DEPT. OF ARCHITECTURAL ENGINEERING,
FACULTY OF ENGINEERING,
MANSOURA UNIVERSITY.

# Solar Energy Applications in Urban Development

Developing of the Egyptian Desert by Silicon Technology

تطبيقات الطاقة الشمسية في التنمية العمرانية

تنمية صحراء مصر بتكنولوجيا السيلكون

A Thesis
Submitted in partial fulfilment of the requirement for the degree of
MASTER OF SCIENCE
in Architecture

By

**Moamen M. El-Soudany,**
B.Sc. Arch. (Hons)

August
**2009**

Research Tilte : **Solar Energy Applications in Urban Development**

Developing of the Egyptian Desert by Silicon Technology

Researcher : **Moamen Mahmoud El-Soudany**

**Supervisors :**

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| 2. | **Assoc. Prof. Sherief Ahmed Sheta** | *Associted Professor.* Department of Architecture. Faculty of Engineering. Mansoura University. | |

**Head**
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**Examination Date:** 20 / 8 / 2009

**Head**
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# Preface

Carbon dioxide ($CO_2$) appears to be the most important measure responsible for around two-thirds of the global warming effect (UNEP and UNFCCC, 2001). In industrialised countries, the most effective actions to effect reduction of $CO_2$ emissions lie in the building sector, largely because buildings, in ***use*** or ***construction***, are the biggest single indirect source of carbon emissions generated by burning fossil fuels. They count for over 50% of total emissions. Humanity needs to move rapidly away from the use of greenhouse gas producing fossil fuels towards a greater dependence on clean renewable energy (RE). Renewable energy systems (REs) must become the major source of the world's energy supply sooner rather than later, and a shift away from conventional fossil fuel energy systems must begun as soon as possible (Roaf et al., 2004)

Solar cities initiatives, studies, and projects are considered important strides towards the reduction of $CO_2$ emissions and demonstration of using sustainable urbanism principles through the recent and future communities. To achieve such a rapid transformation from fossil fuel to renewable energy powered built environments, there is now a global formal requirement for energy conservation, generation from clean sources, and the preparation of an environmental statement to be undertaken for certain projects. Suitable planning conditions and obligation may help promote such trends. From the architectural perspective, the integration of such renewable resources of energy especially solar photovoltaics, emphasize the role and the responsibilities of the architects towards environmental issues.

This thesis has arisen from a deep conviction that an understanding of the development of solar energy in urban developmental scale — as an efficient solution for the development of new communities especially desert–Agriculture communities — can bringing new richness to human grasp and correspondence of the environmental concerns around him.

Hereby, the main purpose of this thesis is to emphasize, update, and support current information on solar energy utilization in urban development and, then, to evaluate the likelihood of applying it thoroughly on the wide extending Egyptian desert development in the light of the governmental medium/ long-term goals regarding the development of new communities in some abandoned 95% of the Egyptian land.

*Professor Rashed*, chair of the Architectural Engineering Department in Mansoura University from 2005 to 2008, had guided the academic effort within the educational programs to contribute to this framework and follow up with Prof. El-Baz's proposal. "***Egypt: the Future***" was the main theme under which numerous graduation projects have been produced since the Academic Year 2005/2006. As a parallel effort in R&D, the **ESU 95%** Lab (Egyptian 95% Sustainable Urbanism Laboratory) was launched as a scientific research group, composed of students and collage members. This group has been developing the findings and data, and sharing the results and outputs with interested governmental parties and private sectors who showed interest in Egyptian sustainable urban development.

As part of the ESU 95% Lab. effort, this thesis is meant to discuss and demonstrate the abilities for developing the Egyptian Desert with the utilization of solar energy. The Very Large-Scale Photovoltaics (VLS-PV) application is particularly addressed as a clean renewable potential that might help create new productive and sustainable urban communities in the Egyptian desert.

The thesis is derived in part from the researcher's work and concurrent research project developed by the author through the **ESU 95%** lab. In this sense, we would like to thank our colleagues ***Eng. Mahmoud Ramadan*** and ***Ahmed Helmy*** for the effort they have contributed in the application initiation and activities, and acknowledge the inspiration and experience of the scientists ***Prof. Farouk El-Baz*** and ***Kosuke Kurokawa***, whose perspectives and thoughts of developing the world's desert helped formulate our own.

***Last but not least***, I am grateful for the opportunity to have gained some foremost experience in the field of sustainable construction and sustainable development , I would like to thank Professor, ***Ahmed Rashed*** and Associated Professor, ***Sherief Sheta***, without whose experience, collaboration, and support, this work would not have been possible in this context.

An endless gratitude goes to Professor ***Moamen Afify*** and Professor ***Osama Farag***, who were supporting the quality of the thesis in all phases.

I am also indebted to all the individuals, organizations, associations, agencies, and institutions inside and outside Egypt- especially the International Energy Agency (IEA) Photovoltaic Power System Program (PVPS) Task 6 and Task 8, Energy Sector Management Assistance Program (ESMAP), New & Renewable Authority of Egypt (NREA) – that made this research updated with their excellent facilities and information.

**Moamen M. Sudany**

*July 2009*

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August
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قســـم الهندســـة المعمـــارية,
كليـــة الهندســـة,
جامعـــة المنصورة.

# تطبيقات الطاقة الشمسية في التنمية العمرانية

## تنمية صحراء مصر بتكنولوجيا السيلكون

# Solar Energy Applications in Urban Development

## Developing of the Egyptian Desert by Silicon Technology

بحث مقدم ال
ى قسم الهندسة المعمارية كجزء من المتطلبات للحصول على
درجة الماجستير فى الهندسة المعمارية

الباحث
**مؤمن محمود السوداني**
معيد بقسم الهندسة المعمارية

اشراف
**احمد يحيى جمال الدين راشد**
استاذ دكتور, كلية الهندسة, الجامعة البريطانية فى مصر
**شريف احمد شتا**
استاذ مساعد دكتور, قسم العمارة, كلية الهندسة, جامعة المنصورة

August
**2009**

# Research's Related Activities;

## Graduation Project:

**Titled**: **Egyptian Silicon Valley " ** Research and Administrative Complex **"** (Alpha)

- Best graduation project for year 2004 - UIA / Egyptian National Section.
- Participate in Archiprix International, Scotland 2005.
- One of World's Best Graduation Projects- Archiprix International Book.

## Post-Graduate:

**Graduate Studies** *for* (MSc.) *in Architectural Engineering, from Faculty of Engineering, Mansoura University.*

## International Competitions:

- **IaaC 2nd Advanced Architecture Competition** for self-Sufficient housing - **Spain**
  (18 Project Title **" Green Mines Community "** ( 18 September) 2007.
  One of 20 finalists project http://www.iaacblog.com/AAC2007-finalists/?cat=3
- **Holcim International Award 2008** for sustainable construction - **USA**
  Project Title **" Green Mines Community,** Egyptian Western Desert **"** ( 20 October*) 2008.
  http://www.holcimfoundation.org/

## International Workshops:

- **As Expert;** International Experts Workshop on Efficient Buildings
  *"Pilot Design Project of a Sustainable Research Building at Algiers Polytechnic School of Architecture and Urbanism"*
  **21-23 June 2008, Algiers, Algeria** *organized by **MENASHDA** and **DAAD**.*
- **International workshop**, *titled "Application of Solar Energy, Solar collectors and Photovoltaic cells"* 14-15th October 2008, Alexandria University, Egypt. *organized by IGSR.*
- **International Conference**, *titled " Global Environmental Change: Challenges and Opportunities"* 20-22 Dec., Alexandria University, Egypt.

## International Conferences (With Paper):

- **Solar 09** , ***" Annual Conference of the Australian and New Zealand Solar Energy Society "*** Australia,
  **Paper Title:** ( Developing The Egyptian Desert by Photovoltaic Technology ) , 29 September 2 October 2009.
- **The Fifth International Arch. Conference** *" Towards a New Architectural Vision: presentation and representation "*
  Cairo, 16th to 17th of December 2009.
  **Paper Title**: (Potentials of VLS-PV Systems: Sustainable Solutions for Egyptian Desert Communities)
- **Kuwait Society of Engineers (KSE) Engineering Congress *"Alternative Energy Applications: Option Or Necessity"***
  Kuwait , 2nd to 6th of November 2009.
  **Paper Title**: (Integrating Of VLS-PV Systems Within Development Scenarios For The Egyptian Desert)
- **4- 8th international Architectural Conference** , *" Architecture & Built Environment : Contemporary issues "*
  Assiut , 13th to 15th of April 2010.
  **Paper Title**: (Using VLS-PV in the Egyptian Developmental Corridor "Green Mines Community (GrMC)"

## ESU Lab, Egyptian 95% Sustainable Urbanism Lab.

Establishing of Specific research lab at the department of Architectural Engineering, Mansoura university- ***for studying the sustainable urban and architectural development*** through the national urban trends, for demonstrates the role of scientific research and architectural education for adopting these trends.
***Egypt, 2008*** *Site: http://ESU.mansouraARC.net*

## Recommended by

**Academic:** *Department of Architecture, Faculty of Engineering, Mansoura University.*
**Professional:** *Housing &Building National Research Center. Vice Chairman Office for Research and Studies Affair.*
**International Universities :** *The Welsh School of Architecture, CARDIFF University, UK.*

# Biography

**Moamen El Sudany** is an assistant teacher and researcher in the Dept. of Architectural Engineering at Mansoura University. He was a founder member of the ESU 95% lab- a scientific research group- for studying the sustainable urbanism of Egypt's 95% of land. Moamen is involved in the integration of architectural studies with the glocal issues, and he is interested in the architectural competitions, academic, and scientific activities.

**Ahmed Y. Rashed** Professor at the British University in Egypt. His profession is Architecture and Urban Design. Prof. Ahmed Rashed was the chair of Architectural Engineering Department, Mansoura University, Egypt from July 2004 to September 2008. Got his Ph.D. January 1995, in Architecture Planning and Conservation, University of York, Institute of Advanced Architectural Studies, UK. He worked as professor at different universities in Egypt, Saudi Arabia and the United Arab Emirates, and founder of - ESU 95% Lab.; in Mansoura University, and Centre for Sustainability and Futuristic Studies; in British University, with publishing of about 45 academic papers in international conferences and magazines.

**Sherief A. Sheta** is an associate professor and BSc in Architectural Engineering, Department of Architectural Engineering, Faculty of Engineering, Mansoura University, where he's taught since 1993. Sheta received both his PhD and MSc from Mansoura University in Egypt, and BSc from the Department of Architectural Engineering, Faculty of Engineering, Alexandria University in 1991. He worked as a visiting Assistant Professor in the Department of Technology Systems, East Carolina University in August 2007 thru May 2008. His research focuses on sustainable architecture (planning and design) with particular stress on design development theories and technique; interrelated socio-economic fields; and human-related issues.

**CONTACT**

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# GLOSSARY

| | |
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| **A Breeder Reactor** | Is a nuclear fission reactor that produces more fissile material than it consumes, and it is isotopes that can be used in the fission process include the fission products plutonium-239 and thorium-232 |
| **AC** | Alternating Current |
| **Asset financing** | All money invested in renewable energy generation projects, whether from internal company balance sheets, debt finance, or equity finance. Excludes refinancing and short-term construction loans. |
| **BIPV** | Building integration photovoltaics |
| **BREEAM** | Building Research Establishment Environmental Assessment Method. |
| **BTOE** | Billions of Tons of Oil Equivalent |
| **Capacity** | The acquisition of renewable power generation and biofuels production companies and projects, and equipment manufacturers. |
| **CFD** | Computational fluid dynamic |
| **Coalification.** | Is the process that Organisms form coal when subjected to coalification includes algae, phytoplankton and zooplankton, and the bacterial decay of plants and, to a lesser extent, animals. |
| **DC** | Direct current |
| **ESMAP** | Energy Sector Management Assistance Program |
| **ESMAP** | Energy Sector Management Assistance Program |
| **ESRC** | Egyptian Solar Research Center |
| **ESU 95% Lab** | Egyptian 95% Sustainable Urbanism Laboratory |
| **ETSU** | Energy Technical Support Unit |
| **FACTS** | Flexible AC transmission system |
| **GDF** | Grid Developmental Form |
| **GDP** | Gross Domestic Product |
| **GEF** | The Global Environment Facility |
| **GHGs** | Greenhouse gases |
| **GrMC** | Green Mines Community |
| **GW** | Gigawatt |
| **IBRD** | International Bank for Reconstruction and Development. |
| **IFC** | The International Finance Corporation |
| **IPCC** | Intergovernmental Panel on Climate Change. |
| **IREDA** | The Indian Renewable Energy Development Agency |
| **IREP** | The Indian Renewable Energy Program |
| **ISCCS** | Integrated Solar Combined-Cycle System |

| | |
|---|---|
| **LCA** | Live cycle assessment |
| **LEDs** | Light-emitting diodes |
| **MBDOE.** | Millions of Barrels per Day of Oil Equivalent. |
| **MIST** | Masdar Institute of Science and Technology |
| **MRT** | Material Rapid Transit |
| **NGOs** | Non-governmental organizations |
| **NIHE** | Northern *Ireland Housing Executive " Organization for housing construction affairs."* |
| **NREA** | New and Renewable Energy Authority |
| **OECD.** | (Organization for Economic Cooperation and Development) Member Countries (30) Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States. |
| **PRT** | Personal Rapid Transit |
| **Public markets** | All new equity investment in quoted companies developing and manufacturing sustainable energy technologies, and building and operating clean energy power generation capacity. |
| **PV** | Photovoltaic |
| **R&D** | Researching and Development |
| **RCC** | Resource Cost Curve |
| **RD&D** | Research, development, and demonstration |
| **RE** | Renewable energy |
| **RETs** | Renewable Energy Technologies |
| **SCE** | Supreme Council of Energy |
| **SGP** | Is Small Grants Program, organized by the United Nations Development Programme, Environment and Energy section. The SGP funds, which do not exceed US$50,000, are eligible for (NGOs) and community based organizations (CBS) in recognition of the key role they play as a resource and constituency for environment and development concerns. |
| **SHS** | Solar home system |
| **Technology** | The acquisition of companies that develop and commercialize products or provide services related to the production of renewable energy or the efficient use and storage of energy. |
| **UNDP** | United Nations Development Program |
| **UNEP** | United Nations Environment Program |
| **UNFCCC** | UN Framework Convention on Climate Change |
| **VLS- PV** | Very Large Scale Photovoltaic |
| **WWF** | World Wide Fund |

# ABSTRACT

Settling the desert has long been an Egyptian dream. Dictated by the population needs, future hopes, and a broader vision for a better life, desert development has widely been considered a national goal. Numerous scenarios tackled the future development of Egyptian desert such as *"Egypt 2020"* by Rageh, and "*The Development Corridor*" by Farouk El-Baz. Studying the international trends related to sustainable development and renewable energies utilization has shown a gap between the entire national trends and the relevant international strategies that call for an optimum utilization of the "Very Large Scale Photovoltaics" (VLS-PV) in the worlds' deserts. Such new visions may help create new productive sustainable communities in the desert while providing for new desert development scenarios.

The thesis suggests an integrated approach to practical utilization of VLS-PV, guided with the national visions of the future of prospected desert communities in Egypt. In this regard, the "*Application of VLS-PV in the Egyptian Desert* " is developed as a sustainable planning and design proposal to provide optimum utilization of photovoltaics in new desert communities. It presents a model for the integration of photovoltaic system within future communities in the Egyptian desert, whether through the "*Development Corridor*" scenario, or the desert development framework in general. The conclusion illustrates a number of recommended actions steps that may possibly make recent development projects more adaptive with the use of solar energy applications; mainly with the VLS-PV systems.

***Keywords***: *Egyptian Desert- Solar Energy- Sustainable Community- VLS-PV systems.*

## AIMS OF THE RESEARCH

This study aims at approaching the following:

- Discussion, analysis, and development of the existing scenarios dealing with the developmental concepts for the Egyptian desert and creation of new urban communities.
- Emphasizing the role of renewable energies (solar energy in particular), handling the implementation of self-sufficient/productive housing units, and fostering the effective role of architecture in disseminating and developing sustainability strategies for desert settlements and regional communities at large.
- Promoting the major governmental projects, implemented in desert hinterlands by expanding the body of knowledge to a larger scale of sustainable photovoltaic application in the local urban communities.
- Proposing some urban and architectural design guidelines for discussion, debate, and further input.

## HYPOTHESIS OF THE STUDY

The use of solar energy applications on the urban scale, regarding an economic development - especially in developing countries - would offer suitable solutions for energy and environmental problems. This hypothesis is to be examined through the Egyptian reality by developing its desert, and exploiting the available local resources, mainly the silicon, as a principal means to achieve sustainable development.

## STRUCTURE OF THE THESIS

Beyond the introductory chapter, the thesis has been organized into three broad parts: One- Literature review, Two- Analytical study, and three – the application study. Each part is separated into individual chapters, which may in turn be divided into subdivisions.

Part One, literature review, presents three chapters. ***Chapter II*** discusses the identification of recent world's problems, as problem of Energy, resources depletion, pollution, environmental degradations and the role of Renewable energy as a solution. ***Chapter III*** presents the forecasting scenarios of energy and the needs for developing solar energy utilization trough the world's energy. Finally ***Chapter IV;*** discusses and illustrates the main outlines of solar energy systems, applications, uses, and devices and compares the electrical and thermal application for developing its uses in Egyptian case through the application in Part Three.

In *Part Two* the research have to illustrates and analyses the principles, technology abilities, and applications of solar energy as one of the renewable energies that may be suitable for achieving the global sustainable directions on urban and architectural scale. *Chapter V* Discusses the main principles, information, outlines, uses and applications of solar energy. *Chapter VI* involves the most recent visions and applications for using solar energy — whether devices or systems — on urban development architectural scale. *Chapter VII* Has to draws out the most available and suitable visions, systems, and guidelines to be the start point of the case study in Part Three; the guides that help imagine and plan the model, of silicon or solar development in the Egyptian desert.

