ClimaSouth Policy Series
Paper N.2

ISRAEL AND DOMESTIC CLIMATE FINANCE: CLEANTECH COMMERCIALIZATION

How to convert cleantech start-ups into commercial successes while contributing to sustainable development

Casper Van der Tak
ClimaSouth project
Mitigation and Finance Expert

ClimaSouth
Low carbon development for climate resilient societies

A project funded by the European Union

ISRAEL AND DOMESTIC CLIMATE FINANCE: CLEANTECH COMMERCIALIZATION

How to convert cleantech start-ups into commercial successes while contributing to sustainable development

Casper Van der Tak
ClimaSouth project
Mitigation and Finance Expert

Citation: ClimaSouth Policy Series, Paper N.2, 2017. Israel and domestic climate finance: cleantech commercialization. Prepared by Casper Van der Tak.

Produced by the ClimaSouth project: www.climasouth.eu

Author & editor: Casper Van der Tak

Graphic design & layout: Raffaella Gemma

Series editor: G.H. Mattravers Messana

ClimaSouth Team Leader: Bernardo Sala

Agriconsulting Consortium project directors: Ottavio Novelli / Ghizlane Lajjal

Project implemented by
AGRICONSULTING CONSORTIUM
Agriconsulting Agrer CMCC CIHEAM-IAM Bari
d'Appolonia Pescares Typsa Sviluppo Globale

© European Commission, 2017

DISCLAIMER

The information and views set out in this document are those of the authors and do not necessarily reflect the official opinion of the European Union. Neither the European Union, its institutions and bodies, nor any person acting on their behalf, may be held responsible for the use which may be made of the information contained herein.

ACKNOWLEDGMENTS

This report is partly the result of a series of fruitful meetings and discussions in Israel in June 2016 and November/December 2016. I would like to especially thank Ronnie Cohen-Ginat for arranging a full and rewarding meeting schedule during my visits to Israel. Also many thanks for our interesting discussions to, in alphabetical order, Ron Adam, Amit Aflalo, Ami Amir, David Asaf, Osnat Avital, David Banitt, Edy Beit Hazavdi, Daniel Ben Yehuda, Asher Bennett, Moran Buganim-Gold, Tzruya Chebach, Galit Cohen, Anat Cohen-Segev, Oded Distel, Anat Eilon-Ganor, Maya Federman, Ofer Finkelstein, Yossi Fisher, Gideon Friedmann, Stav Gilutz, Daniel Gimpel, Jonathan Hadar, Roi Harpaz, Noam Ilan, Sharon Kabalo, Ron Kamara, Nir Kantor, Erez Lanzer, David Miron-Wapner, Chaim Motzen, Sinaia Netanyahu, Snir Niv, Eitan Parnass, Gil Proaktor, Ayelet Rosen, Gil Shaki, Nadav Shashar, Omer Tamir, Yair Teller, Jenny Tynyakov, Dov Vatelmacher, David Waiman, Elah Weinstein, Harold Wiener, Tanya Yegnes, Itay Zetelny and Yuval Zohar.

I would like to apologize in advance for any person I may involuntarily have left out.

Casper Meeuwis Van der Tak

Laveno-Mombello, December 2016

ABBREVIATIONS AND GLOSSARY

ADB	Asian Development Bank
ARPA-E	Advanced Research Projects Agency-Energy
BSE	Besluit Subsidies Energieprogramma's [NL] (decision subsidy energy programs0
CDM	Clean Development Mechanism
CER	certified emission reduction
CIA	Central Intelligence Agency
CIRFF	Concessional Innovation Rollout Financing Facility [this report]
CLEANTECH	environmentally sound(er) and clean(er) technologies
CLIMATECH	climate technologies (adaptation technologies and/or mitigation technologies)
CN	China
CO_2	carbon dioxide
COP	Conference of Parties
DG	Directorate-General
DOE	Department of Energy [USA]
EC	European Commission
EE	energy efficiency
EFG	Enterprise Finance Guarantee [UK]
ENTR	Enterprise and Industry [EC DG]
ESCO	energy service company

ESI	energy savings insurance
EU	European Union
EUR	Euro
EU ETS	European Union Emission Trading System
FI	Finland
GCF	Green Climate Fund
GDP	gross domestic product
IADB	Inter-American Development Bank
ICFPPF	Israel Climate Finance Proposal Preparation Facility
ICT	information and communications technology
INNOVATION	The successful entry of a new science or technology-based product into a particular market (in the case of companies, commercially successful entry)
INVENTION	A protectable commercially promising product or service idea, based on new science or technology
ITMO	internationally transferred mitigation outcome
KTP	knowledge transfer partnership [UK]
KWH	kilowatthour
LTA	long-term agreement [NL]
MDB	multilateral development bank
MOST	Ministry of Science and Technology [CN]
NDC	Nationally Determined Contribution
NL	Netherlands
NLGS	National Loan Guarantee Scheme
NOVEM	Nederlandse Onderneming voor Energie en Milieu [NL] (Netherlands energy and environment agency)

NUTEK	Swedish Board for Industrial and Technical Development [SE]
OECD	Organization for Economic Cooperation and Development
PCP	pre-commercial procurement
PPI	public procurement of innovation
SBIC	Small Business Investment Company [USA]
SBIR	Small Business Innovation Research [USA]
SBRI	Small Business Research Initiative [UK]
SE	Sweden
SME	small- and medium-sized enterprise
STEM	Swedish Energy Agency
STTR (USA)	Small Business Technology Transfer
TEC	Technology Executive Committee
TEKES	Finnish Funding Agency for Innovation [FI]
TSB	Technology Strategy Board [UK]
UK	United Kingdom
USA	United States of America
USD	United States dollar
Valley of death	Period of time from when a startup makes its first major breakthrough (an initial external capital contribution, proof of concept) to when it begins generating a steady stream of revenues. The implication is that many firms don't make it across the valley and die prematurely.
VC	venture capital
WWF	World Wide Fund for Nature

CONTENTS

ACKNOWLEDGMENTS V

ABBREVIATIONS AND GLOSSARY VII

EXECUTIVE SUMMARY XIII

1. INTRODUCTION 1

2. THE VALLEY OF DEATH 5

3. ISRAEL'S CLEANTECH COMMERCIALIZATION CHALLENGE 9

4. INTERNATIONAL POLICY SOLUTIONS FOR CLEANTECH COMMERCIALIZATION 13

4.1. Procurement of innovation 13

4.2. Netherlands: voluntary agreements and subsidies 16

4.3. UK – SBRI, Catapults, Knowledge Transfer Partnerships, guarantee schemes 20

4.4. Government initiated investment funds 23

4.5. Efficacy insurance 23

4.6. Innovatiekrediet (Innovation Credit) 24

4.7. Conclusion 24

5. INNOVATIVE INTERNATIONAL INSTRUMENTS 25

5.1. Mission Innovation 25

5.2. Breakthrough Energy Coalition 26

5.3. Mitigation technology loans and insurance 26

5.4. Climate innovation funding programs 27

5.5. Project preparation....28
5.6. An Israeli Climate/green bond issue and an Eco-Innovate Israel Fund? 28
5.7. A role for the UNFCCC?....29

6. DEPLOYMENT OF ENERGY EFFICIENCY TECHNOLOGIES....31
6.1. Energy efficiency loan guarantees 31
6.2. Energy Saving Insurance....33

7. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS 35

Annex 1. SELECTED PPI AND PCP EXAMPLES 43

Annex 2. ENABLING FRAMEWORK FOR MISSION INNOVATION 45

Annex 3. BREAKTHROUGH ENERGY COALITION INVESTMENT PRINCIPLES 49

EXECUTIVE SUMMARY

Like so many other countries, Israel faces a cleantech innovation challenge: only a (very) few promising cleantech ideas end up as successful, sustainable innovations that reach the market and are the basis for profitable businesses. This phenomenon is called the **valley of death**. In general, it is possible to identify two different valleys of death, an early stage 'technological' valley of death, and a later 'commercialization' valley of death.[1] In the case of Israel, the problem is the latter one, and it is unusually severe as we will explain below.

The ClimaSouth project was requested to provide suggestions on how Israel could increase the rate of success in converting cleantech start-ups to commercial successes contributing to sustainable development. This is within the remit of the ClimaSouth project, firstly because many of the cleantech companies are climatech companies;[2] and secondly because funding committed towards this objective may be considered domestic climate finance and used to leverage international climate finance.

The report provides some examples of how other countries have dealt with this issue, and based on extensive discussions and a literature review, it provides recommendations considered relevant for Israel.

What instruments do governments have available to assist eco-inventions reaching maturity? In the main text, we have reviewed a series of instruments that have been used by other OECD countries (and China). In general, these approaches aim to make innovations more attractive, either by **creating markets**, by **reducing costs**, by **making finance available**, or by **reducing risks**.

For example, several countries have introduced the concept of '**procurement of innovation**', as a means to give clear visibility to a market for (eco-) innovations. This relies on the identification of at least a sizable group of highly interested and motivated buyers, and at best on the identification of actual orders. This approach can be used when the government procures for its own use (direct procurement), but can also be used in combination with private sector buyers (cooperative procurement), or even when the government sector does not buy at all, but organizes private sector buyers in buyer groups (catalytic procurement). It is particularly popular in Sweden, where it has been implemented over a longer period of time.

[1] The technological valley of death is located between the first and second stages of technological development, as laboratory research seeks further capital to develop a commercial product and prove its basic market viability. The commercialization valley of death arises later in the technology's development, as entrepreneurs seek capital to fund demonstration or first-of-a-kind commercial-scale projects or manufacturing facilities.

[2] I will use climatech and the unabridged version, climate technologies, as a shorthand for climate change adaptation and climate change mitigation technologies, analogous to cleantech for technologies that provide clean(er) or environmentally sound(er) solutions.

In the Netherlands, predictable markets have been created through the Dutch system of **sequential voluntary agreements**, in which the various sector organizations of the Netherlands economy 'voluntarily' agree on increasingly ambitious actions to produce cleaner and with less use of fossil fuels. These voluntary agreements are put in place 'under threat' of government action and regulation if the voluntary agreements are not ambitious enough. Each subsequent voluntary agreement has a higher level of ambition; compliance with each agreement is monitored; and the government makes additional tools and instruments available to assist enterprises in meeting the agreed targets. Again, this creates an environment in which eco-innovators can be sure that there will be a market for suitable eco-innovations.

Assistance in meeting the costs of innovation is another approach that is often used. This may take the form of a subsidy on the total cost of pre-commercial demonstration projects and commercial demonstration (or 'market introduction') projects. Usually the government will only partly fund such projects, with the private sector picking up the remainder of the costs. Such an approach can be especially powerful if a single government-linked organization is responsible for the implementation of a series of subsidies, starting from R&D subsidies and covering the whole innovation chain up to market introduction. In such a way, learning can be maximized and information can be exchanged to ensure that social benefits from knowledge spillovers are maximized. Essentially this is the approach the Netherlands followed in support of the voluntary agreements.

Yet another approach is to make finance available for innovation. This is for example done in China, through the establishment of the **partially state-funded venture capital funds**, the so-called guidance funds, that can provide early support for companies with early (eco-) inventions; support that venture capital funds without government funding would be reluctant to provide. Another interesting approach is the **innovation credit** offered in the Netherlands which only needs to be repaid in the case of successful innovation.

Somewhat related to this is the approach based on **guarantees and insurance** to partially eliminate risk. Reducing risks makes it more attractive for the private sector to invest in eco-innovations, and also makes it possible to attract financing. With guarantees or with some type of efficacy insurance in play, banks could provide loans to finance incremental innovations that otherwise would not be able to attract bank funding.

It is very hard to generalize about any 'best solution', partly because of the diversity of challenges that a start-up with an eco-invention faces before it reaches maturity. It matters a great deal whether an innovation is radical or incremental, whether the key problem is the market, whether it takes place within a large corporation or a new start-up without funding, and whether the technology is such that production at high volumes or larger unit sizes is problematic or not. Given this, and also given the pervasiveness of the problem of the valley of death, any suggestions for Israel need to be made with caution.

With this caution in mind, we would like to suggest that Israel implements several measures that would create a predictable market for eco-innovations; a predictable market that innovating companies could rely on. In particular, we **suggest that Is-**

rael implement a procurement of innovation program, together with a system of interlocking sectoral agreements of increasing ambition. Both measures would not require a substantial amount of fiscal resources and could, at least in the case of the sectoral agreements, likely benefit from assistance by international managers who have been implementing this approach in other countries.

In addition to this, if sufficient resources can be made available (see discussion below), a system of other support measures should be made available to companies on request: **subsidies** for projects along the innovation trajectory covering activities from **R&D to commercial demonstration (market introduction)**, ideally implemented through one single government-linked organization; a wider set of **guarantees to enable obtaining bank loans**, and **access to risk-bearing equity funding**. More on how this could be structured below. The key point is that given the multitude of challenges that could hinder successful innovation, a portfolio of instruments (or policy mix) need to be mobilized, along with the flexibility to use these in the most practical manner, on an *ad hoc* basis. Support needs to be predictable, yet be provided in the manner most suited to a particular case.

A crucial issue that needs to be addressed is Israel's market size. Examples for creating a predictable market for innovations are provided by Sweden and the Netherlands. Both countries attach significant importance to the environment, and the sizes of the economies of these countries is considerable. In 2015 the GDP of Sweden and the Netherlands were USD 493 billion and USD 750.7 billion respectively. Israel's economy is smaller (USD 299.4 billion) and perhaps less environmentally conscious, raising the question whether domestic measures to create a predictable market would provide a sufficient incentive for eco-innovation.

To address the limited size of the domestic market, Israel should also consider the **international market opportunities**. In particular, there are significant synergies available with various climate change and climate finance related initiatives. We explore these in the next few paragraphs, discussing first some of the current initiatives Israel may consider joining, and then a few possibilities for Israel to organize its climate finance contributions. The latter are more fully developed in a companion report to this paper.[3]

The **Mission Innovation** and related **Breakthrough Energy Coalition** initiatives offer significant opportunities for Israel. At the 7th Eilat-Eilot Renewable and Clean Energy Conference (end of November 2016) it was announced that Israel had joined Mission Innovation. This is a precondition for (possibly) getting funding from the investors organized in the Breakthrough Energy Coalition and requires a doubling of the public R&D budget for clean energy. However, it also offers several strategic opportunities, such as possibilities for joint research and joint demonstrations that could pave the way for entering new cleantech markets and for launching some of the instruments mentioned below. On balance, it seems worthwhile for Israel to join, in particular if Israel's additional public-funded efforts to commercialize inventions could count towards the goal of doubling public R&D in clean energy, and if water could be added as an additional topic of interest.

---

[3] Van der Tak, C.M. (2016), *Israel and international climate finance: Final report*. Report prepared for the Clima-South project.

