Future Needs in Research Development and Demonstration Report

Future RD&D needs survey results

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Future Cleantech Architects

We are a climate innovation think tank. We exist to close the remaining innovation gaps to reach net-zero emissions by 2050. To reach this objective, we accelerate innovation in critical industries – such as cement, aviation, or shipping – where sustainable solutions are still in very early stages. We urge policy-makers to intensify and better prioritize their R&D activities. Moreover, we initiate and actively drive high-level research consortia on critical technologies for these neglected technological sectors.

List of Abbreviations

CCUS = Carbon Capture, Utilization, and Storage

CDR = Carbon Dioxide Removal

CTCN = Climate Technology Centre and Network

FCA = Future Cleantech Architects

IEA = International Energy Agency

IPCC = Intergovernmental Panel on Climate Change

LDCs = Least Developed Countries

LDES = Long Duration Energy Storage

NDCs = Nationally Determined Contributions

NDEs = National Designated Entities

NGO = Non-Governmental Organization

RD&D = Research, Development, and Demonstration

SIDS = Small Island Developing States

TEC = Technology Executive Committee

TES = Thermal Energy Storage

UNFCCC = United Nations Framework Convention on Climate Change

Key Figures

Development Valley of Death[1]

> 70% selected large-scale deployment as a key area where promising developments are lost

Key Stakeholder

The Public Sector is considered the key stakeholder for accelerating RD&D globally: Within the public sector, governments (29%) and international bodies (11%) are considered key stakeholders

Most Urgent RD&D Acceleration

Energy Storage[2] was highlighted as a key global priority until both 2030 and 2035

Key Takeaways

The survey provides an overview of future RD&D needs and key barriers and enablers to meet these, both globally and specifically in developed and developing economies, and serves as a starting point to identify areas for further analysis. Although the global RD&D environment is seen as slightly favorable overall, both developing and developed economies face a number of challenges in scaling high-impact emission-reduction technologies and meeting their RD&D needs.

The public sector is identified as the key stakeholder for accelerating climate technology RD&D and is considered both by far the most able stakeholder to do so, and one of the biggest current roadblocks. Economic and institutional challenges are identified as the biggest barriers globally, while bureaucracy, political support, and legislation are perceived as the biggest factors preventing the scaling of cleantech solutions if funding and technological challenges are not an issue. Accordingly, financial support and political buy-in are considered the strongest enablers for successful climate technology RD&D. Respondents from both developing and developed economies mentioned political and financial factors as highly relevant in every question pertaining to key barriers, enablers, and/or stakeholders for promoting high-impact cleantech RD&D. The biggest differences between the two groups merely pertained to the type and timing of needed financing. Finally, developed economies appear to be facing bigger challenges when it comes to socio-cultural factors, whereas developing economies are still facing bigger technological challenges.

The biggest differences in responses from participants from developing and developed economies can be found in RD&D needs of mature technologies. Solar energy is seen as the most urgent RD&D acceleration area in developing economies until 2030 and 2035. Respondents from developed economies, however, indicated fuel switching in industry to be the most urgent RD&D acceleration area for both timeframes, the area considered to be least urgent by respondents from developing economies. Similarly, industrial processes are considered to be the second most important RD&D need until 2030 and, by a very small margin, the most important need until 2035 for participants from developed economies, whereas respondents from developing economies consider industrial processes to be the second-to-least important need until both 2030 and 2035.

The stand-out technology sector across almost all regions and professions is energy storage. Whereas needs and priorities tend to differ between different timeframes and regions throughout the survey's questions, the results indicate that, though respondents certainly consider clean energy generation with both mature renewables and more early-stage innovative solutions to be of high importance in the short term, energy storage remains one of the biggest RD&D needs overall. This remains true for the question on long-term environmentally sustainable energy supply, even when excluding those responses given by professionals working in energy storage. Decarbonizing global electricity production will require large amounts of renewable energy and a number of flexibility tools to smooth out supply and demand curves that change throughout the day and different seasons. A wide range of storage technologies, in particular Long Duration Energy Storage, will play a crucial role in keeping up with the growing demand for electricity generation to meet continued population and GDP growth, and to cover the electrification of new sectors previously supplied with fossil fuels (such as heating, transport, and industrial processes). In line with the results of the survey, increased efforts should be made to support storage RD&D acceleration on both global and national scales.

Participant Overview

307 participants
25% Female, 70% Male
73% completion rate
>70 hours of expert knowledge

Regions

All continents/regions represented
Participants from 59 countries
26.4% from developing economies
73.6% from developed economies

The Three Main Wishes

More financing: 22%
Internalize CO_2 costs: 18%
Reduce Bureaucracy: 16%

Background

The IEA's 2019 report on "Innovation Gaps – Key long-term technology challenges for research, development and demonstration" estimates that more than 50% of technical innovations needed to reach net-zero by 2050 either do not yet exist or are not on track. The acceleration of RD&D in critical sectors is imperative to ensure these tech gaps are closed on time.

Future Cleantech Architects is a multi-disciplinary climate innovation think tank with a focus on high-impact RD&D, targeting technologies that carry the potential to drive down greenhouse gas emissions in key sectors massively. The focus on promoting and developing technologies to close the innovation gaps needed to reach net-zero by 2050 led FCA to complete a first comprehensive expert survey on the future needs of climate technology RD&D in 2021, which included structured feedback from 114 expert participants worldwide. Experts were specifically asked to identify gaps remaining in the development of technologies and processes that have the potential to help reduce emissions quickly, thereby effectively tackling the climate challenge.

Based on the results of 2021, the following survey has been jointly conceptualized by the Technology Executive Committee and Future Cleantech Architects as part of the Rolling Workplan of the Technology Executive Committee for 2023–2027, activity A.2 "Stimulate climate technology RD&D through partnerships, strengthening the roles of innovators and incubators and accelerators, and the participation of developing country Parties in collaborative approaches to RD&D":

Activity A.2.1 - RD&D: Building on the TEC's work on collaborative RD&D, analyse the needs for RD&D for high-impact emission-reduction technologies to help countries implement their NDCs and other mitigation strategies, and ensure long-term environmentally sustainable energy supply. Identify ways to increase participation of developing country Parties in collaborative approaches to RD&D.

Objective

The objective of the survey is to achieve a comprehensive overview of the current and future global RD&D needs to fundamentally decarbonize human activity in line with the targets of the Paris Agreement.

The results of the TEC's 2021 "Compilation of good practices and lessons learned on international collaborative research, development, and demonstration initiatives of climate technology" identify five key recommendations for strengthening collaborative RD&D. Recommendation 2 is to "facilitate flexible and evolving participation of countries in line with national needs and capacities" (p. 59). One of the goals in designing the survey was to do so in such a way that the results can help provide a needs-assessment for current and future RD&D needs not only a global scale, but also to assess the difference in needs between developed and developing economies. By enabling a differentiated analysis of global vs. regional needs, the survey hopes to contribute to "identifying (and regularly updating) thematic areas in line with member country priorities" (p. 55).

Methodology

Participants were first asked not only to indicate their location by country, but also their field of profession and the main focus of their work, allowing for an analysis of the responses by both region and sector. Before starting the survey, participants were informed that their answers would be anonymous and asked to answer only those questions which they felt confident answering. Additionally, they were notified that many of the questions would ask them to rate RD&D needs for the same technologies in different timeframes, both in their own country and globally. This was done in order to be able to analyze not only the most urgent RD&D acceleration areas, barriers, and enablers globally, but also to be able to differentiate between the needs of developing and developed economies. Finally, each multiple-choice and ranking question included an "Other (please specify)" option, allowing participants to add answer options they felt were missing from the pre-selected choices.
In addition to the questions asking survey participants to choose and rank the technology segments in which RD&D must be accelerated most urgently, the survey included questions focusing on the stakeholders and tools most qualified to do so. These were complimented by questions aimed at identifying the biggest roadblocks and challenges in advancing RD&D on a global and regional scale.
The survey was made available in English, French, and Spanish.

Target Respondents

In order to identify specific needs and priorities on both a global and regional scale, the survey was directed at experts globally. Participants were asked to indicate the country in which they are located, allowing the answers to be aggregated both by regions and by status as developed or developing economies.
The respondent groups targeted by the survey included:

- Policy-makers from local and national governments
- National Designated Entities (NDEs) and other planners and implementers
- Innovators
- Researchers
- NGOs and Think Tanks
- CTCN members that are research organizations

Distribution of the Survey

The survey was distributed to the identified respondents via both the Future Cleantech Architects' and the TEC's networks. Due to the nature of the organizations, Future Cleantech Architects largely targeted European private sector respondents of the innovator, researcher, and industry representative groups, while the TEC mainly focused on those belonging to the policy-maker and NDE groups on a global scale.
The survey was distributed via a number of channels, including targeted mailings, subject matter newsletters, the organization's respective social media channels, and to expert audiences attending relevant events and discussions organized by both parties.

