This index pillar covers these determinants, drawing from data sources in the Global Innovation Index<sup>14</sup> and the Global Entrepreneurship Monitor<sup>15</sup>. The scoring below demonstrates our quantification of countries' underlying economic, institutional, and social frameworks on shaping their innovation systems.

Figure 6. General Innovation Drivers



It should be noted that the top 10 countries for *general innovation drivers* are amongst the most developed and high-income countries covered by the Index, all lying within North America and Europe (plus **Australia**). In terms of sustainable consumption the top 10 countries also have an ecological footprint per capita<sup>16</sup> that is well above sustainable levels, as well as global-average. There is therefore further responsibility to score well in nurturing innovations that can meet global environmental challenges. Countries such as **Sweden**, the **USA**, and **Switzerland** have the necessary economic size and development for sophisticated government institutions, market capacity, and educational systems spending that is reflected by their high score in the *Innovation Input Sub-Index*, recorded in the general innovation indicator.<sup>17</sup> In turn, the strength of these factors contributes to the perception of entrepreneurial opportunities, measured in the second and third indicators which assess entrepreneurial culture,<sup>18</sup> in which these three countries also rank highly.

Having established their similarities, not all top scorers have the same reasons for their relative success. The **US**, **UK**, and **Switzerland**'s innovation systems benefit from the high quality of domestic education and university research,<sup>19</sup> while **Sweden**'s

<sup>14</sup> INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016

<sup>15</sup> Global Entrepreneurship Monitor, 2016

<sup>16</sup> WWF, Living Planet Report, 2016

<sup>17</sup> INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index - Innovation Input Sub-Index*, pg. 50. Includes indicators covering underlying innovation inputs: Institutions, Human Capital and Research, Infrastructure, Market Sophistication, Business Sophistication

<sup>18</sup> Global Entrepreneurship Monitor, 2016

<sup>19</sup> High ranking in *Global Innovation Index* input 'QS university ranking average score top 3 universities'.

potential innovation talent benefits from its government's strong expenditure on education.<sup>20</sup> **Canada** and **Finland** are strong in their national regulatory quality and government effectiveness,<sup>21</sup> signalling the ability of their governments to formulate and implement cohesive policies that promote the development of the private sector.<sup>22</sup> Other factors, such as the efficiency of national logistics and state of infrastructure give countries like the **Netherlands** an advantage.<sup>23</sup> Top performers in *general innovation drivers* leverage different determinants of the innovation system to their advantage, and each named here score highly in this pillar as a result.

While the successful provision of entrepreneurial opportunities may be a driving factor to start-up generation, this does not translate into high 'total early-stage entrepreneurial activity' scores among the leaders. For example, the percentage of working-age population engaged in starting a business in **Switzerland** is half the score of that of **Canada**. Thus, not all opportunities are realised among top-income countries. Likewise there are some major differences in potential between countries that score less on this indicator. Perceived entrepreneurship opportunities in India are more than double those perceived by the Russian population, according to Global Entrepreneurship Monitor.<sup>24</sup> This observation should contribute to the success of government initiatives, such as Start Up India,<sup>25</sup> as they drive the conversion of perceived opportunities into a strong startup ecosystem.

Among the BRIC economies, we observe scoring in the middle and lower half of this indicator pillar, mainly attributable to lower-than-average Global Innovation Index scores. However, taking a closer look at the level of early-stage entrepreneurial activity, emerging economies fare better. **Brazil**, for example, scores 25<sup>th</sup> place for *general innovation drivers* with a low Global Innovation Index score, but has the highest early-stage entrepreneurial activity worldwide. This pattern indicates that emerging economies' start-up activity may not necessarily be driven by institutional and market sophistication as covered by the Global Innovation Index, and is more driven by other opportunities arising through the large market size in these economies.<sup>26</sup>

It is interesting to note country cases that show good evidence of *general innovation drivers* which then do not translate into outputs in the cleantech innovation sphere. **Saudi Arabia** holds an above-global-average score for *general innovation drivers*, scoring top for *general innovation inputs* and thus giving evidence for a highly streamlined and supported national innovation ecosystem. The country, however, shows almost no *cleantech-specific drivers of innovation*, which in turn translates into low scores for cleantech innovation outputs. This example demonstrates that without clear cleantech-focused drivers, the cleantech theme is not always an attractive choice for entrepreneurs in certain countries.

Comparing the results of this year's *general innovation drivers* to those of the 2014 edition, we can observe a broadly similar spread of countries across the distribution. The top four countries, as well as bottom three countries remain the same.

However, three countries have seen their position in this indicator change significantly over the past three years:

**Poland** jumped from 38<sup>th</sup> to 27<sup>th</sup> place in this pillar. The country's Global Innovation Index score remained the same, so the improvement is fully attributable to a surge in the score of its population's perceived entrepreneurial opportunities (from 26 to 39).<sup>27</sup>

20 High ranking in *Global Innovation Index* input 'Expenditure on education', pg. 317

21 High ranking in *Global Innovation Index* inputs 'Government effectiveness' and 'Regulatory quality', pg.310-311

22 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016, pg.51

23 High ranking in *Global Innovation Index* input 'Logistics performance', pg. 334

24 Global Entrepreneurship Monitor, *Perceived Opportunities Indicator*, 2016

25 <http://startupindia.gov.in/>

26 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016

27 Global Entrepreneurship Monitor, *Perceived Opportunities Indicator*, 2016

This has also begun to translate into an increased total early-stage activity. Ultimately, the cleantech theme should reap the benefits of general advances in innovation support systems, although the impact of current efforts may take a while to realize, and has not been matched with a significant increase in *evidence of emerging, or commercialised, cleantech innovation*. This may be due in part to relatively low national and regional ambition in the climate and energy transition.

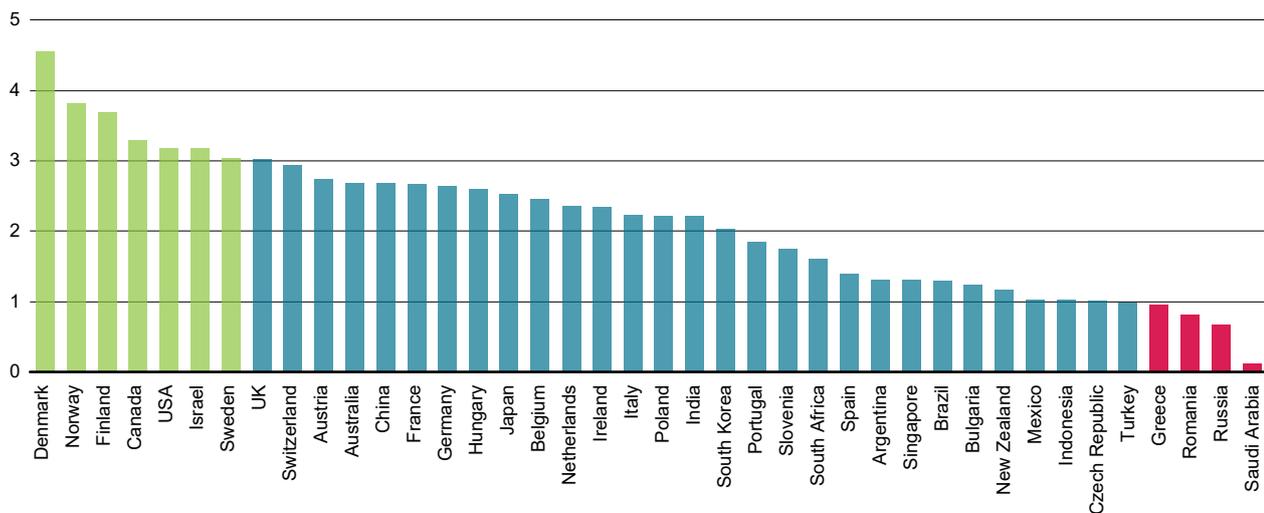
**South Korea** dropped from 7<sup>th</sup> to 18<sup>th</sup> place in this pillar. The Global Innovation Index score for South Korea increased only slightly since 2014, while perceived entrepreneurial opportunities halved in score and are responsible for the country’s drop in rank. This has not yet shown an impact on the total early-stage business activity of the country, which stayed constant between the years.

**Indonesia** has also seen a drop in its rank from 25<sup>th</sup> to 34<sup>th</sup> place in this pillar. Unlike South Korea, this is attributable to a slight drop in all constituent indicators of *general innovation drivers*, the largest being in the total early-stage business activity of the country from 26 to 14.

**B: Cleantech-specific innovation drivers**

*Cleantech-specific drivers* help promote market adoption of clean technologies, drive demand in the green economy, and address any barriers to entry for the industry. Acknowledging that both public incentives and private support play an important role in driving and maintaining entrepreneurial activities in the cleantech sector, this index pillar addresses these in various forms. A government’s contribution to cleantech innovation drivers is determined by the level of cleantech-supportive policy, the public R&D expenditure in the sector, and the country’s market attractiveness for renewable energy investment. Measuring the level of start-up access to private finance via cleantech funds and domestic investors serves as the private capital support assessment. The access to cleantech clusters and organisations, both public and private, provide an additional assessment of the interplay of these drivers.

Figure 7. Cleantech-Specific Innovation Drivers





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Led by three Nordic nations, **Denmark, Norway and Finland**, the top 10 scorers in *cleantech-specific innovation drivers* include some of the highest-income and most highly developed nations in the Index. While there are significant differences in countries' reasons for relative success in this pillar, all countries scoring high for this index pillar support long-term and sustainable solutions to advance their country's prosperity and development, and seek the promotion of innovation in the cleantech investment theme.

The Nordic nations perform strongly in the set of government-backed *cleantech-specific innovation drivers*, with all 4 countries scoring within the top 9 for the public R&D expenditure, cleantech-supportive policy and cleantech cluster organisation indicators. Additionally, **Denmark, Sweden, Norway, and Finland** also show a significant strength in the number of private investors active in the cleantech market, relative to national GDP. Together, these drivers effectively increase market demand for clean technology and provide some necessary capital for the scale-up of innovative start-ups. However, noteworthy is the newly announced (after the 2017 Index data sourcing date) halving of Danish public cleantech R&D expenditure, a change that in itself will push Denmark away from the top index position if this weakened policy persists.

The **USA, Canada** and the **UK** also show good evidence for the public support of cleantech innovation, but have their largest relative advantage in providing start-ups with access to private capital via cleantech-focused funds and domestic investors. **Israel**, ranked 6<sup>th</sup> in this pillar, scores top for all private *cleantech-specific drivers*, and yet scores significantly lower for public drivers to innovation. The Israeli cleantech start-up sphere greatly benefits from the access to domestic and US cleantech funds and investors.

Especially low-scoring countries, including **Greece, Romania, Russia, and Saudi Arabia**, lack the necessary cleantech-focus in the public support of their national innovation system, via government R&D and supportive policy programs, as well as showing very limited private sources of capital. Using Greece as an example, some of these instances of low scores are attributable to limited access to private finance as a

result of a generally depressed investment market,<sup>28</sup> and in some cases the access for cleantech start-ups is further inhibited by a risk-averse investment culture.<sup>29</sup>

BRIC nations show a very mixed performance in *cleantech-specific innovation drivers*. While **China** scores above some European nations like **Germany** and its Asian neighbour **Japan**, attributable to its high renewable investment attractiveness and relative strength in the access to finance via cleantech funds, **India**, **Brazil** and **Russia** fall to the lower end of the distribution.

### Germany and France

Despite having highlighted renewables on their political agendas, which is reflected in their renewable investment attractiveness indicator score, both **France** and **Germany** dropped in their ranks for *cleantech-specific drivers* from 4<sup>th</sup> and 6<sup>th</sup> place to 13<sup>th</sup> and 14<sup>th</sup> place, respectively. For both of these countries a near average number of cleantech clusters and cleantech investors, relative to national GDP, play a large part in these countries' new position in the 2017 Index. However, while investor counts are mid-range, the value of targeted cleantech funds in both of these countries remains in the top 10 globally.

### Canada and Norway

These two countries show improvements in driving their national cleantech ecosystem forward, entering the top 4 for *cleantech-specific drivers* in 2017, up from the 2014 ranks of 18<sup>th</sup> and 25<sup>th</sup> respectively. For **Norway**, this can be explained by the doubling of domestic cleantech investors, and a surge in national cleantech R&D budget. With Norway-equivalent cleantech R&D budgets (currently 0.075% of GDP) the world would invest roughly 4 times more in cleantech R&D (based on the 2017 Index average of 0.019% expenditure on cleantech R&D), which would be very welcome in the fight against a large number of planetary challenges. For **Canada**, the increase in rank can be attributed to the tripling of the number and value of cleantech funds and domestic investors targeting cleantech.

### India

While remaining in their relative order, all BRICs drop significantly in their ranks, with **China** and **India** dropping from 7<sup>th</sup> to 12<sup>th</sup> rank and 14<sup>th</sup> to 22<sup>nd</sup> rank, respectively. For India, this change has can be attributed to a drop in the number of cleantech-specific venture capital funds targeting the country, alongside a drop in the count of cleantech cluster organisations. These are compounded by a significant relative drop in India's cleantech R&D budget, which fell from 15<sup>th</sup> to 32<sup>nd</sup> relative to the other countries in this Index.