As an OECD member country, Israel is expected to provide climate finance under the climate convention. The previously-mentioned report on Israel's international climate finance opportunities and obligations, suggests a few instruments that could further help to create international markets for Israel's cleantech innovations through concrete measures and investment programs. Particular suggestions that are worth mentioning in this regard are:

- **Mitigation technology loans & insurance**, which are loans and insurance to finance (or insure) commercial demonstration projects incorporating relatively new technologies, that are new to the host country. The loans or insurance are concessional (e.g., zero interest rate loans), but in addition, the investor (Israel) shares in the emission reductions achieved in the commercial demonstrations and their replications through a transfer of part of the emission reduction results as ITMOs.

- **Climate innovation funding programs**, which are a combination of Israeli funding (in a cost-effective manner) commercial demonstration projects in developing countries and an agreed 'concessional innovation rollout financing facility' (CIRFF) made available by international sources of climate finance that will fund replication of successful commercial demonstrations.

- **Concepts** such as those outlined in the two previous paragraphs require considerable effort to be translated into concrete actionable programs. One of the suggestions in the International Climate Finance report, is for a preparatory facility that could be used to finance the development of such programs. This could be done through the **Israel Climate Finance Proposal Preparation Facility** (ICFPPF). This is a facility provided by the Israeli government that will share in the costs and risks of preparing a climate finance proposal for concessional funding by international sources of climate finance in support of Israeli exports and investments to/in developing countries.

An internationalization strategy for Israel's cleantech innovations is very important. It increases the likelihood that cleantech inventions will successfully find a market, and it addresses Israel's technology transfer obligations under the climate convention as an OECD member country. Further to the above and as elaborated in the international climate finance report, we also recommend that Israel benchmarks its instruments for export and outward FDI promotion and facilitation, with an eye towards sharpening its tools that could help create markets for cleantech innovations.

The various suggestions outlined above cost money to implement, and it may be the case that the government of Israel is unable to commit sufficient resources to fund these proposals as well as those made in the companion international climate finance report. However, we believe that an attractive financing structure can be devised that will make it possible to implement all recommendations in both reports with limited fiscal implications.

Israel could issue a climate bond (or a more generic green bond), backed by a sovereign guarantee, the proceeds of which would be used to finance a **government-owned fund** (for the moment called the **Eco-**

Innovate Israel Fund). The Eco-Innovate Israel Fund's objective would be to invest in cleantech innovation through various measures aiming to take the eco-invention to commercial maturity. This may for instance be co-funding a demonstration project or a commercial demonstration project. When a company requests some type of support from Eco-Innovate Israel Fund to develop an eco-innovation (say funding of a commercial demonstration abroad), the fund would obtain shares in the company, on the basis of the value of the support offered. The fund would have a portfolio of instruments to choose from to support innovating companies; choices of instruments should be pragmatic and subject to evaluation for effectiveness.

The company requesting the support would co-fund the selected activities. In addition, to avoid a charge of 'trying to pick winners', a condition for such support could be recent success in attracting private sector investors. Eco-Innovate Israel Fund would make a return on a successful exit, just as another venture capital fund. If done well, such returns of the Eco-Innovate Israel Fund will be sufficient to service the bond coupon and principal payments, turn a profit, and stimulate eco-innovation in Israel.

Indeed, the last concept may be generalized and be directly supported by the UNFCCC. We therefore propose that developed countries with an interest in promoting climatech innovations (such as Israel) could issue a climate bond, backed by a sovereign guarantee. As suggested above, the proceeds would be used to finance a government-owned **National Eco-Innovation Fund**, to invest in climatech innovation and support various measures aiming to take the eco-invention to commercial maturity, with further details as described for the Eco-Innovate Israel Fund.

Additionally, we recommend that in international context, it will be proposed that the **UNFCCC** (or one of its related funds and resources) **matches national government contributions to National Eco-Innovation Funds**, provided these focus on climate technologies and that if such a National Eco-Innovation Fund is located within a developed country, the results will be made available to developing countries. Any matching request to the UNFCCC by a developed country for a National Eco-Innovation Fund could, through MOUs or LOIs signed with developing countries, substantiate that there is a developing countries' demand for its climate innovations in developing countries, and that there is a basis for spreading the new climate technologies to developing countries.

On the basis of this discussions, our concrete recommendations are:

1. Discuss the measures proposed (see next points), select the ones that are considered for implementation, decide the financing modalities, detail the proposals, and make a final decision.

2. Create predictable markets for eco-innovations through procurement of eco-innovation and interlocking voluntary agreements with increasing ambition over time.

3. Decide how the following recommendations requiring larger budgets should be financed. In this report it is assumed through a green bond financing Eco-Innovate Israel Fund.

4. Initiate discussions with Mission Innovation on Israel's potential joining of the initiative

5. Establish Eco-Innovate Israel Fund, including its procedures and organization.

6. Create a system of subsidies covering the innovation chain

7. Expand the system of guarantees for eco-investments

8. Establish a system of efficacy insurance, initially focusing on energy efficiency as a test case.

9. Implement the recommendations of the international climate finance report, including those relating to the climate technology loans & insurance, the climate innovation funding programs, and the Israel Climate Finance Proposal Preparation Facility.

10. Promote the concept of multilateral contributions to national funds for the promotion of eco-innovations in their early stages (here called National Eco-Innovation Funds), no matter where these funds are located (both in developing and in developed countries).

11. Regularly benchmark Israel's export and outwards foreign direct investment promotion and facilitation program against best practice.

12. Monitor and evaluate regularly so that relevant lessons can be learned and practices adapted.

1. INTRODUCTION

Israel is considered to be a successful example of country fostering an environment for successful innovation and successful eco-innovation. The global cleantech innovation index of 2014[4] ranks Israel as 'having the greatest potential to produce entrepreneurial cleantech start-up companies which will commercialize clean technology innovations over the next 10 years'. This reflects, in part, general conditions that help to support entrepreneurship. As a relatively recent report notes, the IMD World Competitiveness Yearbook (2011) ranks Israel first in the world for the parameter "Entrepreneurship in business" as well as for several other key parameters that enable, and reflect, an innovation- based society and economy. These include:

- Business expenditure on R&D (as % of GDP) – 1st
- Total expenditure on R&D (as % of GDP) – 1st
- Accessibility to capital markets – 1st
- Central bank policy – 1st
- Entrepreneurship in business – 1st

Zooming in on the global cleantech innovation index, it becomes apparent that Israel combines remarkable excellence in developing early stage cleantech companies ('evidence of emerging cleantech innovation') with relatively poor performance in their commercialization ('evidence of commercialized cleantech innovation'), a picture that is confirmed through in country discussions and other written sources. As commonly said, Israel is facing a particularly deep 'valley of death'.

The ClimaSouth project was requested to provide suggestions on how Israel could increase the rate of success in converting cleantech start-ups to commercial successes contributing to sustainable development. This is within the remit of the ClimaSouth project firstly because many of the cleantech companies are climatech companies;[5] secondly, because funding committed towards this objective may be considered domestic climate finance that may be used to leverage international climate finance.

The report provides some examples of how other countries have dealt with this issue, and based on extensive discussions and a literature review, it provides recommendations considered relevant for Israel.

One of the challenges in advising Israel on this issue is that the topic is a truly complex

[4] Parad, M. et al (2014), *The Global Cleantech Innovation Index 2014: nurturing tomorrow's transformative entrepreneurs*. Cleantech Group and WWF.

[5] I will use climatech and the unabridged version, climate technologies, as a shorthand for climate change adaptation and climate change mitigation technologies, analogous to cleantech for technologies that provide clean(er) or environmentally sound(er) solutions.

and has confounded all industrializing countries to significant degrees. A general feature of innovation is that it generally represents an even bigger concern when it comes to environment and climate change related technologies, for reasons that are further elaborated in the next section. It would be a sign of considerable hubris to assume that this report could provide anything like a final answer. However, hopefully some of the suggestions may provide useful starting points for discussions.

Additionally, it is worthwhile specifying from the outset that the promotion of cleantech and climatech requires a portfolio of different approaches or a policy mix, which together help to achieve a successful transformation from invention to innovation. This is illustrated in the following figure:

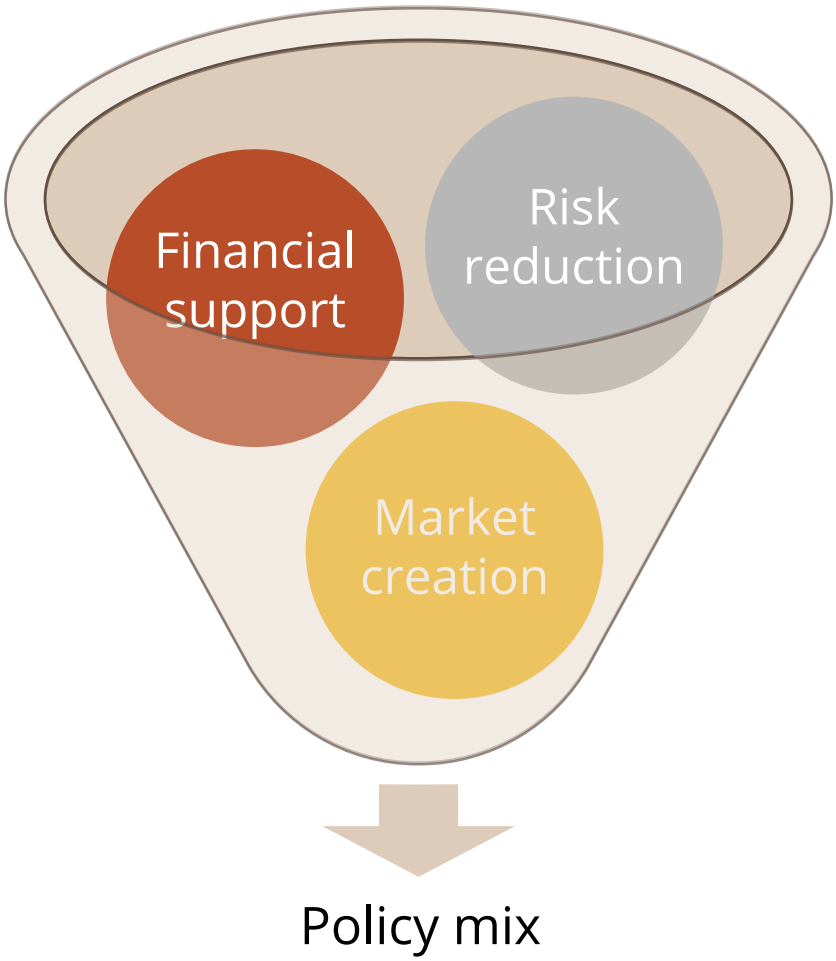


Figure 1. Importance of a policy mix

This report is based on findings from a mission to Israel, which helped to diagnose the main issues, combined with an Internet and literature review to identify approaches that would be useful for the country to consider. Further ideas for policy options that might be attractive to Israel were generated by drawing on earlier work on the promotion of climate technologies, conducted for the Asian Development Bank's (ADB) climate technology finance center. This formed the basis of a draft report that was finalized in November 2016 and subsequently discussed in several meetings and a workshop during November/ December 2016.

Among the major findings that flow from this analysis are, on the one hand, the need for grants and awards that increase returns to early users in the deployment stage, and on the other hand, the need for measures to create markets for cleantech innovations. One theme, widely echoed in interviews and the literature, is that especially smaller-sized innovative companies don't want awards or grants, but customers.

At the request from the Israeli Ministry of Environmental Protection, this report includes descriptions of some policy options, energy efficiency guarantees and energy solutions that are not necessarily linked to innovation or the valley of death, but rather the deployment of technological energy efficiency solutions that are already relatively well known.

This paper is organized as follows: Section 2 provides an overview of literature on the valley of death, while Section 3 presents a brief diagnosis of Israel's situation. We will conclude here that while literature has recognized that more than one valley of death might exist, one early and one at a later stage (but both before commercialization), only the latter is relevant for Israel. Section 4 provides an overview of the key policy instruments that have been used internationally, while Section 5 presents selected international initiatives and instruments that could be explored by Israel. Section 6 describes deployment oriented policy schemes that could be relevant in supporting energy efficiency investments as part of Israel's NDC. Section 7 draws the various parts of the paper together and presents the main conclusions.

2. THE VALLEY OF DEATH

What is the challenge we are talking about? Simply put, it is the difficulty in translating basic science into commercial business, providing innovative products and services. The 'valley of death' is a metaphor that points to the severe difficulties that companies have in translating a concept or prototype for innovative technologies with societal value, into viable revenue-generating businesses. If the companies do not reach the point of generating sufficient revenues, they will die and a potentially great innovation will not reach the market.

As a formal definition of the valley of death, I will use: *'The period of time from when a startup makes its first major breakthrough (an initial external capital contribution, proof of concept) to when it begins generating a steady stream of revenues. The implication is that many firms don't make it across the valley and die prematurely.'* This definition is the same as in the companion report on international climate finance,[6] and follows reasonably close common definitions that have been used in the academic literature and parliamentary discussions.[7]

A few remarks to further clarify this concept: first of all, the valley of death is an issue that is general to all technological innovation (however, as we shall see, to varying degrees). Second, the valley of death is best interpreted at the level of the system, and not as describing the experiences of single companies or businesses.

Where in the innovation process is the valley of death located? It is good to emphasize that there are different ways in which major obstacles to successful innovation arise, with different locations along the pathway from science to market. For example, Jenkins and Manur (2011)[8] distinguish between an early 'technological valley of death' and a later 'commercialization valley of death'. In their view, the technological valley of death is located between the first and second stages of technological development, as laboratory research seeks further capital to develop a commercial product and prove its basic market viability. The commercialization valley of death arises later in the technology's development, as entrepreneurs seek capital to fund demonstration or first-of-a-kind commercial-scale projects or manufacturing facilities.

---

6 See Van der Tak, C.M. (2016), Israel and international climate finance: Ffinal report. Report prepared for the ClimaSouth project.

7 Compare, for instance, House of Commons Science and Technology Committee (2013), Bridging the valley of death: improving the commercialisation of research: Eighth Report of Session 2012–13. The Stationery Office Limited, London. Paragraph 9 reads: *"The valley of death describes the point where a business, often a technology based business, has a working prototype for a product or service that has not yet been developed enough to earn money through commercial sales. The company needs to find sufficient money to develop the prototype until it can generate sufficient cash, through sales to customers, that would allow it to be self sufficient and grow. Growing companies will generate both jobs and wealth, a key objective for any government."*

8 Jenkins, J. and S. Mansur (2011), *Bridging the Clean Energy Valleys of Death: Helping American entrepreneurs meet the nation's energy innovation imperative.* Breakthrough Institute, Oakland.

Wessner,[9] among others, makes a similar point distinguishing between the valley of death and the later Branscomb's[10] 'Darwinian Sea', the struggle for life in a 'sea' of technical and entrepreneurship risks, in competition with other invention & management team combinations, with the latter between inventions[11] & new businesses on the one hand and viable innovations[12] and businesses on the other. Others have made similar points, locating the various valleys and/or seas in slightly different locations.