Included Technologies

Respondents were asked to rank a number of climate mitigation technologies pertaining to their RD&D needs. The IPCC's 2022 Mitigation of Climate Change report has once more highlighted the need for short- and medium-term implementation of climate action. Therefore, the survey focuses on the assessment of RD&D needs between now and 2030 – 2035.
The included technology segments were determined to reflect the expertise and focus of the work of both the Technology Executive Committee and Future Cleantech Architects. Two sets of specific categories were chosen, the first including more established technology sectors (Wind Energy, Solar Energy, Forest and Ecosystem Conversion, Carbon Sequestration in Agriculture, Ecosystem Restoration, Fuel Switching in Industry), the second including less developed cleantech sectors (Energy Storage, CCUS, CDR, Zero Carbon Fuels, Clean Electricity Generation, Industrial Processes).
Recognizing the intrinsic relationship between adaptation and mitigation, it is suggested that the survey be repeated annually, with the focus shifting from adaptation to mitigation technologies on a bi-annual basis.

Additional Question | Energy Supply

In accordance with the Technology Executive Committee's focus on ensuring long-term environmentally sustainable energy supply, an additional question was added to the survey for all respondents indicating that the main focus of their work was in storage and clean electricity generation. The question asked participants to rank the following areas by where RD&D needs to be accelerated most urgently: Energy System Integration, Energy Storage, Energy Transport and Transmission, and Resilient Energy Systems.

Survey Results | Participants

Participants

Survey respondents were asked to indicate their professional field, the country they are located in, their gender, and the main focus of their work. Due to the exclusively technical nature of the survey questions, respondents where not asked to indicate their age or disability status. Future surveys of a similar nature could include such categories if deemed relevant for the evaluation of the questions.
The survey was completed by 307 participants, who on average spent 14 minutes completing the survey, with an overall 73% completion rate. In total, the survey collected >70 hours of expert knowledge.

Participants by Gender

Of the 307 survey respondents, 70% indicated they were male, 25% indicated they were female, and 5% selected the option "Prefer not to answer".

Participants by Country

Respondents were asked to indicate in which country they are located[3] by use of a drop-down menu containing all countries as listed by the *Statistics Division of the United Nations Secretariat.*[4]

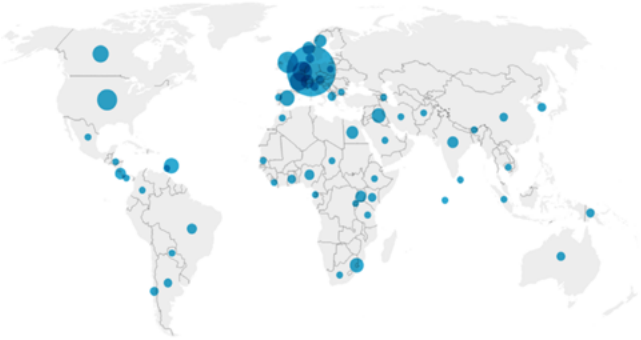

Figure 1: Distribution of Survey Participants by Country

The survey reached participants from 59 different countries from all regions of the world, with particularly strong participation from Western European countries.

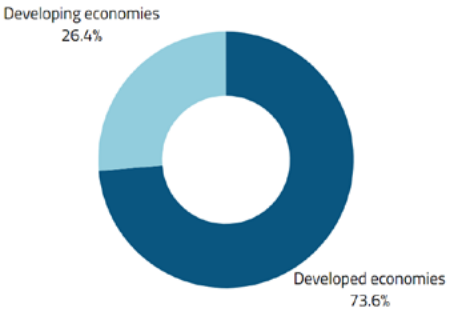

Figure 2: Distribution of Survey Participants from Developed vs. Developing Economies

Overall, approximately one in four respondents were located in developing economies and approximately ¾ of survey respondents were located in developed economies. All survey questions have been evaluated to include an analysis of differences in RD&D needs between respondents from developing and developed economies.
The survey received a total of 12 responses from four Small Island Developing States (SIDs) and a total of 13 responses from 10 Least Developed Countries (LDCs).[5] As requested by the TEC, a general overview of the responses by survey participants from LDCs and SIDS has been provided on pages 17 and 24-25.
Despite the disproportionally high number of responses from countries in the European region,[6] a brief overview of some of the differences of RD&D needs for both mature and early-stage technologies between regions has been provided on pages 17-19.

Participants by Profession

Survey participants were asked to indicate which professional field they worked in[7] and given seven answers to choose from: Industry, Public Sector, Start-up, NGO, Finance and Investors, Researcher, and Other (please specify). The answers of those respondents who chose "Other (please specify)" were assigned to one of the pre-determined groups where possible. Two further categories were identified as encompassing those "Other (please specify)" responses that did not fit any of the above categories: Private Sector and PR and Media.
Public sector staff, industry representatives, and researchers made up more than 60% of respondents, with more than 20% of the participants working for an NGO or start-up (cf. Figure 26).

Participants by Main Work Focus

Survey participants were asked to indicate the main focus of their work[8] and given eight areas to choose from: Energy Storage, Carbon Capture, Utilization, and Storage (CCUS), Carbon Dioxide Removal (CDR), Zero Carbon Fuels, Clean Electricity Generation, Industrial Processes (e.g. Steel, Cement, Chemicals, Non-ferrous), Mobility, and Other (please specify). Approximately half of the participants indicated their main work focus to be on Industrial Processes, Clean Electricity Generation, and Energy Storage.
The answers of those respondents who chose "Other (please specify)" were assigned to one of the pre-determined areas where possible. For those "Other (please specify)" responses that did not fit any of the above categories, five further categories were identified: Climate Change Adaptation and Mitigation (general), Cleantech (general), Energy, Building Sector, and Natural resources and Agriculture.[9] A full table of participants by main work focus can be found in Figure 27 on page 24.

Survey Results | Analysis

RD&D Environment

Respondents were asked to rate first the overall environment for climate technology RD&D globally[10] and then in their country specifically[11] from 1 (not favorable) to 7 (extremely favorable). The current global RD&D environment was seen as slightly favorable with an average score of 4.65 and 80% of survey participants rating it as neutral or higher (cf. Figure 28).
When analyzing the responses from the question asking participants to rate the environment for climate technology RD&D in their own countries in order to determine differences between developed and developing economies, there is a notable difference.

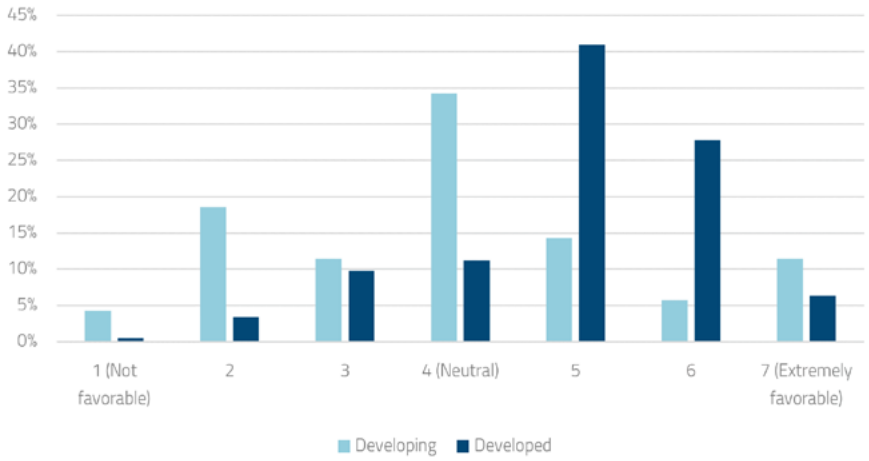

Figure 3: Overall Environment for Climate Technology RD&D in Developing vs. Developed Economies

75% of respondents in developed economies rate the RD&D environment as higher than neutral, as opposed to just 31% in developing economies. The average rating of the climate technology RD&D environment in developing economies was scored 3.99 out of seven, while the average rating of the climate technology RD&D environment in developed economies was scored 4.98 out of seven. Overall, the global RD&D environment is therefore considered less favorable in developing economies than it is in developed economies.

Barriers

According to the IPCCs 2022 "*Mitigation of Climate Change*" report, the barriers and enablers for successful deployment at scale of climate mitigation technologies are Geophysical, Environmental/Ecological, Technological, Economic, Socio-Cultural, and Institutional factors (cf. p. 44).
Survey participants were asked to determine which of the above mentioned barriers (with the additional option "Other (please specify)) they consider to be the biggest roadblocks in advancing critical breakthrough technology both globally[12] and in their country specifically.[13]
Globally, the biggest roadblocks in advancing breakthrough climate technology were determined to be Institutional, Economic, and Socio-Cultural factors (cf. Figure 29).

When comparing developed and developing economies, the biggest roadblocks in advancing breakthrough climate technology display some differences. Although Economic and Institutional barriers were relevant in both developed and developing economies, Technological roadblocks were much more significant for developing economies (24%) than for developed economies (6%). Additionally, it is worth noting that in both cases, Environmental/Ecological and Geophysical factors do not appear to be considered as critical barriers.