**Poland** passes fourteen countries, including **Russia**, **Brazil** and **India**, to reach 21<sup>st</sup> position in this indicator pillar. This is partly attributable to the increased presence of many cleantech-friendly policies, most notably of Green sovereign bonds in 2016.<sup>30</sup> However, while advances have been made in Poland, such as meeting its GHG emissions reduction target of 29% in 2012 with a surplus of 24%<sup>31</sup>, this has occurred despite 81% of electricity generation being provided by coal. This indicator only measures whether policies such as renewable energy feed-in tariffs, automotive efficiency standards, and others, exist in country; it makes no account for their targets, effectiveness, or enforcement.

28 US bureau of economic and business affairs, 2016 Investment Climate Statements: Greece. <https://www.state.gov/e/eb/rls/othr/ics/2016/eur/254369.htm>

29 Global Entrepreneurship Monitor, Data table for 'entrepreneurial finance', 2017 pg. 135-136

30 <https://www.climatebonds.net/2016/12/poland-wins-race-issue-first-green-sovereign-bond-new-era-polish-climate-policy>

31 National Centre for Emission Management-Institute of Environmental Protection, 2014, *Poland's national inventory report 2014, Greenhouse Gas Inventory for 1988-2012*"

## Archetype 1: ‘Top innovation ecosystem creators’

We use the label ‘top innovation ecosystem creators’ to describe countries that come first when combining both *inputs to cleantech innovation* pillars (*general innovation drivers* and *cleantech-specific drivers*). This measurement indicates that the country provides the underlying parameters, incentives, and necessary support for a thriving cleantech innovation ecosystem.

**Figure 8. A comparison of Denmark, Sweden, and the USA, to global average in the four indicator pillars**

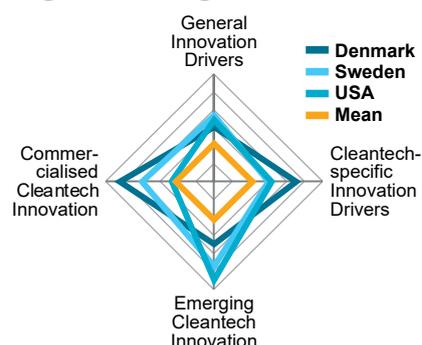


Figure 8 shows the profile of three ‘top ecosystem creators’: **Denmark, Sweden, and the USA**. Others countries that were nearly included in this archetype include **Canada, Finland and Norway**. There is clear evidence for the existence of a streamlined innovation pipeline among these countries, with high inputs to innovation translating into significant evidence for emerging cleantech innovation. This serves to support this report’s inherent hypothesis that there is a clear positive correlation between

the inputs and outputs to cleantech innovation.

**Denmark** leads this edition of GCII, and shows an especially strong performance as a ‘top innovation ecosystem creator’. With 63.8% of the Danish working-age adults seeing good opportunities for starting a business in their area, the country has shown evidence of merging good support structures with an awareness of opportunities. Its outstanding evidence of *cleantech-specific drivers* are attributable to a large public cleantech R&D budget (relative to GDP in 2015, this figure does not account for the cleantech R&D cuts in 2016), large number of industrial cleantech clusters, and high levels of access to private finance via a mature cleantech investment sector.

**Sweden** shows evidence for promoting a leading innovation ecosystem globally, which forms the underlying stage for a successful cleantech-specific start-up sphere. Like Denmark, Sweden’s cleantech innovation is highly incentivised by government policy, and also benefits from the large number of domestic cleantech investors, relative to GDP. Sweden stands out when it comes to renewable energy jobs and high number of recent cleantech IPO launches for a small country. Otherwise, Sweden displays an even score across all indicators with the exception of lower than average amounts in cleantech-focused funds, a gap the country has recently addressed with Gröna Fonden, a new \$75 million greentech fund launched in 2017, alongside a \$338 million (SEK3 billion) portion of the EU structural fund budget targeting the low-carbon economy, which will be half financed by the Swedish state.<sup>32</sup>

The **USA** is home to the largest, oldest, and most developed cleantech innovation ecosystem in the world. This year, our results assign the US the label of ‘top innovation ecosystem creator’. The combination of hubs of highly active cleantech innovation ecosystems around the country provide an organised investment space, holding by far the largest total sum of targeted venture capital of all countries in this Index. Its currently excellent general innovation inputs as well as strong entrepreneurial culture produce a leading cleantech innovation ecosystem where higher commercialisation rates of all that cleantech innovation knowledge and capacity is the main challenge.

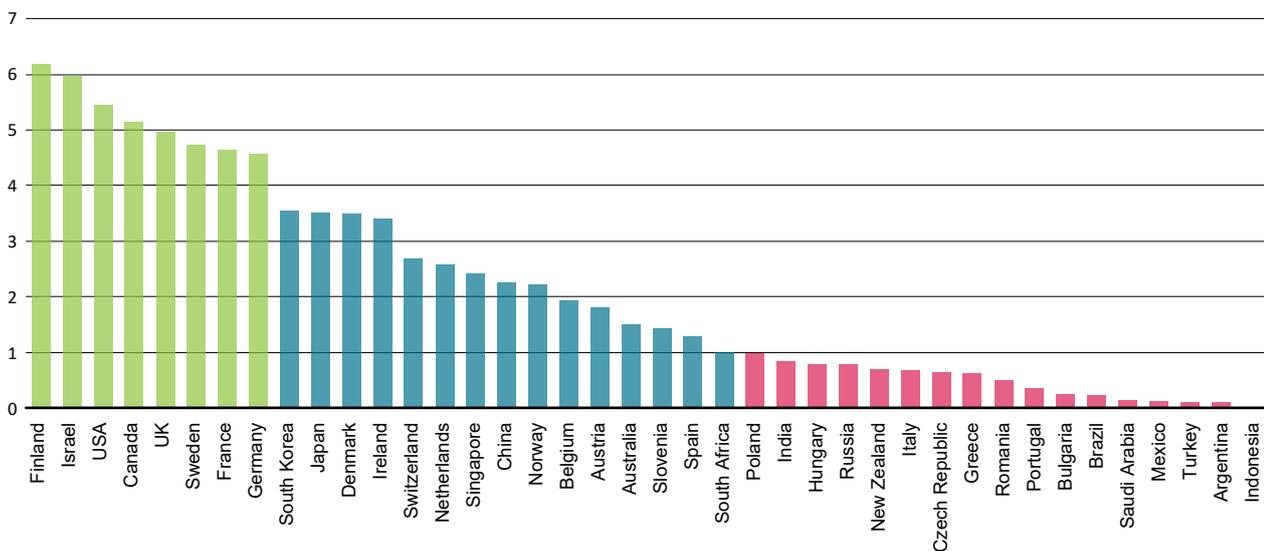
32 [www.klimatsynk.se](http://www.klimatsynk.se)

## Outputs

### C: Evidence of emerging cleantech innovation

*Evidence of emerging cleantech innovation* aims to pinpoint early signals of cleantech innovation by measuring the flow of environmentally related patents and early-stage venture capital to assess the progress of early-stage entrepreneurial cleantech companies. This indicator pillar draws on country records of environmental technology patents filed under the world-wide patent database, PATSTAT, for the most recent available year (2013).

Figure 9. Emerging Cleantech Innovation



This spread of scores for *evidence of emerging cleantech innovation* seen in Figure 9 indicate that there is a larger range of scores than in other pillars, with more extreme differences observed. In part, this can be attributed to very low, and zero, values recorded for many countries when measuring venture capital investment, increasing the long tail on this graph. The pattern is similar when measuring the number of successful cleantech start-ups, where we observed that 75% of the companies are located in only 4 countries (**USA, UK, Germany, and Canada**).

While the top 5 countries share common strengths in early-stage investment activity, and also score high in successful cleantech start-ups, a different set of countries lead the indicator for environmental technology patent filings. Countries with successful cleantech research, which can originate come from national laboratories, start-ups, universities, corporations, or a combination of these, are **Germany, South Korea, and Japan**, followed by three Nordic nations and **Israel**.

Low-scorers for this indicator can be defined as all countries 24<sup>th</sup> (**Poland**) and below, with only minute differences in their performances in the sub-indicators relative to their GDP. Interestingly, none of the Asian countries except **India** and **Indonesia** (and Russia) are included in this category, pointing to the relative strength of the region in producing *evidence of emerging innovation*. On the other hand, all BRIC nations, excluding **China**, fall below the 24<sup>th</sup>.

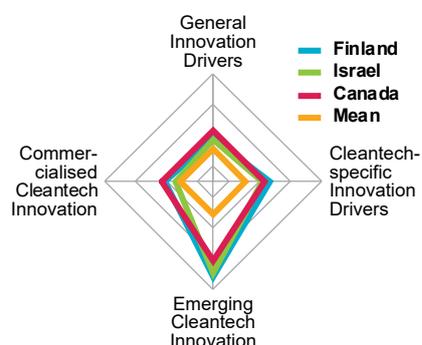
Comparing the results of this year's *evidence of emerging innovation* to those of the 2014 edition, the top 10 nations remain broadly the same, with some relative internal

rank changes mostly due to cleantech-related patent or venture capital investment fluctuations. Among BRIC nations, the low-scoring **Brazil** and **Russia** remain in the lower half, whereas **China** overtakes **India**. China rises from 25<sup>th</sup> to 16<sup>th</sup> place due to a dramatic jump in its early-stage investment activity, despite a relative reduction in filed patents. India, on the other hand, drops from 17<sup>th</sup> to 25<sup>th</sup> due to a drop in venture capital investment and number of promising cleantech companies.

## Archetype 2: ‘Cleantech start-up generators’

We use the term ‘cleantech start-up generators’ for countries that have shown evidence of a strong national entrepreneurial culture, and provide support structures and innovation tools for their local start-up sphere, while also having created the right stimuli to make the cleantech theme attractive to their entrepreneurs. We use this label when a country appears in the top 5 for *evidence of emerging cleantech innovation*, and has above global-average scores in both *input* indicator pillars. By focusing on promoting *emerging cleantech innovation*, these countries share the ability to continually generate a lot of new cleantech business ideas and a pool of risk-willing early-stage investors. **Canada, Israel, Finland, France**, and the **USA** emerge as countries with such a focus and evidence of success. Part of these countries’ success can be attributed to high scores in *inputs to innovation* indicators, with the USA already being labelled a ‘top ecosystem creator’. In this case, strong national input efforts are showing fruitful results in *emerging cleantech innovation*.

**Figure 10. A comparison of Finland, Israel, and Canada, to global average in the four indicator pillars**



**Israel** embodies this innovation archetype, and has now done so in 2014 and 2017. The country has developed an entrepreneurial population, excellent research facilities, and a wealth of local and foreign capital accessibility to create an extraordinary pool of innovative start-ups working in the cleantech sphere. With resource efficiency at the heart of Israeli society and political agenda due to the country’s unique geopolitical situation, innovation in the cleantech sector has evolved as a clear focus in both the public and private

sectors to help ensure a future-oriented technology development of the nation. Considering Israel’s limited size of economy, the country shows significant evidence of successful start-ups, with many being voted into the top Global Cleantech 100 in the last 3 years. This wealth of Israeli start-ups is supported by significant growth-stage funding, for which Israel places 1<sup>st</sup> globally.

**Canada’s** cleantech ecosystem has seen rapid growth in recent years, growing to join the ranks of ‘top innovation ecosystem creators’. This has resulted in the country climbing from 10<sup>th</sup> to 4<sup>th</sup> place in the *emerging cleantech* pillar, attributable to its increasing domestic investor activity in cleantech, and growing public sector support. Strong evidence of Canada’s role as a cleantech start-up generator can be found in the large number of companies it has contributed to the Global Cleantech 100 list over the past three years.

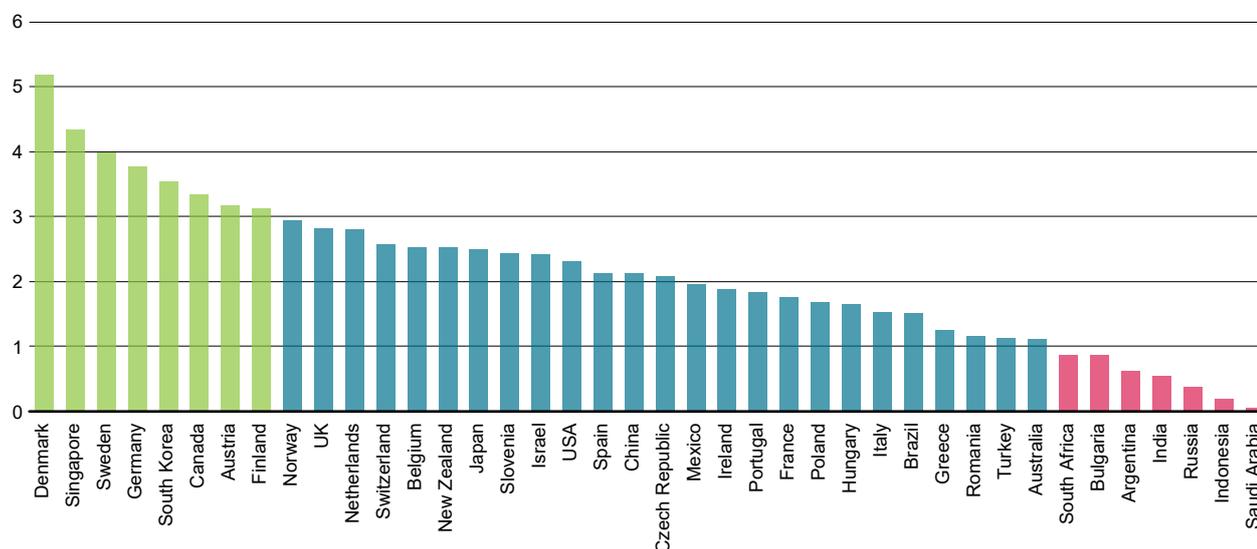
**Finland** continues to show evidence of a burgeoning innovation ecosystem, with cleantech a strong part of that development. Despite its limited market size, the country has produced a number of successful cleantech start-ups that appear in the

Global Cleantech 100 in the last 3 years. Combining this with its high innovation efficiency (see *Figure 4*), the country embodies the archetype of cleantech start-up generator. This trend is set to continue, as Finland scores particularly strongly in both of the earliest signals we measure of emerging cleantech activity: cleantech-related patent filings, where it comes 3<sup>rd</sup> globally, and venture capital investment figures, where it places 5<sup>th</sup>.

