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Clean-Tech Clustering as
an Engine for Local
Development: The Negev
Region, Israel

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Entrepreneurship, SMEs and Local Development

**CLEAN-TECH CLUSTERING
AS AN ENGINE FOR LOCAL
DEVELOPMENT:
THE NEGEV REGION,
ISRAEL**



**A REPORT BY THE OECD
LOCAL ECONOMIC AND EMPLOYMENT DEVELOPMENT (LEED) PROGRAMME**

ENTREPRENEURSHIP, SMEs AND LOCAL DEVELOPMENT:

**CLEAN-TECH CLUSTERING AS AN ENGINE FOR LOCAL DEVELOPMENT IN THE
NEGEV REGION, ISRAEL**

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

Innovation and entrepreneurship are the driving forces of Israel and this is what makes it a model to other OECD countries and beyond. Water, innovation and green growth are all high priorities for the OECD, and Israel's contribution to these key priorities is much larger and deeper than the size of the country might suggest. The case that is addressed in this report is a clear example on how a country can effectively face global challenges and transform them into economic opportunities, creating new firms and consolidating a fabric of high-tech businesses leading to job creation and wealth.

Israel joined the OECD and the LEED Committee only recently, but already stands out for its capacity to interact with other countries and engage in the substantive sharing of knowledge in economic development policy which is highly appreciated and valuable. The strong partnership between the Ben Gurion University, industry and public authorities today form a solid basis for clean-tech development in Israel and in the Negev.

However, the exemplarity of Israel is not only the effective governance of the process in which a high dose of social capital and trust is key, but also the speed and effectiveness at which this is implemented. In a knowledge-based economy, the rapidity of the system is essential to avoid obsolescence, and Israel is a world-wide example of entrepreneurship promotion, innovation support and industry financing.

The clean-tech sector in Israel is well conceived and rapidly implemented in the logic of enabling growth, innovation and technology, while creating jobs and wealth in peripheral and scarcely populated regions. In line with the philosophy of the LEED Committee, Israel is supporting local economic development approaches to guarantee a better life for businesses and individuals outside the large cities.

This has been an extremely interesting project, allowing the LEED Committee and the OECD Secretariat to better understand the complexity of this "Start-up Nation". There are indeed no one size fits all recipes, but it is clear that the Israel case is a model for other countries that is worthwhile examining. I am confident that the analysis and recommendations of this report will be useful for policy makers and practitioners in Israel and around the globe. I would like to thank Israel for the opportunity they gave us to contribute to this project.



Sergio Arzeni
Director, OECD Centre for Entrepreneurship
Head, OECD LEED Programme

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This case study of clean-tech development in the Negev region of Israel is part of the series of reviews on Boosting Local Entrepreneurship and Enterprise Creation of the Local Economic and Employment Development (LEED) Committee of the Organisation for Economic Co-operation and Development (OECD). This work stream is led by Dr. Jonathan Potter, senior economist in the OECD Centre for Entrepreneurship, SMEs and Local Development.

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Additional thanks go to the international experts that contributed with knowledge and chapters for this report, including: Prof. Phil Cooke, Centre for Advanced Studies, Cardiff University UK; Dr. Karen Chapple, Faculty Director, Center for Community Innovation, University of California, Berkeley, USA; Dr. Dieter Rehfeld, University of Applied Science Gelsenkirchen, Germany; and Dr. Grégory Theyel, Senior Research Fellow, University of Cambridge UK. The Ben Gurion University team formed by Dr. Dan Kaufmann, Dr. Miki Malul and Dr. Mosi Rosenboim also provided useful information and analysis on the nature of the Clean-tech industry in Israel and the Negev and a chapter in the report.

This project was led by Dr. Jonathan Potter and Ms. Gabriela Miranda from the OECD LEED Secretariat, who also prepared this report.

TABLE OF CONTENTS

FOREWORD.....	3
EXECUTIVE SUMMARY	9
Main findings	9
Clean-tech potential.....	9
Gaps to fill.....	10
International lessons.....	10
Business.....	10
Research	10
Human Capital.....	11
Key pillars of a regional clean-tech strategy	11
INTRODUCTION.....	12
CHAPTER 1. EXISTING CLEAN-TECH ACTIVITIES IN THE NEGEV	14
Abstract.....	14
Overview of the Negev region	14
Population.....	14
Labour force	15
Economic structure.....	16
Existing clean-tech activity in Israel and the Negev.....	16
Main fields in the clean-tech industry	18
Policy for Clean-tech in Israel	20
Office of the Chief Scientist.....	20
Investment Centre	26
Regional Development Centre	26
Technology Centres in the Negev	27
Steering Committee for Water	27
Feed-In Tariffs.....	27
NewTech Initiative.....	27
Venture Capital and Private Equity Investment	27
Basic assessment of existing conditions for clean-tech development in the Negev	28
Strengths.....	28
Weaknesses	29
Opportunities.....	29
Threats.....	29
REFERENCES	30
CHAPTER 2. CREATING CLEAN-TECH CLUSTERS: LESSONS FOR THE NEGEV	31
Abstract.....	31
Introduction.....	31
The evolution of clean-tech clusters	32
The role of policy in clean-tech cluster emergence	34
Recommendations.....	35
ANNEX – LEARNING MODELS	37

North Jutland, Denmark: Collective Entrepreneurship in Clean-tech	37
Emerging Danish competitive advantage in renewable energy based on wind power	37
Enlightened and Innovative Green Public Procurement	39
A favourable national policy framework.....	40
A ‘cluster management organisation’ and joint innovation incentives	40
The role of local clean-tech demonstration projects	41
Summary of success factors	42
Sweden’s Regional Climate Change Strategies	42
The Norrland cluster.....	42
The Skåne cluster	43
The Västra Götaland cluster	44
California’s Sustainable Development Policies: from Vehicle Emissions to Climate Change	46
California: A Leader in Sustainable Development Policies	46
Clean-tech Cluster Formation	46
REFERENCES	48
CHAPTER 3. PROMOTING BUSINESS DEVELOPMENT	49
Abstract.....	49
Policy Issues	49
Analysis of the current system.....	50
Negev Industrial Ecosystem.....	50
Negev Clean-tech Sub-Cluster	50
Assessment of the Business Sector	54
Strengths.....	54
Weaknesses	55
Opportunities.....	56
Threats.....	56
Recommendations.....	57
Develop Regional Demand for Clean-technology in the Negev Region	57
Develop Regional Supply of Clean-technology Capabilities in the Negev Region	58
Create a Clean-tech Development Plan for the Negev and Israel	59
ANNEX – LEARNING MODELS	61
San Francisco Bay Area Clean-technology Economy, USA	61
Cambridge, England Clean-tech Cluster.....	62
Masdar Clean-technology Initiative, Abu Dhabi	64
REFERENCES	67
CHAPTER 4. STRENGTHENING RESEARCH INSTITUTIONS	69
Abstract.....	69
Policy issues.....	69
Analysis of Research Institutions in Israel and the Negev.....	70
Strengths.....	70
Weaknesses	73
Opportunities.....	75
Threats.....	77
Recommendations.....	77
Strengthen the Negev’s clean-tech research and make it more visible	77
Strengthen the commercialisation of knowledge	79
Set the scene to “green the Negev”	80

ANNEX – LEARNING MODELS	81
Green Building Cluster Lower Austria	81
Solar Valley Mitteldeutschland.....	83
Finnish National Cluster of Expertise	84
REFERENCES	87
CHAPTER 5. BUILDING THE LABOUR MARKET AND HUMAN CAPITAL	89
Abstract.....	89
Labour market challenges in clean-tech.....	89
Analysis of the labour market in the Negev and Israel	91
Inequality.....	91
Immigration to and within Israel	93
Institutional and regulatory framework	93
The labour market for clean-tech	94
Assessment of the labour market	95
Strengths.....	95
Weaknesses	96
Opportunities.....	97
Threats.....	98
Recommendations.....	99
Improve the flow of specialized knowledge to and from the region	99
Ensure that disadvantaged local residents gain access to job opportunities in the clean-tech sector ...	101
Create a comprehensive green strategy for urban development in the Negev	102
Create comprehensive regulation that links environmental and economic development goals	103
ANNEX – LEARNING MODELS	105
National Renewable Energy Laboratory, Colorado, United States.....	105
Eco Towns, United Kingdom	108
Environmental Regulation and Labour Markets, California, United States	110
Cleantech to Market, UC Berkeley Haas School of Business, United States	113
REFERENCES	116
CHAPTER 6. CONCLUSIONS	119
The strategic importance of clean-tech development in the Negev	119
The need for a cluster framework	120
A sub-cluster with assets and gaps	120
Building connections across agents.....	121
The six core elements of the cluster strategy	122
1. Centres of excellence and an inter-disciplinary clean-tech programme	122
2. A clean-tech validation centre.....	122
3. Collaborative innovation projects	123
4. A green strategy for the Negev underpinned by green public procurement and regulation.....	123
5. Transform Eilat into Israel’s model green city.....	123
6. A regional cluster management organisation	124
Inspiration from international clean-tech cluster experiences	124

Figures

Figure 1.	Age structure	15
Figure 2.	OCS Funds in Private Sector R&D	21
Figure 3.	Total R&D Budget for Support Routes	22
Figure 4.	Chief Scientist Grants by Technology Sector (2000 vs 2010)	22
Figure 5.	OCS Programmes	23
Figure 6.	Technology Incubators by Activity Fields (2009).....	24
Figure 7.	R&D Grants for Clean-tech.....	26
Figure 8.	The Wind Turbine Cluster in North Central Jutland, Denmark	39
Figure 9.	Shift from Centralised to Decentralised Combined Heat and Power	40
Figure 10.	Örnsköldsvik Biorefinery Cluster, Norrland Region, Sweden	43
Figure 11.	Modules contributing to emergence of innovative platforms in Skåne, Sweden	44
Figure 12.	Västra Götaland's 'Iconic Projects' Approach	45
Figure 13.	Clean Tech Cluster Components	51
Figure 14.	The Clean Tech innovation eco-system in the Negev	72
Figure 15.	Average PISA score for science in OECD and accession countries, 2006.....	92
Figure 16.	Foreign workers as a percentage of the labour force.....	93
Figure 17.	Distribution of existing workforce by occupation and region, 2009	95

Boxes

Box 1. Green MBA Programmes.....	101
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EXECUTIVE SUMMARY

This report explores the potential to grow clean-tech cluster activity in the Negev region of Israel as an engine for local economic and employment development. This will enable the Israeli government to meet two critical challenges: promotion of a green growth strategy that will generate jobs and income growth in line with the sustainable use of natural resources; and regional development in a priority peripheral region based on exploitation and enhancement of its existing assets.

The report was prepared as part of the programme of work of the Local Economic and Employment Development (LEED) Committee of the Organisation for Economic Co-operation and Development (OECD) in collaboration with the Regional Development Centre in the Israeli Ministry of Industry, Trade and Labour (MOITAL). It is based on a review of data, literature and policy documents on clean-tech and regional development in Israel, a set of stakeholder interviews in the Negev region and at national level, analyses and assessments by international experts, identification and review of international learning model experiences relevant to the Negev, and a workshop to discuss the results with stakeholders that participate in region's clean-tech cluster activity and can help provide the stimulus for its growth.

Main findings

Clean-tech potential

This review concludes that there is good potential to grow clean-tech activity in the Negev, as part of a wider Israeli clean-tech cluster. The Negev region offers a set of specialised assets across business, research, networks, labour, facilities and natural resources that can enable it to strengthen Israeli clean-tech activity in two important niche areas: renewable energy technologies and water management technologies. Within these two technology areas, the Negev's particular contribution will be focused on developing its existing strengths in research, development, demonstration and testing and generating economic spin-offs from them.

The potential of Negev clean-tech is highlighted by the presence of some 50 clean-tech businesses, a high rate of new firm formation in the sector, technological incubators, university research departments and independent research centres that represent around one-third of Israel's total clean-tech research capacity, a skilled and low-skilled clean-tech labour pool together with a strong potential local demand pull from the environmental improvements in the local chemical industry, forthcoming Israel Defence Forces base relocations and planned improvements in the region's housing and infrastructure.

In exploiting this potential for the green growth objectives and the economic development of the Negev, policy can make use of several existing national innovation and infrastructure development programmes. These include New Tech Israel, the National Plan for Developing Alternatives to Oil, the National Strategic Plan to Develop the Negev and the R&D, innovation and entrepreneurship policies of national ministries including MOITAL's Office of the Chief Scientist and the Ministry for Energy and Water. Efforts should be made to include initiatives in these programmes that are adapted to the opportunities for developing clean-tech in the Negev.

Gaps to fill

There are nevertheless some gaps and missing links in the Negev's clean-tech activity that suggest areas for local strengthening and for the building of linkages with clean-tech activity elsewhere nationally and internationally. The gaps concern some areas of supply, demand, production, and support services including investment finance and specialised consultancy, and limited supply of high-skilled labour. In addition, there is a fragmentation of existing policy. Many government departments are involved in support for clean-tech in the Negev, but there is no single co-ordinating actor and different understandings of what is involved.

International lessons

The report examines the lessons of other clean-tech clusters internationally, and highlights the importance of innovation connections among agents in the generation of new activities and the 'branching' of clusters towards niches that arise from new combinations of existing related activities. Mechanisms are required to develop this key to the future of Negev clean-tech: incentives for joint innovation projects, spaces and events for meeting, increased visibility of Negev clean-tech to outside investors and innovation partners, and centres to test new technologies and innovations. Training initiatives and demanding regulations are further important aspects of international success stories that need to be included in any clean-tech development strategy for the Negev.

More specifically, the way forward for the Negev requires actions in the fields of business, research organisations and labour.

Business

One of the priorities for business is to build the demand side, helping national firms identify local supply opportunities, connecting local actors together, and using green public procurement, for example energy efficiency retrofitting in military bases and new and existing settlements. The supply side also strengthening through innovation subsidies and support, an investment fund to provide capital for start-up and growth projects, efforts to attract inward investment and the creation of new innovation and supplier-customer linkages. A key task in building these linkages is a mapping of the components and linkages in the existing system and the development and implementation of a clean-tech cluster strategy for the Negev.

Research

Concerning research institutions, the priority is to strengthen existing research activities, particularly where they involve integrated, business-oriented solutions, and brand and market them as clean-tech. Investment should be focused on priority centres of research excellence, while existing activities should be better tied together through the creation of an interdisciplinary clean-tech research programme in Ben Gurion University of the Negev, with links to other research and technology centres. Actions should also be taken to create collaborations across research institutions and firms within the region from all relevant and related sectors through creation of joint projects between industry and research institutes and an exchange of research specialists between academia and industry. International research links should be promoted through international research projects and conferences, summer schools and hosting of international researchers in the region. Commercialisation of the knowledge generated in the Negev's research institutions should also be encouraged, including facilitating some important research commercialisation opportunities from collaborations with the region's chemical industry and innovative solutions for green building and sustainable settlement projects.

Human Capital

The human capital measures recommended in the report fall into two areas: high-skilled and low-skilled labour. On the one hand, clean-tech clusters are driven by specialised research and engineering labour and a constraint is often the availability of this labour. The Negev is no exception. The solution lies in facilitating brain labour mobility and ‘brain circulation’ into and out of research centres and firms, through initiatives including increasing the visibility of the region’s clean-tech research institutions, facilitating temporary placements of international researchers in the Negev and providing clean-tech training for business, such as a Green MBA and student internships in clean-tech businesses. As regards low-skilled labour, the emphasis must be on supporting disadvantaged residents of the region to access jobs. Training programmes should be introduced focused on equipping low-skilled labour with skills for green building and energy efficiency and implementing new intermediary job matching activities. In addition, green procurement should be used to build local skills and jobs from military base relocations and the implementation of a leading green settlement initiative.

Key pillars of a regional clean-tech strategy

Overall, the report argues that to achieve all the above, and meet the Negev’s potential, a six-pronged strategy should be put in place for the regions’ clean-tech involving the following key actions.

1. Investment in research centres of excellence and creation of an inter-disciplinary clean-tech programme.
2. Creation of a clean-tech technology validation centre.
3. Promotion of collaborative innovation projects.
4. A green strategy for the Negev underpinned by green public procurement and regulation.
5. Transformation of Eilat into Israel’s model green city.
6. Creation of a regional cluster management organisation.

The latter will be critical to co-ordinating strategies, making the necessary innovation, supply, investment and human capital connections, and increasing the visibility of the clean-tech activity of the Negev.

INTRODUCTION

This OECD review project on Entrepreneurship, SMEs and Local Development is undertaken as part of the review series of the Local Economic and Employment Development (LEED) Committee on Boosting Local Entrepreneurship and Enterprise Creation. The reviews involve assessments in case study localities of the challenges and opportunities for stimulating entrepreneurship and innovation, the development of detailed policy recommendations, illustration of the recommendations with international learning model programmes and the development of a policy action plan with stakeholders through a local seminar.

This case study examines the challenges and opportunities for the growth of a clean-tech sub-cluster in the Negev region in the south of Israel. It links to the green growth objective of supporting clean-tech innovation, which refers to a set of clean technology activities that reduce the environmental damage from economic activity including green innovations in energy, water, transport, agriculture and manufacturing. It also links to the regional development challenge of promoting the growth of a priority peripheral region based on exploitation of its existing competitive advantages. The case study seeks to identify the challenges faced in building new business, research and training activities in clean-tech in the Negev and how the challenges can be met through better policies, including references to international good practices and learning models.

The report focuses on how to improve the entrepreneurship and innovation environment for clean-tech activities in the Negev, examining the opportunities and barriers to the development of:

- *Business development in the clean-tech sector*, including entrepreneurship and new firm formation, spin-offs from universities, research laboratories and corporations, value chain linkages with foreign direct investors, access to finance for investment and development of small and medium-sized enterprises (SMEs).
- *Strengthening and exploiting the public research in clean-tech*, including steering public research to opportunity areas, commercialising research outputs and knowledge transfer from research to industry.
- *Labour market and human capital for the clean-tech sector*, including employment and professional training, workforce development, new job opportunities, identification of skills needs, and attraction of qualified staff.

Each of these fields is addressed in a separate chapter in this report. There is also an introductory chapter that presents current clean-tech activities in the region and a chapter that gives an overview of the clusters concept, international practices in this area and lessons for the Negev.

The report has a specific focus on developing a regional clean-tech sub-cluster, linking it nationally and internationally, and creating a shared strategy and cluster management process in clean-tech in the Negev.

The review consisted of the following steps: preparation of a diagnostic study on the Israel economy by the Ben Gurion University team; a one-week study mission in Israel (17-22 September 2011) to meet with national and regional stakeholders, and a wrap-up workshop to discuss preliminary findings and areas

for policy development; preparation and discussion of a draft report with the Israeli steering group led by the Ministry of Industry, Trade and Labour; and a workshop to present and discuss the draft report with local stakeholders during the Eilat-Eilat renewable energies forum in Eilat on 22 February 2012.

CHAPTER 1.

EXISTING CLEAN-TECH ACTIVITIES IN THE NEGEV

By Dr. Dan Kaufmann, Dr. Miki Malul and Dr. Mosi Rosenboim

Abstract

This chapter describes the basic conditions underpinning clean-tech activity in the Negev region. It discusses the geographic and socio-economic conditions of the region, outlines the existing clean-tech activities in the Negev and in Israel as a whole that provide the foundations for future development and identifies the core public policies in operation in Israel that may be employed for clean-tech development in the Negev. The chapter concludes with a basic overview assessment of existing conditions for clean-tech development in the Negev, providing the setting for the more detailed analysis and policy recommendations in subsequent chapters.

Overview of the Negev region

The Negev region is located in the southern part of Israel. While it accounts for 60% of the area of the country, it contains only 10% of Israel's population. It is bounded by Jordan in the east and Egypt in the west and south. Eilat is the southernmost point (it has a triangle shape). The Negev is a rocky desert. It is a mix of brown, rocky, dusty mountains punctuated by wadis and deep craters. This area remains undeveloped and sparsely populated. Most of the population lives in the northern part of the Negev.

The Negev overlaps with the Be'er-Sheva district¹. The major city of the Negev is Be'er-Sheva, which hosts about one third of the district's residents, and is the center for business and public services in the region. The estimated GDP in the Negev region for 2009 was about NIS 47 billion² (6.5% of the GDP in Israel). The GDP per capita was NIS 76 000 compared with NIS 94 000 in the rest of the country. The gap between the GDP per capita in Israel and in the Negev, increased from 11% in 2000 to 19% in 2009.

Population

The Negev region has approximately 614 000 residents. The population growth rate is about 2.5%, significantly higher than the average growth in Israel (see Table 1).

Table 1. Population (thousands)

	2000	2004	2009	Average yearly growth (past 10 years)
Israel	6 369	6 870	7 552	1.91%
Negev	493	545	614	2.46%

Source: Central Bureau of Statistics, Table 2.6

In the Negev region there are about 193 000 Arabs, most of whom are Bedouins. The ratio of Jews to Arabs is 2.2 (see Table 2), significantly lower than this ratio in the rest of Israel (3.9). Due to high birth

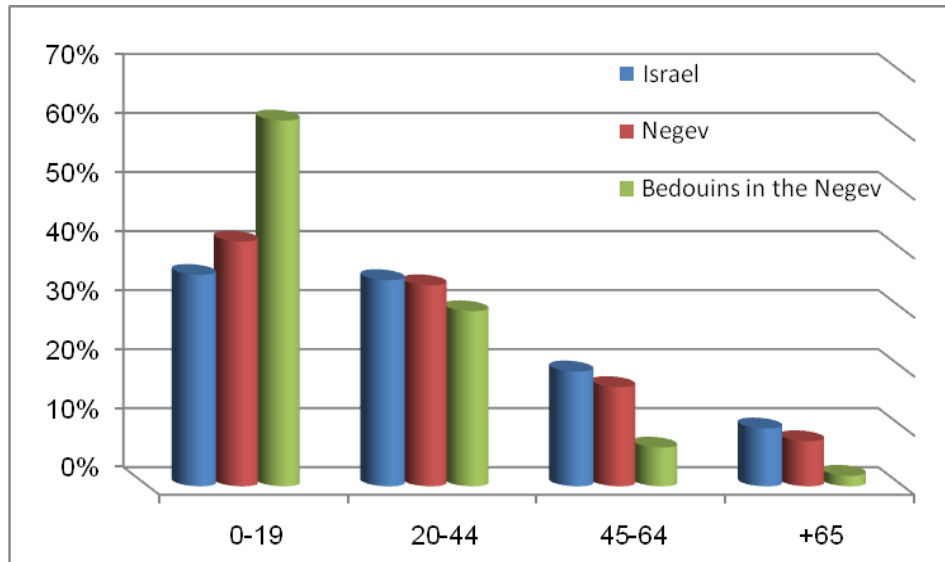
rates (partly as a result of governmental child allowances and a low level of education among Bedouin women), the annual growth rate among the Bedouins is quite high (on average 5.92%). It is this growth rate that accounts for the high growth in population in the Negev in spite of the negative migration from the Negev region (0.61% per year).

Table 2. Population by group

	Israel			Negev		
	2000	2009	Average annual growth	2000	2009	Average annual growth
Jews	5 181	6 016	1.68%	378	421	1.19%
Arabs (incl. Bedouins)	1 189	1 536	2.89%	115	193	5.92%
Ratio Jews/Arabs	4.4	3.9		3.3	2.2	

Delving deeper into the demographic structure of the population (see Figure 1) reveals that the population in the Negev is much younger than the population in the rest of Israel. This is particularly true among the Bedouins in the Negev. The dependency ratio³ in Israel in general is 84%, in the Negev, 97% and among the Bedouins in the Negev, 176%. The relatively high dependency ratio among the population in the Negev, especially among the Bedouins, has two outcomes. First, it leads to socio-economic weakness. Second, it creates an opportunity for the region, because the appropriate education for the younger population in the Negev might serve as an engine for future growth.

Figure 1. Age structure



Source: Central Bureau of Statistics; Self-Processing of Table 2.1

Labour force

There are about 185 000 employees in the Negev. They account for about 6.6% of employment in Israel, even though the Negev contains 8.1% of Israel's population. There are three main reasons for this disparity:

- a) The demographic structure: As previously shown, the proportion of the population in the Negev that is of employable age is significantly lower than in the rest of Israel.
- b) Participation rate: The participation rate among those aged 15+ in the Negev is about 52%, while in the rest of Israel it is about 57%. Therefore, fewer people participate in the effort to create income, leading also to a lower GDP per capita.
- c) Unemployment rates: The average unemployment rate in the Negev is 7.8%, which is a bit higher than the rate in the rest of Israel (7.6%). In recent years, the unemployment rate in Israel has been low, so this gap does not tell the whole story. The usual gap between unemployment rates in the Negev and the rest of Israel is about 2%, as it was, for example, in 2004.

Some of the weak labour force indicators in the Negev presented above may be explained by the level of education and the weak economic structure in the Negev. On average, those who live in the Negev and are of employable age have 11.8 years of schooling, compared with 12.3 years on average in the rest of Israel. Moreover, in the Negev just 15% have more than 16 years of schooling compared to 21% in the rest of Israel. The Bedouins in the Negev have only 9 years of schooling on average. Delving deeper into the data reveals that not only the number of years of schooling are lower in the Negev, but the quality of the education is also lower. For example, the percentage of Jewish pupils in the Negev who study 4-5 units of mathematics is 27% compared with 32% in the rest of Israel. Among those who took this higher level of math study, just 31% accomplished it with distinction compared to 42% in the rest of Israel (Daroma, 2005). Fewer years of schooling lead to lower wages, a lower participation rate in the economy and a higher unemployment rate on the supply side, and negatively affect the demand side due to the shortage of skilled labour.

Economic structure

The economic structure of the Negev is more oriented towards traditional sectors such as manufacturing and agriculture, which account for 22% of the region's employment compared to 17% in the rest of Israel. The Negev also has 7% of the tourism sector compared with 5% in the rest of Israel, mostly concentrated around the Dead Sea and the city of Eilat. On the other hand, the business services sector employs 18% of the population in the rest of Israel compared with 11% in the Negev. This disparity stems mainly from the fact that the Negev is an economically peripheral area and does not have the required economics of scale that are necessary for this industry. Thus, as we see from the description above, the Negev's economy is characterized by industries that are less dependent on skilled workers, resulting in relatively lower income.

Existing clean-tech activity in Israel and the Negev

The potential for the development of clean-tech activity in the Negev region will be strongly influenced by the existing clean-tech activities in the region that there are to build on and the possibility to develop links to clean-tech activities in Israel as a whole. This section sets out the key existing foundations for clean-tech development in the Negev, both within the region and elsewhere in the country.

At the outset, it should be noted that there is no central body, either governmental or non-governmental, that is responsible for directing the progress of the clean-tech industry, although the sector receives attention mainly through support provided by the Ministry of Industry, Trade and Labor and the Office of the Chief Scientist. Furthermore, there is no formal definition of the clean-tech industry in Israel that is accepted by all the stakeholders. Different ministries and other public bodies may have different understandings of the term, and as a result, may implement different (and sometimes uncoordinated) programmes in order to promote it. Having said this, there are useful definitions from the Ministry of

Environmental Protection that outline the principal characteristics of the industry. This indicates that two features shared by most clean-tech firms are eco-innovation and eco-efficiency. Eco-innovation involves increasing the potential for new technologies, products and services that contribute to financial and ecological efficiency. Eco-efficiency refers to the efficient use of natural resources in order to satisfy human needs and demands. This is a key term in developing sustainable production.

The clean-tech industry in Israel consists of companies in various sectors sharing one common goal – to reduce the environmental footprint caused by either users and/or producers of technologies and goods. In general, many of the clean-tech companies belong to sectors such as energy, agro-materials and water technologies. Indeed, only some of them deal solely with the environment.

There are estimated to be around 500 firms in Israel in the field of clean-technologies, centred around three main fields: 192 firms are related to renewable energy (12 in the Negev), 127 firms are related to water (13 in the Negev), and 93 firms are involved in environmental and material development (11 in the Negev). This list does not include companies in related fields such as project management, smart agriculture, and nanotechnology. Today, Israel is considered a leader in the following fields:

- Water technology – wastewater treatment, desalination, and drip irrigation.
- Renewable energy – solar and geothermic energy production.
- Prevention of desertification.

Table 3 presents the number of companies in each sector in Israel and in the Negev, and the major infrastructure related to their activities in Israel as well as in the Negev:

Table 3. Number of companies by sectors and their related infrastructures

	No. of firms in Israel	No. of firms in the Negev (% share)	Related infrastructure – Israel (Negev excluded)	Related infrastructure - Negev
Renewable Energy	192	12 (6%)	Solar Research Facilities Unit, Weizmann Institute for Science	National Solar Energy Centre, Ben Gurion University, Sde Boker
Water	127	13 (10%)	Grand Water Research Institute, Technion, Haifa Centre for Erosion Research, Ministry of Agriculture and Rural Development	Zukerberg Institute for Water Research, Ben Gurion University, Sde Boker
Environment	55	3 (5%)	Israel Oceanographic & Limnological Research	Interuniversity Institute for Marine Sciences, Eilat Arava Institute for Environmental Studies
Materials	38	9 (24%)	Solid State Institute, Technion, Haifa Centre for Nanoscience and	Ilse Katz Institute for Nanoscale Science & Technology, Ben Gurion University, Be'er Sheva

			Nanotechnology, Tel Aviv University Weizmann Institute Nano Initiative (WINI), Rehovot Centre for Nanoscience and Nanotechnology, Hebrew University, Jerusalem	
Agro Technology	86	12 (14%)		
Total	498	49 (10%)		

Main fields in the clean-tech industry

Water Technologies

Given the paucity of water in Israel, there are 127 firms in this field searching for the efficient use of the scant natural resources available. The local demand led to the emergence of firms supplying a variety of end-products as well as products aimed to other firms specializing in water management technologies. Limits placed by the government on the use of water in agriculture led to the development of drip-irrigation technology. Many other companies were formed around related supporting fields, which later evolved to deal with other water technologies, such as desalination, water treatment and wastewater treatment. Today these areas of interest constitute 50% of the water technology firms, with Israel leading the world in wastewater technologies and reusing 75% of its water for agriculture:

Table 4. Water reuse rates

Israel	Spain	Australia	Italy	Greece	Central Europe and USA
75%	12%	9%	8%	5%	1%

Source: Mekorot (www.mekorot.co.il)

A large portion of Israeli water technology companies are at the product sale stage, but have met with marketing difficulties. The growing shortage of usable water and the need to treat wastewater in large quantities contributes to global awareness regarding the importance of the water technology field. Notwithstanding, the target markets are conservative and the pace of assimilation of new technologies is slower than expected. Water services firms tend to purchase components from known local integrators – usually big firms having strong reputation of their abilities to carry out complex projects. In Israel such firms consist of the big construction companies (such as Minrav or Solel) as well as dedicated arms of the major corporates (such as ICI Group). Small companies commonly find difficulties to penetrate these markets even when their technology is promising. This tendency requires the firms to develop markets through cooperation with local companies.

WaTechTM: The Water Technologies Entrepreneurship Centre, was established in 2004 by Mekorot, Israel's national water company. WaTech is intended to serve as a platform for business ventures and emerging collaborations, mostly in the fields of water technology, control and management. The centre

assesses proposals for water technology projects and enterprises, and conducts approximately 50 applied research studies each year. There are three advanced R&D centres, one of which is in Eilat.

Renewable Energy

This is the largest clean-tech sector in Israel, with the largest number of firms (192), amount of capital invested, and technological innovation. The field's proximity to high tech fields of expertise contributes to the fast pace of development of the firms. Israel has created a global precedent for the exploitation of solar energy by installing solar water heaters in every house. This step led to significant savings of 3-4% of Israel's energy consumption. Today 95% of households use solar water heaters.

Solar power technology receives most of the funding (governmental and private) that is allocated to clean-tech and also has the largest number of firms in the energy sector. This trend is not expected to change. For the last three years, a feed-in-tariff has been used as an incentive. This feed-in tariff includes an excess payment for each Kilo Watt (KW) produced by solar, wind or bio-mass energy systems. The feed-in tariff was given in the form of batches in which each new batch receives a lower price for each KW produced. Very recently, the Israeli government approved new batches of 620 Mega Watts (MW) of solar energy. As a result of this governmental decision, it seems that much of the economic activity and the workforce will be concentrated on solar energy. The rate of growth of the solar market and the effort being put into the efficient production of energy ensure the continuation of innovation in this field and continued investment as well. However, it is expected that by 2012 feed-in tariffs will be cut dramatically. Recently, the government has approved additional quotas for renewable energy: 110 MW of photo-voltaic technologies (PV) to be installed on roofs, 510 MW of PV in solar fields, 800 MW of wind energy and 210 MW of biomass. These additional quotas will lead to the production of 10% of the Israeli total national consumption of energy from renewable resources by 2020. All of the solar and wind installations are being established by private investors who raise money from banks, corporations and, in few cases, from the public (through the Tel Aviv stock exchange). The government may participate in financing up to 20% of the initial investments through its *capital investment law* aimed at fostering investments in rural areas (with no direct connection to the sector being promoted).

In the Negev, there are currently two solar energy fields planned in the area of Ashalim. Using solar technology developed by two Israeli companies, Bright-Source Energy Ltd., and Solel (now Siemens Concentrated Solar Power), the plants in Ashalim are expected to produce 250 MW. In addition, the Dudaim waste site, which is responsible for the treatment of household waste in the Negev, is producing 2 MW of electricity from biomass (Globes, 2002). Also it is worth noting Ormat (located in the centre of Israel), a leader in the generation of geothermal power. However, the future use of large areas of land for the production of solar energy is questionable, especially after the discovery of large natural gas fields in Israel.

There are bureaucratic barriers to the implementation of renewable energy projects: lack of a clear policy, lack of land allocation procedures, lack of a national energy master plan, technical failures to obtain installation permits from the Israeli Electric Company (IEC), and a lack of sufficient incentives for renewable energy production. Moreover, the high voltage line for the south of the Negev (the Arava area) has only a 100 MW capacity. This fact limits the ability to build large solar energy fields in the Arava, which is probably the most suitable region for solar energy production. The cost of replacing this line raises the question of the economic benefit of such solar energy initiatives. The role of the Israel Electricity Company (IEC), a governmental company, as the "owners" of all of the electric transmission lines in Israel adds another complexity to the decision-making process about the establishment of renewable energy companies. As an organisation that currently has a monopoly over electricity production and transmission, IEC's interests may be in conflict with other "competitor" initiatives.

Environmental and Materials Fields

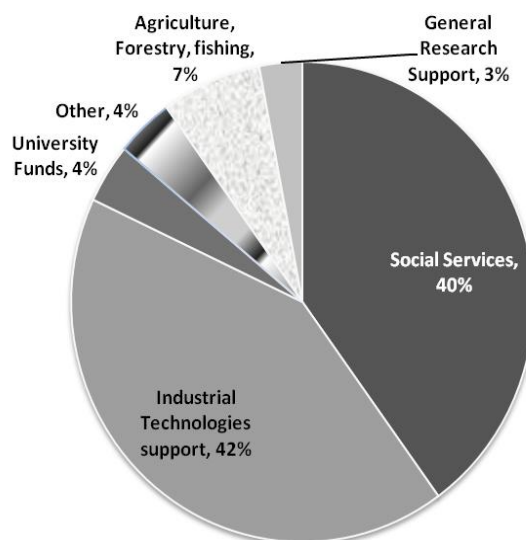
There are about 90 firms in Israel in this rather loose category. Much of the development in this sector is due to local demand for environmental solutions, which has arisen just recently, rather than to global trends. The main fields of development are described below.

- a) **Materials.** The materials production sector seeks to develop materials that are more environmentally friendly or that utilize an industrial process for producing materials more efficiently. Knowledge bases in Israel such as those in chemistry and nanotechnology are used to innovate in this area.
- b) **Recycling.** The materials being processed in the recycling field include plastic, tyres, different metals, and more. The increasing regulation of recycling in Israel and the rising price of goods contribute to the demand for solutions in recycling.
- c) **Waste treatment.** The waste treatment sector includes firms that offer solutions for sorting and treating solid waste. Israel lags far behind the rest of the developed world in waste treatment. However, the shortage of land, which has been exacerbated in recent years by increased demand for housing and the relocation of army bases from the centre of the country to the Negev, will force the country to adopt more efficient waste treatment techniques. Unlike the fields of water and wastewater treatment, there are no large Israeli firms in the area of waste treatment.
- d) **Generation of energy from fossil fuels, biomass, and waste.** The generation of energy from fossil fuels, biomass, and waste is in some cases, closely related to the agricultural sector, an area in which many firms and institutions have considerable experience. Global regulation also triggered local demand. However, there are only a few companies in this field. Most are in the preliminary stages and have no significant sales. In addition, some of the planned projects are facing resistance and opposition from the public and green coalition groups (the extraction of shale oil in the region of Adulam, for example). One example of a start-up in this field is Farm Energy Ltd, located in the Negev, which is developing bio-diesel from agriculture waste, as well as from the waste given off by the wood and paper industry.
- e) **Soil treatment.** Soil treatment companies grew out of local needs. However, improvements in existing technology led to new investments and to the development of a few firms that have global market potential.
- f) **Energy conservation.** There are no large firms in the energy conservation field in Israel. Consulting services devoted to advising on energy savings are also underdeveloped.
- g) **Brownfield redevelopment.** Brownfield redevelopment is usually based on a service firm that uses a broad range of techniques suitable for the Israeli market. However, the lack of experience in such projects presents a challenge.