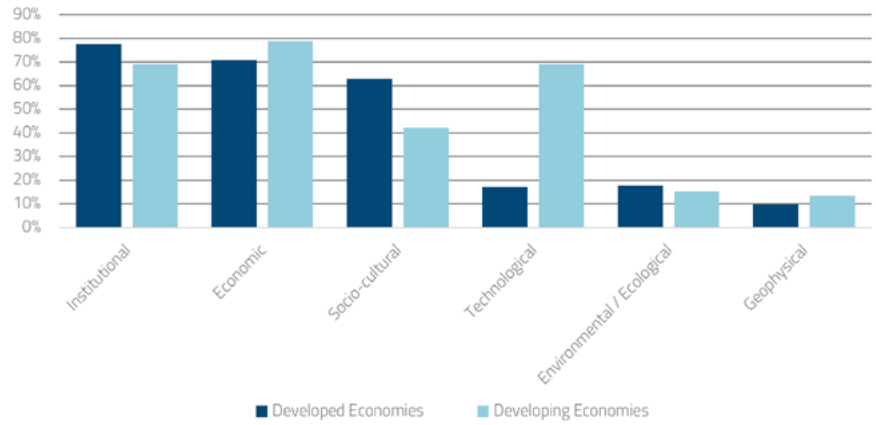

Figure 4: Biggest Barriers in Advancing Climate Technology Globally | Developing vs. Developed Economies

Additionally, Socio-Cultural barriers were chosen by ca. 63% of all respondents located in developed economies and only by ca. 42% of all survey respondents located in developing economies, indicating that increased development and deployment of climate technologies results in a change in the types of barriers on a socio-cultural level. Finally, almost two-thirds of the respondents who selected "Other (please specify)" specified that they considered political factors to be key barriers in advancing cleantech.[14]

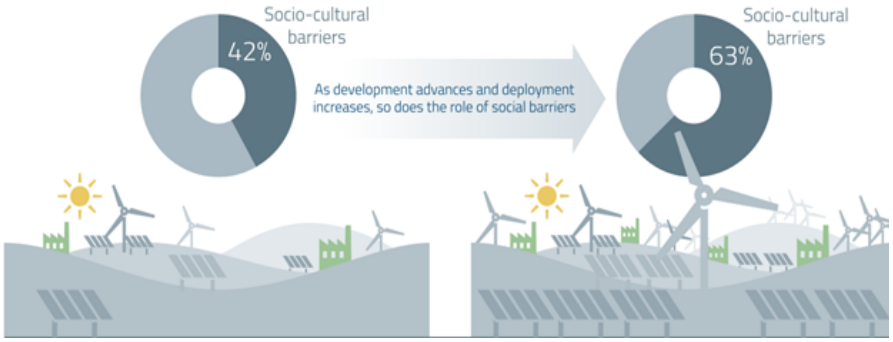

Figure 5: Socio-Cultural Barriers Increase with Advances in Development and Deployment

The next question in the survey asked respondents to determine which additional factors stop cleantech developments from scaling if both funding and the technology itself are available.[15] Possible answers were Political Support[16], Demand, Legislation[17], Bureaucracy[18], and Other (please specify).

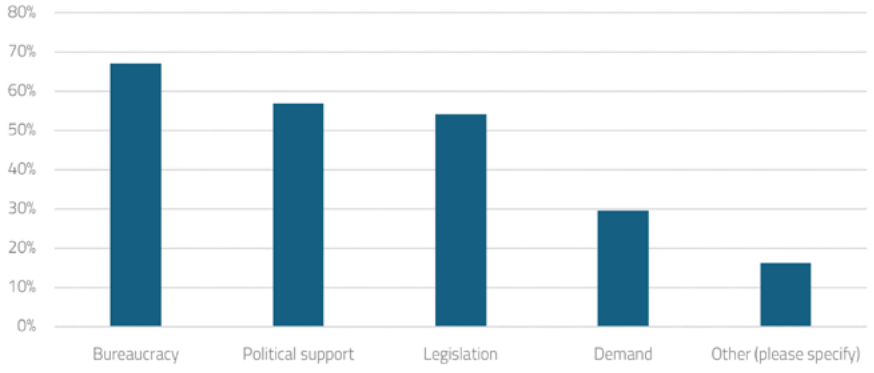

Figure 6: Factors Hindering Scale-Up of Cleantech Globally

Bureaucracy, Political support, and Legislation were each chosen by over 50% of respondents, with demand trailing behind at not quite 30%. No clear trend was discernable in the answers of those survey participants who selected "Other (please specify)". Socio-cultural, political, and market design factors each received multiple mentions, alongside energy costs and other economic factors. Answers of respondents from developing and developed economies demonstrated only small differences.

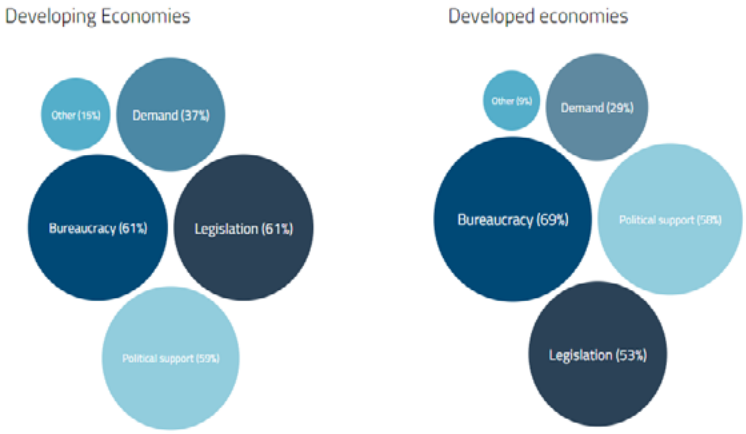

Figure 7: Factors Hindering Scale-Up of Cleantech | Developing vs. Developed Economies

Valleys of Death

Survey participants were also asked to provide insights on which climate technology innovation stages pose the biggest risks of failure for promising cleantech developments[19] by choosing up to three of the following: Lab Phase, Prototyping, Finance (Research), Demonstration, Large-Scale Deployment, Financing, Other (please specify).
Globally, the biggest risk of failure was placed in later innovation stages, with 70% of the survey's respondents choosing Large-Scale Deployment and 57% choosing Financing after deployment.

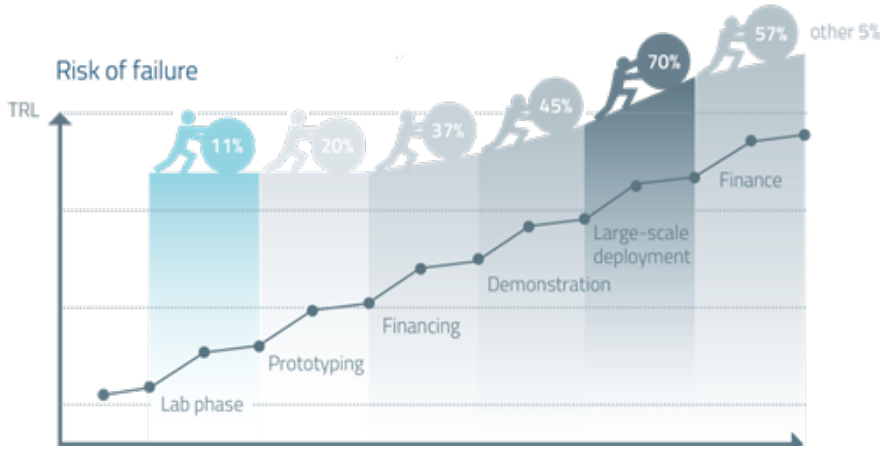

Figure 8: Risk of Failure in Climate Technology Innovation Stages Globally

Of those respondents that chose "Other (please specify)", nearly half mentioned that they believe bureaucratic processes were a reason that promising cleantech developments fail.[20]

However, when differentiating between the replies by respondents from developing economies and those by respondents from developed economies, the picture changes. Risk of failure shifts to earlier development stages in developing economies, with ca. 20% of respondents from developing economies choosing the Lab Phase compared to just 7.5% of respondents from developed economies. And while Financing after Large-Scale Deployment is considered a key

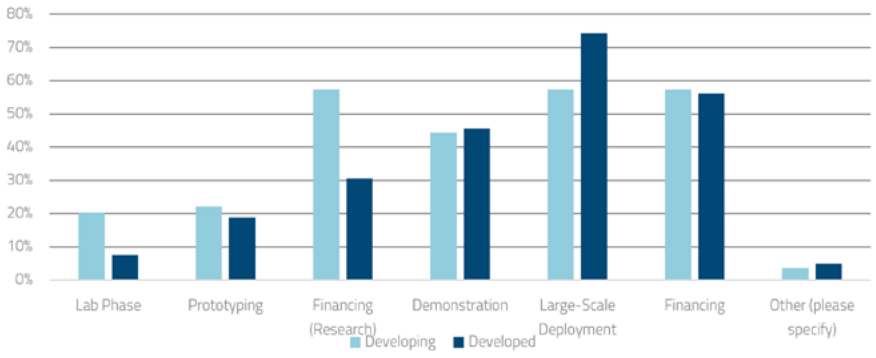

Figure 9: Risk of Failure in Climate Technology Innovation Stages | Developing vs. Developed Economies

Valley of Death by survey participants from developed economies, participants from developing economies were almost twice as likely to consider Research Financing before Demonstration a key Valley of Death than respondents from developed economies.