### D: Evidence for commercialised cleantech innovation

*Evidence for commercialised cleantech* is the final stage of the cleantech innovation process, and takes measurements that indicate the presence of fully commercialised cleantech companies. The pillar measures cleantech commodity import and export<sup>33</sup>, renewable energy consumption data, cleantech late-stage private investment, M&As and IPOs, and the number of publicly traded cleantech companies in major indices.

Figure 11. Commercialised Cleantech Innovation



**Denmark**, this year’s overall top scorer in the 2017 Index, leads the ranking for *commercialised cleantech* by some margin, scoring well ahead of **Singapore** and **Sweden** in 2<sup>nd</sup> and 3<sup>rd</sup> respectively. **Germany** and **South Korea** complete the top five, with the gaps between the countries below the top five becoming less pronounced, until we get to the bottom five. There are a large proportion of countries that score between 1-3, indicating a tight distribution in the mid-range.

The Nordic countries are one of the strongest performing regional groups. **Denmark** and **Sweden** take 1<sup>st</sup> and 3<sup>rd</sup> place, while **Finland** follows in 8<sup>th</sup>, and **Norway** takes 9<sup>th</sup> place. The countries share relatively high levels of renewable energy consumption and have a high number of public cleantech companies. They also have many renewable energy jobs, with Denmark and Finland taking a joint 1<sup>st</sup> place and Sweden 2<sup>nd</sup> place. The exception in this case is Norway, which only takes 21<sup>st</sup> place for the number of renewable energy jobs. However, Nordic countries’ attractiveness for modern renewable energy investments these days is relatively low compared to other countries. The high levels of renewable energy consumption and jobs stem from historic investments in older renewable energy technologies, which are often combined with

<sup>33</sup> This measurement replaces the 2014 indicators ‘Cleantech company revenues’ and ‘cleantech manufacturing value-added’ as these data sets were no longer available. See Appendix B, *Methodological Considerations*, for an explanation of data compatibility

larger environmental sustainability challenges. This presents a challenge to future attractiveness of Nordic countries as a destination for renewable energy investment.

Many of the high scoring countries have an established manufacturing industry with a strong export focus across different industrial sectors. This is the case in particular for **Germany, South Korea, and Canada**, which scored within the top 6 places for *commercialised cleantech innovation* and in the top 10 for the Global Manufacturing Competitiveness Index.<sup>34</sup> It seems that it is easier for these countries to scale up their cleantech innovations by making use of the established industrial and financial framework.

The BRIC countries are all located at the low end of the spectrum, with the exception of **China**, which takes 20<sup>th</sup> place. Despite moving up one place in *evidence of emerging cleantech*, China shows a significant drop of 16 places in *evidence of commercialised cleantech*. This can in part be explained by a methodological change, as a measure of cleantech commodity imports and exports, as opposed to cleantech company revenues, places China 22<sup>nd</sup> instead of 4<sup>th</sup> in this indicator. However, methodological change is not wholly responsible. China drops places in late-stage private equity investment, M&A, and IPOs posting figures that are lower than in the 2014 Index. In real terms, China experienced around 3% growth in renewable energy consumption and clean energy jobs in the Index calculations, however it falls into the lower end of the Index relative to other countries. As China invested just \$3 billion in renewable energy 2004, then multiplied this 13-fold by 2010, and another two and half times by 2015 to a record \$102.9 billion which accounts for roughly a third of all new global investment in renewable energy in 2015, the figures may not reflect the advances being made by China. The overall 2017 Index rank therefore may not be adequately reflecting the size of the internal cleantech innovation market, but it does show some evidence of slowing cleantech commercialisation generally.

The connecting elements between the BRIC countries' weaker performance in the 2017 Index's measurement of *evidence of commercialised cleantech* is a weak late-stage finance environment, and overall low cleantech imports and exports. Conversely, the amount of renewable energy in the total energy mix and the number of renewable energy jobs generally display steady or improving scores, and so do not correlate to these countries' performance for *commercialised cleantech*. In this indicator pillar, China stands out from the rest of the BRIC countries due to its relative strength in cleantech import/export.

In our 2014 Index, **India** and **China** were labelled as archetypal 'cleantech commercialisers'. In the 2017 Index, the evidence is not as strong for these two countries in this indicator pillar. In the 2014 Index, India scored higher in Sales of Low Carbon and Environmental Goods and Services (LCEGS), as previously tracked by UK Department for Business Innovation & Skills, compared to their cleantech export score in 2017 Index. It is possible that India and China suffer from this required change of data sets. However, India also scored lower in measurements of private equity financing, as well as M&A transactions counted, relative to GDP. India did show a slight improvement in number of IPOs conducted, relative to GDP.

Compared to the 2014 Index, there have been some significant shifts in the data. We must note that it is likely that the exact level of change has not been captured due to the change in this indicator's methodology. However, some shifts in ranking are dramatic enough to negate any small change that may be explained by the new methodology.

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<sup>34</sup> Deloitte, *Global Manufacturing Competitiveness Index*, 2016

**Brazil drops from 2<sup>nd</sup> to 29<sup>th</sup> place**

There has been a political and economic crisis in **Brazil** recently, with a 3.4 % economic decline in 2016 serving as one indicator of why this drop may have occurred.<sup>35</sup> While upholding its strength in renewable energy consumption and jobs, Brazil does not show the large quantity of *evidence of commercialised cleantech* it enjoyed in 2014. There are fewer companies in public markets, or taking in late stage investment. Brazil also shows relatively weak cleantech commodity import and export figures. This may speak to a strong cleantech manufacturing industry with a strong internal market, but when combined with other indicators, it is likely due to recent economic instability.

**Singapore and Sweden**

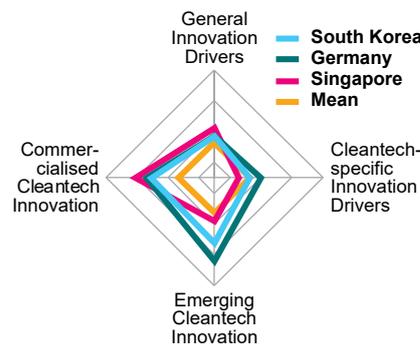
**Singapore** rose from 11<sup>th</sup> to 2<sup>nd</sup> place, attributed to the top scores gained in export and import of cleantech commodities. Similarly, **Sweden** rose from 9<sup>th</sup> to 3<sup>rd</sup> place, attributed to a combination of increasingly large amount of evidence of late-stage investment activity and high renewable energy consumption and related clean energy jobs.

**Archetype 3: ‘Cleantech Commercialisers’**

Countries that are strong ‘cleantech commercialisers’ today are a mix of countries that have an overall strong commitment to environmental protection, resource efficiency, climate mitigation and renewable energy goals, while also having the necessary market sophistication and size to scale domestic emerging innovations. These countries are not driven simply by moral commitments to address climate change but also by the urgency to deploy clean technologies to solve mounting public health and environmental issues.

In addition to a high overall rank, **Singapore, Germany** and **South Korea** also show particular strength in the *evidence for commercialised cleantech innovation* compared to innovation inputs, illustrated by their high cleantech innovation efficiency (Figure 4).

**Figure 12. A comparison of South Korea, Germany, and Singapore to global average in the four indicator pillars**



**Singapore** stands out as a commercialiser, as it shows evidence of the scaling up of cleantech innovation despite its very limited domestic market size. Given this context, it is no surprise that Singapore’s high score for *evidence of commercialised cleantech* can mainly be attributed to its top performances in both imports and exports of cleantech commodities, and it benefits from its position as a strong cleantech trading hub. The country does not have strong evidence of renewable energy consumption or clean energy jobs

due to its limited size, which makes natural resource deployment challenging. This distinguishes Singapore from ‘cleantech commercialisers’ like **Germany** and **South Korea** – for which these are indeed the driving indicators.

From our analysis, **Germany** is the most efficient cleantech innovator – producing the most emerging and commercialised cleantech innovation outputs with a given input (Figure 4 and 5). The world’s 3<sup>rd</sup> largest exporter also shows a significant strength

<sup>35</sup> OECD, *Economic forecast summary – Brazil*, November 2016.

in its cleantech commodity trade activity. While the country shows below global-average renewable energy consumption relative to total primary energy, Germany displays strong renewable energy jobs figures, related to the jobs in construction and installation of clean energy technology under the strict national *Energiewende* programme for renewables expansion. In addition, the country shows good evidence of some late-stage financing activity in the established cleantech ecosystem.

### **South Korea**

As the highest scoring Asian country in the Index, **South Korea** also fits the country archetype of ‘cleantech commercialiser’. Following on from its success in showing *emerging cleantech innovation*, the country also provides the requisite domestic market size to commercialise upon its high level of new innovations. This Asian country has a particular strength in imports and exports of cleantech commodities, pointing to a good domestic demand for cleantech applications as well as a domestic manufacturing sector that is internationally competitive. The country has a good number of companies represented on publicly traded cleantech indices, which is a strength given South Korea's relatively small size of economy. Similar to **Singapore**, the country lacks significant renewable energy consumption.



## Country Profiles

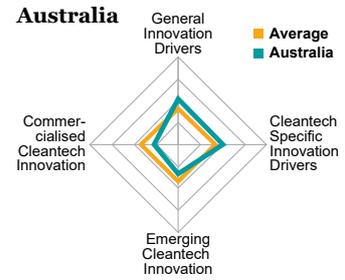
### Argentina

Argentina scores below the mean for all metrics. The country places 2<sup>nd</sup> last in the Global Innovation Index out of the countries measured,<sup>42</sup> but it scores better for perceived entrepreneurial activities and early-stage business activity. Argentina has a very low cleantech R&D budget and lacks financial activity, which accounts for the country's low score for *cleantech-specific drivers*. Very little evidence for *emerging cleantech innovation* was recorded, exemplified by the low number of environment-related patents filed. In addition, Argentina does not register any *commercialised cleantech innovation* to speak of. In this pillar, Argentina ranks last of all countries in the Index for cleantech imports. Neighbouring country Brazil scores higher for most indicators, except in *cleantech-specific drivers*, where Argentina scores higher.



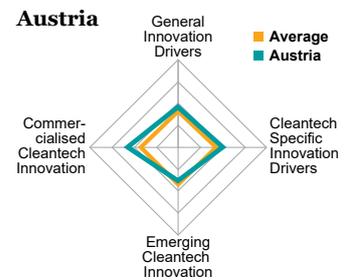
### Australia

Australia scores well above the mean for *inputs to innovation*, but this does not translate into solid *outputs*. The innovation landscape in Australia is well developed, and Australia scores high across all indicators for the *general innovation drivers*. Cleantech funds and investors are well represented, and the amount raised by these cleantech funds lies well above the average. However, the public cleantech R&D budget is relatively low. Australia has relatively few environmental patents, which results in an *emerging cleantech* score that lies below the mean. The country's worst performance is for *commercial cleantech*, where one of the most telling metrics is its very low amount of cleantech exports.



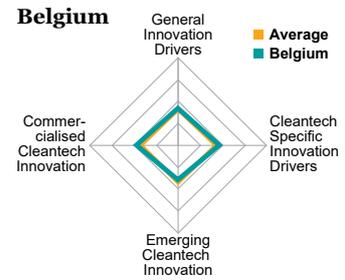
### Austria

Austria displays an average overall performance, with its best performance for *evidence of commercialised cleantech*. The country's ecosystem is well-suited for entrepreneurship, and stands out amongst its neighbours, Germany and Switzerland, for early stage innovation. Austria has a large cleantech R&D budget, but it has mixed results for its attractiveness as an investment market. Despite scoring well above average for its number of patents, Austria is dragged down by its low venture capital investment in the cleantech sector, giving it a score slightly below the mean for *emerging cleantech*. High levels of international trade in cleantech and a well-established renewable energy sector are hallmarks of Austria's strong *commercialised cleantech*.

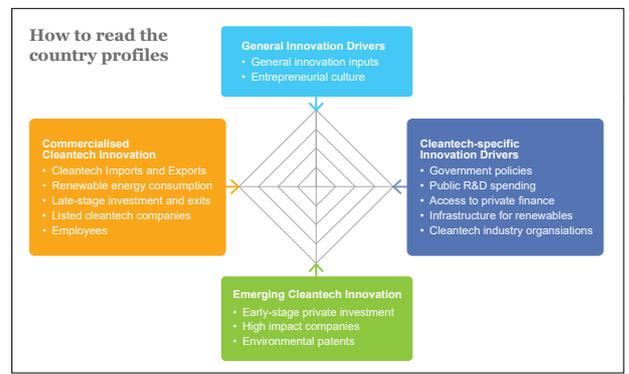


### Belgium

Belgium has an all-round average performance, with *cleantech-specific drivers* and *commercialised cleantech* slightly above the mean. Belgium's relatively strong score for its general innovation landscape is balanced by low perceived opportunities and early-stage entrepreneurship. For *cleantech-specific drivers*, Belgium finds itself in the middle of the pack. A highlight is its strong cleantech R&D budget, which is larger than its neighbours, the Netherlands, Germany, and France, when weighted by GDP. The country's *evidence of emerging cleantech* score is held up by the high percentage of Belgian companies featured in the Global Cleantech 100. Belgium ranks 3<sup>rd</sup> for cleantech IPOs, behind Singapore and the USA, but it is denied a top score for *commercialised cleantech* by its proportionally low levels of renewable energy consumption.