Policy for Clean-tech in Israel

Office of the Chief Scientist

The key player in the Israeli policy efforts to support and promote R&D and innovation is the Office of the Chief Scientist (OCS) at the Ministry of Industry, Trade and Labor (MOITAL). It is therefore a key player in the development of research, development and testing in clean-tech. Its total annual budget is about USD 800 million, which is divided into the spending categories indicated in Figure 2.

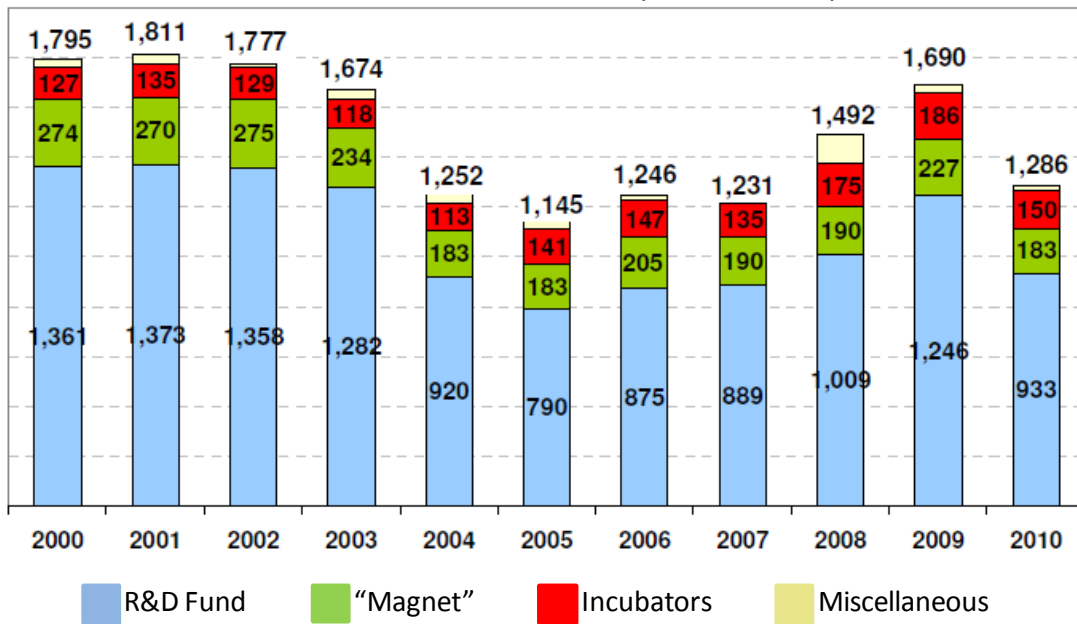
Figure 2. OCS Funds in Private Sector R&D

In general, the support from the OCS is "horizontal" because it sets no sector priorities (such as for clean-tech). The OCS policy is characterized by a bottom-up approach in which excellence in R&D and the ability of the firm to implement its proposed project serve as the main selection criteria.

In general OCS funding is provided on R&D merit and is not distorted by regional preference for economically peripheral areas (including the Negev), although an extra 10% of funding is granted to all "zone 1" areas. Generally speaking, the additional allocation would increase the funding for the project to 60% instead of the normal 50%. This gives a slight incentive for development of clean-tech R&D activities in the Negev relative to central regions.

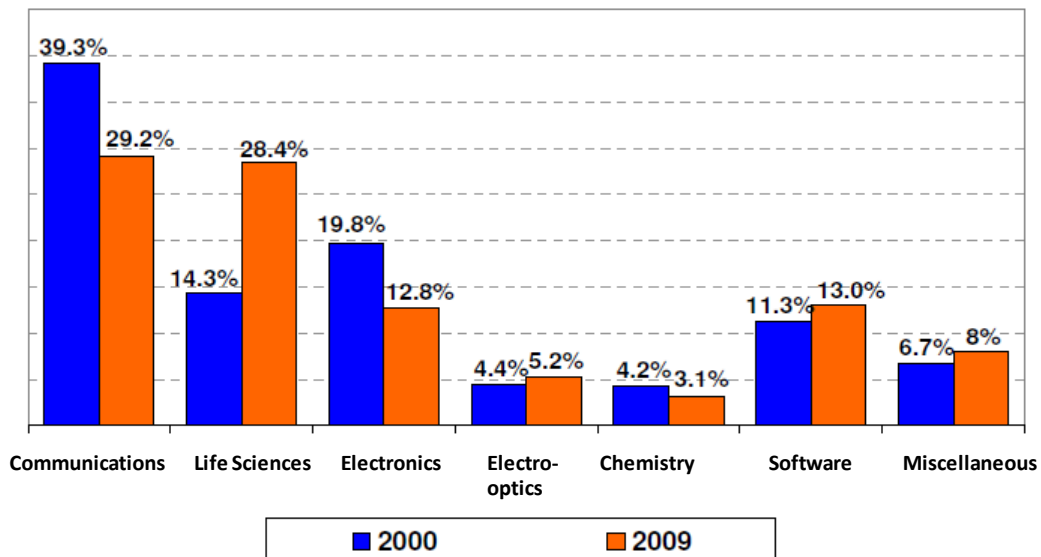
The financial support provided by the OCS takes the form of conditional grants. In other words, if the project fails, the support is treated as a grant, whereas if the project succeeds, it is treated as a loan that the company has to repay to the OCS. The financial support varies between 30% and 50% of the total eligible costs, except for biotech projects that benefit from a support level of 50%. Figures 4 and 5 present the OSC budget and its division among sectors (the clean-tech sector is included within the life science, miscellaneous, and chemistry sectors).

Figure 3. Total R&D Budget for Support Routes



* Authorized commitment (Million NIS)

Figure 4. Chief Scientist Grants by Technology Sector (2000 vs 2010)

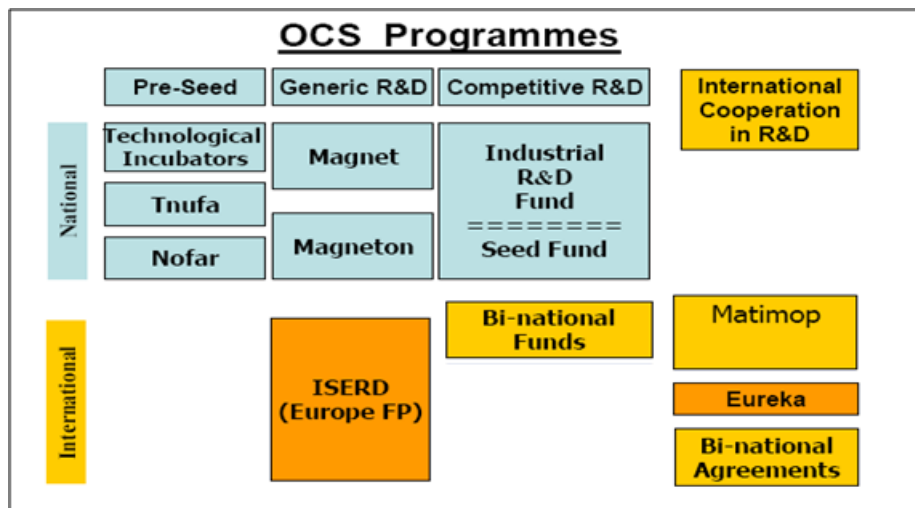


Source: Summary of Activities in 2009 - Office of Chief Scientist, Ministry of Industry, Trade, and Labor.

The OCS works at different levels of R&D (applied, pre-competitive and technology transfer) and manages several programmes that promote innovation. The Generic R&D programme is the general fund for supporting applied research. The Magnet programme supports collaborative, pre-competitive R&D, with its sub-units of Nofar and Magneton that promote the transfer of technology from academia to industry. The Technological Incubators programme supports new start-ups. There are also international

support schemes, which include bi-lateral funds, bi-lateral support agreements and participation in European schemes such as the FP7 and Eureka. The key programmes are shown set out in Figure 5.

Figure 5. OCS Programmes

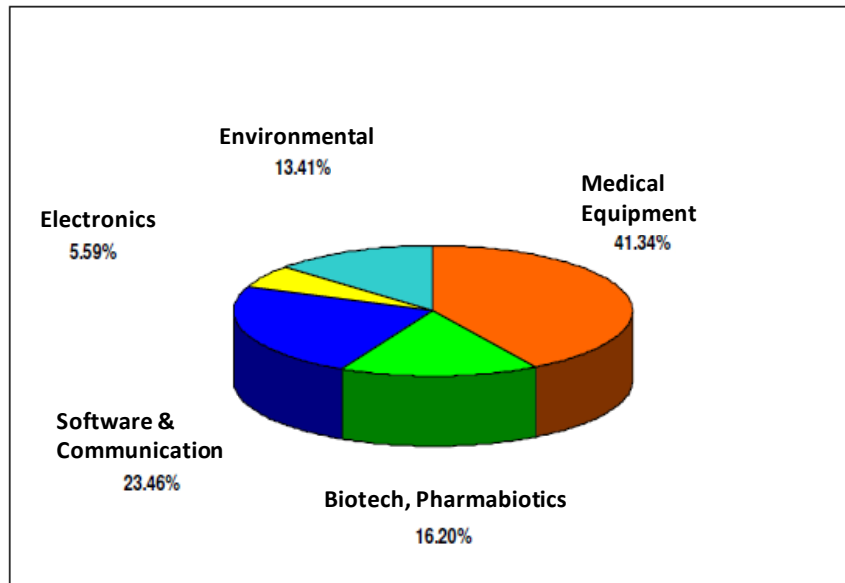


All of these programmes are in principle available to support clean-tech R&D or innovation development in the Negev. They are described in more detail below⁴:

Pre-seed

- a) **Technological Incubators Programme ("Hamamot")**: Incubators have been a major tool in Israeli policy for supporting R&D in SMEs since 1991. The programme supplies entrepreneurs with physical premises, financial resources, professional guidance and administrative assistance, and acts as a venture capital fund at the early stages. An incubator company receives a development grant of up to USD 500,000 for a period of two years. Over the last decade, the Technological Incubators Programme has gone through a process of privatisation during which the ownership of various incubators has passed into private hands, while the OCS still maintains an administrative and supervisory role. Today, 21 private incubators are active, of which 4 are in the Negev area. Over the 19 years of the programme's existence, 1,452 companies "graduated" from the incubators (238 in the Negev), and about 47% of them have survived and are still active independently (in the Negev 104 companies remain active). An evaluation of the programme in 2009 suggested that the programme played a crucial role in building the entrepreneurial spirit that exists in Israel today, as it enabled entrepreneurs who had no real experience in business to realise their ideas without taking very great personal risks. Figure 6 shows the broad activity fields of firms in the technology incubators in 2009.

Figure 6. Technology Incubators by Activity Fields (2009)



- b) **Tnufa programme:** This programme seeks to encourage technological innovation and entrepreneurship by granting limited financial support to new industrial projects in their very first stages. It is directed to entrepreneurs and individuals. The programme operates five different tracks: (1) new entrepreneurship projects with innovative technological ideas; (2) projects to upgrade traditional industry seeking to develop new technology or products; (3) cooperation with international enterprises seeking to develop joint technological projects; (4) “Green Tnufa” for SMEs seeking to develop technologies or products related to water and green energy; and (5) “industrial design” for innovative industrial design ideas. The programme provides conditional grants that have to be paid back in case of success. The scope of assistance from "Tnufa" is 85% of the approved budget, up to a limit of 200,000 NIS. In 2009 the program's committee discussed 560 requests for pre-R&D grants, and approved 168, with a total support of 17 million NIS. With more specific reference to clean-tech, a Green Tnufa support scheme has been established with the aim of developing new environmentally-friendly products or making significant improvements to existing products that render them more environmentally friendly. The scheme offers 66% of the approved budget, up to a limit of 250,000 NIS. In 2009, four projects were approved.
- c) **Nofar:** The goal of Nofar is to encourage cooperation between scientists from the academia and industrial R&D units. The programme provides companies 90% grant for projects up to \$100K for a period of one year. The Nofar programme supports late stage basic research projects which have clear applicative dimensions. It is difficult for such projects to receive academic grants as they become too “applied” while on the other hand they are still too “basic” to receive grants from industrial support schemes. The Nofar projects are conducted within the academic institute where the company that supported the project has a first refusal option to purchase its results.

Generic R&D

- d) **Magnet:** The Magnet programme is aimed at supporting pre-competitive R&D activities conducted by a consortium that consists of a number of companies together with academic institutes. It provides projects with 60% of the allowable cost for a period of up to five years. The Magnet operates one specific track for water technologies, which is called *Katamon*. The *Katamon* scheme promotes the commercialisation of water technologies for industrial applications. It is based on cooperation between

an industrial firm, an academic research team, and a water infrastructure firm working together to develop new water technologies up to the stage of proof of concept. Each project lasts up to 30 months, and can receive a grant of 50% of up to 4.2 million NIS.

- e) **Magneton:** Magneton operates under the general framework of Magnet. It promotes the transfer of technology from the academic sphere to industry. The Magneton is a horizontal scheme, as it sets no priorities with regard to the sectors being supported. The program finances joint university-industry research projects in which the research is carried out by the academic side, and the technological feasibility proof of process is done at the industrial level. In practice, most of the projects funded – almost two thirds – have generated high-growth SMEs. The beneficiaries of the governmental finance are exempt from paying back royalties once the product goes commercial. In 2008, 24 projects were active in the Magneton program and an additional 16 projects were approved. The companies that receive Magneton support come from different high tech fields, such as communications, bio-tech, software, new materials, energy and the environment. An evaluation of Magneton found that most of the projects approved and funded by Magneton were considered successful by the industrial partner and were very effective in facilitating the development of new technologies, thereby affecting the growth potential of the companies.

Competitive R&D

- f) **Industrial R&D Fund:** This is at the heart of the Israeli support schemes for generic R&D, with an overall budget of USD 200 million. It provides R&D grants of 30-50% to selected projects deemed to be industrially competitive. The programme has no specific priorities and selects projects according to their merit. Companies receiving OCS grants are obliged to pay royalties to the OCS upon the success of the project. It serves as a seed fund for enterprises as well as R&D support. According to OCS data, most of the grants are provided to high-growth SMEs, although the OCS is also making efforts to increase the participation of firms in non-technology sectors.

International co-operation projects

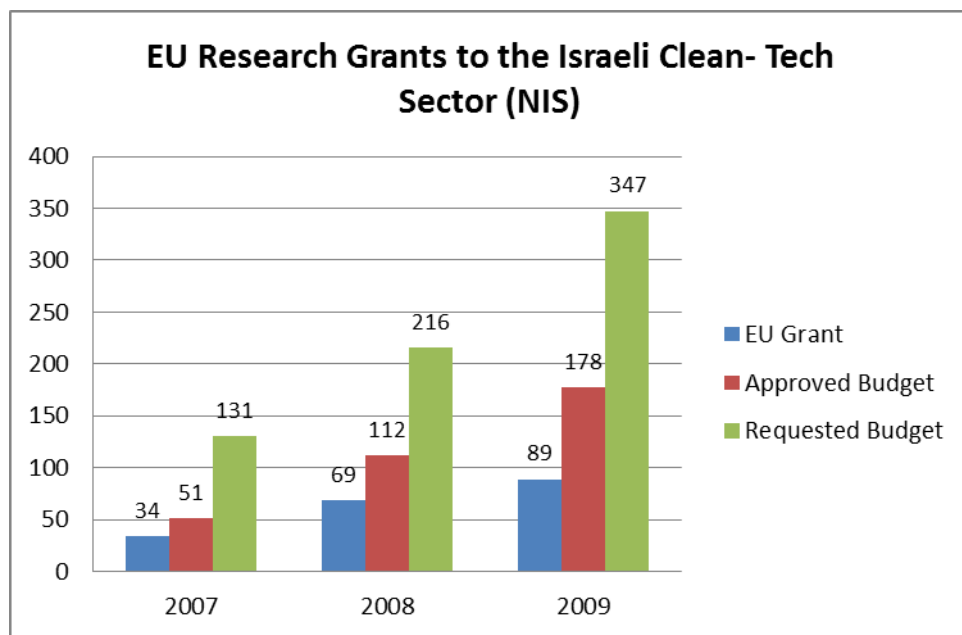
- g) **ISERD** is an inter-ministerial directorate, established by the MOIT and other public authorities to promote joint Israeli-EU R&D ventures within the EU's R&D Framework Programme.
- h) **Bi-National Funds and Agreements:** Independent R&D funds and agreements have been developed by Israel and a number of other countries including the US, Canada, Singapore and Korea. They promote cooperation between Israeli firms and the firms of the other country. The bi-national funds provide 50% of allowable project costs for international collaborative R&D projects.
- i) **Matimop:** The Israeli centre for R&D "Matimop" is an executive agency of the OCS that generates and implements international, cooperative, industrial R&D programmes between Israeli and foreign enterprises (bi-national programmes). Matimop implements international technological cooperation programmes with international agencies, bodies and organisations; initiates meetings between local and foreign companies with mutual technological interests, and assists joint international R&D projects in finding funds. Matimop is also the coordinator of the Eureka programme in Israel, which supports international collaborative R&D.

Although the only clean-tech specific programme of the OCS is Katamon, the industry can participate in all of the horizontal support measures. In this respect there has been a remarkable recent increase in demand for R&D grants in clean-tech. In 2009, 114 clean-tech applications for R&D programmes were made, for 347.4 million NIS. This represents a 75% increase in requests from the previous year and a 61%

increase in the requested budget. Of these, 73 project requests were approved, totalling 177.5 million NIS (in comparison with 48 approved requests in 2008 totaling 111.7 million NIS).

Comparing the data of 2009 to previous years shows that the demand for R&D grants for clean-tech projects rose 165% over two years, as did the total value of the actual grants (Figure 7).

Figure 7. R&D Grants for Clean-tech



Investment Centre

The Investment Law 1959 encourages capital investments. It is implemented by the Investment Centre. The aim is to encourage investments that promote the national economy, have the ability to compete in international markets, and generate innovative technologies (technology/industrial products) and places of employment. The Negev is defined as a national priority region and receives unique treatment under this law. For example, as part of the law, investments made in the Negev are eligible for grants of 20% of the total investment. Companies that invest in the region are also eligible for a 30-50% reduction in their corporate taxes.

Regional Development Centre

The Centre for Regional Development is responsible for integrating, managing and coordinating policy for economic development, financial investments and employment in national priority regions. There are three priority regions: the Negev, the Galilee and Jerusalem. The aim of the policy is to increase growth and employment in these regions. The primary means of achieving this is through the initiation of new programmes and projects that will attract domestic and foreign investors and encourage the establishment of new large and small business in these regions. The Centre works under the authority of the Director General of the Ministry of Industry, Trade and Labor and operates cooperatively with all professional units within the ministry, as well as with various governmental agencies. It is an important potential tool for the development of clean-tech activities in the Negev.

Technology Centres in the Negev

As part of a government decision in 2008 for comprehensive support for water and renewable energies technologies, the Office of the Chief Scientist established two technological centres in the Negev: one in Sde Boker for water technologies (on the Central Plateau) and a second in the Arava (the eastern prairie bordering Jordan) for renewable energy technologies. These centres aim to foster applied research that integrates the functions of academia and industry. They are further important potential catalysts for clean development in the region.

The government has created a 5-year budget plan for these centres, allocating 35 million NIS for the water technologies centre, and 57 million NIS for the renewable energy centre. The centres are managed as not-for-profit private organisations and were chosen through a competitive process.

Steering Committee for Water

As part of a government decision in 2008, an academic steering committee was established to promote water technologies. Its main purpose is defining priorities for academic R&D, based on global needs and demands.

Feed-In Tariffs

Wind and solar energy producers in Israel can obtain favourable electricity tariffs. However, there is no mechanism favouring local producers and technologies in the Negev.

NewTech Initiative

Israel NewTech launched its first programme in 2006. It is a national programme aimed at promoting Israel's water and sustainable energy sectors. The programme is led by the Ministry of Industry, Trade and Labor, and supported by a number of additional government agencies. It was founded on the belief that the water and sustainable energy sectors have the potential to be strong growth industries for the country, and play an important role in meeting the world's rising needs in these areas. NewTech helps to advance the water and sustainable energy sectors by supporting academia and research, encouraging implementation in the local market, and helping Israeli companies succeed in the international arena. Israel NewTech launched a second programme in 2008 focusing on the renewable energy sector. The second programme encourages Israeli companies and individuals to enter and invest in the field, as well as to form relations with potential overseas partners. The objective is to promote Israel's renewable energy technologies in both the local and global arenas.

Venture Capital and Private Equity Investment

Over the first half of 2008 the amount invested in clean-tech companies by both Israeli and foreign venture capital funds reached USD 140 million, following investment of USD 122 million in 2007. These sums do not include two major investments involving the "Better Place Project" – USD 200 million in 2007 – and "Bright Source" – USD 115 million in 2008. Both of these investments involved venture capital and private equity funds as well as bank participation.

The substantial private investment in clean-tech is the result of growing participation of traditional venture capital funds in the clean-tech sector (see below). Since the end of 2006, most Israeli venture capital funds have been increasing their investment in clean-tech, a trend that is expected to grow in the future despite the effects of the global financial and economic crisis.

Additional reasons for the increased investments include:

- a) A growing interest in innovative technologies and clean-tech companies by major Israeli corporations such as Arison, Ofer Brothers, Dankner, Recanati and others, stimulated in part by increased demand from the government for new clean-tech projects. Some of these groups are using these innovative solutions in their plants in combination with imported equipment while others are strategic partners.
- b) Foreign funds including Virgin, Sequoia and Greylock that are establishing local operations to ensure continuous exposure to the local industry.
- c) International companies such as GE and Siemens that are establishing local business development activities.
- d) Israeli private equities that have begun expressing interest in the field and are currently searching for ways to penetrate it.
- e) Significant investments by angels, although each angel investor is investing relatively small sums of money in any individual company.

Basic assessment of existing conditions for clean-tech development in the Negev

Clean-tech development in the Negev region can build on a small but significant base of enterprises, with important connections nationally and internationally. The Negev accounts for 48 of the 499 clean-tech companies. Furthermore, clean-tech accounts for 9.6% of the total enterprises in high tech industries in the Negev compared with only 4.2% of total enterprises in Israeli high tech industry. The clean-tech sector is also more active in the Negev than in the rest of the country. Since 2008, 14% of the new firms in the Negev belong to the clean-tech sector compared to 8% in the rest of Israel.

Clean-tech in the Negev also benefits from the existence of leading research centres such as Ben Gurion University and the Sde Boker Institute for Desert Research (BIDR), and a high volume of chemical industries that create a strong demand for eco-innovations.

Looking more closely at the environment for clean-tech in the Negev, the following basic strengths, weaknesses, opportunities and threats can be identified.

Strengths

- A large body of knowledge in clean-tech sectors in regional enterprises and research establishments that has been accumulated over the last 30 years.
- Unique weather conditions and topography which allow the Negev to become a centre of field studies for testing innovations in various clean-technologies, including solar and water technologies.
- Access to the strong entrepreneurial culture and high technology human resources of the Israeli innovation system as a whole, which can flow into and support clean-tech activity.
- Presence of a regional life science cluster driven by the strong academic research of Ben Gurion University, the large science parks in Omer and a planned park in Beer Sheva, and a strong industrial base of the region, which may have strong synergies with evolving clean-tech activity.

Weaknesses

- Shortage of resident highly-skilled labour and a limited variety of spouse employment opportunities and extreme weather conditions, making it difficult to attract workers to the region.
- Low level of support services for business such as banking, consulting, lawyers, etc.
- Large land areas used by the army for military training and other land areas in dispute with the Bedouin population, which limit the availability of land for new industrial uses.

Opportunities

- A large, young population that could be trained and educated to work in technology in general and clean-technologies in particular.
- The Israel Defense Forces (IDF) plans to invest a sum of approximately 25 billion NIS to relocate bases, including some technological units, from the centre of the country to the Negev. This move will involve a massive investment in infrastructure including roads, railroads, water, electricity, etc. and will create a strong local demand for various clean-tech products.
- Improving the image of the Negev by developing high tech activities may help overcome negative perceptions of the business and residential environment that are only partially true in reality.

Threats

- A relatively low level of environmental regulation and the common use of best-available-technology (BAT) discourage entrepreneurial activity in clean-tech.
- Difficulties in making available land for 'beta sites' concerned with testing and verification may limit innovative activities.
- A lack of coordination between governmental departments involved in clean-tech could hold back the development of a clean-tech strategy for the region.

From the analysis above, it is clear that the Negev region has unique attributes that position it as a location with substantial potential for the development and testing of innovative clean-technologies and in some cases for their commercial implementation. However, the scarcity of skilled labour, lack of appropriate business services and problems associated with land allocation require a clear public policy that will maximise the (sometimes hidden) potential of the Negev to become a centre for clean-tech activities and sharpen the competitive advantage of the Negev in clean-technology.

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ENDNOTES

¹ The major difference is that the Negev includes two cities that are not part of the Beer-Sheva district. The cities are Kiryat-Gat and the city of Sderot. Much of the statistical data cited in this paper come from the Central Bureau of Statistics, which has no official data for the Negev region. Therefore, we used the Beer-Sheva sub district data as a proxy for the Negev data.

² The exchange rate at that time was about USD 1= NIS3.5.

³ The ratio between the populations aged 0-19 and 65+ to the population aged 20-64.

⁴ Source: OCS 2009 summary, <http://www.tamas.gov.il/NR/rdonlyres/DAD0974E-2ED2-4866-8143-D61C74665C65/0/sikum2008.PDF>

CHAPTER 2.

CREATING CLEAN-TECH CLUSTERS: LESSONS FOR THE NEGEV

By Prof. Philip Cooke

Abstract

This chapter focuses upon the processes and practices associated with the development of innovative clean-tech clusters in OECD countries and their lessons for policy to encourage clean-tech development in the Negev region as part of Israel's wider innovation and economic development system. It starts with a brief theoretical perspective on the cluster evolution process in general, emphasising the importance of 'recombinant knowledge' in innovation emergence. This is then illustrated by results from recent international research studies into cluster emergence and development in clean-tech. Recommendations are offered attuned to the challenges and opportunities offered by the Negev region as a potential clean-tech location focused on the renewable energy and water efficiency sectors. The chapter annex highlights international learning models of clean-tech development at regional and national levels that are relevant to the Negev.

Introduction

At the outset, it is useful to clarify two relatively new terms at the heart of the development of innovative clean-tech clusters: 'eco-innovation' and 'clean-technology' or clean-tech itself. The first is defined by the European Union DG Environment as: '...an environmental product, service, management practice or process...'. However this is very wide and indistinguishable from a definition of 'Environmental Technologies', which were often associated with one-off 'clean-up' anti-pollution technologies typical of a preceding era. A better, but still inadequate definition comes from the European Environmental Agency: '...Eco-innovation is the commercialisation of knowledge to elicit direct or indirect ecological improvements.....' which is also somewhat wide and lacking in the important 'system' dimension that is particularly pronounced in eco-innovation. So we will opt for a definition of eco-innovation that captures the classic 'recombinative' and 'systemic' character of innovation as 'new combinations of knowledge commercialised to minimise human-centred ecological degradation'. This is close to our definition of the broad clean-tech platform with which eco-innovation interacts; namely (Cooke, 2008) '...diverse products, technologies and processes which, from the clean energy supply chain through to production, consumption and recycling of goods and services, result in reductions in greenhouse gases...'. These definitions help to provide conceptual clarity in what is a large field of related and semi-related economic activities.

This chapter highlights important processes in the emergence of clean-tech clusters or 'platforms'. Such platforms are related to 'technology platforms', on the one hand, and 'industry platforms' on the other, but are also distinct from them. The idea of a 'technology platform' (e.g. in biotechnology) refers to research which involves a quest for multiple application pathways from a discovery or technology. The 'industry platform' notion refers to the evolution of inter-firm relations within a sector (e.g. Intel in ICT) that facilitates an ecosystem of interdependent suppliers for developing integrated products, technologies and services (Gawer, 2009). Both are important to our key area of interest; the emergence of an 'innovation platform' or more specifically an 'eco-innovation platform' in which clean-tech is embedded.

It is the criss-crossing of knowledge among a group of industries displaying ‘related variety’ that leads to innovation or the other lesser improvements that meet a new need or adjust an old solution to a new problem. Inter-disciplinary science and technology, injunctions for ‘joined-up governance’ from policy makers and the dominance of interactive or recombinant knowledge in modern understanding of innovation are signs that the days of ‘silo-thinking’ are numbered.

Recent theoretical and empirical examination of regional economic growth processes places a profound emphasis on the sharing of knowledge across groups of industries displaying ‘related variety’ supported by high lateral (across sector boundaries) ‘absorptive capacity’. The recognition and facilitation of this related variety and its exploitation in technology, skills or applications is crucial to the economic development of innovative clusters.

Cluster development based on related variety is an example of ‘path dependence’ in a positive sense in that the legacy of history can be a source of growth when cross-fertilisation of knowledge occurs across industry boundaries within a region. Examples include joint agricultural-automotive R&D on biofuels (Jürgens & Blocker, 2010), inkjet printer applications to ceramics and shoe design (Hervas-Oliver & Boix, 2011) and nano-filter paper applied to lake algae for organic, paper-based batteries (Nystrom et al., 2009). Each of these is a clean-tech innovation, adaptation or invention that occurred through a process of *path interdependence* between very different economic activities or assets. It involves industrial and product mutations brought about by recombinations of knowledge that is both driving clusters and facilitating their development because of the existence of a ‘community of practice’ or co-operative mentality among firms, especially at the pre-competitive stage of product or process development.

The next section provides a brief theoretical elaboration and summation of key points on the cluster evolution process, going a little further into ‘recombinant knowledge’ in cluster emergence and development. This is then exemplified by results from recent international research studies into cluster emergence and development in the cleantech ‘platform’.

The evolution of clean-tech clusters

The introduction outlined some key concepts in the explanation of clean-tech cluster formation, which depends in large part on entrepreneurs and innovators making connections across sector boundaries. Clean-tech has the intention of creating diverse products, technologies and processes which, from the clean energy supply chain through to production, consumption and recycling of goods and services, result in reductions in greenhouse gases. We have seen already three examples of sector crossovers that have helped drive cluster growth at regional level:

- The paper batteries example illustrates growth based on the emergence of a new invention, paper batteries, that holds great promise not only in large-scale energy storage, but also in sustainable small device energy storage (Motorola is one sponsor this research), and small device battery charging through, for example, nano-paper curtains that convert solar to electrical energy (IKEA is another sponsor).
- The biofuels example relates instead to a sector cross-over that has resulted in new applications of traditional products and processes. Biofuels is of course an old technology that nevertheless attracts large-scale consortium funding involving small firms (e.g. in Germany, Choren, for agro-forestry expertise) and industry leaders like VW, Daimler, Renault, Shell, BP, Chevron and Total. Choren was the cross-over project leader of the EUCAR second-generation biofuels initiative and is located in Freiburg, the heart of Germany’s ‘Solar Region’ (not to be confused with Leipzig’s ‘Solar Valley’ renewable energy cluster).

- The use of (organic ink) inkjet printer technology is another example of a recombination of knowledge leading to new applications of traditional technologies. Because linkages within a regional cluster, printer technology has been applied in new ways to first the decoration of ceramics in Spain, and more recently to (mainly) women's shoes in Portugal, leading to industry boosts in hard times. The Spanish application was made in 2009 in the Castellon (Villareal-Valencia) ceramics cluster while the application to shoes was first made in 2011 in the Sao Joao de Madeira shoe cluster between Aveiro and Oporto.

Important in all these cases was the existence of industry innovation centres in proximity to the respective clusters. In addition, the following processes had a key role to play in each case in the development of the eco-innovations or adaptations that have driven the eco-cluster:

- Path dependence – local recognition of the history of an industry, its ecosystem and its relevance to new clean-tech market challenges.
- Path inter-dependence – search and selection activities that permit the interaction with other industries in order to evolve clean-tech solutions.
- Platform – the development of such interactions in a platform of activities with geographic proximity or, failing that, at least with 'relational' proximity.
- Related variety – the fruitful engagement of firms that are in industries that are cognitively close even if distant in output.
- Absorptive capacity – capability of firms and research organisations to understand both 'difference' and 'comparability' in business models, market niches and technological expertise.
- Strange attractors – the 'self-organising' way in which systems respond to 'shocks' or disequilibria (e.g. the effect of rising clean-tech demand) involving change elements (firms; innovation centres; policies) coming to occupy a 'basin of attraction' possibly to form a cluster of interacting agents pursuing novelty. This idea was captured sixty years ago by Jane Jacobs: "By its nature, the metropolis provides what otherwise could be given only by travelling; namely, the strange" (quoted in Jacobs, 1961, 238).

It is also important to recognise that the core of creative activities that result in new solutions to environmental problems involve adaptation. This may concern new uses for existing technologies, following the concept of 'exaptation' (Vrba & Gould, 2002) derived from evolutionary biology. This denotes a biological function that has evolved a new use – an example being the buoyancy bags of some fish originating in the era when they had lungs, since replaced by gills; another are the bones of the human inner ear, originally part of the jawbone mechanism of certain fish species from which we evolved. In the world of industry there are many examples of how new alternative uses have been found for old technologies through adaptation of existing knowledge or artefacts. The process is illustrated in the emergence of the first modern wind turbines in the North Jutland region of Denmark discussed below. It may alternatively involve 'retro-innovation' (after Immelt et al, 2009), which focuses on adapting existing high cost or high technology products to vast developing world markets by achieving reduced price or functionality under constraints. This type of creativity may play a significant role in clean-tech development for agro-food and other intensive users of water and energy.

Finally, the role of policy needs to be understood with respect to facilitation of the process through which clean-tech innovation can emerge in a cluster given the above processes. Regional evolutionary economic development theory stresses that the emergence of new solutions through adaptation is based on

the exploration of the ‘adjacent possible’. This means the adaptation or innovation space is a ‘White Space’, a *tabula rasa* or *terra incognita*. An ‘abductive’ step into the unknown must be taken. How is this done? It clearly involves, amongst other things, research, imagination, conjecture, refutation, trial-and-error and recombination of ideas, solutions and elements to hand. Policy has a role to play in bringing together actors across different activities to produce adaptations and innovations that may drive a clean-tech cluster.

The role of policy in clean-tech cluster emergence

This section places the attention on the role, if any, played by policy in clean-tech cluster emergence in OECD countries. Links are made to the learning model annex, which provides more information on the role that has been played by policy in the emergence of clean-tech clusters in Sweden, North Jutland, Denmark, and California, USA. In each of these cases, the emergence of the clean-tech cluster was driven by the meeting of ‘strange attractors’ at path inter-dependent crossroads, which subsequently mutated into cluster-platforms of related variety industry. This has occurred despite differences in their national and regional political and economic contexts. In every case illustrated, clean-tech clusters emerged from something else and combined capabilities from diverse industries – from agro-engineering to wind turbines, from pulp and paper to organic cotton, and algae biofuels from ICT and biotechnology.

How can policy favour this? There are two major points. The first point is that policy has a role to play in facilitating the collaboration among cluster firms that can lead to innovation. It can achieve this by offering three benefits to firms and other agents that actively comply with the new designation of cluster member. All of them are to be seen openly in the Swedish ‘co-ordinated market’ model.

The first is to have the opportunity of meeting new members in their own market segment, or more importantly, different but related market segments to exploit the known innovation and development potential from recombinant knowledge across industry interfaces. This also includes the prospect of forming relationships with larger customer firms seeking to strengthen innovation networks and supply chains.