The Objective of *Part Three* is to examine the Egyptian regions to select the suitable regions for using and applying solar energy system and photovoltaic silicon technology in the specific and selected sites that has a higher priority of national development and potentials of using VLS-PV proposal. This is envisaged to be achieved by *Chapter VIII*, which introduces analytical study of selected regions and sites and examines the design criteria of PV technology applications, uses energy system, devices, energy output, and suitable infrastructure when applying PV Silicon cells to roofs. *Chapter IX;* Develops an application for embodying the potentials of PV integration with the developmental trends of desert through new sustainable communities in Egypt.

## RESEARCH METHODOLOGY

The Research is determined to study the major potential approaches for developing the Egyptian desert. this study mainly stems from theoretical studies carried out by the author through the thesis, conducted academic research, and submitted entries at several environmental architectural competitions. Through all these contributions, solar energy applications in urban development have mainly been focused, and major international experiments studied to draw out practical criteria to pave the way for the Egyptian desert to be home to new communities and future generations. The methodology can be summarized the following;

### Theoretical Study;

- Indentifying of research problem as; global energy crisis, climatic changes, and the environmental degradations, and discussing the abilities of renewable energy as a solution.
- presenting the forecasting scenarios of energy through the 21st Century and the role of RE,
- Studying solar energy theories, systems, and applications and discussing of photovoltaic technology with special mention of the Silicon technology.

### Analytical study;

- Analytical study of solar energy applications — whether thermal or electrical — and comparing its uses and relations to urban or architectural fields,
- Analytical Study of solar energy applications through examples in a number of subdivision to discuss the world's energy development, urban development, rural development, and architecture,
- Studying the principles and design criteria, if solar energy applications are integrated with developmental, urban, rural and architectural applications,
- Drawing out the design criteria from the former examples for examining the potentials of SE through the Egyptian regions,
- Studying the Egyptian reality, desert developmental trends, and RE statements and policy,
- Examining the SE design criteria on the Egyptian regions, sites, and desert regions in particular,
- Conducting a case study, on installing PV cells on one of the selected or suitable sites, to draw out specifications, design notes, achievable design criteria through the urban and architectural scale, learned lessons, and recommendations,
- Creating a study model or application specified the utilization and integration of PV technology in different scales through the Egyptian desert development and new communities.

## *To the attribute of my life-*

*a **father** for his confidence in me,*

*a **mother** for her gift of optimism,*

*a **brother** for his backing.*

*&*

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Amr El Qamary　Asmaa Waheed

Mohamed El Degla　Ahmed Abd-Allah …Joe　Ibrahem Imam

Mostafa Amin　Abdel-Rahmaan Khaleel　Rana Sameer

Raghda Abdel-ellah　Mohamed El Nabawy　Aya Medhat

Shaymaa Shaheen

Amira El-Metwally　Kholoud Basem　Basma Shaheen

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

قال الله تعالى:

اللَّهُ الَّذِي رَفَعَ السَّمَاوَاتِ بِغَيْرِ عَمَدٍ تَرَوْنَهَا ۖ ثُمَّ اسْتَوَىٰ عَلَى الْعَرْشِ ۖ وَسَخَّرَ الشَّمْسَ وَالْقَمَرَ ۖ كُلٌّ يَجْرِي لِأَجَلٍ مُسَمًّى ۚ يُدَبِّرُ الْأَمْرَ يُفَصِّلُ الْآيَاتِ لَعَلَّكُمْ بِلِقَاءِ رَبِّكُمْ تُوقِنُونَ (2)

صدق الله العظيم

قرآن كريم – سورة الرعد الاية **(2)**

# INTRODUCTION

*"If the 19th century was the age of coal and the 20th of oil, the 21st will be the age of the sun"* [1]

*Randall,*

The relationship of architecture to the sun, the wind, the water, and the Earth has been a constant concern to architects. There is a certain amount of hostility today towards solar possibilities for creating sustainable and clean urban development. Among these responsibilities comes the use of sun as a source of energy and development.

## 1.1. **Global issue -** Energy

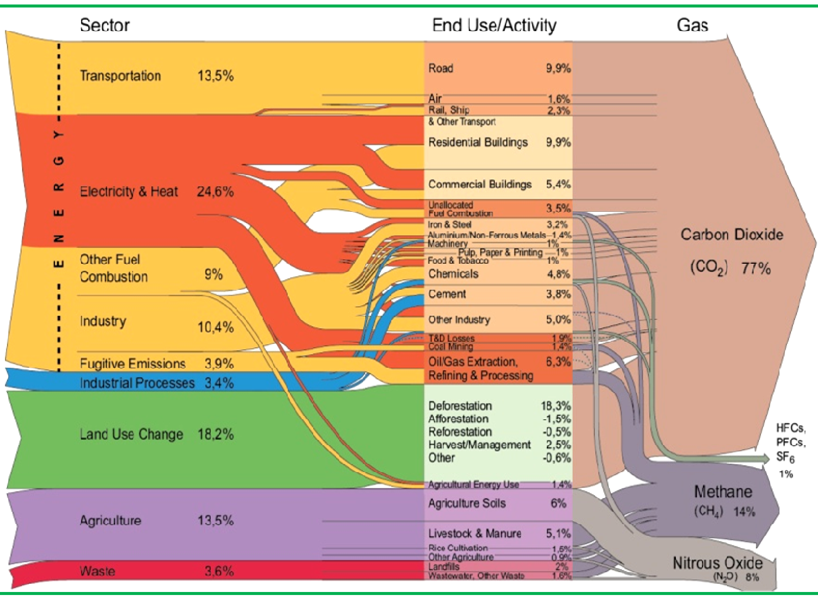
The awareness of energy needs and shortage in the early seventies has grows as a result of the two oil crisis. The energy potential, which the sun places at our disposal on a daily basis, seems inexhaustible. The incident radiation on the landmasses of the earth alone is 3000 times greater than the worldwide demands. Yet we continue to meal these demands almost exclusively with non-renewable energies generated primarily from fossil fuels. The resultant environmental problems — air pollution, acid rain, greenhouse effect, and climate — are also well known. As these were not bad enough, annual consumption is climbing dramatically. China and India considered remarkable examples of trends to adopt the extravagant lifestyle of the West, Urban development and Architecture plays a key role in this context. For nearly half of all the energy consumed in central Europe is expanded in the operations of buildings, that is, for heating, cooling and lighting. This will lead to nearly immeasurable ecological and political consequences in the near future since the conventional energy resources finite and will soon be exhausted.[2] (Figure 1)

Figure. 1

**World's Greenhouse Gas Emission by Sector.**

**Source**: World Resources Institute, Climate Analysis Indicator Tool (**CAIT**), Navigating the Numbers: Greenhouse Gas Data and International Climate Policy,

December 2005; Intergovernmental Panel on Climate Change, 1996 (data for 2000).




[1] **Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"* (London: Spon Press,2003).

[2] **Schittich**,Christian(ed). *In Detail: Solar Architecture Strategies, Visions, and Concept*, (Birkhauser publisher , Berlin, Germany,2003).

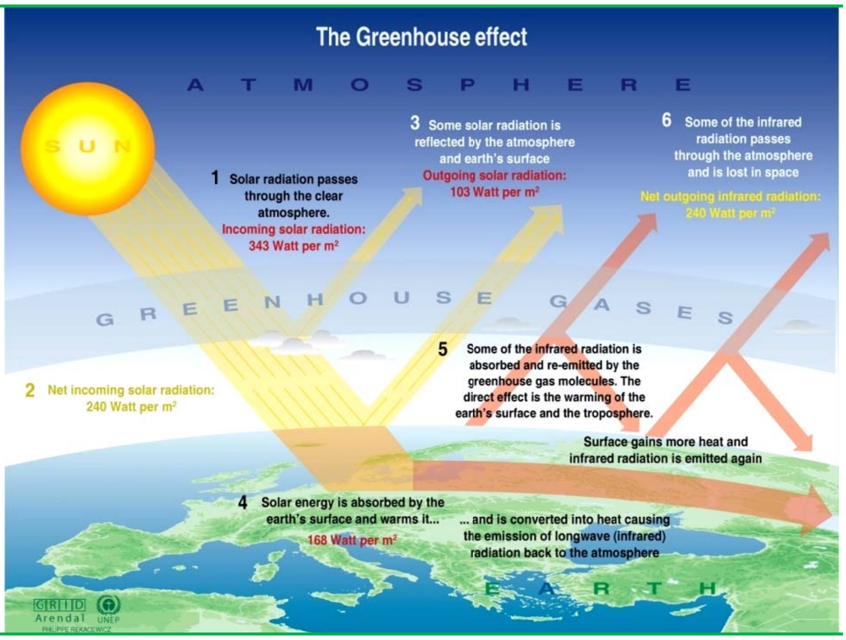
## 1.2. **Renewable Energy;** Solar energy,

Recently, a solar agenda has not been only a sensible environmental policy; it is also a contribution to peace. It is arguable that the solar energy (SE) strikes the earth for approximately 10.000 Hrs/year; a number that exceeds the normal amount needed for the overall human use throughout the world (Figure 1). Therefore, to finally adopt a new philosophy and to embark on the road towards sustainable development based on renewable energy resources. Energy resources are directly or indirectly linked to the sun such as solar irradiation, wind-and hydropower generation, or biomass. Thus, it has become important for developers and decision makers to create sustainable development; minimize energy use; and preserve environmental and natural resources with considerable exploitation of alternative renewable energy sources. Potential obstacles should be alleviated to sustain solar energy use and spread its knowledge and applicability. [3]

Figure. 2

**Global Solar Energy and Greenhouse Effect.**

**Source:** University of Oxford, school of geography: United States Environmental protection Agency (EPA) Washington; Climate change 1995, The science of climate change, contnbution of working group 1 to the second assessment report of the interg UNEP and WMO, Cambridge university press, 2005.




Solar energy is considered low-density energy by nature. Thermal and electrical applications of solar energy provide a wide-range for utilizing solar energy in various scales, whether in developmental, urban, rural, and architectural scale. Electrical solar applications plays ever-increasing role in sustainable development especially urban development. The principal reason for this is that photovoltaic (PV) systems which produce electricity directly from solar radiation are becoming more widespread as their advantages become apparent and as costs fall. PVs are advanced materials technology that will help us design buildings which are environmentally responsible, responsive and exciting.[4]

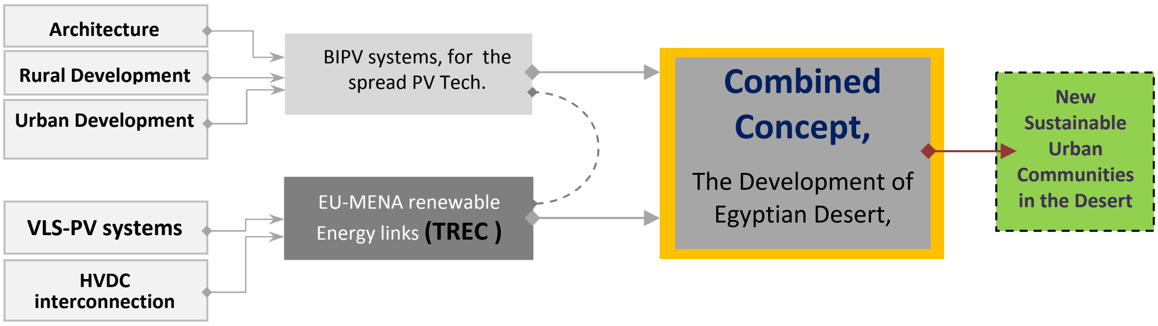
Photovoltaic cells have been thought of, developed and produced by silicon evolved from the sand — the material which is more available on earth. However, the main problems lie in the irregular distribution of solar energy, the sophisticated technical manufacturing of the cells, and their marketing and

[3] Ibid., 181

[4] **Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"* (London: Spon Press,2003).

economic potentials. Accordingly, other alternative means are being considered such as the nuclear technology, which may be of great danger if misused or improperly constructed.[5]

In this sense, Building Integrated Photovoltaics (BIPV) is now a part of every architect vocabulary, while Very Large Scale Photovoltaics (VLS-PV) in the largest applicable utilization of Photovoltaic technology and part of every developer is vocabulary concerning world's desert development. Then, the integration of such trends is a necessity for utilizing these developmental concepts for sustainable development of the Egyptian desert.[6]




## **Egypt;** Desert development,

Egypt covers an extremely arid area (about 1,000,000 km$^2$), of which only 5% is inhabited. According to census estimates, the Egyptian population almost tripled during the last 50 years to become about 74 x 10$^6$ inhabitants in 2008. By the year 2025, it is estimated to become 95 x 10$^6$ people, of whom almost 99% concentrate in the Nile Valley and Delta.[7] Therefore, redistributing the population over a larger area has increasingly become a necessity. Sustainable development strategies along with urban and desert development have become crucial issues in achieving the national strategies. In this sense, numerous studies have discussed the future scenarios.

Partially addressed as part of these studies scenarios, the desert has been focused and its obstacles analysed; raising the following couple of questions: (1) could Egypt grow in the old valley alone; leaving 95% of its total area unexploited? and (2) what would happen after a quarter-century without heading towards the desert? Essentially, the answers will emphasize the importance of conducting R&D along with applicable studies.[8]

Numerous scenarios tackled the future development of Egyptian desert such as "*Egypt 2020*" by Rageh, and "*The Development Corridor*" by Farouk El-Baz. Studying the international trends related to sustainable development and renewable energies utilization has shown a gap between the entire national trends and the relevant international strategies that call for an optimum utilization of the "Very

[5] **Addington**, Michelle., **Schodek** Daniel.," *Smart Materials and New Technologies For the Architecture and Design Professions"* (UK: Oxford , Elsevier,Architectural Press,2005)
[6] Ibid., 180
[7] Data processed from; **Planning Ministry,** Report, 1999, p.20. – Egypt State information Services (SIS), Retrieved March 15, 2009, from: http://www.sis.gov.eg/
[8] **Rashed**, A. **Abolelah**, I.," *Second Egypt and Sustainable Future: Challenges?* "Second International Conference, SUE-MoT 2009, (Loughborough, UK, April 2009), p. 439.

Large Scale Photovoltaics" (VLS-PV) in the worlds' deserts. Such new visions may help create new productive sustainable communities in the desert while providing for new desert development scenarios.[9]

New techniques towards studying the reclamation Egyptian desert by using solar energy have been developed, in order to supply self-dependant regions by electrical energy, heating, and treating water, while being integrated with other environmental systems, an advance that is anticipated to offer self-development of regions without connecting with main systems of the country. Considered particularly as one of the purist to produce photovoltaic cells and electronic chips, the Egyptian silicon and the use of particular resources sharing in the silicon technology production aim to help achieve desert reclamation while obtaining scientific, social, environmental and investment return.[10]

***Finally and most important***, the thesis suggests an integrated approach to practical utilization of VLS-PV, guided with the national visions of the future of prospected desert communities in Egypt. In this regard, the "*Application of VLS-PV in the Egyptian Desert"* developed as a sustainable framework and proposal to provide optimum utilization of Photovoltaics in new desert communities. The proposal presents a structure and studies for the integration of photovoltaic system within future communities in the Egyptian desert, whether through the "Development Corridor" scenario, or the desert development framework in general. And through the *APPENDICES* the research presents private proposal called " *Green mines Community* (GrMC)" discuss the former application through visionally architectural perspective and still under research and development by the author. The conclusion illustrates a number of recommended action steps that may possibly make recent development projects more adaptive with the use of solar energy applications; mainly with the BIPV and VLS-PV systems.

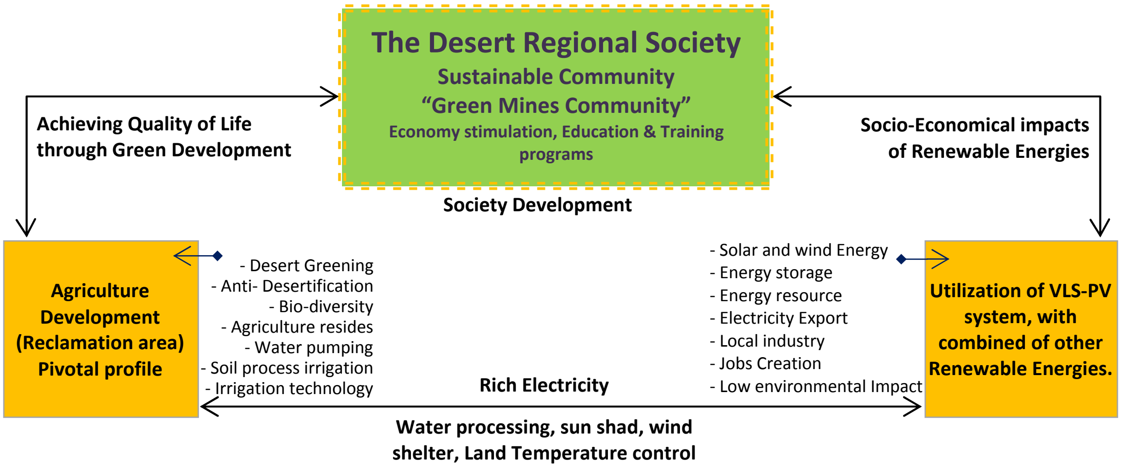



Figure: 3

**Framework of Egyptian desert development; adapted to VLS-PV research studies.)**

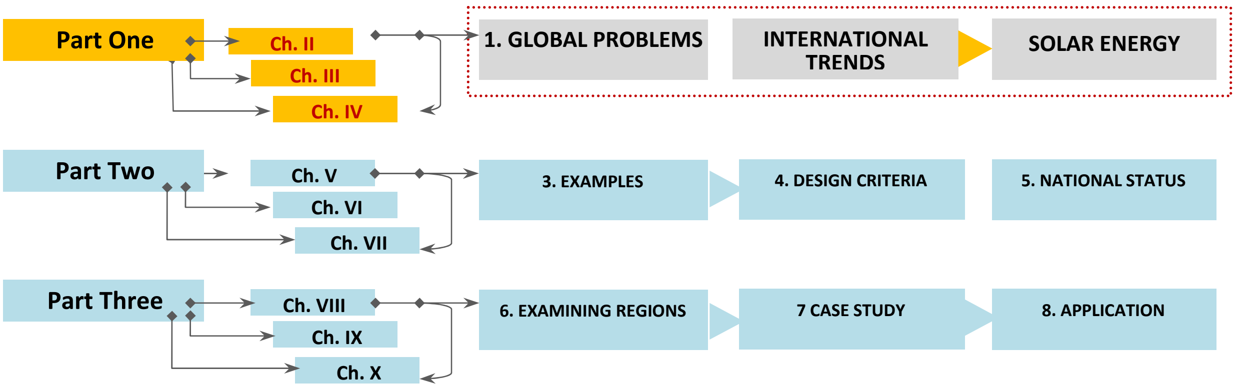
[9] **Sudany**, M., **Rashed**, A., **Sheta**, Sh.; Kuwait Society of Engineers (KSE) Engineering Congress *"Integrating of VLS-PV Systems Within Development Scenarios For The Egyptian Desert"* **(**Kuwait , November 2009).