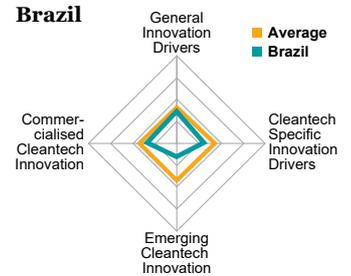


42 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016



## Brazil

Brazil scores below the mean for all metrics. *General innovation drivers* are Brazil's strongest performance, with the country scoring very low for general innovation inputs, but ranking 1<sup>st</sup> for early-stage entrepreneurial activity. Brazil has very limited cleantech-friendly policies and a low R&D score, but the country is an attractive destination for renewable energy investment. *Emerging cleantech* in Brazil is low, but the country performs better than neighbour Argentina in this particular indicator pillar. Brazil's score for *commercialised cleantech* is explained by the country's high renewable energy consumption, and the renewable energy jobs that accompany it. However, the country has low cleantech imports and exports, bringing the overall pillar score to below average.



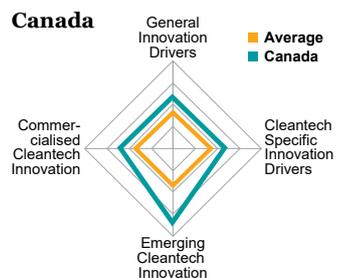
## Bulgaria

Bulgaria scores below the mean on all metrics. The data show that Bulgaria struggles to convert its *inputs to innovation* into *outputs*. For *general innovation drivers*, there is a strong lack of early entrepreneurial activity, despite the country having a Global Innovation Index score that outperforms neighboring countries like Romania, Greece and Turkey.<sup>43</sup> Bulgaria takes the 4<sup>th</sup> place overall for the number of cleantech organisations and has recently seen the establishment of Cleantech Bulgaria, a national business network for cleantech innovation. However, the country scores less well for its cleantech R&D budget and its attractiveness as a destination for renewable energy investment. The country did not register any early-stage investment, stymieing *emerging cleantech*. For *commercial cleantech*, Bulgaria also did not register any late stage investment, combined with low cleantech exports.



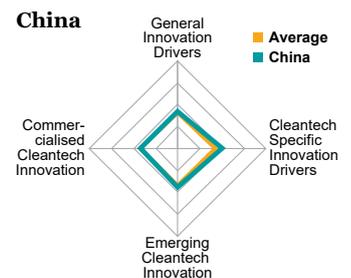
## Canada

Canada registered a high score overall, coming 4<sup>th</sup> in the Index, but with especially strong results for *emerging cleantech*. The country has a strong score in the Global Innovation Index,<sup>44</sup> but what truly distinguishes it is its score for early entrepreneurship, which is 2<sup>nd</sup> overall. For *cleantech-specific drivers*, Canada scores high for the number of cleantech funds, and even ranks 1<sup>st</sup> for the amount of funding available. However, there are only a few cleantech organisations and clusters. The country is a joint top-scorer for the amount of venture capital investment, together with three other countries in the Index, while also having many companies in the Global Cleantech 100. Late-stage investment is well established in Canada, with the country ranking high for public cleantech companies and M&A activity, leading to a strong score for *evidence of commercialised cleantech*.



## China

China has a stable performance, registering close to the mean for all metrics. The country scores quite high for early-stage entrepreneurship, despite low perceived opportunities. For *cleantech-specific drivers*, the country is a favourite investment destination for renewable energy investment, coming in 2<sup>nd</sup> place after the US. It lags behind for cleantech investors when viewed globally, even though the country scores highest amongst its Asian neighbours. China performs strongly for early-stage venture capital investment but ranks lower for cleantech patents, giving it a score close to the mean for *emerging cleantech*. For *commercialised cleantech*, China scores consistently in the middle of the pack, with no particular deviations from the average.

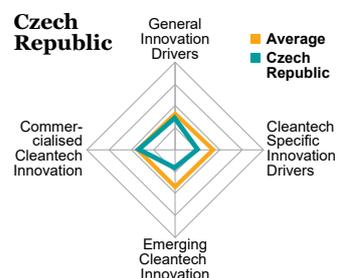


43 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016

44 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016

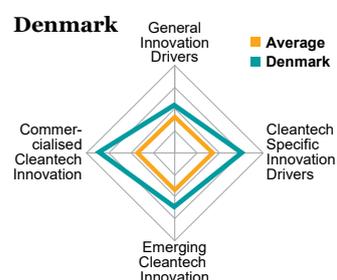
### Czech Republic

The Czech Republic scores below the mean in all four pillars. For *general innovation drivers*, the generally favourable entrepreneurial environment is not translated into a strong entrepreneurial culture, with perceived opportunities and early entrepreneurship that only match the Eastern European average. The country has a low attractiveness for renewable energy investment and an underdeveloped private cleantech investment scene, resulting in a *cleantech-specific drivers* score that lies well below the mean. This is also reflected in low early-stage venture capital investment that, combined with a low cleantech patent score, leads to the Czech Republic being located on the lower end of the spectrum for this *emerging cleantech* pillar and the Index generally. For commercialised cleantech, the Czech Republic has high cleantech imports that stand out among its neighbouring countries, Austria and Poland.



### Denmark

Denmark is the top scorer for this edition of the GCII. The country scores above the mean for all metrics, but is especially strong in *commercialised cleantech*. Denmark takes the 8<sup>th</sup> place in the Global Innovation Index,<sup>45</sup> and performs on the Nordic average for perceived entrepreneurial opportunities and early-stage entrepreneurial activity. The country is the top performer for the amount raised by cleantech funds (sharing its position with Israel) and the number of cleantech organisations, making Denmark the top performer for *cleantech-specific drivers*. As previously mentioned in this report, a recent cut (of around 50%) in the public cleantech R&D budget is not accounted for in the 2017 Index, and is likely to have a detrimental effect on Denmark's ranking in this indicator in future. For *emerging cleantech*, the country is 4<sup>th</sup> in the ranking for patents, but the low amount of venture capital investment pushes Denmark down to 11<sup>th</sup> place in this pillar. *Commercialised cleantech* is Denmark's strong point, with the country scoring top marks for cleantech exports, the number of public cleantech companies and the number of renewable energy jobs, which when combined put Denmark in 1<sup>st</sup> place.



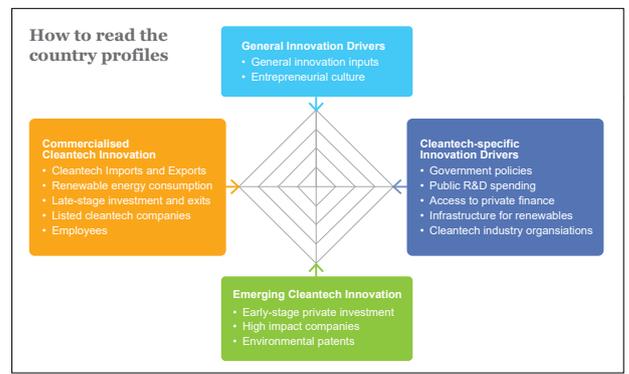
### Finland

Finland reaffirms its reputation as a cleantech leader, scoring above the mean for all metrics. While Finland ranks well on the Global Innovation Index,<sup>46</sup> placing 5<sup>th</sup> overall, it doesn't score as high as its Nordic neighbours for perceived opportunities and early-stage activity. For *cleantech-specific drivers*, Finland takes the 2<sup>nd</sup> place overall, with strong performances for its cleantech R&D budget and the number of cleantech funds present. It is not, however, attractive for renewable energy investment, where only Indonesia, Russia and Greece score lower. *Emerging cleantech* is Finland's strong point, with strong performances across all indicators. For *evidence of commercialized cleantech*, Finland's performance is nuanced, with a strong showing for renewable energy jobs and M&A activity, but relatively low cleantech imports and exports.



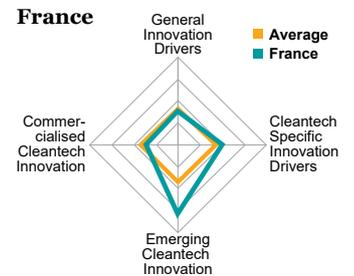
45 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016

46 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016



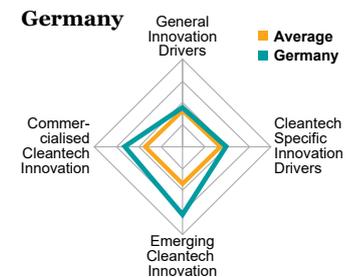
## France

France scores around the mean for most metrics, with a strong showing for *emerging cleantech*. The country has a Global Innovation Index score that is lower than Germany, but higher than Belgium. However, it scores quite low for perceived entrepreneurial opportunities and early-stage business activity. For *cleantech-specific drivers*, the country scores slightly higher than the mean. This is explained by an average showing for all data points, with the country's recent issuing of 7.5 billion euro green bonds promising further cleantech commitment. *Emerging cleantech* in France is strong, backed by the high amount of early-stage venture capital investment in the domestic cleantech sector. *Commercialised cleantech* lies slightly below the mean, despite France taking a shared 1<sup>st</sup> place for cleantech IPOs. Factors explaining the lower score for *commercialised cleantech* include the low renewable energy consumption and relatively low cleantech commodity import and export figures.



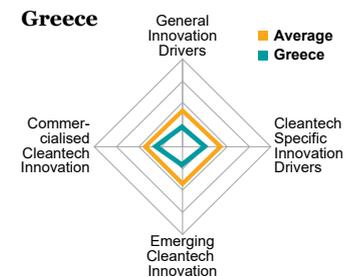
## Germany

Germany scores above the mean for all metrics, but is especially strong in *outputs of innovation*. While Germany scores strong for the Global Innovation Index it has very low evidence of early-stage entrepreneurial activity, coming in second-to-last place, just ahead of Italy. For *cleantech-specific drivers*, Germany is very attractive for renewable energy investment, but it is being held back by the lack of a presence of private investors. The country's score for *emerging cleantech* is supported by its top score for environmental patents. Germany's strong cleantech import and (especially) export figures, as well as the high number of renewable energy jobs are the basis of its strong *commercialised cleantech* score.



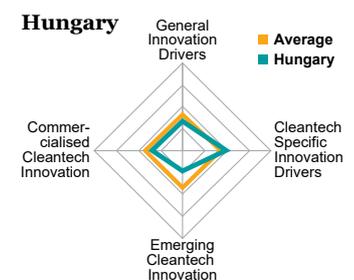
## Greece

Greece scores well below the mean on metrics. Despite a score in the Global Innovation Index that is higher than Russia or India,<sup>47</sup> Greece puts down the lowest score for perceived opportunities and also ranks low for early-stage activity. The *cleantech-specific drivers* are stymied by Greece's unattractiveness as a destination for renewable energy investment (the country takes last place), but its cleantech R&D budget, although quite low on a global scale, is still higher than that of Bulgaria and Romania. *Emerging cleantech* in Greece is low. The country has no Global Cleantech 100 companies. Venture capital investment, and cleantech patent activity also rank low. *Commercialised cleantech* in Greece suffers from an underdeveloped investment environment, with no private equity, M&A, or IPO activity to speak of.



## Hungary

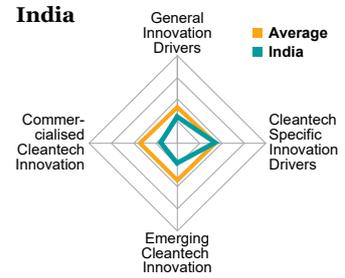
Hungary scores slightly below the mean for *general innovation drivers* and *commercialised innovation*. *Cleantech-specific drivers* are Hungary's strong point, while *emerging cleantech* is lagging behind. For *general innovation drivers*, Hungary puts down an average performance, both for government policies regarding entrepreneurship and the public perceptions of entrepreneurship. Hungary is ranked 1<sup>st</sup> amongst the countries surveyed for cleantech R&D, and it has a high number of cleantech organisations. However, the country is not very attractive as a renewable energy investment destination. Despite bettering many of its neighbouring countries for *emerging cleantech*, Hungary lags behind on a global scale. For *commercialised cleantech*, the country is faced with an underdeveloped investment environment.



47 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016

**India**

India scores below the mean on all metrics, except for a strong performance in *cleantech-specific innovation drivers*. While India’s score on the Global Innovation Index is low, the public seems to have a positive view of entrepreneurship, with relatively high scores for perceived opportunity and early-stage entrepreneurial activity. India’s performance for *cleantech-specific innovation drivers* is explained primarily by its attractiveness as a renewable energy investment destination (coming 3<sup>rd</sup>). However, the country scores low marks for its cleantech R&D budget and the presence of cleantech organisations and clusters. *Evidence of emerging cleantech innovation* in India is quite low, mainly because of a relatively low amount of early-stage venture capital investment. The country’s low performance in showing *evidence of commercialised cleantech* is due to a combination of little late-stage private investment, low cleantech exports, and a relative weakness in renewable energy jobs relative to India’s total work force, which is likely to change with the country’s expanding renewable energy sector.