Second, the ‘transversality’ initiatives underpinning the development of the embryonic Sustainable Business Hub and Training Regions clusters in Sweden were induced by the offer of incentives to companies for participation in innovation projects. Transversality occurs where clusters are seen as modules to be integrated with different clusters to generate innovations and meet higher goals. The incentives take the form of medium-term innovation projects involving teams displaying ‘difference but compatibility’. An output of this induced transversality is ‘green packaging’, which brings together food companies (in fact organic food firms) that cannot be affordably serviced by large firms such as Tetrapak but who seek a packaged branding that shows they are organic and act sustainably. A more technical example relates to milk packaging, which requires perfect sealing from its ‘bioplastic’ (starch-based) packaging. This has been developed through exploitation of nanotechnology expertise from the new materials cluster. The transversal initiatives supporting the development of clean-tech clusters in Sweden have also been facilitated by subsidised cluster management teams, which promote collaboration and broker joint innovation projects across cluster firms.

The final incentive that cluster members receive for participating in clean-tech cluster programmes is access to other clusters in different as well as similar industries. This affords a spreading of good practice knowledge of technological and developmental business paradigms elsewhere, including abroad, and experience of what in support terms may work in one place or industry while being unknown elsewhere. Such advantages would not come easily through market engagement alone.

A second policy lesson is that in the best cases clean-tech cluster emergence is a product of a political process in which learning occurs on both the upper and lower levels of the multi-scalar governance system, involving both national and local policy makers. A striking instance of this is the implementation of a regional green strategy in Västra Götaland, Sweden from the beginning of the 2000s involving the integration of the European Union's 'Gothenburg Model of the Lisbon Strategy' into its regional development strategy. The learning can also occur in the opposite direction, from regional to national level. California was long used to its state anti-pollution policies being templates for later federal regulations as embodied in various Clean Air Acts. In Denmark active 'concertation' between regional industry groupings and national ministries has produced generations of useful regulation and incentive that helped reinforce the regional clean-tech clusters. Nevertheless on occasions such supports were removed, possibly injudiciously, as in 2000 when the relatively protected wind turbine industry lost its subsidy overnight. This nearly killed it outright, yet in forcing it to look beyond Denmark for export markets, notably in the US, the industry proved resilient.

Recommendations

The cluster development concepts and international policy experiences referred to above enable a number of recommendations to be offered for the development of clean-tech activity in the Negev region of Israel, with due regard to the need to adapt policy to the society, economy and governance of Israel. The recommendations can be seen as a set of cross-cutting approaches to the development of a clean-tech sub-cluster in the Negev, which will both support internal connections and growth and tie the Negev into a broader clean-tech innovation system in Israel as a whole.

The recommendations draw inspiration from the dynamic venture support offered in California and the high-grade collective initiative and good governance approaches in Denmark and Sweden. Each of these approaches is described in the chapter annex. The relevance to Israel is clear. In terms of governance, Israel is small like Denmark and Sweden with good innovation policy links from top to bottom, often through the Office of Chief Scientist, policy interventions where there are enterprise or technological market failures, and a welfare state. Yet, viewed from a different angle, it seems quite a lot like California with its high technology share in the economy, skilled workforce and venture capital often originating precisely in California. Indeed, Israel has already seen, on a smaller scale, an entrepreneurship mutation into clean-tech somewhat on the Californian model. It has developed a domestic venture capital industry for clean-tech following the establishment in 2006 of Israel Cleantech Ventures, the first domestic venture capital fund in this area. It also has relatively sophisticated infrastructure for clean-tech development in the Negev, including energy related innovation and testing and advanced research in universities in renewable energy and water efficiency. The opportunity exists to build the clean-tech sector by reinforcing the positive characteristics of both the Scandinavian and Californian models in Israel and the Negev.

Two sub-sectors of the clean-tech industry appear to offer the most potential for further growth: renewable energy and water efficiency. One of the keys to their development will be the encouragement of collaborative innovation projects across related variety enterprises and research activities. There is a wide range of relevant activity. For example, in the research disciplines that sustain solar renewable energy, Israel has research strengths in conversion systems, photovoltaic cells, energy production, heating and cooling systems, dye sensitising, nanotechnology etc, as well as in solar power stations for which there are large global markets, notably in the US where the Mojave Desert alone houses ten in its Solar Park.

Israel has the generic capacity to sustain clean-tech growth in these sectors through application of its prior experience of stimulating cluster emergence in other technology sectors, its technology governance system which allows rapid response to business opportunities, and its private venture capital industry.

Israel already has embryonic sub-cluster activity in clean-tech in all three regions of Israel, often overlapping with existing clusters in medical technology, biotechnology and ICT in the central region.

The key to the growth of the clean-tech sub-cluster in the Negev will be exploitation of the related variety potential for cross-cutting innovation projects both within the Negev clean-tech sub-cluster and with other clean-tech sub-clusters near Tel Aviv and Haifa and clusters in related sectors. The business and policy worlds need to understand, recognise and exploit the innovative potential of related variety as far as possible. Policy needs to focus on supporting interactions among industries, clusters and firms. These transversal connections offer greater potential for innovation and growth than internal interactions because innovation derives from the recombination of different knowledges that are of relevance to the incumbents engaging in the interaction.

In the case of the Negev, critical mass is small, and there are therefore relatively few players in geographic proximity with whom to interact for knowledge exchange on a regular face-to-face basis. There is also greater isolation of the sub-cluster actors compared with those in the Tel Aviv and Haifa regions. Accordingly, policy must work harder to facilitate interactions with related variety industry elsewhere. Electronic interchange will help but it is a limited means of generating new knowledge from the recombination of existing knowledges from different sources. In particular, meetings should be facilitated among local incumbents and with those at a greater distance to promote knowledge interchange and cluster mutation and joint innovation projects should be brokered, incentivised and supported.

Two other actions will support successful policy in this area. Firstly, the Israeli state, either directly or through regional innovation and development governance should ensure dedicated regulatory, incentive and subsidy regimes to support clean-tech clustering in the Negev and elsewhere. Secondly, the state should use its impressive legacy of initiating venture capital, incubation facilities and entrepreneurship in advanced technologies, suitably adapted, to facilitate and improve the context for Israeli clean-tech to develop in a 'self-organising' way.

ANNEX – LEARNING MODELS

North Jutland, Denmark: Collective Entrepreneurship in Clean-tech

Emerging Danish competitive advantage in renewable energy based on wind power

In 2010 wind power's share of Danish electricity supply was 20%. It can be seen from Table 1 that Denmark's share of wind turbine production employment was second largest in Europe at 23,500 after Germany, with 38,000. Interestingly, Sweden and the Netherlands both of which had aspirations and national strategies to develop wind energy industries failed to achieve critical mass. It is argued in Johnson and Jacobsson (2003) that Swedish failure was because national policy only supported large megawatt (MW) turbines for which there was no demand, while the Dutch quickly became path dependent on their local market in which there was little demand and much amenity-planning opposition. Whereas, by contrast:

‘...in the first half of the 1990s, the German industry was aided by industrial policies at the federal and state levels that created a ‘quasi-protected’ market and a German market share of more than 50%.’ (Johnson & Jacobsson, 2003, 34)

There were also responsive ‘regimes’ towards wind power, including early ‘feed-in’ tariffs, on behalf of German and Danish entrepreneurs, that were absent in Sweden and the Netherlands. Moreover the Dutch relied on financial incentives while the Germans used a combination of investment subsidies, legislation, legitimacy and industrial policy (e.g. regeneration of obsolete shipyards for wind turbine production in the Baltic ports; Fornahl et al., 2010).

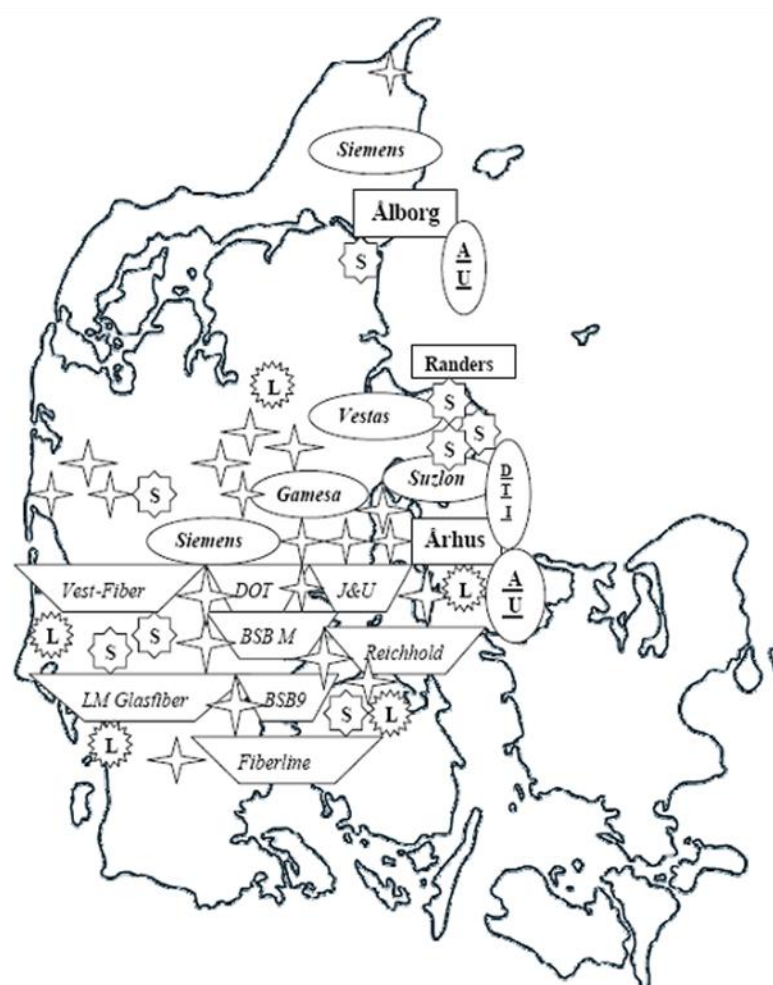
Table 1. Direct Employment from Wind Energy Companies in Selected European Countries (2010)

Country	No. of direct jobs
Austria	700
Belgium	2,000
Bulgaria	100
Czech Republic	100
Denmark	23,500
Finland	800
France	7,000
Germany	38,000
Greece	1,800
Hungary	100
Ireland	1,500
Italy	2,500
The Netherlands	2,000
Poland	800
Portugal	800
Spain	20,500
Sweden	2,000
United Kingdom	4,000
Rest of EU	400
TOTAL	108,600

Source: Danish Wind Energy Association

Though, as is shown below, Denmark's regulators were less benign, even withdrawing a modest subsidy in 2000, nevertheless judicious policy frameworks animated by short communication lines between clean-tech business associations and relevant ministries sustained the innovation stage of Denmark's emergent renewable energy industry. Accordingly, in Denmark, renewable energy at relatively small scale was a viable business option for new entrants or existing entrepreneurs in 'related variety' industries like agro-food and marine engineering. The definitive example of this is Vestas, the world's largest wind turbine producer, located in Jutland, which began life as a producer of agro-food equipment, notably milk coolers. To evolve that 'technology platform' the company later moved into the manufacture of turbo-coolers for ship's engines. This expertise in 'stirring' technology both enabled the firm to cross sector boundaries from cooler engineering to wind turbines and out-perform US competitors like GE and Westinghouse who based their turbines on aeroplane propellers. In Fig. 8 Vestas is the major surviving Danish-owned wind turbine producer; Siemens acquired the others; Gamesa is Spain's leading turbine producer and Suzlon is India's. Numerous supplier firms emerged during the forty year history of the cluster 1970-onwards, as a consequence of which the firms depicted in Fig. 8 comprise some 70% of the total membership of the Danish Wind Industry Association. Interspersed with the wind turbine cluster is an innovation platform of some twenty firms, some like Grundfos and Danfoss being medium-sized multinationals, involved in production both of photovoltaic cells and products, such as pumps, used in clean-tech agro-engineering, building construction, heating and air conditioning. Other firms, such as Logstor, specialise in insulated pipework for district heating power stations and further green applications. Yet others specialise in insulated windows, biogas power plant production, geothermal, wave, waste and biomass heat and power engineering.

Figure 8. The Wind Turbine Cluster in North Central Jutland, Denmark



Note: Quadrangles – fibre glass blade suppliers; star shapes – engineering suppliers; stars marked 'S' – service suppliers; stars marked 'L' – logistics suppliers; AU – universities; DTI – Danish Technological Institute
 Source: Centre for Advanced Studies, Cardiff University based on Danish Wind Industry Association data, 2007

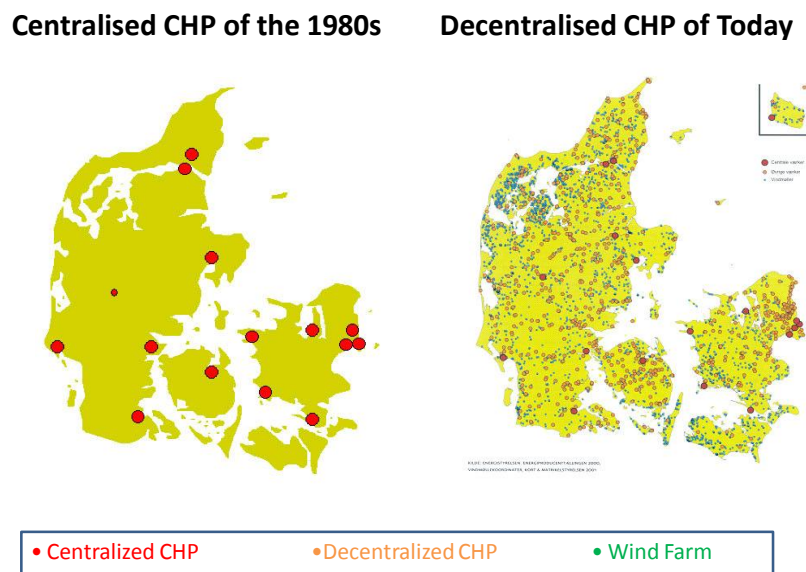
Regional administrations have been established in Denmark since 2007, and these too have played a role in the emergence of clean-tech activities. An exemplar of this new regional-level initiatives has been North Jutland's emergent 'green regional innovation system', a clean-tech cluster-platform which grew out of the early lead established by Danish wind turbine eco-innovators.

Enlightened and Innovative Green Public Procurement

North Jutland is nowadays specialised in building and developing renewable energy through Combined Heat and Power (CHP) systems for electricity production that enable heat produced as a by-product of electricity generation to be captured and used for district heating. One of the key factors behind this growth has been the growth of local demand for Combined Heat and Power (CHP) systems in Denmark. Fig. 10 portrays the 'revolution' that occurred through the decentralisation of power generation in Denmark, where regional and local providers came to dominate the scene after the 1980s.

Municipalities have acted as the major demanding customers for these innovative CHP systems and have been mainly responsible for the shift seen in Fig. 9 towards decentralised production. Most run local energy supply companies and some 60% of Denmark's citizens rely upon it. Municipalities seek a balanced supply and order customised mixes of biomass, biogas, wind, solar and marine energy depending on location and the type of solution required. This creates a fertile area for the development of innovations that are then sold not just nationally but internationally. We can easily see municipal purchase of locally engineered district power stations fuelled by varieties of renewable energy as an exemplar of enlightened 'green' public procurement.

Figure 9. Shift from Centralised to Decentralised Combined Heat and Power



Source: Danish Energy Authority

A favourable national policy framework

The framework for this evolution towards decentralised CHP was set by the Danish National R&D Strategies for Renewable Energy Technologies (2003), Subsidies for Renewable Electricity Generation (2004) and Energy Strategy 2025 (2005). These initiatives set the appropriate framework for Danish heating and cooling engineers to evolve multiple renewable energy systems combining wind, solar, marine, geothermal, biomass and biogas energy to offset variability in supply of single sources. Hence, system variety and adaptability became 'emergent' in Danish renewable energy portfolios. North Jutland became the dominant region where most companies and clients are based because it was able to press home its inherited collective advantage in the development of these innovations in terms of path inter-dependence across existing related variety sectors (Cooke 2010a).

A 'cluster management organisation' and joint innovation incentives

An important element in the emergence of the region's competitive advantage in this field was the creation in each of the Danish regions of what serves as a 'cluster management organisation' and incentive provider for joint innovation projects. This comes in the form of an association entitled *Innovative Region: Flexible District Heating*, which was set up by regional district heating firms, municipalities, university laboratories and technology transfer agencies. This association, since renamed *Flexenergie*, successfully bid for a EUR 4 million project from the Danish 'Demand Driven Innovation Fund' which has been

managed and implemented in each of Denmark's five regions since 2007. The association funds a number of future projects on multiple renewable energy combinations. These involve development of advanced software, sensors and systems management of the necessary shifts from one energy source to another. It also involves associated energy storage issues for minimising fluctuations in outputs during transitions. Back-up generator facilities remain necessary for the hiatus between on-stream energy varieties and a key intent is to replace hydrocarbons with renewables even for this modest function. A group of projects mixing wind with gas, biogas and geothermal are thus underway, many in the self-sustaining renewable energy municipality of Thisted in north west Jutland. This place acts as precisely an 'environmental foreign policy' lighthouse as visits in 2010 of delegations from Canada (Mayor of Toronto), USA (Pentagon), the Venezuelan Embassy and Indian and Bangladeshi energy ministries testify.

The role of local clean-tech demonstration projects

One of the best and most impressive stimuli for clean-tech development was Copenhagen's leadership of the *Dogma* programme, which was completed by 2009. The intention was that *Dogma* should be a 'lighthouse' demonstration project on how to make cities more sustainable while also acting as good global neighbours. Each municipality that was a member of the programme's network agreed and signed up to a set of rules on sustainability practices. They also had to 'walk the talk' by fulfilling their commitments, otherwise their membership of the network was terminated in 'punishment'. The programme therefore served to generate public procurement initiatives targeted on environmental sustainability.

Dogma was fundamentally a policy network; that is, an informal or semi-formal organisational mechanism involving public and private individuals, stakeholder groups, organisations and associations interacting around specific multi-level policies and programmes. Network stability derived from establishment of trust, reliability, reputation and customary rules to which network members adhered. Network maintenance was secured by the access members had to resources and influence in projects. Network management, brokerage and facilitation were necessary functions taken by different network members in the target group. This is illustrated in the practical sense by Jensen and Tollin (2004) in their disclosure of how networks spread innovative policy knowledge in Copenhagen's *Dogma* sustainable development strategies and actions.

Interestingly, for its first and best communicated initiative, Copenhagen tackled the important climate change issue of agro-food emissions. This was achieved by transforming food procurement from conventional to organic, which in Copenhagen and the other *Dogma* towns included schools, hospitals, day care and long-term care homes. Together, these city strategies on organic canteen food alone contributed to a 2.25% reduction in CO₂ emissions from their institutional food chains. In the further important emissions sphere of mobility, renewable energy vehicles were promoted and bought for bus, car and light truck or van fleets. Comparably, passenger transport CO₂ emissions were reduced by 10-15% in Copenhagen 1996-2006 following establishment of urban environmental zones and clean-technology measures. Next, in regard to waste management, another significant climate change contributory factor, in Copenhagen up to 80% of city household waste is used in Energy from Waste (EfW) power plants while over 70% of all waste is recycled. Finally, with respect to energy, a further major contributor, more than 25% of electricity generation in Copenhagen, is from renewables, notably wind (4%) and solar power (3%) in addition to waste (26%). Other *Dogma* cities approved building of biogas from waste biofuels power plants. Copenhagen had, from 1990 to 2005 reduced overall CO₂ emissions by 23% with the further reduction aim of 35% by 1990-2010. These achievements led to Copenhagen, home to the EU's Environmental Protection Agency, being elected Environmental Capital of Europe and International Solar City. In the Copenhagen Carbon Neutral Plan for 2025 the city committed to further reduce carbon emissions by 20% by 2015 through 50 specific initiatives, many involving more efficiency in the energy (wind, geothermal, solar replacing coal) and transportation grids.

Thus *Dogma* acted as an umbrella for various demonstration initiatives, rendering environmental policy more efficient. The exercise also displayed evolutionary complexity inasmuch as many sustainable development networks formed and evolved into a 'network of networks' structure. This itself became formalised into a 'platform project' with envisioned modules, actions, rules, and performance audits in what became a continuously adaptive policy model. Accordingly, the *Dogma* project, involving the cities of Copenhagen, Albertslund, Ballerup, Fredericia and Herning, succeeded in that all members achieved the sustainability objectives agreed to in the rules and it gave rise to new networks, like Copenhagen's *Key2Green* environmental network involving the city and private entrepreneurs. *Dogma* became an inspiration for policy makers, firms and stakeholders supportive of the need for lower-tier swift action to act resiliently in the face of the climate change 'shock' through evolving City Climate Change Strategy. This is something often neglected in the 'strategic niche management' literature on how public procurement can enable 'green markets' to evolve for clean-technologies (Geels, 2006).

Summary of success factors

In the case of North Jutland, all the cluster factors highlighted in the chapter come together to explain the 'emergence' of a new (from the 1970s) green cluster that subsequently mutated into a green innovative platform or regional innovation system. It demonstrates the importance of 'related variety' among distinctive engineering skills, technologies and activities, notably around municipal district heating scheme procurement, with associated lateral absorptive capacity of a high order. It also shows the positive role of path inter-dependence as agricultural and marine engineering capabilities spawned wind turbine design and construction competences. Accordingly these and the related innovation platform industries in the region constitute the 'strange attractors' drawing industry into the 'basin of attraction' marked 'clean-tech engineering'. We can further observe elements of 'preadaptation' in the innovation moves taken from cooling to wind turbine engineering, which also proved superior (evolutionary process of 'selection') to its US competitors. But moving into flexible renewable energy design and engineering was an exploration of the 'adjacent possible' since no-one else did this and work continues to perfect renewable fuel transition phase control systems. Clean-tech cluster emergence thus ensued from the different design and engineering 'modules' that acted as a self-organised (unplanned) system, which came to form a broader combined heat and power energy platform in the north and central Jutland regions of Denmark.

Sweden's Regional Climate Change Strategies

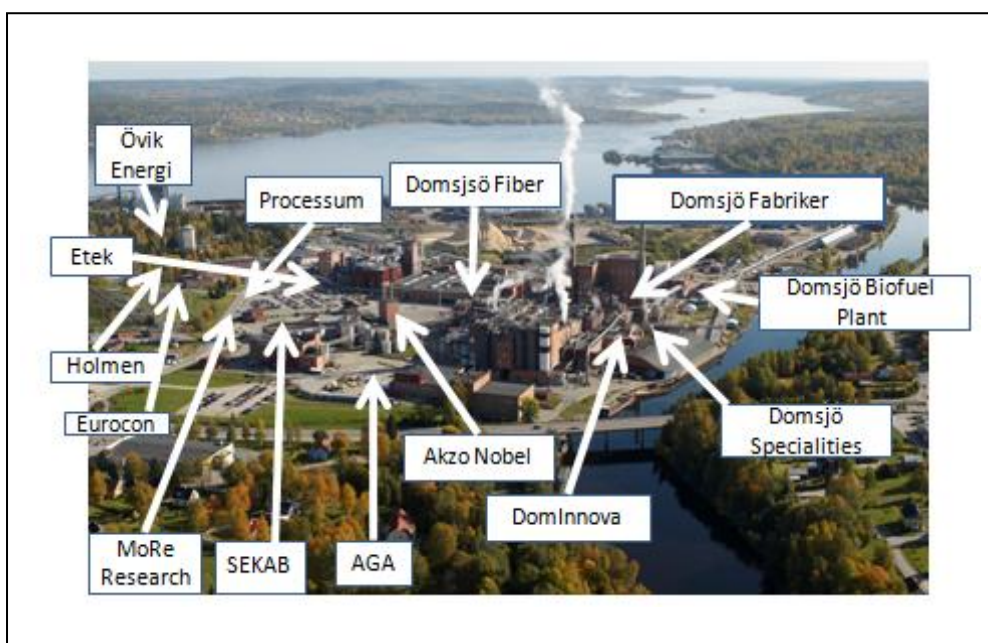
Swedish innovation agencies like the former NUTEK (now TVV) and VINNOVA promoted cluster strategies in the 2000s. Approximately twenty such initiatives have been funded overall. In what follows, we will anatomise three regional cases. The first is in northern Sweden's Norrland region at the port of Örnsköldsvik, the second in the southern region of Skåne and the third in Västra Götaland, the Gothenburg region.

The Norrland cluster

The heart of the first cluster, in the Norrland region, is the Processum biorefinery. This had its origins as a sulphite mill built in the 1940s to produce alternative fuels because of wartime petroleum scarcity. Over the years it evolved into a pulp and paper plant which produced substantial and polluting waste. Nevertheless this waste has proved to have enormous value through the application of 'industrial ecology' management which reincarnates the waste as useable products. These range from biofuels, used to power the cluster's renewable energy power plant, industrial chemicals, paint (Akzo-Nobel) construction materials, road surfacing material and organic cotton. As can be seen from Fig. 10 this is a highly defined and geographically circumscribed cluster. Such has been the attraction for global markets of Örnsköldsvik's organic cotton during the era of 'peak cotton' in the 2000s that the old sulphite plant was in

2011 purchased for EUR 500 million by the Indian textile company Bharat. The factory, Domsjö Fabriker AB, nowadays operates as a subsidiary of Thai Rayon Public Co. Ltd. and PT Indo-Bharat Rayon.

Figure 10. Örnköldsvik Biorefinery Cluster, Norrland Region, Sweden



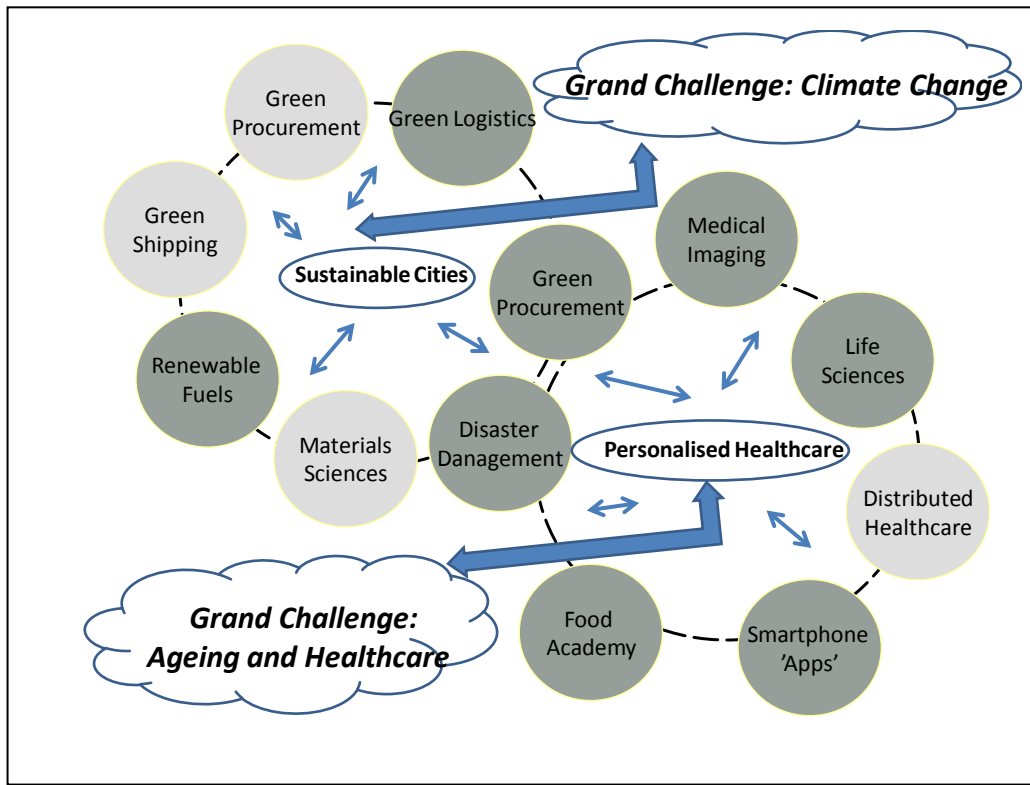
Source: Processum

This case shows clearly how a narrow path dependence, initially on sulphite production from timber and later on pulp and paper, was transformed into multiple pathways by the ‘reframing’ of the core plant’s core function with the emergence of the clean-tech paradigm. Path inter-dependence connecting strange attractors like biofuel, paint and cotton production are indicative of the power of related variety and high cross-sector absorptive capacity to create a high proximity, high value-added innovation platform in a remote location. Most of the new industries were enabled by research into the ‘adjacent possible’ of how to utilise varieties of waste ‘black liquor’ from pulp and paper production. This could never have been predicted in the pre-clean-tech era but analysis of the various fir tree genomes over the years revealed that there were manifold opportunities for valuable economic activity once the clean-tech perspective evolved after the 1990s.

The Skåne cluster

The second case is an emergent cluster in Region Skåne. It has at its heart an eighty firm Sustainable Business Hub with expertise in water management, purification and recycling. Others contribute to the platform with expertise in waste treatment, including firms that produce organic fertilizer from waste and others that have designed pipeline transportation of fertilizer to networks of farms, thus further reducing CO₂ emissions. There are also firms involved in green packaging (Tetrapak), green visualisation (multimedia simulation for training), disaster management (‘Training Regions’ cluster) and green construction, including Sweco, a global architectural and engineering practice that designs eco-cities, mainly for the Chinese market. The elements of modularity and emergence are demonstrated in Fig. 12, which shows a stylised version of how related and apparently unrelated variety in the region’s clusters were recombined into two ‘innovative platforms’, one dealing with Personalised Healthcare (i.e. healthcare in the home rather than the hospital) and the other emphasising The Sustainable City.

Figure 11. Modules contributing to emergence of innovative platforms in Skåne, Sweden



N.B. Darker circles represent active modules, lighter circles are potential modules

Source: Centre for Advanced Studies, Cardiff University

Skåne's real time strategy builds on waste and water treatment capabilities combined with the design of more sustainable city living as encompassed in Sweco's expertise. The facilitation for this is provided by the Skåne Regional Development Agency (for further detail, see Cooke, 2012a). The 'emergence' dimension is completed by the Skåne region's accompaniment of Västra Götaland and other Swedish regional expertise in sustainability as modules in the Swedish national innovation strategy, part of which is driven by the 'Grand Challenge' of mitigating climate change. This, finally, contributes to the equivalent Grand Challenge goal for the European Union and, through the United Nations, the world. Clusters, and the Sustainable Business Hub in particular, act as modules in a process of multi-scalar 'policy emergence'. Naturally, related variety and lateral absorptive capacity are designed into this modular approach to policy which utilises clusters for greater purposes. Path inter-dependence involving stimulation of 'strange attractors' to induce innovation is also clearly evident in the emergence of the two platforms. Finally, the multi-scalar nature of 'emergence' is also captured in Fig. 12.

The Västra Götaland cluster

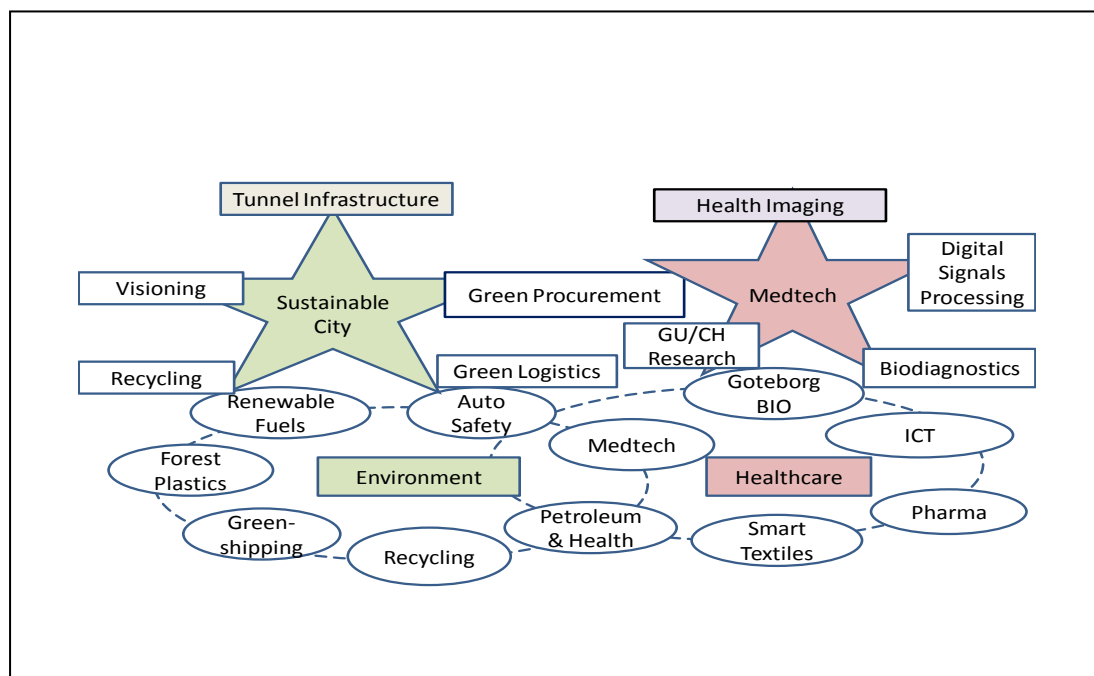
The development of clean-tech in the Västra Götaland region, centred upon Gothenburg, has been supported by the development of a regional strategy for the Sustainable City, which has been linked to achieving European Union and national government objectives in this area. The approach taken by Västra Götaland has been to be innovative in a way that is nested with European Union Mutual Learning Platform initiatives (e.g. 'Europe 2020', 'Innovation Union', and the 'Grand Challenges', such as climate change), with Swedish National Strategies and that links to municipal and local policies. Accordingly, in 2010 the

strategic decision was taken to concentrate initially on meeting the Grand Challenges of Climate Change and Healthcare. Both initiatives have been developed around an ‘Iconic Project’ and involve policy support for innovations that bring together actors from a range of related variety sectors that are committed to innovation, learning and collaborative platform management processes in what are considered ‘project laboratories’.

One of the motivations for the Climate Change initiative was that the region had been one of the first in the world to publish in 2003 a Climate Change response strategy report ‘*Gothenburg 2005*’ involving policies for ‘Smart Energy.’ This later evolved into the strategic Climate Change target of Region Västra Götaland being totally Fossil Fuel Free by 2030. This swift and innovative approach became known as the ‘Gothenburg Model of the Lisbon Strategy’. Working out the regional position on that Grand Challenge well in advance gave scope for the new environmental strategy to be down-to-earth and practical. The region’s approach to meeting the Climate Change Grand Challenge involved translating it into a ‘Sustainable City’ initiative.

The Sustainable City initiative itself was triggered by an ‘Iconic Project’ in the form of an actual infrastructure commitment to a new tunnel. This project brings together numerous regional clusters involved in renewable automotive fuels, forest plastics and petroleum and health (Fig. 13). The associated environment initiative assembles pilot projects mixing expertise in cluster firm capabilities in logistics, public transport, visioning (computer graphics and imaging) and green accounting. For example, there is a collaboration around ‘Sustainable Green Transport’ used to bring together expertise from the auto cluster, renewable fuels, and ‘green shipping’. These innovation initiatives link to academia at Chalmers University and firms like Asta AB. A comparable ‘Iconic Project’ approach is being taken in healthcare.

Figure 12. Västra Götaland’s ‘Iconic Projects’ Approach



Source: Centre for Advanced Studies, Cardiff University

In Västra Götaland, engagement with Grand Challenges like ‘Sustainable Cities’ is presumed to be both good for regional sustainability and to open up into important future markets. As noted, strategic

thinking is informed by a hierarchy of strategic governance levels from the European Union Europe 2020, Innovation Union and Smart Specialisation initiatives to the Swedish National Strategy and regional cluster platforms. The national and international levels find it useful to engage with regional clusters as policy modules for eco-innovation.

Like Skåne, Västra Götaland takes a 'modular systems' approach to policy formulation and implementation because of its development of a wide variety of clusters ready for integration as platforms. These are rapidly re-focused on specific Grand Challenge projects and early adoption of Grand Challenge thinking. This has taken the form of 'Green Regional Strategies' since the first in 2005 (VG Green Strategy), followed by 'Smart Energy' (2008) whose vision was heavily to reduce the region's dependence on fossil fuels and to secure a sustainable energy supply by 2030. This is now embodied in the policy 'Fossil Fuel Free Region by 2030'. Contributing to that aim is Gothenburg's integrated waste system that has collected, sorted and burnt 345,000 tonnes of rubbish annually. Compared to an oil-based energy strategy waste-to-energy production saved the city an estimated 205,060 tonnes of CO₂ even in 2006. Hence, this Swedish region, which like Skåne, has special status in the Swedish regional set-up, plays a lead role in supporting eco-innovation while fitting in with the broader framework of EU and national eco-innovation policy, sometimes also influencing it.