[10] **Abulfotuh** Fuad, *Workshop; "Application of Solar Energy; Solar Collectors and Photovoltaic Cells" PV Technology: Status and Prospects"*, Lecture, (Egypt: Alexandria, IGSR, October 2008).

# PART ONE

## LITERATURE REVIEW

### Problems Identification




- ***Part One**, literature review, presents three chapters. Starting with **Chapter II**: which discusses the identification of recent world's problems related to the Energy crisis, resources depletion, pollution, environmental degradations, rural poor population and the role of Renewable energy as a solution. While, **Chapter III**; justified the reasons for studying solar energy through the research, and presenting the forecasting scenarios of energy and the needs for developing solar energy utilization with the use of conventional energy. Finally, in **Chapter IV**; the research discusses and illustrates the main outlines of solar energy systems, applications, uses, and devices and comparing the application areas of Electrical and Thermal systems, for developing its uses through the Egyptian case in part three.*

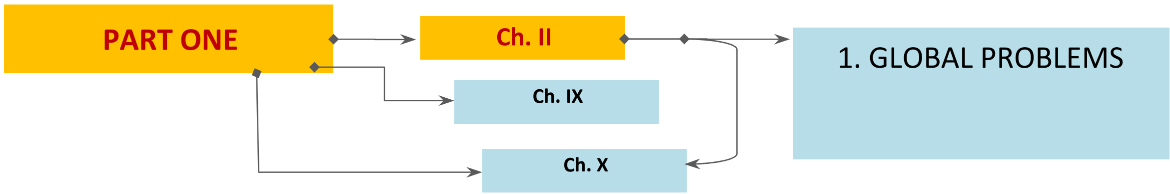
## PART 1: LITERATURE REVIEW

*Chapter*

# CHAPTER

# II

## IDENTIFICATION OF THE PROBLEM



# Chapter II. IDENTIFICATION OF THE PROBLEM

Today's world faces challenges in the form of population growth, resource consumption and environmental degradation. The environment is threatened by the perils of global warming, climate change, and energy crises. Unless some immediate remedial measures are taken, things are only expected to get worse. There is a need to protect the environment, if we get involved with conserving the environment by producing clean energy, then we will simultaneously address the problems of energy and environmental degradation.

The environmental deterioration that we are experiencing is primarily due to global warming and climate change. Global warming occurs when greenhouse gases like carbon dioxide and methane stay trapped in the earth's atmosphere. These gases are known as greenhouse gases because of their capacity to retain heat, and this effect is known as the greenhouse effect. Originally, it was this effect that made the earth a habitable place, or it would have been too cold to live in. However, retention of excess heat, or the "Enhanced Greenhouse Effect" is a serious threat to the planet as it leads to an increase in global temperature; (global warming) which in turn is the cause of global climate change. Land degradation, air and water pollution, sea-level rise, flood of coastal and low lying areas, and loss of biodiversity are only a few examples of the consequences of climate change.[1]

In this chapter, the numerous problems of energy and its environmental sequences are identified to present nowadays problems and global trends to solve these issues.

## 1 Problem of Energy

Energy is closely linked to economic development and to environmental quality. It is central to the world economy, providing the power needed for industrial production, transportation and (increasingly) agriculture. Energy is a major contributor to health, wellbeing and productivity, making possible the existence of services that include heating, lighting and refrigeration. The energy chain delivering these services starts with the collection or extraction of a primary energy source – for example, coal – which may be transformed into another form of energy such as electricity, transported or transmitted to the point of use, and finally used to power a piece of equipment such as a heater, lamp or motor. Figure 1-1 shows an energy chain, using coal as an example.[2]

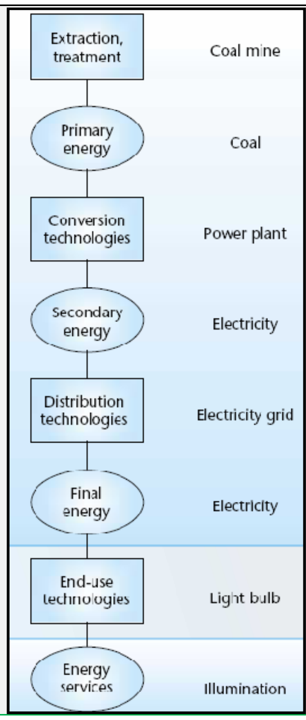



Fig. 1-1 **Energy Chain: From Extraction to Energy Sevices.** Source: UNEP, Industry & Environment. *Sustainable Energy*, 4.

The rapid expansion of cities throughout the late 19th and the 20th centuries was a direct outcome of the fossil fuel economy. Today, the growth and operation of cities and urbanized areas absorbs roughly three-quarters of the world's fossil fuel production. This is a staggering amount given that fossil fuels supply 85% of total global commercial energy use – and their use is increasing at a rapid rate. Economic regions, nations and cities worldwide will soon be under great pressure to find alternative sources.

Because of the fatal triad of carbon emissions induced climate change, fossil fuel depletion and mounting environmental damage due to the use of oil and coal cities will have to be powered differently. The use of

[1] **Youth Employment Summit**, "*Report A: Youth Employment Opportunities in Renewable Energy*", (London, Education Development Center Inc. 2002), 1, 2.

[2] **UNEP**, **Industry and Environment**, "*Sustainable Energy: Energy efficiency, Renewable energy sources, Alternative fuels and technologies, Energy and climate change, Energy in developing countries*". (Paris: UNEP DTIE 2000), 4.

renewable and distributed micro-power systems is already on the rise today but the current speed of change is much too low to meet global goals in time to avert serious crises. Besides the introduction of solar and other renewable energy technologies, cities will also have to be re-engineered in terms of their transport and land-use systems, their facility and urban design principles and the very use patterns they engender.[1]

## 2 Problem of Resources Depletion

The world's fossil fuel dependency is no less clearly documented than their impending expiration. Fossil fuel use increased five-fold over this past half century, from 1.7 billion tons of oil equivalent in 1950 to 8 billion tons in 1999, providing 85% of the world's commercial energy. The majority of this energy is used either within cities, or for transport from and to cities. [2]

Most contemporary fuel sources are due to expire well within this century as widely available and predominantly peacefully contested sources, and much of this reality will become globally pervasive within these next decades. Even conservative industry, national and international governmental sources estimate that oil will expire by 2050 – the depletion of the more easily accessible supply sources is likely to take place already in the 2020-2030 time frames.[3]

It is arguable, However, That the global economic output, as measured by Gross Domestic Product (GDP), rose on average nearly 3 percent per year from 1980 to 2005. Worldwide GDP is expected to increase by approximately the same rate to 2030, led by rapidly expanding economies of developing countries. While the global economy grew since 1980, the world also became more energy efficient. This gain in efficiency is illustrated by a significant decline in "energy intensity" **Figure 1-2** – a measure that reflects global energy demand divided by global GDP. As a result, energy intensity in 2030 will be almost 50 percent below the level of 1980. Global energy demand from all sources – expressed in million barrels per day of oil equivalent (MBDOE)[4] – is expected to increase 1.3 percent per year on average from 2005 to 2030. This rate is considerably slower than the growth experienced from 1980-2005, reflecting strong improvements in energy efficiency. Still, global demand in 2030 is likely to reach nearly 325 MBDOE.[5]

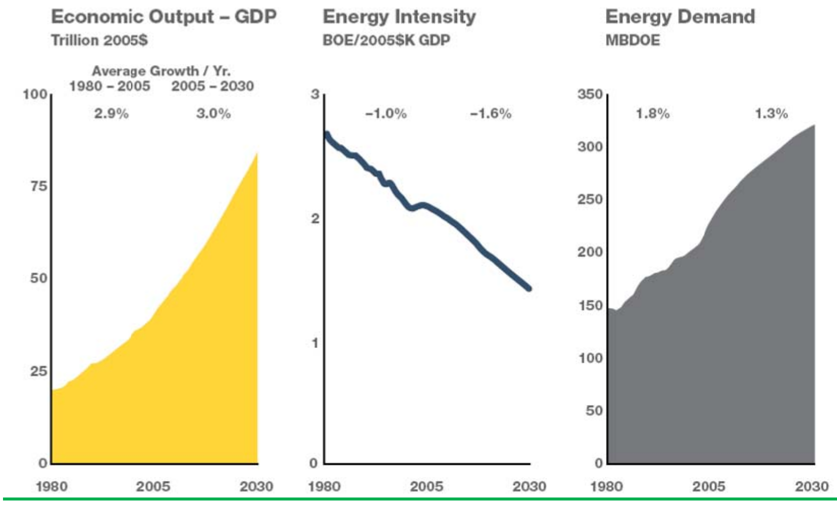



Fig. 1-2

**Global Economics and Energy.**

**Source: Exxon Mobil**. Repot: *The Outlook for Energy A View to 2030*, (Las Colinas Boulevard,Texas, November 2007),1.

[1] **Droege**, P. *Renewable Energy and the City: Urban life in an age of fossil fuel depletion and climate change,* (Japan: Institute for Global Environmental Strategies, 2002),1,2.
[2] **Girardet**, H. *Creating Sustainable Cities: Schumacher Briefings* (Devon: Green Books.1999), 2.
[3] **Scheer**, H. *Solare weltwirtschaft*,(Kunstmann1999)
[4] ***MBDOE*** = Millions of Barrels per Day of Oil Equivalent
[5] **Exxon Mobil**. Repot: *The Outlook for Energy A View to 2030"*, (Las Colinas Boulevard,Texas, November 2007),1.

# 3 Problem of Pollution

It is now widely accepted that concerted efforts to reduce greenhouse gas emissions (GHGs) are important to keep the levels of GHGs from tripling by the year 2100. Resolving the problem of climate change requires multiple, long-term strategies that will demand enormous sustained effort, engaging the cooperation of both developed and developing countries. Currently, developed countries count for the larger share of greenhouse gas emissions, but developing-country emissions continue to rise steadily. BY the year 2025 emissions from developing countries are expected to represent some 50% of the global total. This calls for immediate action globally.[1]

The environmental impacts of energy production and consumption occur at every level, from individual households to the planet. Air, water, the soil/land and living organisms are all affected. (Table 1-1) presents examples of impacts from two major energy-related industrial sectors.

## 3-1 *Air Pollution*

Energy-related air pollution is caused by the combustion of fossil fuels in vehicles, industrial boilers and furnaces, and electrical power plants. Burning of biomass fuels for charcoal production (and directly for household use) results in local and indoor air pollution. Air pollution is the primary cause of energy-related effects on human health.

The major air pollutants created by the burning of fossil fuels are $CO_2$, other carbon compounds including methane ($CH_4$), and carbon monoxide (CO), sulphur dioxide ($SO_2$) and nitrogen oxides ($NO_x$). Coal combustion produces other compounds and heavy metals as well, depending on the type and quality of coal and the types of pollution control being used. $CO_2$, the most important greenhouse gas, is by far the largest in terms of quantity. Total $CO_2$ emissions since 1950.$SO_2$ is one source of acid deposition, which remains a widespread problem. Critical loads (the threshold at which acid deposition causes damage) are frequently exceeded over large parts of North America, Europe and Southeast Asia.[2]

**TABLE 1-1** **Environmental Impacts of Major Industries.**

| Sector | Air | Water | Soil/land |
|---|---|---|---|
| Coal mining and production | • Emissions of dust from extraction, storage, and transport of coal<br>• Emissions of CO and $SO_2$ from burning slag heaps<br>• $CH_4$ emissions from underground formations<br>• Risk of explosions and fires | • Contamination of surface water and groundwater by highly saline or acidic mine water | • Major surface disturbance and erosion<br>• Subsidence of ground above mines<br>• Land degradation by large slag heaps |
| Refineries, petroleum products | • Emissions of $SO_2$, $NO_x$, hydrogen sulphide, hydrocarbons, benzene, CO, $CO_2$, particulate matter, PAHs, mercaptans, toxic organic compounds, odours.<br>• Risk of explosions and fires | • Use of cooling water<br>• Emissions of hydrocarbons, mercaptans, caustics, oil, phenols, chromium, effluent from gas scrubbers | • Hazardous waste sludges from effluent treatment; spent catalysts, tars |

**Source**: UNEP, Industry and Environment. *Sustainable Energy*, 7.

[1] **Youth Employment Summit**, "*Report A: Youth Employment Opportunities in Renewable Energy*", (London, Education Development Center Inc. 2002), p. 2.

[2] **UNEP**, Report: Industry and Environment, p.7.

If the developing countries followed the conventional development path, there would be a massive increase in emissions of atmospheric pollutants. However, this need not be the case – as has been proved in some industrialized countries. For example, sulphur emissions in Europe peaked in the 1970s and then steadily declined, despite increasing energy consumption. Similarly, the implementation mechanisms developed for the Kyoto Protocol are intended to help developing countries restrict their emissions of greenhouse gases.[1]

## 3-2 *Ozone Depletion*

The depletion of ozone layer has recently become an area of major concern. Bio mechanism haven't been develop to protect from large amount of high-energy ultraviolet (UV) radiation, as most of this filtered out the ozone layer. The likely consequences of the continued loss of ozone layer in the atmosphere include a higher incidence of skin cancer and eye cataracts, and damage to land and marine vegetation by UV radiation.[2] A major contribute of the dangerous depletion of the earth's ozone layer is the building industry, as it is responsible of about 40% of airborne chlorofluorocarbons in the atmosphere.[3]

## 3-3 *Indoor Air Quality*

By far the greatest source of indoor pollution is the use of traditional cooking and heating fuels in developing countries. Some 3.5 billion people, mainly in rural areas but also in many cities, rely on biomass fuels, which produce large amounts of particulate-laden smoke and other air pollutants in the confined space of the home, creating conditions for high exposures. In such conditions, exposure to pollutants is frequently much higher indoors than outdoors. (Figure 1-3) The health threat is so serious that the World Bank has designated indoor air pollution in developing countries as one of the four most critical global environmental problems.[4]

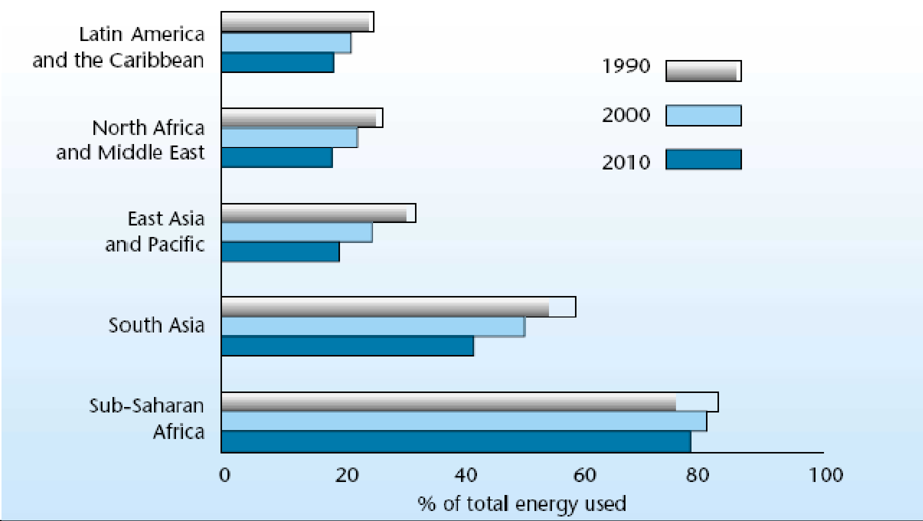



Fig. 1-3

**Current and Projected Use of Biomass for Energy.**

**Source**: *World Resources Institute* (WRI), World Resources 1998-99, on-line document, 1998.

[1] **UNEP** (1999) *Global Environmental Outlook 2000,* GEO-2000); (IEA 1998), 38.
[2] **Randall** Thomas. *Environmental Design: An Introduction For Architects and Engineers* (London: E&FN Spon, 1999),16.
[3] **Brubaker**, C.Williams." *Indoor Pollution*" Interior Design,(August 1991),86.
[4] World Resources Institute (**WRI**), *World Resources* 1998-99, on-line document, 1998.

## 3-4 *Global worming*

The past few decades have seen lots of treaties, conventions, and protocols in the field of environmental protection. As early as 1896, the Swedish scientist Svante Arrhenius had predicted that human activities would interfere with the way the sun interacts with the earth, resulting in global warming and climate change. His prediction was borne out and climate change is disrupting global environmental stability. Scientists and environmentalists have studied, over the past few years, the impact of conventional energy systems on the global environment. Due to the increased use of technology and mechanization in human activities, the delicate ecological and environmental balances are being disturbed. For instance, carbon dioxide is being pumped into the atmosphere faster than the oceans and flora can remove it and the rate of extinction of animal and plant species far exceeds the rate of their evolution.[1]

Global worming is arguably the most urgent environmental problem of today. Increased emission of carbon dioxides, CFCS methane, and other greenhouse gases are resulting in global worming. A significant potion of greenhouse gases arises from electricity generation and the specialists should strive to improve the energy efficiency of their designs to mitigate global worming[2].