Enablers

When asked to determine up to three key elements for successful climate technology RD&D[21] from a choice of Financial Support, Knowledge Sharing, Human Capital, Political Buy-In, and Other (please specify), 88% of respondents chose Financial Support, whereas Human Capital was only relevant for <50% of respondents. The overall share of priorities can be seen below:

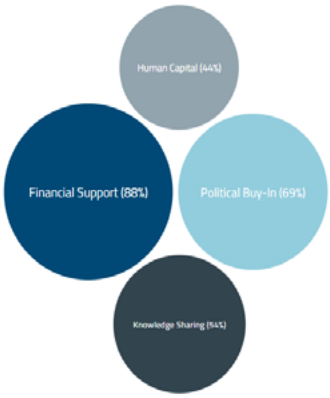

Figure 10: Key Elements for Successful Climate Technology RD&D Globally

While respondents from both developing and developed economies selected Financial Support to be the top key element for successful climate technology RD&D, Knowledge Sharing and Human Capital was considered to be more important than Political Buy-In for survey participants from developing Economies. However, Political Buy-In was selected as a key success factor by more than 70% of participants from developed economies, resulting in second place for that participant group.[22]

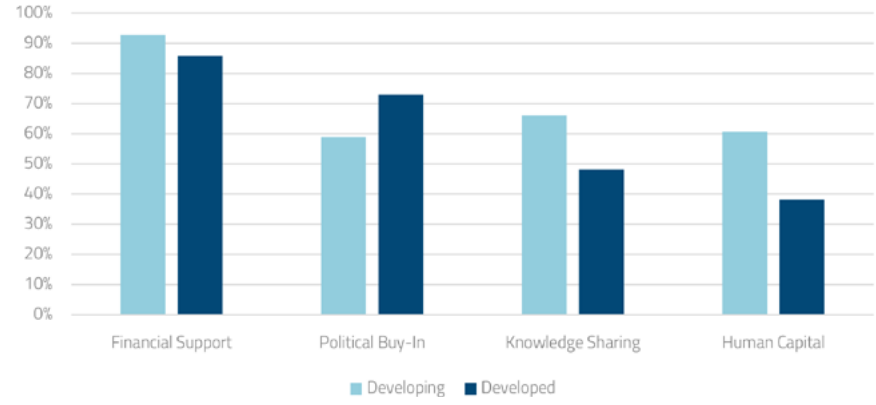

Figure 11: Key Elements for Successful Climate Technology RD&D | Developing vs. Developed Economies

Similarly as was the case when asked about key barriers in scaling-up cleantech (cf. p. 12), those survey participants who selected "Other (please specify)" mentioned socio-cultural, political, and market design factors alongside innovative financial mechanisms and a reduction of bureaucracy.

Key Stakeholders

An open answer question asked respondents to indicate which key stakeholder is most able to accelerate the development of high-impact emission-reduction technologies in their respective sectors.[23] An overwhelming 73% of all answers mentioned the public sector as the most important stakeholder for speeding things up, followed by the private sector, which was mentioned by 18% of survey participants, and the financial sector (15%). Within answers mentioning the public sector, national governments (29%) and international bodies (11%) were named most frequently, alongside regional and local governments.

Speeding Up Cleantech Development

A further open answer question asked respondents for their three main wishes to accelerate the development of climate breakthrough technology in their region.[24] The wishes mentioned by survey
participants could generally by sorted into four categories: Financial, Institutional/Political, Technological, and Socio-Cultural. The most common wishes were of a financial nature, with more funding being requested in general and public sector financing for early-stage technologies often specifically mentioned. While many of the Institutional wishes centered around a reduction of bureaucracy, more political will to speed up effective legislation, innovative policy tools, and green public procurement, the second most common wish across all responses was the internalization of CO_2 costs and higher costs for CO_2 emissions. Most technological wishes requested more collaboration on RD&D, not only between countries but also between the public, private, and academic sectors. Finally, those wishes pertaining to Socio-Cultural factors most often mentioned better education around the benefits of clean technologies, more participation of civil society, and the enhancement of social acceptance for climate technologies.

Figure 12: Main Wishes for Speeding Up Cleantech Development

The Role of the Public Sector

In order to provide policy makers and other public sector stakeholders with information on how to best support high-impact climate mitigation technologies in scaling, survey participants were asked to determine what role they believe the public sector should play.[25] Overall, respondents believe that the public sector should first and foremost provide long-term planning security (73%) and reduce bureaucracy (62%). Of those respondents that selected "Other (please specify)", over 50% mentioned that the public sector should provide financial support and de-risk investments through the creation of innovative market and financing tools, while ca. 25% explicitly mentioned the need for the public sector to create the right regulatory frameworks to foster cleantech innovation (cf. Figure 30).

When differentiating between the responses by survey participants from the public sector and all other participants, there are a number of notable differences. First of all, the public sector considers its role in performing green public procurement as slightly more involved than the private sector +[26] respondents, and sees its role less in internalizing CO_2 costs than the other respondents did. Second of all, while non-public sector respondents see the bringing together of different stakeholders as the least of the public sector duties, public sector respondents themselves attribute considerably higher importance to their own role in that task.

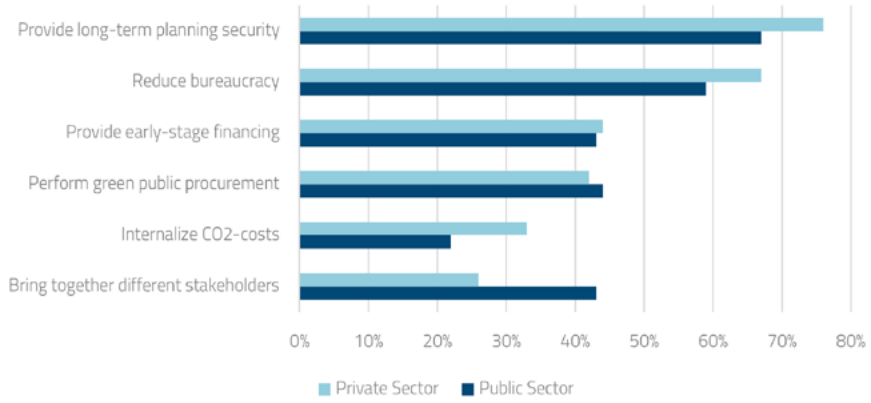

Figure 13: The Role of the Public Sector Globally | Public vs. Private +

Although the first two roles attributed to the public sector stay the same for survey participants from developing and developed economies, respondents from developing economies see the bringing together of different stakeholders as one of the public sector's main responsibilities in third place, whereas it is the task least attributed to the public sector by respondents from developed economies (cf. Figure 31).

Mature Technologies | RD&D Needs

In order to be able to determine the overall future mature technology RD&D needs and priorities globally both in the short and medium term, the survey asked participants to rank in which of the selected established mitigation technology areas RD&D must be accelerated most urgently until first 2030[27] and then until 2035.[28] Respondents were then asked to repeat the ranking for their own country, both until 2030[29] and until 2035,[30] so that differences between the needs of developing and developed economies could be determined.
Overall, respondents consider Solar Energy, Forest and Ecosystem Conversion, and Wind

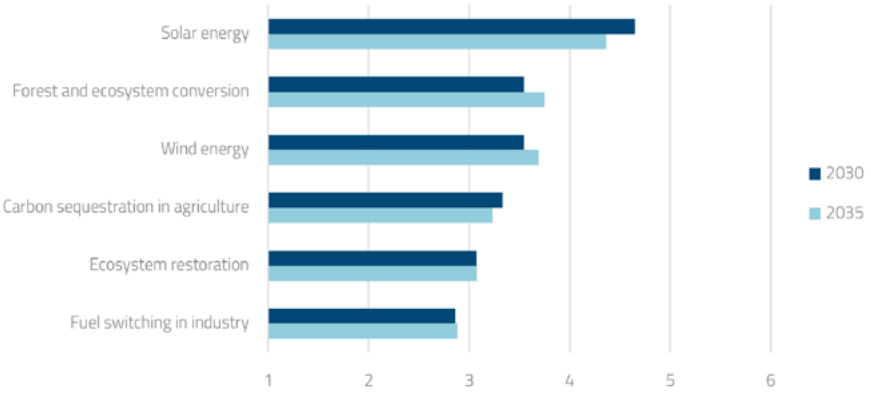

Figure 14: RD&D Priorities Mature Technologies | 2030 & 2035

Energy to be the areas in which global RD&D must most urgently be accelerated. Whereas Solar Energy is considered to be slightly less urgent from 2030 onward, Forest and Ecosystem Conversion and Wind Energy both gain in importance slightly from 2030 to 2035. Carbon Sequestration in Agriculture, Ecosystem Restoration, and Fuel Switching in Industry are considered the least urgent areas for RD&D acceleration on a global scale.
When asked to rank the urgency of RD&D acceleration of the mature technology sectors in their own countries, however, a distinct difference becomes apparent between the future needs

of developing economies versus those of developed economies. While the three most urgent areas remain the same in developing economies, Fuel Switching in Industry takes the top spot in developed economies until both 2030 and 2035, leaving Ecosystem Restoration as the least urgent area for RD&D acceleration until 2030 and Carbon Sequestration in Agriculture as the least urgent area until 2035.