California's Sustainable Development Policies: from Vehicle Emissions to Climate Change

California: A Leader in Sustainable Development Policies

It may be argued that California's 'sustainable development' policy has gone through three mutations as it has evolved over time. In the first period, 1945-1989, the emphasis was initially on responding to new understanding that the interaction of vehicle emissions with sunlight generated the toxic atmospheric pollution condition popularly known as smog. However, from the 1970s, as policy continued to be concerned with vehicular emissions, it also showed an increasing concern with energy efficiency and early fears consequent upon the discovery of the existence of greenhouse gases (GHGs) and the first anxieties about the new concept of 'global warming'. Numerous anchor agencies, like the Air Resources Board for monitoring and regulating pollution, were set up in this era and a lead role was given to the California Energy Commission. In the second era, from 1990 to 1999, policy started to respond to more widespread concern about global warming and the need to get a firmer grip on the quest to move beyond the exploitation of fossil fuels. The actions included incentivisation of moves towards discovery and utilisation of renewable fuels. California was a leader in these policy developments. Indeed, so much was there a symbiosis between California's early concerns with environmental pollution and the later realisation of the extent of the problem over much of the urbanised areas of the United States that the basis of the federal Clean Air Acts was California's 1988 Clean Air Act. The third era, from 2000, displayed a growing emphasis upon measures intended to contribute to the mitigation of climate change involving targeted GHG emissions reduction measures, experimentation with hydrogen and fuel cells both static and in vehicles and a policy for cap-and-trade carbon reduction strategy. All in all, given California's massive motorisation culture, it would be misleading to say that mobility pollution occupied a low agenda position, rather that it was joined by wider concerns regarding energy, construction and potential infrastructure systems failure occasioned by climate change. In general, California has been ahead of much of the rest of the US in these concerns and its strategies have often preceded and seldom clashed with those adopted at the federal level.

Clean-tech Cluster Formation

The regulatory and financial incentives provided in California for new approaches to addressing environmental pollution gave a major stimulus to the growth of its modern clean-tech cluster in the 2000s. Today's cluster clearly builds on previous industrial activities developed as part of California's long

running sustainable development strategy through a process of entrepreneurial mutation. It also received a stimulus from the Bush administration's Energy Independence and Security Act of 2007, which was the result of the policy to actively promote energy efficiency in the automotive industry, household appliance and lighting industry and to stimulate green jobs growth. Taxpayer funding would also be used to increase biofuel production and R&D in solar, geothermal, marine and hydrokinetic technology. This Act clearly focused more on renewable energy than the 2005 policy which it superseded. At any rate, shortly afterwards there was a rush of Silicon Valley entrepreneurs and venture capitalists into clean-tech.

This resulted in new cluster formation (Fig. 7) among firms that often shared venture capitalists, advisory board members and former career histories. One of the most celebrated was Israeli Shai Agassi, who set up Project Better Place, which actively supplies mainly Renault electric vehicles in schemes across the world, including Israel. These and other mainly renewable energy or electric vehicle (EV) firms found locations in familiar territory, around San Francisco Bay and south-east into Silicon Valley.

The evolution of the cluster is an example of system self-organisation rather than top-down policy direction, driven by market processes of local investment of retained profits and local investment of venture capital with its requirements that generally investees should be located within an hour's drive of Sand Hill Road, Palo Alto, where most of the venture capital firms are located. It is also interesting to see how related variety has allowed the re-use of some pre-existing skills in the new industry and that absorptive capacity was accordingly high. Furthermore, many of the clean-tech firms have oil industry representatives on their advisory boards and some from the agro-food and chemistry industries. These would clearly be unlikely advisory board members in ICT companies. Hence we see, as if in laboratory conditions, path inter-dependence occurring and a new pathway being cleared involving often 'strange attractor' entrepreneurs exploring a 'white space' of the adjacent possible in some instances (e.g. algae for biofuels) but also some well-trodden pathways (e.g. solar power) presumably with 'ahead of the curve' substrate materials from the semiconductor industry.

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CHAPTER 3.

PROMOTING BUSINESS DEVELOPMENT

By Gregory Theyel

Abstract

This chapter begins with important foundational policy issues related to business development in clean-tech clusters. They include the identification of existing regional resources, understanding of existing and potential customers, and appreciation of variations in resource needs and technologies within the clean-tech sector. These policy issues are followed by an analysis of the existing conditions and likely opportunities for developing a clean-tech sub-cluster in the Negev region of Israel. The chapter concludes with policy recommendations, including proposed measures to enhance regional demand and supply conditions, establish a regional clean-tech organisation leading a planning process to establish regional clean-tech information and connections; procurement agreements with the Israeli government, including the military; expansion of the green business programme; attraction of foreign direct investment; enhancement of the commercialisation of local clean-technology; and development of a clean-tech financing approach.

Policy Issues

Locations are made up of resources that shape their future industrial composition. New industries can emerge from older, established industries that can offer new technology, spin-off companies, and support for emerging industries. This is described as a ‘branching process’ (Boschma and Frenken, 2009) involving building of new opportunities from the resources and capabilities of existing regional industries and institutions. Companies in older industries often become suppliers and sources of employees, investment capital, and innovations for companies in the new industries (Nefke et al. 2011). The policy implication for clean-tech clusters is that if a location lacks the relevant resources for the growth of new clean-tech industries, or these resources are poorly developed, the challenge of growing a clean-tech industry will be great. In this case either the sector can be built with a significant input of resources in the form of capital and/or transplant corporations, or the option can be taken to focus on different industries that are a better match with the region’s particular existing resources.

Firms, and clusters of firms, can benefit from proximity to customers who can help with insight on their needs, more rapid feedback leading to innovations, and an extension of firms’ research and development in the form of user innovations and co-development of products and processes (von Hippel, 2005). Customer requirements may spur technology and process development, and it is likely that proximity to demanding customers can enhance the learning process for both parties (Porter, 2003). Companies working with local customers can gain traditional benefits of collaboration such as risk and resource sharing, but they can also improve their communication and information flow with these local customers. This is especially relevant for new, emerging industries like clean-tech where technology and its application are at early stages and there is significant learning by doing. It is therefore important to identify existing regional customers or potential new regional customers for the development of a clean-tech cluster.

Clean-technology is a broad category of segments with differing characteristics and needs and includes activities such as energy generation, infrastructure, storage, and efficiency; agriculture and nutrition; air quality; water purification and management; transportation fuels and logistics; building construction; materials development, recovery, and recycling; information technology for greater efficiency; and cleaner manufacturing and industrial processes. To understand the opportunities for clean-tech development one must appreciate the differences between the segments. Technological innovation can differ in cost and likelihood, the amount and type of land needed varies, the number of people and their skill types differ from segment to segment, and financing amounts and likely returns and payback period will also vary between clean-tech segments. This implies that the nature and extent of policy support will vary depending on the clean-tech segments targeted within a region.

The issues described above form a policy context for the development of a clean-technology cluster. Understanding the larger industrial ecosystem that a clean-tech cluster exists within, inventorying and valuing the supply and demand characteristics of a region, and appreciating the differences between clean-tech segments are essential for analyzing a region's potential for clean-tech development. The next section will apply the concepts above to the analysis of the Negev region leading to the third section, which makes policy recommendations for developing a clean-tech sub-cluster in the Negev region through business development.

Analysis of the current system

Negev Industrial Ecosystem

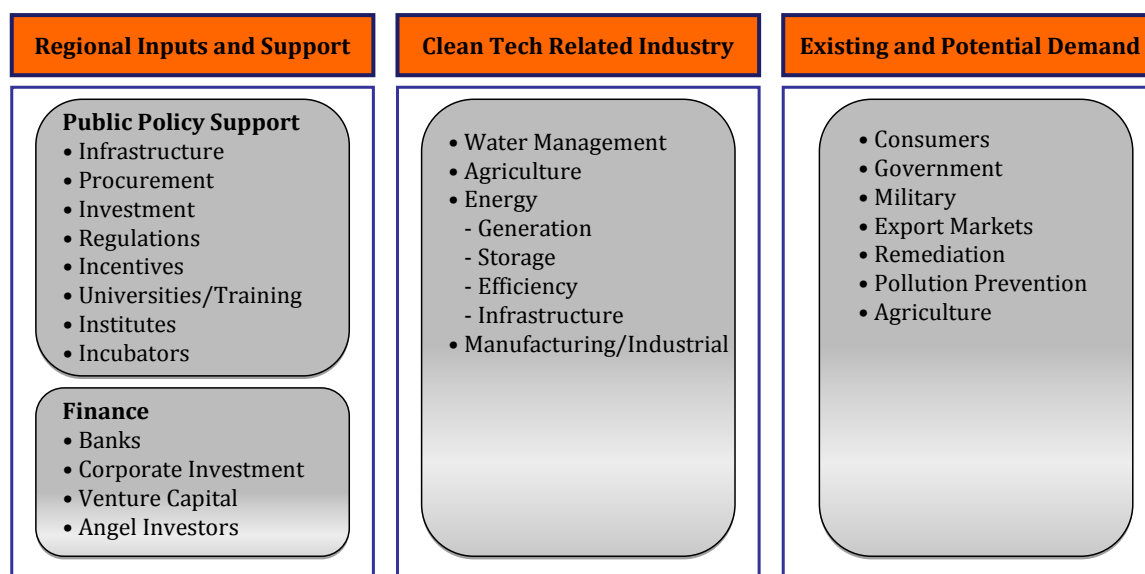
The starting point for the analysis of the Negev region is describing the region's industrial ecosystem. The Negev region centres on Be'er Sheva, which has an industrial base, a university, hospital, and medical school, and supports the region's primarily agricultural and light manufacturing economy. The regional offices of companies extracting potash, phosphates, bromide, magnesium, salt, and lime from the Negev desert are located here, alongside factories producing products such as ceramics, irrigation equipment, and pesticides. There are several technology parks surrounding the city, which are home to light manufacturing firms, including some solar technology and water management companies. Ben Gurion University of the Negev is one of Israel's largest universities, with over 20 000 students, and is located in Be'er Sheva. There are a few other notable centres of activity in the region including Eilat (250 km south of Be'er Sheva), which is a resort destination on the Red Sea, the Dead Sea, which is a popular tourist destination, and Dimona (50 km east of Be'er Sheva), where there is a nuclear power and research station.

Negev Clean-tech Sub-Cluster

The Negev region clean-tech sub-cluster is nested within the larger Negev industrial ecosystem, and connected to other clean-tech activities in the rest of Israel. The sub-cluster contains regional inputs and support, clean-tech related industry, and existing and potential demand for clean-tech products and services. These components of the Negev clean-tech sub-cluster are shown in Figure 8.

One of the strengths of the sub-cluster is the local presence of approximately 50 clean-tech companies. They are mostly small and early-stage companies and are primarily in water management, energy generation, agriculture, and materials. Another important strength is the local presence of support industries and potential customers, as well as a university, a few incubators and research institutes, and government agencies. However, there are also gaps compared to a fully-fledged cluster. In particular, there is little local capital for clean-tech in the region in the form of angel, venture, and corporate capital. In addition, the sub-cluster is made up of primarily disparate parts with few connections between them. The rest of this section describes these components.

Figure 13. Clean-tech Sub-Cluster Components



Source: The Author

(i) Regional inputs and support

Public Policy Support

As discussed in Chapter 1, the **Office of the Chief Scientist (OCS)** at the Ministry of Industry, Trade and Labour (MOITAL) is the primary government institution supporting the development of clean-technology in Israel and the Negev region. This agency has not supported the clean-tech industry explicitly, but it provides resources to support excellence in R&D and firms to implement proposed projects.

Over the last two decades, the OCS has supported **incubators** as a tool in the Israeli policy for supporting R&D in small and medium-sized businesses. The OCS and private entities have jointly financed these incubators. The incubator programme supplies entrepreneurs with physical space, financial resources, professional guidance and administrative assistance, and acts as a venture capital fund at the early stages. There are 21 incubators in Israel, of which four are in the Negev area. Nearly 1 500 companies have graduated from Israeli incubators (238 in the Negev region), and about 47% of them have survived and are still active independently (in the Negev 104 companies remain active) (OECD, 2011).

The OCS established two **technological centres** in the Negev region: one in Sde Boker for water technologies (on the Central Plateau in the Negev) and a second one in the Arava (the eastern prairie bordering Jordan) for renewable energy technologies. These centres are to foster applied research that integrates the functions of academia and industry. The government has set up a 5-year budget plan for these centres, allocating USD10 million for the water technologies centre, and over USD16 million for the renewable energy centre. These centres are managed as not-for-profit private organisations and were chosen through a competitive process.

The Water Technologies Entrepreneurship Centre (**WaTech**), which was established in 2004 by Mekorot, is also a Negev region clean-technology institution. WaTech serves as a platform for business ventures and emerging collaborations, mostly in the fields of water technology, control and management. The centre assesses proposals for water technology projects and enterprises, and conducts approximately

50 applied research studies each year. There are three advanced R&D centres sponsored by Mekorot, one of which is in Eilat, at the southern tip of the Negev region.

The availability of support services for clean-technology is a weakness of the Negev region. There is a shortage of highly skilled labour, a limited amount of business services such banking, consulting, and lawyers, a limited variety of employment opportunities, making it difficult for households to move to the region (in many cases only one of the spouses can find a job) and the extreme weather conditions that make the Negev region less attractive for living. In addition, the Negev region has large areas of land that are used by the army for military training and other areas that are used by the Bedouin population. Both of these factors may limit the use of land (OECD, 2011).

Finance

Solar technologies receive the most **public and private investment**, in large part because of a feed-in-tariff that has subsidised the installation of solar power since 2008. The renewable energy projects in Israel are initiated by private investors who raise most of the money from banks, corporations, and the Tel Aviv stock exchange, but in some cases the government may participate in financing up to 20% of the capital costs through its capital investment law aimed at fostering investment in rural areas.

The **Israeli Investment Centre**, which is a government-established investment scheme, is focused on encouraging investments that promote the national economy, have the ability to compete in international markets, and generate innovative technologies and places of employment. The Negev region is defined as a national priority region and receives unique treatment. For example, investments made in the Negev are eligible for grants of 20% of the total investment. Companies that invest in the region are also eligible for a 30-50% reduction in their corporate taxes.

The **Israeli Centre for Regional Development** is responsible for integrating, managing and coordinating the designated policy for economic development, financial investments and employment in national priority regions such as the Negev region, with the aim of increasing growth and employment in these regions. The Centre's primary objective is to initiate new programmes and projects that will lure investors, to develop new sources of employment, and to encourage the establishment of large and small business within these regions.

Private venture capital for clean-technology in Israel has grown to over USD100 million per year (OECD, 2011). This does not include two major investments: Better Place Project - USD200 million in 2007 and Bright Source - USD115 million in 2008, which involved venture capital funds, private equity funds and banks. Israeli and foreign investment groups, multinationals such GE and Siemens, and angel investors have been contributing financial support for clean-technology in Israel, including the Negev region.

While the finance capital available for clean-technology in the Negev region is growing, the amounts of capital are still limited compared to the size of investments needed for most, significant clean-technology projects, e.g. solar farms, production facilities for clean-technology manufacturing. There is a need for continued financial support from the Israeli government and additional investment from sources such as corporate funds, private venture capital, and foreign direct investment.

(ii) Clean-tech related industry

Israel and the Negev region have legacy industries, labour markets, supply networks, and production capabilities that are related to clean-technology and could be leveraged to support a clean-tech sub-cluster in the Negev region. These clean-technology-related industries are primarily in water and renewable energy technology and in environmental and materials industries and described below.

Israel has expertise in **water technology** (wastewater treatment, desalination, and drip irrigation), and there are 127 water-related companies focusing on the efficient use of the limited water in Israel. Thirteen of these companies are located in the Negev region. There is existing and potential demand for water technology because of the agricultural base of the region. This is a good example of the potential for local demand assisting the emergence of companies supplying a variety of end-products as well as products aimed to other firms specializing in water management technologies.

There is also expertise in **renewable energy technology** (solar, biofuel and geothermal energy production) in Israel and in the Negev region, with 192 renewable energy companies, including 12 in the Negev region. There are currently two planned solar energy fields in the area of Ashalim in the Negev region. Using solar technology developed by two Israeli companies, Bright-Source Energy Ltd. and Solel (now Siemens Concentrated Solar Power), the plants in Ashalim are expected to have an installed capacity of 250 MW. In addition, the Dudaim waste site, which is responsible for the treatment of household waste in the Negev, has an electricity generation installed capacity of 2 MW from biomass (see Chapter 1). Compared to water technology, environmental, and materials companies and projects, most renewable energy ventures require large amounts of financing and take longer to reach profitability. The piloting and scale-up of energy projects can take 5 to 10 years, and in excess of USD100 million, while most other types of clean-technology ventures require much less funding and pay back investors much sooner.

There are about 90 **environmental and materials firms** in Israel, including 12 in the Negev region, which provide products and services in the areas of waste treatment, air purification and monitoring, ground and soil treatment, recycling, advanced materials, and transportation. The materials companies are developing greener substances and processes that are less environmentally harmful. Plastic, tyres, and metals are the materials being recycled. These clean-tech segments serve customers in Israel and the Negev region, and these are examples of local demand assisting the emergence of clean-tech companies in the Negev region.

(iii) Existing and Potential Demand

There is existing and potential demand for clean-technology that the Negev clean-tech sub-cluster could build upon. The Israeli government could help build demand through **green procurement** of water, energy, and environmental technology. For example, the Israeli Defence Forces are planning to invest approximately USD7 billion to relocate its bases (including some technological units) from the centre of the country to the Negev region. This move will involve a massive investment in infrastructure including roads, railroads, water, electricity, etc. and will create a strong demand for various environmental products and services. This could create local demand assisting the emergence of companies supplying a variety of end products and services.

The Israeli government plans to develop **communities** for the Bedouin people in the Negev region and relocate people from other parts of Israel to the Negev region. These government financed projects could be excellent opportunities for implementing renewable energy, green building, smart grids, and water management technologies.

Negev industries could build demand for clean-technology by **remediating existing pollution** and by preventing future pollution. Applications of clean-technology, such energy and water use efficiency and material recycling, are possible in existing manufacturing and agricultural industries in the Negev region. In many cases, pollution clean up and prevention can enhance regional economies through better working and living conditions and new employment and entrepreneurial opportunities.

Companies in the Negev region with expertise in water management and solar power technology could **expand their global markets**. The region has research and development and production expertise,

which could be built upon through further development of testing and manufacturing products. There are advantages of locating research, development, and production in proximity in order coordinate learning and innovation. Developing more of the water and solar technology value chains in the Negev region would enhance the current research capabilities and provide needed manufacturing and testing expertise to build a more vibrant clean-tech sub-cluster.

Assessment of the Business Sector

This section evaluates the strengths, weaknesses, opportunities, and threats of the Negev region's clean-tech sub-cluster in light of the policy issues discussed and the resources and capabilities of the Negev region presented previously.

Strengths

The Negev region lacks some of the strengths that underpin the world's largest, self-contained clusters, such as a large human capital base, large mass of lead customers and suppliers, locally based investment capital and strong local partnerships and leadership, as summarized by Potter and Miranda (2009). However, there are already the foundations for a clean-tech sub-cluster in the Negev region, which could grow further by filling cluster gaps with stronger linkages to the rest of the Israeli clean-tech cluster and through the stimulation of local entrepreneurship building on the region's expertise in water and solar technology, and the availability of land and weather conditions for clean-technology test and demonstration facilities.

Israeli Incubation Culture

Israel is known globally for having an entrepreneurial culture as exemplified by thousands of yearly start-up firms, one of the highest per capita spending levels on research and development, and a vast network of business incubators (see Chapter 1). There were nearly 50 000 new firms launched in 2010 (Israel Central Bureau of Statistics, 2011) and Israel has over 20 incubators, including four in the Negev. The Israeli incubator programme has played an important role in building the entrepreneurial culture that exists in Israel, as it enables entrepreneurs who have little business experience to commercialise their ideas while taking limited personal risks. Incubators in the Negev region are home to clean-technology companies in solar and biofuels (e.g. Rotem Renewable Energy Innovation Centre). Israel's entrepreneurial culture can be an important component for further development of clean-technology businesses, and it can be encouraged by government and university support and enhanced with stronger linkages between incubator companies and angel, venture, and corporate financing.

Existence of Clean-tech Seed Activity

Israel and the Negev region have expertise in water technology and management and there are 127 water-related companies focusing on the efficient use of the limited water in Israel. Thirteen of these companies are located in the Negev region. This is an important strength because, as presented above, the legacy resources and capabilities of a location are critical for the seeding and emergence of new industries. In addition, the existence of local, sophisticated customers enhances the innovation and commercialisation processes, as there is sharing between suppliers and customers, and often urgency from customers to develop new and better technologies and solutions.

Solar power technology has been advanced to globally leading levels in Israel, including in the Negev region. The National Solar Energy Centre at the Ben Gurion University of the Negev in Sede Boqer and the Eilat-Eilat Renewable Energy Centre are examples of supply expertise in the Negev region and could be built upon with additional funding and connections to customers in Israel and globally.

Land and Solar Radiation Availability

The outstanding solar radiation for electricity generation and the availability of land in the Negev region are strengths for field studies for testing innovations in solar power technologies. For example, the two developments being built in the Negev region using solar technology developed by Bright-Source Energy Ltd. and Solel. The Negev region could offer Israeli companies, as well as multinational companies, an excellent location for test and demonstration facilities. The Negev region is especially well suited for solar and water technology development, testing, and demonstration. This strength could be promoted to multinational leaders in solar and water technology in order to lure these companies and their technical and financial resources to enhance the development of the Negev region clean-tech sub-cluster.

Weaknesses

Limited Linkages between the Clean-tech Parts of the Existing Industrial Ecosystem

The Negev clean-tech sub-cluster is made up of primarily disparate parts with few connections between them. There are approximately 50 clean-tech companies (most are small and early stage), and there is very little capital for clean-tech in the region in the form of angel, venture, and corporate capital. These disparate parts represent the lack of a critical mass of clean-tech resources in the Negev region, which holds back the development of sustainable clusters. A national and Negev region clean-technology plan could help with building better linkages between the clean-technology components and the larger existing industrial ecosystem.

Disadvantages for Attracting Businesses and Skilled In-Migrants

The Negev region has a shortage of highly skilled labour, a low level of support services for business such as banking, consulting, lawyers, etc., a limited variety of employment opportunities, making it difficult for households to move to the region (in many cases only one of the spouses can find a job) and extreme weather conditions that make the Negev region less attractive for living. While there are skilled people, innovative companies, and dense networks of support services in the Central region of Israel, there is a notable spatial disconnect between this region and the Negev region. In addition, the Negev area has large areas that are used by the army for military training and other areas that are in dispute with the Bedouin population. Both of these factors may limit the use of land.

Lack of Commercialisation from Research Institutions

The Negev region has several incubators and technology centres specializing in clean-technology, as well as research activity occurring in its university laboratories. However, due to shortages of capital, labour, and market access, there is a lack of commercialisation. Locations that have success with commercialisation have a critical mass of assets such as successful start-ups, academic innovation activity, and financing options (Alcacer and Chung, 2007). The Negev region needs to strengthen its commercialisation resources, but it also needs stronger ties to the resources in the central region of Israel and from international sources.

Weak Shared Understanding, Policy and Planning

The clean-technology industry in Israel has little clear definition. Clean-technology is aggregated losing the appreciation for the unique segments and the benefits and challenges of each segment, as described earlier. All of the participants seem to have a different understanding of what clean-technology entails, leading to different (and sometimes uncoordinated) programs in order to promote it. There is no central body and no Israeli and Negev region clean-technology plan for focusing and coordinating efforts.

Opportunities

Potential to Develop Additional Regional Demand for Clean-tech Products and Services

There are several promising opportunities to build demand for clean-technology products and services in the Negev region. The Israel Defence Forces are planning to invest approximately USD 7 billion to relocate bases from the centre of the country to the Negev region. This move will involve a massive investment in infrastructure including roads, railroads, water, electricity, etc. and will create strong demand for various environmental products and services. There is potential for local demand assisting the emergence of companies supplying a variety of clean-technology products and services. There are also plans to develop communities for the Bedouin people and for relocating people from other parts of Israel to the Negev region. These could be excellent opportunities for implementing renewable energy, green building, smart grids, and water management technologies.

Potential to Build Additional Clean-tech Supply-Side Capacity in the Negev Region

The Negev region has globally noteworthy expertise in water management and solar power technology. This expertise can be built upon in order to continue progress in research and development and use the strengths of the Negev region such as solar radiation and land to add to the water and solar technology value chains. This could entail the further development of testing and manufacturing products using Israel's leading technologies. There are advantages of locating research, development, and production in proximity in order to coordinate learning and innovation. Developing more of the water and solar technology value chains in the Negev region would enhance the current research capabilities and provide needed manufacturing expertise to build a more vibrant clean-technology cluster.

Threats

Lack of a National and Negev Regional Clean-tech Plan

Israel and the Negev region lack a clean-technology development and finance plan. There is a lack of clear and long-term policy objectives for the development of the clean-tech industry in Israel. Part of this problem stems from the fact that different segments of the policy are scattered among different public authorities, making the policy process and the articulation of an effective policy problematic. The lack of a clear mission, vision, and plan and a leading agency for clean-technology development in Israel and the Negev region threatens the efficient use of efforts and financing, as well as long-term success.

Overemphasis on a Start-up and Venture Capital Model of Clean-tech Development

A start-up and venture capital model, which was described above as a strength, can also be seen as a threat. This approach is rife with risk and guarantees little in the form of location-specific economic development. Most start-up firms fail because of poor technology or management or both. Therefore, an approach that funds start-ups and incubators as its primary focus can lead to no new, long-term companies, and even if a company does survive and grow, there is no guarantee it will stay in the Negev region or even in Israel. A more balanced economic development plan includes a combination of funding start-ups and incubators with the attraction of multinational corporations' research, development and production facilities, and the financing of local demand for Clean-tech products and services.

Global Competition in Most Segments of Clean-technology are Further Ahead and Dedicating More Resources

There are numerous regions and countries in the world that have been developing clean-technology for decades. In addition, some of these locations have more advanced technology and more resources to

invest in building a clean-technology cluster. Therefore, a notable threat to Israel's and the Negev region's clean-technology efforts is that other companies and locations will succeed in developing and commercialising global, leading technologies. This is why it is essential for Israel and the Negev to understand their strengths and focus their efforts in these areas by building local demand and supply to assist with the advancement of these particular clean-technology segments.

Recommendations

This section presents policy recommendations to enhance the clean-tech sub-cluster in the Negev region through business development. In particular, these recommendations offer important elements of a Negev region clean-tech plan for the development of the sub-cluster based on regional demand for clean-technology and regional supply based on stimulating entrepreneurship and attracting foreign direct investment, planning for better linkages within the Negev region and with the rest of Israel and the world, and attracting more and larger sources of capital investment.

Develop Regional Demand for Clean-technology in the Negev Region

Demand Location for Green Buildings, Solar Energy, Water Management, and Eco-Efficiency

The Negev region should be seen as a demand location for clean-technology such as green buildings, solar PV installation, energy efficiency, and water use and recovery, thus strengthening the region's clean-technology industries. This could include the establishment of world-leading green building standards. Green buildings can improve living conditions and save resources (water, energy) and generate environmental benefits. The revised Israeli Standard of Green Building #5281 was accepted in 2011, and relates to new buildings or renovations. Implementing these kinds of activities in the Negev region may improve the region's standard of living and its image, concurrently with attracting a new population. In addition, green construction would create specialised green economic activity in the Negev region that would find expression in demand for a qualified labour force, the use of current knowledge, and the establishment of a unique field of study for the research and the development of innovative clean-technologies.

Military Procurement of Clean-technology Products and Services

The Negev region should develop coordination, collaboration, and procurement with the Israeli military to demonstrate and install water and energy efficiency, renewable energy, alternative fuels, clean-up and pollution prevention technologies in the Negev region as part of the base relocation to the region. This would build demand for clean-technology products and services and offer the learning by doing of implementing technologies for a demanding and sophisticated customer.

Leadership from the OCS and the Israeli military should meet and develop an agreement for clean-technology procurement and economic development through the patronage of Negev and Israeli clean-technology companies, e.g. biofuels, solar power generation, water efficiency, etc. This agreement should include the identification of opportunities for the use clean-technology products and services by the military as part of its relocation and operations in the Negev region and procurement targets from Negev region and Israeli companies.

Government tender procedures on renewable energy should include assessment of the social and economic benefits as well as costs in selection of purchases, including the contribution to the development of Israeli innovation, employment, regional development and environmental protection. It is important to have a national level directive to ensure that the relocations are accompanied by efforts to find green solutions.

Implement Industrial/Business Eco-Efficiency Auditing and Sustainable Operations Consulting

The Negev region should expand the green business programme to build demand for eco-efficiency technologies and applications and capabilities. The current programme, run by the Israeli Centre for Green Businesses, offers grants and assistance for green operations audits and improvements. Expanding this programme would help create greener businesses as well as develop regional expertise in environmental assessment and technology implementation.

Develop Regional Supply of Clean-technology Capabilities in the Negev Region

Attract Multinational Corporations' Clean-technology R&D and Production Facilities to the Negev Region

The Negev region would benefit from the attraction of multinational corporations' research, development, and production facilities to the Negev region. As presented above, there are advantages of locating research, development, and production in proximity in order to coordinate learning and innovation. For example, developing more of the water and solar technology value chains in the Negev region would enhance the current research capabilities and provide needed manufacturing expertise to build a more vibrant clean-technology sub-cluster.

The Negev region clean-technology investment plan should include active promotion of the region by organising tours for investors of the Negev region to attract foreign investment. External financing will help the region with the necessary funding needed to advance clean-technology, and it will also advertise the Negev region's expertise to global markets. The promotion efforts should stress the particular niche the region plays as a demonstration and test area for clean-tech. They should also contribute to building a brand for the Negev in collaboration with relevant stakeholders.

Create a Clean-tech Cluster Management Organisation

A regional clean-tech cluster organisation, that could be funded by the government and participating companies, should be established. It would have a number of roles. It could act as a clearinghouse of information and connections between companies supplying clean-technology products and services and potential customers such as existing companies, industry associations, government agencies, and residents. This regional organisation would attract companies as partners and help find customers for clean-technology products and services. The Negev clean-tech cluster organisation could also promote the Negev region as a location for foreign direct investment (FDI). It would identify target multinational companies, offer incentive packages that could include regulation streamlining, tax reductions, labour force training assistance, and discounted land and infrastructure, and negotiate agreements for the location of clean-technology research and production facilities in Negev region. The process could begin with a global inventory of leading clean-technology companies, contact with targeted companies, tours of the Negev region, and negotiation of agreements with chosen companies for their location and investment in the Negev region. The successful attraction of FDI in the areas of medical and information technology by Technology Transfer Company at the Ben Gurion University of the Negev offers a possible model.

Encourage Systemic Production and Utilisation Model in the Negev Region

Attracting both demand and supply aspects of clean-technology can lead to additive systemic benefits. Production models that develop and manufacture a technology locally, implement it locally, and produce output from its use to show market readiness can produce outcomes that are greater than the sum of the parts. The demand for technologies can drive suppliers to develop better and new applications in a co-evolving manner.

The Ben Gurion University of the Negev, the National Solar Energy Centre and Zuckerman Institute for Water Research, Ben Gurion University, Sde Boker, and Rotem Renewable Energy Innovation Centre, Eilat-Eilat Renewable Energy Centre, and the Arava Institute for Environmental Studies are all home to promising clean-technology that need help to develop production facilities in the Negev region and assistance with commercialization. The regional Clean-tech organization described above could offer a programme to help local clean-tech companies advance from research to commercialisation with matching services with national and international investors, location assistance, and connections to local, national, and international customers.

Establish a Clean-tech Validation Centre

An additional approach for enhancing the supply of clean-technology products and services would be the development of a Negev region Clean-tech Validation Centre. The purpose of a Clean-tech Validation Centre would be to provide clean-technology companies with testing and confirmation of technology soundness, and in some cases the legality of product and service claims. The validation centre should be open to use by foreign as well as Israeli companies, in order to build critical mass and to attract spin-offs to the region. A Clean-tech Validation Centre could be operated by the regional clean-tech cluster organisation described above. The Centre would need a staff of clean-technology experts and facilities to offer testing of a potentially wide variety of technologies. An example of such a validation entity is the Underwriters Laboratory (UL), which is a global independent safety science company offering product safety testing and verification services.

Create a Clean-tech Development Plan for the Negev and Israel

Convene Stakeholders for Developing a National and Negev Region Clean-tech Development Plan

It is important to have a coherent national plan for promoting the clean-tech sector, and to situate support to the Negev within this policy. This plan should set out the priorities and actors involved and build synergies across them. The first step to developing a national and Negev region clean-technology plan is to convene business, government, industry association, academia, investment, and community leaders for developing the mission, vision, and policies for a plan. Inclusion in the process will help develop the best plan and will enhance implementation efforts. This effort could be organised and facilitated by the regional clean-tech cluster organisation described above. The cluster clean-tech development plan would need to look further than the Negev, in order to identify actions that will help the sub-cluster connect with clean-tech actors and resources elsewhere in Israel as well as locally.

Map components and their linkages of the Israel and Negev Region Clean-tech Sub-Cluster and industrial Ecosystem

Mapping the Negev region clean-tech sub-cluster and the larger industrial ecosystem of Israel will help identify the components and increase understanding of the linkages that can be built between the components for knowledge development and diffusion, market development, entrepreneurship, advocacy, and sharing resources. This would help educate the stakeholders of the existing linkages and the linkages that could be improved. It is also an important exercise for the development of innovation based on the recombination of knowledge discussed in Chapter 2. It could be an activity developed by the proposed clean-tech cluster organisation.

A possible example to learn from of this type of mapping and linkage exercise is the Greater Cambridge Partnership's (2010) *Clean-tech Strategy and Action Plan*. The Negev region Clean-tech organization could lead this exercise by convening workshops throughout Israel and Negev region that would bring stakeholders together, but would also involve the groups in the mapping of organisations,

description of their relationships, and formulation of action steps. This process of developing conceptual understanding, relational connections, and action plans is described in Senge et al. (2007).

Develop the Plan with Clear Structure, Policies and Tasks for Execution

Convening the stakeholders and inventorying the components, linkages, and action steps of the Negev region clean-tech sub-cluster and the larger industrial ecosystem of Israel are the initial steps that need to be followed with a structure, policies, and tasks for execution of a plan for developing the clean-tech sub-cluster in relation to activities in the rest of the clean-tech cluster in Israel. The clean-tech cluster organisation should be the leader responsible for moving the planning and execution forward and held accountable for progress. The initial meetings would entail development of a shared understanding of clean-technology, clusters, and economic development, identification of stakeholders, description of linkages between entities, and identification of future steps. The future action steps are likely to include the recommendations described above such as establishing a clearinghouse of regional clean-technology information and connections, procurement agreements with the Israeli government, including the military, expansion of the green business programme, attraction of FDI, and enhancement of the commercialization of local clean-technology.

Establish a Negev Region Clean-technology Investment Fund

A Negev region clean-technology investment fund should receive focused effort as part of the Clean-tech Development Plan for the Negev since financing is essential for any plan's success. This investment component of the Clean-tech Plan should involve active input and participation from the Israeli investment community including banks, venture capitalists, and angel and corporate investors. Elements of the investment component could include business mentoring, equity and government matching funds development, and facility and cost sharing for clean-technology start-up companies.

The Negev region should develop a balanced finance fund that includes a combination of financing start-ups and incubators, financing the attraction of multinational corporations' research, development and production facilities, and financing of local demand through procurement of Clean-tech products and services.

ANNEX – LEARNING MODELS

San Francisco Bay Area Clean-technology Economy, USA

Description of the model

The San Francisco Bay Area (SFBA) clean-technology economy can be best described as a large-scale clean-tech ecosystem, or end-to-end innovation system combining stewardship mechanisms, funding bodies, research institutions, and structures for business and academic collaboration in support of an overall regional strategy. The SFBA is far beyond the programme level of regional development, though there are numerous programmes around the region focused on encouraging the development of clean-technology. For example, a USD 500 million centre for biofuels and energy research is based at the University of California at Berkeley. Funded mostly by BP and in part by the state of California, the Energy Biosciences Institute is managed by the federal Lawrence Berkeley Laboratory, also located in Berkeley. The biofuels program in the Berkeley area is developing a research and entrepreneurship environment in proximity and in collaboration with the University of California – Berkeley campus. Other clean-technology clusters in the SFBA include Santa Clara County's cluster of solar energy technology companies and incubator and San Francisco's cluster of smart grid and energy efficiency companies.

Relevance to Israel/Negev

The SFBA is relevant to Israel and the Negev region because it offers a developed industrial ecosystem and several clean-tech clusters for Israel to see as a vision for the future. The SFBA offers an exemplar region of the needed components and actors and the linkages between them. The SFBA also shows the role of both demand and supply development and their potential as dual forces for cluster development.