The domestic use of world civilization by the energy used for water and space heating is about 25% of the total world consumption. It is this quantity which can be strongly influenced by buildings and building services, thus it is the direct responsibility of architects, and the building professions.[3]

## 3-5 *Greenhouse gases, climate change and the Kyoto Protocol*

The sun provides the energy, which drives weather and climate. Of the Solar radiation reach the earth, one third is reflected back into space; the remainder is absorbed by the land, biota, Oceans, Ice and the atmosphere. Some of the long-wave infrared radiation reflected back from the earth is re-reflected to the earth by geen house gases, and this is what causes warming of the planet (Figure1-4). [4]

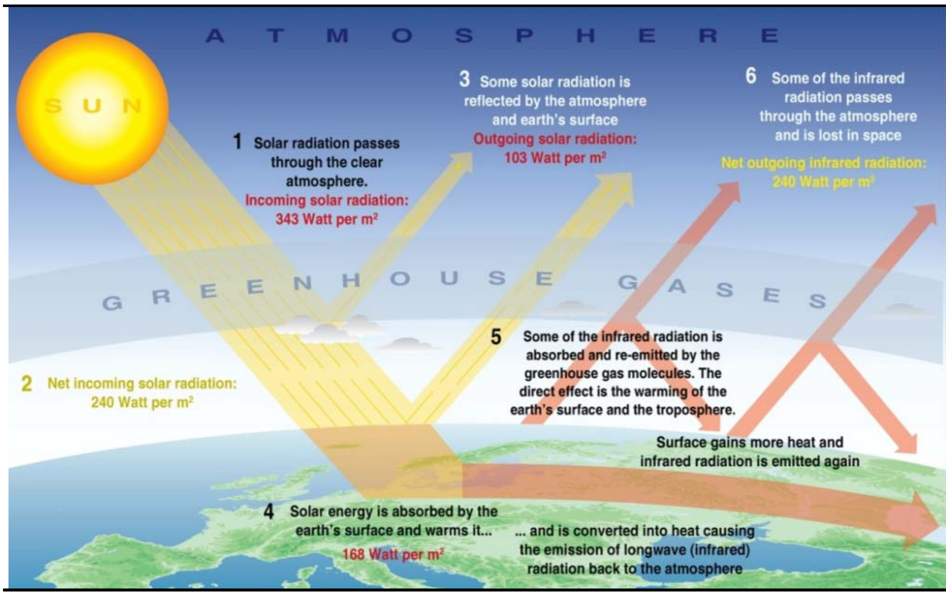



Fig. 1-4

**The Greenhouse Effect**

**Source**: **John** R. **Fanchi**. *Energy: Technology And Directions For The Future*,(Oxford, Academic Press is an imprint of Elsevier 2004),204.

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[1] **Youth Employment summit**, *Global Warming and Climate Change,* 4.
[2] **Thomas**, *Environmental Design*, 16.
[3] **S.V. Szokolay**, "*Solar Energy and Building*", (London: The Architectural press, Halsted press Division), 3.
[4] **Smith**,Peter F. and Adrian C. Pitts. "*Concept in Practice Energy: Building for the Third Millennium*", (London: B. T. Batsford Ltd., 1997), 10.

There is still no definitive proof that human activities are causing global warming, but the intergovernmental Panel on Climate Change (IPCC) says the balance of evidence suggests that there is indeed a discernible human influence on the global climate. Expected results include a shifting of climatic zones, changes in species composition and the productivity of ecosystems, an increase in extreme weather events, and temperature- and weather-related impacts on human health.

Through the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, efforts are underway to control and reduce greenhouse gas emissions. The parties to the Kyoto Protocol have developed a plan of action for using new international policy instruments such as the Clean Development Mechanism. However, implementation of the Kyoto Protocol alone will not be enough to stabilize CO2 levels in the atmosphere (TABLE 1-2 ).[1]

**TABLE 1-2** **Share of greenhouse gases in total GHG emissions ;** in Annex I countries and the contribution of the energy sector, 1995

| Gas type | $CO_2$ | $CH_4$ | $N_2O$ | Others | Total |
|---|---|---|---|---|---|
| Share | 82% | 12% | 4% | 2% | 100% |
| Contribution of energy sector | 96% | 35% | 26% | NA | 85% |
| Main source, energy sector | Fuel combustion | Fugitive fuel | Fuel combustion | NA | |

**Source**: UNFCCC, *"Second compilation and synthesis of second national communications,"* FCCC/CP/1998/11/Add. 1, September 1998

### 3-6 *Land and water impacts*

Primary energy impacts on land and water are caused by oil extraction and refining, coal mining and combustion, and dams producing hydropower. Other impacts are mainly related to use of fuel for vehicles, but they may also be caused by energy-related waste disposal, soil and water contamination by airborne pollutants, and power transmission lines. The air pollution associated with coal has had severe effects on land and water in some regions as a result of acid rain. Acid deposition, which damages both natural and man-made surfaces, can result in acidification of lakes, leading to the loss of fish populations. It has caused extensive damage to forests in many parts of Europe and North America.[2]

## 4 Problem of Environmental Degradation

The reason that global warming and climate change are considered serious global threats is that they have very damaging and disastrous consequences. These are in the form of:

- Increased frequency and intensity of storms, hurricanes, floods and droughts.
- Permanent flooding of vast areas of heavily populated lands and the creation of hundreds of millions of environmental refugees due to the melting glaciers and polar ice that causes rising sea levels.
- Increased frequency of forest fires.
- Increased sea temperatures causing coral bleaching and the destruction of coral reefs around the world.
- Eradication of entire ecosystems.[3]

[1] **UNEP**, Report: "*Industry and Environment.*" 8.
[2] **UNEP**, Report:" *Industry and Environment*" ,9 .
[3] **Youth Employment Summit**, "*Global Warming and Climate Change", 4.*

According to the IPCC assessments, if the present rate of emissions continues, the global mean temperature will increase by 1°Celsius to 3.5°Celsius compared to 1990 levels by the year 2100. The best estimate is at 2°Celsius. The IPCC concludes that:

- Concentrations of greenhouse gases could exceed 700 ppm by 2100 under the "business as usual" scenario –levels not seen on the planet for 50 million years. The projected temperature increase of 1°Celsius to 3.5°Celsius over the next 100 years could exceed rates of change for the last 10,000 years.
- Increased temperatures are expected to speed up the global water cycle. Faster evaporation will lead to a drying of soils and in some areas increased drought. Overall, however, due to the faster global cycling of water, there will be an increase in precipitation.
- Sea levels are expected to rise between 15-94 centimeters over the next century. A 50-centimeter sea level rise could double the global population at risk from storm surges- from roughly 45 million to over 90 million, even if coastal populations do not increase. Low-lying areas are particularly vulnerable.
- Human health is likely to be affected. Warmer temperatures will increase the chances of allergic disorders. Diseases that thrive in warmer climates, such as dengue fever, malaria, yellow fever, encephalitis and cholera are likely to spread due to the expansion of the range of disease-carrying organisms. By 2100, there could be an additional 50-80 million cases of malaria each year.[1]

## 5 Energy for Rural Poor Populations.

Another strong motivating risk for energy problem is the fact that about 2 billion people of the earth's population do not have access to modern energy services. Such services are pivotal for the improvement of the quality of their lives. The World Bank's World Development Report of 1992 noted that a number of health hazards threaten the lives of those children and adults who depend on traditional fuel-wood for their energy supply. In 1996, the Bank issued a major paper on improving energy supplies to this underprivileged segment of the population[2]-[3]. (Figure1-5).

Fig. 1-5

**PV Application in Remote Regions, Mongolia.**

**Source:** Volume 1 ,"*Photovoltaic Program 2002, list of projects annual reports of 2001 Officers"* NET Nowak Energy & Technology Ltd, April 2002.

[1] **Youth Employment summit**, *Global Warming and Climate Change,* 5.

[2] International Bank for Reconstruction and Development (**IBRD**). *Rural Energy and Development: Improving Energy Supplies for Two Billion People*. Development and Practice Series.( Washington, D.C. USA: IBRD, 1996).

[3] Energy Sector Management Assistance Program (**ESMAP**), *Renewable Energy Potential in Selected Countries; Volume I, Final Report,* **(**Washington: ESMAP, THE WORLD BANK 2005)

# 6 Renewable Energies as a Solution.

Access to energy is fundamental to our civilization. Economic and social developments are fuelling a growing demand for reliable, affordable and clean energy. Moreover, nearly 1.6 billion people, or roughly a quarter of the world's population, today lacks access to modern energy services. On the other hand, global energy resources are abundant and energy production, conversion and transport technologies are improving rapidly. This makes it possible to transport energy ever more efficiently over long distances and creates logistical conditions which were unimaginable just a few years ago. At the same time, environmental factors are playing an increasingly important role in shaping the global energy sector and the entire energy supply and use chain.

The natural energy resource consists of two types of resources; first one is conventional resources 'Fossil fuels' which are considered as Non-renewable Energies, and the second is The new and renewable resources which are-called *alternative energy*.

## 6-1 TYPES OF ENERGY RESOURCES

### 6-1.1 *Non-Renewable Energy*

Fossil energy and nuclear energy are considered nonrenewable energy types. Nonrenewable energy is obtained from sources at a rate that exceeds the rate at which the sources are replenished. For example, if the biogenic origin of fossil fuels is correct, we could consider fossil fuels renewable over a period of millions of years, but the existing store of fossil fuels is being consumed over a period of centuries. Because we are consuming fossil fuels at a rate that exceeds the rate of replenishment, we consider fossil fuels nonrenewable.

#### 6-1.1.1 *Fossil Fuels*

Fossil fuels have been used by civilizations for millennia. Coal was the first fossil fuel to be used on a large scale. Nef [1977] describes sixteenth century Britain as the first major economy in the world that relied on coal. Britain relied on wood before it switched to coal. Coal was an alternative for wood and was the fuel of choice during the Industrial Revolution. It was used to boil steam for steam turbines and steam engines. Coal was used in transportation to provide a combustible fuel for steam engines on trains and ships. The introduction of the internal combustion engine has allowed oil to replace coal as a fuel for transportation. Coal is used today to provide fuel for many coal-fired power plants.[1]

**a) Coal**

Coal is formed from organic debris by a process known as coalification[2]. When some types of organic materials are heated and compressed over time, they can form volatile products (water and gas) and a residual product (coal). In some cases, a high-molecular-weight, waxy oil is also formed. The most abundant and widely distributed fossil fuel is coal- which can provide an affordable, reliable, and safe source of energy for hundreds of years, but today it faces serious environmental challenges.[3]

Although there are advanced clean coal technologies, which significantly reduce emissions from coal-fired power generation plants, their costs are high. This will inevitably inhibit their wider deployment in the

[1] **John** R. **Fanchi**, "*Energy: Technology and Directions for the Future, chapter 6"* (Oxford, Academic Press is an imprint of Elsevier 2004), 159.
[2] ***Coalification*** :is the process that Organisms form coal when subjected to coalification includes algae, phytoplankton and zooplankton, and the bacterial decay of plants and, to a lesser extent, animals.
[3] **John** R. 2004, Energy*: "Technology and Directions for the Future", 161* .

regions and countries where the use of coal is expected to grow most. Moreover, the issue of the high $CO_2$ emissions of coal-fired plants compared to gas-fired combined cycle technologies remains unresolved.[1]

### b) Oil

The past couple of years have clearly demonstrated the volatile nature of oil and the world's continuing dependence on this leading energy resource. The doubling of oil prices during the last few years has not, however, been caused by dwindling reserves. The Survey demonstrates that global reserves of oil are still large enough to meet the demand for the next few decades, and the continuous improvement in exploration, processing, conversion and end-use technologies may extend this period even further. Concentration of oil resources in a few regions and long supply routes to the main markets are at the heart of the issue.[2] ( Table 1-3 ) illustrates the elemental composition of petroleum fluids.

**TABLE 1-3**

**Elemental Composition Of Petroleum Fluids.**

| Element | Composition (% by mass) |
|---|---|
| Carbon | 84%–87% |
| Hydrogen | 11%–14% |
| Sulfur | 0.6%–8% |
| Nitrogen | 0.02%–1.7% |
| Oxygen | 0.08%–1.8% |
| Metals | 0%–0.14% |

**Source**: John R. Fanchi. *Energy: Technology And Directions For The Future*,(Oxford, Academic Press is an imprint of Elsevier 2004),165.

### c) Natural Gas

Global natural gas reserves are large and currently yield a reserve/production ratio of 50 to 60 years. It is widely expected that in the coming 2-3 decades natural gas will overtake oil as the most important energy resource in the world. Few, however, realize that this would be a huge challenge, not least due to the enormous investment requirement. Where will the necessary investment come from? The most prominent project in the gas industry so far, the development of the Troll gas field in the Norwegian part of the North Sea, has cost billions of Euros to implement. Such investment would have hardly been possible on the basis of spot market prices.[3]

### d) Uranium and Nuclear

The first commercial nuclear power plant was built on the Ohio River at Shippingport, Pennsylvania, a city about 25 miles from Pittsburgh. It began operation in 1957 and generated 60 MW of electric power output. Today, nuclear power plants generate a significant percentage of electricity in some countries. lists the top ten producers of electric energy from nuclear energy and their percentage of the world's total electric energy production from nuclear energy for the year 2000.[4]

Nuclear power's share of worldwide electricity supplies has been steady at 16–17% for many years, but it is expected to decline as old plants are de-commissioned and only a few new ones built. Reactor safety, waste disposal and plant decommissioning are still matters of concern.[5]

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[1] **World Energy Council**, *2004 "Survey of Energy Resources*" (Oxford, Academic Press of Elsevier 2004),p. xiii.
[2] I bid, p. xiv.
[3] I bid, p. xiv.
[4] **John** R. "*Energy: Technology and Directions for the Future",323*.
[5] World Energy Council, *2004" Survey of Energy Resources"*, p.xiv.

## 6-1.2 *Renewable Energy*

Although the worldwide production of renewable energy is expected to grow quickly, its share of the global energy mix will hardly increase. The Seven main types are reviewed in the following:

### a) Hydropower

Energy from the water in rivers and streams is known as hydropower, or hydroelectric power. Hydropower is among the most widely used forms of renewable energy in the world. It accounts for about 20% of worldwide electricity supply. The most common way in which a hydro-electric power plant works can be summarized in the following Figure (1-6)

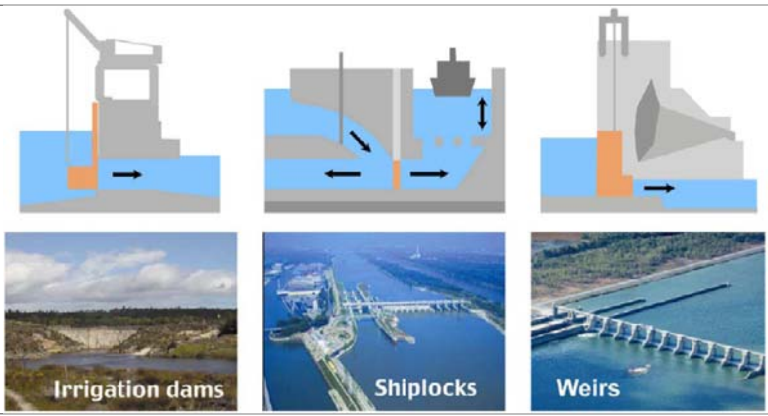



Fig. 1-6

**Principles of Hydroelectric Power Generation, and Typical applications of dams.**

**Source**: John R. Fanchi. *Energy: Technology And Directions For The Future*,46, **World Energy Council**, *2004 Survey Of Energy Resources*, 205.

energy is released when water falls through a vertical distance (called "head", measured in meters) and this energy moves turbines which produce electricity (Figure 1-6). The magnitude of the electricity produced by a hydropower plant depends on the head and on the flow (the volume of water per unit of time, measured in cubic meters per second), the greater the head and the flow, the greater the amount of electricity that can be generated. [1]

However, the drawback of hydropower is that damming rivers can change the ecology of the region. For example, it could result in changing natural river flows, degrading the water quality, blocking seasonal fish migration, impacting fisheries, flooding large areas of land, and affecting plants that grow along the river banks.

### b) Wind

Winds are created when various layers of the atmosphere absorb different amounts of heat and expand differently. For centuries, wind has been used to sail ships, grind grains, and pump water. To produce the maximum electricity possible, wind turbines need to be located in areas where the wind blows at a constant speed. Large groups of wind turbines, called wind farms or wind plants, are connected to electric utility power lines and provide electricity to many people. An advantage of wind turbines over some other forms of renewable energy is that they produce electricity whenever the wind blows (at night and also during the day). However, even in the windiest of places, the wind does not blow all the time. Therefore, small wind systems need back up batteries. Hillsides, hill tops and open places are the best locations to set up wind turbines.[2]

Improved turbine designs and plant utilization have contributed to a decline in large-scale wind energy generation costs from 35 cents per kWh in 1980 to less than 5 cents per kWh in 1997 in favorable

[1] **Youth Employment summit**, "*Forms of Renewable Energy", 24.*
[2] **Ibid,** p. 22.

locations (**Figure 1-7**). At this price, wind energy has become one of the least-cost power sources. Major factors that have accelerated the wind-power technology development are as follows:

- *High-strength fiber composites for constructing large low-cost blades.*
- *Falling prices of the power electronics.*
- *Variable-speed operation of electrical generators to capture maximum energy.*
- *Improved plant operation, pushing the availability up to 95 percent.*
- *Economy of scale, as the turbines and plants are getting larger in size.*
- *Accumulated field experience (the learning curve effect) improving the capacity factor.*[1]

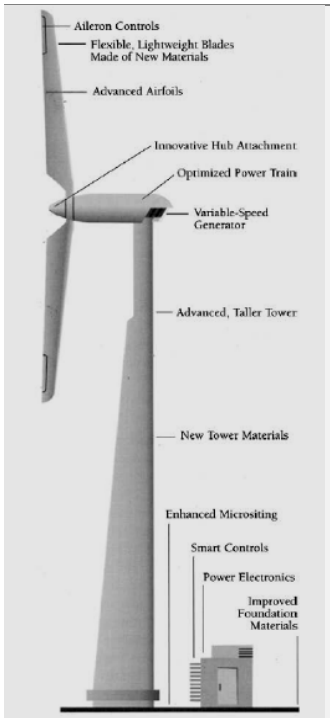



Fig. 1-7
**Modern Wind turbien for utility scale power generation.**

**Source**: **Mukund** R. Patel. *Wind and solar power systems*, (New York, CRC Press LLC, 1999) chapter2,25.

### c) Geothermal

The earth's interior is subdivided into a crystalline inner core, molten outer core, mantle, and crust. Basalt, a dark volcanic rock, exists in a semi-molten state at the surface of the mantle just beneath the crust. Drilling in the earth's crust has shown that the temperature of the crust tends to increase linearly with depth. Geothermal energy can be obtained from temperature gradients between the shallow ground and surface, subsurface hot water, hot rock several kilometers below the earth's surface, and magma. Magma is molten rock in the mantle and crust that is heated by the large heat reservoir in the interior of the earth. In some parts of the crust, magma is close enough to the surface of the earth to heat rock or water in the pore spaces of rock. The heat energy acquired from geological sources is called *geothermal energy*. Magma, hot water, and steam are carriers of energy (**Figure 1-8.a.b.c** ).[2]

*Geothermal Energy* is an important renewable resource and it can be utilized for base-load electricity production. The best geothermal fields are located within well-defined belts of geologic activity. Geothermal energy converting systems are able to provide electricity with an annual capacity factor of over 90%. The issue of geothermal problem that the availability of technologies able to tap the resource economically.[3] In the near future, the growth rate will most probably be 3–4% annually, as has been the case during the past few years.[4]

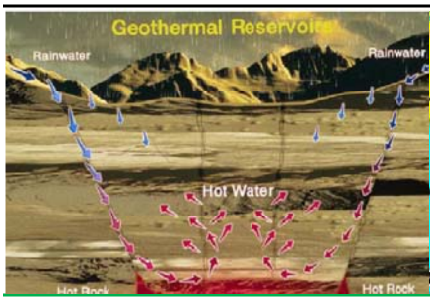



Figure 1-8.a
**Representative Geothermal Reservoir.**
**Source**: World Energy Council, *2004 Survey Of Energy Resources*, 336.

