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Encouraging the commercialization of Israeli Cleantech

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Jerusalem Institute for Israel Studies מכון ירושלים לחקר ישראל
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About the Milken Innovation Center Fellows Program

The Milken Innovation Center Fellows Program accelerates Israel's economic growth through innovative, market-based solutions for long-term economic, social, and environmental issues. The program focuses on connecting government, philanthropic, and business resources that are vital to national growth and development.

The program awards annual fellowships to outstanding graduates of Israeli and international institutes of higher education. Fellows serve yearlong internships at the center of the nation's decision-making—the Knesset, government ministries, and other Israeli agencies—and aid policymakers by researching and developing solutions for various economic and social challenges.

In addition, fellows craft their own policy studies aimed at identifying barriers to economic and employment growth in Israel. The fellows' studies, carried out under the guidance of an experienced academic and professional staff, support legislators and regulators who shape the economic reality in Israel. The program offers the ultimate educational exercise, combining real-life work experience with applied research five days a week.

Throughout the year, fellows receive intensive training in economic policy, government processes, and research methods. They acquire tools for writing memorandums, presentations, and policy papers, and they develop management, marketing, and communication skills. The fellows participate in a weekly research seminars, where they meet senior economic and government professionals, business leaders, and top academics from Israel and abroad. They also participate in an accredited MBA course graduate-level academic credits that are transferable to other universities in Israel. The course, which focuses on financial and economic innovations, is taught at the Hebrew University of Jerusalem's School of Business Administration by Professor Glenn Yago, Senior Director Milken Innovation Center and senior Fellow / Founder, Financial Innovation Labs.

Fellows Program alumni can be found in senior positions in the public and private sectors. Some serve as advisers to government ministries while others work at private-sector companies or go on to advanced studies at leading universities in Israel, the United States, and Great Britain. Within the program's framework, more than 80 research papers have been published, catalyzing reforms, reducing barriers, bringing about economic growth, and improving the quality of life for Israeli citizens.

The Milken Innovation Center Fellows Program is nonpolitical and nonpartisan.

More about the program: www.milkeninnovationcenter.org

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Contents

1. Executive summary

This policy paper investigates the need for governmental intervention to support applied research conducted jointly by Israeli academic researchers and industrial professionals for development of early-stage environmental technologies (known as cleantech).

In documenting the economic conditions and prospects in the cleantech sector in Israel, this policy research identifies and compares several key indicators. Examining the patent activity in the sector in Israel and globally, only 4.8% of Israeli patent are environmental- related as a percentage of total patents. This places Israel in last place out of 35 OECD countries. As for the volume of publications in the environmental related fields, Israel shows a relatively low activity level compared to other sectors in Israel and remains constant over a decade.

On the other hand, the quality of published and cited articles in the field compared to other fields in Israel is high. This is reflected by high numbers of financing and investment application in Israel and Europe's sector-specific programs. It appears that while the number of published papers and registered patents in Israel's cleantech sector are not high in absolute terms, the Israeli and EU Horizon 2020 investment approval rates for Israeli cleantech is very high, indicating a high research quality.

This applied research focuses on the systemic challenges from the technology-transfer process from academia to a project and then to a company selling the solution in the Israeli and global markets.

In order to accomplish this, the policy process includes a review of the global and regional best practices in the literature and interviews with stakeholders in the environmental technology value chain. This includes interviews with all the university's tech-transfer offices (TTOs), cleantech incubators and accelerators, key environmental researchers, and the stakeholders in policy, government and finance.

Among the specific barriers facing the cleantech sector, the research demonstrates several key obstacles.

First, we found a lack of demand for environmental technologies at the early stages from the industrial firms and from the cleantech companies. This lack of demand is reflected in a very low number of applications for the supporting programs at the Israel Innovation Authority (IIA) that require a company's involvement.

Second, we found a lack of cleantech-dedicated investment funds due to high costs and high technological risk in terms of technology readiness level (TRL[1]). Those risks are expressed when the technology scales up.

Most importantly, these obstacles result in a breakdown in the flow of new environmental technologies to the industrial markets. Further, without additional resources for support for new technology development (e.g. time, budget, etc.) in the TTOs, these barriers hamper environmental technology projects in competition with different fields of technology such as information,

[1] See Appendix 1.

communications and telecommunications (ICT) due to an annual limitation of 20 applications for the supporting programs at the IIA. That is, TTOs tend to invest where there is pull in the market and they expect likely results. Further, because of the limited and long-term uptake in the market and the generally flatter growth in the sector (with limited terminal values on exits or sales of the technology), this research finds that TTO's prioritize other sectors over environmental technologies for their programs and services which results in knowledge remaining in the academia.

Finally, this research recommends focused technology support and investment programs in cooperation with the Israel Innovation Authority in order to offer a new source of finance along the following guidelines:

1. The supporting program will be open to environmental technologies research only. This will create a pool of ideas which will compete fairly among themselves. That will solve the problem of competition among the sectors for limited support and funding.
2. Industry and cleantech sector involvement will be requested in all applicable support programs. That will close the gaps in the value chain from the laboratory to industry, leveraging private sector investment and support to ensure that capital flows smoothly along the value chain and increase the demand from both cleantech companies and industry. According to the IIA's experience, supporting these transfer programs has the highest potential to accelerate the transfer of technology from the academia to the market.
3. Create a sustained, long term investment strategy to ensure that more capital is available from long term investors for projects. This includes facilities to blend capital investment using public, philanthropic, and private investment to ensure that returns are competitiveness and compelling for each investor. Over time, these new capital investment structures will open the flow of capital.

2. Background: Promoting technological-environmental innovation in early stages of development

During the last two years the Ministry of the Environmental Protection ("the Ministry") has been working to promote environmental technologies in Israel, with the assumption that Israeli cleantech sector does not fulfill its economic potential in Israeli and global markets. In order to respond to this gap, the Ministry aims to increase the number of Israeli companies and projects of environmental technologies throughout the economic value chain.

In the context of promoting environmental innovation, the Ministry has adopted a large definition for the term 'environmental technologies' as the following: technologies which prevent and reduce pollutant and environmental risks or reduce and/or make more efficient use of natural resources.

Included in this definition are different renewable energy (production and storage), Industry 4.0 technologies[2], waste management, carbon capture and storage technologies and recycling.

In order to promote environmental technologies ,the Ministry is acting mainly in cooperation with the Israel Innovation Authority) IIA (in several ways:

- Launch of new, pilot supporting programs for beta sites.
- Open an innovation laboratory for environmental technologies (Innovation Lab). the last date to apply for the call for proposals was on 06/02/2019 and it is expected to commence by 2020.

The pilot program and the Innovation Lab are designated to support environmental technologies at the stage of growth and in the start-up phase of valley of death, respectively. Alongside these programs, the Ministry and the IIA are examining the need to support environmental technologies projects at earlier stages of development, i.e. applied R&D in the transition from academy to industry (called technology transfer).

In order to examine the need for a supporting program for applied R&D, a preliminary study was conducted with the aim of mapping the activity in the applied R&D ecosystem (Wright, 2018) in Israel to identify specific challenges and barriers.

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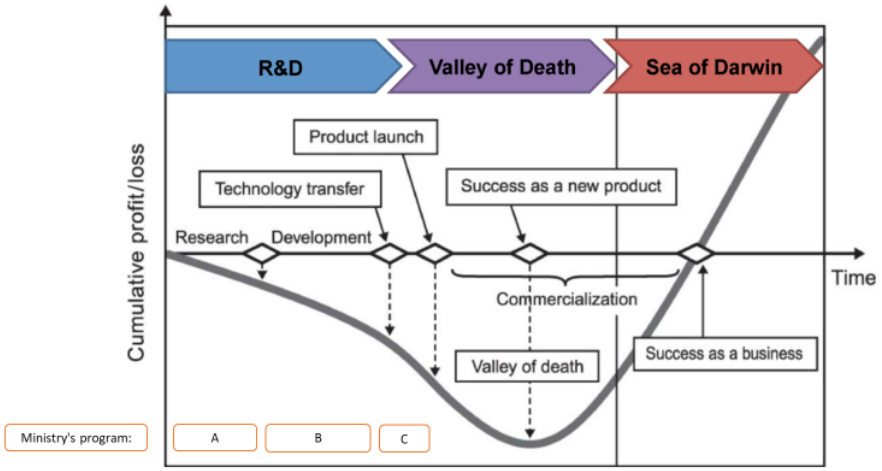
[2] Industry 4.0, also referred to as the Fourth Industrial Revolution, is a name given to the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things, cloud computing and cognitive computing.

Figure 1. R&D cost curve and matching the ministry's supporting program respectively



Source: Osawa and Miyazaki, 2006.

Where A is the investigated phase in this conducted paper, B is the pilot supporting programs for beta sites and C is the innovation laboratory for environmental technologies.