Results of the approach

The SFBA has an entrepreneurial culture that has enabled the region to grow multiple clean-technology branches from its legacy resources. As external factors have affected the region, it has reinvented itself by extending in new directions such as solar energy, smart grids, biofuels, and energy efficiency. Each of these examples concerns a clean-tech cluster that has its start in other industries and the nature of the culture and the available resources have enabled the region to grow in these new directions. These new clean-technology clusters are outcomes, but more specifically there are new companies, trained employees, and clean-technology products and services.

Reasons for success

The SFBA succeeds as a vibrant clean-technology region because it has the critical components that enable regional entrepreneurship. There is knowledge development and diffusion from regional universities, research labs and institutions, and companies, which represent supply factors. There are strong demand conditions in the form of company and government procurement of clean-technology goods and services. There is also social acceptance and support for relevant institutions such as government procurement programs and investment from public pension funds. The region has strong mobilisation of resources such as competence/human capital, financial capital, and complementary assets.

An additional aspect that helps the SFBA clean-technology economy is how California's public policy framework provides continuity that is important to companies and investors. The policy framework includes measures to reduce the emission of greenhouse gasses and promote the deployment of renewable

energy and energy efficiency technologies, including the Global Warming Solutions Act of 2006 (AB 32), the Sustainable Communities and Climate Protection Act (SB 375), a Low Carbon Fuel Standard, building and appliance efficiency standards, large-scale energy efficiency programs, a Renewable Portfolio Standard and, more recently, a Renewable Electricity Standard for electrical generation and the California Solar Initiative.

Obstacles faced and response taken

The main obstacles faced for the SFBA's clean-technology development are larger global forces such as shifting spatial division of labour, changes in government support programmes, and macro-economy financial conditions. The approaches by governments influencing the SFBA are primarily demand (procurement) and supply (research labs and institutions and universities), but there are also significant market forces that influence supply and demand in the SFBA clean-technology clusters. These include company demand for clean-technology products and services, corporate, angel, and venture capital, corporate and government financed research laboratories, and university programs for educating people for clean-technology jobs.

Considerations for adoption in Israel/Negev

The Clean-tech Development Plan recommended above for Israel would be a strong first planning step to emulating the SFBA's clean-technology clusters. This plan needs to include representatives from all of the important stakeholder groups such as government agencies, companies, universities, financiers, non-governmental advocacy groups, and communities, and it needs to focus on tangible plans to build demand (e.g. procurement and standards) and supply (e.g. multinational corporation research labs and production).

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Cambridge, England Clean-tech Cluster

Description of the model

The Cambridge clean-tech cluster can be best described as a free market driven regional cluster because little directive action has guided the clean-technology development of this region. This does not mean there have not been attempts during the past 10 years to use policy levers to seed and grow a regional clean-tech cluster. For example, the East of England Regional Development Agency (RDA) has tried a variety of policy-driven initiatives. These include the RDA Clean-tech competitive voucher programme that provided government-funded grants for clean-tech startups and the RDA-sponsored green procurement programme. Both of these examples and other regional policy efforts have had only limited success in the building of a Cambridge Clean-tech cluster because there has generally been a lack of stakeholder interest and engagement. However, in 2010 the Greater Cambridge Partnership and East of England Development Agency commissioned a study of the Cambridge Clean-tech cluster (Greater Cambridge Partnership, 2010). The purpose of this study was to map the Clean-tech sector, undertake an analysis and create a strategy and action plan to help develop the clean-technology sector in Greater Cambridge, the aim being to develop Greater Cambridge as a world leader in the Clean-tech sector. There is currently no schedule and budget associated with the strategy and action plan.

Relevance to Israel/Negev

The Cambridge Clean-tech cluster is relevant to Israel and the Negev region because it represents an organic, market-based model of economic development. This model has grown over the past two decades through research, development, and commercialisation. This growth has been driven by the entrepreneurial culture of the region, and this culture appears to be present in Israel as are universities with researchers and technology transfer offices. There is also a start-up infrastructure in Cambridge that includes patent lawyers, financiers, incubators, and intermediaries such as technology consulting firms, e.g. Syngentia and Cambridge Consultants. Many of the clean-technology start-ups in the region have developed as university and corporate spin-outs based on the regional legacy of biotechnology, information technology, and electronics companies. These characteristics are present in the central region of Israel and to a lesser extent in the Negev region.

The planning process in Cambridge is similar to what is recommended above for Israel and the Negev region. In addition, the Cambridge region has demand and supply conditions, similar to what are recommended for the Negev region, such as procurement and provision of locally produced biofuels, energy efficiency technology, and information technology solutions for improving industrial processes. This organic growth, orchestrated loosely by regional participants, is a possible cost-effective approach for the development of a clean-tech sub-cluster for the Negev region. While there is significant risk in funding start-ups, incubators, and institutions, a case can be made for allowing the market to pick the winning technologies and companies. From a market perspective, the Cambridge clean-tech cluster is an exemplar model for Israel and the Negev region.

Results of the approach

The outcomes of the Cambridge clean-tech market-based model include hundreds of clean-technology companies in the areas of agrosience, information technology, fuel cells, biofuels, and energy efficiency. There is also significant clean-technology-related product and process research being conducted at the University of Cambridge.

Reasons for success

The Cambridge clean-tech cluster has been a success because of the strong resources at the University of Cambridge and the regional supply of expertise and regional demand from companies. These assets have been research-based at the University of Cambridge and at local companies, but they have also been spurred by demand for clean-technology products and services. This market-based approach has also been successful in the context of financial resource efficiency. By not forcing the technology and companies into government-chosen areas, the market has efficiently sorted the allocation of resources and effort. In an era of financial constraints, this may be the most realistic and successful approach to regional economic development.

Obstacles faced and response taken

The main obstacle faced by the Cambridge region regarding clean-technology development has been efforts to speed up the development process by regional government entities marketing clean-technology expertise in an effort to grow it by attracting external funding and demand. These efforts have sometimes distorted market signals resulting in funding going to technologies without sufficient market demand. These distortions to clean-tech market signals have been lessened by the realities of the financial strain in the public sector in England. There has been less money available for promoting clean-technology development, so the market has been the default mechanism deciding which companies and sectors have succeeded in the Cambridge region. The Cambridge clean-tech cluster has also been hindered by

constrained land supply and strong planning constraints, which have limited residential and industrial expansion and resulted in higher costs for growing a business, especially those with manufacturing. The response has been minimal, and the result has been either lost opportunities or muted growth in some aspects of clean-tech in the Cambridge area.

Considerations for adoption in Israel/Negev

Israel and the Negev region have expertise in several clean-technology segments that have developed over the past decades. These segments may be the best segments for future growth and success. Artificially distorting market signals by picking Clean-tech segments for funding and promotion carry high risks. One critical aspect of a clean-tech development plan for Israel and the Negev region is allowing demand to dictate the support. There are clear areas of demand in Israel such as water management, energy efficiency, biofuels, solar power generation, green building practices, and industrial pollution prevention. These are the clean-tech segments that are the best for development in Israel due to demand conditions, as well as supply capabilities. The key stakeholders for this approach are the potential customers for Israel's most promising clean-tech products and services and the companies supplying these products and services.

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Masdar Clean-technology Initiative, Abu Dhabi

Description of the model

The Masdar Clean-technology Initiative can best be described as a government mandated programme. Masdar is a planned clean-tech sector, with the aim of diversifying the economy, offsetting contributions to global warming, and making growth more sustainable by leveraging energy expertise and abundant sunlight. The business model entails an investment arm taking stakes in clean-technology projects around the world; an industries unit manufacturing clean-technology equipment; a carbon strategies unit developing systems and solutions to deal with global-warming pollution; and a clean-tech-focused university. The Masdar Initiative is being built one neighbourhood at a time integrating technologies and learning from doing. The clean-tech project is funded by USD 15 billion of government seed money, free land, a foreign free zone, and policies for innovation and entrepreneurship (Johnson and Suskewicz, 2009).

Relevance to Israel/Negev

The Masdar Initiative is relevant to the Negev region because it represents a focused clean-technology plan with tangible outcomes in the form of a city and builds capabilities in clean-technology development, implementation, investment, and education. This could fit the Negev region's interest in building settlements, which would involve development and implementation, and Israel's national focus on clean-tech investment and education. The Masdar plan is systemic, but it is also tangible with a city as an outcome. The recommendations above concerning building both demand and supply for clean-technology are consistent with the Masdar approach, as are the recommendations for a national and regional plan and finance plan for clean-technology.

Results of the approach

The first building phase of Masdar has been completed, including the university and a large photovoltaic power plant, which will be the main source of energy to power the city. During the second phase of the project, the larger square of the city is to be completed and during the third phase, the smaller square of the city. The whole city of Masdar is expected to be completed by 2015. The Masdar project is being built in phases, which has facilitated learning by doing. In addition to the university and solar power installation, the Masdar Initiative has been investing in clean-technology projects, including large solar power developments in Spain.

Reasons for success

The Masdar Initiative has succeeded in part because it has been designed to be incremental aiding learning by doing. The development teams have been gaining valuable insight as they have completed each step. This learning has played into revised approaches for each next step. The initiative has also been a success because it is multi-faceted, thus enabling risk balancing. By including an investment arm, a manufacturing unit, a carbon strategies unit, and a university, there has been cross-learning as well as risk sharing as some units have progressed faster than others.

The Masdar model offers a targeted, mandated, approach to clean-technology cluster development. This approach may represent a model for consideration in other locations because it offers tangible outcomes people can see and experience. It also builds skills of the location by offering construction jobs, investment experience, manufacturing capabilities, and education and training. This approach is offered in contrast to the start-up venture finance approach, which is rife with risk and guarantees little in the form of location-specific economic development.

Obstacles faced and response taken

The Masdar Initiative has faced the project finance challenges of large, long term projects. Economic conditions have caused some government financing challenges, and some clean-technology investments have suffered because of global financial difficulties. Because the Masdar Initiative was planned in phases, the financial challenges have only delayed parts of the project while other parts have progressed and been completed.

Considerations for adoption in Israel/Negev

The Masdar Initiative could be configured in many ways to fit the needs of Israel and the Negev region. The settlement aspect would likely to be larger and less contained because of greater land availability in the Negev region compared to Abu Dhabi. The Negev settlement(s) could be used to relocate people from other parts of Israel, house Bedouin people, or be used for the relocated Israeli military troops. If Israel adopted the investment unit, it could use it for internal and/or external clean-technology projects and companies. Israel could also decide whether they form a new clean-technology focused university or continue to build on the strengths in clean-technology at existing universities in Israel.

A plan such as the Masdar Initiative needs participation from a broad set of stakeholders. While stakeholder involvement is critical for success, strong central leadership is also necessary. Israel/Negev stakeholders would move forward an initiative like Masdar by following the government's lead with the provision of labour, products, and services during construction, investment in clean-technology projects, companies, and university clean-technology training and education.

Further information

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CHAPTER 4.

STRENGTHENING RESEARCH INSTITUTIONS

by Dieter Rehfeld

Abstract

This chapter focuses on the role of research institutes in the Negev clean-tech sub-cluster. It studies the region's clean-tech research institutes as knowledge hubs that can link local, national and global knowledge circulation, hence promoting clean-tech innovation and commercialisation in the region and contributing to strengthening Israel's broader clean-tech cluster. To achieve this, the attention needs to be placed on developing three features of the research institutions: firstly, they must host an excellent knowledge base with strong links to other centres of excellence in clean-tech research at national and global levels; secondly, they must possess tools and instruments to encourage a fruitful interchange of knowledge within the region aiming at leveraging research knowledge for the creation of new products and services locally; and thirdly they must offer an inspiring and dynamic environment in which knowledge circulation can work best. The policy recommendations focus on these three components of a research strategy for Negev clean-tech, based on making the best use of national programmes in the region.

Policy issues

As the role of knowledge grows within the international economy, there is no doubt that research institutions play a crucial role in cluster development. There are several examples of clusters developing around a university based on the commercialisation of knowledge from its research (Markusen 1996: 306ff, discussing state-anchored clusters; Benneworth and Hospers, 2007, discussing the role of universities in the process of restructuring traditional industrial regions). Traditionally, there are two essential functions of research institutes (in most cases universities) in a cluster: the performance of research and the training of high qualified personnel (Wolfe, 2004). Research has shown that for cluster benefits to arise, these functions have to be linked on the two levels of 'local buzzes', which refers to knowledge exchanges within a region, and 'global pipelines', referring to international knowledge exchanges (Storper and Venables, 2004). It also requires the generation of knowledge that is capable of generating new products and services and creating jobs and the commercialisation of this knowledge.

This chapter focuses on the role of research institutions in supporting cluster development by the generation and transfer of knowledge to promote regional economic growth. Research institutes act as knowledge hubs within a regional economy, producing scientific knowledge which provides spillovers, especially for firms located in proximity to the universities, and results in local innovation outputs. However, in order to generate regional economic benefits, policy needs to employ more sophisticated tools than the simple funding of research institutions as 'knowledge factories' (Uyarra 2010: 1223; Carlsson, 2010: 4; Wolfe 2004).

The concept of the relational university is more appropriate to understanding the role of research institutes or universities in a regional economy. This concept stresses the importance of bi-directional and implicit linkages between research institutions and companies (Uyarra 2010: 1232). The intensity of interaction depends on the institutional context. Cluster organisations, research-industry consortia, and entrepreneurial support networks and so on all build an environment that facilitates interaction and spill-

over effects (Wolfe, 2004: 10). Within this context, knowledge flow works best when it includes modes of direct interaction, including the exchange of qualified people between universities and companies and working together across universities and industry in joint projects.

Virtuous knowledge flow emerges from self-organised interactions among actors within a cluster, but it can be facilitated by the use of a set of innovation policy instruments to initiate and support knowledge flow: directing science and education policy resources to build up centres of research excellence that are crucial for the regional economy; launch of joint innovation projects between industry and research institutes, often bundled under a thematic umbrella that indicates interaction and transfer; development of different types of technology centres working as a knowledge exchange platform; provision of incentives to encourage the exchange of specialists between academia and industry; and the implementation of an ambitious lead project financed by public funds that drives researchers and companies to find new solutions that open a competitive edge on the national or global market.

Analysis of Research Institutions in Israel and the Negev

Strengths

The Negev is the leading edge clean-tech research location in Israel

Without any doubt, the Negev is the leading research location in the Israel clean-tech research landscape. For example, the Israel Science and Technology directory¹ indicates that in the thematic field “Earth and Environment”, 6 out of 16 departments and 6 out of 18 research centres are located within the Negev.

In institutional terms, the dominating core of clean-tech research in the Negev is the Ben-Gurion University (BGU) and within this university, the Sede Boqer Campus, hosting the Zuckerberg Institute for Water Research and the National Solar Energy Centre. Within clean-tech, the water and solar energy technologies are the most advanced in Israel and in the Negev and have been developed in areas (photovoltaic, drip irrigation, seawater desalination) where Israel holds international expertise (OECD 2011a).

Beside this core within the BGU there are two further cores in clean-tech research, development and testing in the Negev:

- The Arava Institute for Environmental Studies (Kibbutz Ketura/Hevel Eilat). The Arava Institute is strongly linked to the Arava Power Company (with German Siemens as 40% shareholder) in Kibbutz Ketura, which inaugurated the first solar field in Israel in 2011, and the Eilat-Eilat Renewable Energy Initiative. The latter initiative was established by the Eilat-Eilat Community, which aims at making the Negev an area that will be sustained exclusively by renewable energy resources by 2020. Its key institutions include the international annual energy conference and the Technology Centre for Renewable Energy. The latter centre results from winning a tender from the Israeli Ministry of Industry, Trade and Labour. The Ben-Gurion University and the Arava Group are involved in the group running the centre. The Israeli government and the group will each invest one half of a total of USD 30 million over a five-year period. The group includes industrial leaders such as Ormat, Elbit Systems and Rafael; leading investment companies, including ProSeed Venture Capital Fund, Direct Insurance Group and the Consensus Business group; academic and research groups such as the Ben-Gurion National Solar Energy Centre on the Sede Boqer campus; and the Eilat-Eilat Renewable Energy Authority (BGU 2011: 11).

- The Rotem Industrial Park in Dimona, a government owned company which hosts about 10 start-ups in the Clean-tech sector and a solar demonstration, testing and technology verification centre (SDTV) in which a variety of solar technologies will be tested, measured and verified.

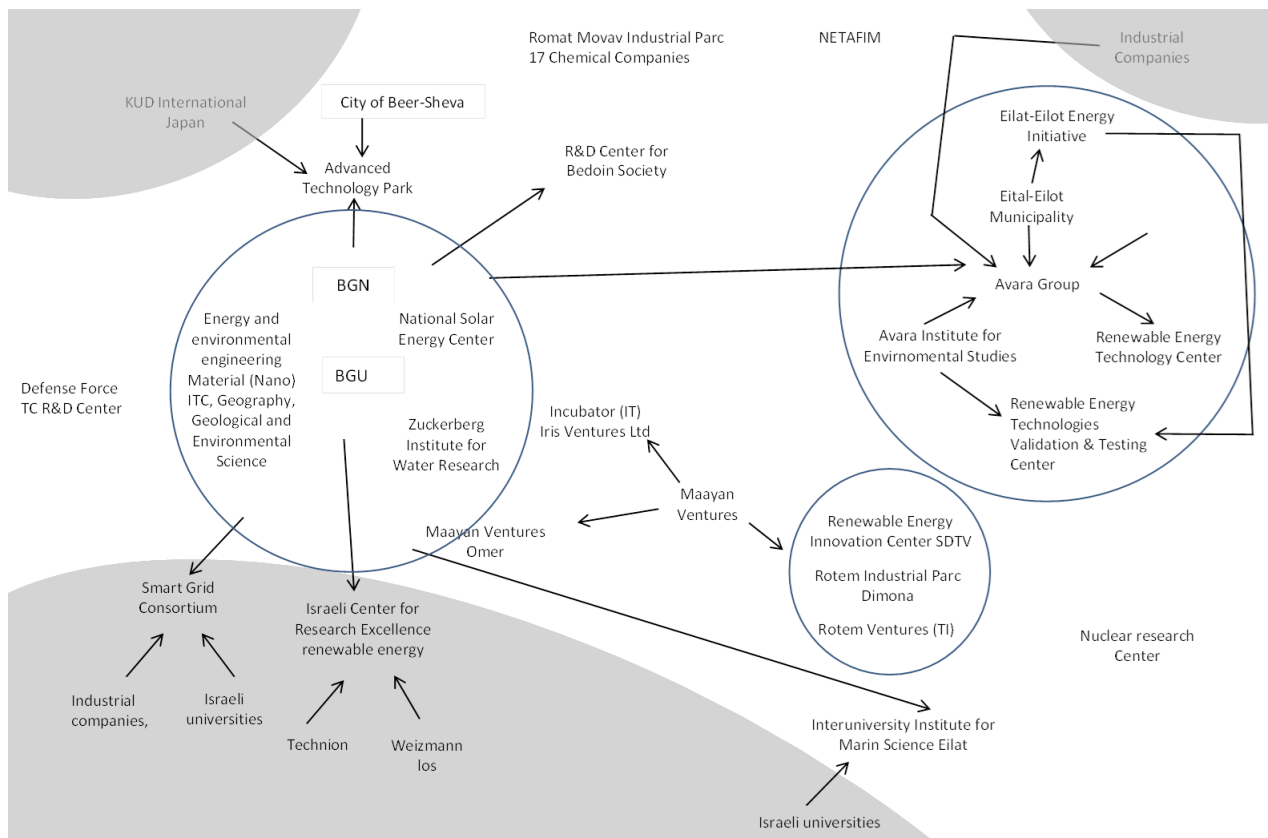
Taken together, these three cores represent a strong position in clean-tech research in the Negev encompassing basic research in the BGU, advanced research in the Arava Institute and research and development services like piloting, testing or monitoring in the Eilat-Eilat activities and in the Rotem Industrial Park. These research activities and research related functions have the potential to work as a core driver of the clean-tech sub-cluster within the Negev.

There are existing and potential local linkages between core clean-tech research and related research and industry competences

The development and exploitation of the core clean-tech research competencies in water and renewable energy are facilitated by a range of related research and development competences in the BGU and in industry. Several research departments in various faculties of the BGU can contribute to an interdisciplinary approach in clean-tech including energy and environmental engineering, material engineering and nanotechnologies, ICT, geography, geological and environmental sciences. In industry, the 17 chemicals companies located in the Ramat Hovav Industrial Zone could work as lead users for clean-tech solutions.

Figure 14 presents the research base of the clean-tech sub-cluster in the Negev. It shows that the BGU is the key player, and it has strong links with institutions within the Negev. The strongest activity is in the southern part of the Negev grouped around the Arava Institute, the Eilat-Eilat Renewable Energy Project, and the Renewable Energy Technology Centre, where the research activity seems to be more strategic and the institutional thickness (including the links between the actors) is stronger. The activities in Dimona (Rotem) are partially linked with the other activities in the Negev: for instance companies located in Dimona are involved in the Eilat-Eilat activities. An example of further links is the government driven Maayan Venture Group with activities on the BGU campus (Omer, Iris) and in Dimona.

Figure 14. The research base of the Clean-tech sub-cluster in the Negev



Source: The Author

The BGU and the Arava Institute are strongly committed to regional activities and work together in certain fields. This is true not only for the classical technology transfer activities of the BGU, but also for activities in biotech (Bio-Negev), in desert studies and on the Eilat campus (in collaboration with other universities in Israel). A further example is the regional R&D centre for the Bedouin society in the Negev, built with the assistance of the Ben-Gurion University. The objective is – on the one hand – to use science in order to improve the population's quality of life and knowledge in the Hura Local District and – on the other hand – to take part in shaping the daily lives of the Abu-sama Regional District population.

There are links between the actors within the Negev and related actors in Israel that keep the knowledge base open for complementary competencies

The research institutes in the Negev have many links with other research institutes and companies located in other parts of Israel as well as with global actors in the field of clean-tech. Examples include:

1. The involvement of nine researchers from the BGU in the recently launched Israeli Centre of Excellence for Renewable Energies (guided by Technion and with the Weizmann Institute of Science as a third partner) and membership of BGU researchers in the Israeli Smart Grids Consortiums, which involve various companies and universities.
2. BGU is the Israeli university with most partnerships in the European Seventh Framework Programme in the fields of environment and engineering.²

3. The annual International Eilat-Eilat Conference on Renewable Energy, which has gained a strong international reputation.
4. The Interuniversity Institute for Marine Science Eilat is a joint institute of BGU and several Israeli universities.
5. Many companies from other countries are present in the activities of the research institutions (often in an indirect way through their shares in energy and water companies). For instance, Israeli companies from the electronic and the ICT sector are involved in running Arava Group's Renewable Energy Technology Centre.
6. International service and venture companies are in contact with the incubators and technology centres in the Negev.

Taken together, the academic excellence in clean-tech, the research links inside the Negev and the external research links provide a strong base for generating knowledge and innovation, which is the key asset for developing the clean-tech sub-cluster in the Negev and contributing to clean development in Israel as a whole.

Weaknesses

The research potential of the Negev is fragmented and not visible from outside

To start with the simplest but most basic issue: The academic competencies outlined above are presented in a very fragmented way on the web and in documents and are not visible as a coherent whole from outside. While they are embedded in different institutional contexts within the BGU, they are not communicated in any way that would raise attention or interest. The research activities are presented by academic disciplines rather than in from integrated and interdisciplinary point of view. But if the BGU is to work as an anchor or hub to brand the Negev with a national clean-tech cluster and to attract inward investment, there is a need to communicate the competencies in a much more integrated way.

Fragmented presentation and missing visibility is only the surface. There is an ongoing discussion about how to organise the improvement of the research base of the clean-tech sector: whether to focus on specific subsectors and technologies or on the systemic aspect of making use of clean-tech in green building, urban development, industrial processes, etc. To put it in a nutshell: The closer one gets to the market, the more integrated solutions are on the agenda and the more companies try to organise clean-tech in an integrated way. For instance, Siemens presented in 2011 a new product line combining smart grids, building technology and mobility solutions aiming at sustainable urban infrastructure. This is not reflected in the organisation and presentation of clean-tech research at BGU. Another example is smart grids, aimed at integrating infrastructure, energy mix, continuous energy flow, net reliability and security, consumer behaviour, communications technologies, etc. These developments underline the importance of related variety innovations across sectors and activities discussed in chapters 2 and 3. The research institutes in the Negev have the broad range of research potential and the links with complementary research fields in other parts of Israel that are needed to become excellent in interdisciplinary clean-tech research and to promote related variety innovation, but further incentives and new links between the actors are needed in order to make this potential work.

There is a lack of capacity to commercialise academic knowledge

To date, research has followed strong disciplinary paths and advanced research has taken place in the context of specific technologies. Research grants are provided in line with the needs of the discipline – not due to societal or economic needs and related emerging markets. For instance, Getz and Segal (2008: 10)

claim in their report on the Israeli innovation system that the “academic establishment is reluctant to set any priority other than excellence in academic research”.

As long as knowledge transfer starts from a narrow disciplinary base it is difficult to make use of it for the integrated problem solving that drives clean-tech innovation. Innovation policy needs to be much more than technology transfer from the academic to the industrial field. BGU has strong experience and success in the latter. However, clean-tech innovation depends on impulses from both sides: from academic research and from the problem solving needs faced by industrial companies. This needs to be strengthened through the use of various instruments to intensify the knowledge circulation in the Negev clean-tech sub-cluster and with other actors in the Israeli clean-tech cluster.

The industrial base to make use of the research results in the Negev is weak and differs from subsector to subsector

Effective knowledge transfer that aims at commercialisation relies on continuous feedbacks between research institutes and companies. But the role of companies varies according to their position in the innovation system³ and it is important to keep the whole value chain in mind when considering how to commercialise research results. The Negev possesses some parts of the value chain activities needed for innovation, but has gaps in others. These gaps in the industrial base may result in limited economic development spill-over from the research institutes unless ways are found to fill them.

On the one hand, there are strengths in the Negev’s clean-tech industrial base. Research and development companies are strong in the Negev, as well as in other regions in Israel, particularly in the various technologies of renewable energies and somewhat less in water technologies and solutions. However, their direct potential for job creation is limited, despite their key position within the sub-cluster. They are often based on academic research and involved in measurement, testing, piloting, certification, consulting and so on. When established, these companies work for the key players in the sector and accumulate knowledge in their field of competence. Due to disclosure agreements, these companies are not allowed to commercialise the specific knowledge, but the accumulated knowledge enables them to become key actors in the sector’s knowledge flow and to innovate in the space close to basic research. Often they are so specialised in their one technology field that academic competence lags behind them in this specific technology. They therefore have a key role to play in knowledge circulation and should be closely involved in the innovation networks and projects of the sub-cluster.

There are also two groups of industry locally that are of interest as lead users: the chemical industry located in an industrial park near Be’er Sheva, and the construction industry. Both are material intensive industries and both have strong impacts on energy efficiency: the chemical industry is an industry with energy costs that are far above average; the construction industry has to be renewed in order to deliver green building. Their relationship to research is quite different. Processes in the chemical industry are very complex and changes in the process are strongly linked across all the steps of the process. Therefore, knowledge from different disciplines is needed to redesign the processes towards greater energy efficiency. In construction, however, the knowledge is more basic: which material in what kind of climate, which combination of energy sources, how to avoid loss of energy or secure cooling? Companies from both sectors should be targeted by knowledge transfer instruments, but because of their specific needs different instruments have to be applied.

Furthermore, Israel as a whole has a strong set of system engineering companies in two fields of water management (desalination and drip irrigation) operating on the provision of infrastructure often with public funding (national, as well as international, via World Bank for instance). At the same time the Negev region has several young companies in engineering and managing power fields on the basis of new energies, such as the Arava Corporation. These companies provide greater job creation potential than the

research and development companies. In water technologies, the start-up companies play an important role in design-driven research and innovation in specific technologies such as membranes, filters or sensors and the more they grow, the more ICT is needed to integrate and control their systems. Therefore, there is a good chance to involve those companies in innovation networks and projects in the Negev clean-tech sub-cluster, although the potential of research-industry cooperation has not been fulfilled to date. Furthermore, most of these companies are hindered by difficulties in attracting funding for investment in growth. For example, two of the three leading drip irrigation companies in the region needed foreign money to grow and the third one, Netafim, is in search of foreign shareholders. This suggests that a priority for the sub-cluster is to draw in international companies to the Negev, both as investors and as players in joint innovation activities.

On the other hand, the Negev sub-cluster lacks leading utility companies, which normally occupy important positions in innovative networks as lead users in the large scale implementation of new technologies and follow an innovation path that is strongly design driven. They are in many cases based on a conventional (fossil or nuclear) energy base but have started to diversify into new energy technologies, energy efficiency and related engineering services. In Israel, the Israel Electric Corporation and Mekorot, Israel's national water company are the key actors. They have so far been conservative in their innovation strategies and so far have had little active involvement in the activities to build up a clean-tech sub-cluster in the Negev. Incentives may be needed for these companies to join the networks and projects in the Negev clean-tech sub-cluster that may be of benefit to them, for example work on smart grids.

In addition, the Negev is relatively weak in the availability of suppliers of components, tools, aggregates, etc. Those that exist are dispersed in spatial terms and there is therefore no strong basis for innovation activities that target those companies. Supplier firms are usually important components of innovation networks and projects because their labour market potential is high and often their products are very complex (turbines, modules, or aggregates for instance) and for these companies, it is most important to be present in a context (platform, networks, and fairs) where they get information about the kind of product and the quality that is needed and about the key innovation paths of the system engineering companies.

Taken together, the industrial base in the Negev for the commercialisation of clean-tech research is subject to gaps in certain innovation system functions and is often dispersed and lacking in connections. Patent data confirm this impression. Companies from the Negev count for less than five percent of all Israeli patents in the European Patent Office in the last decade. At the same time, there are interesting starting points for the strengthening of the region's clean-tech industry. This discussion of the existing industry base for research commercialisation in the region underlines the nature of the current Negev clean-tech activities as a sub-cluster rather than a fully-fledged, self-contained cluster. There are two priorities. One is greater connection with the rest of the clean-tech cluster nationally to involve companies from other parts of Israel, especially when their presence in the Negev is missing or limited. The other is to fill gaps locally where possible, by investing in start-ups and growth and in targeted inward investment projects and by encouraging existing players in the region to become more involved in integrating, cross-sector innovation projects that would benefit them.

Opportunities

Clean-tech is on the political agenda in Israel and associated clean-tech innovation programmes are an opportunity to strengthen the Negev sub-cluster

Israel is a latecomer in environmental policies and in supporting the establishment of a national clean-tech sector compared to the most advanced countries, but is now catching up quickly in terms of regulations, R&D budget and clean-tech programmes. This represents an opportunity to support national

clean-tech development objectives and national regional development objectives at the same time through projects to build Negev clean-tech activity.

In terms of research and development, the environment has only counts for 1% of government R&D while transport, telecommunications, energy and other infrastructures counts for another 1% (OECD, 2011a), but the R&D budget in the environmental field increased seven-fold in 2009. In addition to the Ministry of Industry, Trade and Labour (MOITAL), the Ministry of Science and Technology (MOST) is the most important player in research. Whilst its five top national priority fields have no direct focus on clean-tech, there are some activities related to clean-tech research including the support for the development of scientific technological infrastructures, the Israeli Fuel Cells and Batteries Centre in Tel Aviv and Bar Ilan. Furthermore, there is a specific research programme on materials, chemical technologies and energy and these topics are of high relevance for all fields of clean-tech innovation. The Israel Council for Higher Education also needs to be mentioned, headed by the Minister of Education, which has established the Israeli Centres of Research Excellence. Four centres have been funded so far, with one in the field of alternative energy sources with participation of researchers from the Technion, the Weizmann Institute of Science and Ben-Gurion University of the Negev. There may be potential to use this programme for the establishment of an interdisciplinary clean-tech research excellence centre in the Negev.

Furthermore, since the middle of the 2000s, Israel has introduced new national programmes to strengthen the Israel clean-tech sector. The pioneering programme is NewTech Israel, which was launched in 2006 and started with a focus on research and development efforts and further activities to promote Israel's water activities. In 2008, a second programme within NewTech was launched, aiming at the renewable energy sector. The Sde Boker Technology Centre for Water Technology and the Arava Centre for Renewable Energy have been initiated and funded by this programme. In addition, the National Plan for Developing Alternatives to Oil aims at mobilising private capital through 15% public subsidies for innovation projects in this field. Future scientific activity is planned to be reinforced by collaboration programmes and agreements with foreign countries. A third key policy activity with relevance for the development of clean-tech activity in the Negev is the Israeli Greenhouse Gas Mitigation National Plan 2011-2020, which focuses on green building, energy efficiency, and transportation. Pilot projects for new and existing green buildings will be initiated and investment in education and information is planned. The programme can be used to install pilot projects aimed at green building or a green city in the Negev. Chapter 1 has detailed a range of further programmes that can also be applied to the development of innovation networks and commercialisation-oriented entrepreneurship in clean-tech in the Negev, including the Tnufa and Green Tnufa programmes for technological innovation and entrepreneurship, the MAGNET programme for collaborative pre-competitive R&D activities and the Matimop programme for internationally cooperative industrial R&D programmes.

The National Strategic Plan to Develop the Negev can be used to support clean-tech procurement and attractiveness for skilled labour

The programmes outlined so far work at national level. In certain cases, their implementation has been within the Negev (e.g. the water and energy technology centres), but in most cases these programmes have no priority for the Negev. However, the National Strategic Plan to Develop the Negev has since 2005 offered an important potential platform to support the growth of clean-tech activity in the Negev. This is strongly in line with its objectives of finding new sources drivers of economic development in the region.

The plan focuses on economic development, improving the infrastructure, and making the region more attractive for residence, and community building. Innovation is not prominent in the programme, but it nonetheless has important implications for clean-tech development. This is because it includes the relocation of the Israel Defence Force and its technology units to the Negev and involves investments in

infrastructure, housing and education. These offer lead purchasing opportunities for clean-tech and can be expected to raise the attractiveness of the Negev, which will help overcome a barriers in the attraction of highly-skilled people to the region.

Threats

The Negev clean-tech sub-cluster depends on institutional innovation in Israeli innovation policy

The innovation system in Israel is strong in supporting high-tech industries and in bringing new technology companies to the market. It is a worldwide leader in supporting technology-based innovation. But clean-tech is market-driven and on its way to become design-driven innovation. In its public institution-driven rather than market-driven approach, a number of aspects of traditional Israeli innovation policy instruments are not well adapted to the needs of supporting the Negev clean-tech sub-cluster. Adaptation of these instruments should be envisaged.

Firstly, there are very few incentives for academics to engage outside fields that are important for academic reputation. For example, BGU is involved in various activities within the Negev, but all these activities have strong links to academic tasks. There appear to be cultural gaps that hinder a deeper engagement and interaction between research and companies. These problems are not unique to the Negev, but nonetheless may harm the development of fruitful cooperation between research and industry.

Secondly, whereas cluster initiatives – as an institutional arrangement to promote innovation cooperation and spill-over – have been established in most countries since the early 1990s, Israel has little experience with cluster policy and cluster initiatives. The lack of cluster initiatives has a number of disadvantages: it is a barrier to international contacts in programmes that could encourage international cooperation across actors from research, government and industry in cluster development, in particular European programmes such as “Regions of Knowledge” or “Innova”; it reduces the visibility and branding of the clean-tech research and innovation strengths of the Negev and hence its attractiveness to new players such as financial investors, research partners and inward investors; and it hinders the mobilisation of a broad range of companies and research institutions in joint projects within the region. Bio-Negev, with the BGU as a key actor, is one of the first Israeli experiences in cluster initiatives and offers a basis to build on.

The clean-tech sub-cluster in the Negev could be the place where new instruments of the Israeli innovation policy could be launched and tested with respect to incentivising greater academic-industry linkages and new cross-sector innovation projects.

Lack of regional governance arrangements for developing the Negev

The approach to development of the peripheral regions has a strong top-down bias in Israel, for good reason, since there is no overall experience with regional governance in the Negev. There is no coordinating actor in the Negev as a whole; MOITAL is in charge of coordination. However, this holds back co-operation and strategic thinking in the sub-cluster. A clean-tech cluster management organisation could help to fill this gap.

Recommendations

Strengthen the Negev’s clean-tech research and make it more visible

Establish an interdisciplinary clean-tech research programme at the BGU

Inter-disciplinary research and sector crossovers are t the heart of clean-tech innovation. Within the BGU there is a research potential that covers much more than renewable energy and water technologies.