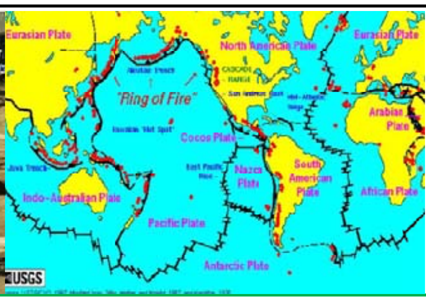



Figure 1-8.b
**World Map Showing Lithospheric Plate Boundaries,U.S. Geological Survey.**
**Source**: World Energy Council, *2004 Survey Of Energy Resources*, 337.

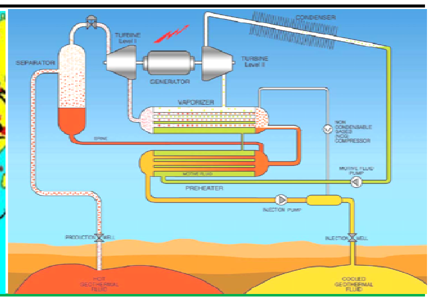


Figure 1-8.c
**Air-Cooled Binary Plant ,Ormat.**
**Source**: World Energy Council, *2004 Survey Of Energy Resources*, 337.

1 **Mukund** R. Patel. *Wind and solar power systems*, (New York, CRC Press LLC, 1999) chapter2, 24.
2 **John** R. **Fanchi**. 2004, *Energy: Technology and Directions for the Future*, 117.
3 **World Energy Council**, *2004 Survey of Energy Resources*, 335.
4 **Ibid**,p. 343.

## d) Solar Radiation

Each day more energy reaches the earth from the sun than would be consumed by the globe in 27 years. Solar energy is renewable as long as the sun keeps burning the massive amount of hydrogen it has in its core. Even with the sun expending 700 billion tons of hydrogen every second, it is expected to keep burning for another 4.5 billion years. Solar energy comes from processes called solar heating, solar water heating, photovoltaic energy and solar thermal electric power. [1]

Figure 1-9 shows an 'exemplary path' to 2050/ 2100 studied by the German Advisory Council on Global Change, which points, in the long term, to a major contribution to global energy consumption from solar energy. This scenario, which will be published in full in the first half of 2004, is based on the recognition that it is essential to turn energy systems towards sustainability worldwide, both in order to protect the natural life-support systems on which humanity depends and to eradicate ***energy poverty in developing countries***.

By 2100 oil, gas, coal and nuclear, as shown in (Figure 1-9) should cover less than 15% of world energy consumption while solar thermal and photovoltaic should cover about 70%. Key elements of this long-term scenario are the energy efficiency and energy intensity policies that will make the contribution of renewable and solar energy a substantial factor. Those policies will deeply transform the building, industry and transport sectors, increasing their reliance on renewable energy resources.[2]

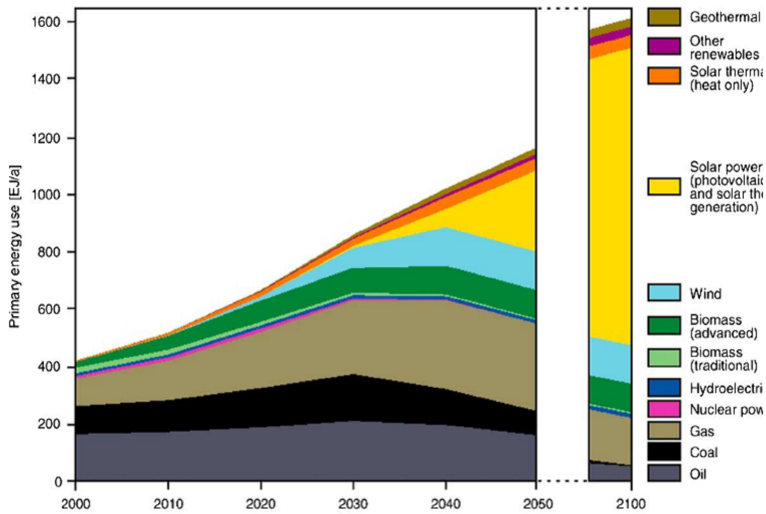



Figure 1-9

**Transforming The Global Energy Mix: The Exemplary Path To 2050/2100**

**Source**: German Advisory Council on Global Change, 2003. *World in Transition-Towards Sustainable Energy Systems*. Summary for Policy Makers.

Buildings are already the largest human fabric intercepting solar radiation and, therefore, potentially, a driving sector for the development of solar energy use.[3] The most widely used solar systems for the production of electricity, heat and fuels are: ***Solar Photovoltaic Systems (PV), Solar Thermal Systems, Solar Thermal Power Plants, Solar Energy Storage Systems.***

## e) Ocean & Waves

Ocean energy draws on the energy of ocean waves, tides or on the thermal energy stored in the oceans. it cover more than two thirds of the Earth's surface, and are thus the world's largest solar collectors. The heat from the sun warms the surface of the water more than it warms the waters in the deep ocean. This temperature difference between the surface water and the deep ocean water creates ***thermal energy***, which can be used for many applications including electricity generation.[4]

[1] **Youth Employment summit**, *Forms of Renewable Energy,* 17.
[2] **World Energy Council**, *2004 Survey of Energy Resources*, 296.
[3] **John** R. Fanchi.2004, *Energy: Technology and Directions for the Future*, Solar Energy,214 .
[4] World Energy Council, *2004 Survey of Energy Resources*, 401.

Since this form of energy is available on 70% of the earth's area, more research is necessary to exploit and use it in the process of sustainable development. As the main source of energy from the oceans is through the sun's rays, ocean energy systems offer certain advantages. They have no fuel costs, and do not release greenhouse gases into the atmosphere. However, the technologies for tapping ocean energy are very expensive with high initial costs and so have not been implemented on a large scale worldwide ( Figure 1-10.a.b.c).[1]

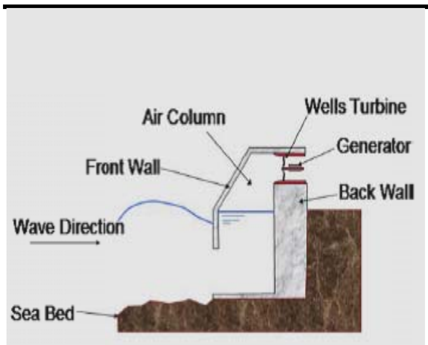



Fig. 1-10.a
**Mini Oscillating Water Column** (schematic).

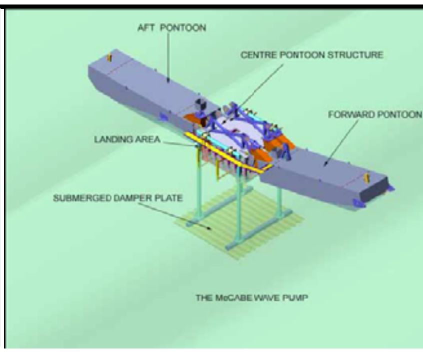



Fig. 1-10.b
**The McCabe Wave Pump.**
**Source**: *IEA-Ocean Energy Systems Newsletter*

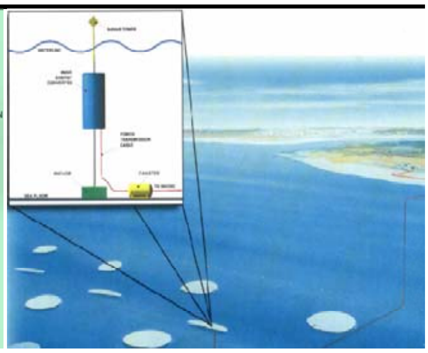


Fig. 1-10.c
**The PowerBuoyTM**
**Source**: *Ocean Power Technologies.*

## f) Bio-Energy

Bioenergy is the energy from biomass or organic matter such as wood. Biomass has been used for thousands of years, right from the time people started burning wood to cook food or to keep warm. Even though wood, in various forms, is still the largest biomass resource for bioenergy, there are now other sources such as agricultural residues, plants, and waste materials. Even though the use of bioenergy generates as much carbon dioxide as fossil fuels, each new plant that grows removes carbon dioxide removed from the atmosphere, thereby maintaining an ecological balance, with net emissions being close to zero if new plants are grown each time an old one is burnt. To increase agricultural profits while at the same time maintain environmental balances, fast growing trees and grasses can be planted. These plants are called ***Bioenergy Feedstocks***. [2] It can be classified into three main categories: (i) *woodfuels*, (ii) *agrofuels*, and (iii) *fuels* derived from urban waste. Bioenergy can also be classified according to a chosen technology route, as (i) *traditional applications* (e.g. firewood and charcoal) and (ii) *modern uses* (e.g. electricity generation and combined heat and power (CHP). Modern applications are rapidly replacing traditional uses, in particular in industrial countries, e.g. in Finland and Sweden 15–20% of their primary energy is generated from biomass.

## g) Waste Material

Municipal solid waste has the potential to be a large energy source. In addition, it mitigates the problem of waste disposal especially in countries where there is not enough landfill space to dump the waste. This municipal solid waste can be burnt in large power plants to generate electric power. Municipal waste-to-energy plants currently generate about 2500 megawatts of electricity. There is also another way to trap the energy in garbage. When food scraps and wastes decay, methane, a greenhouse gas with 22 times the global warming potential of carbon dioxide is produced. It can be collected, cleaned and burnt to produce steam in a boiler or power generators to produce electricity.

[1] Youth Employment summit, *Forms of Renewable Energy,* 26.
[2] Youth Employment summit, *Forms of Renewable Energy,* 27.

## ▪ CONCLUSION

Forecasting scenarios of energy in entire twenty-first century; was not only the main guide for the recent global trends towards renewable energy, the fact that the depletion of fossil fuels and its environmental consequences is also considered (Figure 1-11). The last summit of the greatest eight industrialized countries in July 2009; recommends the rapid development and utilizations of renewable energy's Researching and Development (R&D) and its applications regarding the reduction of $CO_2$ emissions to 50% by the year 2020. Consequently, Egypt announced immediately, promotion and developing *new thousand acres for renewable energy* applications in Suez Canal region, In additions, the projected solar Photovoltaic plant uses efficient PV modules( Concentrator Tech.) in western desert . Hereby, it demonstrates *the serious strides towards the development and utilization of RE in Egypt.*

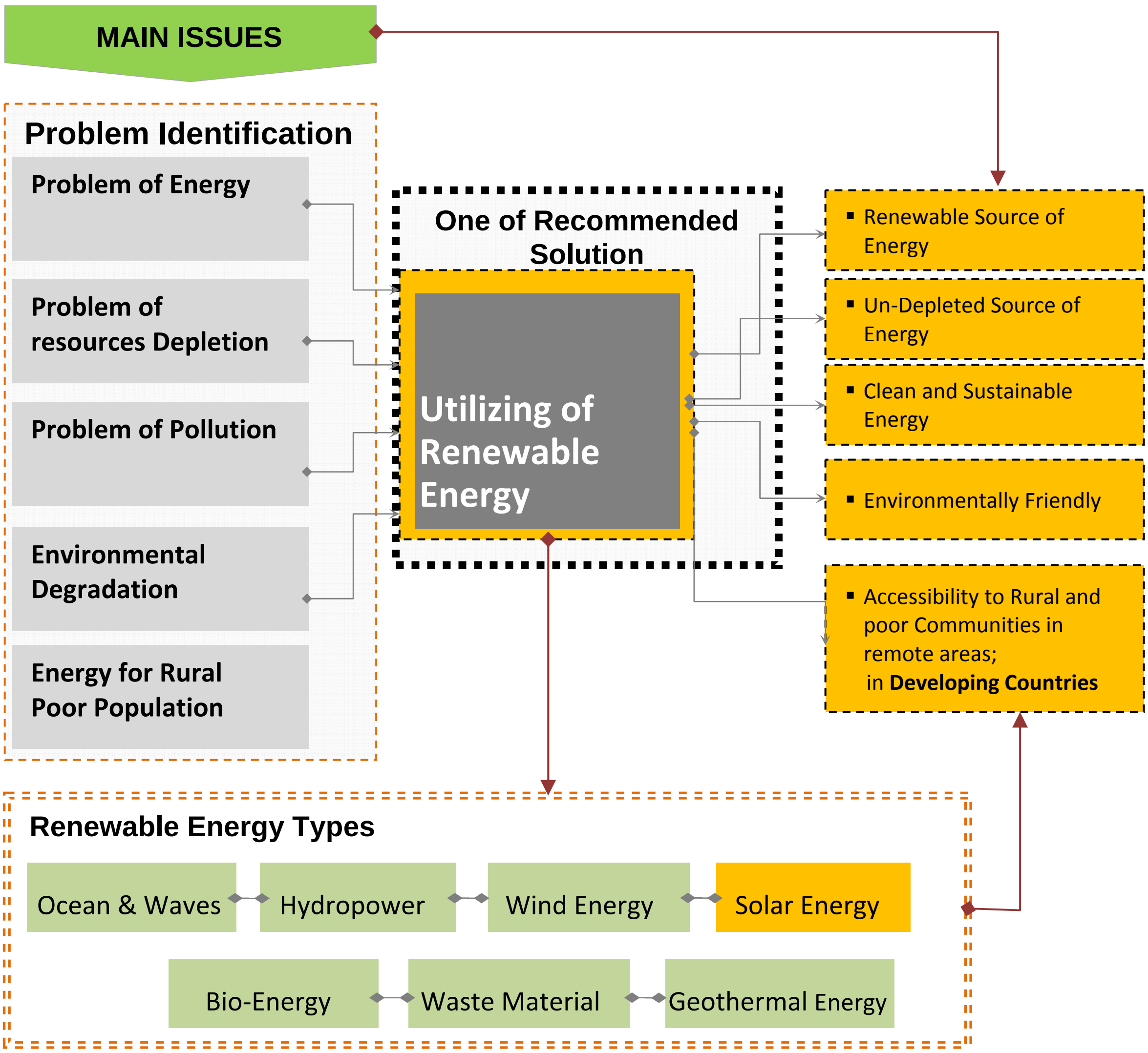



Figure: 1-11

**Research Problems and Trends for Using Renewable Energy as One of Recommended Solution Especially in Developing Countries.**

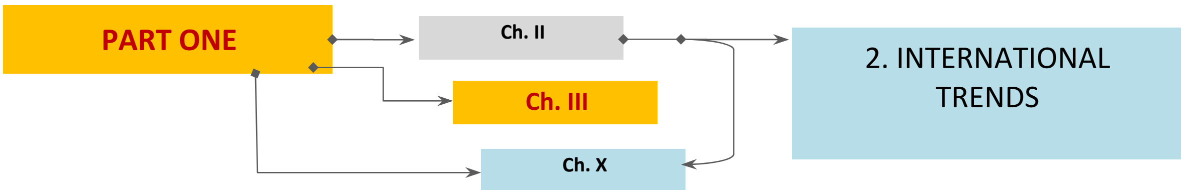
# CHAPTER

# III

**SOLAR ENERGY;**

RENEWABLE &

SUSTAINABLE OPTION



# Chapter III. SOLAR ENERGY; RENEWABLE SUSTAINABLE OPTION

Energy is the potential for carrying out work and is measured in the same units as work. In the System International (SI) this unit is derived from the three basic assumed and agreed units: length, mass and time. The logical way of this derivation is useful also to show the relationship of the physical quantities themselves.

When the rate of energy flow of 1 W is maintained for an hour (3600 seconds), the amount of energy spent is 1 Wh (watt-hour). Thus Wh is an energy unit, of the same physical dimension as

J: 1 Wh = 3600 J

Although the officials 1 unit of energy or work is the Joule, we adopt the watt-hour (Wh) as a much more practical unit. Its multiple, the kWh is in general use as a unit of electricity. Even the non-scientific mind can get a 'feel' of its' magnitude:

- *A 1 kW electric bar heater, used for one hour, consumes 1 kWh electricity and (emits 1 kWh of heat.*
- *A 100w incandescent electric lamp used for 10 hours consumes 1kwh electricity and emits some 950w of heat and 50w of light.*[1]

*The following Table (1-4 ) illustrates the identification of Energy units and relationship of physical quantities;*

**TABLE: 1-4** **Identification of Energy Units and Relationship of Physical Quantities**

| | | |
|---|---|---|
| **Length** | | **m** (meter) |
| **Mass** | | **kg** (kilogram) |
| **Time** | s (second) | |
| **Velocity** | the length of movement in unit time | **m / sl** |
| **Acceleration** | change of velocity in unit time | **m / s2** |
| **Momentum** | the state of a body, the product of its mass and its velocity | **kg m / s** |
| **Force** | measured by its effect: the change in momentum per unit time, or the acceleration given to unit mass: | **kg m / s2** |
| | This unit is known as the Newton: | **N** |
| **Work, energy** | measured as the product of a force and the distance over which it has acted: N x m: | **kg** m2/s2 |
| | This unit is known as the Joule: | |
| **Power** | measured as the rate at which work is done or the rate of energy flow: | **kg m2 / S3** |
| | or J/s, known as Watt: | **W** |

**Source**: **Szokolay**, S.V. *Solar Energy and Building*,(New York: The Architectural press, Halsted press Division,2004),5.