3. Methodology

The findings are based on an international literature review, analysis of inventive activity data such as intellectual property rights and research publications in Israel and international, analysis of IIA's data of the current supporting programs for apply research stages in Israel and at the European Union supporting programs and semi-structured interviews conducted with all technology-transfer ecosystem's following actors[3]: Israel Innovation Authority (IIA), The Israel-Europe R&D Directorate (ISERD), Technology-Transfer offices (TTO) of all leading Israeli universities, Technological incubators for cleantech companies, Leading researchers in the environment filed, Ministry of Energy and the Ministry of Environmental Protection Chief Scientists and business consulting firms.

[3] See detailed list of interviewed actors in appendix 2.

4. Environmental technologies in Israel – updated picture and measures of inventive activity

4.1 Cleantech Companies in Israel

According to Start-up Nation Central's (SNC) database, there are 6,303 Israeli technology companies[4]. Among them, 466 companies are engaged in environmental technologies in the fields of water, energy, environmental services and materials (not including AgriTech technologies). Thus, cleantech companies account for about 7% of technology companies in Israel.

Table 2: Cleantech Companies in Israel - Distribution by Sector

Cleantech sub-sector	Number of companies
Climate change (management and forecasting)	3
Energy (renewable energy, energy efficiency and storage)	188
Waste (waste to energy, organic waste tech, management and waste disposal)	46
Materials (composite and constructions cleantech)	46
Water (management, cleaning tech, desalination, water waste, control solutions)	142
Environment (monitoring, control, air pollutants, forest, maritime, recycling)	41
Total Cleantech	466

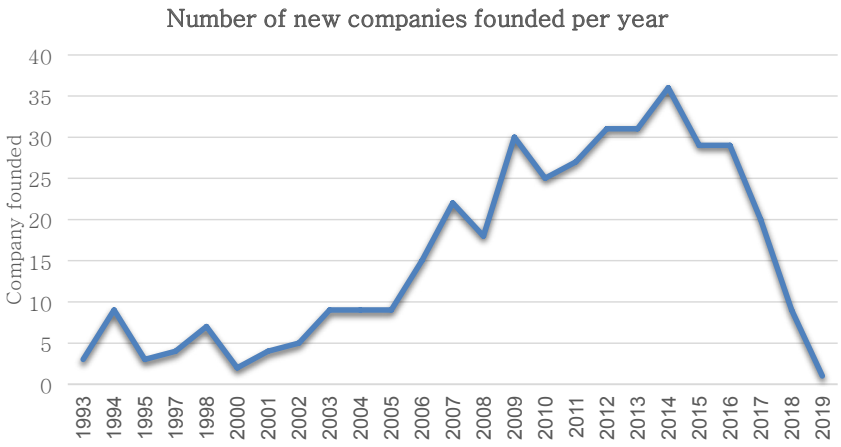
Source: Start up Nation Central database, Milken Innovation analysis, 2019

4.2 Trends in Israeli Cleantech market

Unfortunately, the number of companies are in decline in Israel. Using the number of companies founded since 1993 we can see that 2014 was the year with the maximum of companies founded (36). From that point, the number of new companies each year dramatically decline.

[4] As of June 2019. For further information please see https://finder.startupnationcentral.org.

Figure 2. new companies in the Israeli cleantech sector



Source: database, Milken Innovation analysis, 2019

According to IVC's database[5], in a comparison of data as of October 2, 2017, to data at the end of 2015 show that the number of cleantech companies in Israel decreased by 13%, including AgriTech. Without AgriTech companies, the decline in the number of companies is 16%. The number of AgriTech companies decreased by only 1.7%.

The number of companies in the energy sector decreased by 28%, water sector decreased by 22%, and environment (waste) decreased by 30%.

4.3 Measures of inventive activity: intellectual property rights and research activity in Israel

4.3.1 Intellectual property rights

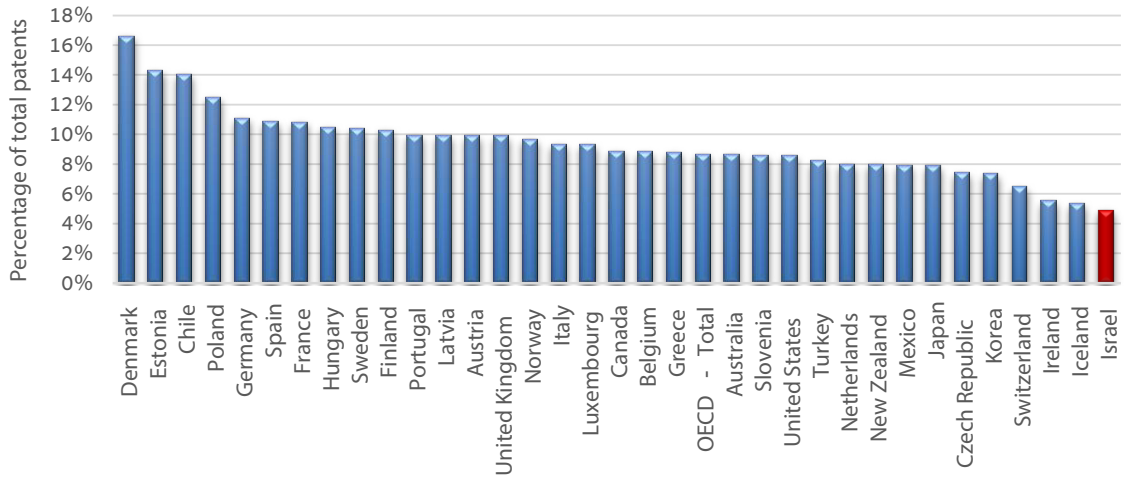
According to OECD data, only 4.88% of all Israeli patents are in the field of environmental technologies. The data refers to patent applications filed under the PCT[6]. Compared to the OECD countries, this is a very low rate, which places Israel in the last place out of the 35 OECD countries. For comparison, the

5 As of October 2, 2017. https://www.ivc-online.com.

6 The Patent Cooperation Treaty (PCT) assists applicants in seeking patent protection internationally for their inventions, helps patent Offices with their patent granting decisions, and facilitates public access to a wealth of technical information relating to those inventions. By filing one international patent application under the PCT, applicants can simultaneously seek protection for an invention in a very large number of countries. Read more about the PCT.

share of patents in information and communication technologies (ICT) out of all Israeli patents stands at about 35% and places Israel in the fourth place in the OECD in this index.

Figure 3: Percentage of environmental patents out of all patents in OECD countries in 2015



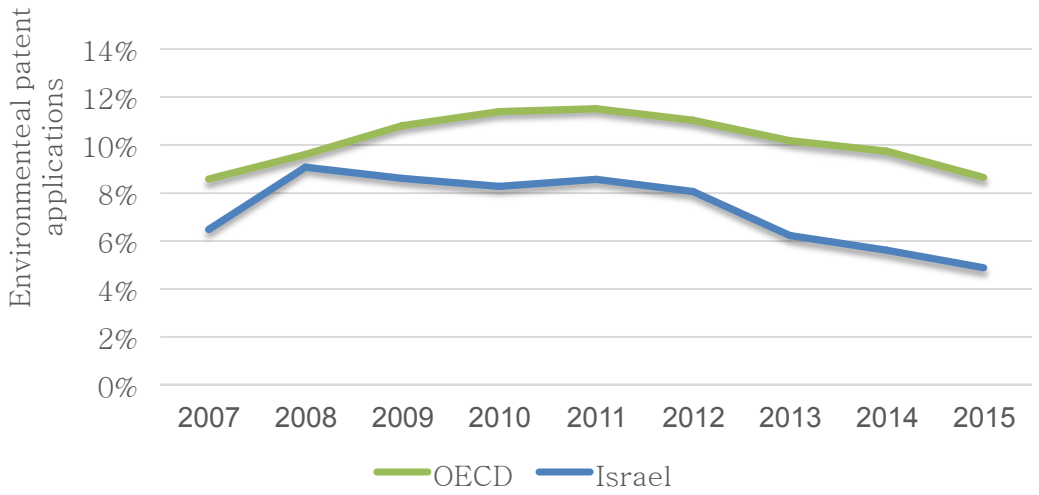
Source: OECD, 2019.

The number of environment-related inventions is expressed as a percentage of all domestic inventions (in all technologies). Changes in 'environmental' technological innovation can then be interpreted in relation to innovation in general.

Indicators of technology development are constructed by measuring inventive activity using patent data across a wide range of environment-related technological domains, including environmental management, water-related adaptation, and climate change mitigation technologies.