The university therefore offers strong potential for the development of interdisciplinary research projects. This can be achieved with an inter-disciplinary research programme that aims to widen the generation of clean-tech knowledge into integrated projects fields that have the strongest potential for innovation development in the sub-cluster and to make the research more visible through a clean-tech branding, which will help build BGU's reputation in this field and increase the attractiveness of the region to external companies wishing to locate research and developing functions in the Negev. There is a window of opportunity for this in the global context because there are currently few, if any, universities with an excellent reputation in clean-tech.

Widening the research base could be achieved with the application of additional resources targeted at interdisciplinary research projects that cover at least two disciplines in all fields of clean-tech. Universities are autonomous institutions and in the end, the institutions of the BGU have to decide whether they follow this recommendation and build a strong brand in clean-tech research. But there are possibilities for policies to give incentives. For example, the National Strategic Plan to Develop the Negev might be adapted to include investment in clean-tech research, while the activities of the Ministry of Science and Technology might be adapted to integrate clean-tech as a further (6th) field of national priority, which could then launch a project to establish an interdisciplinary clean-tech programme in the BGU.

There are a number of international models that can be drawn on in developing such an approach. For example, the German Excellence Cluster approach gives additional resources to excellent research concepts in academic fields and the Austrian Comet Programme establishes and funds research fields that are related to regional clusters (with a strong focus on university-industry cooperation). Within Israel, the Grand Technion Energy Program (<http://tep.technion.ac.il/>) provides another example of such an interdisciplinary research programme and branding strategy.

Implement a programme to strengthen the Negev's international research links in clean-tech

Active involvement in strong international networks is an important way to present the Negev's research strengths on a global platform, to brand and strengthen its research activities and to bring international researchers into the region as part of an enhanced process of knowledge flows and brain circulation. Moreover, establishing international research linkages is an additional way of strengthening the inter-disciplinary research, where relevant specialisations do not exist already within the region. A programme is therefore recommended to strengthen the existing global links of Negev research institutes in a systematic way. The programme should target involvement in bilateral and international projects and the intensification of international brain circulation including through the organisation of international events like conferences and summer schools. These international research links should be developed in the interdisciplinary clean-tech research programme of the BGU recommended above, but should also be built by other research institutes such as the Arava Institute.

The Matimop programme already offers financial and technical support to join international research activities and it is recommended to include within the programme a mechanism to focus on clean-tech in the Negev, for example through a regional department of Matimop with a focus on clean-tech in the Negev. The programme should include support for bilateral Israeli agreements and international co-operation, including in European activities that are being planned in the coming Horizon 2020 framework, in which clean-tech will have a high priority. A special focus could be on strengthening the role of Negev research institutes as lead partners in European consortia.

To promote international brain circulation, there appears to be no need to launch additional national and international programmes, given their prevalence, but it would be helpful to have a focus on clean-tech issues. In addition, the organisation of a regular summer school would bring international researchers (from university as well as from companies) into the Negev under a specific thematic umbrella. This could

be introduced as a strong tool to transfer knowledge and discuss upcoming problems and research questions. It might usefully be combined with the annual Eilat-Eilat Conference on Renewable Energies. For branding a summer school high level speakers are needed to attract international guest. Therefore, financial support will be required at least for the first years, suggesting the need for a project to be launched that combines national funds (MOST, MOITAL) and resources from the regional research institutes.

Integrate the research capacities of the Israel Defence Force in collaborative projects

The relocation of the Israel Defence Force (IDF) is part of the National Strategic Plan to Develop the Negev and will involve the relocation of some technological units with research activities that related to clean-tech and BGU activities, for example in terms of the integration of ICT in energy efficiency and integrated water management projects and smart grids research. In the context of this plan a pilot project should be launched for joint research activities with BGU. This would contribute to broadening the research competence of the sub-cluster.

In addition, the BGU expects that up to 4,000 IDF personnel might become future students at the university following base relocations to the Negev. Academic courses that combine professional interest of members of the IDF and the BGU might therefore be established, such as a master course in environmental engineering, clean-tech-related technologies and/or environmental planning. This qualification could contribute to improving the supply of skilled labour for inward investors and local companies in the cluster and contribute to increasing the potential for start-ups in the clean-tech sector in the Negev.

Strengthen the commercialisation of knowledge

Organize a Negev-wide clean-tech innovation platform

There is a broad range of clean-tech-related research within the Negev and interactions with several national and international projects. The recommendation is to create a platform through which those results can be presented and discussed with researchers from research institutions and companies, including the testing and piloting centres, on a regular basis, for example once a month. The platform should cover the key actors of the triple helix (research, industry, public administration) and should include venture capital and finance institutions.

The anticipated benefits of the platform are better integration of the research questions of industrial companies in the Negev into research and the identification of complementary interests that can generate related variety innovation. In addition, a platform like this can help to avoid uncoordinated parallel research activities.

The development of such a platform will require resources for a data base that includes potential participants and an infrastructure for the exchange. The Swiss research-café for the construction industry is an interesting example of a format to realise these objectives⁴. A pilot project for the first years could be driven jointly by the Negev research institutes and technology centres and might be supported by national funds such as the Magnetron programme.

Establish a large-scale research collaboration framework project between the chemical industry and academic research

The Ramat Hovav industrial park in the Negev hosts chemical companies that have strong adverse environmental impacts. A number of these companies have recently become more committed to solving their ecological problems (Cohen 2007). In doing so, there is potential in building an innovation network linking researchers from the engineering departments of the BGU and chemical companies, aimed at joint

projects to strengthen material and energy efficiency in the chemical industry. In order to trigger such networking, a large-scale framework project should be developed involving collaboration between companies from the chemical industry and related sectors or technologies and research institutes on a range of more specific joint projects with financial contribution from the industrial partners. A call for a framework project like this could be launched by MOITAL in the context of the MAGNET/Magneton programme and would be facilitated through the creation of a unique track for clean-tech within the programme. This fits with plans to make more use of MOITAL research funds for traditional industry such as chemicals. It could draw inspiration large scale research-industry projects in Solar Valley, Saxony, and the Finnish Clean-tech Cluster as discussed in the chapter annex.

Set the scene to “green the Negev”

Develop research and pilot projects in the field of green building and sustainable infrastructure

Housing, buildings and settlements are among the most important factors in energy use and Israel is a leader in using solar energy to provide households with warm water. However, green building and sustainable infrastructure goes far beyond the use of single technologies: they require the integration of different energy efficiency technologies, improvements in materials, and optimising the energy efficiency of settlements and neighbourhoods as a whole. In order to capture part of the innovation element of the value chain for this growing market, it is recommended to develop an integrated research project for the development, testing and dissemination of concepts and tools to make buildings more energy efficient and develop sustainable infrastructure (energy, water, traffic). Such a project might include the combination of evaluation tools such as life cycle models, monitoring tools to evaluate the combination of different technologies, techniques to process and steer the systems, and social studies to overcome bottlenecks resulting from the user’s attitudes and would involve a combination of research, industry and lead users.

One of the strengths of developing such a project in the Negev is the opportunity to capitalise on the possibility to test and pilot relevant innovations in a green city, village or Kibbutz in the region, given the investments to be made in communities through the National Strategic Plan for the Development of the Negev. Whilst more and more cities claim to be “Green Cities”, most of these projects are focused on metropolitan areas and there is a niche for the Negev to develop testing in smaller settlements in peripheral areas and extreme climates. Within the framework of the National Strategic Plan to Develop the Negev, a competitive call for local entities for a green community could be issued, including criteria for company involvement, commitment by local authorities, new business models to be applied and expect results in resource and energy reduction.

The Lower Austria Cluster discussed in the chapter annex is one of the leading clusters in green building and offers a potential model for such an initiative.

ANNEX – LEARNING MODELS

Green Building Cluster Lower Austria

Description of the model

The Green Building Cluster Lower Austria is one of 6 cluster initiatives of the Austrian federal state of Lower Austria. The cluster in its present form started to work in 2003. The overall budget is composed of public funds and membership fees. During the current funding period 2007-2013 the cluster will receive more than EUR 11 million funding from regional and national government and the European Commission. Additional financial resources are provided by cluster members, which have to pay a fee of between EUR 280 and 1 100 depending on company size. These membership fees account for 10% of the cluster's budget. The Green Building Cluster currently has about 200 members including private companies and research institutions. Members cover almost the whole value chain of the construction industry.

The main fields of the cluster's activities are the refurbishment of old buildings to low-energy standards, energy-efficient new multi-storey buildings and development of healthy interiors and comfortable living conditions. The cluster management activity is undertaken by "Ecoplus", the regional business agency of Lower Austria, which is responsible for all the cluster initiatives in the region. Ecoplus supports co-operation among cluster members, offers comprehensive sector-specific training measures in order to enhance knowledge transfer, supports international co-operation in R&D and provides assistance for the internationalisation efforts of individual companies.

In 2009 the cluster managers of Ecoplus successfully initiated a four-year co-operative project called Future Building in the context of the national programme COMET (Competence Centres for Excellent Technologies), attracting EUR 3.8 million of national funding. The project aims to establish a longstanding Centre of Competence with a focus on sustainable and energy-efficient building. The lead partner is the Donau University in Krems, while six further research institutes and 20 companies are also involved. It involves a series of university-industry joint projects grouped into three categories: new and improved products with a specific focus on compatibility with system needs, harmonization and integration of components in integrated systems and adaptation of systems to concrete circumstances. Some concrete examples of projects are thermal insulation composite systems from Perlite, an environmental heat meter for heat pump systems, innovative glass elements, or evolution in modular light-weight building systems.

Relevance to Israel/Negev

The model shows how links can be developed among the members of regional clusters, how complementary funding can be developed in high-level research and industrial development and how vocational training initiatives can be used to upgrade the industries. It demonstrates that very concrete innovation projects and high-level research in green building can be effectively combined.

Results of the approach

Up to now the Green Building Cluster Lower Austria has realised about 250 cooperation projects in which 490 companies have participated in total. A substantial part of these projects have been co-financed by national and regional programmes that support cooperative research projects by SMEs. In 2011, the

cluster was one of the finalists of the Regio Star Awards of the European Union. The government of Lower Austria has evaluated the macroeconomic effects of its all 5 regional cluster initiatives, estimating that the cluster initiatives generated additional regional value added of EUR 2.7 million and 560 additional jobs.

Reasons for success

One of the factors behind the success of this initiative was a comprehensive prior analysis of regional economic strengths and deficiencies, which enabled the identification of green building as an important field of regional strength. The cluster management activities provided by the regional business agency were also a key element in the success of the initiative, brokering knowledge transfer projects across the value chain of the cluster and creating strong linkages between education institutions, advanced and basic research and organisations piloting technologies. Additional public funding for co-operation projects was also important to achievement of inter-firm cooperation and the successful inclusion of SMEs, which are often highly skeptical about collaboration. The cluster management activities also successfully improved the image of quality in the sector. Some important instruments in this context have been the development of common quality standards within the cluster, supply-services in the context of material testing and certification of new products and processes and support for the implementation and marketing of pilot projects.

Obstacles faced and response taken

Currently cluster members seem to belong to the more innovative part of the construction industry value chain. The vast majority of regional companies in the sector have not participated in the cluster activities, although they may benefit from the improved quality image of the sector and the training measures that have increased the sector's skilled labour base. Furthermore, cluster members contribute only about 10% of the cluster's total budget. These problems have been recognised but no major initiatives have been undertaken to correct them.

Considerations for adoption in Israel/Negev

The comprehensive sector-specific training measures for green building companies are relevant to the Negev, where such activity can be associated with the development of a green settlement and public procurement in green building activities in order to generate new opportunities for local resident labour. The cluster management activities undertaken by the regional business centre are also relevant to the Negev, where they would be taken on by a specific cluster management organisation. These activities have been very important to getting agreement of SMEs and other firms to participate in local knowledge transfer projects and to creating links across the innovation chain, for example through basic research and piloting.

Further information

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COMET Competence Centres for Excellent Technologies - K-Projects:

http://www.ffg.at/sites/default/files/images/comet_k-projekt-factsheet_fb_eng.pdf

Solar Valley Mitteldeutschland

Description of the approach

The Solar Valley cluster is one of 10 clusters supported by the German central government's Clusters of Excellence Programme, which is being funded over 5 years (2008-2013) as part of the government's High Tech Strategy. Its budget is approximately EUR 150 million, 50% raised by private companies and 50% by central government under the aegis of the Ministry of Education and Research. Above all, Solar Valley Mitteldeutschland is a research-driven cluster, as are all 10 clusters in the programme. The main goal is the significant reduction of solar electricity generation costs so that solar energy can be produced at a cost similar to traditional energy. The cluster consists of 35 companies, 9 research organisations, 5 universities and 5 colleges, 3 educational institutions and government representatives of the 3 neighbouring federal German states that together host the cluster: Saxony, Saxony-Anhalt and Thuringia.

An important feature of the cluster is its cluster management organisation, which is located in Thuringia with branch offices in the 2 other federal states. The main activities of the cluster management organisation are the co-ordination of innovation networks in photovoltaic innovation activities in the region. Furthermore, it supports the expansion of the cluster's size by attracting inward investor firms and institutions and by supporting start-ups and spin-offs.

The cluster is also supported by an inter-disciplinary research and training centre for solar energy research in the form of the Graduate Photovoltaic School, established by three universities in the region hand-in-hand with the companies that are part of the cluster.

All in all, the cluster enables a concentration of research and education resources in one innovative technology.

Rationale and relevance of the approach to Israel/Negev

This is a model of a large-scale research-driven cluster development project involving companies, research institutes, universities, and the education sector, illustrating how the triple helix approach can be applied. It is based on an ambitious budget that is aimed at building critical mass. It also requires a significant contribution to costs from the cluster actors. The current clean-tech activities in the Negev are particularly focused on research, and such a research-driven approach fits well with its strengths. The Ben Gurion University of the Negev is a strong player with the strategic capacity to implement an inter-disciplinary project like this, given complementary research funding.

Outcomes/results of the approach

The private companies and research institutions of the Solar Valley Cluster Mitteldeutschland are conducting more than 90 co-ordinated joint research projects in the context of crystalline silicon technology and thin film technology. These projects accounts for the main part of the overall budget. In the beginning of 2011 a first interim evaluation has taken place which gave an overall positive evaluation of the results obtained over the first part of project implementation.

Reasons for success/failure of the approach

The cluster is located across three federal states. Each federal state is pursuing its own strategy for its sub-cluster, based on promotion of research co-operation between private photovoltaic companies, regional research institutes like institutes of the Fraunhofer Society and regional universities and promotion of human capital formation, involving bachelor and master degree courses in the field of photovoltaic technologies by universities and universities of applied sciences in close cooperation with regional

companies in order to offer practical training opportunities and in-house-placements to their students. The three states also take joint action in marketing the region as the most important centre of the German solar industry, which accounts for more than 75% of German production of photovoltaic cells. These three elements of the programme together have underpinned its success, namely joint research, joint training and joint marketing.

Obstacles faced and response taken

Although the joint research undertaken is leading to positive outcomes, the future of the region as a photovoltaic production site is uncertain. The German photovoltaic industry in general suffers from strong international competition, particularly from new competitors in Asia offering photovoltaic products at significant lower prices than German manufacturers. As a result a growing share of domestic photovoltaic firms have established their own production capacities in Asian markets in order to benefit from lower labour and production costs, such as Q-Cells and Solarworld. The current difficult market conditions and growing off-shoring of regional companies may be two reasons for the relatively poor performance of the cluster in establishing new firms and start-ups.

Considerations for adoption of this model in Israel/Negev

The Solar Valley cluster illustrates how to implement the recommendation for a large-scale research collaboration framework project between the chemical industry and academic research. The transformation of the chemical process into a green direction is a very systemic challenge because the specific problems are strongly linked and a lot of basic as well as applied research is needed to overcome the problems. A large-scale research project could be launched in the context of the MAGNET programme using the engineering competencies of the BGU and other universities in Israel and the chemical companies and related industrial companies from mechanical engineering and/or plant engineering and construction. The activities of the Solar Valley cluster in promoting collaborative research as well as joint training and branding could provide a model for such an initiative.

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Finnish National Cluster of Expertise

Description of the approach

The Finnish clean-tech cluster is supported as part of the national Centre of Expertise Programme, which funds 13 clusters in different sectors and technical fields and 21 Centers of Expertise in different Finnish regions. There are more than 300 companies in the Finnish clean-tech cluster. Together they account for approximately 60% of the national environmental business and 80% of the sector's research activity. The main fields of action of the cluster members are water technology, air purification, eco- and energy-efficiency, renewable energy, environmental measuring and monitoring, environmental health and safety, risk assessment and environmental informatics. The cluster is comprised internally of four sub-clusters, each linked to a different regional Centre of Expertise. The leading sub-cluster is found in the Lahti Science and Business Park within the Lahti region. The others are located in the Oulu, Kuopio and Uusimaa regions.

Each of the sub-clusters has a regional cluster management organization, with the regional cluster management organisation in Lahti taking the lead in co-ordinating the activities of the cluster as a whole. The cluster management organisations support co-operative R&D projects, offer services in order to expand the internationalisation of the companies within the cluster and aim at cluster expansion by attracting new firms and institutions and by supporting start-ups and spin-offs. In addition, the cluster management in the Lahti Science and Business Park is specialised in the acquisition of venture capital.

The activities are co-financed by TEKES, the Finnish funding agency for technology and innovation. In 2010, funding for energy and environment related activities in Finland summed to EUR 245 million (this is the same amount as for ICT-related activities). In addition, the Lahti Science and Business Park management had a turnover of EUR 7.2 million in 2009, approximately EUR 0.9 million (12%) financed by the ERDF, EUR 2.7 million by other public institutions (ministries, Tekes, etc.) and the ESF, EUR 1.5 million by private stakeholders, and EUR 2.1 million by municipalities (mainly the city of Lahti).

Rationale and relevance of the approach to Israel/Negev

The Finnish situation has a lot in common with Israel. As Israel, it is one of the world's leading countries in R&D expenditure, with a strong focus on start-ups and ICT. It is also a small country with regions with low population density and with strong international links. Its clean-tech cluster approach provides an example of how to combine a national strategy and regional sub-clusters in a medium-sized country. Not least, the Finnish approach also illustrates how to renew traditional industries by implementing new technologies.

Outcomes/results of the approach

In 2010, a study by the international Clean-tech Group ranked the Finnish clean-tech cluster in the top 3 of the world's best green technology clusters. Up to 2010 the cluster had promoted the creation of 65 new clean-tech companies and about 500 new jobs. Apparently the cluster management is lagging behind its ambitious target of creating about 200 new start-ups by 2013. The business development and relocation services of the park have attracted investment worth more than EUR 30 million and some 170 new jobs to the region. In the last few years, the cluster has implemented projects to a total value of EUR 65 million. Particularly commendable have been the cluster's internationalisation projects directed at China, Russia and India.

Reasons for success/failure of the approach

The Finnish cluster and innovation approach is based on a long tradition. Among the key success factors is continuous policy learning that is driven by (in most cases unpublished) evaluation, a limited number of well-organised key public innovation support players like TEKES and VTE for applied research, and a commitment to networking and cooperation by leading companies, including strong international links. The four regional clean-tech clusters have no clear division of labour and certain aspects of clean-tech activity like renewable energies are of less importance (Palmberg/Nikulainen 2010). The success is more in modernising industrial sectors like mechanical engineering or paper and wood. So far, the rise of a specific clean-tech sector is an ongoing challenge.

Obstacles faced and response taken.

A 2009 evaluation of the Finnish innovation system resulted in two key messages. Firstly, the Competence Cluster Programme attempted to co-ordinate widespread regional cluster approaches on a national level. However, so far success was mainly in marketing activities. Real coordination and networking between cluster members of different regional clusters does not take place systematically.

Secondly, the evaluation suggested redirection of the cluster approach from a science and R&D-based orientation to a more applied research driven concept which supports mutual learning and non-science based innovation. This approach would better correspond to the innovation modes of the regional Finnish cluster resources.

Considerations for adoption of this model in Israel/Negev

The Finnish clean-tech cluster programme provides several ideas that could be useful to strengthening of the strategy of the Renewable Energy Technology Centre and the Water Technology Centre. The international links that are promoted (participation in international fairs, bilateral agreements, organising visits and delegations) and the topics and tools of networking (mini-clusters, business contacts) are basic elements in managing clusters. A further specific programme idea concerns the Advisory Professorship, which is seen as a model for responsible and cost-efficient regional innovation policy. In the Advisory Professorship model, strategic alliances are created between universities and innovation actors in Lahti and university units located globally. They contribute to the common research projects, teaching or development projects more systematically than in traditional co-operation models. Furthermore, the Finnish cluster strategy itself is important. In the Negev, a clear systematic strategy building process (basing on the balanced score card model for instance) is an important first step to decide what tools and instruments could be used.

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ENDNOTES

¹ See: <http://www.science.co.il/>

² Basing on the FP 7 project databank: http://cordis.europa.eu/fp7/projects_de.html (FP7)

³ Cf. Rehfeld/Nordhause-Janzen 1995 and Rehfeld/Schepelmann 2007 for empirical results from German regions and OECD 2011a and Chapter 1 for the Israeli sectors and companies.

⁴ See : <http://www.zukunftbau.ch/de/innovationsfoerderung/forschungs-cafe-bau/index.html>

CHAPTER 5.
BUILDING THE LABOUR MARKET AND HUMAN CAPITAL

By Karen Chapple

Abstract

This chapter analyses the labour market challenges involved in growing the clean-tech sub-cluster in the Negev. Negev clean-tech is experiencing difficulties in attracting and retaining skilled workers and in improving training and employment opportunities for its low-skilled resident workforce. Two different but complementary approaches will help respond to these problems and provide labour for the growth of the clean-tech sub-cluster: facilitating the transnational and inter-regional flow of skilled labour and ensuring that disadvantaged local residents gain access to job opportunities in the clean-tech sector through local clean-tech training programmes and creating a green urban development strategy for the Negev.

Labour market challenges in clean-tech

As new industries emerge and grow, firms often face a paradox in the skilled labour market. They typically owe their existence to an innovation – new knowledge that stems from unique combinations of resources – often coming from interaction across sectors or specialisations, or from the collaboration of experts with market actors. But as they grow, they tend to specialise, losing that dynamic exchange.

The industries that comprise the clean-tech sector are facing this paradox as they grow. In the case of renewable energy and water technology, many of the technologies were developed decades ago, but lacked appropriate market and regulatory conditions to take off. If they are successful today, it is likely due to an infusion of entrepreneurs with market competence. Shortages of skilled labour, not just environmental scientists and engineers but also lab technicians, persist even in the regions that are most competitive in clean-tech (for instance, see East Bay Economic Development Alliance, 2011).¹ But in emerging industries, realising the promise also means connecting current R&D better to market knowledge. Thus, the primary challenge in developing a clean-tech cluster is first developing knowledge capacity in specialised areas and attracting skilled and talented labour and then facilitating linkages across sectors and universities, brain circulation among countries, and interaction between researchers and the market.

A parallel challenge besets the low-skilled labour market – in the case of clean-tech, principally in the construction industry (including installation of renewable energy facilities, green building construction, and energy efficiency retrofits), but also in component manufacturing and assembly. As a new product or process emerges, there is a shortage of trained, specialised labour, so existing workers in traditional occupations take on new tasks in a process of “job enlarging” (Useem, 1986). But as innovations mature, new education and training programmes emerge to prepare a specialised workforce. The dilemma is how best to match the preparation and quantity of labour supply to labour demand. It is very difficult to anticipate labour demand in emerging industries. As new occupations emerge, training programmes are slow to develop, but then may overproduce workers as the industry changes. The challenges in preparing low-skilled workers for clean-tech are thus first to determine the extent to which work will take place in traditional, versus emerging, occupations, and second to link job training closely enough to employers that labour demand absorbs the new supply. Both of these challenges have undermined the promise of jobs in

clean sectors: in a slow economy, most of the new work has been absorbed by existing workers in traditional occupations, and job training programmes have oversupplied graduates. Enabling green growth requires strong local labour market institutions in order to facilitate communication among stakeholders, develop labour market information systems, and support the training infrastructure (OECD, 2012). Investment in low-skilled workers in clean-tech sectors is not only about meeting current labour demand but also developing a pipeline for high-skilled work, as some will obtain advanced training or college education in order to move into more technical fields.

Clean-tech differs from high-tech sectors in its dependence on a governmental regulatory framework: environmental regulation and standards play a key role in generating market demand, and government subsidies remain critical for growth. Studies have found that environmental regulations were spurring innovation and building markets, creating local and regional economic development (OECD, 2012; Chapple, Kroll & Montero, 2010). Thus, the government must integrate support for the clean-tech labour market and its human capital development into that regulatory framework. Left alone, the market will not train workers appropriately, hire workers in priority regions, or adopt high labour standards. Moreover, the market needs more certainty in the environmental arena to create significant numbers of jobs. Thus, a competitive clean-tech workforce requires proactive government intervention.

Because of its small size and complicated geopolitical situation, Israel experiences a more serious set of labour market challenges – and opportunities – than do most advanced industrialised countries. Inequality has grown more rapidly, due in part to the increasing divide between workers in the high-tech and financial sectors and the poor Ultra-Orthodox and Arab populations. Though the country was founded on immigration, and has recently gained most of its competitiveness from newcomers, workforce issues now may be holding it back. And though the government has gradually strengthened its environmental regulation, the link to labour force outcomes is weak, as are labour market institutions more generally.

These challenges have distinct implications for the development of a labour force for a clean-tech sub-cluster in the Negev. Experiences in the OECD countries that are global leaders in clean-tech suggest the importance of three overarching strategies to help develop the necessary labour market and human capital for a clean-tech sub-cluster in the Negev:

- Build local high-skilled and innovative labour in clean energy and related sectors through supporting educational programmes at research institutions, integrating entrepreneurship training with science education, and facilitating brain circulation among the leading clean-tech regions globally.
- Prepare the low-skilled workforce through carefully matching labour supply and demand, coordinating among local labour market institutions, investing public funds in training, and brokering connections between job seekers and employers.
- Use environmental regulation and urban development projects strategically to support labour market and human capital development goals by funding education and training in related occupations, developing certifications and standards, and incentivising employers to hire locally.

This chapter will examine these issues as they apply to clean-tech in the Negev region.

Analysis of the labour market in the Negev and Israel

In order to understand the challenges specific to the clean-tech labour market in the Negev, we first need to establish the economic and institutional context: inequality, immigration to Israel and between regions, and relatively weak labour market institutions and regulations.

Inequality

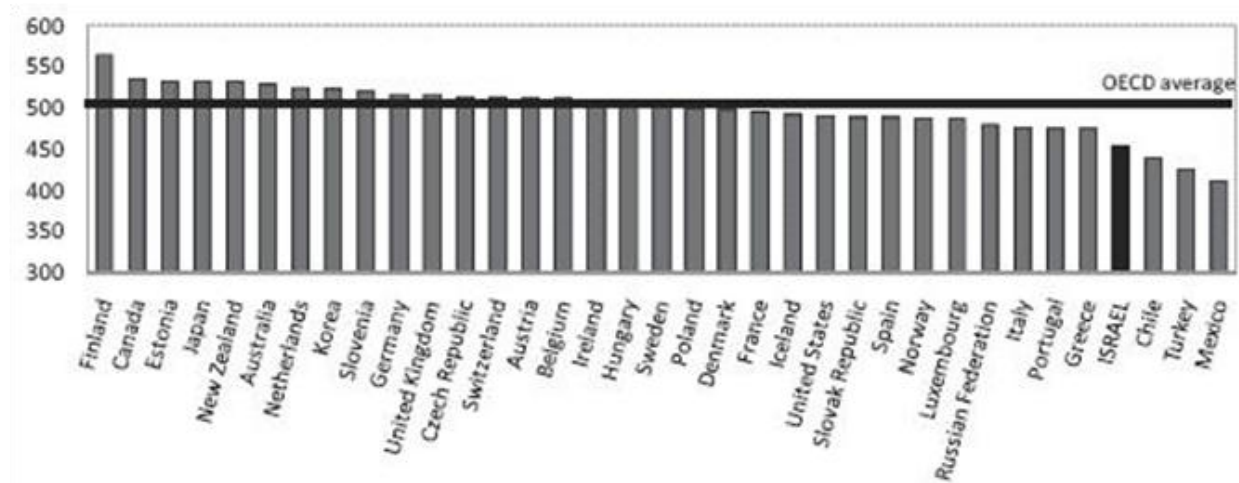
Overall the poverty rate in Israel is just over 20%, almost doubling since the 1980s (OECD, 2010). Over half the Arab population and 60% of the Ultra-Orthodox live in poverty, and the country's child poverty rate, at 29%, is higher than that in any other OECD country (OECD, 2010, 2011). At the same time, Israel has high levels of income inequality. Among the OECD member countries it lags only the USA, Turkey, Mexico and Chile, and its income inequality has accelerated rapidly in the 2000s (OECD 2010).

One main cause is changing government policy; specifically, declining government spending on social supports. Another key factor behind inequality is the rapid growth of the high-tech and related sectors. Although Israel's high concentration of high tech firms is a global competitive advantage, its strength is in innovation and start-ups, which have not been associated with large scale job creation and income growth (OECD, 2011).

Also shaping inequality is the deep segmentation of the Israeli labour market. Labour force participation is relatively low (64% versus the OECD average of 71%), due mostly to low participation from Arab women – most of whom lack access to formal child care – and Ultra-Orthodox men – who devote time instead to religious study (OECD, 2011). The incidence of long-term unemployment has become nearly as common as in other OECD countries; in 2008, 21% of the Israeli unemployed had been out of the workforce for over a year, compared to just 5% in 1998 (OECD, 2010). Gaps in educational attainment (measured as either years of education or test scores) contribute to poor labour market attachment: it is estimated that the government spends one-third less on children in Arab localities than it does for those in Jewish municipalities (OECD, 2010). Furthermore, relative to other OECD countries, unemployment in Israel is concentrated among those with lowest educational attainment (OECD, 2009).

Israel has one of the highest rates of completion of tertiary education among OECD countries, surpassed only by Canada, Japan and Korea. But Israeli teenagers perform poorly in international student tests, such as the Programme for International Student Assessment (for science) (see Figure 15). Moreover, both the Arab and the Jewish residents of the Negev lag the rest of the country in education: in the 20-29 age groups, just 2% of Arabs and 12% of Jews have any post-high-school education (compared to 6% and 16% nationally, respectively) (Jewish Agency for Israel, 2005).

Figure 15. Average PISA score for science in OECD and accession countries, 2006



Source: OECD/PISA database (OECD 2010)

There are important regional aspects to welfare inequalities in Israel. Ministry of Finance figures show that across a range of measures such as average income, car possession and rates of higher education participation the Negev population is well below the national average. Disparities between quality of life and opportunities in the core and the periphery lead to migration to the former from the latter. In the case of the Negev, this has led to the out-migration of residents with relatively high human capital. These spatial aspects of inequality tend to be self-perpetuating. For instance, the poor labour force participation among Bedouin Arabs is due in part to the distance from employment opportunities, particularly for those without access to an automobile (OECD, 2010).

The workforce in the Negev is concentrated in a few cities, such as Be'er Sheva and Eilat, or living in the rural areas, on the kibbutzim. The lack of a professional workforce is a major problem, even in Be'er Sheva. Salaries are much higher in Tel Aviv, where a PhD can earn twice as much. Also, since high-tech or clean-tech firms in the Negev are relatively dispersed, workers have to drive significant distances. Though some commute from Tel Aviv (1.5 hours), few like to travel this distance daily.

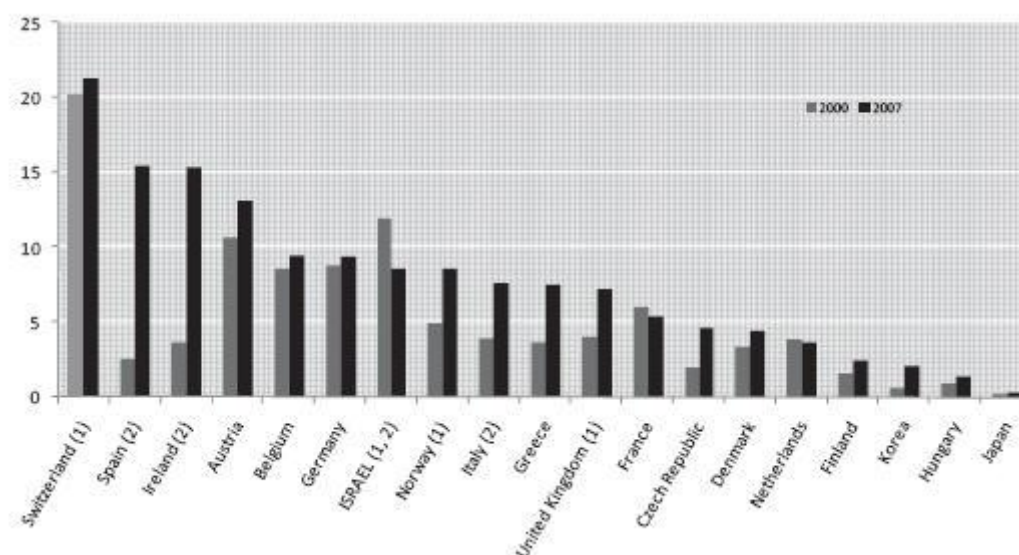
In general, the employment situation for the 160 000 Bedouins who live in the Negev is worse than in the country as a whole. Because they live in "unrecognised villages," they tend to be isolated from job opportunities; participation in the workforce for the Be'er-Sheva Bedouin is just 27%, compared to an average of 57% in that district (Robert H. Arnow Center for Bedouin Studies and Development and Negev Center for Regional Development, 2010). Isolation is not just physical; with no formal labour market institutions mediating connections between workers and employers, nearby companies often cannot figure out how to access the local workforce.

Overall, the poverty rate for the Negev Bedouin is 80% (OECD, 2010). Just 26% of the population is at the minimum level for university entrance, compared to the Israeli average of 40% (Robert H. Arnow Center for Bedouin Studies and Development and Negev Center for Regional Development, 2010). Bedouin men are disproportionately concentrated in agriculture, manufacturing and construction and underrepresented in the utilities and finance. Women tend to work in education, health and social services (Ibid.).

Immigration to and within Israel

Israel relies heavily on immigrant labour, not without challenges, and in fact is decreasing its dependence over time. This is in stark contrast to the other OECD countries, which almost all experienced increases in immigration in the 2000s (Figure 16).

Figure 16. Foreign workers as a percentage of the labour force, 2000 and 2007 (selected countries and Israel)



Source: OECD, 2010

About 200 000 low-wage workers from Southeast Asia, India and China work temporarily in household services, agriculture and construction. Increasingly, quotas are reducing the number of workers per sector. There is a negative relationship between relying on this temporary workforce and the labour force participation rate of other Israeli groups (Gottlieb, 2002; OECD, 2010; Romanov and Zussman, 2003).

Historically, in-migration of Jewish immigrants has provided a high-skilled workforce; the wave of immigration from Russia in the early 1990s is credited with bringing a large pool of workers with engineering and science skills. Now, employers rely almost exclusively on high-skilled professionals produced through the Israeli system. Employers can apply to bring in specialists or experts (wages must be at least double the Israeli average), but applications are individually approved (i.e. approval is not automatic). Thus, there is not presently a culture supportive of attracting high-skilled immigrants to work in Israel (OECD, 2010).

Within Israel, there is a net outflow of the more educated population from the Negev to the more populous regions. Although just 4.5% of the general Negev population leaves each year, 29% of Ben Gurion University graduates who are from the Negev out-migrate (Jewish Agency for Israel 2005). Overall, migration into the region has been flat or negative since 1996.

Institutional and regulatory framework

Accompanying the rise in inequality in Israel is the weakening of labour market institutions. Minimum wage enforcement is poor, there are few supports to remove barriers to labour force participation for under-represented groups, and unionisation and collective bargaining are in decline. Labour market

programmes receive just 0.1% of GDP (compared to an OECD average of 0.6% in 2006) (OECD, 2010). The budget for unemployment services is in decline and the number of unemployed per counsellor is relatively high. Less than one percent of the unemployed participate in a vocational training programme, due in part to cuts. Private training centres provide the majority of job training, and apprenticeship programmes have declined: just 3% of the young population are in apprenticeships, a much lower share than in Europe. The weak institutional support for job training is due not just to public sector retrenchment but also lack of employer engagement in preparing the future workforce.