[1] **Szokolay**, S.V. "Solar *Energy and Building"*, (New York: The Architectural press, Halsted press Division, 2004), p. 3.

# 1 Why Solar Energy

***What is happening in the built environment around us?*** We are witnessing an essential change in society. Governments are spending hundreds of millions of dollars on research, development and the demonstration of renewable energy. Big oil companies such as BP Amoco and Shell have invested more than a billion dollars in solar energy. Current developments show that renewables, *such as solar energy systems*, will be incorporated into our daily life in the near future, as conventional energy sources become depleted and environmental concerns grow.[1]

Solar energy is low-density energy by nature. To utilize it on a large scale, a massive land area is necessary. One third of the land surface of the Earth is covered by very dry desert and high-level insulation (in-coming solar radiation), where there is a lot of available space. It is estimated that if a very small part of these areas. Approximately 4 %, was used for installing photovoltaic (PV) systems, the resulting annual energy production would equal world energy consumption. Apparent from the perspective of the global energy situation, global warming and other environmental issues that solar energy systems can:

- contribute substantially to global energy needs;
- become economically and technologically feasible;
- Contribute considerably to the environment; and contribute considerably to socio-economic development.[2]

On other hand, from The ***Architectural perspective***; in the early 1970s as a result of the two oil crisis, solar architecture gained in impotence. The attention was initially focused entirely on devices such as collectors or photovoltaic installations on the roof. However, a building must be understood as a complex configuration - *a total energy concept* - that makes the best possible use of locally available natural resource such as ***solar energy, wind*** *and* ***geothermal energy*** *for variety of requirements*.[3]

Within a short period of time, solar systems will become an integral part of our society, and thus our environment. There are large incentives for urban planners and architects to incorporate these techniques into their design. New products are emerging, yet need further developments to fully meet the architectural needs for sustainable buildings. Architects therefore need to start thinking about this new *Smart Solar Architecture*.[4]

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[1] **Reijenga** T, *"The Changing Cities Of Europe"*, Proc Sustain 99, Amsterdam (1999).

[2] **Kurokawa,** Kosuke.,**Komoto**,Van der **Vleuten**, **Faiman**; *Energy From The Desert :Practical Proposals For Very Large Scale Photovoltaics Systems* ( Earth Scan , London, UK, 2007 ),1.

[3] **Schittich**,Christian(ed). *In Detail: Solar Architecture Strategies, Visions, and Concept,* (Birkhauser publisher Berlin, Germany, 2003), 9.

[4] **Reijenga** T., ***BEAR*** *Architects,* "*Photovoltaic in Architecture, Gouda ",* 2002.

# 2 Energy Forecasting Scenarios

## 2-1 *SCHOLLNBERGER'S FORECASTS*

Forecasts of the twenty-first century energy mix show that a range of scenarios is possible. The forecast discussed here is based on Schollnberger's forecasts[1], which were designed to cover the entire twenty-first century and predict the contribution of a variety of energy sources to the twenty-first century energy portfolio. Schollnberger's forecast is worth studying because it uses more than one scenario to project energy consumption for the entire twenty-first century. Schollnberger considered three forecast scenarios:

A. *"Another Century of Oil and Gas" corresponding to continued high hydrocarbon demand*

B. *"The End of the Internal Combustion Engine" corresponding to a low hydrocarbon demand scenario*

C. *"Energy Mix" corresponding to a scenario with intermediate demand for hydrocarbons and an increasing demand for alternative energy sources.*

Schollnberger viewed scenario C as the most likely scenario. It is consistent with the observation that the transition from one energy source to another has historically taken several generations. Leaders of the international energy industry have expressed a similar view that the energy mix is undergoing a shift from liquid fossil fuels to other fuel sources.

There are circumstances in which scenarios A and B could be more likely than scenario C. For example, scenario B would be more likely if environmental issues led to political restrictions on the use of hydrocarbons and an increased reliance on conservation. Scenario B would also be more likely if the development of a commercially competitive fuel cell for powering vehicles reduced the demand for hydrocarbons as a transportation fuel source. Failure to develop alternative technologies would make scenario A more likely. It assumes that enough hydrocarbons will be supplied to meet demand. [2]

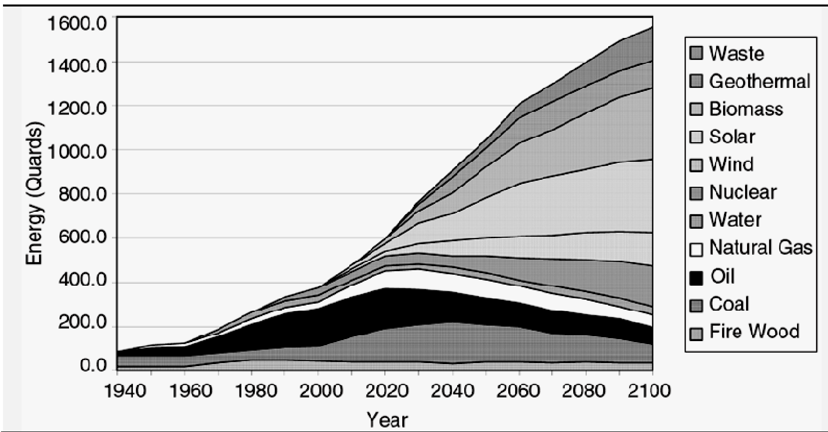


Figure 1-12

**Forecast Of Twenty-First Century Energy Consumption.**

**Source**: Fanchi, R. John. *Energy: Technology and Directions for the Future*, p.450

Scenario C shows that natural gas will gain in importance as the economy shifts from a reliance on hydrocarbon liquid to a reliance on hydrocarbon gas. Eventually, renewable energy sources such as biomass and solar energy will displace oil and gas (Figuer 1-12).

[1] Schollnberger, W.E., 1999, "*Projection of the World's Hydrocarbon Resources and Reserve Depletion in the 21st Century; The Leading Edge*, (May 1999), 622–625

[2] Fanchi, R. John. *Energy: Technology and Directions for the Future, chapter 15*(Oxford, Elsevier 2004), 449.

## 2-2 *Alternative forecasts*

The forecasts presented above are just a sampling of the twenty-first century energy forecasts that are appearing in the literature. It is instructive to note two other energy scenarios: ***a nuclear energy scenario*** [Hodgson, 1999[1]] and ***a renewable energy scenario*** [Geller, 2003[2]]. These scenarios illustrate the range of perspectives that must be considered in deciding global energy policy.

Hodgson presented a scenario in which the world would come to rely on nuclear fission energy. He defined five objective criteria for evaluating each type of energy: capacity, cost, safety, reliability, and effect on the environment. The capacity criterion considered the ability of the energy source to meet future energy needs. The cost criterion considered all costs associated with an energy source. The safety criterion examined all safety factors involved in the practical application of an energy source. This includes hazards associated with manufacturing and operations. The reliability criterion considered the availability of an energy source. By applying the five objective criteria, Hodgson concluded that nuclear fission energy was the most viable technology for providing global energy in the future. According to Hodgson, nuclear fission energy is a proven technology that does not emit significant amounts of greenhouse gases. He argued that nuclear fission reactors have an exemplary safety record when compared in detail with other energy sources. *Breeder reactors*[3] could provide the fuel needed by nuclear fission power plants, and nuclear waste could be stored in geological traps. The security of nuclear power plants in countries around the world would be assured by an international agency such as the U.N. [4]

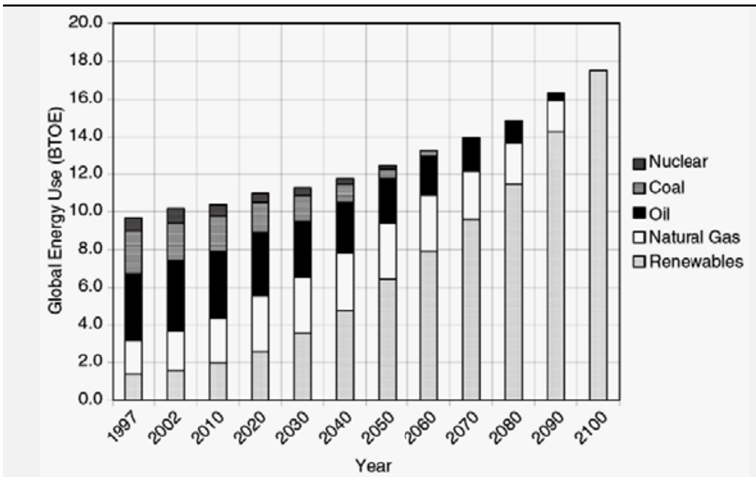


Figure 1-13

**Forecast of a twenty-first century energy mix that eventually relies on renewable energy only.**

Billions of Tons of Oil Equivalent (**BTOE**).

**Source**: Geller, H., *Energy Revolution*, (Washington: Island Press, 2003), 227.

In this nuclear scenario, renewable energy sources would be used to supplement fission power, and fossil energy use would be minimized. Hodgson did not assume that the problems associated with nuclear fusion would be overcome. If they are, nuclear fusion could also be incorporated into the energy mix. The nuclear fission scenario articulated by Hodgson contrasts sharply with the renewable energy scenario advocated by Geller [2003]. Geller sought to replace both nuclear energy and fossil energy with renewable energy only. An important objective of his forecast was to reduce greenhouse gas emissions to levels that are considered safe by the Kyoto protocol. (Figure 1-13) summarizes Geller's energy forecast. The figure shows global energy use as a function of time.

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[1] **Hodgson**, P.E.," *Nuclear Power, Energy and the Environment"*, (London: Imperial College Press, UK, 1999).
[2] **Geller**, H.," *Energy Revolution"*, (Washington: Island Press,2003)
[3] **A Breeder Reactor**: is a nuclear fission reactor that produces more fissile material than it consumes, and it is isotopes that can be used in the fission process include the fission products plutonium-239 and thorium-232.
[4] **Fanchi**, R. **John**., Elsevier 2004, *chapter 15,* 454.

# 3 (RE) Initiatives , Trends, and Obstacles

Renewable energy is recognized as one solution for global energy problem, however, the presented solutions cover several of human daily activities whether, industrial, commercial and residential areas. From this point, many applications, trends and obstacles of renewable energy will be presented in the following context.

- ***Renewable electricity generation capacity*** *reached an estimated 240 gigawatts (GW) worldwide in 2007, an increase of 50 percent over 2004. Renewables represent 5 percent of global power capacity and 3.4 percent of global power generation.*
- *Renewable energy generated as much* ***electric power*** *worldwide in 2006 as one-quarter of the world's nuclear power plants, not counting large hydropower. (And more than nuclear counting large hydropower.)*
- *The largest component of renewables generation capacity is* ***wind power***, *which grew by 28 percent worldwide in 2007 to reach an estimated 95 GW. Annual capacity additions increased even more: 40 percent higher in 2007 compared to 2006.*
- *The fastest growing energy technology in the world is* ***grid-connected solar photovoltaics (PV)***, *with 50 percent annual increases in cumulative installed capacity in both 2006 and 2007, to an estimated 7.7 GW. This translates into 1.5 million homes with rooftop solar PV feeding into the grid worldwide.*
- *Rooftop* ***solar heat collectors*** *provide hot water to nearly 50 million households worldwide, and space heating to a growing number of homes. Existing solar hot water/heating capacity increased by 19 percent in 2006 to reach 105 gigawatts-thermal (GWth) globally.*
- ***Biomass and geothermal energy*** *are commonly employed for both power and heating, with recent increases in a number of countries, including uses for district heating.More than 2 million groundsource heat pumps are used in 30 countries for building heating and cooling.*
- *Production of* ***biofuels*** *(ethanol and biodiesel) exceeded an estimated 53 billion liters in 2007, up 43 percent from 2005. Ethanol production in 2007 represented about 4 percent of the 1,300 billion liters of gasoline consumed globally. Annual biodiesel production increased by more than 50 percent in 2006.*
- ***Renewable energy***, *especially small hydropower, biomass, and solar PV, provides electricity, heat, motive power, and water pumping for tens of millions of people in rural areas of developing countries, serving agriculture, small industry, homes, schools, and community needs. Twenty-five million households cook and light their homes with biogas, and 2.5 million households use solar lighting systems.*
- ***Developing countries*** *as a group have more than40 percent of existing renewable power capacity,more than 70 percent of existing solar hot watercapacity, and 45 percent of biofuels production.* [1]

[1] Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2007 Global Status Report*, (Washington, DC: Worldwatch Institute, 2008), 6.

## 3-1 *Plans and Initiatives*

Throughout the previous scenarios of energy forecasts, the following points will discuss the global plans and approaches for solving energy problem, which are highlighted in the following points; [1]

- *Energy efficient design.*
- *Renewable energy use.*
- *Assessing potential renewable energy projects.*
- *Beyond petroleum: towards a biomass-based energy future.*
- *Sustainable energy technologies.*
- *International Renewables and sustainable rural electrification.*
- *Developing the capacity to reduce environmental impacts of energy consumption.*

### 3-1.1 The 1994 Solar Initiative

Several units in the World Bank Group have been working in developing standalone projects or project components featuring renewable energy applications. These include technical departments and operational divisions in the Asia, Africa, Latin America, South Asia, and Middle East regions. The term "Solar Initiative," originally referred to a program launched by the Energy Department Power Division (IENPD) in the spring of 1994 to refer to the collective efforts of all units Bank-wide in renewable energy development. ***The Solar Initiative was established with two major objectives;***

(a) *To provide active support to the Bank's regional units for the identification and preparation of renewable energy (RE) projects that are commercial or near-commercial.*
*(b) To play a coordinating, strategic, and catalytic role in removing barriers that impede the introduction of renewable and other environmentally sustainable technologies in developing countries, including facilitation and coordination of international activities in Research, Development, and Demonstration (RD&D).* [2]

The Concept of a Solar City: A working definition of a Solar City is a city that aims at reducing the level of greenhouse gas emissions through a holistic strategy for the introduction of RES and the RUE to a climate stable and thus sustainable level in the year 2050 [3]. Some of the stated goals of the emerging Solar Cities concept include:

- Lowering of greenhouse gas emissions by the year 2050 to an amount equal to a city's 1990 population level multiplied by 3.3 tonnes of CO2. [3] This target is based on fundamental equity calculations that each person has only an annual 3.3 tonnes emissions 'allowance', in order to allow oceans and forests to neutralise excessive carbon emissions.[4]
- Identifying near- and medium-term milestones for greenhouse gas reductions according to a schedule for the years 2005–2050.
- Identifying corresponding improvements in the transformation of energy production to solar and other renewable systems, reduced energy consumption, reduced consumption of natural resources,

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[1] **UNEP**, Industry and Environment, "*Sustainable Energy: Energy efficiency, Renewable energy sources, Alternative fuels and technologies, Energy and climate change, Energy in developing countries*". (Paris: UNEP DTIE 2000).
[2] Youth Employment summit. *Report A: youth Employment Opportunities in renewable Energy*, (London, Education Development Center Inc. 2002) P.16.
[3] Droege, P. (2002) *Solar City*, Retrieved on 30 May 2003 from the World Wide Web: http://www.solarcity.org/solarcity/contents.htm
[4] Byrne, J., Wang, Y.-D., Lee, H. and Kim, J.D. (1998) An Equity- and Sustainability-Based Policy Response to Global Climate Change. *Energy Policy*, **26(4)**: 335–343.

protection and improvement of urban environmental quality, improvement of social equity and improved quality of life.

The Oxford Solar Initiative (OSI) Focus areas (One of the Recent Initiatives)

- The OSI emerges from a new generation of research and development that seeks city-wide applications of renewable energies and other means of greenhouse gas emissions reductions and absorption that will be applied in a coherent spatial and social context, as well as within community-wide framework.
- The OSI proposes three areas of focus. They have to be advanced simultaneously. These are briefed below. [1]

### 3-1.2 *Barriers to the Adoption of Renewable Energy in Developing Countries*

There are several barriers in the form of limited information, lack of technical skills and institutional capacity, prohibitive costs, and inaccessibility to technology. These make it difficult to adopt renewable energy in Developing and poor countries.

- *Lack of Information: Rural communities frequently have limited access to existing knowledge bases that promote the use of renewable energy through economically and financially sustainable models.*
- *Lack of Technical or Commercial Skills: Even if they have the above-mentioned knowledge base, rural communities, and their youth frequently lack the skills, experience , information, and technical know-how to maintain and service the equipment to produce and promote renewable energy.*
- *Inaccessibility of Technology: Rural communities often do have access to renewable energy technologies and thus may not understand these technologies or the technical assistance to support its promotion and adoption. In off-grid areas, there is a natural market for services that may be tapped into by young people marketing and maintaining renewable energy systems, in coordination with larger efforts to provide renewable energy systems to those areas.*
- *Lack of Institutional Capacity for Promoting Renewable Energy: Throughout the developing world there is a lack of institutions serving developers that have expertise in renewable energy technologies and business development. There is therefore a need to find ways of integrating development initiatives, where possible, with capacity building exercises.*
- *Risk Involved with High Costs: Some forms of renewable energy are very expensive to produce and local institutions cannot afford to adopt these without adequate financial support from other organizations. Businesses are not always ready to invest in renewable energy technologies because of the lack of a guarantee that it will become commercially viable or profitable.*
- *Youth employment in the area of renewable energy: the lack of youth involvement. Young people generally have the energy, the vision and the belief to get involved with new and innovative projects. However, in the majority of poor countries,*
- *Lack of infrastructure to support youth employment projects: and youth are not provided the necessary coaching, trust and enabling environment to make viable contributions to the local economy and environment. To be able to link sustainable development and youth employment, there is a pressing need to involve youth in to this project.*[2]

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[1] **Mike** J. , **Nicola** D., *"Future forms and Design For sustainable Cities"* (Elsevier :Architectural Press , 2005),p.355.