One useful measure of innovations by sectors is the percentage a particular sector, for example, environment technology, as of all technologies. For environment technologies, Israel's share of all technology grew from 6 percent in 2007 to a high of almost 9% in 2008, then falling to 5 percent in 2015. While following a similar trend, the OECD's environment technology has constituted a higher share of total technology, average about 3 percent more than Israel's sector.

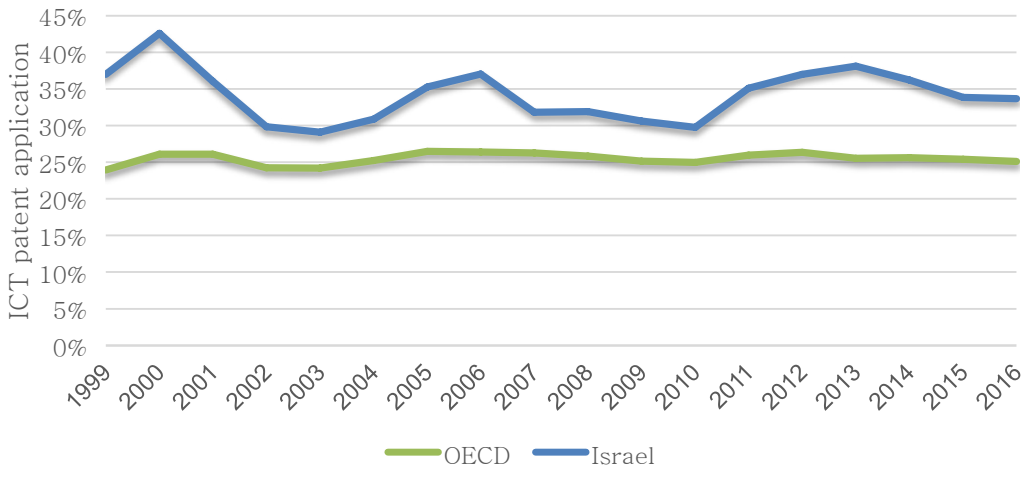
Figure 4: Percentage of all Environment-related technologies, % all technologies



Source: OECD. STAT, 2019.

In contrast, Israel's competence and reliance on innovation in the ICT sector is clear. The ICT sector in Israel has consistently been higher than the OECD average for technology sectors, ranging from 29.8 percent to 42.5 percent from 1999 through 2016.

Figure 5: Percentage of all ICT technologies, % all technologies.



Source: OECD.STAT, 2019.

4.3.2 Research publications as an indicator for innovation activity

As a top down approach, after the examination of the PCT patent applications in Israel, an examination of the amount of publication in the field is important since in many cases are the base to an innovative patent.

Samuel Neaman Institute for National Policy Research published a policy research which studies the situation of publication trends of research in Israel. The main goal of their study "R&D Outputs in Israel- Characteristics of Inventive Activity 2000-2015" (Getz, Zatcovetsky & Eran, 2017), is to provide decision makers with an in-depth picture on the scope and characteristics of Israeli inventive activity during the last two decades and to examine Israel's position in the inventive arena in relation to OECD countries.

The study divides the publication of research fields into 26 categories, out of these categories five can be environmentally oriented. These fields include environmental sciences, chemistry, chemical engineering, energy and materials science.

Between the years 2012-2016, the percentage of publications of the materials science field among all publication in Israel was 4.1% (9th place out of 26), chemistry was 3.5%, environmental sciences were 1.8%, chemical engineering was 1.6% and energy was 0.7% (24th place). Compared to the previous decade (2002-2006, highlighted in Figure. 6a), the field of environmental sciences, materials science and energy have shown a better ranking (marked in green) of one place unfortunately. These slight differences show a status quo in the environmental-related publications. In contrast, the chemistry's field declined in two places and chemical engineering declined in four places (highlighted in red in figure 6b). For comparison, for the two periods, Medicine science was the leading field in terms of publications with ~19% of all publications in Israel.

Accordingly, compared to the world, the fields of energy, engineering, and the environmental science, Israel's share in world publications is relatively low compared to its share in other fields.

As an opposite example, to illustrate, we can observe what happened in the neuroscience field. Compared to the world, the field presents a high percentage of publications among of total publications. This led to an increased number of theses, international cooperation and the percentage of publications published in leading journals.

This momentum has been translated into the recruitment of new researchers in the Centers of Excellence in Israel[7] (the I -CORE program). As a result, the flow of knowledge from academia to

[7] The Israeli Centers for Research Excellence (I-CORE) is an initiative designed by the Planning and Budgeting Committee (PBC) and the Government of Israel. The initiative is part of the Higher Education multi-year Reform Plan, which gradually establishes leading research centers specializing in a range of disciplines. The Centers of Excellence and the program's vision are aimed at fundamentally strengthening the long-term positioning of Israel's academic research and its stature among leading researchers in Israel and abroad.
For further information: http://www.i-core.org.il/The-I-CORE-Program

industry arises directly through direct or indirect collaborations by academy graduates. All this is reflected in the number increment of patents, and the opening of a MAGNET consortium (see below).

Figure 6a & 6b: Distribution of Israeli Publications by Field - Comparison of Two Periods

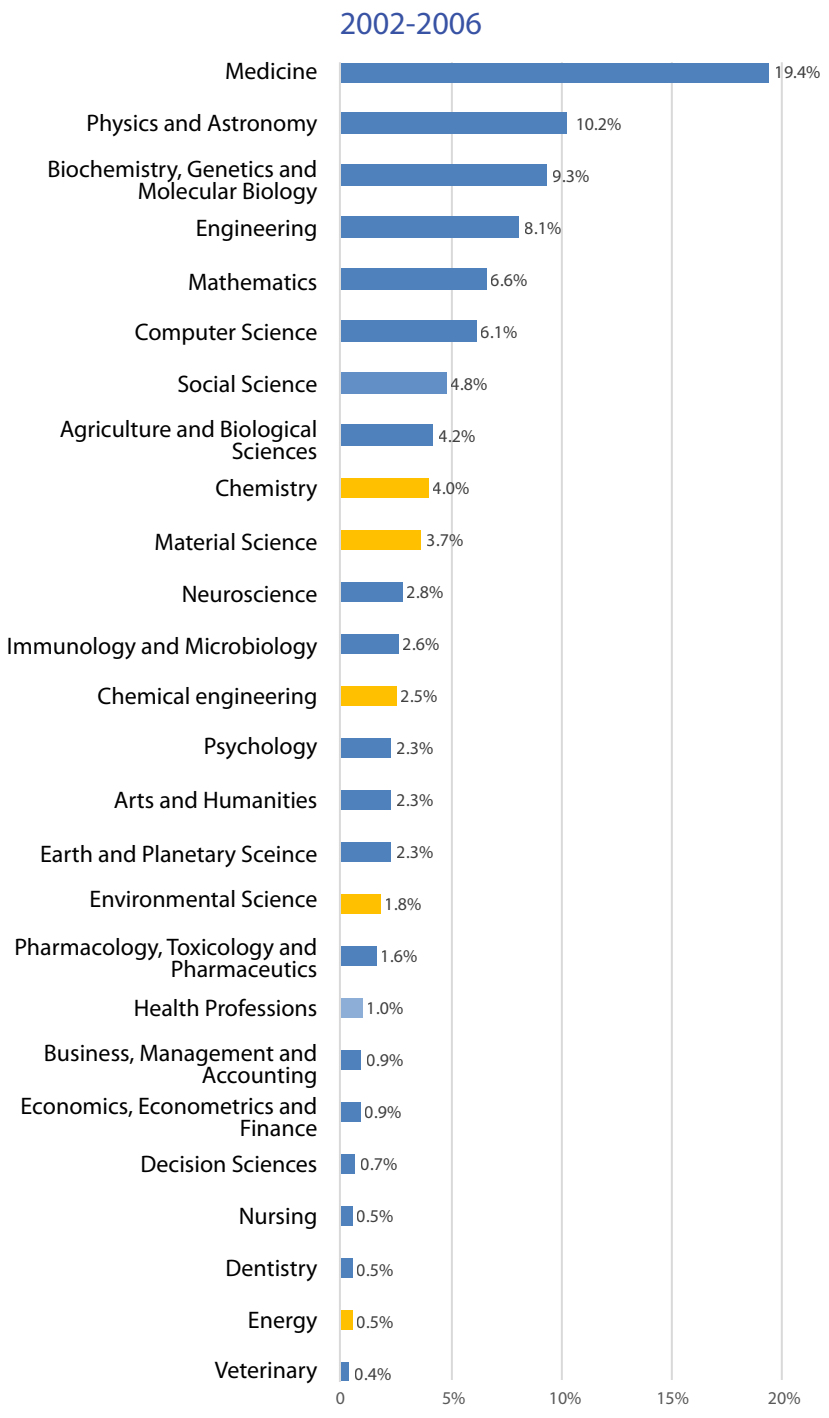
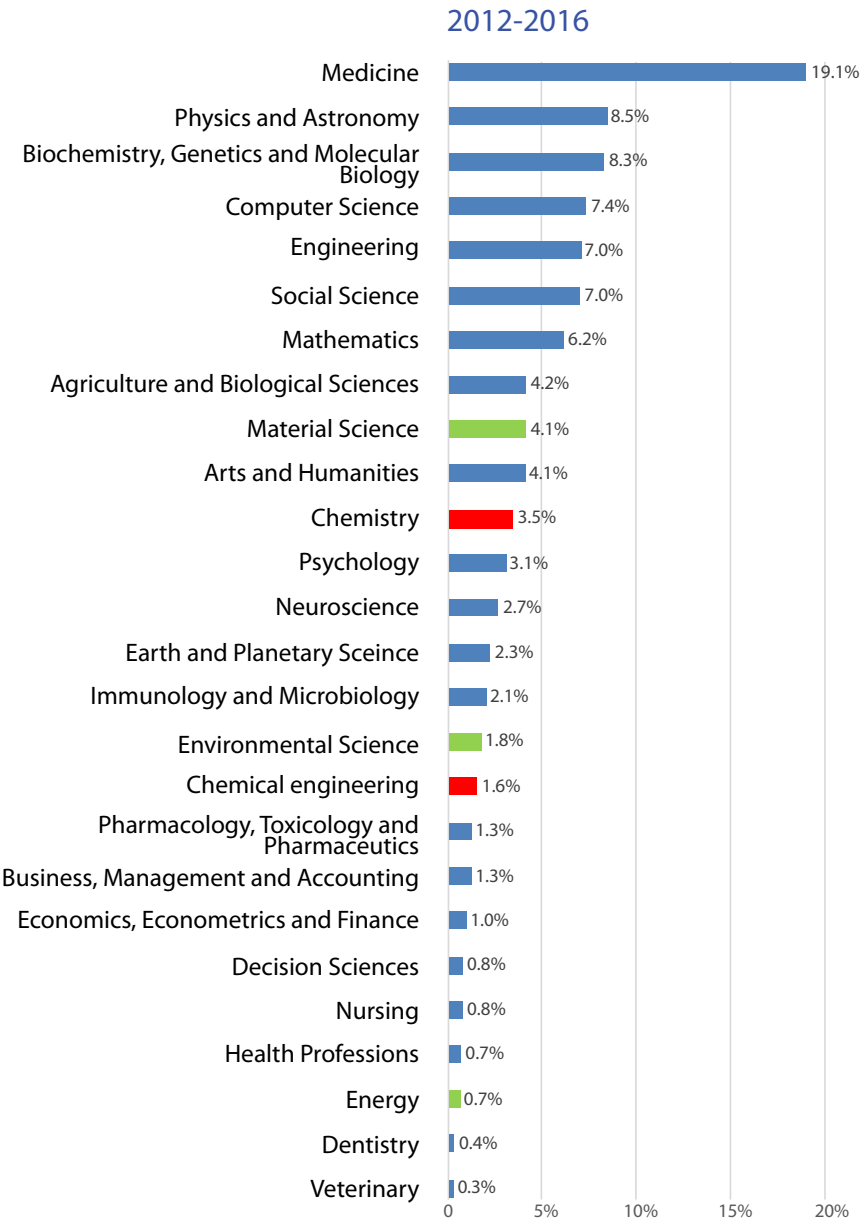