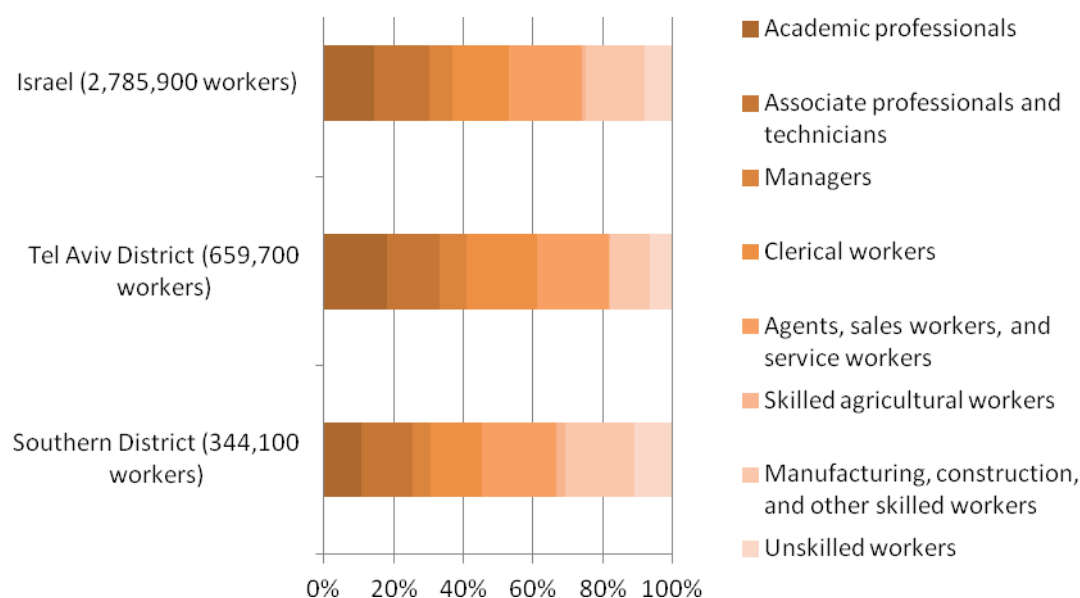
It is also worthy of note that environmental regulations rarely incorporate any labour training standards. For instance, though installing air conditioning effectively is key to energy efficiency, certification is not yet required for technicians. However, labour issues are gradually gaining attention: in conjunction with new pilot programmes for green building and energy efficiency standards, MOITAL will be preparing a training plan for professionals.² Slow implementation of environmental regulations means limiting job creation opportunities; for instance, though the country has set ambitious goals for recycling, the low cost of land filling and the lack of enforcement has slowed the pace of change. Yet, recycling is far more labour intensive than traditional waste management, providing over ten times as many jobs (Leigh, 2011).

The labour market for clean-tech

The clean-tech cluster in Israel includes renewable energy, energy efficiency, water, waste, green buildings, and agriculture; renewable energy and water efficiency technologies are most prominent in the Negev sub-cluster (Fortuna, 2011). Despite the international buzz about jobs in clean and green sectors, throughout the world workers in traditional occupations perform most of this work (OECD, 2012). The top non-clerical workers in renewable energy, energy efficiency, and green building include electricians, plumbers and pipefitters, construction labourers and supervisors, carpenters, sheet metal workers, and HVAC mechanics and installers. In water technology, there are environmental engineers, operators and mechanics, and electricians, and in recycling, truck drivers and machine operators. However, many of these traditional workers will benefit from short-term job training in specific skills, such as photovoltaic systems installation and energy auditing. The government currently subsidises a limited number of such training courses, typically offered as on-the-job training or in vocational programmes.

To support innovation in clean-tech, firms must draw from a high-skilled workforce including PhDs trained in environmental hydrology, microbiology, chemical engineering, computer science, climate science, physical biosciences, particle physics, materials sciences, and many others. Yet, this technical expertise must be coupled with managers familiar with market needs and entrepreneurship. Relative to Tel Aviv and Israel as a whole, the Negev has a concentration of unskilled workers and manufacturing, construction and other skilled workers (Figure 17). It lacks academic professionals, managers, and clerical workers, particular compared to the Tel Aviv district.

Figure 17. Distribution of existing workforce by occupation and region, 2009



Source: Israel Central Bureau of Statistics, Labour Force Survey 2009.

Though Negev region has a significant concentration of low- and semi-skilled workers in areas likely to be in demand by clean-tech, its share of workers is low in absolute terms (with just over 100,000 workers currently). Moreover, there is a clear shortage of workers trained in clean-tech-related industries, particularly engineers able to work in renewable energy and water. Although this is particularly true in the southern part of the region, even firms in Be'er Sheva struggle with human resources. For instance, Rotem (the Renewable Energy Innovation Center in the industrial park in Dimona) does have access to 150 PhDs through various networks, but lacks the capacity at present to help firms scale up past the testing stage.

There are multiple efforts throughout the region to better prepare high-skilled workers. Bright spots include the water technology programme at Ben Gurion University (Sde Boker); the efforts by many, including NewTech, to raise awareness of environmental professions; the Ben Gurion university campus at Eilat; and even the community workshops on renewable energy held by the Arava Institute. But these curricula generally fail to prepare workers for entrepreneurship, and more important, may not succeed in attracting their graduates to stay in the region. The following examines these strengths and weaknesses, as well as opportunities and threats.

Assessment of the labour market

Strengths

Entrepreneurship and ICT. Among Israel's many strengths, there are two that are particularly advantageous in building the human capital and labour market for a clean-tech cluster: its entrepreneurial culture and its high-tech workforce. Start-up creation rates are relatively high due to what has been called the "chutzpah" of Israeli entrepreneurs, and this creative human capital also fuelled the rapid growth of its ICT sector (de Haan, 2004). Powering the growth in ICT was the influx of engineers and scientists from Russia in the 1990s, and that knowledge base remains one of the country's most critical human capital

assets. Moreover, the ICT cluster has developed close links to other high-tech innovation clusters throughout the world, connections that may pay off for clean-tech as well (Engel and del-Palacio, 2011).

Institutional infrastructure. Within the Negev, there is significant institutional infrastructure to support human capital development and knowledge transfer. The Office of the Chief Scientist has established two technology centres in the region, including the Zuckerberg Institute for Water Research and the Centre for Renewable Energy and Energy Conservation at Arava; in addition the Ben-Gurion National Solar Energy Center already has an international reputation. The two satellite locations of the Ben Gurion University of the Negev, at Sde Boker and Eilat, are growing rapidly. Regional industrial parks, including Rotem, are building stronger connections to these centres and universities. Taken together, these institutions already offer nearly all of the educational programmes critical to support a clean-tech cluster, and many have the capacity and ability to expand as the cluster grows.

Perhaps even more important than the capacity of formal institutions is their openness to the global exchange of ideas and human capital. In this regard, the Arava Institute provides a model to its sister institutions in the Negev. Researchers at Arava have made an effort to establish cross-border projects with the Palestinian Authority and Jordan, and hold numerous international workshops and conferences on environmental issues.

Local residents. Another key regional strength is the local residents. The diversity of the labour force (despite the underrepresentation of very high-skilled workers) is well suited to accommodate clean-tech, which offers jobs at a variety of skill levels. The local culture of sustainability, as evidenced particularly in the local kibbutzim, provides built-in support for clean-tech firms, especially those that are green producers, not just producing green products.

Finally, the region's future residents are an asset as well: with a significant number of new towns planned to accommodate 300 000 new residents in the next decade, there is significant potential for the workforce to grow – and for policymakers to shape local human capital.

Weaknesses

Although Israel's high-skilled labour market is generally an asset for the national clean-tech cluster, there are significant weaknesses in the Negev region in particular. Key issues are the need to attract and retain high-skilled labour, to incorporate local low-skilled workers into a clean-tech cluster strategy, and to build a more effective policy and programme infrastructure to support clean-tech.

Shortage of high-skilled labour. The Negev region lacks high-skilled workers, particularly engineers and researchers with graduate education in energy and environmental technologies. The shortage of high-skilled labour stems from several different causes. First, as noted above, the region has experienced net outmigration for most of the last decade, and has particular difficulty retaining qualified graduates from Ben Gurion University, even those who are native to the region. The university itself has limited physical and financial capacity to support students, so enrolment is constrained. Second, companies complain that they are not able to attract high-skilled residents to the Negev, particularly south of Be'er Sheva. Third, there is a marked lack of transnational labour flows in the clean-tech area. This contrasts with the ICT sector, which not only benefited from the influx of high-skilled Russian immigrants, but also the global exchange of human capital as Israeli ICT firms developed close relations with similar firms in areas such as California's Silicon Valley. These weaknesses can be addressed, but some require more long-term solutions. Attracting and retaining highly educated workers and their families will be more feasible as the region develops more infrastructure and amenities. Bringing more high-skilled workers to the region on a temporary basis may be more readily feasible – though such programmes do not yet exist on a large scale.

Unprepared low-skilled labour. The low-skilled labour market in the Negev suffers from three problems: relatively high unemployment, low levels of human capital attainment, and a Bedouin community that is not well integrated either physically or socially with the rest of the region. Yet, the extent to which these weaknesses threaten the clean-tech cluster is not yet clear. In areas such as biofuels and renewable energy, there is not yet need for a large low-skilled workforce, either because the new products innovated have not yet reached the production phase, or because the labour needs are only short-term (e.g. installation of a solar field). Moreover, Israel cannot compete globally on labour cost, given that wages are still higher than in much of Southeast Asia. However, the unpreparedness of the low-skilled labour may be a future constraint. In particular, although Israel is implementing new building standards, local workers are not yet ready to work in the associated jobs, and thus potentially to participate in the construction of the planned new towns for the Negev.

Slow implementation of environmental regulations. Relative to its OECD counterparts, Israel has been very slow to implement (and enforce) its environmental regulations; for instance the national plan to reduce greenhouse gas emissions (Government Resolution 2508), which includes pilot programmes for job training, is just one year old. This means not only that there are relatively few training programmes related to energy efficiency and renewable energy, particularly the apprenticeship programmes that are so critical for successful job placement, but also that there has been little opportunity to develop the critical links between employers and training that make training valuable to employers and placements available to trainees.

Opportunities

The Negev offers significant opportunities to use the clean-tech cluster as a vehicle for regional development. Despite the lack of high-skilled workers locally, there are increasing connections to high-skilled workers in other regions. There are promising new pools of low-skilled labour. Local institutions are training both high- and low-skilled workers and have plans and capacity to expand. Most importantly, regional development plans will bring substantial new resources to the region.

ICT workforce. Several regions around the world have benefited from the existence of an existing ICT cluster as they seek to develop a competitive advantage in clean-tech. Clean-tech firms have drawn from the managerial expertise in ICT firms and gained from pre-existing relationships with venture capitalists. The majority of jobs in clean sectors are in construction-related firms, which are more labour intensive than sectors such as agriculture and utilities (OECD, 2012). Clean-tech R&D firms hire computer programmers, software and hardware engineers, network administrators, and ICT systems managers. In growing areas such as the smart grid, clean-tech firms are integrating ICT workers into the design work for their core product. Israel's labour strength in the ICT occupations offers an opportunity to develop a global niche in products that integrate information and environmental technologies, and the shift of the army's ICT corps to the region will enhance its competitiveness.

Labour availability. There are also opportunities in the low-skilled workforce. High unemployment among the Bedouin population, as well as underemployment in the kibbutzim, means that labour is available. Bedouin men are concentrated in construction-related occupations, and it is possible for them to shift into energy efficiency and related skills with minimal training. Kibbutz residents have already begun to develop this proficiency through their work on new solar installations, as well as energy upgrades they are conducting on the kibbutzim.

Low-skilled labour development. The Negev region already houses the basic infrastructure for human capital development in clean-tech. Despite the decline in public employment services and the low enrolment in vocational training, the Israeli government has invested in developing one-stop centres in the Bedouin settlements, with a focus on job preparation and search. In addition, there is capacity to support

entrepreneurship. There are three SME development centres in the Negev that provide business counselling, and MOITAL has already established a centre for green businesses at Esek-Yarok that provides training and loans primarily for businesses making themselves greener. With training, business coaches in the Negev centres could also provide these services.

High quality higher education. There are also opportunities in higher education. Though there are capacity constraints (e.g. housing shortages at Sde Boker) for the growth of university enrolment, the high quality of faculty and curricula makes most programmes very popular. The Arava Institute for Environmental Studies provides a particularly interesting example of an opportunity to build on existing regional assets via international linkages. The student population at Arava is an equal mix of Israeli Jewish, Arab, and other international students, and many continue to Ben Gurion University to finish their degree. Arava faculty are already interested in designing graduate programmes in renewable energy in conjunction with the university. And the Institute maintains close connections with its 600 alumni around the world, which can help to attract a talented student body.

Planned investment. Another set of opportunities lies in the development plans for the region. As the planned infrastructure investment, army moves, and new towns become reality, construction and related procurement will create significant numbers of jobs, and even more importantly, the perception of the region will shift. Accelerating this shift will be the continuing housing price appreciation in the central district, which will force families to the periphery in search of affordable space.

Currently, a significant number of workers are commuting between metropolitan areas and/or research hubs – from Tel Aviv to Be'er Sheva, from Be'er Sheva to Sde Boker, and less commonly, from the central area to Eilat. The extension of Highway 6 and widening of Highway 40 will ease this commute, in the short run attracting more workers to work in the south, at least temporarily. Longer term, the region should begin to see the conventional pattern of suburban development. Workers will begin relocating to the area in larger numbers due to three factors; increasing congestion, greater familiarity with the region, and housing costs in the core.

The relocation of four military bases to the Negev, supported by a government investment of 26 billion NIS, along with the Bedouin settlement programme (6 billion NIS), suggests an opportunity for job creation in green construction and related fields. Although Israeli policies rarely include preferential procurement on a geographic basis (local purchasing or hire requirements), the scale of the proposed construction implies that many local businesses will benefit. As young local companies and workers gain valuable skills and work experience in green building for the new settlements, the region will gain capacity to conduct energy efficiency retrofitting (in accordance with Government Resolution 2508) in existing towns such as Eilat.

Threats

Both external and internal threats affect the development of a clean-tech cluster in Israel and the Negev region in particular. Global competition in clean-tech industries is intense, and many point to the inability to compete with China in solar energy. Even if the government's investment in R&D can pay off in leading-edge technological innovations, bringing them to market is challenging. As the product cycle reaches mass production, firms are unlikely to continue operations in Israel, since labour costs, even in the Negev, will remain high relative to developing countries.

Development challenges. Even within Israel, there are challenges to developing and retaining clean-tech industries. For instance, the development of renewable energy for both internal use and export is limited by inadequate capacity in transmission lines. In the southern Negev in particular, there are

environmental challenges that could slow the proposed development and thus hinder the ability of local residents to acquire new green job skills.

Political issues. The geopolitical situation concerning Israel, as well as the uncertainties associated with the Arab Spring, may hinder efforts to increase international labour mobility. Despite efforts to attract international students, they may look elsewhere because of political considerations. It may also prove increasingly difficult to attract specialised workers from clean-tech clusters elsewhere around the world. Moreover, the trade associations for Israel's clean-tech firms are young and have not yet organised themselves politically. In countries like the U.S.A., executives understand that facilitating transnational flows of high-skilled workers is critical for successful competition, and they lobby for more visas. There is no such lobby in Israel.

Recommendations

In many ways, the labour force in the Negev region is well positioned to become part of Israel's national clean-tech cluster. Sub-regions in the Negev host small teams of researchers with high levels of expertise in fields such as water technology, biofuels, and renewable energy, housed at institutions that attract high quality students. A pool of low-skilled workers, though not yet trained in particular skills, is conversant in related industries such as construction and manufacturing. Planned development for the Negev will help sustain and grow both the high- and low-skilled labour pools.

Yet, as continued out-migration from the region testifies, it is an ongoing challenge to retain and attract workers of all kinds to the region. To capitalise on the upcoming development opportunities, it will be necessary to attract and support a critical mass of high-skilled workers, as well as develop the institutional infrastructure to train low-skilled workers in energy efficiency and related skills. This leads to two different but complementary approaches: facilitating the flow of specialised knowledge to the Negev from leading clean-tech regions (including Tel Aviv), and anchoring expertise in the region through strengthening local institutions. To make it more attractive, the Negev needs to develop an image as a regional node in the clean-tech innovation system. Enhancing the capacity (and reputation) of local institutions is key to first attracting activity to the region and then creating concentrations of the sub-cluster. In other words, developing a labour market is an iterative process: (1) creating the perception that the Negev is a key node in clean-tech globally by hosting events and programmes in the region (even on a temporary basis); (2) in the process, developing new capacity in existing institutions; and (3) thereby attracting new workers to migrate permanently to the region. The rest of this section develops recommendations for the labour market and human capital development, focusing in turn on high-skilled workers, low-skilled workers, the development plans for the region, and environmental regulation in the country more generally.

Improve the flow of specialized knowledge to and from the region

Though a clean-tech cluster is emerging in Israel's various regions, its heart – and key human capital – is in Tel Aviv, and it is not simple or perhaps even feasible to shift this activity to the Negev sub-cluster. Yet, there are other ways to improve human capital in the region. As the *Israel 15 Vision* describes, there are assets already in the region that can support 'leapfrogging'. Attracting a critical mass of high-skilled workers to live in the region, particularly the southern part, is a long-term development challenge. But in the short-term, the government can work to enhance the reputation of the Negev and establish it as a core knowledge centre in the clean-tech cluster by helping to connect the institutions and firms in the Negev to inter-regional and global knowledge flows. These short-term actions may catalyse the longer-term change. To facilitate these knowledge flows, the following actions could be undertaken:

Strengthen and highlight existing research institutions and centres to attract high-skilled labour.

Many successful clusters develop not because of the reliance on a permanent skilled workforce but because of the ability to access skilled labour as needed. The idea of urbanisation or Jacobian economies is that a large volume of activity helps drive down costs, but in the 21st century, these economies can occur through transnational labour and knowledge flows as well as agglomeration in a specific place (Saxenian 2006).

Even the regions leading globally in clean-tech face challenges in attracting a skilled workforce, from graduates of technical institutes to PhDs (see, for instance, the National Renewable Energy Laboratory learning model in the chapter annex). The two locations of the Ben Gurion University of the Negev, complemented by the region's technology centres (in water, renewable energy, and solar energy), are well positioned to train more students and raise their profile globally.

Expanding educational programmes requires significantly greater public investment. But this support should come with strings attached. Funding for new infrastructure and R&D might be linked to outcomes in human capital development such as students attracted from different regions or graduates retained in the region.

There are several ways to attract researchers and engineers not just from other countries but also from other regions within Israel. One approach might be called the post-doc approach – providing one or two years of research funding to doctoral programme graduates in exchange for some limited research or teaching obligations. Another is cross-university collaborations, often facilitated by joint application to government R&D programmes. In a scarce funding environment, the R&D support already targeted to researchers and firms in the Negev could attract collaborators (and their students) from other high-quality universities around the world. Continued support for such collaboration could be contingent on the publication of co-authored articles or research grants obtained from other countries.

Already, the conferences held by the Centre for Renewable Energy and Energy Conservation draw a large international audience, and these events should be an opportunity to advertise the permanent resources in the Negev. Finally, the location of test and demonstration sites in the Negev should be seen as an opportunity to attract researchers to visit; perhaps researchers could be offered access to a test site in exchange for living in the region for a sabbatical period.

Facilitate cross-sectoral linkages with both entrepreneurs and the ICT sector.

As noted previously, despite offering high quality curricula in environmental technology and related fields (with plans for advanced degree programmes in renewable energy), regional academic institutions are too isolated from the market. Though there is strong and growing capacity for technology transfer in the region (for instance, BGN Technologies), market knowledge is not part of the training for scientists and engineers. Graduate programmes in science and engineering need to introduce entrepreneurship training into the curricula and facilitate joint degrees with business schools (such as the “green MBA” programmes that are emerging in other countries as described in Box 1; see also the Cleantech to Market learning model).

Box 1. Green MBA Programmes

Over 20 business schools (most in the U.S. but several in the U.K. and India) offer a Green Master of Business Administration degree, an MBA with a focus on corporate sustainability. In addition to the traditional one- or two-year curriculum in business management, the Green MBA programme educates students about how to manage a sustainable enterprise, including reducing waste, increasing energy efficiency, mitigating its environmental impact, and incorporating sustainable practices throughout business operations. Graduates gain expertise on how to meet goals of environmental and social sustainability while making a profit, and typically go on to work in large corporations in traditional sectors.

Another approach would be to establish and fund internship programmes specifically for business and ICT students at test sites, either at the industrial parks or technology centres. The local institutions would benefit from an infusion of different types of knowledge, while the interns would gain expertise and connections in an emerging industry. In a similar vein, the *Israel 15 Vision* suggests establishing ‘centres of entrepreneurship’ in regional academic institutions that connect potential investors to local businesses. *Innovation 2011* suggests a role for NewTech in attracting veteran business entrepreneurs to clean-tech. It will likely take action by multiple agencies and stakeholders to make these connections, but they are critical for future growth.

Ensure that disadvantaged local residents gain access to job opportunities in the clean-tech sector

At present, there are far fewer job opportunities for low-skilled workers in the Negev than for engineers and technicians graduating from Ben Gurion University – but that should change as new environmental regulations are gradually implemented and development schemes for the Negev get underway. Introducing the low-skilled workers to various forms of clean-tech work not only will meet coming needs in the short-term but also will develop a pipeline to advanced educational programmes (from two-year to graduate) training students in clean energy and related fields. Thus, over the long-term, training low-skilled workers is integral to the development of a workforce for the clean-tech sub-cluster in the Negev. Combined, smart government regulation and investment can help prepare thousands of local workers for jobs in clean and green sectors, while strengthening local anchor institutions (OECD, 2012). This will be a wiser long-term investment for low-skilled workers than providing incentives for a firm to come to the region, since the firm will provide training only in specific skills, and also may relocate due to rapidly changing global cost dynamics. In general, to prepare workers for green job opportunities, it will be most strategic to provide retraining for those in traditional occupations, rather than to prepare trainees only in green skills (e.g., training electricians, rather than unskilled workers, in solar installation). To ensure that disadvantaged local residents gain access to green job opportunities, the following actions could be undertaken:

Prepare the workforce for future opportunities in energy efficiency and green building

Due to the Government Resolution 2508, which targets reductions in greenhouse gas emissions, MOITAL is currently launching pilot training programmes in energy efficiency and green building. Given the lack of training programmes in the region at present, these pilots should be conducted in the Negev and build upon existing apprenticeship or NGO training programmes. Thus, the region may gradually expand these programmes; employment opportunities in energy efficiency and green building should not be seen as temporary. Market demand will increase due to the combination of government regulation and lifestyle preferences, and even when the local market for energy efficiency is fully tapped, local construction is likely to continue for decades due to the land constraints in other parts of Israel.

A regional training centre should be developed for clean-tech activities connecting businesses, academic, professional training organisations and job placement bodies. Through close contact with business, efforts should be made to map expected industry sector training requirements in terms of expected numbers and skills contents of future jobs in order to assist the planning of training facilities, training courses and student internship programmes. Government support will be required for the support of training in these activities.

Ensure that government investment leads to green job creation for local residents.

To the extent that the government does subsidise the relocation of firms to the Negev via tax incentives and other measures, firms should be required to locate in energy efficient facilities built or retrofitted by the local workforce. Another opportunity is the greening of traditional companies. The government might provide incentives for major employers in the Negev (Teva, Vishay, Macteshim-Agan), which are in chemicals and electronics, to green their operations, in exchange for creating green apprenticeship or job opportunities for local residents from training programmes.

Create intermediaries that help broker connections between the Bedouin community and local employers

There is a need for local employment offices connected to the Bedouin settlements that function as intermediaries linking Bedouin Arabs to local job opportunities (such as the “day labour centres” in immigrant-rich metros in the United States, essentially a one-stop hiring hall with access to social services for registered workers). If the local Bedouins were trained and certified to work in energy efficiency and related industries – and such certification were required in environmental regulation – the centres could become a valuable source of labour for firms with short-term green projects.

Create a comprehensive green strategy for urban development in the Negev

The planned development of the Negev – including government investment in relocating the army, building Bedouin settlements, and other new towns – provides an unparalleled opportunity to green the region. The government might also include existing towns, such as Eilat, in the strategy by facilitating energy efficiency retrofits. A green city strategy could have a catalytic effect, transforming perceptions of the region. By linking local procurement and hire programmes to the public sector expenditures, the strategy could provide new skills for existing residents and also support local green business start-ups. This strategy would embody the endogenous development approach advocated in the *Israel 15 Vision*, by building on the pre-existing culture of sustainability (exemplified by the kibbutzim), cultivating local leadership, and engaging local non-profits in the implementation, thereby enhancing their capacity. Thus, this strategy illustrates strengthening local institutions and their expertise, thereby making the region more attractive to high-skilled migrants. To create such a comprehensive green strategy, the following actions may be undertaken:

Transform Eilat into Israel’s model green city.

The idea of making Eilat into a green city is not new, but few government policies yet support this transformation.³ Greening the city would involve several different programmes, each with significant implications for the local labour market. Energy efficiency retrofitting of local hotels would be an important first step in branding Eilat. If the significant up-front costs were subsidised (for instance, by the government issuance of low-cost bonds, to be repaid via the energy savings), hoteliers would likely support the approach. A similar approach might be taken for industrial uses, particularly those relocating to the area, as well as institutional buildings, including municipal structures, utilities, schools and hospitals. The institutional sector is often considered the “low-hanging fruit” of retrofits because the public sector has control of the buildings, can readily procure the financing, and, unlike the commercial and residential

sectors, can ensure that the jobs are high quality through labour and compensation standards (Irwin et al., 2011). Another component of the green city is transportation: the government could require a shift to electric buses and rely on a fleet of electric vehicles for its own staff. Finally, a green business certification programme and registry could help promote local business.

Create other unique green living opportunities throughout the region.

Other opportunities for greening development occur in the planned new settlements, which should adopt green building standards and sustainable urban plans. The Negev Development Plan emphasises the importance of creating unique communities and real estate options that will help attract families tired of high housing prices and small living spaces in the centre. Given the rise of the so-called LOHAS (“lifestyles of health and sustainability”) market niche, one option would be to create net zero energy communities that consume no more energy than is produced by solar panels, and rely on recycled materials for construction. The kibbutzim also offer potential for a green development path. The social organisation of the kibbutz might permit the designation of a representative responsible for promoting energy efficiency and renewable energy throughout the community. Existing efforts by NewTech and the Arava Institute to promote environmental education could help develop appreciation and capacity for such living over the long term.

Create comprehensive regulation that links environmental and economic development goals

The countries that have succeeded at using clean-tech for regional development have coupled environmental regulation with procurement and labour standards, supported by a proactive government. One example is the Mecklenburg-Western Pomerania state in Germany, which rapidly lowered its unemployment rate via a new niche in wind energy; it now has 6,000 jobs in renewable energy in 704 companies.⁴ Propelling the transformation was the country’s goal of relying on 35% renewables by 2020. Another example is the recycling industry, which turns waste diversion into a labour-intensive industry. Unions and trade associations can ensure that the jobs created are high quality by requiring certifications. As regulation catalyses the engagement of such labour market institutions with the private sector, local institutions develop new capacities for development. Concrete actions to create a comprehensive environmental regulation linking environmental and economic development goals could include the following:

Create green building codes with tax benefits to offset costs and labour standards for quality jobs

Although green building standards are becoming more common in Israel, they are not yet powerful engines for high quality job creation. In order to offset the higher costs, some countries have enacted tax credits for developers who adopt the standards. Labour standards, such as certifications for workers, are also becoming increasingly common as awareness increases of the benefits of high quality work. For instance, studies have shown that half of air conditioning systems are installed incorrectly, significantly reducing energy savings (Zabin, Chapple, Avis and Halpern-Finnerty, 2011). To accomplish this, it will be necessary to first delineate the skills, certifications, and other standards governing workers and contractors, and then to require contractors who participate in government programmes (e.g. energy efficiency rebate and incentive programmes) to have third party certifications, licenses, building permits, or other relevant standards. MOITAL might develop a best-value contractor rating system that rewards high quality work, hiring of workers with appropriate certifications, and investments in worker training.

Use local hire and procurement to build local green workforce and business

Incorporating local hire and procurement requirements into local government contracts is becoming increasingly common in order to capture more of the economic benefits of green growth. The exact share

of local procurement varies widely across regions and industries but is typically linked to local capacity and expertise. Despite this rationale, local preferences are often criticised because of the difficulty of implementation; local capacity does not guarantee fit for particular tasks. One work-around is to give contractors a bid discount for making good faith efforts to hire or source locally.

Design effective green job training programmes linked to employers

The green workforce planning process begins by prioritising public investments that create more jobs (such as energy efficiency). Then, the need for training programmes should stem from an understanding of the types of occupations that will be created by investment. Rather than running pilot green training programmes, MOITAL should consider greening traditional occupational programmes instead (in vocational training, practical engineering and apprenticeship programmes). Adopting a sector strategy approach to workforce development will ensure its effectiveness, i.e. working closely with both traditional industries (e.g., electrical contracting) and emerging industries (such as energy storage and commercial lighting controls) to establish skill standards, co-fund training, and obtain job placements.

ANNEX – LEARNING MODELS

The following learning models demonstrate successful practices in attracting high-skilled labour and commercialising new technologies (the National Renewable Energy Laboratory case); planning green cities (the U.K. Eco Towns); and developing training programmes and labour standards linked to environmental regulation (the California case).

National Renewable Energy Laboratory, Colorado, United States

Description of the model

The National Renewable Energy Laboratory's (NREL) mission is to advance the goals of the nation and the US Department of Energy (DOE) in renewable energy and energy efficiency research and development. Further, one of the Lab's main focuses is to contribute to the creation of green jobs in renewable energy and accelerate the creation of market-viable products that will emerge from research and enter the commercial market. The Lab was opened in 1978 as the Solar Energy Research Institute (SERI) and eventually changed to its current name in 1991. The DOE estimates that the Lab's budget was USD 536 million in the fiscal year 2010, almost exclusively from federal funds.

NREL is managed for the DOE under contract by the Alliance for Sustainable Energy, LLC, which assumes full responsibility for the laboratory's mission and operational performance. The Lab collaborates actively with MIT, Stanford, the University of Colorado, Colorado State University, and the Colorado School of Mines in the Joint Institute for Strategic Energy Analysis, and one executive from each university now serves on the Board of Directors for NREL.

NREL has 13 main areas of research, all of which participate in industry partnerships and technology transfer: Analysis, Biomass, Buildings, Electricity, Federal Energy Management Program, Hydrogen and Fuel Cells, Geothermal, Integrated Deployment, International, Solar, Vehicles, and Wind Energy and Water Power. In addition, NREL also holds state-of-the-art facilities for both Solar (National Center for Photovoltaics, or NCPV) and Wind Energy and Water Power (National Wind Technology Center, or NWTC).

The Lab has several arms through which it forms partnerships and aids technology transfer in the industry locally, nationally, and internationally. Through technology partnerships, NREL offers paid technical assistance for companies who wish to commercialise and launch their technologies and products. The commercial assistance programme aims to help start-up companies overcome barriers to commercialising their technology, free of charge for a limited period of time. The Lab also collaborates with several countries (including Israel) in research and development, analysis and deployment.

Recently, NREL launched a unique tool called the Energy Innovation Portal, which gives the private-sector free access to energy efficiency and renewable intellectual property, which includes more than 15 000 DOE patented technologies. The website, which also provides market summaries on different technologies intended for businesses, is intended to foster public-private collaboration and accelerate innovation and commercialisation.

Many of the U.S. national labs play a major role in furthering science education in local schools, as part of their core mission. The Visitor Centre at NREL currently plays some of this role, by making presentations to local elementary schools to complement the energy curriculum taught in schools. However, none of the funding from the DOE is specifically earmarked for this sort of spending and in turn creates an obstacle for the Lab to accomplish this.

Researchers gravitate to the Lab because it allows scientists to bridge their academic training with the invention of real life solutions. The Lab is prestigious and thus has no shortage of workforce and is able to attract scientists from all over the country who wish to be a part of these cutting edge studies of energy efficiency. Open positions at NREL are known to solicit anywhere from 500 to 1 000 applications per position (Bosch, 2011).

Key to the success of the national labs is the temporary workforce. From 25-50% of the workers at the lab are graduate students, post-doctoral scholars, or visiting scientists (typically faculty on sabbatical). NREL's Research Participant Program creates a formal structure to attract guests from other educational institutions, industry, and research organizations, creating a centralised application process and providing information about relocation.

Relevance to Israel/Negev

NREL illustrates first how to attract and circulate high-skilled labour, and second how to link R&D effectively to entrepreneurship. Both are central to developing the labour market for the clean-tech sub-cluster in the Negev. It differs from the other national labs in its focus on renewable energy and the application of research findings to the commercial market, which makes it directly relevant to the Israel case. It also provides an appropriate analogy for a lab in the Negev because it is relatively new, and though it has a close relationship with a mid-level research university (the University of Colorado), it is not co-located with the university.

Given the pre-existing structure of Israel's R&D funding, the government is unlikely to endorse starting a new national lab. However, it may be possible to emulate some of the strengths of the model – in particular, the link to the commercial market, the efficient management structure, and the collaboration with other universities – without actually replicating it. This then should help to attract top scientists and post-doctoral scholars to the facility, in turn raising the profile of the clean-tech sub-cluster in the Negev.

Results of the approach

NREL currently employs 2 300 people and held contracts with 329 Colorado companies in 2010. Since 2002, funding for NREL has more than doubled from USD 215 million to USD 536 million. Forty-five technologies developed at NREL have gone on to receive R&D 100 awards, which are awarded annually by R&D Magazine to the 100 most significant contributions to research in development around the world. These technology transfer successes and awards are proof of NREL's success in translating academic research findings into commercial value.

Reasons for success

Key to NREL's success is its ability to attract top scientists. Also, the competitive process in picking a management firm plays a large role in the success of the Lab, since it creates an incentive for the lab to perform well and meet expectations. Finally, NREL's liberal use of public-private partnership tools has contributed to its ability to quickly commercialise technologies coming out of research and development. A University of Colorado study commissioned by the DOE advocated for even more active use of public-private networks and models in order to maximise returns to federal investment and optimise economic development as a result.⁵

Obstacles faced and response taken

On a macro level, the Lab's major obstacle is balancing the federal research portfolio while maximising the commercialisation of new and emerging technologies. The federal research agenda is a long-range task that will develop over time, while commercialisation of new technologies can have major impacts in the short term. This task cannot be accomplished through private funding alone since development of a technology and, eventually, a product is a high-risk investment.⁶

Government funding can also act as a hindrance to progress. Funding cuts put the Lab in a precarious situation, where lack of funds can hinder the progress of current research projects or stop them from continuing completely. The Lab responds to funding uncertainty by maintaining a positive public presence, i.e. offering laboratory tours to the public, working with the media by giving interviews, and publicizing its renewable energy programmes. In the past year, NREL scientists were quoted in 1500 news stories.⁷

While the Lab does not have obstacles in recruiting employees, it does sometimes struggle to retain them. Because energy is currently a widely popular field, there are many private companies competing with the same applicant pool and offering drastically higher compensation. There are many recent graduates seeking to contribute to a greater public purpose, but many are searching for jobs that will allow them to pay off student loan debt. The Lab invests a great deal of time and energy in training each employee, but retaining these scientists afterwards can be a struggle, when competing with the bonuses offered by private sector firms.

Considerations for adoption in Israel/Negev

Much of the infrastructure for a lab is already in place: for instance, the three technology centres (two in Sde Boker, plus one in Arava) and BGN Technologies (the technology transfer office at Ben Gurion University of the Negev) would constitute key components of the lab. These would then be united under an umbrella entity, without actually co-locating the facilities; the lab would be managed by a private contractor selected through a competitive process. This consolidation would serve several purposes: it would heighten the visibility of the individual facilities, facilitate better communication among them, and allow for more efficient operation.

The new lab would then focus on two goals: developing new collaborations with top universities and facilitating partnerships with entrepreneurs. Formal collaborations might grow out of existing relationships, or, the Negev lab might seek to work directly with NREL. Technology partnerships might take the form most common at NREL – researchers providing paid technical assistance to firms. But also the lab could function as an entrepreneurship centre, a place for investors to visit and learn about commercialisation opportunities.

By itself, this activity should help attract more talent to the region, but the lab could help by developing formal programmes for post-doctoral scholars. Of course, individual centres already host visitors, but consolidating the post-doctoral programme at the lab would help it gain more visibility, and there would be efficiency gains by centralised administration.

Further information

For more information <http://www.nrel.gov/> is a comprehensive source for a complete list of programmes and partnership affiliates, as well as current research projects and accomplishments.