It should be pointed out that within a given technology sector, more than one major obstacle might hinder new technologies, and that the exact location of the obstacles might vary by sector, depending on the characteristics of the technology, production processes, regulation and market demand.[13]

How do these valleys of death arise? The earlier valley of death arises when the development of the invention requires significant amounts of funding that need to be raised externally, and no such funding is available. In this phase, often funding may be available from government agencies, so this valley tends to be less pernicious than the later one. The later valley of death can arise in a variety of ways, which all ultimately have to do with changing from an orientation focused on the development of a technology (a technical issue) to a business, with management teams that need to take a product to the market (a commercial issue). Whereas earlier on, the key is to have the best possible technology, in the later stage, the best possible business will win out.

The latter valley of death can take various concrete shapes, and it is useful to think of what is needed in order to upgrade an invention into an innovation. In general, this will require attracting a strong management team and the development of documentation, plans, models, prototypes and proof of concepts to make it possible to attract sufficient financing to finance the last push of the invention towards successful entry into the market. However, this may generally encounter significant difficulties:

- Psychology: The factors that motivate a scientist or an inventor towards a breakthrough are generally not the same that would motivate them to engage in the substantial amount of difficult and potentially costly research (sometimes requiring many years) needed to transform the product into a commercial reality.
- Communication and trust: Successfully transforming an invention into a business requires a handover between a technologist/scientist and an investor/

9 Wessner, C. (2003), *Public/Private Partnerships for Innovation: Experiences and Perspectives from the U.S.* Presentation. US National Academy of Sciences.

10 See, for instance, Branscomb, L.M. and P.E. Auerswald (2002), Between Invention and Innovation: An Analysis of Funding for Early-Stage Technology Development. National Institute of Standards and Technology, Gaithersburg.

11 A protectable, commercially promising, product or service idea, based on new science or technology.

12 A successful entry of a new science or technology-based product into a particular market (in the case of companies, commercially successful entry).

13 For example, there is a huge difference between ICT, medicine (drugs), cars, air transport, and fossil fuel based power generation, reflecting differences in scale of individual units, importance of economy of scale in production, research intensity of the basic breakthrough, importance of safety and health testing prior to release in the market, etc. Drugs, for instance, do not have the issues relating to the huge investment required to scale up production and increase unit sizes vis-à-vis prototypes that the car industry and energy industry usually face. Other differences arise from the possibility to charge premiums for quality – not possible in some sectors that are commoditized.

manager. Each has its own training, experiences and focuses, and effective communication and trust may be difficult to achieve.

- Change in sources of financing: Research funds that the inventor has relied upon to create the invention are typically corporate research funds, funds from government agencies or sometimes personal assets. However, except in the case of research funds at large corporations, these sources are not available for the further development of inventions.
- Uncertain demand: Especially when inventions are drastic, it is difficult to predict what market demand will be. One of the challenges is to attract funding at a time when market demand for the product or services that will eventually be developed remains hard to predict.

It is worth elaborating on the latter point. In the case of personal assets, usually the availability of funds is not sufficient to self-finance the next steps in the innovation trajectory. Moreover, inventors may have a limited appetite to expose themselves to risk of personal ruin from a failing technology by putting all eggs in a single basket.

Is the above sufficient cause for government intervention? There exists a perception that the government should not engage in 'picking winners'. One of the arguments is that at this stage, the benefits from the next development steps will be captured by a single player (the owner of the invention), and that hence, in contrast to the preceding research phase, there would be limited social benefit from government support for further development and thus no justification for government spending (a point to which we will return). Also, it is often thought that the government would be unusually badly suited to select the winners to back with further support.[14] In addition, there might be a prevailing (but incorrect)[15] perception that funding in this stage of moving from invention to innovation is covered by venture capitalists. The relative scarcity of government funding for inventions in pre-commercial stages may therefore have at least as much to do with ideology as with logic or scarcity of government funds. In fact, there might exist significant social spillovers from government spending in this stage, benefits that cannot be fully captured by the firm, while the risk will be carried by the firm in absence of co-funding. For example, a full-scale pre-commercial demonstration will create valuable knowledge spillovers, and not only because competitors could reverse engineer the technology. Also the success or failure of the demo will help competitors, as will problems that occur when scaling

[14] This argument is discussed in some depth in Nemet, G.F. (2016), The Valley of Death, the Technology Pork Barrel, and Public Support for Large Demonstration Projects. *DIW Berlin Discussion Papers 1601*, Deutsches Institut für Wirtschaftsforschung, Berlin. They highlight literature that supported this assertion, and discuss some cases such as the US Synthetic Fuels Corporation and Solyndra. Nemet et al note that in both of these cases, difficulties of government supported companies occurred because of external shocks (a drastic drop in oil prices respectively of silicon) that were not expected by the government, but neither by the private sector. They also point out that *'Several of the funded projects were completed on time and within budget; the technology performed so well that the core gasifier technology became widely used in China; and some have even argued that the potential for synthetic fuels influence the OPEC decisions to increase production and drop prices'*. Placing this in a context of the typical venture capital hit rates, in which only a minority of funded ventures makes money with maybe 1 or 2 real successes out of 10, makes one question whether the concerns about the relatively bad performance of the government are not severely overstated.

[15] See Wessner, C. (2003), *Public/Private Partnerships for Innovation: Experiences and Perspectives from the U.S.* Presentation. US National Academy of Sciences.

up from smaller prototypes. Such information will leak, because it is extremely difficult in this stage to bind all employees and suppliers to the firm. Additionally, the size of the financing required may be very large in relation to the value and size of the firm, making financing difficult and risky. The considerations above apply in principle to all innovations. However, environmental innovations are often deemed to have an especially difficult time to achieve commercial viability. Why are environmental technological innovations a special case? The key is **regulatory risk**. As Hug (2009)[16] points out, demand for environmental innovations is *fragile*. In general, it depends on government regulations that will need to create the demand, and is not something that (the majority of) the market will demand on its own. I myself have expressed this as a derived demand, a demand that arises mostly from governmental regulation. This means that a change in governments, or a change in government perceptions, or regulations not being updated for general changes in the economy could hurt environmental innovators. Moreover, if environmental regulations are badly formulated, they could prevent an environmentally superior product or service entering the market. In the case of environmental innovations, it is necessary to anticipate the direction of future environmental regulations, and these might not always benefit early environmental innovators.[17]

The system of environmental regulation definitely has an impact on eco-innovation. Regulations that lock in specific solutions at the expense of new, superior solutions need to be avoided, as is the case for any regulations that do not reward or recognize superior performance (e.g. lower emissions than required under applicable standards). Apart from the contents of regulations, it can also be helpful to encourage frequent changes of work positions between public and private sectors, which encourages information exchange and sound standard setting in the face of innovation.[18]

Another risk that some eco-innovations face is what may be dubbed as **production risk**. Some eco-innovations involve products that need to be installed at the production processes of third parties, for example to reduce energy use, or use waste energy for the production of useful energy such as power. Such projects may have attractive returns.

However, from the perspective of the host, they are also risky, because the possibility of malfunctions in the new equipment will threaten the production processes and production lines, potentially leading to losses that can be several factors more significant than the cost of the equipment installed. Usually the third party would want to have protection against the possibility of such losses; however, the source of the eco-innovations is usually a smaller company, and any contractual indemnification clauses will usually be fairly meaningless.

[16] Hug, V. (2009), *Bridging the Valley of Death: public support for commercialisation of eco-innovation. Final Report.* COWI A/S, Kongens Lyngby.

[17] A case in point is the CDM, which results in a product called Certified Emission Reductions (CERs) that could be used in compliance with the Kyoto Protocol and the EU ETS. Many firms, including one owned by the authour, moved in and started to develop greenhouse gas emission reduction projects producing CERs (in itself an innovation), often using innovative technologies. The anticipation was that with the growing concern about climate change, these CERs would gain value over time. Instead, the EU restricted the access of CERs to its market, and CER prices dropped to about 1% of their highest value, to the detriment of many project developers that are now stuck with loss-making projects.

[18] See for example Wallace, D. (1995), *Environmental Policy and Industrial Innovation: Strategies in Europe, the US and Japan*, Earthscan.

3. ISRAEL'S CLEANTECH COMMERCIALIZATION CHALLENGE

Israel's challenge with the commercialization of cleantech innovations can be well illustrated using the data in the global cleantech innovation index, mentioned above. The index was calculated for 40 countries. It was constructed from a series of variables for which data had been collected, coded, normalized, scored, and used to calculate sub-indices as simple averages of the indicator scores. The index and sub-indices are:

- Global cleantech innovation index: average of 'input to innovations' and 'outputs of innovations'.
- Input to innovation: average of 'general innovation drivers' and 'cleantech innovation drivers'.
- Output of innovations: average of 'evidence of emerging cleantech innovation' and 'evidence of commercialized cleantech innovation'.
- General innovation drivers: general innovation inputs and entrepreneurial culture.
- Cleantech innovation drivers: government policies; public R&D spending; access to private finance; infrastructure for renewables and cleantech industry organizations.
- Evidence of emerging cleantech innovation: early-stage private investment; high impact companies and environmental patents.
- Evidence of commercialized cleantech innovation: company revenues; renewable energy consumption; late-stage investment and exits; listed cleantech companies and employees.

Table 1 presents some of the data in the global cleantech innovation index report, slightly modified. We focus on the top-5, because the gap in the overall score between Denmark (nr. 5) and UK, Canada and Switzerland (numbers 6-8) is relatively large, with the latter three closely clustered together.

One of the things that is apparent from the table is that Israel is very successful at creating environmental inventions (captured by 'evidence of emerging cleantech innovation'), but on the other hand, that it is not very successful at converting these inventions into successful businesses (captured by 'evidence of commercialized cleantech innovation'). Israel drops from rank 1 for the creation of environmental inventions measure to rank 8, a relatively steep fall. Note that USA drops from rank 3 to rank 18!

Another notable point is that the 5 countries generally dominate the top ranks in the table, accounting for at least 4 of the five top positions, except in two cases. 'General innovation drivers' show a good score by Switzerland (3.38, ranked 2) and Canada (3.34, ranked 3), while in the case of 'evidence of commercialized cleantech innovation' several new names pop up: Brazil (3.03, rank 2), New Zealand (3.00, rank 3), China (2.85, rank 4), Norway (2.82, rank 5) and Spain (2.80, rank 6).

Rank	1	2	3	4	5
Country	Israel	Finland	USA	Sweden	Denmark
2014 score	4.34 (1)	4.04 (2)	3.67 (3)	3.55 (4)	3.45 (5)
Inputs to innovations	2.87 (6)	2.90 (4)	3.13 (1)	2.98 (3)	3.13 (1)
Outputs of innovations	5.81 (1)	5.18 (2)	4.21 (3)	4.12 (4)	3.76 (5)
General innovation drivers	2.86 (8)	2.83 (10)	3.29 (4)	3.59 (1)	3.15 (5)
Cleantech innovation drivers	2.88 (5)	2.97 (3)	2.98 (2)	2.37 (18)	3.12 (1)
Evidence of emerging cleantech innovation	8.92 (1)	7.59 (2)	6.41 (3)	5.56 (4)	3.23 (12)
Evidence of commercialized cleantech innovation	2.70 (8)	2.77 (7)	2.01 (18)	2.68 (9)	4.29 (1)

Table 1. Top of global cleantech innovation 2014.

Source: Parad, M. et al (2014), *The Global Cleantech Innovation Index 2014: nurturing tomorrow's transformative entrepreneurs*. Cleantech Group and WWF.
Ranks added between brackets.

Anticipating discussions in later sections of this paper, the high ranks of Brazil and China are especially noteworthy. These countries are considered strong cleantech commercializers, with strong policies to promote the uptake of cleantech solutions for environmental and resource problems. The two countries could potentially be key partners for Israel in commercially demonstrating and commercializing cleantech and climatech.[19]

In any case, the figures in the table suggest that Israel faces quite a severe valley of death in the cleantech sector, one that means that out of a large number of cleantech inventions, only a limited number appear as successful cleantech innovations. Reports from Israel display similar findings, and this picture was also confirmed through discussions in June 2016. The difficulty is not funding of early research and R&D, which

[19] This is not wishful thinking. Note that the Finnish Funding Agency for Innovation – Tekes – was partnering with MOST, China's Ministry of Science and Technology, in 2014 on joint calls for proposals for cleantech-related R&D projects.

can be covered through the existing government funding programs and mostly the private sector; the problem arises when it comes to turning inventions into successful businesses. Following the terminology introduced in the previous section, Israel faces a commercialization valley of death, and not a technological valley of death.

For example, a recent report focusing on the renewable energy sector concludes "(...) *the main barrier is the funding of the initiatives at the commercialization stage, after proof-of-concept has been achieved. Although the State of Israel offers support at the R&D stage, entrepreneurs often have difficulty raising capital for the following two stages – even though the technological risk at this point is significantly smaller. At these stages, projects either have difficulty achieving bank funding ("non-bankable"), or get financed at a very high rate of interest – impacting the project's ROI and profitability.*"[20]

Based on the evidence, the next sections will focus on the commercialization valley of death. This means that some of the policy tools such as SBIR, STTR, ARPA-E and R&D tax credits will not be presented in any detail in this paper.[21]

---

[20] See Samuel Neaman Institute for National Policy Research (2015), *The Israeli renewable energy and energy efficiency industry: Status update and policy recommendations for leveraging Israel's R&D and industry potential. Executive Summary* pp. 3-4.

[21] Respectively Small Business Innovation Research, Small Business Technology Transfer and Advanced Research Projects Agency-Energy (all USA programs). Nevertheless, programs like SBIR and STTR in the USA might be well-worth looking into, as they are considered good examples of how R&D support programs can be designed that benefit small businesses. SBIC then provides complementing access to capital for SMEs.

4. INTERNATIONAL POLICY SOLUTIONS FOR CLEANTECH COMMERCIALIZATION

This section of the paper discusses international policy solution for the commercialization of cleantech innovations, offering an array of different approaches that have been tried and tested. The examples are international in that they come from different countries (all relatively high in the global cleantech index); however, they are also national, for the experiences shown in this section are each individually confined to one country or economic union.

4.1 Procurement of innovation

Usually companies want to be sure there is demand for to-be-commercialized products and services before taking the risks and spending the funds to commercialize their inventions. However, demand normally only expresses itself after the products and services have been commercialized and enter the market. This raises a chicken-and-egg problem – it is very risky for the company to commercialize their invention before demand is certain, and vice versa, before the commercialized products and services enter the market, there will usually be no expressed demand, unless special policy measures are taken.

One of the approaches governments can take to promote the commercialization of inventions, including cleantech inventions, is to use various procurement tools that provide a clear perspective on market demand for innovations. Reducing uncertainty about demand for the innovation will make it less risky and more attractive for investors to provide financing for cleantech commercialization. This is generally referred to as public procurement of innovation[22] or demand-side innovation policy.

Public procurement of innovation (PPI) and Pre-commercial procurement (PCP) may not be well-known policy tools in Israel. In contrast, PPI and PCP are of greater importance in other OECD countries where the innovation policy-makers and funding agencies consider them as key market-creation measures. As low-carbon technology test-beds, they contribute to low-carbon and green transformation, based on private and public partnership – without interfering with market competition.