Figure 6a & 6b: Distribution of Israeli Publications by Field - Comparison of Two Periods



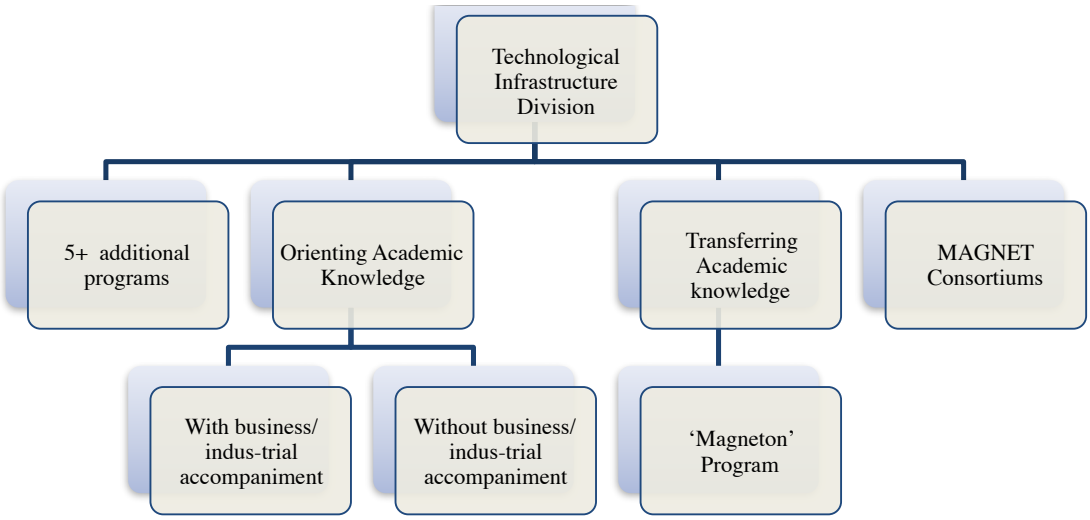
5. Supporting programs at the Israel Innovation Authority (IIA)

In the technological infrastructure division at the IIA, there are different supporting programs for R&D at the early stages in terms of technology readiness level (TRL)[8] of technology development.

The main goal is to aid and support the creation of R&D capabilities in research institutes that conduct applied research in order to further the development of Israeli advanced manufacturing. In contrast to other supporting programs at the IIA, this division does not have conditional payment of royalties to the IIA.

The programs promote cooperation, exchange of knowledge and develop generic knowledge in academia. The program that focuses on the earliest stage in terms of technological maturity is 'Orienting Academic Knowledge' (OAK) which includes two sub-programs: a supporting program with the involvement of a company and a supporting program without any involvement i.e. to the researcher only. Alongside these, the IIA operate 'Magneton' program. 'Magneton' is suitable for technologies at a later stage of development and require a more intensive involvement of the accompanying company. In addition, the infrastructure division offer is the MAGNET consortium program.

Figure 7: the IIA's Technological Infrastructure Division structure with emphasize of relevant program for supporting environmental technologies researches



Source: IIA and Milken Innovation Center adaptations.

[8] See Appendix 1

Table 3. summarizing relevant IIA's supporting programs

	'OAK' Without business/industrial accompaniment	'OAK' With business/ industrial accompaniment	'Magneton' Program	MAGNET Consortiums
Technology readiness level (TRL)	2-3		4-5	4-6
Beginning of program	Basic research		A company interested in advanced applied research still with technological risk	a limited resources company to deal with a great technological challenge
End of program	reaching significant milestones, enable companies to sign an agreement to commercialize technology with the TTO.		Practical analysis of the technological risk with potential to be implemented in a company	A ready product in 3-7 years that can compete globally

Source: Israel Innovation Authority and Milken Innovation Center Adjustments.

IIA's Programs characteristics:

5.1 'Orienting Academic Knowledge' (OAK) programs

This program aims to bridge the gap between knowledge in academia and the needs of industry. i.e. to promote research to a stage that business entities will show interest until a commercialization agreement with the TTO. Alternatively, the research project is supported by a company that sees business potential in the project. The main objective of this program is to reach significant milestones,

which will enable the industry company to sign with the research institution on an agreement to commercialize technology. The integration of an accompanying company in the project enables the research institution to increase the chances of commercialization of the project to Israeli industry.

Historically, OAK program is a merger of two programs that existed until recently ("Kamin" and "Nofar"), which were merged since, except for the eligible applicants (TTOs), the programs had too much overlap of activities, amounts, stage of development. Moreover, both programs aim to treat the same TRL challenge (2-3).[9]

Each research institution may not submit more than 20 requests per year, subject to the three calls for proposals published by the IIA each year.

5.1.1 OAK without an accompanying company[10] : sub-program

This program is designed to promote academic research that may develop into research that is relevant to industry needs. In other words, the supporting program serves as a bridge between the basic research to applied research, thus encouraging academia to carry out research and bring it to the attention of business entities.

The program is intended for research institutions when there is no business company involved in the grant. The financial support offered is 85% - 90% of the project's approved budget. The maximum annual amount of financing is $120,000[11] and the rest is financed by the TTO. In general, support is given for two years and in special cases for three years with a reduced grant rate of 66% of the total project cost.

Program Production

The share of approved applications for environmental technologies applications is 64.7%, higher than the average approval from total requests in all sectors, which averages 35%.

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9 See Appendix 1.