Eco Towns, United Kingdom

Description of the model

Eco Towns, as defined by a 2009 UK government policy, are ‘exemplar green developments of up to 20 000 homes. They will be designed to meet the highest standards of sustainability, including low and zero carbon technologies and good public transport.’⁸ Two UK-wide mandates motivate the Eco Towns, a goal of building 240 000 new houses per year by 2016, and a CO₂ emissions reduction target of 80% below 1990 levels by 2050. Eco Towns are intended to showcase sustainable living and minimal environmental impact, accomplished via partnerships of government, business and communities. By demonstrating new, cost-effective models of eco-sensitive infrastructure provision, the towns are to spur market and developer interest.

First proposed by Prime Minister Brown in 2007, Eco Towns were originally planned to have 5 000 to 20 000 new homes in each settlement, and 30-50% of the new homes were required to be affordable.⁹ Many of the Eco Town settlements are intended to make use of brownfield development, ‘particularly surplus public sector land such as former Ministry of Defence or [National Health Service] sites.’¹⁰ Finally, the ‘eco’ aspect of the settlements would be fulfilled by many different standards: e.g. mandatory community heat sources, green building and energy efficiency standards, smart energy monitoring and transport information, waste diversion from landfills, and a density that places all homes within a 10 minute walk of all town activity centres.¹¹ Altogether, the Eco Towns would produce zero carbon, meaning that the yearly CO₂ emissions from all energy use in the town’s buildings are zero or below. It is interesting to note however that the standards did not include any requirements for economic development beyond planning for short commute trips. (The sole reference to jobs is as follows ‘The strategy should also set out facilities to support job creation in the town and as a minimum there should be access to one employment opportunity per new dwelling that is easily reached by walking, cycling and/or public transport.’)¹²

Relevance to Israel/Negev

The UK Eco Town case is of interest for the Negev because it illustrates how to incorporate green standards into the extensive new development planned for the region. It illustrates not only the sustainability standards that a green city might try to achieve, but also the obstacles that might arise in the planning process. Although there are other examples of green cities, both greenfield and retrofit, the Eco Town model mirrors the Israeli context better because of its location in suburbs and exurbs, its institutional context, and its small size. It illustrates how Israel might approach the creation of green living opportunities, either within Eilat or as unique real estate developments elsewhere in the Negev. It also shows the importance of planning for the job creation potential of these new settlements.

Results of the approach

After developing the specifications for building types and energy efficiency, the UK Department of Communities and Local Government considered 12 development proposals. By July 2009, four towns were selected as hosts to eco town prototypes and received a total of GBP 36 million. They are: North West Bicester, Whitehill-Bordon, St Austell in Cornwall, and Rackheath in Norfolk. Although the UK government highlighted these sites for development and set standards for them to be certified as exemplar Eco Towns, the impetus remained on the private sector to ultimately come forward with a plan and design. Ultimately, all English town plans must be approved by the respective local council.¹³

Early in August 2011, the Creswell Regional Council consented the constructions of 393 housing units and a 21 hectare renewable energy centre in the footprint of the North West Bicester Eco Town.¹⁴

The developer, P3eco, is actually a coalition of private enterprises (including Farrells and ARUP) that produced the plan ultimately approved by the local council. Situated just over 50 miles west-northwest of central London as the crow flies, Bicester is well within a reasonable commuter range. That distance, coupled with the existence of two train stations, may be motivators in expanding the number of residences. Additionally, P3eco observes how Bicester sits along the corridor connecting London to Birmingham and while lying just 10 miles north of Oxford. The positioning of Bicester as a crossroads of commerce and knowledge corridors offers an enticing marketing opportunity behind the Eco Town.

Situated on an old army training camp that plans to vacate by 2015, the plan for Whitehill-Bordon was recently incorporated into the revised master plan of the East Hampshire District Council. The plan, which had not changed in 20 years, seeks to offset the loss of 1,500 Ministry of Defence jobs with the creation of 5,500 jobs. This employment will complement the plan for 4,000 new homes, up to 3 primary schools, and 70,000 square meters of business park space. Barracks would be retained and retrofitted. The East Hampshire District Council's outreach to a community naturally concerned about the loss of jobs has come in the form of frequent regular open meetings regarding the master plan's implementation.¹⁵

The St. Austell-Cornwall plan has not seen approval by Cornwall County Council, but the developer, Eco-Bos is standing behind a pilot phase of '92 affordable and open market houses'. The new employment would be part of a small commercial retail and dining centre. Cornwall County Council, still committed to green development, is currently focused on funding employment skills trainings in sustainable building and retrofitting technologies. The idea is to improve the capacity of local workers and businesses to compete in the sustainable construction industry that will construct the towns and retrofit existing community spaces.

Reasons for success

Three out of the four final Eco Towns have seen progress in the development stage. The key reasons for their success to date appear to include: a commitment to sustainable design from developers, a plan scaled down from the original national Eco Town standards, and the frequent outreach to the community about plans.

Because construction has yet to begin on any of the Eco Towns in the UK, it remains too early to gauge the full extent of the initiative's success. The fact that approvals have been granted by planning governing bodies speaks to the potential for the UK Eco Town initiative to move forward to some degree, albeit a smaller one than originally planned. Particular to Bicester, the Eco Town plan benefitted from a coalition of developers, a location facing a need of new commuting residents, and a substantially smaller scope. The smaller extent of houses, paired with consistent communication with the town, has benefitted Whitehill-Bordon. Finally, the developer for St. Austell, Cornwall, has also taken the scaled down approach, favouring a pilot project.

Obstacles faced and response taken

The development of the Eco Town initiative has been complicated due to changes in the political makeup of the British government since it was initiated. Changes to the National Planning Policy Framework are pending approval by Parliament, but the most recent iteration of the standards state that 'the shape and distribution of housing growth, including the potential for eco-towns and similar projects, should be led and determined at local level'.¹⁶ While remaining committed to sustainable communities and housing growth, the policy asks the local councils outlined in the original document to decide how to proceed on the specific Eco Town plans. This decentralisation of the policy could reduce its momentum, although it empowers pioneering councils to move ahead.

Considerations for adoption in Israel/Negev

The U.K. Eco Town planning process has involved the development of standards at the national level, solicitation of developer proposals, and increasingly, local implementation. The process may actually be simpler in the Israeli context, given that the land is already under the control of the public sector. The national government could put forth a town planning policy framework, and most of the Eco Town principles could readily be adapted to the Israeli context (except perhaps the transit-oriented development guidelines). To avoid the implementation issues experienced in the U.K. case, it would be advisable to involve the local community in planning from the onset. The planning for Eco Towns in the Negev should overcome one shortcoming of the U.K. case – the lack of preparation for economic development. The town planning policy framework should incorporate goals for local job creation via green construction, and contractors should be required to source a share of labour from local training programmes, as well as prioritise local businesses for purchasing. For maximum visibility and impact, the approach could be piloted in a major integrated programme focused on environmental retrofitting in an Eilat green city.

Further information

For more information, contact *Eco-Towns Team* at Zone 2/G9, Eland House, London, SW1E 5DU, ecotowns@communities.gsi.gov.uk.

Environmental Regulation and Labour Markets, California, United States*Description of the model*

The state of California has long pioneered environmental regulation that then is adopted by other states, forcing the federal government to act; perhaps most well known are the vehicle emissions standards, which have forced the auto industry to innovate more efficient cars and the federal government to adopt its own more stringent standards. A similar dynamic is occurring in energy policy. Beginning in the 1970s, the state began incorporating standards for energy efficiency in its building code, and now is adding green building standards as well. The state also has adopted a renewable portfolio standard of 33% by 2020 (the current share is 12%). The California state government has established a complex array of programmes, many supported by the national government funding as well, to support its energy goals. For energy efficiency and distributed generation (photovoltaics, wind turbines, and fuel cells), these policies include customer information, customer incentives, upstream incentives for manufacturers and suppliers, and building codes and standards for appliances and equipment. In addition, a number of policies address the smart grid or demand response, including dynamic rates and smart meters.

Less well known are the labour market effects of this environmental regulation, but it has resulted in significant job creation, and effective training systems have emerged to prepare workers. Public and private investment in these programmes totalled USD 6.6 billion in 2010 and is projected to nearly double by 2020. Public investments (from the utilities and state and federal government) account for over 60% of the total investments in 2010, while private investments (primarily participant costs), account for almost 40%. This leveraged private investment is key to financing the programme, and occurs primarily through participant contributions in solar and energy efficiency programmes, as well as higher real estate prices due to strict building codes.

California's workforce development system is extensive but fragmented. A resource inventory of existing training and education programmes identified 1,500 distinct programmes for training in energy efficiency and related industries, housed at the state's 4-year colleges and universities, apprenticeship programmes, community colleges, community-based training organisations, private-industry training organisations, regional occupational programmes, and utility energy centres (which offer educational

seminars). Excluding the utility centre programmes, about half of trainees graduate from private training organisations, almost one-fourth from apprenticeships, and one-tenth from community-based organisations (non-governmental organisations).

Apprenticeship training is a “learn-while-you-earn” model,” a long-term contractual agreement between employers and workers. Over the course of several years, apprentices work full-time (for wages and benefits) supervised by a skilled tradesperson, with additional classroom instruction. This demand-driven and self-financing form of training produces very highly skilled workers with a broad occupational foundation and enables workers to earn a number of educational and industry-recognised certifications throughout the course of their training (a “journey card”). Wages usually start at 40% of a journey worker’s wages, increasing every six months. Training is in traditional occupations, but incorporates energy efficiency skills.

NGO training programmes typically offer specific training in emerging occupations, such as solar photovoltaic installation, energy auditing, or weatherisation. They tend to serve disadvantaged groups with barriers to work such as limited education, and thus they train in soft skills and basic literacy as well as energy efficiency. Most of these programmes are not stand-alone, but rather prepare trainees either for further education (typically at a community college) or a pre-apprenticeship programme.

Relevance to Israel/Negev

At present, the Israeli government has not taken advantage of the potential to use environmental regulation to develop human capital and labour for clean-tech. The implementation of environmental regulation in California (the most advanced regulatory structure in the U.S.) has been accompanied by significant job creation and the development of a complex training system with several significant successes, including an apprenticeship system connected to industry certifications and high levels of workmanship, and a community-based system that is effective for more disadvantaged workers. This illustrates how environmental regulation creates jobs and also demonstrates apprenticeship and community-based training programmes that Israel could readily adopt to prepare its workforce for future job opportunities in the clean sector, ensure high job quality, and broker connections between the Bedouin community and local employers.

Results of the approach

As a result of public and private investments, California created approximately almost 28 000 direct job person-years in 2010 – and almost three times as many indirect and induced jobs, due to the savings in energy costs which then get spent elsewhere in the economy. The industries most affected by policy-induced spending are in the construction sector, professional services related to construction, administration, and manufacturing.

The community college and private training organisations that train in energy efficiency and related skills do not report placement rates, and little is known about their effectiveness. Placement rates for NGOs training in emerging energy efficiency occupations are very low (19%), suggesting that jobs in clean sectors may require higher skill levels than these programmes offer. Yet, the NGOs report high placement rates (74%) for training in construction generally, and act successfully as a transition programme between unemployment and college degree programmes. The most successful training programme in California is apprenticeship, where completion (and placement) rates are 88%. Because of the near guarantee of a job placement, decent compensation, and formal career pathway, demand for apprenticeships is high and programmes are very selective.

Apprenticeship programmes have been incorporating energy efficiency into their curricula since the first energy efficiency standards were adopted, and they update regularly as the industry changes. Most programmes integrate energy efficiency skills into programme offerings, rather than offering separate training. For example, since early in the decade, all electrical apprenticeship programs have provided solar photovoltaic (PV) training to fifth year apprentices.

One example of an apprenticeship programme that integrates the highest levels of energy efficiency with job quality is commercial lighting controls, specifically, the *California Advanced Lighting Controls Training Program (CALCTP)*. This programme results from an industry partnership between the utilities and the labour-management partnership between electrical contractors and workers. In the lighting sector, the utilities pro-actively set standards that support quality work and financed the development of curricula that were adopted by electrical apprenticeship programmes, community college programmes and utility training centres. The programme offers a certificate available only to licensed electricians.

Reasons for success

The apprenticeship programme became the most successful model for job training in clean sectors in California because it is demand driven: employers work closely with their apprentices and must teach them new energy efficiency standards as regulations emerge. At the same time, the apprentices learn a traditional construction trade, which gives them more employment security. Though the NGO programmes are not successful as stand-alone training, they work effectively as pipelines for disadvantaged groups into the advanced training and apprenticeships.

The success of the apprenticeship programmes, such as CALCTP, is the productive partnership between the utilities, the employers, and the workers. With all the stakeholders at the table, it becomes possible to reach agreement about skill standards – reinforced by incentive programmes for contractors whose workforce achieves the standards. Because of this, contractors compete on the basis of quality rather than cost.

Obstacles faced and response taken

In terms of job creation, the state of California is just beginning to understand that different energy efficiency and renewable energy strategies have different job creation effects. Specifically, energy efficient retrofit programmes tend to be more labour intensive than are renewable programmes, and also the indirect job impacts of renewables may be relatively low if components are imported. As California and other states and countries learn about the job creation impacts of energy policy, many will start becoming more strategic about public investment.

Apprenticeship programmes are not able to accommodate trainee demand and enrolment has slowed significantly since the economic slowdown. Also, they only exist in union construction trades – in California, the commercial sector but not the residential sector. Moreover, the factors that made CALCTP so successful are not present in all apprenticeship programmes. CALCTP succeeds because of their rigorous skill standards and certifications, which raise the technical skills of workers and raise the bar for contractors, enabling them to compete on quality rather than cost cutting. However, not all construction trades have succeeded in enacting certification requirements that are state approved and mandated for contractors; for instance, both HVAC and residential retrofit have struggled to develop ways to ensure that workers are certified. Finally, the industry partner must be cooperative. In the case of CALCTP, the state utility understood that the installation of commercial lighting controls must be of high quality in order to save energy, but not all industries have the goal of work quality.

Considerations for adoption in Israel/Negev

MOITAL should begin by developing a better understanding of the job creation impacts of its investments. This then will aid in workforce planning. There are challenges in developing apprenticeship and NGO training programmes in Israel, but it is important to model training on the most successful programmes. Rather than developing new green job training programmes in specialised occupations (like solar photovoltaic installation), training should build on existing apprenticeship programmes in the construction trades. Likewise, to the extent possible, existing NGOs should run training programmes in energy efficiency and related skills, in order to build on existing assets and relationships.

Further information

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Cleantech to Market, UC Berkeley Haas School of Business, United States*Description of the model*

Cleantech to Market (C2M) is a collaboration between the Energy Institute at the Haas School of Business, Lawrence Berkeley National Laboratory (LBNL), the UC Energy Institute, and the Berkeley Energy and Resources Collaborative (BERC). C2M is one of the courses offered to MBA students in the Energy and clean-technology concentration of the programme, and acts as a stimulus for clean energy innovation on campus¹⁷. The programme directly addresses the “valley of death” that occurs in the gap between innovation and commercialisation and, in particular, the lack of resources the LBNL Technology Transfer and Intellectual Property Management Department has available to focus on bringing clean energy technologies closer to market and into the hands of the correct venture capitalists.¹⁸

Graduate students from Haas team up with scientists, law students, and venture capitalists to perform detailed market research for inventions coming out of LBNL and UC Berkeley. Students identify distinguishing features of the technology that are competitive with existing technologies; target customers and industry partners; perform cost sensitivity analysis; and identify barriers in commercialisation and government policies. They then work together to imagine what products the technology could potentially be used for, create a marketing plan for the product, make presentations to industry leaders and recommend the next steps for commercialisation.¹⁹

The programme recruits private sector research sponsors and partners, such as AT&T, Pacific Gas & Electric Co., Siemens Technology-to-Business Center, Rockport Capital and Mohr Davidow Ventures, who fund stipends for the students who participate.²⁰

Relevance to Israel/Negev

This programme provides a textbook example of how to develop a high-skilled workforce for a clean-tech cluster. It shows not only how to integrate entrepreneurship and science and engineering education, but also how to build connections to the market. By involving companies and venture capitalists, the programme ensures engagement of the private sector in research and education while also exposing young scientists to market knowledge.

Results of the approach

The goal of attracting top-tier talent to the energy industry has been met successfully. Many students who participated in the programme attribute C2M with launching their career in the clean energy industry. Because the students gain in-depth knowledge of the market for their assigned technology, students have the fundamental skill set that they need to enter the field. One student won USD 30 000 in the regional finals of the Cleantech Open Business Plan Competition, which is the world's largest business competition for clean-tech entrepreneurs. A C2M project team, Imprint Energy, was named a winner of the Berkeley Center for Entrepreneurship and Technology Venture Lab Competition, and in turn received one year of incubator space from the Center and access to mentors and potential investors.²¹

While some of the projects that have been put through the C2M programme are still in early or very early stages of development, there are also projects in the later stages of development that are practically ready to be marketed. Students essentially provide a streamlined incubator for the technology, pushing the progress for science that would otherwise sit on a shelf for an extended period of time before moving along the commercialisation pathway. One group was assigned a nanosolar invention by Cyrus Wadia, the co-director of C2M. By the end of the term, the students had conducted an in-depth market analysis for the technology and determined that the ideal market would be off-grid communities in rural areas of developing countries, such as India.²²

Reasons for success

C2M differs from many other clean energy-focused academic programmes in that it directly addresses the "valley of death" that has become synonymous with technology transfer from academic research. The programme collaborates with LBNL to combat a weak technology transfer department and a lack of funding for the cause. According to Cheryl Fragiadakis, head of the Technology Transfer and Intellectual Property Management Department at LBNL, the Lab markets 40 to 50 technologies a year and does not have the resources to do a market analysis for each one. By having talented students perform this research, they are able to give each technology a better chance at success in the market and help to find the right venture capitalist to take on the project.²³

In this way, the programme leverages an obstacle to become a strength for the University with little to no cost to either of the parties involved. In fact, the collaboration between all of the research institutes and groups mentioned becomes an asset because all of the affiliated partners of the University and the Lab maintain a sense of community by working together.

The method for formation of the teams also contributes greatly to its success. The teams are chosen in a competitive process among numerous graduate students from multiple disciplines. Those that are chosen are carefully selected to leverage their existing knowledge from previous positions they have held. Because each member of the team views the technology through a different lens based on their background, the group is able to push the project further than a team of only scientific researchers could.²⁴ Then, students have access to leaders in the industry and venture capitalists to ensure their success and obtain mentorship as needed. In the end, students gain an understanding of how commercialisation happens from start to finish, beginning with government-funded research and ending in implementation of the technology. This process is the closest possible scenario to how commercialisation happens in the real world, as opposed to most university courses and research opportunities.²⁵

Obstacles faced and response taken

Key obstacles include the difficulty of obtaining the engagement of companies, the capacity constraints that force it to turn away many prospective students, and the challenging of aligning the

interests of students and faculty researchers. Since the programme is still young, it is still experimenting with ways to overcome these barriers.

Considerations for adoption in Israel/Negev

Many of the Silicon Valley venture capital and other firms engaged in the Cleantech to Market programme at UC-Berkeley also have investments in Israel. It may be possible to leverage these relationships to replicate the programme at Ben Gurion University of the Negev.

Further information

For more information, visit the website at: <http://ei.haas.berkeley.edu/c2m/index.html>. The main contact person for this programme is Beverly Alexander, Lead Director of Cleantech to Market (beverly_alexander@haas.berkeley.edu).

The Collegiate Energy Association produced a comparative report of academic programmes that support energy research and education. The report provides a broad overview of these programmes, and may serve as an additional resource: <http://collegeenergy.org/?p=2535>.

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ENDNOTES

¹ Recent reports such as this have documented a shortage of U.S. workers educated in clean energy not just at the graduate level, but also from four-year and two-year college programmes.

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³ See: <http://eilat-today.com/index.php/environment-mainmenu-75/710-when-quality-and-environment-meet>.

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CHAPTER 6.

CONCLUSIONS

The strategic importance of clean-tech development in the Negev

In May 2011, the OECD launched its Green Growth Strategy. It is a strategy for governments that contains recommendations on policy instruments and tools for achieving economic growth in line with the sustainable use of natural resources and a measurement framework for progress towards these goals. As set out in one of the strategy's central reports, *Towards Green Growth*, OECD governments share the objective of introducing green growth policies that will achieve efficiencies in the use of natural resources and reduce environmental problems whilst expanding economic growth and job creation in new directions. These policies are critical to addressing what may otherwise become irreversible problems of increased water scarcity, resource bottlenecks, air and water pollution, climate change and biodiversity loss. Innovation will be at their heart.

Clean-tech is a central part of green growth and green innovation. It involves the creation of new products and processes that increase the efficiency of the use of natural resources and reduce the environmental footprint of human activities across a range of areas including energy generation and efficiency, waste reduction, water management, logistics, construction, and smart agriculture. It is high on the political agendas of OECD governments and has risen up the political agenda in Israel during the last decade.

The increasing priority placed on clean-tech in Israel over the last 5 to 10 years follows recognition of a responsibility to play a part in addressing global environmental problems and of the potential for Israel to develop and demonstrate innovations that can meet the challenges faced, and at the same drive income and employment growth, particularly where its own challenges are common with other countries, for example in developing solar energies and managing water use based on an abundance of solar energy, arid environments, lack of oil resources and celebrated environment for R&D, innovation and high technology entrepreneurship. There is now significant Israeli government activity behind the promotion of clean-tech through new clean-tech regulations such as those contained in Government Resolution 25-8 on greenhouse gas emissions, new clean-tech innovation programmes such as Israel's pioneering New Tech programme.

A significant part of the new clean-tech activities arising from market and government pressures will be located in the Negev region, reflecting its solar and land resources, its new settlement plans as part of regional development efforts, which are expected to bring 300,000 new residents to the region in the next decade, its technology centres including the two New Tech programme centres for renewable energy and water technologies, its educational infrastructure for training in clean tech activities and a substantial proportion of Israeli clean-tech research and business activity. Hence achievement of national clean-tech objectives is strongly tied up with the future development of clean-tech in the Negev, based on exploitation and strengthening of the available clean-tech assets in the region.

Clean-tech development in the Negev is also of strategic importance to regional development. Along with the Galilee, the Negev region, in Israel's periphery, is one of Israel's two priority regions for economic development. Israel has an important regional development objective of contributing to a more even distribution of population and economic opportunity across the country by developing its peripheral regions, and it has long been a core national government objective to increase the economic growth of the

Negev. This must rest on the exploitation of the regions' existing strengths and the competitive advantages that can be built around them.

Clean-tech activity is one of the most important opportunities for the economic development of the Negev region, because of the region's existing assets and potential for growth in this area tied to the high global growth trajectory expected for this industry in the next two decades. In meeting this potential, a clean tech strategy for the Negev will be able to draw on some key regional development instruments: the National Strategic Plan to Develop the Negev will make substantial investments in infrastructure and settlement development in the region, the relocations of bases and technology units of the Israel Defence Forces to the Negev represent further opportunities, and there are investment grants available to companies in the Negev that are not available in Israel's core. Clean-tech development in the Negev region will also be able to make use of the key national innovation programmes developed by MOITAL and other ministries. Both the regional policies and the national innovation policies need, however, to take account of the opportunities for clean-tech development and how clean-tech development in the Negev can help them meet their own policy objectives through the introduction of relevant initiatives.

This report on growing clean-tech activities in the Negev therefore examines twin opportunities: promoting green growth by strengthening the Israeli clean-tech industry and promoting regional development by exploiting and growing the Negev's existing assets.

The need for a cluster framework

A sub-cluster with assets and gaps

The Negev has good existing assets for clean-tech innovation. One of its greatest areas of strength is in research, development and testing. The region has a host of clean-tech related research departments in Ben Gurion University of Negev and several clean-tech research and technology centres, including the Zuckerberg Institute for Water Research, the National Solar Energy Centre, the Arava Institute for Environment Studies, the Eilat-Eilat Renewable Energy Initiative and the solar technology demonstration and testing centre at the Rotem Industrial Park. These organisations are equally offering educational programmes in clean tech that are helping to build a specialised clean-tech workforce. The Negev also has important strengths in the business sector, including some 50 clean-tech companies, in some cases start-ups supported by one of the region's four technological incubators, and a group of long-standing chemical and extraction industry companies with growing needs for clean-tech solutions. The region's land availability and weather conditions also lend themselves to clean-tech test and demonstration facilities. The region also possesses an important pool of available low-skilled workers in construction and manufacturing, which could easily shift into energy efficiency and related clean-tech activities as the sector grows.

At the same time, clean-tech activity in the Negev is best seen as a sub-cluster, fitting into Israel's wider clean-tech cluster as whole, rather than as a fully-fledged, self-contained cluster. There are two reasons for this. Firstly, the major clean-tech strengths of the Negev lie only in a subset of clean-tech activities: water efficiency, including wastewater treatment, desalination and drip irrigation, and renewable energies technologies, including solar, biofuel and geothermal energy production. Secondly, within this subset of activities, the Negev contains only a subset of the actors normally found in fully-fledged clean-tech clusters. Whilst it possesses research organisations, some lead customers, and innovative start-ups, there are gaps in the region's business development services and growth finance, high-skilled labour and supplier base.

Missing elements can be filled through better linkages to the rest of the Israeli clean-tech cluster, underlining the nature of the Negev clean-tech activity as a sub-cluster rather than a self-contained and fully-fledged cluster. In the long term, gaps can also be filled through the stimulation of local

entrepreneurship, the attraction of inward investment, the strengthening of research centres of excellence, the involvement of public actors in procurement and training and skills development projects. Actions to fill these gaps should be focused on the Negev's key niche, namely research, development, demonstration and testing in renewable energies technologies and water technologies.

Building connections across agents

Another important gap identified in the report relates to weaknesses in the connections across clean-tech agents that generally promote innovation and competitiveness in clusters and a fragmentation of policies and programmes supporting the region's clean-tech. Although there are several good examples of cluster connections involving Negev's clean-tech players, the sub-cluster nevertheless suffers from a relative lack of internal and external supplier-customer connections among firms, lack of innovation connections among firms and between research and industry, insufficient commercialisation of public research, few joint investments, little cross-disciplinary research, limited local and international brain circulation, and a lack of common foresight and common initiative.

There is also lack of a clear policy to promote clean-tech activity locally. In place of a clean-tech strategy there is rather a set of separate programme initiatives all being applied in some way to clean-tech, including for example the New Tech Israel technology centres, investments in infrastructures and settlements in the National Plan to Develop the Negev and the Israel Defence Force relocations, the innovation investments of the National Plan for Developing Alternatives to Oil and the Israeli Greenhouse Gas Mitigation National Plan, the Tnufa programme for innovation and entrepreneurship, the national and international research collaboration support of the MAGNET and Matimop programmes and the research funding of the Ministry of Science and Technology and Israeli Council for Higher Education.

A cluster framework triggered by public policy offers a solution to this fragmentation that can deliver the following benefits:

- Creation of a common strategy and linked policy measures and programmes for the sub-cluster with engagement from all the stakeholders.
- Facilitation of formal and informal innovation linkages across cluster actors from government, industry and research, regionally, nationally and internationally.
- Increased visibility of the clean-tech innovation strengths of the Negev, leading to increased investment and partnership opportunities.
- The ability to test new innovation policy instruments for incentivising inter-disciplinary and cross-sector industry and academic-industry collaborations.
- The ability to attract and develop the human capital needed for the full range of activities in that sector.

The development of a framework for the sub-cluster and its links with the broader Israeli clean-tech cluster will be facilitated by the creation of a written development plan that will enhance understanding of the sub-cluster, set out priorities to strengthen it and identify the key actors that will be involved from business, research and government and the synergies that can be built across them. This plan would of course look further than the Negev in identifying necessary links to the rest of Israel and abroad. It will stress in particular the role the Negev can play in the research, demonstration and testing of clean-tech innovations in renewable energies and water and its high-skilled and entrepreneurial labour force. It will

also stress the development of green settlement strategies in the future development of the region, with links to training and employment opportunities for the low-skilled workforce.

In Israel, regional development is promoted largely in a top-down manner, through national government spending and programmes applied locally. Therefore the development of clean-tech in the Negev will draw on a range of national programmes. The benefit of a cluster framework will be to coordinate these programmes and ensure that they are applied in a strategic way to the economic development challenge. It also maximises the chances of forms of self-organisation emerging across sub-cluster actors, as has been so important in the development of many world clean-tech clusters.

The development of policy to achieve these benefits should focus on designing and implementing actions in each of the six core areas presented below.

The six core elements of the cluster strategy

1. Centres of excellence and an inter-disciplinary clean-tech programme

The region already possesses important research and technology centres within and outside of its University. The successful development of the region's clean-tech depends on exploiting these centres as regional, national and international knowledge hubs, sources of innovation and research commercialisation and sources of training and skilled labour. This in turn depends on two actions: developing and growing the key research centres through targeted investments in their research capacities; and linking them in an inter-disciplinary clean-tech programme.

Investment in centres of research and teaching excellence should be strategically placed in those competencies that are crucial for the development of the sub-cluster. Activities should also be promoted that create links to other centres of excellence at national and global levels in terms of involvement in research projects, hosting of international researchers and putting on events such as conferences and summer schools.

The visibility and interactions of these research and teaching activities will be supported by establishing an inter-disciplinary clean-tech research and educational programme, centred on Ben Gurion University, able to deliver joint inter-disciplinary projects in clean-tech, collaborate with other universities, attract national and international researchers in a temporary manner as part of a brain circulation process and better brand clean-tech in the Negev. As well as University departments other research and technology centres in the region could be associated to the programme. An inter-disciplinary centre would certainly enhance the reputation of the Negev as a knowledge centre in clean-tech and help to connect its agents regionally, nationally and internationally.

In any case, the knowledge, innovation and training should not be limited to the centres of excellence alone. They should be strongly engaged in innovation, commercialisation, entrepreneurship and human capital development across the whole range of cluster activities and actively promote research-industry linkages.

2. A clean-tech validation centre

The specific niche of Negev clean-tech activities is in research, development, demonstration and testing location in renewable energies and water management technologies. In order to reinforce this specialisation, it is essential that a clean-tech validation centre is established. The centre would provide testing and confirmation of technology soundness, both for local firms and researchers and for national and international parties. It could also provide technology consultancy and spin-out support.

3. Collaborative innovation projects

The discussion of clean-tech innovation in this report has stressed the fundamental role played by sector crossovers and related variety innovation. This recognises that clean-tech innovation is characterised by the combination of knowledge across different industries and activities, leading to branching processes that create new product opportunities and move cluster actors into new market niches based on new applications that combine existing products and services, often across ‘strange attractors’.

Favouring this important source of innovation requires more innovation connections across compatible but not identical sectors and actors and more interdisciplinary and academic-industry problem solving. Priorities need to be placed on facilitating information exchange among clean-tech companies and researchers, promoting joint innovation projects and favouring the exchange of skilled labour across innovation actors. These connections should be promoted at each of the local, national and international scales, the latter particularly where actors are missing in the Negev, and should stretch across sectors.

There are three other measures that can be important in favouring related variety innovation in the Negev sub-cluster. First, the implementation of a publicly-supported lead innovation project driving researchers and companies to find new solutions to specified clean-tech problems concerning the government that open potential new markets such as oil substitutes. Second, the creation of a clean-tech research platform for regular exchange of research results among research institutions and industry players. Third, a mechanism for joint foresight across sub-cluster actors aimed at identifying future industry opportunities and developing interactive projects that will create the innovations. The government should promote these collaborative efforts with larger scale and more targeted government grants.

4. A green strategy for the Negev underpinned by green public procurement and regulation

Increasing levels of demand for renewable energy and water management technologies through public procurement and the application of environmental regulations can be one of the most important stimuli to the development of clean-tech in the Negev. As in other clean-tech experiences around the world, demanding regulation and public procurement initiatives can be expected to stimulate innovations, increase the number of local companies and their capabilities and build up the region’s human capital base in clean-tech. There are two major opportunity areas. One is a more strategic use of military procurement in order to incorporate clean-technologies in the investments made in the base relocations of the Israel Defence Forces, benefiting both the military through more efficient infrastructure and the Israel clean-tech industry through the creation of a demanding customer. The second is to introduce local green procurement into national and municipal government investments in green building and eco efficiency projects in the region as part of the new settlement projects planned during the next decade. The use of environmental regulations stipulating minimum energy and water efficiency requirements and renewable energy content in new settlements and base relocations will promote this procurement activity.

5. Transform Eilat into Israel’s model green city

An explicit ‘green strategy for the Negev’ can be an important stimulus to its clean-tech development. The centrepiece, and one of the keys to success, will be a high-profile lead initiative that pilots an integrated set of green building and sustainable settlement approaches in Eilat, as a model ‘green city’. The effect could be catalytic, transforming perceptions of the region, providing new skills and employment opportunities for existing residents and supporting local green business start-ups.

The idea of transforming Eilat into a green city is not new, but few government policies are encouraging it as yet. As well as meeting immediate environmental objectives, a green city initiative will provide a source of demand for applied research projects leading to marketable innovation amongst the

Negev's clean-tech cluster actors and enable training and employment opportunities to be provided for low-skilled and disadvantaged workers in the Negev, including the Bedouin population. It needs to be recognised that these training and employment opportunities will not be limited to green skills *per se*, but will likely be even more prevalent in traditional skills areas in construction, electricity, etc. that are required for green building and eco sustainability. New intermediaries to link job seekers to the relevant training and employment opportunities generated will also be required.

One of the keys to the Eilat green city project will be support for the energy efficiency retrofitting of local hotels using government loans and subsidies to meet up-front costs, with repayments potentially covered by future energy savings. A similar approach might be taken for industrial buildings and municipal structures, utilities, schools and hospitals. Another component of the green city is transportation: the government could require a shift to electric buses and rely on a fleet of electric vehicles for its own staff. A green business certification programme and registry and a regional training centre for clean-tech training activities would help complete the initiative.

6. A regional cluster management organisation

Finally, a regional clean-tech cluster management organisation should be established to help build a clean-tech cluster strategy across the key research, industry and public policy actors and co-ordinate the sector, building its connections and anchoring the cluster framework outlined above. This cluster management organisation would have a small, dynamic staff respected by and able to work with industry and research. It could be set up as a public or non-profit organisation. It would have the following tasks:

- Present an agreed definition of the clean-tech sector in Israel and the Negev.
- Map the components of the cluster in the region and nationally, including research and testing, education and business and the linkages that exist and can be built.
- Facilitate agreement around a clean-tech cluster policy strategy for the region and Israel and help implement the strategy.
- Broker joint innovation and knowledge transfer projects across industry and research.
- Promote the human capital development effort and establish incentives for human capital mobility to and within the region.
- Promote the region as a location for clean-tech inward investors and research organisations and as a source of collaborators and partners.
- Create regional, national and international supply and demand linkages for sub-cluster players.
- Undertake finance matching services to national and international investors for local research commercialisation and innovation projects.

This cluster management organisation will be a critical player in creating greater strategic direction and connections in the sub-cluster and for clean-tech nationally.

Inspiration from international clean-tech cluster experiences

Policy development in the Negev can draw inspiration from the various international learning model experiences presented in the report. The cases presented include collective action models from Denmark,

Sweden, and Saxony in Germany, the California high technology approach, including its training and regulation aspects, the university research-driven approach in Cambridge, UK, the green building and eco-settlement approaches in Abu Dhabi, Lower Austria and the UK Eco Towns, the centres of excellence approach in Finland and the attraction of high skilled labour and commercialisation of new technologies wrapped up in the Colorado National Renewable Energy Laboratory model in the USA. Such experiences will need to be adapted to the Negev conditions and different elements of these international approaches can be used and combined. Many of the experiences come from clean-tech clusters that started from small origins in other industries and developed through branching processes favoured by procurement, centres of excellence, start-up funding, collaborative innovation projects, and eco-city development. These are all elements of the policy approach that should be applied to growing clean-tech in the Negev.



Entrepreneurship, SMEs and Local Development

Clean-tech Clustering as an Engine for Local Development: the Negev Region, Israel

This report summarises the findings of a case study project on growing clean-tech cluster activity in the Negev region of Israel as part of a series of reviews on Entrepreneurship, SMEs and Local Development carried out by the Local Economic and Employment Development (LEED) Committee of the Organisation for Economic Co-operation and Development (OECD).

The review examines entrepreneurship, SMEs and local development in the Negev in the south of Israel, where there is strong potential for the growth of significant clean-tech industry cluster activity, involving a critical mass of firms, human capital, research organisations, support infrastructure and associated formal and informal linkages.

This report looks at the ways in which such capacity can be strengthened by public policies, including investment in centres of research excellence and specialised testing facilities, creation of spaces for innovation exchange, and the introduction of a green strategy and eco-city approach. The analysis provides guidance and policy recommendations on how best to support the emergence and expansion of clean-tech cluster activity that will enhance economic development capacity in the region while contributing to national green growth objectives.