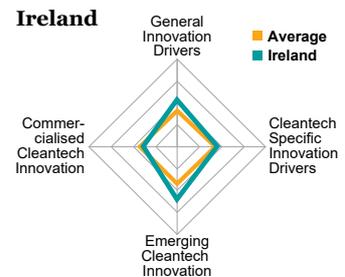
**Indonesia**

Indonesia scores well below the mean for metrics, and the country shows little sign of commercialising the *low inputs to innovation* scores into innovation *outputs*. With regard to *general innovation drivers*, Indonesia has the lowest Global Innovation Index ranking of all countries, but this is not reflected in the country’s perceptions to innovation and its strong early-stage entrepreneurial activity. *Cleantech-specific drivers* are low as well, with Indonesia having the second-lowest cleantech R&D budget and the third-lowest country attractiveness for renewable energy. Indonesia did not register any *emerging cleantech*, coming last for every single metric. There is little evidence for *commercialised cleantech*, with the country registering low cleantech import and export numbers, in particular.



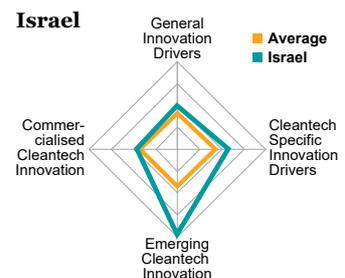
**Ireland**

Ireland puts down high marks for *general innovation drivers* and *emerging cleantech innovation*, while performing around the mean for *cleantech-specific drivers* and *commercialised cleantech*. Ireland scores high for the Global Innovation Index, and puts down reasonable scores for early-entrepreneurship and perceived opportunities. With regard to *cleantech-specific drivers*, Ireland is the top scorer for the number of cleantech funds and has a high number of cleantech organisations, but this does not translate into a top score for the amount raised in cleantech funds. The country has high levels of early-stage venture capital investment, but a small number of patents lowers the country’s overall score for *emerging cleantech innovation*. In *commercialised cleantech*, Ireland is the top scorer for M&A activity, but has low levels cleantech imports and exports.

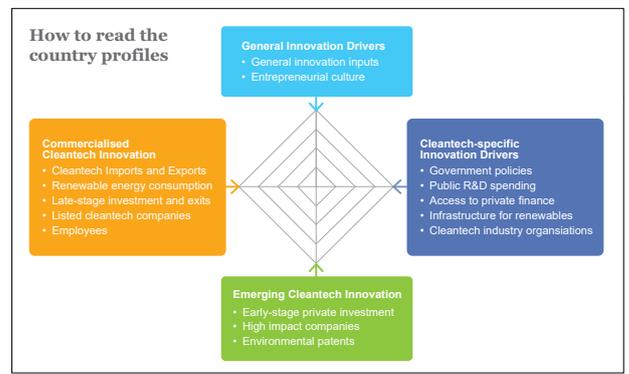


**Israel**

Israel, the champion of the 2014 GCII, scores above the mean for every metric. The country scores relatively high for perceived opportunities for entrepreneurship, while also registering a good score in the Global Innovation Index.<sup>48</sup> Israel scores strongly in investment indicators in *cleantech-specific drivers*, ranking 1<sup>st</sup> for the number of cleantech funds and cleantech investors, and the amount raised by these funds, but the country lacks attractiveness as a renewable energy investment destination. Israel’s score for *emerging cleantech* is explained by its top scores for the amount of venture capital investment and the presence of Israeli companies in the Global Cleantech 100. With regard to *commercialised cleantech*, Israel has high M&A and IPO numbers, but it has low renewable energy consumption.

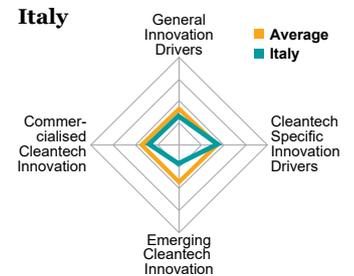


48 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016



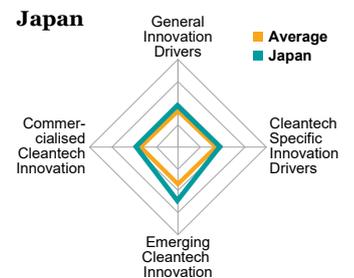
## Italy

Italy generally scores below the mean, except for *cleantech-specific innovation drivers*. Italy's score for the Global Innovation Index is quite low,<sup>49</sup> and this is further compounded by the country's last place overall for early-stage entrepreneurship. While Italy has many cleantech-friendly government policies, an underdeveloped early-investment landscape drags Italy's *cleantech-specific drivers* score down. *Emerging cleantech* in Italy is quite low, and this is mainly due to low venture capital investment. For the presence of companies in the Global Cleantech 100, the country scores higher than fellow Southern European countries, Greece and Portugal, but lower than Spain. The *commercialised cleantech innovation* score is mixed, with Italy leading other Southern European countries in M&A activity, but lagging behind them for the number of public cleantech companies included in cleantech indices.



## Japan

Japan is the 2<sup>nd</sup> highest ranked Asian country, after South Korea. It scores above the average across both *inputs to* and *outputs of cleantech innovation*, with a particular strength in *emerging cleantech*. For *general innovation drivers*, Japan scores slightly above the average. The country has low perceived opportunities for entrepreneurship, and Japanese culture is traditionally risk-averse. Japan is ranked 14<sup>th</sup> for *cleantech-specific drivers* and shows a mixed performance. While the country has a relatively high cleantech R&D budget and a high renewable investment attractiveness, there are very few cleantech funds and investors active in the country. For *emerging cleantech*, Japan ranks 3<sup>rd</sup> for cleantech-related patent filing, indicating an active and successful cleantech research sphere. However, Japan ranked 1<sup>st</sup> for patents in the 2014 GCII report, showing a relative decrease in patent activity. *Commercialised cleantech* shows a mixed picture. Both early- and late-stage financing relative to Japan's size of economy is lagging behind the majority of other Index countries, and there are only a few Japanese companies included in cleantech publically traded indices. However, Japan has high levels of cleantech imports and exports.



## Mexico

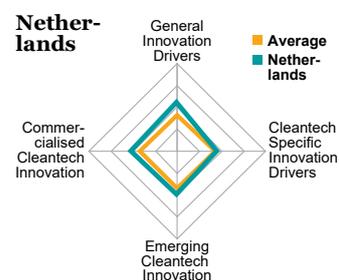
Mexico scores below average in both *inputs to* and *outputs of cleantech innovation*, occupying the 32<sup>nd</sup> rank in the GCII. The country displays a below-average score for *general innovation drivers*, mirroring its score for *cleantech-specific drivers* of innovation. Weaknesses in this pillar include public cleantech R&D expenditure, as well as access to private finance, and a lack of cleantech organization/cluster establishments. Thus, there is a general failure to promote the growth of the cleantech innovation ecosystem, illustrated in the 36<sup>th</sup> rank for *emerging cleantech innovation*. Mexico's relative strength lies in *commercialised cleantech*, scoring close to the Index average. This strength can in part be attributed to Mexico's high cleantech commodity trade activity, scoring 4<sup>th</sup> place for imports, which is fueled by new policy and market instruments aimed at meeting the country's renewable energy goals. The Mexican *outputs to innovation* seem to be limited, however, by the lack of significant late-stage financing and limited strategic cleantech road-maps.



49 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016

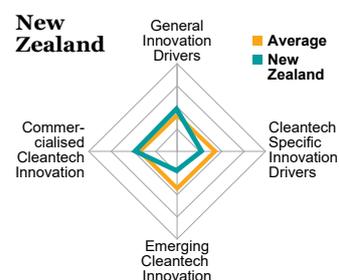
### Netherlands

The Netherlands scores above the global average in both *inputs to* and *outputs of cleantech innovation*, achieving the 15<sup>th</sup> rank in the overall Index. Scoring 5<sup>th</sup> in *general innovation drivers*, the Netherlands succeeds in producing a high-quality innovation ecosystem, and promotes a strong national entrepreneurial culture. Above average access to private finance for start-ups together with a good score for public R&D expenditure in the cleantech sector provides the country with significant *cleantech-specific drivers*. This manifests in the country's good score for *emerging cleantech*, scoring 11<sup>th</sup> place for evidence of early-stage venture capital investment. This culminates in the Netherlands' relative success in *commercialised cleantech*, particularly in its strength in cleantech trade, scoring 3<sup>rd</sup> and 6<sup>th</sup> place in cleantech commodity imports and exports respectively. A weakness, however, is its low renewable energy consumption relative to total primary consumption.



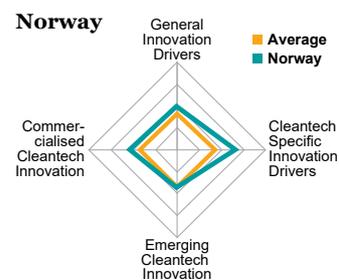
### New Zealand

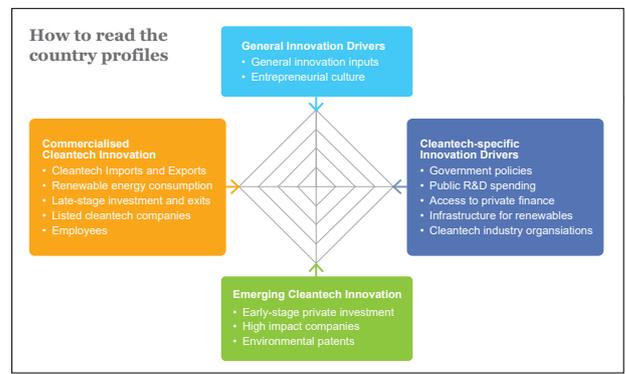
New Zealand shows a mixed performance across *inputs to* and *outputs of cleantech innovation*, and occupies the 21<sup>st</sup> rank in the overall Index. It performs above average for *general innovation drivers*, indicating that the overall national innovation ecosystem is streamlined and entrepreneurial culture supported. However, *cleantech-specific drivers* are lagging behind – illustrated by particular weaknesses in cleantech-supportive government policies and low public R&D expenditure to the cleantech sector. This lack of government support as well as limited private early-stage financing translates into New Zealand's low 28<sup>th</sup> place in *emerging cleantech*. Despite this, the country scored above global-average for *commercialised cleantech*. This is attributed to its 3<sup>rd</sup> place in the renewable energy consumption indicator, providing a proxy for clean energy technology, and related clean energy jobs.



### Norway

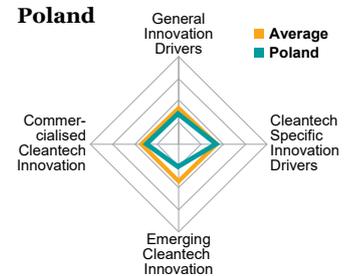
Norway performs above the global-average in both *inputs to* and *outputs of cleantech innovation*, with a particular strength in producing *cleantech-specific drivers*. While the overall score for *general innovation drivers* remains above average, Norway shows a relatively low score for total early-stage entrepreneurial activity, indicating that the good innovation support frameworks do not directly translate into a large proportion of the population starting a business. Norway's strength lies in promoting *cleantech-specific drivers* of innovation, ranking 2<sup>nd</sup> in this pillar with top performance in public R&D expenditure to the cleantech sector. For *evidence of emerging cleantech*, Norway scores just above the global-average, with a relative weakness in cleantech-related patent filings as evidence for new innovations. Norway's success in *commercialised cleantech* is reflected in its top score for number of late-stage private equity investments in cleantech, as well as a high share of renewable energy consumption, although the latter relates mainly to old hydropower assets rather than a strong uptake of modern renewable power which is also clear in this Index from the low score in renewable energy investment attractiveness.





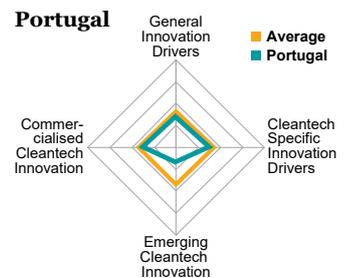
## Poland

Poland ranks 24<sup>th</sup> in the GCII, only beating the global-average in *cleantech-specific drivers*. A weakness in its *general innovation drivers* indicates that the Polish innovation ecosystem requires streamlining and support. Poland's strength in *cleantech-specific drivers* can be attributed to a top score in cleantech-supportive governmental policies, and above average scores for access to private funds, as well as public R&D expenditure. The weak score in *emerging cleantech*, ranking Poland at 24<sup>th</sup> place for this index pillar, can be explained by the complete absence of early-stage venture capital investment into the cleantech sector and no companies making the GCT100 list in the last 3 years. Nevertheless, Poland's cleantech-related patent filing scores at global-average. *Commercialised cleantech* highlights strong national cleantech commodity demand through Poland's high import score. Low late-stage investment in Polish cleantech companies, as well as below-average evidence of renewable energy consumption and employment, highlight the country's areas for improvement.