10 Former IIA's 'Kamin' program.

11 The financing support is given in New Israeli Shekel with exchange rate of 3.61 to one dollar.

Table 4: Applications approval for the 'OAK' without an accompanying company in 2017-2018

	Environmental technologies supporting requests	Approved requests for environmental technologies	As %
Number of applications	34	22	64.71%
Total granted (in $)	4,039,374	2,418,027	59.86%

The explanation for the relatively high success share of approved applications for environmental technologies in this program may be as result of the stringent sorting conducted by the TTOs due to low potential for commercialization in comparison to other fields. In other words, the TTOs tend to apply for research projects after more stringent filtering.

5.1.2 OAK with an accompanying company[12] : sub-program

This program is designed to promote academic research for implementation in industry, where the accompanying company is involved and determines the research objectives. The company participates in funding the research at a level of 10% (up to $15,000). The governmental support offered in this program is 85% to 90% of the approved budget of the project up to a maximum annual amount of $150,000 for a single research institution or $195,000 for cooperation between research institutions. The support is given for two years and in special cases for 3 years at a reduced grant rate of 75%. At the end of the research, the accompanying company receives the first right to conduct negotiations for the commercialization of the technology with the TTO. Relative to the 'Magneton' program described in the following section, the company has a low degree of involvement in the project. Usually, at this early stage of the technology, the company is interested in the generic idea of technology. Therefore, participation in program costs is relatively low. It should be noted that the commercialization rate of projects is higher than the rate of commercialization in the program without the involvement of the company.

Program Production

The percentage of approved applications in the field of environmental technologies corresponds to the rate of approved applications in the other fields. However, due to the low number of requests, the rate of approved applications can vary in both directions in a particular year.

[12] Former IIA's 'Nofar' program.

Table 5: Applications approval for the 'OAK' with an accompanying company in 2017-2018

	Environmental technologies supporting requests	Approved requests for environmental technologies	Approval rate
Number of applications	7	3	42.86%
Total granted (in $)	1,050,752	451,105	42.93%

5.2 'Magneton Program'

The 'Magneton' program encourages the transfer of technological know-how accumulated in academia for industry use by creating cooperation between Israeli companies and an academic research group. The cooperation exposes the industrial company to relevant research achievements in its field of activity and assists the research group in turning academic development into commercial implementation. The program is intended for Israeli industrial companies interested in collecting innovative technologies developed in academia at the early TRL of 4-5 and aspiring to develop a product or improve an existing product based on current and relevant research. The program is also intended for academic research groups from Israeli research institutions interested in conducting innovative and original applied research in collaboration with a leading company interested in relevant technology.

The 'Magneton' framework provides the industrial company a convenient environment for testing the technology's application potential. Without this environment, the company would find it difficult to withstand a process that entails a relatively large risk and uncertainty. Therefore, the research should be focused on proving the technological feasibility of the industry and the research institution should be the sole owner of the knowledge that is the subject of the project. This program offers an applied research grant of up to 66% of the project's approved budget, up to a maximum of $950,000 for a period of up to 24 months. Like others OAK programs, grant recipients are exempt from payment of royalties.

Program Production

The data in Table 6 show a small number of applications in the Magneton program. Therefore, we cannot conclude. However, finding reflects the low demand for commercialization of environmental technologies by industrial companies.

Table 6: Applications approval for 'Magneton' program in 2017-2018

	Environmental technologies supporting requests	Approved requests for environmental technologies	Approval rate
Number of applications	3	2	66.66%
Total granted (in $)	868,749	731,953	84.25%

5.3 MAGNET Consortiums

This program offers support for cooperation in R&D between several companies and research groups from different research institutions (optionally). This support program has been operating for 30 years, with the aim of solving technological challenges and producing solutions that will provide Israel a competitive advantage over the next 10 years at the international level.

Usually, opening a consortium is taking place when a company is limited in its ability and resources to perform significant R&D comparing to the technological challenge dimension it identifies.

The program has undergone several changes over the past year to adapt it to shorter development times and to fierce global competition over leadership in future technologies. The time period offered for the support of the program is now only three years (previously, most consortiums were given support for five years);

On average, the budget is $5.5 million per year, depending on the consortium size and its requirements, aggregative to $16.5 million. If the R&D stage does not progress enough during the development period, it is possible to extend the development period for another two years through the 'Magneton' program mentioned above. From the moment the consortium ends, the aspiration is to reach a ripe product within 3-7 years. Mostly, the intellectual property rights belong to companies that take part in the consortium,

depending on the level of the technology developed in the research institutions at the beginning of the program. In 2018, 18 applications were submitted for the creation of a consortium. Which 10 of them received an approval to continue the process of application and finally 6 of them received final approval for the creation of a consortium.

Several new consortiums were granted approval in 2018: an IoT consortium in the field of food products, a space communications consortium, a generic processor consortium for electronic components, and a consortium for quantum sensing.

Every year, 3-5 new consortia are established.

5.4 Business consulting and accompaniment

Alongside the finance support, the IIA's technological infrastructure division offer business accompaniment by professional experts in line with the research field.

For the 'OAK' sub-program that does not include an accompanying company, the IIA assigns a business advisor who is responsible of orienting the innovative technology to market needs. Ideally, business accompaniment is carried out by companies in the relevant field of research. If not, the service is provided by professionals from TTOs, private sector or academia.

Understandably, the sub-programs that include an accompanying company, business guidance and objectives setting are determined jointly with the company.

The IIA is able to provide $4,100 for each business advisor annually for two years.

For 'Magneton' program, of course, the professional accompaniment is fully carried out by the company partner. In this case, the company are familiar with the complexity of research at the early stages. Therefore, the company provides an appropriate response to technological challenges.

However, in terms of consulting, a great practice for supporting commercialization can be learned from the C2M (Cleantech to Market) program conducted by The Energy Institute at Haas, University of California Berkeley. C2M is an interdisciplinary program that helps innovators commercialize emerging cleantech from top-tier universities such as UC Berkeley, Stanford, Caltech, Princeton, and MIT. C2M provides 1,000 hours of free technology assessment, market research, and highly redefined recommendations for each project, including the identification of initial target customers, commercialization pathways, market-based performance specifications, and potential funding sources. Innovators value C2M's help with technology positioning, target market assessment, customer needs identification, business model brainstorming, funding ideas, cost–performance tradeoff insights, and deep market research that can be used with potential partners and investors. This support leads to a great record of commercialization.[13]

5.5 Penalties

The purpose of the IIA's support programs for applied R&D is to promote technologies and to encourage growth and employment in Israel. according to this viewpoint, the technology that is traded abroad will not directly benefit the local economy. Therefore, the different supporting program at the Technological Infrastructure division stipulate a fine of six times the grant budget in when the technology is sold abroad.

For environmental technologies, it should be considered to change this approach. Many environmental technologies can create solutions that is needed in emerging countries such in

[13] Further details in appendix 4.

Africa. For instance, great source of finance is available in the United Nation via the Sustainable Development Goals[14] (SDG's) 6,7,9,12 and 13)Clean water and sanitation, Affordable and clean energy, Industry innovation and infrastructure, Responsible consumption and production and Climate action respectively). To achieve these funding the technology needs to be ready to the market. Hence the cleantech market in Israel is relatively minor, while the products in this sector are very applicable abroad, it should be considered to reduce or change the penalty system. This change aims to ensure that penalties such that are not acting as chilling effect of participation in IIA's supporting programs.

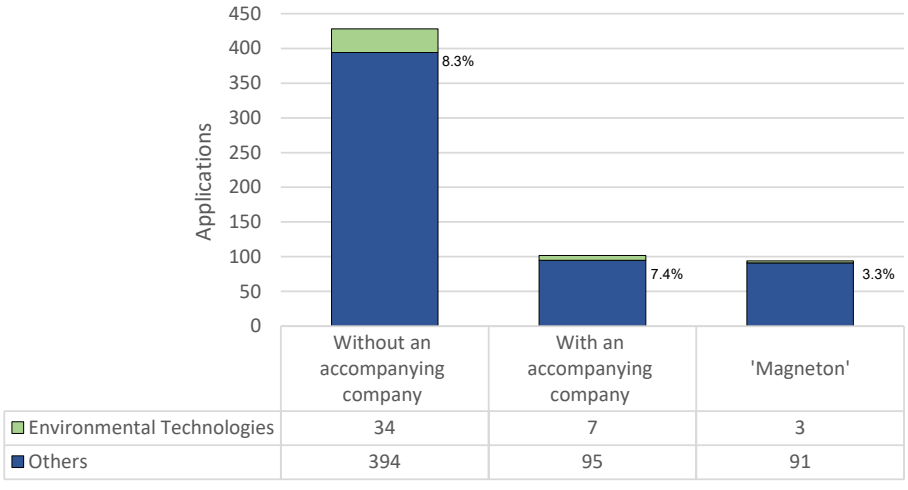
5.6 R&D for Environmental technologies applications support to the IIA analysis

The data analysis in 2017-2018 for R&D shows that the of applications in the environmental fields subprogram without an accompanying company ('OAK' program) was 34 application. That represent 8.63% from total applications at the program.