PPI occurs when public authorities act as a launch customer for innovative goods or services – which are typically not yet available on a large-scale commercial basis and may include conformance testing. PCP is an approach within the public procurement of innovation, developed specifically for the procurement of R&D services rather than actual goods and services.

Successful cases of using PPI and PCP to stimulate innovative technologies and solu-

[22] Not to be confused with green procurement, which can also help to create stable demand for environmental products and services and thus indirectly stimulate eco-innovation by providing a better enabling environment.

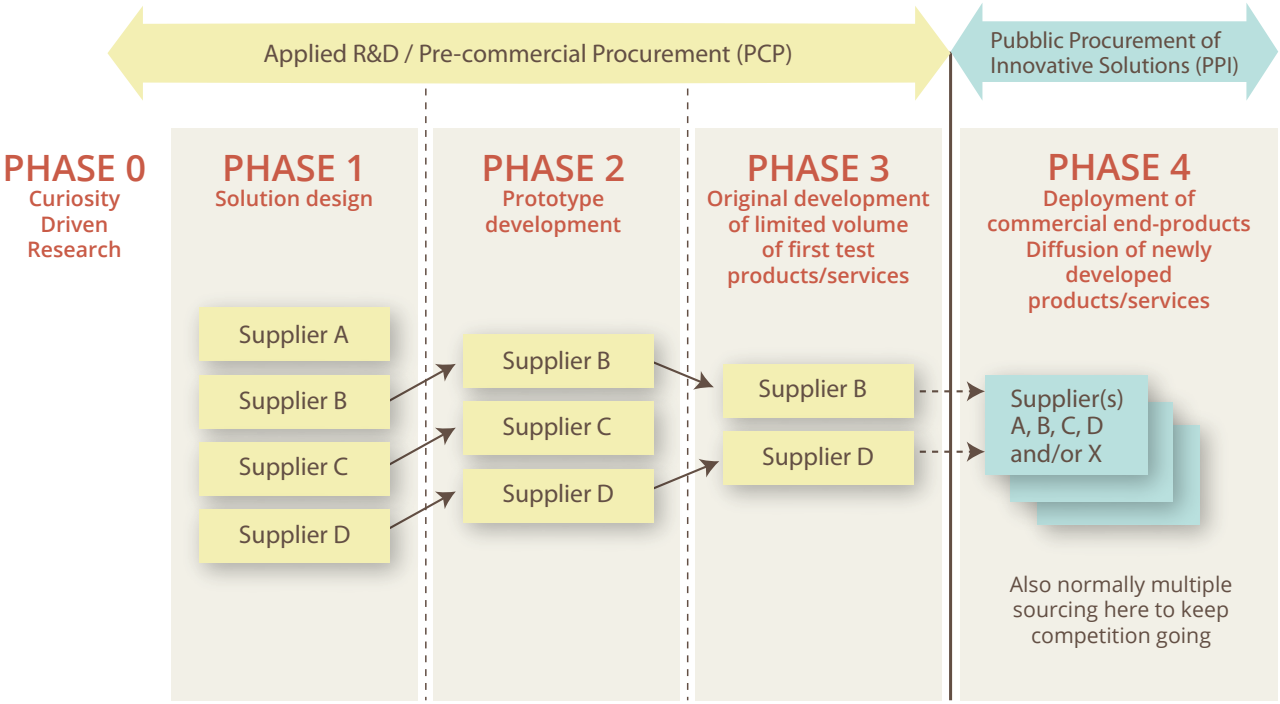


Figure 2. Overview of the PPI / PCP approaches

Redrawn from: Public Demand Driven Innovation PCP and PPI in Horizon 2020, EU Commission, 2013

tions in energy efficiency, green transport and infrastructure can be found in an increasingly large number of EU Member States, such as Germany, the Netherlands and Sweden (see Annex 1). They have become both necessary and important complements to the market-ready solutions – where "cost-effectiveness" has become a de-facto barrier to innovations.

It may be instinctively clear how these approaches work when the government is procuring for its own direct use (direct procurement). However, it is also possible to apply similar mechanisms in situations where the government is not the main buyer (cooperative procurement), or not even a buyer at all (catalytic procurement), but organizes the process. Hug (2009) provides an excellent description of the process in these latter two cases. Paraphrasing, cooperative procurement of innovation and catalytic procurement of innovations can be organized as follows.[23]

- A feasibility study is conducted to assess whether the proposed approach could work for a specific product or service. The feasibility will cover technical possibilities for eco-innovation, demand, interested buyers, an estimate of market size, etc.
- A 'buyer group' is created, gathering together purchasers with an interest in an innovation with environmental characteristics. These buyers set out what they desire from an innovation,

[23] The process described here is most suited for incremental innovations that improve existing products and services, and don't involve radical changes.

in terms of its function, characteristics and price.

- A public agent plays the role of a facilitator of product innovation and product commercialization. This agent may not be the buyer. For example, in Sweden such buyer groups have been facilitated by the Swedish Board for Industrial and Technical Development (NUTEK) and the Swedish Energy Agency (STEM), and has involved eco-innovations such as sun-shading of buildings, which are far out of NUTEK's and STEM's buying remit.
- The buyer group must be big enough to encompass a significant market share. If the buyer group is too small, the indication of future demand is not meaningful enough.
- The buyer group draws up detailed technical specifications describing the innovation that they would want to be available. This goes beyond any solution already on the market, but must be technically possible. The process is informed by discussions with technical experts, manufacturers and innovators about what is feasible. In many cases, innovations which could meet the desired qualities are already known, but not commercialized. It is important that the specifications are appropriately formulated. For example, in the USA a competition for superefficient refrigerators had as focus kWh saved, rather than the percentage energy saving, resulting in oversized refrigerators that were not well adapted to the market.
- To provide the incentive needed for innovators and manufacturers to engage in the information exchange, the gathering of information on the potential of innovations is usually set up as a bidding contest, in which the prize for the best bid is its selection for future market support, which may be in the form of a contract for the purchase of the products and services incorporating the innovations.
- Various policy and market instruments should be pre-announced before the bidding. The policy and market instruments will be the method for supporting the market uptake of the new products and services. The choice of instruments depends on the barriers faced by the companies and the depth of support needed. Some suggestions are provided below.
- Independent testing and demonstration are part of the program and valuable in themselves.

As mentioned above, usually the procurement process will be accompanied by policy support measures that further help to build the demand for the eco-innovation.

- Testing, demonstration and verification of the products. This should be a fixed ingredient of any program.
- Publicity campaigns for the best product(s). For example, award of a prize, promotion at trade fairs and establishment of product demonstration facilities.
- A financial 'prize' when the best product is put on the market.
- Sales support through subsidies for a certain number of products sold,

either to the manufacturer or to purchasers (including those purchasers in the buyer group).

- The revision of product labelling classes (e.g. energy labels) to allow the innovative products to differentiate their performance from products already on the market.
- Matching future green public procurement criteria to the technical requirements set up for the product.
- Guaranteed markets – a pre-commitment to purchasing of a certain number of products meeting the technical specifications (including price).

In Sweden especially, several decades of experience exist in using procurement of innovation to stimulate eco-innovation. It seems that various approaches to procurement of innovation can be very helpful in stimulating eco-innovations. Excellent sources for further information are Hug (2009) and https://www.innovation-procurement.org/.

4.2 Netherlands: voluntary agreements and subsidies

In the late 1990s and early 2000s, the Netherlands was using an interesting set of instruments to promote innovation in the energy sector, focusing on energy efficiency, renewable energy and reduction of greenhouse gas emissions. The key ingredients of the system were voluntary agreements and a subsidy scheme to drive development of inventions and innovations into the market.

Voluntary agreement

In 1993, the first sectoral Long-Term Agreement on Energy Efficiency (LTA or voluntary agreement) in the Netherlands was signed. Economic sectors committed themselves to achieving a 20% reduction in aggregated specific energy consumption by 2000, with 1989 as baseline. Individual firms joining the agreement undertook to improve energy efficiency as far as technically and economically achievable, with the aim of contributing to this collective target. In return, the government agreed not to introduce new regulations on energy conservation, and to provide financial support to the voluntary agreement program (see below). An important motivation for the sectors to sign the voluntary agreements was that if they would not self-organize and commit to a course of action, the government would issue binding regulations, which were deemed to likely be much more onerous.

In 1999, representatives of government and industry entered into a Benchmarking Agreement, through which industrial sectors agreed to achieve levels of energy efficiency in line with world best practice, while the government committed not to impose any new specific measures requiring increased energy efficiency or CO2 reduction.

The sectoral voluntary agreements are entered into following negotiations between the Ministry of Economic Affairs, industry sectoral associations, and the Netherlands energy and environment agency NOVEM.[24] NOVEM coordinates the implementation of the voluntary

[24] Nederlandse Onderneming Voor Energy en Milieu – Netherlands Enterprise for Energy and Environment. A not-for profit enterprise owned by the Netherlands government.

agreement, administers the financial support programs to industry, and advices enterprises on how they can meet their targets.

Prior to the signature of a voluntary agreement, the feasibility of the proposed target is assessed. Potential signatories are consulted to check their willingness to participate in such an agreement. In general the following steps lead to the signing of the voluntary agreement:

1. The government agency (NOVEM) approaches the industry for a preliminary assessment of its energy efficiency potential.
2. The industry association issues a Letter of Intent to undertake energy efficiency improvement, addressed to the Ministry of Economic Affairs.
3. NOVEM makes an inventory of economically viable measures (acceptable payback period) that can be implemented in representative companies within the sector. This yields the basis for the target for energy efficiency improvement.
4. The voluntary agreement is signed by the industry association, the Ministry of Economic Affairs and NOVEM. Individual companies express their participation by accession letters.

The measures needed to achieve the objectives of a voluntary agreement are set out in the "Long Term Plan for Improvement of Energy Efficiency". This plan is the basis for the voluntary agreement. It is flexible to allow for unexpected developments in market economics and technology.

A Long Term Plan starts with a description of the concerned sector and the role of energy within that sector. It includes:

- Assessment of energy consumption in 1989, as "reference year";
- Survey of opportunities for energy efficiency improvement;
- Model for company energy plans;
- Monitoring and energy management in each company;
- Research and development on new low energy technologies;
- Demonstration projects for energy savings measures;
- Market introduction of low-energy techniques;
- Assistance to individual companies;
- Transfer of know-how and information.

The commitments of the signatory parties vary from one agreement to another, depending on the specifics of the sector. All companies agree to work out an energy efficiency improvement plan, and improve energy efficiency as far as practically and economically viable, to contribute to the industry target. Basically this is similar to the "Company plan" outlined above. Following approval of the plan by NOVEM, the firm is required to report their results to the sector organization on an annual basis. Both the sector and individual firm results are verified by NOVEM.

In case of non-compliance, a voluntary agreement or an enterprise participation in a voluntary agreement may be terminated, As result of such termination, a firm will become subject to more onerous permitting requirements.

Government support

The Minister of Economic Affairs agrees to provide support to the program, including:

- Financial instruments aiming at industry: tax reductions can be granted if investments in energy efficient (or clean) technologies are realized. This scheme, however, applies to all companies, whether they are signatories to a voluntary agreement or not.
- Financial assistance within the framework of voluntary agreement, including various subsidy schemes (for a discussion of an important one of these, see below).
- Increase of the above mentioned financial assistance if the program yields more results than expected.
- Support in the form of a detailed audit of the industries' facilities. This includes an inventory of energy consuming equipment within plants, the specification of how energy is used, and the identification of cost effective energy efficient investments.
- Coordination of regulatory measures aimed at energy efficiency in industry, including requirements to obtain permits and energy taxes.

At a later point in time, additional tools were added, such as list of measures that could be implemented, scans and other analytical tools to help identify areas for improvement, and methods to calculate the effects of measures that impact product chains.

Results of the voluntary agreement

The first voluntary agreements were signed in 1992.

- By 1 January 1997:

  – 31 voluntary agreements were signed with industry associations;

  – More than 1000 industrial companies participate within voluntary agreements;

  – Over 90% of industrial primary energy consumption in the Netherlands was covered;

- By the end of 1997 the energy efficiency improvement actually turned out at 14.5%;
- 6 voluntary agreements with groups of users in services sectors.
- In the year 2000, annual savings of about EUR 660 million were realized as a result of the measures implemented.

In the long-term, the Netherlands achieve about 2.4% increase in energy efficiency per year through the sectors covered in the voluntary agreement. This is from a relatively high starting point, in a country with only very limited opportunities for renewable energy generation due to lack of resources and high population density.

Energy subsidies

A specific form of financial support was the Besluit Subsidies Energieprogramma's (decision subsidy energy programs - BSE) subsidies scheme for energy efficiency and renewable energy. Subsidies were available for several types of energy programs that were

considered very promising in the Netherlands context: new energy conversion technologies, fuel cells, energy storage in aquifers, municipal energy consumption, windpower, energy from waste and biomass, thermal solar energy, and new intersectoral technologies. Subsidies could be used in support of several types of projects that bring inventions increasingly close to the market:

- Feasibility assessment (project): analysis and assessment of the feasibility to develop a new device, system or technology for practical applications.
- R&D project: activities to increase the technical or scientific knowledge regarding a device, system or technology; or activities to make a device, system or technology ready for use in practice, with exceptions of field trials.
- Field trial project: a coherent set of activities consisting of the adoption of technical or managerial measures, to increase the understanding of the fitness for use in the practice of a device, system or technology, as well as related activities, focused on the improvement of the fitness of the device, system or technology.
- Knowledge transfer project: a coherent set of activities aimed at transfer of knowledge and information to a target group.
- Demonstration projects: a set of activities entailing economic and/or technical risk, aimed at introducing environmental and/or energy saving measures at the applicant's site, using either devices, systems or technologies that have not been used in the Netherlands, or that have not yet been used for the specific (demonstrated) purpose in the Netherlands.
- Market introduction projects: a set of activities entailing economic and/or technical risk, aimed at introducing environmental and/or energy saving measures at the applicant's site, using either devices, systems or technologies that have previously been demonstrated in the Netherlands, but that are not common practice. (What we elsewhere in this report have called a commercial demonstration).

Subsidy percentages offered depend on the distance to the market and the level of risk involved. The original launch of the BSE program used the following percentages:

- Research and development, maximally 100% subsidy.
- Demonstration projects, maximally 40% subsidy.
- Market introduction projects, maximally 40% subsidy (later lowered to 20%).

The BSE subsidy scheme was administered by NOVEM[25] on behalf of the Netherlands Ministry of Economic Affairs. The BSE subsidy scheme provided NOVEM with a flexible tool to assist the development of new energy-saving technologies, from a theoretical concept to a proven and commercially viable technology, through a series of projects supported with subsidies. On the one hand, the voluntary agreements were requiring the Netherlands enterprises to take up eco-solutions;

[25] NOVEM was paid by the Ministry of Economic Affairs, owned by the Netherlands government, and did not have a profit objective.

on the other hand, the subsidies helped to drive new eco-innovations into the market.