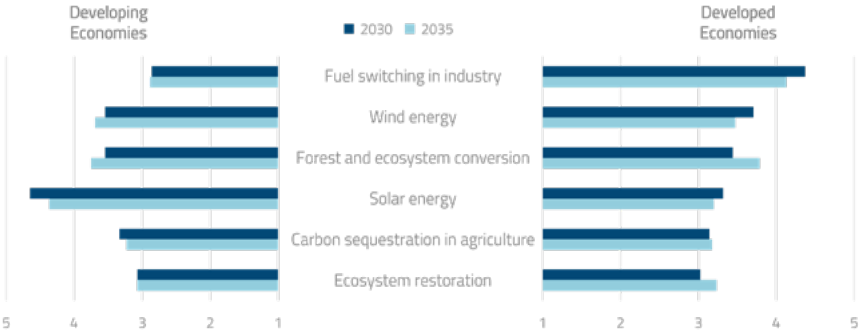

Figure 15: RD&D Priorities Mature Technologies | 2030 & 2035 | Developing vs. Developed Economies

For respondents from developing economies, Fuel Switching in Industry was indicated as the lowest priority until both 2030 and 2035, while Solar Energy was ranked as the top priority across both timeframes. Clean electricity generation with established renewables solar and wind, although predicted to become less urgent by 2035, is identified as a top RD&D priority overall.

Early-Stage Technologies | RD&D Needs

The survey asked participants to complete the same rankings for the future RD&D needs of selected early-stage climate mitigation technologies as they did for more mature technologies. When asked to rank in which early-stage technology sectors RD&D needs to be accelerated most urgently from today until 2030 globally,[31] Energy Storage solutions take the top spot, followed by Industrial Processes and Clean Electricity Generation. When comparing these figures to those of the most urgent RD&D global acceleration areas from 2030 to 2035,[32] Storage, Zero Carbon Fuels, CCUS, and CDR solutions increase in urgency, whereas participants perceive Industrial Processes and Clean Electricity Generation to be less urgent. Clean Electricity Generation, while still considered the third most urgent RD&D area until 2030, is no longer in the top three most urgent areas until 2035.

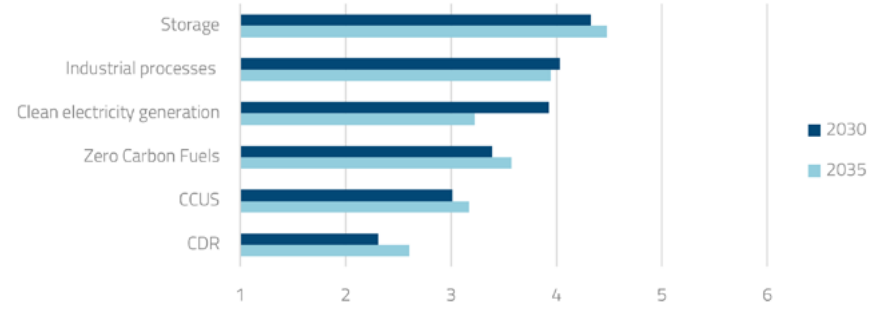

Figure 16: RD&D Priorities Early-Stage Technologies | 2030 & 2035

As was the case for the more mature technologies, the survey also asked participants to once more rank in which of the early-stage technology areas RD&D most urgently needs to be accelerated in their respective countries from today until 2030[33] and from 2030 until 2035.[34]

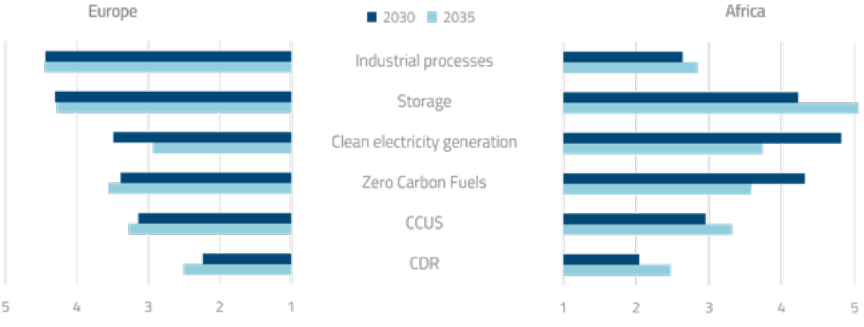

Figure 17: RD&D Priorities Mature Technologies | 2030 & 2035 | Developing vs. Developed Economies

Both Energy Storage and Industrial Processes (such as steel and cement) were ranked as top RD&D priorities until 2030 and 2035 by respondents from developed economies, with Storage taking the top spot by a minimal margin until 2030 and Industrial Processes doing the same for 2035. Survey participants from developing economies, on the other hand, ranked Clean Electricity Generation as the key priority until 2030, with Energy Storage only becoming the top priority from 2030 to 2035.
Finally, the survey gave respondents the opportunity to mention important technologies/sectors not included in the survey.[35] The 10 most mentioned sectors were: 1) Energy Efficiency, 2) Grid Infrastructure and Technology; Energy Management, 3) Carbon-Free Hydrogen Solutions, 4) Nature-Based Solutions and Agricultural Sector, 5) Carbon-Free Thermal Energy Generation (domestic and industrial), 6) Nuclear Energy, 7) Transport and Mobility, 8) Waste Sector, Recycling, and Resource Management, 9) Alternative Foods (alternative proteins), and 10) AI, Machine Learning, Internet and Computers.

Additional Question | Energy Supply

For all respondents who had indicated that the main focus of their work was on storage and clean electricity generation, an additional question was added to the beginning of the survey asking them to rank the following areas pertaining to long-term environmentally sustainable energy supply from most to least urgent for RD&D acceleration: Energy System Integration, Energy Storage, Energy Transport and Transmission, and Resilient Energy Systems.[36] Energy Storage was ranked as the most urgent RD&D acceleration area, followed by Energy System Integration.

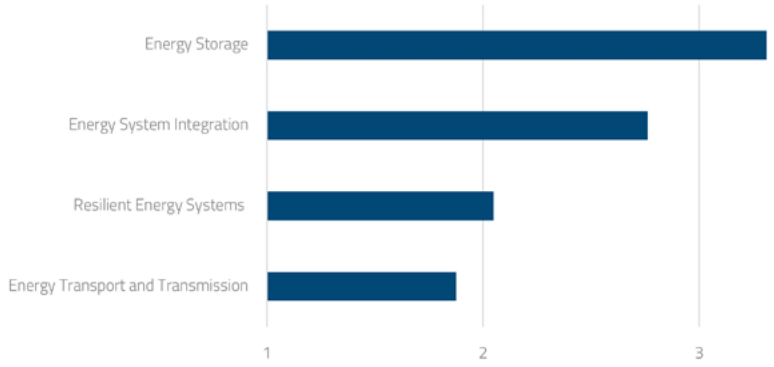

Figure 18: RD&D Needs Long-Term Environmentally Sustainable Energy Supply Globally | All Respondents

When excluding the responses by survey participants working in energy storage and only considering those by participants working in clean energy generation, Energy Storage is still ranked as the most urgent RD&D acceleration area, albeit by a smaller margin (cf. Figure 32).
Finally, when differentiating between responses from survey participants from developing and developed economies, the overall order of least to most urgent RD&D acceleration areas stays the same. However, Energy Storage and Energy System Integration are considered slightly more urgent needs for respondents from developing economies, while Resilient Energy Systems and Energy Transport and Transmission are considered slightly more urgent needs by respondents from developing economies (cf. Figure 33).
A follow-up question gave respondents the opportunity to highlight specific energy technologies.[37] Various storage technologies were mentioned frequently, with Long Duration Energy Storage (LDES) technologies in general and Thermal Energy Storage (TES) technologies in particular being mentioned most often amongst those.

Differences by Gender

The survey results were analyzed to explore any potential differences in responses by gender. A few minor variations were observed:

- Males survey participants were slightly more likely than female survey participants to mention that the public sector's role should be the internalization of CO_2 costs. Meanwhile, female participants were more likely than male participants to mention the role of bringing together different stakeholders.
- For the stage where most promising climate technology developments are lost (Valleys of Death), male respondents more commonly cited Demonstration than female respondents did. Financing was cited less by males than by females.

- Knowledge Sharing was more often named by females as a key element for successful climate technology RD&D than by males.
- Female respondents more frequently viewed Industrial Processes and Fuel Switching in Industry as important RD&D priorities.

However, the results were largely similar between genders overall. Given the minor variations observed and potential influence from other variables, no meaningful conclusions can be drawn or assumptions made based on gender from the survey findings.

LDCs and SIDS | An Overview

Although total respondents from LDCs (13) and SIDS (12) are limited, thereby reducing the statistical significance of the results, some similarities and differences in their answers can be identified:

- When asked to rate from 1 (favorable) to 7 (not favorable), the country specific climate technology RD&D environment was seen as neutral (4.00) in SIDS and slightly favorable in LDCs (4.55).
- Both LDC and SIDS respondents ranked Solar Energy as the biggest mature tech RD&D priority, both until 2030 and 2035 (cf. Figure 34).
- LDC respondents highlighted Energy Storage as the biggest early-stage climate tech RD&D priority in their country until both 2030 and 2035.
- SIDS respondents highlighted Clean Electricity Generation as the biggest priority until 2030 and Energy Storage until 2035 (cf. Figure 35).