The subprogram that require an accompanying company shows a decrease of 80% in the cleantech applications for support and represent 7.3% of total applications.

The Magneton program - shows another decrease both at the absolute number of applications (-57%) and in its share in total application - only 3.3%.

Figure :8 Number of applications for environmental technologies to the IIA in 2017-2018



	Without an accompanying company	With an accompanying company	'Magneton'
Environmental Technologies	34	7	3
Others	394	95	91

Source: IIA, analyzed by Milken Innovation Center, 2019.

[14] For further information see: https://sustainabledevelopment.un.org.

Clearly, we can say that more the TRL is advanced, more companies will be interested in. therefore, in most of the cases, an application for a support without an accompanying company will represent an earlier TRL than an application to support with an accompanying company.

For the applications to the program without an accompanying company the share of environmental related applications appropriates the share of cleantech company as notice in section 3.1 (Cleantech companies account for about 7% of technology companies in Israel). For the sub-program that require an accompanying company we can see the same share of environmental technologies applications coherently with the share of cleantech companies in Israel as well, but the absolute decrease show that for both environmental and for other technologies applications its more complicated to find an accompanying company.

From the 'Magneton' program applications data we can see another decrease both in absolute and as a share of total application. As notice, 'Magneton' represents a higher TRL, that may point the difficulties of cleantech innovation to overcome the valley of death challenge.

From the interviews (as detailed below), there are several reasons for the decrease in the environmental applications:

1. Lack of demand for environmental technologies
2. Lack of cleantech technological incubators in the field
3. Due to the shortage of companies and the small size of the Israeli market, the TTOs advance and prefer to commercialize abroad, therefore, they won't apply to the IIA.

6. European Union supporting programs

Horizon 2020 is the biggest EU Research and Innovation program with Euro 77 billion funding available over 7 years (2014 to 2020) – in addition to the private investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market.

For Israelis, The Israel-Europe R&D Directorate (ISERD) is the national contact point for participation in the European Framework program and is also responsible for promoting the participation of Israeli entities in in the European Framework Programs and in bilateral and multilateral research and innovation activities with European countries.
ISERD is an inter-ministerial directorate, established by the Israeli Ministry of Economy, the Planning and Budgeting Committee of the Council for Higher Education the Ministry of Science and Technology, the Ministry of Finance and the Ministry of Foreign Affairs.
ISERD is operated through the IIA.

Horizon 2020 include 3 main programs who's relevant for supporting environmental technologies research:

1. **Excellent Science:** Activities under this pillar aim to reinforce and extend the excellence of the Union's science base and to consolidate the European Research Area in order to make the Union's research and innovation system more competitive on a global scale. The program that is relevant for supporting environmental technologies are the ERC.[15] The ERC will provide attractive and flexible funding to enable talented and creative individual researchers and their teams to pursue the most promising avenues at the frontier of science, based on Union-wide competition.
2. **Industrial Leadership:** This pillar aims to speed up development of the technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies.
3. **Societal challenge:** aims to bring together resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities. Two priorities are relevant to this challenge:
   a. Secure, clean and efficient energy
   b. Climate action, environment, resource efficiency and raw materials.

Descriptive statistics

As a part of the "Industrial Leadership" program which focuses on climate change, environment, efficiency of resources and raw materials, from the beginning of 2014 until March 2019, 195 requests for support were submitted by Israeli researchers.

Out of 20 research disciplines, the environmental field is the tenth in terms of number of applications submitted. In first place, for example, is ICT (information communication and technology) with 998 requests submitted. Out of the 195 Israeli requests within the discipline of environmental technology, 31 were accepted, i.e. 15.8%. In other fields, an average of 13.9% requests are accepted.

European Research Council (ERC) - descriptive statistics

As stated, the ERC program is part of the Horizon 2020 program and supports research in various fields. The data base is supplied by the EU and is a good reflection of submissions and funding; however, it is only partial data.[16] Between 2014 and March 2019, 1201 requests for support were submitted by Israeli researchers, 245 of which were approved, i.e., 20.2% applications were approved.

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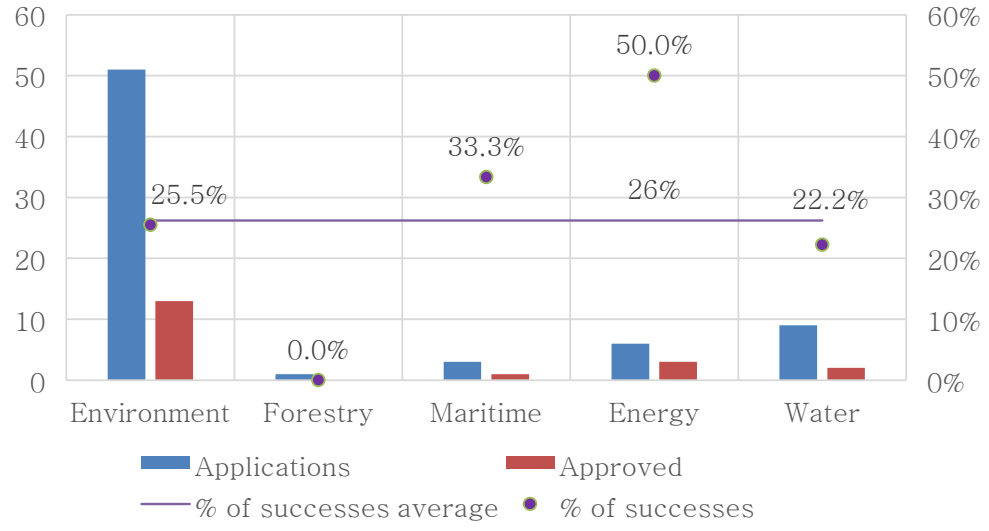
15 European Research Council.

16 The projects funded database and the submissions database can be updated retroactively within a year. Learn more at Horizon 2020 Dashboard.

When segmenting the environmental related fields, about 51financing requests were submitted by Israeli researchers; 13 of which were approved. In the energy sector, 3 submissions out of 6 were approved. Lastly, the water sector, 2 out of 9 requests were approved.

Based on the approval rates among sectors, environment technologies from Israel are more competitive than other sectors, with a 26% of approval rate compared to 20.2% for all fields.

Figure 9: Number of Israeli applications and approvals for ERC support segmented to environmental areas between the years 2014-2019



Source: ISERD, analyzed by Milken Innovation Center.

7. The Interactions in the Technology Transfer Process

This section describes the links in the value chain development of environmental technology and the interactions among the actors in this value chain.

7.1 TTO – Technology-Transfer Office

Technology-Transfer Offices (TTOs) in universities lead the entire technology - transfer process, beginning with contacting and accompanying the researcher, followed by patent registering, and finally the business development so that the patent license can be commercialized to a potential buyer.[17]

[17] According to The *Bayh–Dole* Act the intellectual property assets belong to the research institution

Most of the TTOs are owned by the research institutions as a for-profit subsidiary to the NGO research institutions (universities).[18] The TTOs prefer to commercialize technologies which are patented, in contrast to commercializing "Know-how" products (Intellectual property that is not patentable). It is easier to reach agreements with industries over patented technologies, especially since researchers publish papers describing technologies in detail. Therefore, technologies which are not patentable have a lower probability of reaching industries. One of the main focuses of TTOs is maintaining regular contacts with researchers in order to identify research projects that are worthy of patenting and advancing to further stages. TTOs maintain constant connections with different industries, especially global ones. In order to branch out their business, the TTOs are conducting business connections with companies and enterprises in the world, especially with the United States and European Union where the market is much larger.

During the patenting process, the TTOs are challenged in the evaluation of the invention for two reasons:

a. Lack of manpower that can conduct market research and estimate properly the potential of the invention. The TTOs are relatively small that employ basically patent experts and a business development officer. The business development officer has many projects ongoing alongside the interactions with the researcher. Thus, they are limited in their ability to conduct a market research. However, the best source of knowledge about the innovation of the invention is the researcher themselves, but they have limited market expertise.

b. An abundance of caution in sharing information about unpatented research and developments in the pipeline, resulting in a lack of ability to share the information with professionals, companies or consultant. Thus, the TTOs understandably won't take the risk of technology stealing.

Major TTOs in Israel host 20-30 foreign delegation of investors every year. The TTOs have reported that foreign delegations are very impressed by the IIA's supporting program models, specifically the amount of investments and the risks the country takes upon itself. Due to low manpower level, if certain delegations aren't interested in a specific technology, the TTOs prefer to prioritize and invest time on delegations which do show an interest in a specific technology where the potential for commercialization is greater. However, as pointed out above, this results in a vicious cycle of less exposure and less market interest.