Several factors played a role in subsidy decisions, such as:

- The additionality of the activity subsidized. If the activity would be carried out without the subsidy, this argued against subsidizing the activity.
- The potential for the use and energy savings of the technology developed. The higher the total nation-wide energy savings that could be expected, the more attractive subsidizing the activity.
- The expected cost-effectiveness of the technology.
- The chances of success for the technology.

The application of these criteria could be quite interesting. For example, in the case of demonstration projects, NOVEM might make available (small) subsidies for projects that would have been carried out anyway, in order to remain familiar with the project and the technology involved, so that it can become/remain an effective "broker" for the technology that has been demonstrated.

An evaluation of the BSE formulated the following key lessons:

1. The subsidies were provided through one single government-owned entity, which in the process of evaluating subsidy applications and implementation of approved activities, as well as through implementation of other government programs, built up considerable knowledge, enabling it to act as a valuable source of information for the private sector.
2. In some cases, subsidies were provided to gain knowledge and information that could contribute to the development of new sets of technologies.
3. Generation of information that is accurate and according to a standardized methodology was key to the successful implementation.
4. The information collected from commercialization activities needs to be relevant for the decision-making by the targets for replication, and therefore include an assessment of the commercial payback period.
5. Tracking of the replication of the technologies is very important.

The Netherlands approach based on voluntary agreements and supporting instruments, such as the BSE energy subsidies schemes, have several decades of accumulated experience. They are now also being tried in other countries, such as China, with the assistance of managers who have been implementing this approach for NOVEM (later several times renamed) in the Netherlands.

4.3 UK – SBRI, Catapults, Knowledge Transfer Partnerships, guarantee schemes

The UK has a strong science and university system, and has several instruments to help translate its scientific strength into inventions and innovations. These efforts are guided by Innovate UK (what used to be called the Technology Strategy Board), and are comple-

mented by several instruments that assist especially SMEs in general business activities. This is not the place to discuss all instruments in detail, so we have highlighted a number that are relevant and provided sources for additional information. For example, we don't discuss the advanced training partnerships and SMART (R&D grants) here. We also discuss two guarantee schemes that make it easier, especially for smaller enterprises, to access financing they might need to develop inventions into innovations.

SBRI

SBRI is the Small Business Research Initiative. It is an instrument that allows SMEs to prepare to deliver innovative solutions to the market. It is a broad-based program, and not only focused on eco-innovations. The idea is to match public sector needs with ideas for innovative solutions through a competition. Note that the government agency launches the competition, not the innovator. The winning companies (addressing the problem identified in the competition) get development contract to test the feasibility of their ideas (contract of GBP 50,000 – 100,000), and in a second phase granted after another competitive assessment, to build a prototype (contract worth GBP 250,000 – 1,000,000). In addition, the companies will have a potential route to market via the government agency that initiated the competition. The competitions are open to UK companies and/or companies that will be UK registered (pre-start-ups). While the competitions are targeting SMEs, they are open for enterprises of all sizes.

The recent report by the House of Commons Science and Technology Committee[26] criticized the lack of matching between the research contracts of the SBRI with the follow-up procurement of the government agencies. The report noted that agencies' very risk-averse procurement culture made it difficult for the enterprises participating in SBRI to fully benefit from their built capacities to serve the market. However, this is not a criticism of SBRI, but rather of the procurement by the government agencies.

More information:

https://www.gov.uk/government/collections/sbri-the-small-business-research-initiative

https://www.gov.uk/government/publications/government-challenges-ideas-from-business-innovative-solutions

Catapults – technology and innovation centers

Over the last 9 years the UK has established a network of "Catapults" under the TSB – InnovateUK umbrella. Catapults are technology and innovation centers that bridge the gap between universities and businesses. They help businesses undertake late-stage R&D and commercialize traditional academic research. Catapults are not-for-profit, independent physical centers which connect businesses with the UK's research and academic communities. Each Catapult center specializes in a different area of technology, but all offer a space with the facilities and expertise to enable businesses and researchers to collaboratively solve key problems and develop new products and services on a commercial scale. Catapults exist to:

[26] House of Commons Science and Technology Committee (2013), *Bridging the valley of death: improving the commercialisation of research: Eighth Report of Session 2012–13.* The Stationery Office Limited, London.

- Reduce the risk of innovation
- Accelerate the pace of business development
- Create sustainable jobs and growth
- Develop the UK's skills and knowledge base and its global competitiveness

The catapults are funded through a mix of core funding from Innovate UK and commercial funding.

More information:

https://catapult.org.uk/

Knowledge Transfer Partnerships

The Knowledge Transfer Partnerships (KTP) is a program that has over 40 years of history in the UK. KTP is a UK-wide program that enables diverse organizations – including newly emergent companies, established market players and commercial research groups – to improve their competitiveness, productivity and performance. KTP achieves this by helping organizations to access knowledge, technology or skills from the UK's knowledge base, which includes universities, further education colleges and research and technology organizations. It thus serves a bridge function between knowledge institutes and basic research, and commercial interest in inventions and innovations.

More information:

https://connect.innovateuk.org/web/ktp

Guarantee schemes
Enterprise Finance Guarantee

The Enterprise Finance Guarantee (EFG) is a UK government loan guarantee protecting the lender against 75% of the losses from a client's inability to repay loans. It is available to support business loans to small- and medium-sized enterprises that otherwise would not be eligible for the loan. The borrower remains liable for the full amount of the loan. The advantage the borrower obtains from the EFG is not a protection against losses & liabilities, but access to debt finance that otherwise would not be available.

The relevance for innovation is that such schemes may make it possible for SMEs to finance investments needed to realize incremental innovations. This instrument is unlikely to support more radical innovations, as these are not suited to loan finance. There would however also be a favorable impact on deployment of energy efficiency solutions, by making borrowings for energy efficiency projects easier.

The EFG is implemented through British Business Bank plc. Decisions to make loans available with the guarantee in place are made by the participating commercial banks (delegated decisions), not by British Business Bank plc. nor by the UK government. The guarantee carries a cost, a 2 percentage-points add-on to the normal commercial interest rate of the loan offered.

More information:

http://british-business-bank.co.uk/ourpartners/enterprise-finance-guarantee/

Guarantee schemes
National Loan Guarantee Scheme

The National Loan Guarantee Scheme (NLGS) is a scheme that allows enterprises to borrow more cheaply. The NLGS works by using government guarantees on bank borrowing to allow banks to reduce the costs of their funds, a benefit that they then pass fully on to their clients, reducing their cost of borrowing by 1 percentage-point. Reducing the cost of funds makes it easier for the enterprises to invest in realizing incremental innovations. There would however also be a favorable impact on deployment of energy efficiency solutions, by making borrowings for energy efficiency projects cheaper.

More information:

http://www.icaew.com/-/media/corporate/archive/files/about-icaew/what-we-do/policy/budget-and-pbr/20120319-nlgs-key-messages-for-businesses.ashx?la=en

4.4 Government initiated investment funds

In the early 2000s, the USA started to experiment with venture capital funds owned by government organizations that invested in startups operating in sectors that were directly relevant for the government organization. For example, both the CIA and the Department of Defense set up such venture capital funds.

In China, a different variant of the same principle has been established, with the government leading the way in establishing venture capital funds, so-called guidance funds, covering all sectors of the economy. There are about 780 such funds, with total funding of around USD 336 billion. In China, these guidance funds are especially influential and tend to point the way, as the economy has for decades followed the example set by the government and the communist party.

For example, targeted venture capital funds, specifically investing in climate related technologies and companies have been set up using the China CDM Funds, which rely on the government's share in the revenues from the sale of CERs under the CDM. Like other guidance funds, these funds are expected to invest early and actively contribute to the commercialization of innovations.

4.5 Efficacy insurance

Efficacy insurance aims to cover a specified performance. For example, if an energy efficiency project is supposed to save 10,000 tons of coal, the price of coal is 100 EUR/t, and the actual coal savings are only 8,000, a total of 200,000 EUR would be paid under an efficacy insurance policy. Obviously such insurance policy would cost money, but even with the premium it will often be a much more attractive proposition to invest in the project with efficacy insurance than without. Of course, the insurance provider would seek coverage in the form of a premium that is higher than the assessed expected loss, and in case of very large projects, may seek to provide the insurance as part of a consortium, or to reinsure the efficacy insurance policy.

For many years, efficacy insurance has been almost non-existent, while earlier it was largely employed as an instrument to help

fund large projects (e.g., nuclear power). In the case of energy efficiency, the instrument is now back in operation – see also section 6 of this paper.

4.6 Innovatiekrediet (Innovation Credit)

The Netherlands Innovation Credit (Innovatiekrediet) is a new and attractive instrument in support of innovation. It is an interest bearing loan provided by the Netherlands government to Netherlands companies, used to finance the development of new innovations into commercially viable products and businesses. The loan only needs to be repaid if the development of the innovation is successful, in other words, the government is bearing a substantial portion of the risk. However, the company requesting the innovation credit should be able to invest in the follow up phase after the successful development of a new innovation.

More information:

http://english.rvo.nl/subsidies-programmes/innovation-credit

4.7 Conclusion

In this section we have seen how various countries have tried to address the challenge of the valley of death. Some recurring themes worth emphasizing are:

- SMEs are an important focus of the innovations commercialization instruments - agile and innovative on the one hand, but often lacking in funds and in the ability to absorb setbacks.
- Increasing the attractiveness of investing in the commercialization of innovation – by reducing costs (subsidies, co-investing approaches), by reducing risks (guarantees, insurance), by creating predictable markets (procurement of innovation, series of long-term agreement driving innovation), and by early-on connecting R&D activities to market demand (SBIR, subsidies in different links of the innovation chain).
- In addition, several attempts are being made to link knowledge institutes to the private sector, to stimulate new ideas and inventions.

These instruments are all national in nature. The next section looks more closely at international instruments and initiatives, especially those linked to climate change.

5. INNOVATIVE INTERNATIONAL INSTRUMENTS

This section presents a few relatively novel instruments and transnational initiatives, potentially relevant for dealing with Israel's cleantech innovation challenge, such as Mission Innovation and the Breakthrough Energy Coalition. The cleantech implications of some of the suggestions made in the companion volume on international climate finance are also discussed, including the possibilities of financing cleantech policy instruments.

Finally, we suggest how the UNFCCC may support such activities, both in Israel and in other countries. With the agreement of the Israeli government, this could be turned into a submission to the UNFCCC / TEC, as appropriate.

5.1 Mission Innovation

Mission Innovation[27] is an initiative launched at COP21 in Paris, whereby parties agreed to double public sector R&D into clean energy (including state directed R&D). Furthermore, Mission Innovation foresees some joint research activities, and some possibilities to jointly pursue financing of promising initiatives. The full text of the enabling framework of Mission Innovation has been included in Annex 2.

[27] The following section is as it appeared in the draft report. During the second mission (November-December 2016), after the preparation of the draft report, it appeared that Israel had joined the Mission Innovation.

Is Mission Innovation relevant for Israel? Doubling public R&D in clean energy is not really necessary in Israel's case, as the main challenge for the country is not to develop new inventions, but to get them more successfully to the market. On the other hand, Israel's public sector R&D is not very high, so the cost in committing to doubling public sector R&D into clean energy might not be excessive. In exchange for such a commitment, Israel would obtain:

- A seat at the table.
- Potential access to funding.
- Potential access to collaborative research, which could lead to collaboration in innovation and market introduction, e.g. commercial demonstration of new Israeli technologies outside of Israel.

On balance, this appears to be a worthwhile exchange. Israel could possibly discuss joining the Mission Innovation, while suggesting the following:

- Allow, in the case of Israel, the public sector applied research and demonstration budget to count towards the doubling of public sector R&D.
- Include water as a sector, with important adaptation and mitigation related concerns, to be an additional focus of Mission Innovation.

5.2 Breakthrough Energy Coalition

The Breakthrough Energy Coalition, also announced at the COP21 in Paris, is a global group of 28 high net worth investors from 10 countries, committed to funding clean energy companies emerging from the initiatives of Mission Innovation. Only a limited amount of information is available, with crucial information on investment structure, type of contributions, and conditions presently missing (see Annex 3 for the investment principles). However, for Israel the link to the Breakthrough Energy Coalition could be very valuable, because the intent of the coalition to invest early could be critical in bringing Israel's many cleantech solutions to the market.

In this context, Israel would be advised to also promote the idea of extending the scope of the initiative to include water. Water management is an Israeli strength, while countering drought and floods are significant adaptation concerns, so that it would make sense to address this issue within this coalition.

5.3 Mitigation technology loans and insurance

The concept of mitigation bond and mitigation loans were introduced In the International Climate Finance companion report. A mitigation bond is defined as: *Zero or very low interest rate bonds and loans invested in mitigation projects and programs in developing countries, that instead of yielding interest provide a share in the mitigation results obtained, transferred as ITMOs.*

Similarly, mitigation technology loans and insurance with reference to the mitigation bond / mitigation loan concept, were introduced as follows: *Another perhaps more straightforward way* [compared to adaptation bonds, not discussed here] *in which the mitigation loan concept can be extended, is to introduce mitigation technologies that are new to the host country (but that may be known in other countries). Introducing such technologies runs several implementation risks, and lack of local familiarity and local proof of performance may be significant barriers towards the uptake of mitigation technologies.*

The mitigation technology loans & insurance scheme aims to address this barrier by providing soft loans and insurance against adverse impacts of the "new" mitigation technology. As with the mitigation loan, the interest rate of the loan is very low; however, contrary to the mitigation loan, Israel will not only share in the mitigation results of the funded project, but also in the results of the replications after a successful demonstration project. This increases the returns on the loan vis-à-vis the mitigation loan, and can be used, in part, to compensate the insurance provider against the risk it takes in providing the insurance.

As with the mitigation loans, and ideal case would be for the MDBs to manage such programs, and for Israel to be one of several investors. Perhaps the various climate technology finance centers that have been set up at the MDBs could be interested in setting up such loan programs, with funding from various investor countries, including Israel.

In the ideal case, the mitigation technologies would preferentially use Israeli technologies where possible. In such a case, an instrument that is meant to assure compliance with Israel's greenhouse gas mitigation and climate finance obligations could, at the

same time, help to promote international markets for Israeli products, in an early stage of the technology. Joining the Mission Innovation may thus give Israel another avenue to discuss such opportunities and gain acceptance for the idea of mitigation technology loans or insurance.

5.4 Climate innovation funding programs

In the companion report, the concept of climate innovation funding programs was also launched and described as follows: *[A] combination of Israeli funding (in a cost-effective manner) commercial demonstration projects in developing countries and an agreed 'concessional innovation rollout financing facility' (CIRFF) made available by international sources of climate finance that will fund replication of successful commercial demonstrations.*

Israel, as a country from which many new climate and environmental technologies originate, has a clear interest in promoting international mechanisms that promote the diffusion and adoption of climate technologies. This is also a key objective under the UNFCCC and under the Paris Agreement. However, the barriers towards adoption and diffusion are well known, in the form of risks and uncertainty of unfamiliar technologies, and in some cases the lack of skilled personnel to use them. Is it possible to think of a funding program that would help to resolve such barriers?