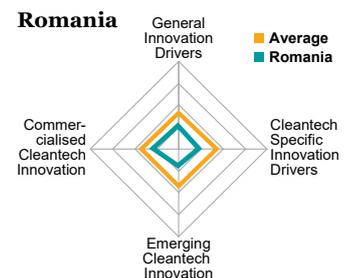
## Portugal

Portugal scores below the global-average in both *inputs to* and *outputs of cleantech innovation*, scoring 27<sup>th</sup> place in the overall Index. The country lacks a strong entrepreneurial culture and also a streamlined innovation ecosystem, resulting in a low score for *general innovation drivers*. Success in *cleantech-specific drivers* is limited by a small public R&D budget allocated to cleantech, and very limited cleantech start-up access to private capital. However, the presence of cleantech clusters and organisations, as well as the above average cleantech-supporting government policy score, are relative strengths for Portugal. *Evidence for emerging cleantech innovation* scores put Portugal in a low 33<sup>rd</sup> place, the country's weakest across the four pillars measured. Portugal shows mixed performance in *commercialised cleantech* resulting in a 24<sup>th</sup> place in this pillar. While the country shows above average evidence of renewable energy consumption and related energy jobs, this strength is outweighed by the absence of late-stage private finance and activity in cleantech commodity trade. Portugal's overall performance lies well below the average for all European countries analysed.



## Romania

Romania scores below average for both *inputs to* and *outputs of innovation*, ranking 35<sup>th</sup> overall in the Index. A low score for *general innovation drivers* indicates that the country is lacking necessary support structures, education and policy to build a strong entrepreneurial environment. Romania ranks lowest among all European countries for *cleantech-specific drivers*, highlighting a particular weakness that inhibits *emerging cleantech innovation*. No evidence of early-stage funding was recorded, and little measure of successful cleantech start-ups exists, but Romania's score for cleantech patents reaches 28<sup>th</sup> place, above neighbouring Bulgaria. A total lack of observed late-stage cleantech financing and very low scores for cleantech commodity trade set Romania's *commercialised cleantech innovation* score low. However, the country shows a relative strength in the proportion of renewable energy consumption by total primary consumption (ranking 11<sup>th</sup>), highlighting the establishment of clean energy technology in the country.



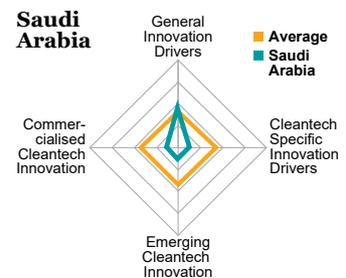
**Russia**

Russia ranks second-to-last in the GCII, with both *input to* and *outputs of innovation* well below global-average. The country lacks a strong entrepreneurial culture, as well as a streamlined support structure for the general national innovation ecosystem. The country’s weaknesses in *cleantech-specific innovation drivers* are especially shown in a regulatory system unsupportive of cleantech innovation, an absence of cleantech specific industrial clusters and the lack of any private native cleantech investors. Russia’s strength, which is still below global average, lies in providing *evidence of emerging cleantech innovation* – ranking 27<sup>th</sup>. A lack of successful start-ups is countered by Russia’s small amount of venture capital financing, and an indication of strong cleantech research and intellectual property protection, with 1279 patents filed under cleantech-related technologies in 2013. This, however, does not translate into any significant *commercialised cleantech* in Russia, evidenced by a lack of cleantech trade activity and late-stage investment. The country nevertheless shows a relative strength in clean energy jobs.



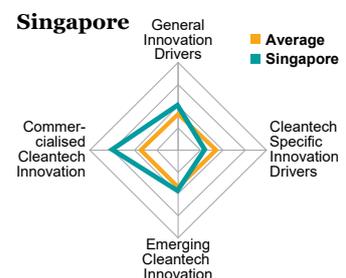
**Saudi Arabia**

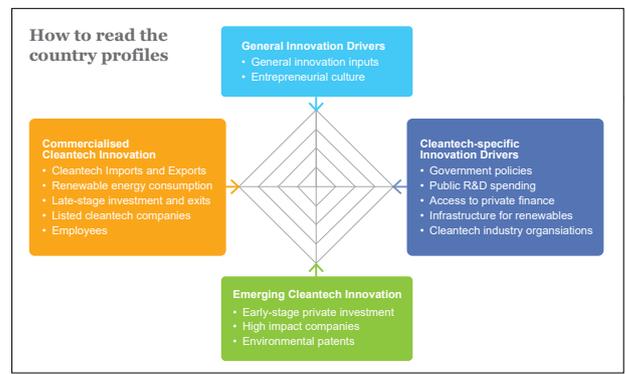
Saudi Arabia occupies the 37<sup>th</sup> place in the Index. The only representative from the Arabian peninsular shows a unique spread of scores between the four indicator pillars. Saudi Arabia scores above average for *general innovation drivers*, occupying the top rank for the indicator of perceived entrepreneurial opportunities. This indicates that the country succeeds in streamlining the innovation ecosystem, having support and incentives in place to build a strong entrepreneurial culture. However, this does not translate into innovation support to the cleantech sphere in any way, highlighted by Saudi Arabia scoring last in *cleantech-specific drivers*. This strong contrast is mirrored in the performance in *outputs of cleantech innovation*, scoring second-to-last. Particular weaknesses are the lack of cleantech research, represented by low scores for cleantech-related patents relative to GDP; very low level of private early- and late-stage financing; low cleantech trade activity; and also low renewable energy consumption. Saudi Arabia’s data demonstrates that the lack of national emphasis on *cleantech-specific drivers* inhibits the establishment and growth of a cleantech innovation ecosystem. However, in its recently unveiled project, Vision 2030, Saudi Arabia outlines the goal to construct a renewable energy capacity of 9.5 GW by 2030, or 10% of the Saudi electricity demand. Although this target is not overly ambitious, it could provide the necessary impetus for the Saudi economy to develop some *cleantech innovation outputs* and become a more efficient innovator in the field of cleantech.



**Singapore**

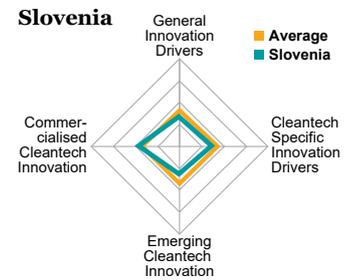
Singapore occupies the 14<sup>th</sup> rank in the GCII, showing a mixed performance across *inputs to* and *outputs of* cleantech innovation. While the country scores well above average in *general innovation drivers*, it does not uphold its high rank in *cleantech-specific drivers*, ranking only 29<sup>th</sup>. This indicates that while the country successfully promotes an overall streamlined innovation ecosystem, it lacks focus in the cleantech sphere – with particular areas requiring improving being cleantech-supportive policy and access to cleantech focused funds. Singapore’s *emerging cleantech* scores above average, with a strong score for available early-stage private capital, and a relative weakness in the number of cleantech-related patents filed in 2013. The country places 2<sup>nd</sup> for *commercialised cleantech*, with top scores in cleantech commodity trade and a good number of cleantech company IPOs and M&A activity. Whilst partly attributed to the country’s limited natural resources and size, Singapore’s weakness for this pillar is its renewable energy consumption and related jobs.





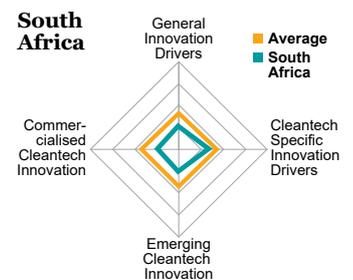
### Slovenia

Slovenia occupies the 21<sup>st</sup> rank in the GCII, but scores below the global-average in *general innovation drivers*, *cleantech specific drivers*, and *emerging cleantech*. Scoring just below Bulgaria for *general innovation drivers*, Slovenia still has great potential to improve its innovation ecosystem and embedded national entrepreneurial culture. Slovenia shows a mixed performance of *cleantech-specific innovation drivers* Whilst the country yields a top score for cleantech industrial cluster development and scores well for cleantech supportive government policy, the total lack of start-up access to private finance and low renewable energy investment attractiveness of the country outweigh the relative strengths. This translates to low *emerging cleantech*, with a particular weakness again being the lack of evidence for early-stage financing in the cleantech sector. Despite these weaknesses, Slovenia manages to score 16<sup>th</sup> place in *commercialised innovation*, with strong cleantech commodity exports and imports, but no strength in late-stage private finance indicators.



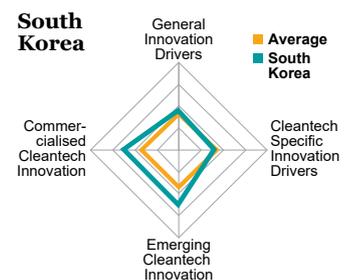
### South Africa

South Africa scores below the global average in both *inputs to* and *outputs of* cleantech innovation, ranking 31<sup>st</sup> in the overall Index. The only Sub-Saharan Africa country representative ranks 4<sup>th</sup> to last for *general innovation drivers*, indicating that the country lacks a streamlined innovation pipeline and a good entrepreneurial culture. South Africa's relative strength, yet still below global-average, lies in *cleantech-specific drivers* with a good amount of cleantech-friendly government policy. The country lacks *evidence of emerging cleantech*, especially shown in the low number of filed cleantech-related patents and low showing of successful cleantech start-ups, despite some early-stage venture capital deployed in the sector. The country scores very low for *commercialised cleantech*, despite a decent amount of cleantech imports, due to lack of evidence of any late-stage private finance activity, a low score for cleantech commodity exports, and low renewable energy consumption and related employment.



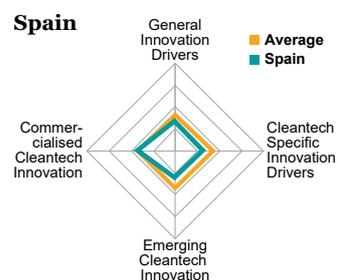
### South Korea

South Korea scores highest amongst all Asian countries in the Index, occupying the 11<sup>th</sup> rank overall, with a particular strength in *outputs of cleantech innovation*. The country's performance in *general innovation drivers* is just above the global average, indicating a relatively streamlined innovation pipeline, but not necessarily a widely embedded national entrepreneurial culture. The score for *cleantech-specific drivers* lies slightly below the global average, attributable to weaknesses in access to private finance and low numbers of industrial cleantech clusters, despite the relative strength in public R&D expenditure on the cleantech sector. South Korea's *outputs of cleantech innovation* are, however, well above average. While South Korea ranks top for cleantech-related patents, it lags behind in early-stage finance and successful start-up indicators, ranking 10<sup>th</sup> place for *emerging cleantech*. South Korea shows significant success in the *commercialised cleantech*, with its export and import of cleantech-related commodities ranking 2<sup>nd</sup> highest overall, only after Singapore. This top performance is contrasted by South Korea's continued lack of late-stage financing in the cleantech sector, or significant shares of renewables in the national energy mix.



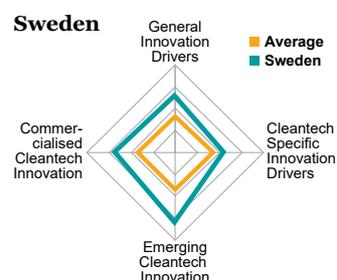
### Spain

Spain ranks 25<sup>th</sup> in the Index, with a relative strength in *evidence of commercialised cleantech*. *Inputs to innovation* score both below the global average and below its smaller European neighbour, Portugal. Particular weaknesses in *cleantech-specific drivers* are the limited start-up access to cleantech funds and a lack of a cleantech-supportive policy environment, and low R&D expenditure on cleantech, especially compared to other European nations. Failure to show successful *emerging cleantech* is shown by the low number of successful Spanish cleantech start-ups. Yet, Spain's *commercialised cleantech* ranks 19<sup>th</sup>. The country shows evidence of late stage private equity deals, some successful public listed cleantech companies, strong exports of cleantech commodities, and an above average renewable energy consumption. Spain's clean energy related jobs, however, lie below the global average. Another relative weakness lies in Spain's very low cleantech commodity imports.



### Sweden

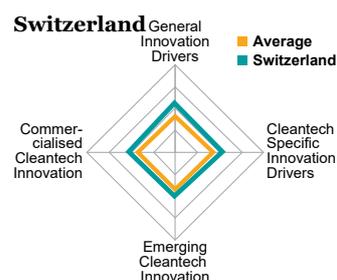
Sweden scores 3<sup>rd</sup> in the Index, trailing its two Nordic neighbours, Denmark and Finland. For *general innovation drivers*, Sweden shows a particular strength in its citizen's perceived entrepreneurial opportunities, ranking 2<sup>nd</sup> behind Saudi Arabia. Highlights in Sweden's *cleantech-specific drivers* are the high public R&D expenditure in the cleantech sphere, evidence for a cleantech-friendly policy environment, and a large number of domestic private cleantech investors. Evidence for *emerging cleantech* in Sweden is shown by the country achieving the top score in the successful cleantech start-ups indicator, and filing 1.5 times the global average number of cleantech-related patents by GDP. Sweden's *commercialised cleantech* ranks 3<sup>rd</sup> overall, with particular national strengths in renewable energy consumption by total primary energy, a proxy for clean energy technology deployment, and related clean energy jobs. The country also scores the top rank for the number of cleantech company IPOs in the last 3 years, when weighted by GDP.