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and not to the TTO or the company interested in technology. In the commercialization agreement, the company receives the exclusive license to use the patent.

18 Except for T³ (Technion), which is part of the Technion Research Authority.

7.2 Researchers

Researchers play a key role in tech-transfer processes, the champion of the technology invention. As for the importance of patenting, most researchers are fully aware of this importance; however, they naturally give more attention to the research project itself and publication at the expense of giving attention to important technical aspects (such as patenting). As learned in the interviews, the grants provided from the IIA at this TRL are enough.

Once agreements are reached and projects receive grant approval, much of the income gained from these agreements is distributed to the laboratory and the researcher. Therefore, researchers are incentivized to make their projects applicable in the business world. The incentive may change between academic institution.

7.3 Interactions between Researchers and TTOs

Ideally, The TTOs and the Researchers maintain a continual and mutual connection. The TTOs send relevant Calls for Proposals to the researchers and arrange regular visits and meetings. Some of these visits are performed by "Scouters" (workers who specialize in finding technologies and research projects). These connections are initiated by the TTOs, who in return receive regular updates regarding the progression of projects of interest. It is not unreasonable to expect certain tensions within this framework. These tensions are the outcome of a gap between the aspirations of the researchers and the determination of the TTOs to protect the research projects so they can be commercialized in the future. While the TTOs are interesting in investing time patenting the projects, the researchers are interested in publicizing their ideas as soon as possible. A positive relationship between both sides may help in reducing these tensions. It must be noted that the patenting process can be strenuous and complicated for the researcher, who must also cope with the hardship of explanation the benefits of the project and his ability to compete at the local and international level.

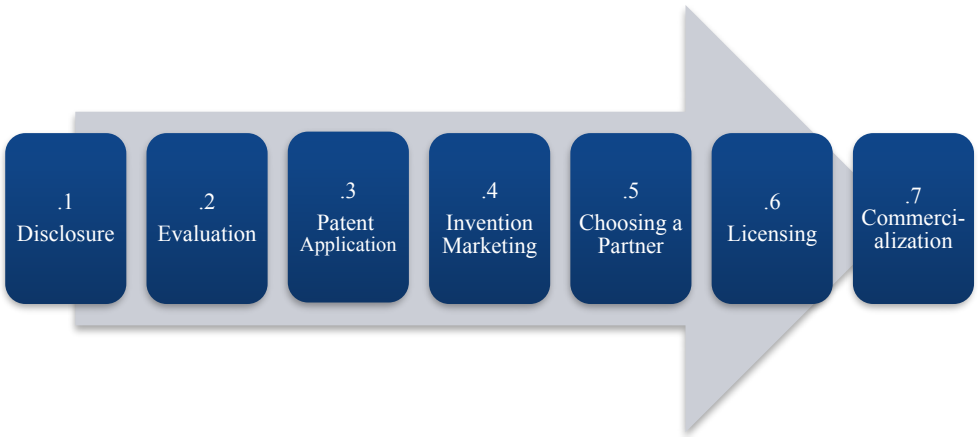
The TTOs lead the business development of the projects, and tailor them to the needs of the industry, while the researchers also play a key role in commercializing the project. This role includes choosing which business will purchase the project. In many cases, the patenting stage is skipped, or a provisional request is filled, while TTOs search for a source of income to finance the project.

7.4 Interactions between TTOs and the Israel Innovation Authority (IIA)

Consultations and guidance from the IIA contribute greatly to the research projects, especially via the 'OAK' program without a guiding company. For the IIA, like the TTOs, patented projects or projects with

a potential to be patented are more preferred than projects with a "Know-how" intellectual property. A sum of 20 thousand ILS is given for patenting in order to support throughout different IIA's platforms.

Figure 10: Technology transfer process



8. Barriers

This section will identify the barriers in the tech transfer process for environmental technologies.

a. A lack of funding resources for the early stages of environmental technologies development

The development of environmental technologies is characterized by significant costs in the transition between the stages of proof of concept (TRL 3) to the prototype production (4 TRL) and its suitability to the field (5 TRL). Considering the high development costs combined with the high technological risk at the early stages of R&D, it is difficult to find investors to finance the technologies development for lower stages than TRL 7. Moreover, the possibility of financing by technological incubators is particularly limited in the field of environmental technologies because in Israel, there is only two incubators dedicated to environmental technologies: Terra Labs and Capital Nature.

b. Under prioritization of TTOs for environmental technologies

As the local economy show a lack of cleantech companies, TTOs have confirmed that there is a limited demand for environment technology in development stages. Therefore, TTOs see low potential for commercialization of environmental technologies in comparison to other fields that TTOs promotes (information and communication technologies, medicine, etc.). Due to this lack, they tend in advance the commercialization of technologies in other fields and less in environmental

technologies. Thus, in the internal prioritization process, for environmental technologies it is difficult to compete with other technologies with higher commercialization potential.

c. A lack of demand from the manufacturing industries

Industrial manufacturing companies are customers of environmental technologies because they are required to implement technological solutions to reduce pollution and environmental risks. Due to environmental regulatory requirements for the manufacturing industry, it was reasonable to assume that they would be interested in the development of innovative technological-environmental solutions that developed in academia. Unfortunately, from the interviews with the TTOs it appears that demand for environmental R&D activities is limited. This is may be due to the reluctance of a traditional manufacturing industry to take the technological risks involved in early-stage R&D activities, where there is a significant gap between the maturity of applied research and the readiness of the product for industrial application.

Recently, there has been considerable interest from large industrial companies in promoting environmental R&D. However, from the industry's standpoint, environmental technologies remain only a solution to regulatory requirements. Therefore, they'll prefer to dedicate R&D expenditure to their profitable core business over environmental solutions.

d. A lack of demand from cleantech companies

In contrast to industrial companies that are "only" customers of environmental technology solutions, companies that provide environmental technology solutions should show a strong demand for new inventions. For them, innovative developments are a potential source of added value for their products and services they can offer to customers. Nevertheless, the demand for new and commercialized inventions is respectively low, as noted in Section 3.1, due to a limited number of environmental technology companies in Israel.

Those specific identified barriers are extremely important to overcome as they are extending the valley of death period

9. Recommendations

Based on this review of the environment technology sector, the following recommendations are proposed:

1. **Special program development and focus for environment technologies.**
   Allocate support for applied R&D to environmental technologies through the support mechanisms of the Technological Infrastructure Division at the IIA. Thus, to finance a supporting program that only environment technologies can apply to via a specific call for proposals for them. After a pool of proposals will be collected at the IIA, in cooperation with the Ministry of Environmental Protection, a committee of professionals will choose the best breaking through research ideas. Beyond the grant, as mentioned, the winners candidates will receive a business advisory in order to orient the research to me more applicable at the market and regulatory advisory from the Minister's expert.

2. **Increase private sector collaborations and partnerships with project developers.**
   In the first stage, it is proposed to focus support to both the 'OAK' program with an accompanying company and the 'Magneton' program[19]. Those two, are requiring at some level, a company involvement. This financed collaboration will motivate companies to show interest in new innovative researches. this will dramatically rise the potential of commercialization as a result of the impact they are going to have on the research alongside with the priority for negotiation on licensing with the TTO.

3. **Commercialization consulting.**
   As mentioned in section 7, consulting is a critical part in the commercialization. It recommended that during the suggested program, an expert team from relevant disciplines will consult to the research tea in order to promote the potential examination, provide a better orientation to the market the TTOs doesn't have the full ability to asses a market research in order to understand properly the potential of the examined innovative technology. This is not unique only to environmental technologies. However, it is highly recommended to provide a proper consulting to the researcher.

4. **Collaborate with relevant ministries to ensure policy development, regulation, and program development for environment technologies are coordinated.**
   In the second stage, it is proposed to examine the support of the Ministry of Environmental Protection in the establishment of a consortium (see section 4.3 above), in order to prioritize environmental challenges amongst companies and researchers.

[19] For full details of the supporting program recommended see Appendix 3.

5. Create new models for investment in clean tech, including development and implementation of projects

It is critical to create a sustained, long term investment strategy to ensure that the investment opportunities are available and dependable for long term investors and projects and the public awareness will increase. Blend capital investment using public, philanthropic, and private investment to ensure that returns are competitiveness and compelling for each investor.

Table 7: summarizing barriers and recommended response.