Of course, mitigation technology loans, described above, are one way to address this issue. A more general approach is described here as a climate innovation funding program. Basically, in such a programme Israel, possibly together with other innovative countries that create climate technologies, approach countries keen on acquiring climate technologies with a proposition: Israel will fund (or de-risk[28]) a limited set of demonstration projects per each targeted technology in the interested countries, and provided that these commercial demonstration projects meet certain agreed targets, will then replicate the demonstration projects together with the host.[29]

Together with countries who are committed to this idea, Israel and like-minded countries can approach potential sources of climate finance (e.g., the GCF or the MDBs, who could attract funding for this purpose) with the proposal to open a 'concessional innovation rollout financing facility' (CIRFF). The CIRFF will be used to provide concessional financing to the replication projects, possibly including the production facilities, for the technologies that have demonstrated their worth and reliability.

For Israel, this proposal would at the same time contribute to its technology transfer obligations and to its climate finance obligations (the demonstration project funding and/or their de-risking). Furthermore, this approach would open

[28] De-risking would involve insuring the performance of the technology and insuring against adverse impacts of the technology's application if it fails. Thus the risks of the demo are drastically reduced and funding may, with these insurance measures in place, be provided on commercial terms.

[29] Details to be agreed. For example, as part of the overall deal, it may be agreed that equipment embodying the technology is produced under license or in a joint-venture arrangement. Alternatively, the replication projects in the rollout phase could in some cases be JV projects. Both of these options could also benefit from the concessional innovation rollout financing facility described in the main text.

up new markets for Israeli companies, technologies and exports.

As in the previous example, this concept would help to create a global market for Israeli climatech innovations. The outlay could be limited, because commercial demonstrations (and perhaps 1 - 2 non-commercial demonstrations) would be funded by Israel, while the replications of successfully demonstrated technologies would be covered through concessional international climate finance sources. This approach would allow Israel to commercially benefit and fulfill several of its climate change obligations at the same time (providing climate finance, technology transfer).

5.5 Project preparation

Concepts such as outlined in the two previous subsections, require considerable effort to be translated into concrete actionable programs. One of the suggestions in the International Climate Finance report is for a preparatory facility that could be used to finance the development of such programs. This could be done through the Israel Climate Finance Proposal Preparation Facility (ICFPPF). This is a proposed facility to be provided by the Israeli government that will share in the costs and risks of preparing a climate finance proposal for concessional funding by international sources of climate finance in support of Israeli exports and investments to/in developing countries.

5.6 An Israeli Climate/green bond issue and an Eco-Innovate Israel Fund?

The various suggestions in this report and the companion report cost money, and the amount of funds involved may be considered prohibitive. However, as further elaborated in Section 7 – Israel could issue a climate bond (or a more generic green bond), backed by sovereign guarantee. The proceeds of the bond issued would be used to finance a government-owned fund (for the moment called the **Eco-Innovate Israel Fund**) to invest in cleantech innovation, and the various measures needed to take the eco-invention to commercial maturity.

When a company requests support from the Eco-Innovate Israel Fund to develop an innovation (say funding of a commercial demonstration abroad), the fund would obtain shares in the company, on the basis of the value of the support granted.

The company requesting the support would co-fund the selected activities. In addition, to avoid a charge of 'trying to pick winners', a condition for such support could be recent success in attracting private sector investors. If done well, the proposed Eco-Innovate Israel Fund could service the bond coupon and principal payments, turn a profit, and stimulate eco-innovation in the country, all at the same time. This concept could also be worthwhile to pursue for other developed countries.

Box 1. National Eco-Innovation Funds

We propose that developed countries with an interest in promoting climatech innovations (such as Israel) could issue a climate bond, backed by sovereign guarantee, the proceeds of which would be used to finance a government-owned fund, the **National Eco-Innovation Fund**. The Fund would invest in climatech innovation, and the various measures to take the eco-invention to commercial maturity. When a company requests support from such a National Eco-Innovation Fund (say funding of a commercial demonstration abroad), the fund would obtain shares in the company on the basis of the value of the support granted. A condition for obtaining such support could be recent success in attracting private sector investors. If done well, such National Eco-Innovation Funds could service the bond coupon and principal payments, turn a profit, and stimulate eco-innovation in the host country, all at the same time.

5.7 A role for the UNFCCC?

The UNFCCC has been promoting the importance of technology, and in particular technology transfer from developed countries to developing countries. However, the goals of the UNFCCC also require a steady flow of new climate technology innovations, no matter where these innovations are conceived. Pushing the climate technology frontier is necessary to reduce the greenhouse gas emissions and to adapt to the consequences of climate change.

A case can be made for the UNFCCC to support climate technology innovations in both developing *and developed* countries, provided that the new technologies are also made available to developing countries. It does not make a lot of sense that the burden and risk of promoting new climate technologies is born by one country and its public resources, if the benefits of successful innovations accrue to all of mankind.

Returning to the concept outlined in Section 5.6, we suggest that the UNFCCC could match national contributions to such National Eco-Innovation Funds, to the extent that the fund focuses on climate technologies, and provided that the climate technologies being developed are made available to developing countries. It appears worthwhile to propose in future international discussions that a limited amount of funding be set aside for such purpose.

Box 2. UNFCCC matching contributions to National Eco-Innovation Funds

We recommend that a proposal be developed for the **UNFCCC** (or one of its related funds and resources) to **match national government contributions to National Eco-Innovation Funds**, provided these focus on climate technologies and that if such National Eco-Innovation Fund is located inside a developed country, the results are made available to developing countries. Any matching request to the UNFCCC by a developed country for a National Eco-Innovation Fund could, through MOUs or LOIs signed with developing countries, substantiate that there is a demand for its climate innovations in developing countries, and that there is a basis for spreading the new climate technologies to developing countries.

6. DEPLOYMENT OF ENERGY EFFICIENCY TECHNOLOGIES

Energy efficiency is a promising approach to reduce greenhouse gas emissions, often with significant co-benefits, and often at negative costs. In other words, environmental benefits from energy efficiency are accompanied by economic benefits. However, much of the potential for energy efficiency improvements does not get realized, both in the developed and in the developing world. The essential problem may be the lack of trust. Market participants need to have confidence that investing in energy efficiency projects will have an attractive return. Financiers need to have the trust that loans to finance energy efficiency projects will be repaid. With these conditions in place, private sector development and implementation of energy efficiency projects will take off.

Incentives will have a role to play in creating such trust. Obviously, if an energy efficiency subsidy increases the internal rate of return of a project, this will be good for the developer and the financier. Thus, targeted incentives and revenues from carbon markets may have a role in creating the above mentioned trust. However, returns may already be attractive, in which case such incentives are not needed (although still welcome).

A much more fundamental issue is how to ensure that loans for energy efficiency projects are repaid and how the technical performance of energy efficiency equipment can be guaranteed. The first issue has been traditionally covered through guarantees (see section 6.1 for an example), while the second issue has recently been tackled by the Ministry of Climate, Energy and Buildings of Denmark, the Inter-American Development Bank (IADB) and the Climate Lab through a new instrument, the energy savings insurance (see section 6.2). In essence, this is an example of 'efficacy insurance' mentioned in the previous section.

Before continuing, it is also important to emphasize the difference in structure between guarantee and insurance: a guarantee provides compensation to the bank, and does not offer compensation to the borrower, while insurance provides compensation for the borrower, in case of underperformance of the equipment.

6.1 Energy efficiency loan guarantees

Energy efficiency loan guarantees have been a popular measure to promote energy efficiency projects and other energy related objectives (e.g. clean energy goals, when combined with renewable energy). In general, banks may be reluctant to lend money to renewable energy and energy efficiency projects due to lack of familiarity. The guarantees reduce the risk to the bank and make it possible for banks to lend to companies and clients wishing to implement energy efficiency and renewable energy projects. As noted before, the advantage for the borrower is

the possibility of receiving loans, which without the guarantees would be unobtainable, or only obtainable at high cost. It should be noted, however, that in general some costs are charged to the borrower.

Two examples are provided below of energy loan guarantees – the first, a US program implemented by the DOE, the second, one of several projects implemented by the Asian Development Bank in China.

DOE Loan Guarantee Program

Section 1703 of Title XVII of the Energy Policy Act (EPAct) of 2005 created the Department of Energy's (DOE's) Loan Guarantee Program. Under Section 1703, DOE is authorized to issue loan guarantees for projects with high technology risks that "avoid, reduce or sequester air pollutants or anthropogenic emissions of greenhouse gases; and employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued."

Loan guarantees are intended to encourage early commercial use of new or significantly improved technologies in energy projects and thus support deployment of new energy technologies, including energy efficiency. The loan guarantee program does not support research and development projects.

Loan guarantees are provided in response to open solicitations. Up to $3 billion is available in loan guarantees for projects in renewable energy, efficient end-use, and efficient generation, transmission, and distribution technologies (plus an additional amount that may be imputed based on the credit subsidy cost of the loan guarantee authority).

Section 1703 requires either an appropriation to cover the Credit Subsidy Cost (the expected long term liability to the Federal Government for providing the loan guarantee) in which case the government would cover the cost of the guarantee, or payment of the Credit Subsidy Cost by the borrower. In the latter case, an interest rate spread will be added based on credit risk (e.g., worse credit risks will have a higher spread added to the loan base rate).

The guarantee is a partial guarantee for 80% of the loan and is only available for projects implemented in the USA.

More information:

http://energy.gov/lpo/loan-programs-office

http://energy.gov/savings/us-department-energy-loan-guarantee-program

ADB EE loans – Guangdong Energy Efficiency and Environment Improvement Investment Program

The Asian Development Bank (ADB) has ample experience with formulating and financing energy efficiency programs. In the Guangdong Energy Efficiency and Environment Improvement Investment Program for example, ADB provided a line of credit for on-lending by participating banks: In addition, it provided a partial risk guarantee to reduce the risk of loss for the energy efficiency loan and supported the development of ESCOs. This package stimulated significant lending in energy efficiency projects, and was backed by the strong interest of the Chinese government.

A later independent evaluation concluded: Partial credit guarantees can encourage commercial energy efficiency lending. A par-

tial credit guarantee offered from a credible source, such as a multilateral development partner or a government, can reduce the risk perceived by commercial banks for energy efficiency lending and help improve the credibility of newly established or small energy service companies. To the extent that a partial credit guarantee backstops energy performance contracting-based projects, it can also provide a good opportunity for banks to interface with energy service companies. This helps both entities better understand and appreciate each other's role in broad-basing energy efficiency investment and financing.

More information:

https://www.adb.org/projects/39653-023/main#project-pds

ADB (2012), *Evaluation Knowledge Study: Review of energy efficiency interventions*. Independent Evaluation Department, Asian Development Bank, Mandaluyong City, Philippines.

6.2 Energy Saving Insurance

The energy savings insurance instrument has been developed at first for Colombia and Mexico. This section discusses the core idea, then mentions an additional element that has been included in the two Latin American countries mentioned above.

The basic idea is that energy efficiency solution providers guarantee a certain performance of the equipment in saving energy. The energy saved will have a certain price. Together with the performance guarantee offered by the energy efficiency solution provider, this would in principle generate a 'guaranteed' revenue flow or savings flow to the investor and its financiers and hence imply a 'guaranteed' return.

For the energy efficiency solution provider, offering such guarantee is risky, while for the investor and financial intermediaries, the question is whether the energy efficiency solution provider would be willing and able to pay in case of shortfalls. To solve this potential problem, the *energy savings insurance* comes in.

According to this concept, the energy efficiency solution provider takes out an insurance policy, which implies a one-time payment of a fixed premium (to be determined; in Latin America the premium is 1-5% of the total contract value). Through the policy, the insurance company commits to make good on shortfalls of the guaranteed energy savings vis-à-vis the guarantee, provided that the equipment is properly operated. Because the insurance company is financially strong and a reliable counterparty, such an insured guarantee from the energy efficiency solution provider will be credible for the investor and the financial intermediary.

Would the insurance company be willing to provide such an insurance? Practice and experience with energy savings insurance have shown so far that the answer to this question is positive. One key aspect is third-party validation of the energy efficiency solutions. Such third party validation from a reputed organization will give insurance companies the comfort that the guarantee to be insured is realistic. Another part of the puzzle is that insurance companies may reinsure part of their risk exposure with large reinsurance companies. This further limits the risk to the insurance company. Further measures can be designed, if needed, to reduce the risk

exposure of the insurance company (discussed below).

Is such an approach attractive for the energy efficiency solution provider? The energy efficiency solution provider would need to take out an insurance policy, which imposes a cost. Would the energy efficiency solution provider be willing to do this and face a reduction in the profit margin? We would argue yes. The reduction in profit margin is used to reduce the risks faced by the investor and financial intermediary, thus making it easier for them to invest and finance the projects. In other words, the reduction in profit margin will lead to an increase in the size of the market.

A final consideration is that the energy savings insurance has many actors that would need to enter into contracts with each other, potentially implying large transaction costs. Additionally, there is the question of the protocol to use in validating the energy savings, which again may be difficult and costly to establish. The key to this issue is to utilize standardized contracts and protocols provided by an impartial organization that has no commercial stakes in this. If the government develops standardized contracts and protocols that are used between the various parties, this will lend credibility to the effort and reduce transactions costs.

Another element of the energy savings insurance concept in Colombia and Mexico

In the implementation of the energy savings insurance concept in Colombia and Mexico, another element was included to further reduce the risk for the insurance company while providing an incentive for energy efficiency solution providers. Part of the payment for the energy efficiency equipment was retained, and only released when the guaranteed performance was met. Additionally, the benefits from over-performance relative to the guarantee were shared 50-50 between the investors and the solution provider.

The energy savings insurance concept has been used in a recently approved application for funding to the Green Climate Fund. See FP009, Energy Savings Insurance (ESI) for Private Energy Efficiency Investments by Small and Medium-Sized Enterprises (SMEs),[30] submitted by the Inter-American Development Bank. This application is for El Salvador, and could provide a good blueprint for use of a similar, domestically developed program in Israel.

See also:

http://www.iadb.org/en/sector/financial-markets/financial-innovation-lab/energy-savings-insurance-esi,19717.html

[30] See GCF (2016), *Consideration of funding proposals – Addendum Funding proposal package for FP009,* GCF/B.13/16/Add.01 http://www.greenclimate.fund/documents/20182/226888/GCF_B.13_16_Add.01_-_Funding_proposal_package_for_FP009.pdf/4066a0de-aaaf-4a71-a800-d6399a24ffd9

7. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Like so many other countries, Israel faces a cleantech innovation challenge: only a (very) few promising cleantech ideas end up as successful, sustainable innovations that reach the market and are the basis for profitable businesses. This phenomenon is called the **valley of death**. In general, it is possible to identify two different valleys of death, an early stage 'technological' valley of death, and a later 'commercialization' valley of death.[31] In the case of Israel, the problem is the latter one, and it is unusually severe as we will explain below.