Comparing LDCs and SIDS, the biggest barriers to advancing breakthrough climate technologies[38] show some further differences. Technological barriers were again highly relevant, chosen by 100% of respondents from LDCs and 64% of respondents from SIDS. For SIDS, Institutional and Economic barriers were both most frequently cited (each chosen by 82%), with none of the respondents citing Geophysical barriers as a major roadblock.
Regarding the barriers to scaling cleantech if funding and technology were available,[39] respondents from LDCs especially highlighted Political Support (86%), whereas respondents from SIDS most frequently chose Bureaucracy (82%). Demand was seen as the smallest of the barriers in both LDCs (57%) and SIDS (18%).

Regional Differences | RD&D Environment

Respondents were asked to rate the overall climate technology R&D environment in their country on a scale from 1 (favorable) to 7 (not favorable), with 4 being neutral.[40] Respondents in the US and Sweden rated their climate technology environment as the most favorable, while respondents in Eswatini rated theirs as the least favorable.[41]

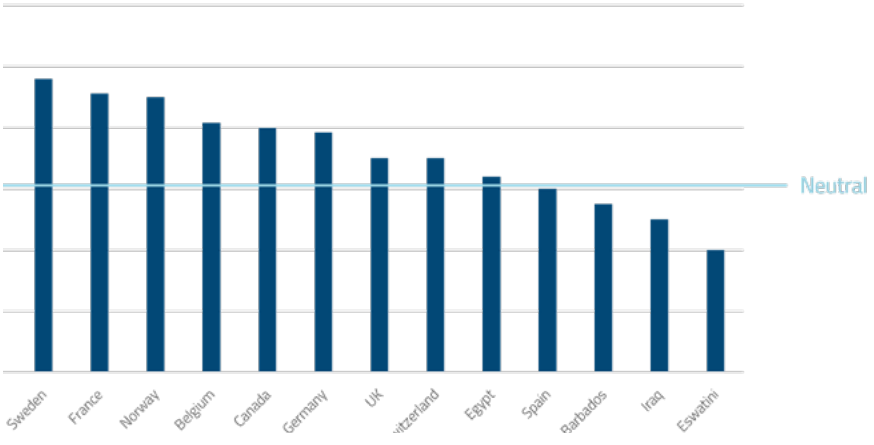

Figure 19: Perception of Overall Environment for Climate Technology RD&D by Country

Regional Differences | RD&D Needs

Despite the disproportionally high number of responses from countries in the European region,[42] a brief overview of some of the differences of RD&D needs for both mature and early-stage technologies between regions can be found below. The answers from survey participants located in Europe has been used as a baseline and is compared to the responses from respondents located in the Americas, Africa, and Asia. Due to the low number of responses from survey participants located in Oceania (4), no graphs charting these technologies.

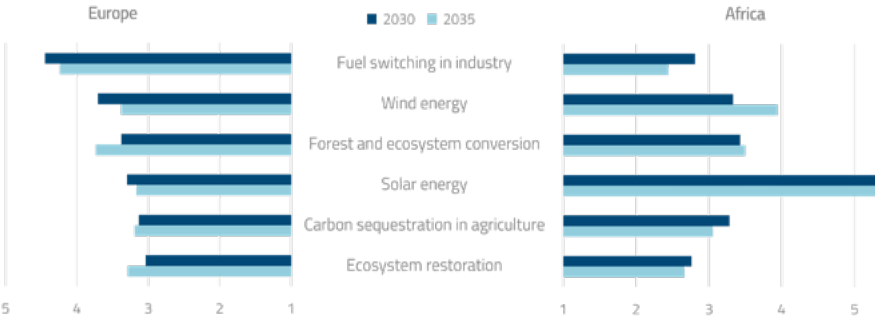

Figure 20: Regional RD&D Acceleration Needs Mature Technologies | Europe vs. Africa | 2030 & 2035

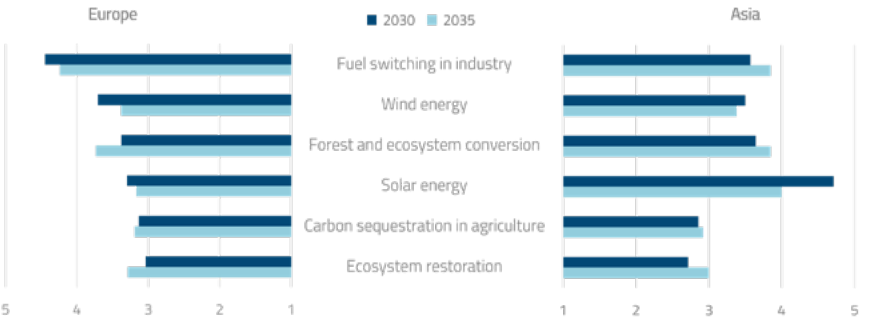

Figure 21: Regional RD&D Acceleration Needs Mature Technologies | Europe vs. Asia | 2030 & 2035

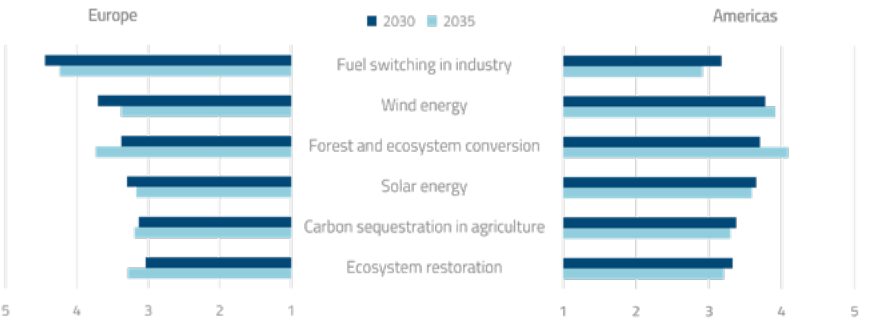

Figure 22: Regional RD&D Acceleration Needs Mature Technologies | Europe vs. Americas | 2030 & 2035

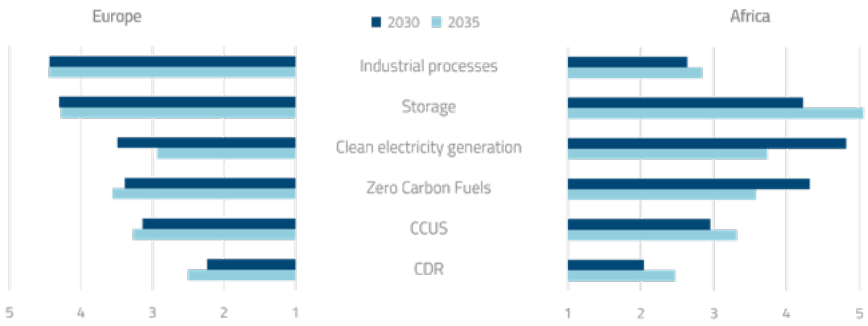

Figure 23: Regional RD&D Acceleration Needs Early-Stage Technologies | Europe vs. Africa | 2030 & 2035

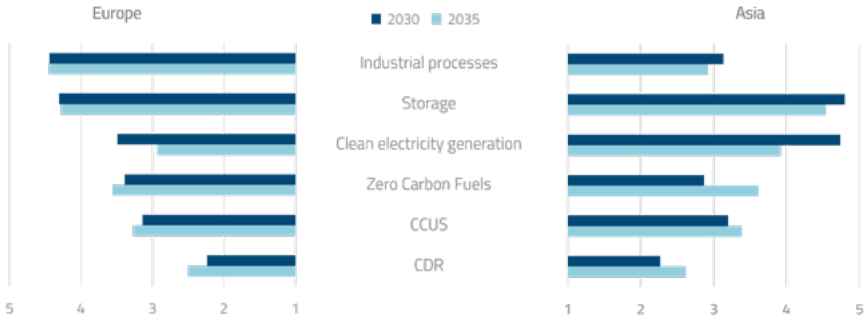

Figure 24: Regional RD&D Acceleration Needs Early-Stage Technologies | Europe vs. Asia | 2030 & 2035

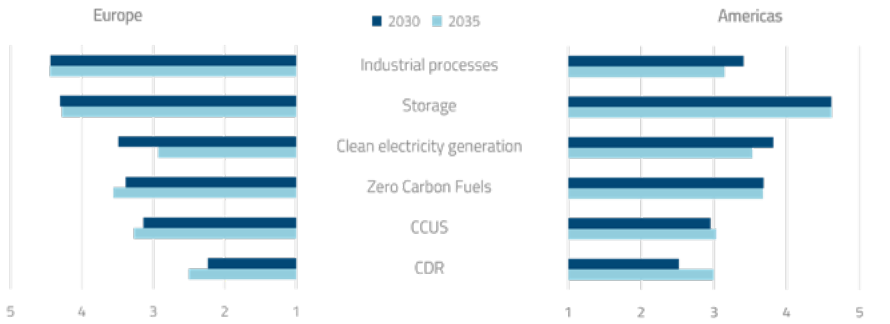

Figure 25: Regional RD&D Acceleration Needs Early-Stage Technologies | Europe vs. Americas | 2030 & 2035

Footnotes

1 “Valleys of death” are critical (often financial) phases that innovations face from which many fail to progress.