Barriers	Recommended response
lack of funding resources for the early stages of environmental technologies development	Government's participation in technological risk by financing designated early-stage R&D.
	Support for R&D projects involving corporations that participate in financing (industrial companies or cleantech companies), in order to expand the supply of financing.
	Creation of a specific sustained, long term investment strategy.
Under prioritization of TTOs for environmental technologies	Enabling TTOs to submit more applications in different environment fields by creating a specific program for environmental technologies only.
lack of demand from the manufacturing industries	Promoting joint academic and industrial projects to expose companies to innovative solutions and regulatory requirements.
	Raising awareness of different supporting programs among industry.
lack of demand from cleantech companies	Promoting joint projects for academia and cleantech companies to expose them to potential innovation in products and services.
	Raising awareness of different supporting programs among cleantech companies.
	Supporting cleantech companies in early R&D stages, in order to ensure that early developments will be collected by theme as they potentially can become a product in the market.

10. Appendices

10.1 Appendix 1: TRL-Technology Readiness Level

Technology Readiness Level (TLR) is an index, developed in 1974 by NASA[20], which estimates the maturity and usability of evolving technology on a scale of 1-9. The TLR index is of significance for standardizing the world of technical innovation, by allowing comparison between the maturity and readiness of technologies for the industries.

TRL is an accepted index amongst decision makers who are involved with transferring knowledge from academia to the industry within the countries of the OECD, United Nations and NATO.

Table 8- definitions of the TRL Scale

TRL	Definition
0	Idea- Unproven concept, no testing has been performed.
1	Basic Research- Principles postulated and observed but no experimental proof available.
2	Technology formulation- Concept and application have been formulated.
3	Applied Research- First laboratory tests completed; proof of concept.
4	Small scale prototype built in a laboratory environment ("ugly" prototype).
5	Large scale prototype tested in intended environment.
6	Prototype system tested in intended environment close to expected performance.
7	Demonstration system operating in operational environment at pre-commercial scale.
8	Fist of a kind commercial system- Manufacturing issues resolved.
9	Full commercial application, technology available for consumers.

The 'OAK' programs focus on TRL stages 2-3 and 'Magneton' program focuses on TRL stages 4-5.

20 Technology Readiness Level Definitions.

10.2 Appendix 2 - List of interviews conducted

detailed list of interviews conducted during the research process:

1. **Innovation Authority:** Gil Shaki, senior director, energy, cleantech and infrastructure. Aviv Zeevi, VP, Technological Infrastructure division, Noa Materasso, Director of Academic Research Programs, Lital Burian, Academic Infrastructure Coordinator and Hagit Schwimmer, Director of Life Sciences (ISERD).
2. **Among the technology-transfer offices (TTO) of all leading Israeli universities, we interviewed the directors of business development of environment, water, agriculture, chemistry and energy fields:** Mr. Amichay Baron, Yissum Ltd, the Hebrew University of Jerusalem. Dr. Ronen Kreizman, Yeda Research and Development Company Ltd, the Weizmann Institute of science. Shirley Sheffer, BGN Technologies Ltd, Ben Gurion University of the Negev. Gabriel Shemmer, T3, Technion Israel Institute of technology. Larry Love, CEO of ASI Ltd, Ariel University. Liat Hadad, Ramot Ltd, Tel Aviv university.
3. **Technological incubators for cleantech companies:** Dr. Harold Weiner, managing partner VP, Terralab Ventures Partners. Dr. Gaya Loren, CTO, Hutchison Kinrot and Shirley Sheffer, VP investments, Capital Nature.
4. **Leading research researcher in the environment filed:** Professor David Broday and Professor Ori Lahav, both from the Civil and Environment faculty of the Technion, Israel Institute of technology.
5. **Governmental chief scientists:** Dr. Gideon Friedman and Dr. Yael Herman from the Ministry of Energy and Dr. Orna Metzner from the Ministry of Environmental Protection.
6. **For business consulting insights we interviewed:** Leehe Skuler, Development Finance & Impact investment Advisory Lead and Anny Degani, Head of R&D and Innovation Incentives both from Deloitte Israel.

10.3 Appendix 3 – Possible guideline for an environment technologies program

The following guideline describes how the Government could adopt new and/or amended program approaches to support environment technologies using existing infrastructure of the IIA's both 'OAK' program with an accompanying company and 'Magneton'.

Goals:

Encouraging the transfer of environmental technological knowledge accumulated in academia for the use of industry, by creating collaborations between Israeli companies and academic research groups.

Missions:

1. To increase demand in the market for applied research.
2. To create a new source of finance.
3. To better realize the potential of environmental technologies.
4. To create a pool of competitive environmental technologies applications in order to increase their ability to get funding approvals.

Eligible applicants:

Technology Transfer Offices.

Eligible beneficiaries:

1. Researchers that will gain a grant to fund the laboratory activity and the research progression.
2. Accompanying company involved that will gain the opportunity to orient the research to her business and to have primary rights to start the negotiation for commercialization of license.
3. TTO that will find easier companies interested in applied research thanks to governmental funding.

Terms and conditions:

1. Two different call for proposals will be published every year for 'OAK' with accompanying company and for 'Magneton'.
2. At the end of call for proposals date, the judgment will be conducted by the ministry of Environmental Protection and IIA professional. The judgment will encompass both the environmental and the business viewpoints.
3. An accompanying company will be required.
4. No limit for number of applications.
5. No royalties will be asked.

Funding:

'OAK' with accompanying company: The maximum annual amount of financing is $120,000 and the rest is financed by the TTO and the accompanying company. Support will be given for two years, in special cases for 3 years with a reduced grant rate of 75%.

'Magneton': up to 66% of the project's approved budget, with a maximum of $ 950,000 for a period of up to 24 months.

Penalties:

In cases where the accompanying company will decide to hand over her primary rights to commercialize and the TTO will eventually commercialize the technology to a non-Israeli company. The TTO will be fined by the amount of money granted in the first place.

Impact

These collaborations will expose cleantech companies and industry to the research achievements and assist research groups in transforming academic developments into commercial applications.

10.4 Appendix 4 – Cleantech to Market (C2M) program

Cleantech to Market (C2M) is a partnership between graduate students, entrepreneurs, researchers, and industry professionals to help accelerate the commercialization of emerging cleantech. In the process, C2M also develops the next generation of innovative cleantech leaders.

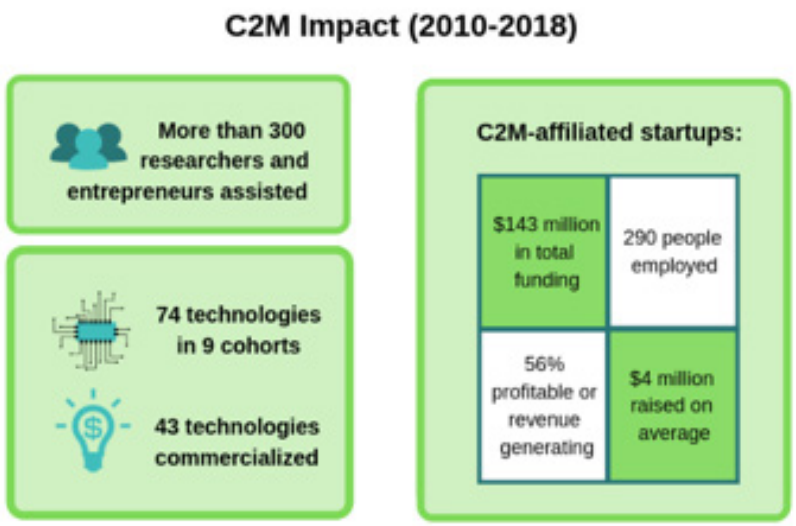
C2M first identifies promising cleantech from (1) existing startups, (2) top-tier universities such as UC Berkeley, Stanford, Caltech, Princeton & MIT, (3) accelerators & incubators such as Cyclotron Road and the Cleantech Open, and (4) government sponsored programs such as the Department of Energy, ARPA-E, and the Lawrence Berkeley National Laboratory. C2M then handpicks graduate student commercialization teams from over 20 UC Berkeley disciplines, including business, engineering, science, law, policy, and the Energy and Resources Group. C2M matches their academic and work experience with each project.

C2M supports the teams with leading cleantech professionals who bring deep subject matter expertise (e.g., energy generation, efficiency, storage, and transportation, green chemistry, water purification, grid operations, economics, early stage venture, and much more). They help guide the students as speakers, mentors and contacts.

Each project receives approximately 1,000 hours of free commercialization assessment. Every project's team will prepare a 100-page, in-depth commercialization study of their innovation and recommended pathways to market along with related presentation slides. The team may use them for any purpose including grant applications and discussions with investors. the team will present their findings and recommendations at C2M's annual symposium. In addition to showcasing the innovation within the C2M network, founders have valued the rare opportunity to see someone else present their

technology. This lets them "stand in the shoes of an investor" and gain a more objective view of their own endeavors.

Figure 11.



Source: Energy institute at HAAS, UC Berkeley, 2019.

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