This challenge of the valley of death calls for government action. On the one hand, there is quite a severe mismatch between private incentives to invest in the commercialization of eco-inventions, due to knowledge spillovers and various risks involved; on the other hand, there is a difficulty in attracting the often substantial amounts of capital that may be needed at this stage to scale-up either the production volumes or the unit sizes, or both. Simply put, successfully innovating companies can bring a country well-paying jobs, employment, tax revenues and other benefits, which are lost if the company fails before reaching maturity, or if it is funded by foreign parties and moves to another country.

There is a counter challenge that governments should not 'pick winners', because governments would be particularly unsuited in selecting early-stage technologies and companies that are bound for success. This argument has some validity, but overstates the case: the private sector (especially the VC funds) also has a track record displaying more than 50% failure rates. On the other hand, some of the government support for emerging technologies has proved to be farsighted, for example the long-term government support for the precursors of Internet from the early 1960s (ARPANET).

Assuming that the government takes action to help (eco-) inventions reach maturity, what instruments does it have available? In the preceding sections we have reviewed a series of instruments that have been used by other OECD countries (and China). In general, these approaches aim to make innovations more attractive, either by **creating markets**, **reducing costs**, **making finance available**, and **reducing risks**. Usually several of these instruments and policies are combined into a policy mix.

For example, several countries have introduced the concept of '**procurement of innovation**', as a means to give clear visibility to a market for (eco-) innovations. This relies on the identification of at least a sizable group of highly interested and motivated buyers, and

[31] The technological valley of death is located between the first and second stages of technological development, as laboratory research seeks further capital to develop a commercial product and prove its basic market viability. The commercialization valley of death arises later in the technology's development, as entrepreneurs seek capital to fund demonstration or first-of-a-kind commercial-scale projects or manufacturing facilities.

at best on the identification of actual orders. This approach can be used when the government procures for its own use (direct procurement), but can also be used in combination with private sector buyers (cooperative procurement), or even when the government sector does not buy at all, but organizes private sector buyers in buyer groups (catalytic procurement). It is particularly popular in Sweden, where it has been implemented over a longer period of time.

In the Netherlands, predictable markets have been created through the Dutch system of **sequential voluntary agreements**, in which the various sector organizations of the Netherlands economy 'voluntarily' agree on increasingly ambitious actions to produce cleaner and with less use of fossil fuels. These voluntary agreements are put in place 'under threat' of government action and regulation if the voluntary agreements are not ambitious enough. Each subsequent voluntary agreement has a higher level of ambition; compliance with each agreement is monitored; and the government makes additional tools and instruments available to assist enterprises in meeting the agreed targets. Again, this creates an environment in which eco-innovators can be sure that there will be a market for suitable eco-innovations.

Assistance in meeting the costs of innovation is another approach that is often used. This may take the form of a subsidy on the total cost of pre-commercial demonstration projects and commercial demonstration (or 'market introduction') projects. Usually the government will only partly fund such projects, with the private sector picking up the remainder of the costs. Such an approach can be especially powerful if a single government-linked organization is responsible for the implementation of a series of subsidies, starting from R&D subsidies and covering the whole innovation chain up to market introduction. In such a way, learning can be maximized and information can be exchanged to ensure that social benefits from knowledge spillovers are maximized. Essentially this is the approach the Netherlands followed in support of the voluntary agreements.

Yet another approach is to make finance available for innovation. This is for example done in China, through the establishment of the **partially state-funded venture capital funds**, the so-called guidance funds, that can provide early support for companies with early (eco-) inventions; support that venture capital funds without government funding would be reluctant to provide. Another interesting approach is the **innovation credit** offered in the Netherlands which only needs to be repaid in the case of successful innovation; see Section 4.6.

Somewhat related to this is the approach based on **guarantees and insurance** to partially eliminate risk. Reducing risks makes it more attractive for the private sector to invest in eco-innovations, and also makes it possible to attract financing. With guarantees or with some type of efficacy insurance in play, banks could provide loans to finance incremental innovations that otherwise would not be able to attract bank funding.

It is very hard to generalize about any 'best solution', partly because of the diversity of challenges that a start-up with an eco-invention faces before it reaches maturity. It matters a great deal whether an innovation is radical or incremental, whether the key problem is the market, whether it takes place within a large corporation or a new start-up without funding, and whether the technology is such that production at high volumes or larger unit sizes is problematic or not. Given

this, and also given the pervasiveness of the problem of the valley of death, any suggestions for Israel need to be made with caution.

With this caution in mind, we would like to suggest that Israel implements several measures that would create a predictable market for eco-innovations; a predictable market that innovating companies could rely on. In particular, we **suggest that Israel implement a procurement of innovation program, together with a system of interlocking sectoral agreements** of increasing ambition. Both measures would not require a substantial amount of fiscal resources and could, at least in the case of the sectoral agreements, likely benefit from assistance by international managers who have been implementing this approach in other countries.

In addition to this, if sufficient resources can be made available (see discussion below), a system of other support measures should be made available to companies on request: **subsidies** for projects along the innovation trajectory covering activities from **R&D to commercial demonstration (market introduction)**, ideally implemented through one single government-linked organization; a wider set of **guarantees to enable obtaining bank loans**, and **access to risk-bearing equity funding**. More on how this could be structured below. The key point is that given the multitude of challenges that could hinder successful innovation, a portfolio of instruments (or policy mix) need to be mobilized, along with the flexibility to use these in the most practical manner, on an *ad hoc* basis. Support needs to be predictable, yet be provided in the manner most suited to a particular case.

A crucial issue that needs to be addressed is Israel's market size. Examples for creating a predictable market for innovations are provided by Sweden and the Netherlands. Both countries attach significant importance to the environment, and the sizes of the economies of these countries is considerable. In 2015 the GDP of Sweden and the Netherlands were USD 493 billion and USD 750.7 billion respectively. Israel's economy is smaller (USD 299.4 billion) and perhaps less environmentally conscious, raising the question whether domestic measures to create a predictable market would provide a sufficient incentive for eco-innovation.

To address the limited size of the domestic market, Israel should also consider the **international market opportunities**. In particular, there are significant synergies available with various climate change and climate finance related initiatives. We explore these in the next few paragraphs, discussing first some of the current initiatives Israel may consider joining, and then a few possibilities for Israel to organize its climate finance contributions. The latter are more fully developed in a companion report to this paper.[32]

The **Mission Innovation** and related **Breakthrough Energy Coalition** initiatives offer significant opportunities for Israel. At the 7th Eilat-Eilot Renewable and Clean Energy Conference (end of November 2016) it was announced that Israel had joined Mission Innovation. This is a precondition for (possibly) getting funding from the investors organized in the Breakthrough Energy Coalition and requires a doubling of the public R&D budget for clean energy. However, it also offers several strategic opportunities, such as possibilities for joint research and joint demonstrations that could pave the way for entering

[32] Van der Tak, C.M. (2016), *Israel and international climate finance: Final report*. Report prepared for the ClimaSouth project.

new cleantech markets and for launching some of the instruments mentioned below. On balance, it seems worthwhile for Israel to join, in particular if Israel's additional public-funded efforts to commercialize inventions could count towards the goal of doubling public R&D in clean energy, and if water could be added as an additional topic of interest.

As an OECD member country, Israel is expected to provide climate finance under the climate convention. The previously-mentioned report on Israel's international climate finance opportunities and obligations, suggests a few instruments that could further help to create international markets for Israel's cleantech innovations through concrete measures and investment programs. Particular suggestions that are worth mentioning in this regard are:

- **Mitigation technology loans & insurance**, which are loans and insurance to finance (or insure) commercial demonstration projects incorporating relatively new technologies, that are new to the host country. The loans or insurance are concessional (e.g., zero interest rate loans), but in addition, the investor (Israel) shares in the emission reductions achieved in the commercial demonstrations and their replications through a transfer of part of the emission reduction results as ITMOs.
- **Climate innovation funding programs**, which are a combination of Israeli funding (in a cost-effective manner) commercial demonstration projects in developing countries and an agreed 'concessional innovation rollout financing facility' (CIRFF) made available by international sources of climate finance that will fund replication of successful commercial demonstrations.
- **Concepts** such as those outlined in the two previous paragraphs require considerable effort to be translated into concrete actionable programs. One of the suggestions in the International Climate Finance report, is for a preparatory facility that could be used to finance the development of such programs. This could be done through the **Israel Climate Finance Proposal Preparation Facility** (ICFPPF). This is a facility provided by the Israeli government that will share in the costs and risks of preparing a climate finance proposal for concessional funding by international sources of climate finance in support of Israeli exports and investments to/in developing countries.

An internationalization strategy for Israel's cleantech innovations is very important. It increases the likelihood that cleantech inventions will successfully find a market, and it addresses Israel's technology transfer obligations under the climate convention as an OECD member country. Further to the above and as elaborated in the international climate finance report, we also recommend that Israel benchmarks its instruments for export and outward FDI promotion and facilitation, with an eye towards sharpening its tools that could help create markets for cleantech innovations.

The various suggestions outlined above cost money to implement, and it may be the case that the government of Israel is unable to commit sufficient resources to fund these proposals as well as those made in the companion international climate finance report. However, we believe that an attractive financing structure can be devised that will make it possible to implement all recommendations in both reports with limited fiscal implications.

Israel could issue a climate bond (or a more generic green bond), backed by a sovereign guarantee, the proceeds of which would be used to finance a **government-owned fund** (for the moment called the **Eco-Innovate Israel Fund**). The Eco-Innovate Israel Fund's objective would be to invest in cleantech innovation through various measures aiming to take the eco-invention to commercial maturity. This may for instance be co-funding a demonstration project or a commercial demonstration project. When a company requests some type of support from Eco-Innovate Israel Fund to develop an eco-innovation (say funding of a commercial demonstration abroad), the fund would obtain shares in the company, on the basis of the value of the support offered. The fund would have a portfolio of instruments to choose from to support innovating companies; choices of instruments should be pragmatic and subject to evaluation for effectiveness.

The company requesting the support would co-fund the selected activities. In addition, to avoid a charge of 'trying to pick winners', a condition for such support could be recent success in attracting private sector investors. Eco-Innovate Israel Fund would make a return on a successful exit, just as another venture capital fund. If done well, such returns of the Eco-Innovate Israel Fund will be sufficient to service the bond coupon and principal payments, turn a profit, and stimulate eco-innovation in Israel.

Indeed, the last concept may be generalized and be directly supported by the UNFCCC. We therefore propose that developed countries with an interest in promoting climatech innovations (such as Israel) could issue a climate bond, backed by a sovereign guarantee. As suggested above, the proceeds would be used to finance a government-owned **National Eco-Innovation Fund**, to invest in climatech innovation and support various measures aiming to take the eco-invention to commercial maturity, with further details as described for the Eco-Innovate Israel Fund.

Additionally, we recommend that in international context, it will be proposed that the **UNFCCC** (or one of its related funds and resources) **matches national government contributions to National Eco-Innovation Funds**, provided these focus on climate technologies and that if such a National Eco-Innovation Fund is located within a developed country, the results will be made available to developing countries. Any matching request to the UNFCCC by a developed country for a National Eco-Innovation Fund could, through MOUs or LOIs signed with developing countries, substantiate that there is a developing countries' demand for its climate innovations in developing countries, and that there is a basis for spreading the new climate technologies to developing countries.

On the basis of this discussions, our concrete recommendations are:

1. Discuss the measures proposed (see next points), select the ones that are considered for implementation, decide the financing modalities, detail the proposals, and make a final decision.

2. Create predictable markets for eco-innovations through procurement of eco-innovation and interlocking voluntary agreements with increasing ambition over time.

3. Decide how the following recommendations requiring larger budgets should be financed. In this report it

is assumed through a green bond financing Eco-Innovate Israel Fund.

4. Initiate discussions with Mission Innovation on Israel's potential joining of the initiative

5. Establish Eco-Innovate Israel Fund, including its procedures and organization.

6. Create a system of subsidies covering the innovation chain

7. Expand the system of guarantees for eco-investments

8. Establish a system of efficacy insurance, initially focusing on energy efficiency as a test case.

9. Implement the recommendations of the international climate finance report, including those relating to the climate technology loans & insurance, the climate innovation funding programs, and the Israel Climate Finance Proposal Preparation Facility.

10. Promote the concept of multilateral contributions to national funds for the promotion of eco-innovations in their early stages (here called National Eco-Innovation Funds), no matter where these funds are located (both in developing and in developed countries).

11. Regularly benchmark Israel's export and outwards foreign direct investment promotion and facilitation program against best practice.

12. Monitor and evaluate regularly so that relevant lessons can be learned and practices adapted.

REFERENCES

ADB (2012), *Evaluation Knowledge Study: Review of energy efficiency interventions*. Independent Evaluation Department, Asian Development Bank, Mandaluyong City, Philippines.

Beard, T.R. et al (2009), A Valley of Death in the innovation sequence: an economic investigation, *Research Evaluation, 18(5), December 2009*, pp. 343-356.

Branscomb, L.M. and P.E. Auerswald (2002), *Between Invention and Innovation: An Analysis of Funding for Early-Stage Technology Development*. National Institute of Standards and Technology, Gaithersburg.

Cincera, M. et al (2011), Efficiency of public spending in support of R&D activities, *Reflets et perspectives de la vie* économique *2011/1 (Tome L)*, pp. 131-139.

De Minister van Economische Zaken (1998), *Uitvoeringsregeling BSE 1998-I*. 's Gravenhage. [Implementation regulation decision subsidy energy programs]

Ford, G.S. et al (2007), *Discussion Paper: An Economic Investigation of the Valley of Death in the Innovation Sequence*. Phoenix Center for Advanced Legal & Economic Public Policy Studies.

GCF (2016), *Consideration of funding proposals – Addendum Funding proposal package for FP009*, GCF/B.13/16/Add.01. http://www.greenclimate.fund/documents/20182/226888/GCF_B.13_16_Add.01_-_Funding_proposal_package_for_FP009.pdf/4066a0de-aaaf-4a71-a800-d6399a24ffd9

Hartley, P.R. and K.B. Medlock III (2013), The Valley of Death for New Energy Technologies. *UWA Economics Discussion Papers 14.14*. University of Western Australia, Crawley.

House of Commons Science and Technology Committee (2013), *Bridging the valley of death: improving the commercialisation of research: Eighth Report of Session 2012–13*. The Stationery Office Limited, London.

Hug, V. (2009), *Bridging the Valley of Death: public support for commercialisation of eco-innovation. Final Report*. COWI A/S, Kongens Lyngby.

Jenkins, J. and S. Mansur (2011), *Bridging the Clean Energy Valleys of Death: Helping American entrepreneurs meet the nation's energy innovation imperative*. Breakthrough Institute, Oakland.

Murphy, L.M. and P.L. Edwards (2003), *Bridging the Valley of Death: Transitioning from Public to Private Sector Financing*. National Renewable Energy Laboratory, Golden Colorado.

Nemet, G.F. (2016), The Valley of Death, the Technology Pork Barrel, and Public Support for Large Demonstration Projects. *DIW Berlin Discussion Papers 1601*, Deutsches Institut für Wirtschaftsforschung, Berlin.

Niosi, J. (2009), Bridging Canadian Technology SMEs Over the Valley of Death. *International Productivity Monitor*, Number 18, Spring 2009, pp. 80-84.