[2] Youth Employment summit. *Report A: youth Employment Opportunities in renewable Energy*, (London, Education Development Center Inc. 2002) P.42.

### 3-1.3 Issues in Harnessing Renewable Energy

The various renewable energy technologies available are not uniformly mature or cost effective. However, most forms of renewable energy still have a significant way to go before they become competitive with fossil fuel technologies, especially for power generation. This requires intensive of Research & Development efforts. Unsuccessful attempts in the integration of social and environmental considerations ***into the economic decision making process*** can be identified as one of the main reasons for the unsatisfactory outcome of sustainable development efforts. Issues such as poverty alleviation and equity should be addressed in the light of energy and environmental factors. [1]

*Action is required in key areas, which, depending on the energy sources and the needs of the country in question,* can pave the way for substantial contribution to the world energy supply. Here, the government needs to step in. Producing and delivering energy to the consumer involves environmental costs and energy prices should reflect them in a better way. Investments in new energy supply plants and the necessary infrastructure should be optimized from both economic and environmental stand points.

Greater investment in research, development and demonstration should aim at bringing down the costs of renewable energy technologies. Attracting private investment in renewable energy, in both developed and developing countries require initiatives such as guaranteed initial markets for the output of renewable energy. Raising public's awareness of renewables should be high priority. International funding bodies, public and private organizations, and development assistant agencies should engage themselves in the activity of promoting international cooperation.

The Implementation of Renewable Energy Projects in developing countries delivers clear benefits for energy efficient technologies.

*In the case of most of the less developed or developing countries*, the technical-know-how is invariably transferred from the experienced developed countries. ***The transfer of technologies should meet three basic criteria:*** the presence of locally appropriate technologies and processes, they must reflect the best practices at the time of the project in order to avoid the dumping of obsolete ones and of course, they should be very low emitters of greenhouse gases.

The successful implementation of local to global renewable programs requires, the identification of the role-players, as pointed;

- First is the government, which must provide a policy framework and offer various incentives and measures to promote renewable energy technologies.
- Then there is the renewable energy manufacturing industry and the renewable energy service industries, including distributors, retailers, installers and consultants.
- Traditional energy companies can also be identified as potential vehicles of development.
- Trade union organizations, environmental NGOs, and consumers who need energy services can drive market forces. [2]

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[1] Youth Employment summit. *Report A: youth Employment Opportunities in renewable Energy*, (London, Education Development Center Inc. 2002) P.43.

[2] Ibid, p. 43.

### *3-1.4* The Indian Renewable Energy Program (IREP) Case Example

Which has encountered some, or most of these issues raised above and how it has sought to address them. n India, (IREP) is today among the world's largest programs for renewable energy. Significant efforts have been made towards the ***design, development, field demonstration and large-scale use of a number of renewable energy products and systems***.

- BIOGAS: large-scale use of biogas plants and improved cook stoves (commonly known as "chulhas") is promoted as part of the National Program of rural energy. Over 3 million biogas plants and nearly 31 million improved cook stoves have been installed. These rural energy programs effectively save about 22 million tons of fuel wood every year.
- SOLAR: solar photovoltaic and solar thermal technologies are finding ready acceptance for a variety of industrial and commercial applications, as well as in rural areas without electricity.
  - *More than 700,000 PV systems aggregating to 57 MW and covering over 30 different applications have been deployed.*
  - *Solar lanterns and home lighting systems are now being used in nearly 390,000 homes and are contributing to substantial savings of kerosene.*
  - *About 190,000 rural radiotelephones are also being powered by solar energy.*
  - *About 500,000 square meters of solar collector area has so far been installed for solar water heating systems in domestic and industrial sectors.*
  - *Another 222 MW capacity through biomass power A 140 MW **Integrated Solar Combined Cycle Power Project**, to be set up at Mathania near Jodhpur in Rajasthan has recently been approved by the Government. It will have a 35 MW solar thermal power component based on parabolic trough collectors, and a 105 MW combined cycle component using gas turbines and naphtha as fuel.*
- WIND: More than 1600 MW capacity of grid power is now based on renewable energy sources. Major achievements have been made in wind electric generation with 1170 MW installed capacity.

GOVERNMENT POLICY

To encourage power generation from renewable energy, 14 States have so far announced policies to provide arrangements for wheeling, banking, third party sale and buy back of power for non-conventional energy based power generation.

- The spread of various renewable energy technologies has been aided by a variety of fiscal and other support measures.
- Clear directed policy towards a greater thrust on overall development and promotion of renewable energy technologies and applications.
- The recent policy measures provide excellent opportunities for increased investment in this sector, technology upgradation, induction of new technologies, market development and export promotion.
- (IREDA) the Indian Renewable Energy Development Agency, corporate financing arm of the Ministry for Non Conventional Energy Sources, is the only agency of its kind in the world dedicated to financing of renewable energy projects.
- Interest rates vary from 0% to 15%, with special concessions being offered for projects in the ***Northeast, hilly areas, islands, and desert areas, and categories of borrowers.***
- R&D is being strengthened. The *Centre for Wind Energy Technology* has recently been established in Chennai. A *Wind Turbine Test Station* is being set up as an integral part of this Centre to undertake standardization, testing and certification of wind turbines. *A National Institute of Renewable Energy* is being established to support R&D, human resource development, commercialization activities, and training. [1]

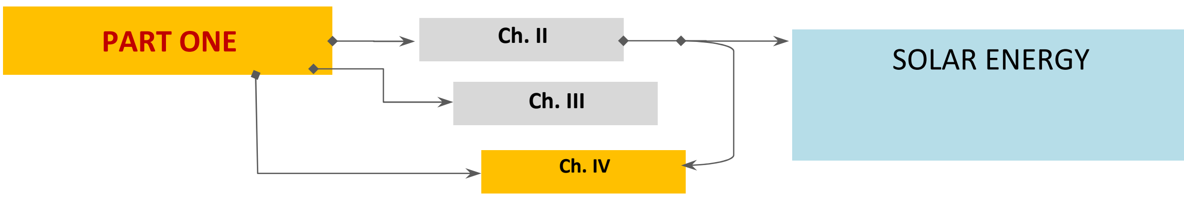
[1] Youth Employment summit. 44.

# CHAPTER

# IV

## SOLAR ENERGY

## OUTLINES AND SYSTEMS



# Chapter IV. SOLAR ENERGY OUTLINES AND SYSTEMS

*"It is the mission of modern architecture to concern itself with the sun "*

***Le Corbusier from a letter to Sert .***

## 1 SOLAR ENERGY OUTLINES

The sun continues to send out vast amounts of high quality energy. Although only 1 trillion of this energy reaches the earth, this is still about 10,000 times the total commercial energy used, so that even very modest progress in utilizing solar energy could provide us with a large part of our energy needs. On a clear day, a surface directly facing the sun receives about 1 KW of solar radiation per square meter. For the situation of cloudy day only about one tenth of this is received, of course, there is none at all at night. One average, much of the populated world receives 200 W /$m^2$ of solar radiation.[1]

This is common sense approach in solar energy ability to provide and cover human daily activities as a point of view of many researchers. So, the aim of the following points is to illustrate the facts of solar energy principles, radiations, and quantity.

### 1-1 *SOLAR CONTEXT AND PRINCIPLES*

The sun is a huge fusion reactor in which light atoms are fused into heavier atoms and in the process energy is released. This reaction can occur only in the interior of the sun where the necessary temperature/of 25,000,000°F exists- The solar radiation reaching earth. Solar radiation is, therefore, the kind of radiation emitted by a body having a temperature of about 10,000'F. The amount and composition of solar radiation reaching the outer edge of the earth a atmosphere are quite unvarying and are called the Solar Constant.[2] As (Figure 1-14). Earth receives radiant energy from the sun at the rate of $173x10^{15}$ W. (For comparison taking the annual energy consumption of humanity as 61 x $10^{15}$ Wh and dividing this by the number of hours in a year, 24x365 = 8760, get a rate of consumption of $7x10^{12}$W.[3](Figure 1-15)

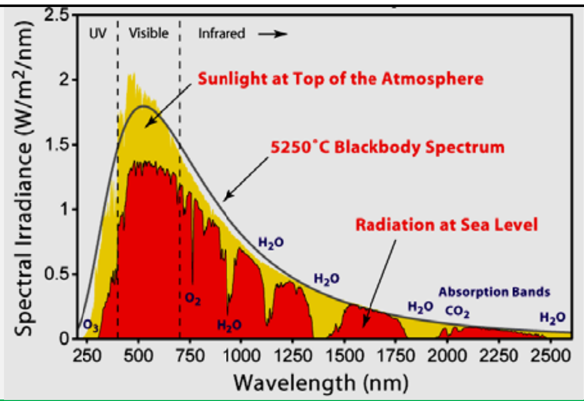



Fig. 1-14 **The Solar Spectrum At The Earth's Surface Consists Of About 47% Visible 48% Short-Wave Infrared, And About 5% Ultraviolet Radiation.**
**Source**: http://upload.wikimedia.org/wikipedia/commons/4/4c/Solar_Spectrum.png. date; 11/2008

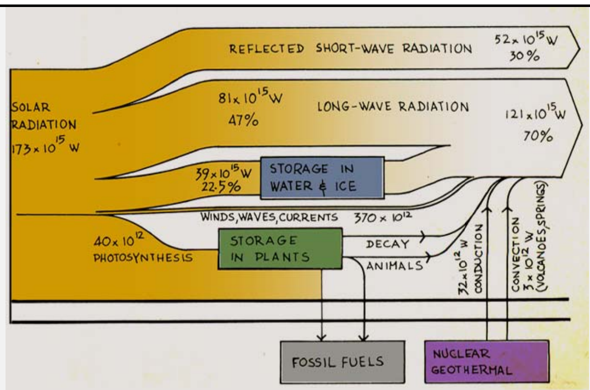



Fig. 1-15
**Flow of energy through the terrestrial system.**
**Source**: **Schittich**,Christian(ed). *In Detail: Solar Architecture Strategies, Visions, and Concept,* (Birkhauser publisher Berlin, Germany, 2003), 5.

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[1] **Cyril,** Carter. De Villiers. *Principles of Passive solar building design with microcomputer progress*, ( Pergamon, New York, USA, 1987 ), 1.
[2] Ibid.,90.
[3] **Szokolay**, S.V. *Solar Energy and Building*,(New York: The Architectural press, Halsted press Division,2004),5.

Some 30% of the incoming radiation is reflected without change in wavelength. About 47% is absorbed by the atmosphere and the earth's surface, Causes a temperature increase and is subsequently re-radiated to space. Only the remaining 23%enters the terrestrial system "arid becomes the motive force of winds, currents, Waves shape our climate and causes the hydrological cycle. And forms many of utilization of solar energy, which are not of direct interest to architecture. [1]

### 1-1.1 Solar radiation: quantity and quality

*Solar Quality*

The emission spectrum of black body radiators is determined by their temperature. The spectrum of solar radiation outside the atmosphere very nearly corresponds to the emission of a black body at 6000 °K. Atmospheric absorption is to some extent selective, changing the quantity and the spectral composition of the radiation received, by absorption bands of our atmospheric gases: oxygen, nitrogen, carbon dioxide, but mainly of water vapor, (Figure 1-15).

Electromagnetic radiation (such as light.) shows dual characteristics. The energy content of radiation is determined by its wavelength. The shorter wavelengths represent a higher grade energy. And all of the solar radiation can be considered for conversion to heat, but only the short wave. High energy components will be able to produce a photoelectric effect (Figure 1-16).

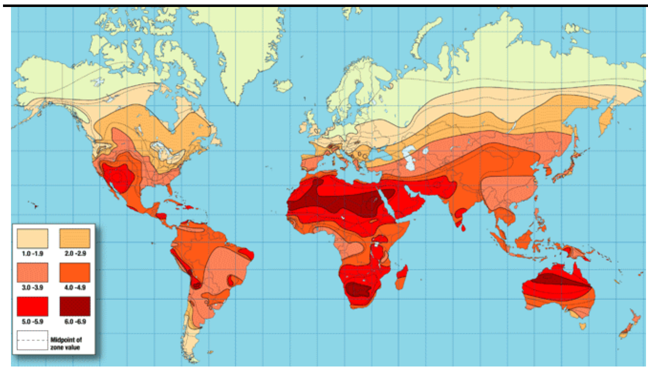



Fig. 1-16 **Solar radiation map of the world: shows the average annual radiation in kWh/m$^2$ year**.
**Source**: http://www.oksolar.com/abctech/solar-radiation.htm. (2 of 9) 10/19/2008.

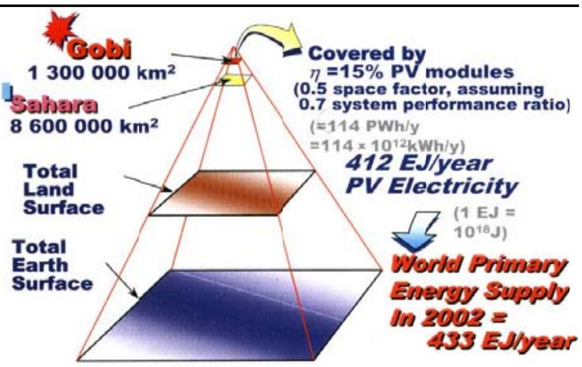



Fig. 1-17 **Solar Pyramid.**
**Source**: **Kurokawa, Kosuke**; *Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaics Systems,* xxx.

*Solar Quantity*

The intensity of radiation reaching the upper limits of our atmosphere shows some variations, due to the variation of the earth-sun distance. Atmospheric absorption reduces this intensity to an extent depending partly on the atmosphere and partly on the state of the air mass (cloudiness, suspended particles}. When the sun is at a low altitude angle, the intensity is less. *With a zenith*, position the intensity measured on a horizontal plane may approach 1 kW/m2 (at sea level). The annual total amount of radiation received at a given location depends on its geographical latitude and on local climatic factors. (Figure 1-16) the solar radiation map of the earth, gives a rough indication of what can be expected at various locations.

[1] **Szokolay**, V. Steven, *Introduction to Architectural Science the Basis of Sustainable Design, 2004*, 213.

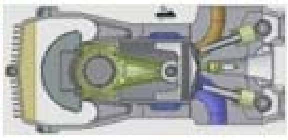
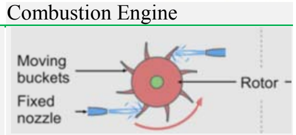
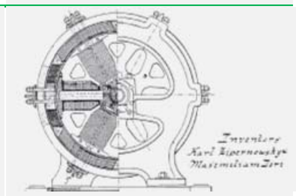
The previous context forms the idea of using very large-scale photovoltaic systems in the world dry deserts and high-level of insulation (in-coming solar radiation), highlighted by international group. Where there is a lot of available space, It is estimated that if very small part of these areas, approximately 4%, was used for installing photovoltaic (PV) system, the resultant annual energy production would equal world energy consumption.[1] Figure 1-17

## 1-2 *SOLAR ENERGY CONVERSION*

The dominant energy conversion process on earth is photosynthesis, which converts the electromagnetic radiation of the sun into plant material.

The most important conversion processes we make use of are *chemical-to-thermal*, *thermal-to-mechanical*, *mechanical-to mechanical* (e.g. pressure to rotation) and *mechanical-to-electrical*[2]-[3] , as illustrates in (Table 1-5)

**TABLE 1-5** **Most Important Conversion Process.**

| TYPES | Methods | Figure |
|---|---|---|
| ***1. Chemical -to- Thermal*** | ➢ Fire is the oldest form of *Chemical-to-Thermal* conversion, but all our thermal engines are based on this, either by generating steam to drive reciprocating engines or turbines, or by internal combustion engines of various kinds. |  Combustion Engine |
| ***2. Thermal -to- Mechanical,*** | ➢ *Thermal-to-Mechanical* conversions drive most of our transport system as well as electricity production. |   Turbines concept |
| ***3. Mechanical-to - Mechanical*** | ➢ (Pressure to rotation) such as wind pressure rotate turbines to generate electricity. |  Wind Turbine |
| ***4. Mechanical - to-Electrical*** | ➢ *Mechanical-to-Electrical* conversion. (The generation of electricity involves a triple conversion: *Chemical- Thermal-Mechanical-Electrica*l.) |  Dynamo |
| ***5. Radiant -to- Electrical*** | ➢ Solar cells convert *radiant-to-electrical* energy by photovoltaic processes. Thermoelectric cells convert *heat-to-electricity* directly |  Solar cell |
| ***6. Chemical -to- Electrical*** | ➢ Dry cell batteries and fuel cells convert *chemical-to-electrical* energy |  Battery |

Data adapted and processed from: **Szokolay**, V. Steven, *Introduction to Architectural Science The Basis of Sustainable Design, 2004*, 199-200. **Szokolay**, S.V. *Solar Energy and Building*,(New York: The Architectural press, Halsted press Division,1967),11,12.

[1] **Kurokawa,** Kosuke; *Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaics Systems,* xxix.
[2] **Szokolay**, V. Steven, *Introduction to Architectural Science the Basis of Sustainable Design, 2004*, 199.
[3] **Schittich**,Christian(ed). *In Detail: Solar Architecture Strategies, Visions, and Concept,* 2003.

# 2 SOLAR ENERGY SYSTEMS, TECHNOLOGIES AND APPLICATIONS

This section introduces solar energy systems, thermal and electrical, in a way that could be understood and applying. It discusses these systems and applications through the international and regional scales on urban development. In this section of the study, the urban and architectural scales – it will discussed in the end of this chapter- as an approach for utilizing The adapted solar energy systems through the new developmental trends for the Egyptian desert.

*The work in this part goes in three main points,*

- First; is the solar thermal and photovoltaic system, the answer for the question about the way we can achieve the energy solution for new urban communities especially in remote communities' area in the desert.
- Second; presenting the recent thermal and photovoltaic system technologies for assessing the utilization of solar systems in Egypt.
- Third is connecting solar systems with the architectural and urban process to realize the suitable system for our architectural and urban design.

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***Next Points;*** Highlights two types of *conversion related to direct solar energy conversion*, which are *Electrical conversion* and *thermal conversion*.