2 Unless otherwise specified, the term “storage” refers to energy storage throughout the report.

3 Q: What country are you located in?

4 A full list of respondents by country can be found in the Appendix on page 21.

5 A full list of respondents from LDCs and SIDS can be found in the Appendix on page 21.

6 Responses by region: Europe (196), Americas (51), Africa (32), Asia (24), Oceania (4).

7 Q: Which professional field are you in?

8 Q: What is the main focus of your work?

9 The minimum number of responses needed in order to form a new category was set at five. All other “Other (please specify)” responses that did not meet this minimum remained can be found in the “Other” category in Figure 27 in the appendix.

10 Q: What is the overall environment for climate technology RD&D globally right now?

11 Q: Compared to this, how is the overall environment for climate technology RD&D in your country?

12 Q: What do you consider the 3 biggest roadblocks in advancing the development of critical breakthrough climate technology globally? (Please choose up to 3 answers).

13 Q: What do you consider the 3 biggest roadblocks in advancing the development of critical breakthrough climate technology in your country specifically? (Please choose up to 3 answers).

14 Amongst others, answers included: political issues, political, politics, policy mandates, policy, policy support, and political environment.

15 Q: If you have the funding and the technology is available: What stops you from scaling up in your country specifically? (Please choose up to 3 answers).

16 Political Support refers to the endorsement or backing from political leaders or influential figures.

17 Legislation pertains to formal laws and regulations that may facilitate or hinder the scaling up of a project.

18 Bureaucracy involves the organizational structure and efficiency of government agencies responsible for implementing projects.

19 Q: Let us look at climate technology innovation stages: At which step do we lose a lot of the most promising developments? (Please choose up to 3 answers).

20 Amongst others, answers included: policy and permits, regulations in Germany and the EU, permitting, and bureaucracy.

21 Q: What are the key elements for successful climate technology RD&D? (Please choose up to 3 answers).

22 In the figure below the columns for “Other (please specify)” have been intentionally omitted due to the minimal selection by respondents (only 1,79% of respondents from developing economies and 5,88% of respondents from developed economies chose Other).

23 Q: In your sector, which key stakeholder could speed things up the most and how?

24 Q: If you could wish for three measures to speed up the development of breakthrough climate technology in your country, which would they be?

25 Q: What role should the public sector play? (Please choose up to 3 answers).

26 “Private Sector +” includes all participant groups that are not part of the public sector.

27 Q: Regarding more mature technologies, where do we need to accelerate RD&D most urgently globally until 2030? (Please rank from most to least urgent).

28 Q: Pertaining to more mature technologies; where do we need to accelerate RD&D most urgently globally until 2035? (Please rank from most to least urgent).

29 Q: Once more looking towards more mature technologies, in what areas do we need to accelerate RD&D most urgently in your country until 2030? (Please rank from most to least urgent)

30 Q: Finally, in what more mature areas do we need to accelerate RD&D most urgently in your country until 2035? (Please rank from most to least urgent).

31 Q: Let us first take a look until 2030. Where do we need to accelerate RD&D most urgently globally? (Please rank from most to least urgent).

32 Q: Let us now look towards 2035. Where do you see the biggest RD&D needs from 2030 to 2035 globally? (Please rank from most to least urgent).

33 Q: Again, looking to 2030: Where do we need to accelerate RD&D most urgently in your country? (Please rank from most to least urgent).

34 Q: Once more looking towards 2035: Where do you see the biggest RD&D needs from 2030 to 2035 in your country? (Please rank from most to least urgent).

35 Do you think we have forgotten an important option/technology? If so, please specify.

36 Q: Regarding long-term environmentally sustainable energy supply, in which areas do we need to accelerate RD&D most urgently? (Please rank from most to least urgent).

37 Q: Follow-up: Are there any energy technologies in particular that you would like to highlight?

38 Q: What do you consider the 3 biggest roadblocks in advancing the development of critical breakthrough climate technology in your country specifically? (Please choose up to 3 answers).

39 Q: If you have the funding and the technology is available: What stops you from scaling up in your country specifically? (Please choose up to 3 answers).

40 Q: How is the overall environment for climate technology RD&D in your country?

41 Only countries with a minimum of five respondents were included in this analysis.

42 Responses by region: Europe (196), Americas (51), Africa (32), Asia (24), Oceania (4).

43 As classified by United Nations Conference on Trade and Development (p. 25-27).

44 As classified by United Nations Conference onTrade and Development (p. 19-25).

Appendix

Participating developed economies:[43]

- Germany (113)
- United Kingdom of Great Britain and Northern Ireland (17)
- United States of America (16)
- Belgium (15)
- France (12)
- Canada (10)
- Spain (8)
- Switzerland (6)
- Norway (5)
- Sweden (5)
- Netherlands (4)
- Albania (2)
- Australia (2)
- Austria (2)
- Denmark (2)
- Italy (2)
- Republic of Korea (2)
- Bulgaria (1)
- Poland (1)
- Portugal (1)

Participating developing economies:[44]

- Barbados (8)**
- Eswatini (7)
- Iraq (7)
- Egypt (5)
- Costa Rica (4)
- India (4)
- Uganda (4)*
- Brazil (3)
- Nigeria (3)
- Argentina (2)
- Chile (2)
- China (2)
- Ghana (2)
- Kenya (2)
- Papua New Guinea (2)**
- Afghanistan (1)*
- Azerbaijan (1)
- Bhutan (1)*
- Cambodia (1)*
- Chad (1)*
- Colombia (1)
- Ethiopia (1)*
- Equatorial Guinea (1)
- Grenada (1)**
- Honduras (1)
- Indonesia (1)
- Iran (Islamic Republic of) (1)
- Liberia (1)*
- Maldives (1)**
- Mexico (1)
- Morocco (1)
- Panama (1)
- Paraguay (1)
- Rwanda (1)*
- Saudi Arabia (1)
- Senegal (1)*
- South Africa (1)
- Sri Lanka (1)
- United Republic of Tanzania (1)*

* LDCs, as classified by United Nations Conference on Trade and Development (p. 38-40).
** SIDS, as classified by United Nations Conference on Trade and Development (p. 41-43).

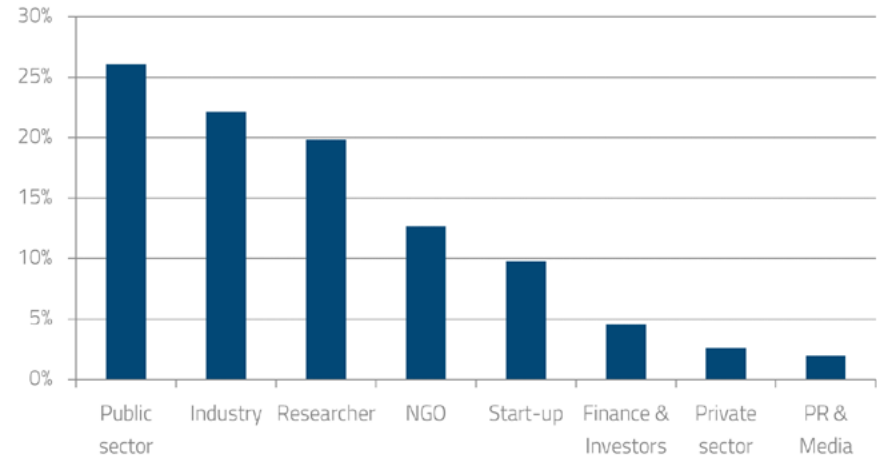

Figure 26: Survey Participants by Profession

Participants by Main Work Focus	%	Total Responses
Storage	15,64%	48
CCUS	1,63%	5
CDR	3,91%	12
Zero Carbon Fuels	5,86%	18
Clean electricity generation	17,26%	53
Industrial processes (e.g. Steel, Cement, Chemicals, Non-ferrou	18,89%	58
Mobility	6,51%	20
Climate change, adaptation and mitigation in general	10,75%	33
Cleantech in general	2,93%	9
Energy	2,93%	9
Building sector	1,63%	5
Natural Resources and Agriculture	1,63%	5
Other	10,42%	32