Overheid der Nederlanden (1994), Besluit subsidies energieprogramma's. 's Gravenhage. [Decision subsidies energy programs]

Parad, M. et al (2014), *The Global Cleantech Innovation Index 2014: nurturing tomorrow's transformative entrepreneurs*. Cleantech Group and WWF.

Rizzo, A. (2016), *Transparency of Climate Action in the ENPI South Region*. Policy paper prepared for the ClimaSouth project (www.climasouth.eu)

Samuel Neaman Institute for National Policy Research (2015), *The Israeli renewable energy and energy efficiency industry: Status update and policy recommendations for leveraging Israel's R&D and industry potential. Executive Summary*.

Shaviv, E. M.E. Caine and G. Grossman (2013), *Clean Energy Innovation Policy in Israel: Identifying Fundamental Principles through a Case Study of Smart Grid Policy*. Samuel Neaman Institute.

Van der Tak, C.M. (2016), *Israel and international climate finance: Final report*. Report prepared for the ClimaSouth project.

Wallace, D. (1995), *Environmental Policy and Industrial Innovation: Strategies in Europe, the US and Japan*, Earthscan.

Wessner, C. (2003), *Public/Private Partnerships for Innovation: Experiences and Perspectives from the U.S.* Presentation. US National Academy of Sciences.

Websites

- https://www.adb.org/projects/39653-023/main#project-pds
- http://british-business-bank.co.uk/ourpartners/enterprise-finance-guarantee/
- https://catapult.org.uk/
- https://connect.innovateuk.org/web/ktp
- https://www.gov.uk/government/collections/sbri-the-small-business-research-initiative
- https://www.gov.uk/government/publications/government-challenges-ideas-from-business-innovative-solutions
- http://www.iadb.org/en/sector/financial-markets/financial-innovation-lab/energy-savings-insurance-esi,19717.html
- http://www.icaew.com/-/media/corporate/archive/files/about-icaew/what-we-do/policy/budget-and-pbr/20120319-nlgs-key-messages-for-businesses.ashx?la=en
- https://www.innovation-procurement.org/

Annex 1.
SELECTED PPI AND PCP EXAMPLES

Table A1.1 Examples of PPI and PCP for low-carbon innovation in the EU

Country	Description
NORWAY	Statoil and Gassnova, Norwegian oil and gas operators governed by public law, launched a pre-commercial procurement in July 2011 to get innovative solutions developed for carbon capture and storage. The PCP finished in early 2013 and successfully compared solution approaches from 5 vendors representing different carbon capture technology approaches. The Carbon Capture Mongstad PCP project is a large industrial and technological development project, and a plant of similar size has never been built before.
NETHERLANDS	A PCP was launched in 2013 by the province of Brabant, in cooperation with the Ministry of Infrastructure and the Environment, which is focusing on Intelligent Transport Solutions for resolving shockwave jams.
SWEDEN	The Swedish Transport Administration, the Swedish Innovation Agency and the Swedish Energy Agency have launched a large PCP of demonstrators for electric traction of heavy lorries and other larger vehicles in 2013. Swedish environmental/energy efficiency PPIs has also been carried out by the Swedish Energy Agency, targeted at heating-ventilation-cooling of buildings, public transportation (hydrogen busses), office blocks (sun shading, lighting), appliances (washing machines, fridges) and wind energy parks. These PPIs, in combination with product certification/labelling and other subsidies and tax incentives have yielded a reduced dependency on nuclear energy of Sweden by 15%
UK	Low carbon healthcare PPI started 2006, introducing more energy efficient LEDs in networks of over 20 hospitals in 8 EU countries (cross border PPI cooperation funded by EC/DG ENTR). The PPI led to 30% energy consumption saving and 88% maintenance savings. Also, the total cost savings enable the hospital to take in, on average 10% more patients.

Source: Public Demand Driven Innovation PCP and PPI in Horizon 2020, EU Commission, 2013

Annex 2.
ENABLING FRAMEWORK FOR MISSION INNOVATION

"ENABLING FRAMEWORK" FOR MISSION INNOVATION

Approved 1 June 2016 at the Inaugural Ministerial of Mission Innovation

The Governments of Australia, Brazil, Canada, Chile, China, Denmark, France, Germany, India, Indonesia, Italy, Japan, Mexico, Norway, Republic of Korea, Saudi Arabia, Sweden, the United Arab Emirates, the United Kingdom, and the United States, and the European Commission on behalf of the European Union (hereinafter collectively referred to as the "Members"),

Underscoring that accelerating widespread clean energy innovation is an indispensable part of an effective, long-term global response to our shared climate challenge, and thereby supporting the Paris Agreement reached at the 21st Conference of Parties to the United Nations Framework Convention on Climate Change; is necessary to provide affordable and reliable energy for everyone and to promote economic growth, as committed to in the sustainable development goals; and is critical for energy security;

Acknowledging that while important progress has been made in cost reduction and deployment of clean energy technologies, the pace of innovation and the scale of economy-wide transformation and adoption remains significantly short of what is needed;

Recognizing that while each Member's clean energy research and development portfolio is unique and reflects national priorities, all Members share the common goal to accelerate the pace of clean energy innovation now underway;

Appreciating that businesses and investors play a vital role in bringing new technologies to market, and noting, in particular, the significant commitment made by the Breakthrough Energy Coalition; and

Acknowledging the important role played by regional and intergovernmental organizations, non-governmental organizations, universities, and private research institutions in contributing to clean energy innovation,

Set forth the following Enabling Framework for Mission Innovation ("Enabling Framework"):

I. MISSION STATEMENT

In support of economic growth, energy access and security, and an urgent and lasting global response to climate change, our mission is to accelerate the pace of clean energy innovation to achieve performance breakthroughs and cost reductions to provide widely affordable and reliable clean energy solutions that will revolutionize energy systems throughout the world over the next two decades and beyond.

II. ACTIONS

A. Doubling Investment. Each Member seeks to double its governmental and/or state-directed investment in clean energy research and development over five years;

B. Information Sharing. Members intend to formulate and implement an information sharing system that can efficiently and flexibly:

1. Provide information on plans for and progress toward each Member's efforts to seek to double clean energy research and development investment over five years;
2. Facilitate, where appropriate, cooperation between and among Members on research and development needs, priority-setting, collaborative opportunities, projects, and best practices; and
3. Facilitate engagement with and investment by investors, businesses, and industry.

C. Innovation Analysis and Roadmapping. Interested Members intend to work together, and with existing centers of analytical expertise, to:

1. Collate, review, and share analysis to provide more readily accessible insights into the role innovation can play to address key global and regional clean energy systems;
2. Commission, as supported by interested Members, new analysis to address gaps in our current understanding;
3. Map existing and planned public and business activities onto identified needs in order to identify gaps and opportunities; and
4. Communicate insights into the most critical innovation needs to decision-makers in the public and business sectors.

D. Joint Research and Capacity Building. Members intend to collaborate on joint research and capacity building, where mutual interest exists, to:

1. Help leverage the combined knowledge, capabilities, and resources of Members;
2. Promote common principles and good practices;
3. Share expertise and identify, promote, and utilize available platforms for collaboration; and
4. Facilitate bilateral and multi-lateral research partnerships, where there is mutual interest, and help enhance collective global capacity.

E. Business and Investor Engagement. Interested Members intend to pursue opportunities to identify and engage prospective businesses and investors to:

1. Exchange information and build relationships;
2. Improve mutual understanding of perspectives and priorities regarding clean energy innovation needs and opportunities;
3. Attract and encourage investment in emerging technologies to expand and enhance the innovation pipeline; and
4. Accelerate the realization of benefits to the Members from the most promising ideas.

III. ORGANIZATION AND PROCESSES

A. Members consist of the 20 countries that endorsed the Joint Launch Statement on 30 November 2015 and additional countries and regional economic integration organizations that meet the following criteria:

1. Endorse this Enabling Framework;
2. Document clean energy research and development baseline and a doubling plan, as referred to in Section II.A.; and
3. Evidence efforts, activities, and capacity to help accelerate clean energy innovation and contribute to Mission Innovation's overall global effort.

B. Each Member should independently determine the best use of its own clean energy research and development funding and define its own path to reach the doubling goal according to its own priorities, policies, processes, and laws; as well as the extent to which it participates in any international collaborations.

C. Determinations impacting all Members (e.g., changes to this Enabling Framework, additions of new Members, statements issued on behalf of all Members, and other recommendations by the Steering Committee to all Members) should occur on a non-objection basis following an opportunity for input from all Members.

Given the voluntary, bottom-up nature of Mission Innovation, many collaborative efforts that develop organically over time may proceed with the support of two or more interested Members and not require approval by all Members. Members not adhering to a specific collaboration will not be obligated by its results.

D. A Steering Committee, comprised of an efficient number of diverse Members serving staggered, two-year, renewable terms, is to be created to provide high-level strategic guidance to:

1. Foster implementation of the Enabling Framework
2. Make recommendations through consensus to all Members in a transparent manner, including by sharing minutes of all Steering Committee discussions;
3. Facilitate implementation of outreach and communication strategies; help achieve progress on projects and events; and ensure Mission Innovation is providing maximum value to all Members;
4. Help arrange funding as needed to implement the Enabling Framework; and
5. Create Sub-Groups to carry out specific tasks, as needed.

E. A Secretariat is to consist of a small, flexible team with an initial focus on carrying out core administrative functions (e.g., logistics support for meetings and calls; gathering, sharing, and posting information). The need for additional support functions will be considered as Mission Innovation's work programme develops. The Secretariat is to provide support to and be overseen by the Steering Committee.

F. This Enabling Framework was approved at the Inaugural Mission Innovation Ministerial Meeting on 1 June 2016, held in the United States in San Francisco, California. Activities under this Enabling Framework may continue for five years unless the Enabling Framework is discontinued by determination of the Members in accordance with Section III.C of this Enabling Framework. This Enabling Framework may be modified or extended for additional periods upon determination of the Members in accordance with Section III.C of this Enabling Framework.

G. This Framework does not create any legally binding obligations for any Member, or between or among the Members.

Annex 3.
BREAKTHROUGH ENERGY COALITION INVESTMENT PRINCIPLES

Technology will help solve our energy issues. The urgency of climate change and the energy needs in the poorest parts of the world require an aggressive global program for zero-emission energy innovation. The new model will be a public-private partnership between governments, research institutions, and investors. Scientists, engineers, and entrepreneurs can invent and scale the innovative technologies that will limit the impact of climate change while providing affordable and reliable energy to everyone. The existing system of basic research, clean energy investment, regulatory frameworks, and subsidies fails to sufficiently mobilize investment in truly transformative energy solutions for the future. We can't wait for the system to change through normal cycles.

The foundation of this program must be large funding commitments for basic and applied research, and here governments play the key role. Only our governments have the mandate to protect the public interest as well as the resources and mechanisms to do this. We know government investment in research can lead to the creation of industries that advance the common good and are driven by private capital. We have seen big successes before with government-funded research programs in space, defense, technology, and medical research, seeding private creativity which has produced many of the innovations that define our current way of life. The political will is emerging to do this again, through aggressive increases in government funding for basic and applied energy research, which can lead to breakthrough technologies for our energy future. However, current governmental funding levels for clean energy are simply insufficient to meet the challenges before us.

Government research, however, is not enough. We must also add the skills and resources of leading investors with experience in driving innovation from the lab to the marketplace. The private sector knows how to build companies, evaluate the potential for success, and take the risks that lead to taking innovative ideas and bringing them to the world. But in the current business environment, the risk-reward balance for early-stage investing in potentially transformative energy systems is unlikely to meet the market tests of traditional angel or VC investors – not until the underlying economics of the energy sector shift further towards clean energy. Experience indicates that even the most promising ideas face daunting commercialization challenges and a nearly impassable Valley of Death between promising concept and viable product, which neither government funding nor conventional private investment can bridge. This collective failure can be addressed, in part, by a dramatically scaled-up public research pipeline, linked to a different kind of private investor with a long term commitment to new technologies who is willing to put truly patient flexible risk capital to work. These investors will certainly be motivated partly by the possibility of making big returns over the long-term, but also by the criticality of an energy transition. Success will provide the economic proof points necessary for the mainstream market-driven clean energy economy required for our planetary future.

We are committed to doing our part and filling this capital need by coming together in a new coalition. We will form a network of private capital committed to building a structure that will allow informed decisions to help accelerate the change to the advanced energy future our planet needs. Success requires a partnership of increased government research, with a transparent and workable structure to objectively evaluate those projects, and committed private-sector investors willing to support the innovative ideas that come out of the public research pipeline.

Together we will focus on early stage companies that have the potential of an energy future that produces near zero carbon emissions and provides everyone with affordable, reliable energy. We will invest based on a few core investment principles:

1. Invest Early

The most transformative ideas are emerging out of research institutions and the great capital gap is in getting these ideas out of the lab and on the path to commercialization. We'll take a flexible approach to early stage, providing seed, angel and Series A investments, with the expectation that once these investments are de-risked, traditional commercial capital will invest in the later stages.

2. Invest Broadly

We don't know where the best ideas will come from to transition the world to a near zero-emissions energy future, so we will invest across a number of sectors:

a. Electricity generation and storage

b. Transportation

c. Industrial use

d. Agriculture

e. Energy system efficiency

3. Invest Boldly

We are looking for outliers both in developing novel technologies AND in innovations which enable current technologies to be dramatically more efficient, scalable, or cheaper. Whether core or enabling technology, the key differentiating factor must be a credible pathway to rapid scaling – providing affordable energy to the greatest number of people without overburdening essential resources including land use.

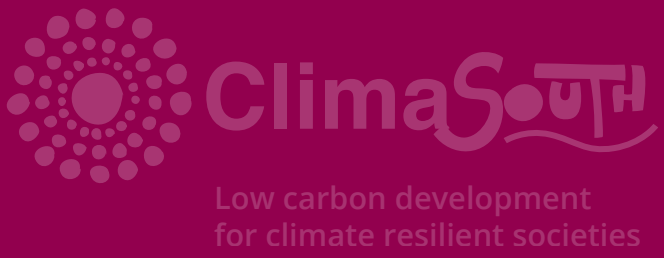
4. Invest Wisely

One of the challenges to effective financing in this area is a lack of depth in terms of technical review and analysis of underlying science and technology to guide investment decisions. To tackle this, we will work with a coalition of the world's best minds, in partnership with leading public and private institutions, to guide investment decision-making.

5. Invest Together

Because the foundation of these innovations will likely come through government research pipelines, we will focus our investments on those countries that have committed to increase the size of those pipelines by participating in the international initiative known as Mission Innovation. Those countries are making a serious commitment to using smart government spending to increase the rate of innovation in their domestic innovation sector while helping the world find solutions to the serious problems created by climate change, high costs of power, and energy price volatility.

Over the next year, we will work together to develop effective and creative mechanisms to analyze potential investments coming out of the research pipeline, create investment vehicles to facilitate those investments, and expand the community of investors who join us in this endeavor.


ClimaSouth
Low carbon development
for climate resilient societies