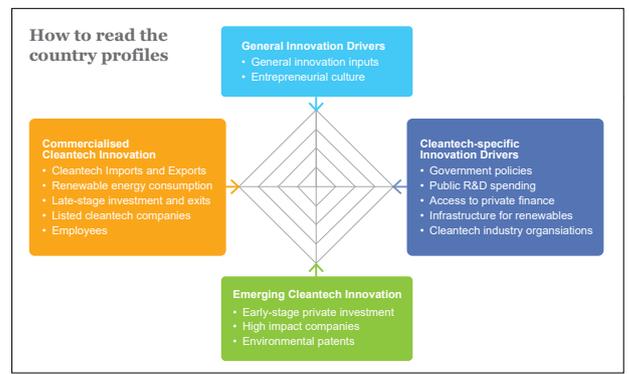
### Switzerland

Switzerland ranks 10<sup>th</sup> place in the Index, with an even performance across all indicator pillars above the global average. For *general innovation drivers* the country scores the 5<sup>th</sup> place, with a top score in the Global Innovation Index,<sup>50</sup> but lagging behind in indicators of entrepreneurial culture. This indicates that while the national innovation pipeline is supported by policy, education, and finance, it does not yet translate into a high level of actual entrepreneurial activity among the Swiss population. For *cleantech-specific drivers*, Switzerland's strengths lie in high government cleantech R&D expenditure and cleantech-supportive policy, whilst the country's weaknesses lie in its number of cleantech industrial clusters and below-average score for renewable energy investment attractiveness.

Switzerland's performance in *emerging cleantech* is consistently above average for all indicators, covering early-stage venture capital investment to cleantech-related patent filings. This consistency does not translate to indicators of *commercialised cleantech*. Switzerland scores high in its share of renewable energy consumption and level of late-stage equity and M&A activity within the cleantech sector, but shows weaknesses in producing publicly listed cleantech companies, the related number of IPOs, and a very low level of cleantech commodity exports/GDP.



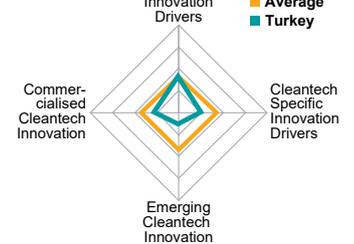
50 INSEAD, Cornell University, World Intellectual Property Organisation (WIPO), *Global Innovation Index*, 2016



## Turkey

Turkey ranks 33<sup>rd</sup> in the Index. The country's clear strength lies within *general innovation drivers*, scoring high in entrepreneurial culture indicators and giving evidence of an active early-stage ecosystem. For *cleantech-specific drivers*, Turkey lacks strength across all constituent indicators, from a cleantech-supportive policy environment to access to private finance. This reflects in Turkey scoring 3<sup>rd</sup> to last for *evidence of emerging cleantech*, with even Saudi Arabia surpassing it. Whilst still well under the global average, the country shows some *evidence for commercialised cleantech*, mainly attributable to its cleantech commodity imports and above-average share of renewable energy consumption of its total primary energy.

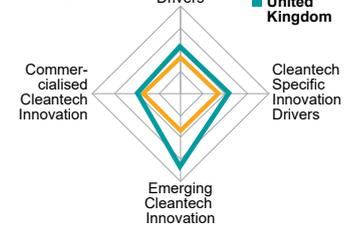
### Turkey



## UK

The United Kingdom ranks 7<sup>th</sup> in the Index, with the highest European country score, excluding the Nordics. The UK yields high scores for all *general innovation drivers*, except early-stage activity measurements, which is on the lower end of the indicator distribution.<sup>51</sup> For *cleantech-specific drivers*, the country shows strength in start-up access to private finance, and a relative weakness for government R&D expenditure on the cleantech sector. The UK performs best in *evidence of emerging cleantech*, ranking 5<sup>th</sup>, partly attributable to its top score in early-stage venture capital investment activity and a high number of successful start-ups. For *commercialised cleantech*, the UK lags behind the global average in producing cleantech commodity exports and renewable energy consumption, but shows strength in late-stage financing activity, scoring top in a measurement of cleantech company IPOs.

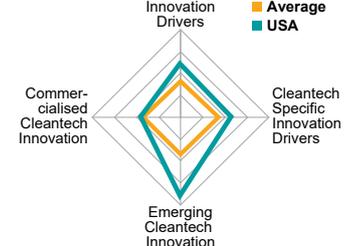
### United Kingdom



## USA

The USA upholds a leading rank in the Index, placing 5<sup>th</sup> after three Nordic countries and its neighbour, Canada. High scores for *general innovation drivers* point to the streamlined national innovation pipeline and strong entrepreneurial culture in the USA. For *cleantech-specific drivers*, the USA shows strengths in start-up access to private finance and scores top for renewable energy investment attractiveness, but has potential to improve in providing a cleantech-supportive policy environment and R&D expenditure on cleantech relative to its GDP. The USA ranks 3<sup>rd</sup> for *emerging cleantech*, performing well across all indicators and scoring top for early-stage financing activity. The US also shows *evidence of commercialised cleantech* with a top position in late-stage cleantech financing through private equity, M&As, and IPOs, as well as a good and growing number of renewable energy jobs. However, the total share of US renewable energy consumption and cleantech commodity exports are lower than global average, and these two indicators bring the score down.

### USA



51 Global Entrepreneurship Monitor, *Early-Stage Activity*, 2016

## Transportation and Energy Efficiency in the Index

In 2010, the buildings sector accounted for around 32% of final energy use and annual emissions of 8.8 Gigatonnes carbon dioxide (GtCO<sub>2</sub>) (direct and indirect); and the transport sector accounted for 27% of final energy use and emissions of 6.7 GtCO<sub>2</sub>. UNEP estimates of both direct and indirect emissions reduction potentials in 2030 are 5.9 GtCO<sub>2</sub>e (gigatonnes of carbon dioxide equivalent) for buildings and 2.1 GtCO<sub>2</sub>e for transport.<sup>36</sup> A UNEP study notes that these estimates are conservative and the real potential in each sector is likely bigger. A more recent analysis by the International Energy Agency indicates that the cumulative direct and indirect emissions estimates to 2035 are 30 GtCO<sub>2</sub>e for buildings and 12 GtCO<sub>2</sub>e for transportation.<sup>37</sup> The two studies are not comparable due to basic differences in approaches, but, collectively, illustrate the significant potential in the two sectors. Dramatically increased energy efficiency in these two sectors is a necessary disruption for combating climate change, thus they must remain key areas for further cleantech innovation disruption in the years ahead..

### Changing early-stage investment landscape

While energy efficiency has been a leading sector

for venture capital investment for a number of years, and has consistently been a 1 billion dollar venture capital investment sector since 2010, transportation has taken longer to catch the cleantech venture capital investment network's eye. After a 2013 low of \$390 million, transportation has become cleantech investment's fastest growing sector, recording just under \$3 billion in 2016, and accounting for 22.7% of total dollars invested in cleantech start-ups that year.

Figure 13. Sector share by volume

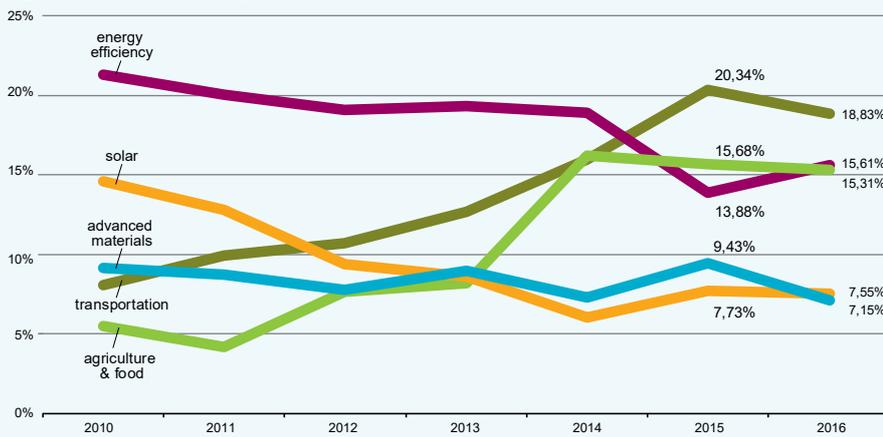
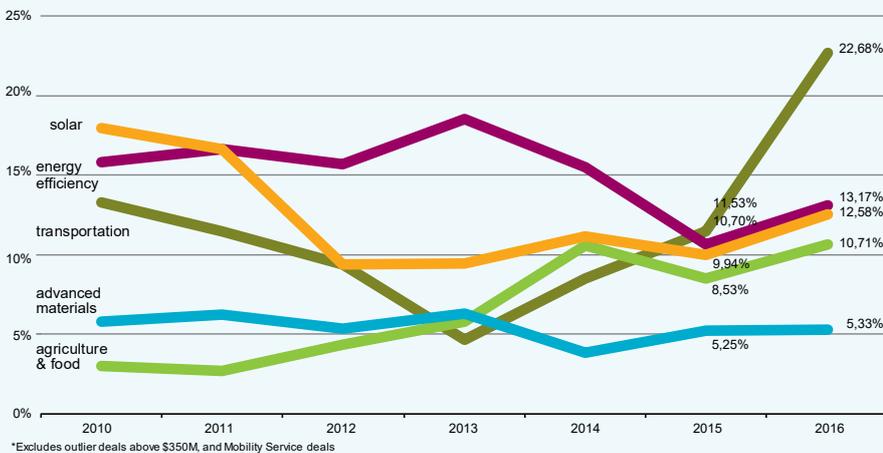


Figure 14. Sector share by dollar amount



Apart from 2016, the transportation sector experienced a consistent rise in share of venture capital deal volume from 2010, even during the relatively low investment period in 2013. However, the quantity of deals has not overtaken energy efficiency to the same degree as in dollar amounts.

While most indicators used in the GCII methodology will be influenced by both the transportation and energy

<sup>36</sup> UNEP, *The Emissions Gap Report, 2016*

<sup>37</sup> International Energy Agency, *The Efficient World Scenario, World Energy Outlook 2012*



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efficiency sectors, there are three specific indicators for which the development of these sectors are measured directly: cleantech-friendly government policies in *cleantech-specific drivers*, and a combination of early- and late-stage financing in *emerging cleantech* and *commercialised cleantech*, respectively.

**Energy Efficiency in the Index**

39 countries in this Index have codified energy efficiency measures into law. Only Argentina is recorded as having neither energy efficiency laws nor an energy law that makes provisions for energy efficiency.<sup>38</sup>

A total of 516 venture capital equity investments were made in energy efficiency companies over the course of 2014 to 2016, for a total of \$4.25 billion. While the majority of this was focused in North America, and the USA in particular, weighting by GDP provides some insight into countries which currently contain the most innovative energy efficiency companies.

**Figure 15. A comparison of position in the 2017 GCII with total venture capital investment in energy efficiency**

Country	2014 – 2016 Venture Capital in Energy Efficiency (/GDP)	Rank in the 2017 Index	Rank in total VC Investment in Energy Efficiency
USA	1153.2	(5)	(1)
Israel	398.3	(6)	(5)
Ireland	150.1	(16)	(9)
Canada	106.3	(4)	(2)
Finland	87.1	(2)	(13)
Sweden	71.1	(3)	(10)
UK	56.5	(7)	(3)
France	42.5	(13)	(6)
Belgium	39.8	(19)	(12)
Norway	37.2	(9)	(17)

<sup>38</sup> World Energy Council, *Energy Efficiency Policies and Measures*, last updated December 2015

As can be seen in the *Figure 14*, there are some countries that are showing signs of increased activity in the Energy Efficiency sector. When measuring venture capital figures it is unsurprising to see the **USA** at the top of the list. However, looking at **Ireland**, it is clear that energy efficiency is a core sector for its innovation ecosystem. Despite ranking 16<sup>th</sup> in the Index, it places 9<sup>th</sup> in total venture capital investment in Energy Efficiency companies, and places 3<sup>rd</sup> when this is weighted against GDP. Similarly, **Belgium** finds itself in 9<sup>th</sup> position for its venture capital investment in energy efficiency, despite coming in 19<sup>th</sup> in the Index.

### Transportation in the Index

While there were some countries that scored marginally lower due to missing transport and auto-efficiency obligations and mandates, a good level of regulation was recorded in this indicator.<sup>39</sup>

A total of 580 venture capital equity investments were made in transportation companies over the course of 2014 to 2016, for a total of \$10.39 billion. Yet again, and reflective of most cleantech sectors over a similar time scale, the majority of this was focused in North America, and the USA in particular. Weighting by GDP provides some insight into countries that currently contain the most innovative transportation companies.

**Figure 16. A comparison of position in the 2017 GCII with total venture capital investment in transportation**

Country	2014 – 2016 Venture Capital in Transportation (/GDP)	Rank in the 2017 Index	Rank in total VC investment in Transportation
United States	6852.1	(5)	(1)
Singapore	3037.5	(14)	(3)
Israel	1646.3	(6)	(6)
China	617.9	(18)	(2)
Indonesia	193.1	(40)	(5)
India	167.8	(29)	(4)
France	158.6	(13)	(7)
Austria	129.8	(17)	(14)
Finland	115.0	(2)	(17)
Spain	95.5	(25)	(10)

In *Figure 16*, where there is a disparity between a countries, ranking in the 2017 GCII and the rank in total venture capital investment in transportation, we can infer that this sector is significant in that country’s cleantech investment ecosystem. Asian countries like **China, India, Indonesia** and **Singapore** all show evidence for transportation being a core cleantech investment sector. We note the same is true for Spain. Conversely, and although it is still ranked in the top 10 for venture capital investment in transportation companies relative to GDP, **Finland**’s results indicate that transportation start-ups are either lacking access to funding, or it is not well established or supported , compared to other cleantech sectors, which thrive in Finland’s highly innovative market.