Figure 27: Survey Participants by Main Work Focus

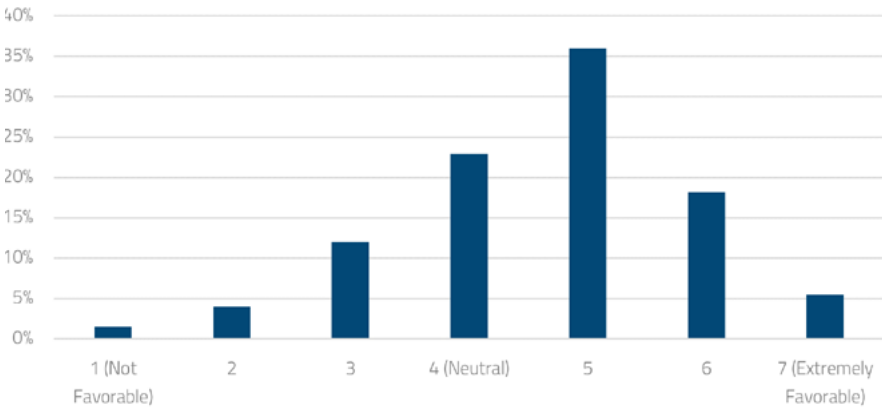

Figure 28: Overall Environment for Climate Technology RD&D Globally

Figures

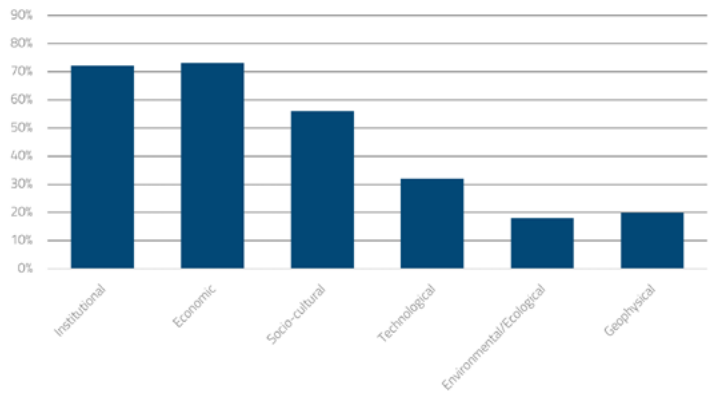

Figure 29: Biggest Barriers in Advancing Climate Technology Globally

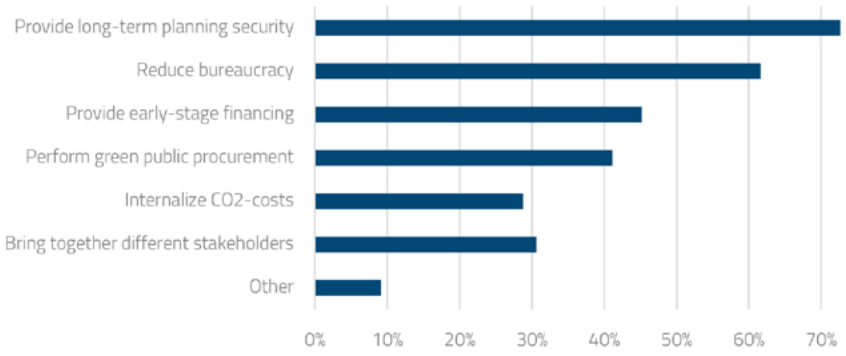

Figure 30: The Role of the Public Sector Globally

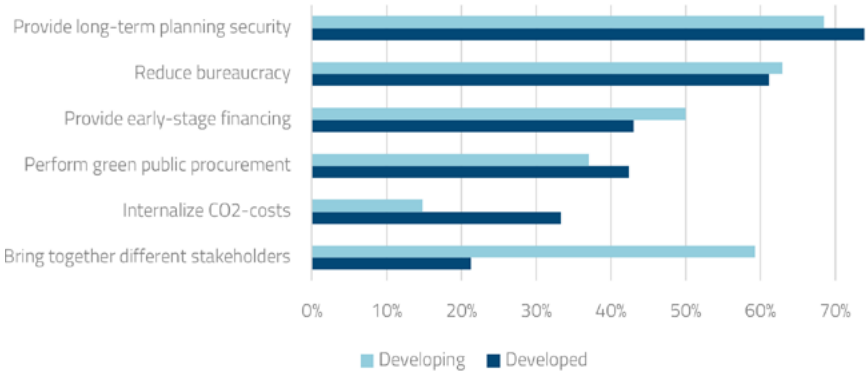

Figure 31: The Role of the Public Sector | Developing vs. Developed Economies

Figures

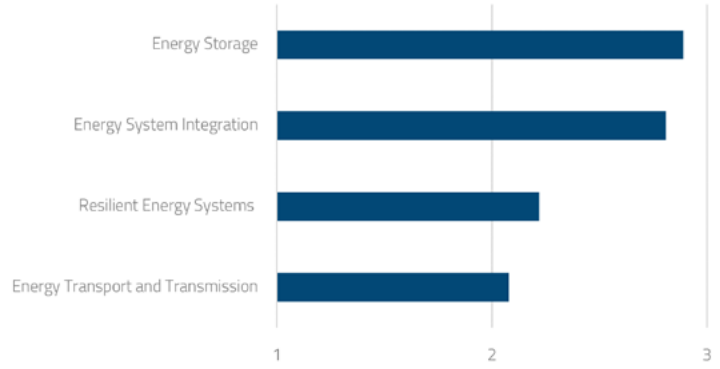

Figure 32: RD&D Needs Long-Term Environmentally Sustainable Energy Supply Globally | Excluding Respondents Working in Energy Storage

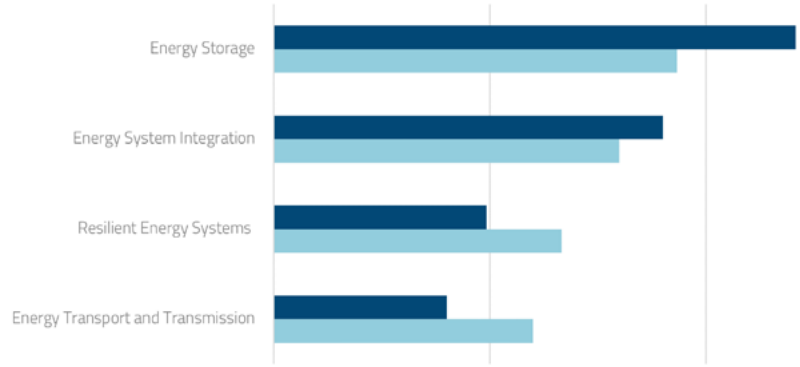

Figure 33: RD&D Needs Long-Term Environmentally Sustainable Energy Supply | Developed vs. Developing Economies | All Respondents

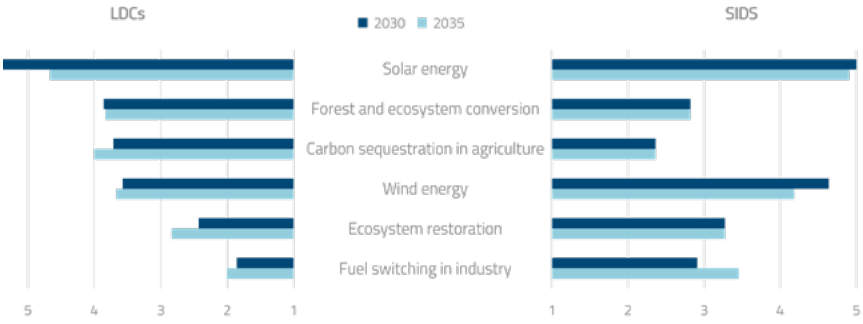

Figure 34: Mature Technology RD&D Needs | LDCs vs SIDS | 2030 & 2035

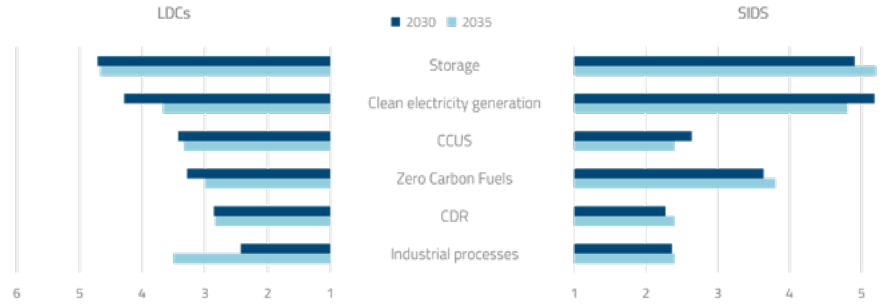

Figure 35: Early-Stage Technology RD&D Needs | LDCs vs. SIDS | 2030 & 2035

Figures

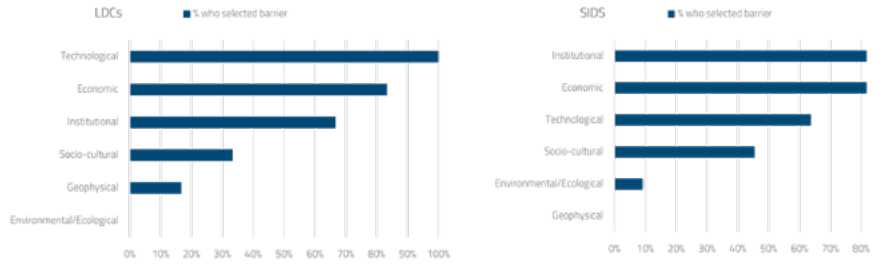

Figure 36: Biggest Barriers in Advancing Climate Technology | LDCs vs. SIDS

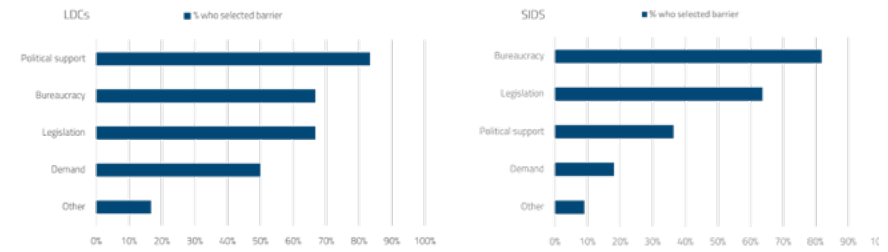

Figure 37: Barriers to Scaling Cleantech if Funding and Technology is Available | LDCs vs. SIDS