<sup>39</sup> REN-21, *Renewables 2016 Global Status Report*, 2016

## Conclusion

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There is no ceiling, or ‘full marks’, for indicators used in this Index. More needs to be done globally across all measurements, whether it is to increase investment in research by increasing cleantech R&D budgets (as is the driving commitment for those countries joining the group of 22 countries backing Mission Innovation)<sup>40</sup> or increasing renewable energy penetration to combat climate change. Each of the countries in the Index should aspire to improve each indicator in their country profile rather than improve rank, and use this Index to support and communicate strengths while addressing weaknesses.

The GCII process allows for exemplary countries to act as pathfinders in continually nurturing a vibrant cleantech innovation ecosystem that plays part in addressing global sustainability challenges. Our methodology highlights *drivers* of innovation, but also gives examples of the real benefits that can accrue from a focus on innovation generally, and cleantech innovation specifically. For the leading countries in this Index, it is possible to highlight relative weaknesses, exemplify their strengths in our ‘archetype’ analysis, and shine further light on the path to cleantech innovation for lower ranked countries.

Among the top 15-20 scorers in the overall Index, there is substantial variation in the countries’ performances across the 4 pillars, pointing to the various ways a country can nurture a cleantech ecosystem. While some show strength in private sector participation (such as the USA), others’ strong performances are backed by policy and government support (such as in Finland).

The *emerging cleantech* pillar is a useful guide for understand which countries are likely to realise the environmental and economic benefits of successfully commercialised cleantech companies in the next few years. A comparison of the pillar in the 2014 Index to the 2017 Index shows that improvements have been made, and greater success in the *commercialised cleantech* pillar should follow. In the 2014 Index, a great disparity was recorded between the top 5 (Israel, Finland, USA, Sweden, and Japan) and the rest of the indexed countries. The leading country in *emerging cleantech* in the 2014 Index, Israel, accrued four times average score of countries such as India and Belgium, and seven times better than the median country, New Zealand. In the 2017 Index, our top scorer (Finland) scored only 3 times more than our median marker (Czech Republic). From this, we may expect the distribution in the *emerging cleantech* pillar and, in time, the *commercialised cleantech* pillar to even out. .

The incorporation of a measurement of cleantech conversion should aid countries in identifying pathways to a strong *commercialised cleantech* sector. By measuring how much *output* is created by a unit of *input to cleantech innovation*, this report has outlined the most efficient cleantech creators. The three top ‘cleantech commercialisers’ outlined in *Archetype 3* should be considered closely, alongside the top scorers in the overall Index. Some of the higher ranked countries show relatively low cleantech conversion scores, and may require high levels of *input* to achieve its level of *output*, or the country has more cleantech commercialisation potential to realise in the coming years.

There is an emerging convergence between clean transportation, energy efficiency and renewable energy accounting for the majority of early-stage venture capital investments while also dominating areas for rapidly growing scaling opportunities through green bonds. This emerging trend is crucial to accelerate towards achieving universal energy access by 2030, and facilitate a just transition to a sustainable and fossil fuel-free energy system by 2050. To have any chance of staying well below 2 degrees of global warming, we must halve global greenhouse gas emissions every decade in future. This task will be impossible without a combined and concerted effort to work on improving cleantech deployment and innovation.

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40 <http://mission-innovation.net/>

## Appendix A – Indicators and Sources

<b>General innovation drivers</b>				
<b>Indicator</b>	<b>Source</b>	<b>Date</b>	<b>Definition</b>	<b>Weighting</b>
General innovation inputs	INSEAD Global Innovation Index	2016	Insitutions, human capital, infrastructure, market sophistication and business sophistication facilitating innovation	50%
Entrepreneurial culture	Global Entrepreneurship Monitor	2016	Positive attitudes towards entrepreneurship and early stage entrepreneurial activity	50%
<b>Cleantech-specific innovation drivers</b>				
<b>Indicator</b>	<b>Source</b>	<b>Date</b>	<b>Definition</b>	<b>Weighting</b>
Cleantech-friendly government policies	REN21 – Renewables 2016 Global Status Report; World Bank Group – State and trends of carbon pricing 2016; OECD & Bloomberg Philantrophies – Green bonds, Policy perspective 2015	2015 - 2016	Selected government policies supporting clean technology including tax incentives, feed-in tariffs, green bonds, renewable energy mandates and others	25%
Government R&D expenditure in cleantech sectors	OECD-IEA database; UN GERD database	2013 - 2015	Total budget for cleantech R&D as a proportion of GDP (PPP)	25%
Access to private finance for cleantech start-ups	Cleantech Group data	2014 - 2016	Number of cleantech investors and cleantech-focused funds recently raised weighted by GDP	25%
Country-attractiveness of Renewable Energy Infrastructure	Ernst & Young Renewable Energy Country Attractiveness Index	2015	Index score covering national renewable energy markets, renewable energy infrastructures and their suitability for wind, solar, biomass and other renewable energy technologies	20%
Cleantech cluster programs & initiatives	Cleantech Group research	2016	Number of industry associations, physical clusters and economic initiatives supporting the cleantech industry as a proportion of GDP (PPP)	5%
<b>Evidence of emerging cleantech Innovation</b>				
<b>Indicator</b>	<b>Source</b>	<b>Date</b>	<b>Definition</b>	<b>Weighting</b>
Patents in cleantech sectors	OECD database	2013	Environment-related technology patents covered by the Worldwide Patent Statistical Database (PATSTAT) weighted by GDP (PPP)	45%
Early-stage private investment	Cleantech Group data	2014 - 2016	Amount of venture capital invested in cleantech companies as a proportion of GDP (PPP)	45%
High impact cleantech start-ups	Cleantech Group data	2014 - 2016	Number of companies included in the Global Cleantech 300 weighted by GDP (PPP)	10%
<b>Evidence of commercialised cleantech innovation</b>				
<b>Indicator</b>	<b>Source</b>	<b>Date</b>	<b>Definition</b>	<b>Weighting</b>
Trade of cleantech commodities	UN Comtrade	2015	Trade value of national export (25% weighting) and import (25% weighting) of cleantech-related commodities, weighted by GDP (PPP)	50%
Renewable energy consumption	BP Statistical Review of World Energy 2016	2016	Total renewable energy consumption as % of Primary Energy Consumption	20%
Late-stage private investment and exits	Cleantech Group data	2014 - 2016	Number of cleantech private equity deals M&As, and IPOs weighted by GDP (PPP)	15%
Successful public cleantech companies	Cleantech Group, FTSE, Ardour and WilderHill indices of public cleantech companies	2016	Number of publically listed cleantech focused corporates weighted by GDP (PPP)	10%
Renewable Energy Jobs	IRENA Renewable Energy and Jobs Annual Review	2016	Number of direct and indirect employees related to renewables as % of total labor force	5%

## Appendix B – Methodological Considerations

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We would like to acknowledge that despite the robust methodology of this Index, like in any study, there are parts of the framework that could be improved. We therefore would like to focus on the following methodological considerations and potential improvements that we encountered during the data gathering and planning stages of this Index, which were limited in their implementation either due to a lack of data availability or due to the wish to maintain methodological consistency between this and the 2014 edition of the Global Cleantech Innovation Index.

### **Renewable Energy Focus**

A brief look through our indicators and sources could prescribe this Index with too strong a renewable energy, and energy in general, bias for this to be a true measure of ‘cleantech’ innovation. However, and as shall be described below, there are multiple sectors of cleantech accounted for in the data we use, especially with the provision of Cleantech Group data.

It is also relevant to mention that measurements of renewable energy penetration, renewable energy jobs, and other such clean-energy related indicators provide a valuable signpost for a wider cleantech definition.

### **Private & Public Finance**

To form a full picture of expenditure into the research and development of a country’s cleantech innovation, the inclusion of private R&D in addition to public R&D is desirable, but it could not be undertaken in this Index due to lack of available data related specifically to cleantech industries. Furthermore, the measurement of ‘access to private finance’ neglects access to capital via commercial banks. We could not find a comprehensive dataset covering commercial loan access across the required geographies.

### **Green Bonds**

In researching this report, and the supplements to this edition of the GCII, it is apparent that support for cleantech is increasingly sophisticated. The range of policy measures, as well as support networks and organisations, has increased across the board. In this edition, this has led to our inclusion of green bonds issuance as a part of our indication of *inputs to innovation*. Green bond issuance has soared in recent years, with sales typically being over-subscribed.

### **Geographic targeting of investment funds**

Venture capital flows are increasingly geographically liquid. Specifying an amount of venture capital available within one country is therefore inexact. Our methodology assesses the number and dollar-value of funds with a specific country focus. Where more than one specific country is being targeted, there may be instances of double counting as each country was prescribed the full amount of the fund in question. This value is balanced by the venture capital investment figures used in other Index indicators.

### **Cleantech Clusters & Initiatives**

Recognising the rise of incubator and accelerator programmes as a means of cleantech start-up support, we see the potential to widen the definition of this indicator to include these categories, or even act as a substitute to the more traditional industrial clusters covered in the current definition. Cleantech Group is focused on tracking global cleantech-related incubators and accelerators, which will allow the formation of a comprehensive dataset for use in future editions of the Index. WWF strategy reviews also recognises the increasingly strategic role that incubator and accelerator programmes play in nurturing cleantech innovation world-wide. This year's Index, however, draws only on cleantech cluster programmes and initiatives to maintain methodological consistency to the 2014 Index.

### **Cleantech Commodities**

This indicator serves as a substitute for 'revenues of cleantech companies' used in previous editions of the Index, as the collection of this dataset was not continued by third party organisations. The new indicator measures the country's activity in the export and import of a number of selected cleantech-related commodities. This gives an indication of the national cleantech manufacturing sector and its international competitiveness (through export measurements), and the demand for clean commodities to be adopted in its national green economy balanced with a potential lack of cleantech manufacturing (through import measurements). We consider the combination of these a valuable substitute indicator as it similarly provides a measurement of the strength of a nation's 'green economy', and is based on publicly available commodity trade data that will be accessible for all future editions of the Index.

### **Renewable Energy Jobs**

A measure of renewable energy jobs serves as an approximation for the general level of employment across the cleantech sector. However, there are potential improvements to this indicator. For example, IRENA figures show there are 769,000 direct and indirect jobs related to renewables in the USA. If this is expanded to include all jobs in energy efficiency, smart grid, energy storage, electric power generation, renewable fuels production, and electric, hybrid, and hydrogen-based vehicles, we may be looking at 3.3 million jobs according to the US Department of Energy.<sup>41</sup>



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41 US Department of Energy, *Fact Sheet: Jobs in Renewable Energy and Energy Efficiency*, 2017

## Appendix C – Abbreviations

<b>ADB</b>	Asian Development Bank
<b>BP</b>	British Petroleum
<b>BRIC</b>	Brazil, Russia, India and China; Acronym denoting the major developing economies
<b>CTG</b>	Cleantech Group
<b>EU</b>	European Union
<b>EY</b>	Ernst & Young
<b>FTSE</b>	Financial Times Stock Exchange index
<b>GCI</b>	Global Cleantech Innovation Index
<b>GCIIP</b>	Global Cleantech Innovation Programme; Cleantech programme developed by UNIDO
<b>GDP</b>	Gross Domestic Product
<b>GEM</b>	Global Entrepreneurship monitor; report by GERA
<b>GERA</b>	Global Entrepreneurship Research Association
<b>GERD</b>	Gross Domestic Expenditure on R&D
<b>GHG</b>	Greenhouse Gas
<b>GII</b>	Global Innovation Index; report by Cornell University, the World Property
<b>GtCO<sub>2</sub></b>	Gigatonnes of carbon dioxide
<b>G20</b>	Group of Twenty; forum of twenty major economies
<b>IEA</b>	International Energy Agency
<b>INSEAD</b>	Institut Européen d'Administration des Affaires; International business school based in Fontainebleau, France
<b>IPO</b>	Initial Public Offering
<b>IRENA</b>	International Renewable Energy Agency
<b>i3</b>	Cleantech Group's proprietary data platform
<b>M&amp;A</b>	Mergers and Acquisitions
<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>PATSTAT</b>	Worldwide Patent Statistical database; Developed by the European Patent Office
<b>PE</b>	Private Equity
<b>PPP</b>	Power Purchasing Parity
<b>RD&amp;D</b>	Research, Development and Deployment
<b>REN-21</b>	Renewable Energy Policy Network for the 21st Century
<b>R&amp;D</b>	Research and Development
<b>SEK</b>	Swedish Krona
<b>UK</b>	United Kingdom
<b>UN</b>	United Nations
<b>UNEP</b>	United Nations Environment Programme
<b>UNIDO</b>	United Nations Industrial Development Organisation
<b>USA</b>	United States of America
<b>VC</b>	Venture Capital
<b>WIPO</b>	World Intellectual Property Organisation
<b>WWF</b>	World Wildlife Fund







THIS PUBLICATION  
HAS BEEN PUBLISHED  
IN PARTNERSHIP  
BETWEEN



# The Global Cleantech Innovation Index 2017

**WHICH COUNTRIES LOOK SET TO PRODUCE  
THE NEXT GENERATION OF START-UPS?**

This report investigates the global state of cleantech innovation in entrepreneurial start-up companies. We are currently faced with a range of climate, energy and economic challenges. Technology start-ups provide one of the most important vehicles for developing and commercializing innovation to meet these challenges, while generating value for investors. This report reasons as to where these innovative cleantech companies will spring-up over the next decade, and shows which countries are falling ahead and below the curve for cleantech innovation.

The index was first launched in 2012 and reiterated 2014. This is the third edition.