(Figure 1-18) attempts to summarize most technologies and purposes of using solar energy in direct or indirect form;

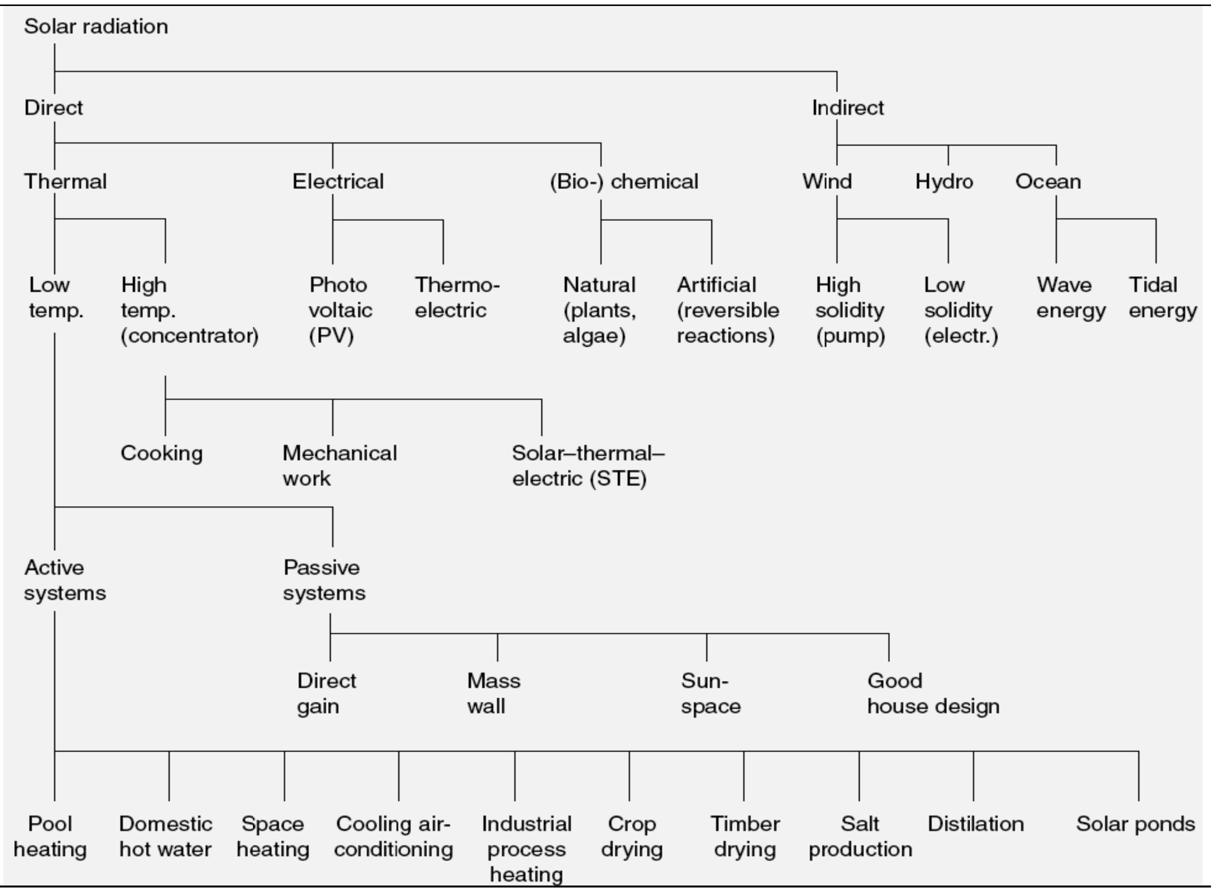



Figure 1-18

**Solar Energy Conversions, Technologies, and Purposes.**

**Source**: **Szokolay**, V. Steven, *Introduction To Architectural Science The Basis Of Sustainable Design, 2004*, 213.

## 2-1 *SOLAR THERMAL SYSTEMS*

The solar thermal power system collects thermal energy in solar radiation and uses at high or low temperature. The low temperature applications include water and space heating for commercial and residential buildings. [1]

### 2-1.1 *Low Temperature Applications*

Passive solar design represents one of the most important strategies for replacing conventional fossil fuels and reducing environmental pollution in the building sector. Depending on the local climate and the predominant need for heating or cooling, a wide range of passive techniques is now available to the building designer for new and retrofit building projects which, at little or no extra cost compared with conventional construction, can result in buildings which are both more energy-efficient and offer higher standards of visual and thermal comfort and health to the occupants.

#### 2-1.1.1 Passive Systems

Solar energy can make a major contribution to the heating requirements of a building. For most parts of Europe it is appropriate to use the following strategy (Figure 1-19):

- *Solar collection*, where solar energy is collected and converted into heat.
- *Heat storage*, where heat collected during the day is stored within the building for future use.
- *Heat distribution*, where collected/stored heat is redirected to rooms or zones which require heat.
- *Heat conservation*, where heat is retained in the building for as long as possible.

*Direct Gain* is the most common approach, with large, south-facing glazed apertures opening directly into habitable rooms in which are exposed appropriately-sized areas of heavy materials to provide thermal storage.

*Indirect Gain* systems include Mass, Trombe and water walls. Storage is in a south-facing wall, of considerable thermal mass, whose external surface is glazed to reduce heat losses. Movable insulation may be deployed at nighttime. [2]

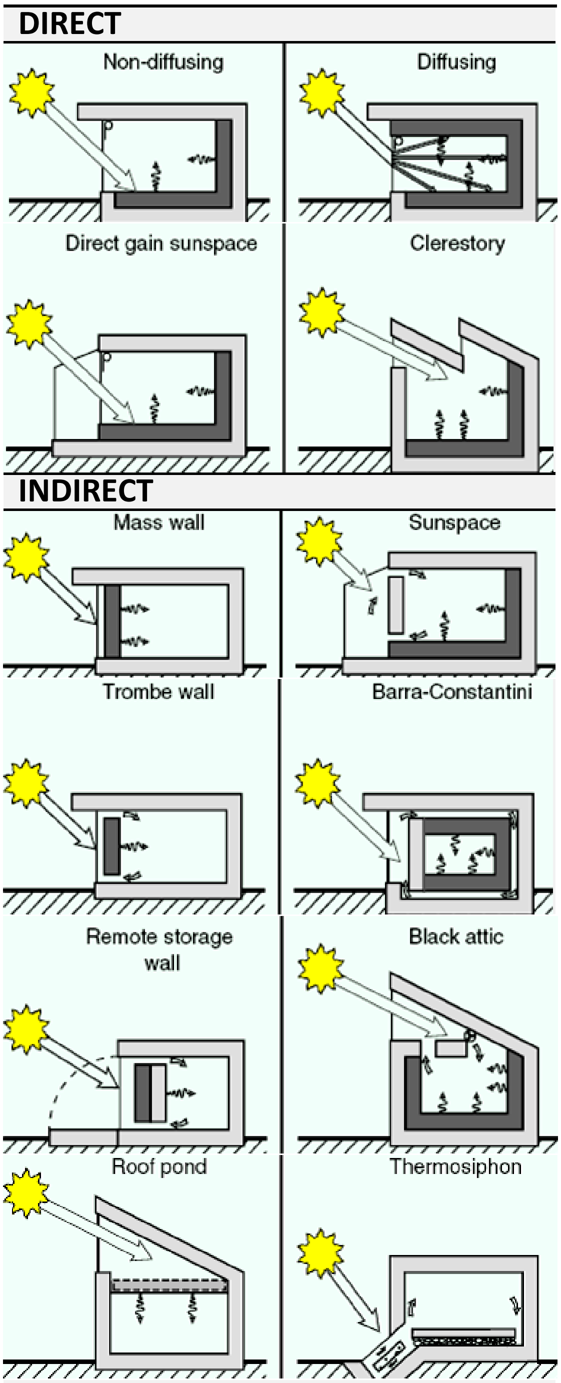



Fig. 1-19 **Passive Solar Heating Configurations.**

**Source: John** R. **Goulding** and J. **Owen**, **THERMIE PROGRAM ACTION** " *Bioclimatic Architecture* " ( the European Commission Directorate-General for Energy, Energy Research Group, University College Dublin) p.5.

[1] Mancini, T. "*Solar Thermal Power Today and Tomorrow,*"( London, publication of the Institution of Mechanical Engineers, , August ,1994)
[2] **John** R. **Goulding** and J. **Owen**, **Thermie Program Action** *"Bioclimatic Architecture "(* the European Commission Directorate-General for Energy, Energy Research Group, University College Dublin) p.5.

### 2-1.1.2 Active Systems

**TABLE 1-6** **Solar Energy; Actives Thermal Uses.**

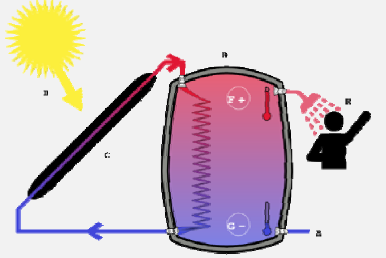
| | NATURE OF USE | Figure |
|---|---|---|
| ***a. Domestic water Heating*** | ▪ *The simplest water heating system, based on the thermosyphon principle, consists of a **collector panel** and **tank**. The tank must be positioned above the top of the collector panel. The water heated in the collector, becoming lighter, will rise and colder (heavier) water will be, drawn in its place from the bottom of the tank. The greater the height difference (d), the larger the flow will be and increase the collection efficiency, although reduce the collection temperature.*<br>▪ *The situated on roof tops can be rather unsightly. It can be accommodated in the roof-space if the collector panel is installed in a lower position.*<br>▪ *In a pumped system, it has been suggested that if a D/C motor is used, by an array of silicon cells of about 0.25 m2 in area, this will be a self-regulating system. With a greater solar intensity a higher voltage is produced, the pump will run faster, the flow rate will be increased, thus the collection temperature will be kept at the desired level. (Figure 1-20)* |  <br>Fig. 1-20 **Water Collector Units** |
| ***b. Swimming Pool Heating*** | ▪ *The heating of a typical small swimming pool containing 85m$^3$ water would require large quantities of energy, almost 100 kWh of heat for every degC increase in temperature. A comfortable pool temperature is between 21° and 25°C (low grade temp.). As the efficiency of solar collectors is best with the lowest collection temperature, their use for swimming pool heating is profitable, even in locations where water or space heating would not be economically justified. **(Figure 1-21)***<br>▪ *In swimming pool installations the circulating pump is normally given, serving the filtration plant. The solar heating panels may be connected in series. As the collection temperature is lower, there is no point installing double glazing.*<br>*To get the greatest benefit from such an installation, it is advisable to prevent the night-time heat loss, from the pool surface by some form of cover. (Rolled up polythene sheet - inflated plastic bags. Floating, polystyrene balls) These can be removed automatically* | <br>Fig. 1-21 **Water Collector on roof** |

**TABLE 1-6** *Continued*

## *General Uses of Active Uses Solar Energy*

NATURE OF USE | Figure

### c. Space Heating

*There are three methods for the utilization of solar radiation in space heating:*

1- The Building As Collector *Its basis is a thermally very efficient building, with good insulation outside the main mass of wall and roof elements. It has large windows facing the equator, which can be closed by shutters or heavy curtains when there is no solar gain, in order to reduce heat loss.*

2- Special Building Elements *An external enclosing element of the building (a wall or a roof) may be designed to act as a collection device (massive wall), with the outside painted black, covered by one or two sheets of glass. It will act as an absorber, storing some of the heat in its mass and providing an output mechanism through the convection currents induced. (Figure 1-22) (Figure 1-23)*

3- Flat Plate Collectors : *in this category two basic types must be distinguished:*

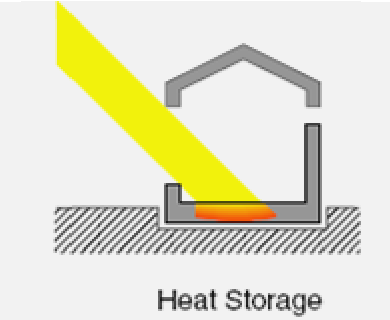



Fig. 1-22 **Space Heating**

a. *Water System: it may have as much as 80m2 collector area for single family dwelling. And circulation must be pumped. The system required using storage tank for the short period of insufficient collection when the sky is heavily clouded. And the system will consist of FIVE COMPONENT;*

*1- Collector 2- Storage 3- Auxiliary heater 4- Distribution system 5- Controls (Pumps &fans )*

b. *Air System: Some collectors using air, provide warm air for space heating purposes, the distribution network and the collector be much bulkier. But the method does however have certain advantages, e.g. it avoids the risk of freezing.*

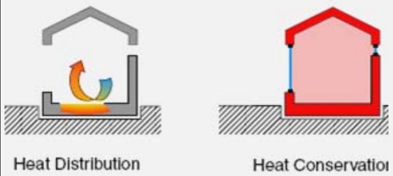



Fig. 1-23 **Space Heating**

### d. Cooling and Air Conditioning

*Cooling by solar energy holds out a great promise, as this is about the only application where the maximum energy demand coincides with the maximum energy collection*

Refrigeration can be produced by two methods.

a. *Use of mechanical work that described above, which in turn will be used to drive a compression type refrigeration cycle.*

b. *Use of the heat obtained from the sun directly, to drive an absorption refrigerator.*

*This is essentially the same machine as the domestic gas or paraffin (kerosene) operated refrigerator*

*It uses (ammonia) as the refrigerant is more soluble in the carrier fluid (water), at low temperatures. (Figure 1-24)*

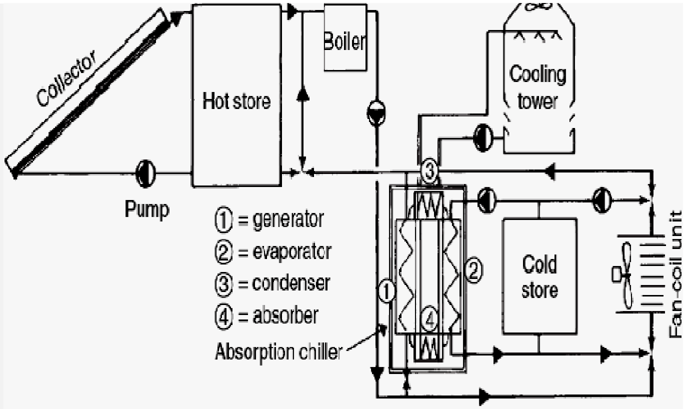



Fig. 1-24 **Cooling and Air Conditioning**

**TABLE 1-6** *Continued* ***General Uses of Active Uses Solar Energy***

### *e. Drying*

- *Drying of various crops and products (grain, fruit, eg sultanas, palm or sugar cane juice, rubber, meat timber) was traditionally done under natural conditions, perhaps only providing cover as a protection against rain. The traditional source of heat, the sun's radiation, can be harnessed and controlled. Like the present machines that uses electricity, oil or some other fuel, for achieving a controllable performance and an accelerated process.*
- *Drying can be carried out in two ways:*

  *a. The product itself may be exposed to the sun in a covered tray of some kind, or*
  *b. Air may be heated in some device and blown through or over the product to be dried*

### *f. Distillation and Desalination*

- *Distillation is a very attractive use of solar energy, as the energy requirement is in the form of low grade heat.* ***(Figure 1-25)***
- *The low-technology nature of the system makes it suitable for use in developing countries, where other forms of fresh water supply are non-existent and natural fresh water is scarce.*
- *Hot-box is the simplest system type distiller; using black bottom of the tray absorbs the solar radiation, heats the water, which will evaporate. The air-water vapor mixture will develop convection current. Condensation will occur on the inside of the transparent cover, which is being cooled by the outside ambient air. The condensate will be collected in the channels along the bottom edge of the cover.*

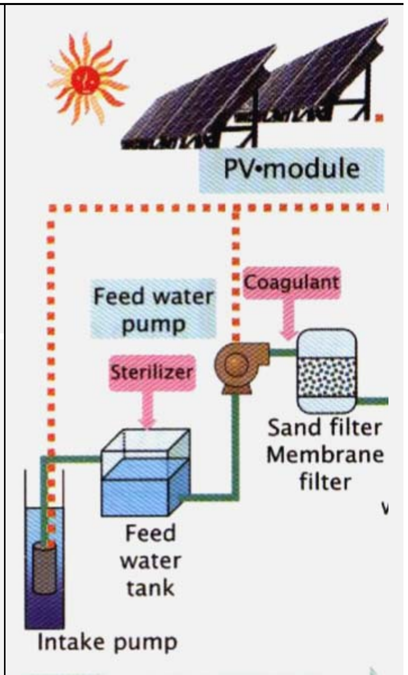



Fig. 1-25 **Desalination PV System**

### *g. Electricity Production*

* *Is considered the main subject of the research, and it will be discussed clearly in the next section.*

*Electricity can be produced from solar radiation by two methods:* ***(Figure 1-26)***

*a. Direct conversion by photoelectric or thermoelectric processes,*
*The Practical applications of direct conversion are restricted to small scale power generation in remote locations. Various systems of photoelectric cell arrays are in use for navigation aids, for telephone amplifier in remote areas or as battery chargers for boats and caravans.*

*b. By producing mechanical work which will then be used to drive conventional electric generators.*
*With large scale production of mechanical work for the purposes of electricity generation. An area of 4 hectares would produce 800 kW for 6 hours a day on annual average. This transfer of energy can take two forms: 1- optical 2- thermal*

Fig. 1-26 **Photovoltaic Plant**

Data Processed by author Form: Mancini, T. "*Solar Thermal Power Today and Tomorrow,"*( London, publication of the Institution of Mechanical Engineers, , August ,1994.) **John** R. **Goulding** and J. **Owen**, **Thermie Program Action** *"Bioclimatic Architecture "(* the European Commission Directorate-General for Energy, Energy Research Group, University College Dublin). **Szokolay**, V. Steven, *Introduction To Architectural Science The Basis Of Sustainable Design, 2004*, 213.

## 2-1.2 *High Temperature Application*

There are other types of thermal system under the name of "*Medium-temperature Collectors*" . Their its applications include ***Cooking, Disinfection and Desalination***. However, the focus will be on the ***high temperature application****s* are considered suitable applications for the concept related to urban development and the object of the research. Electricity Production using the ***Steam-Turbine-Driven Electrical Generator*** is a high temperature application discussed in this section.

The technology of generating electrical power using the solar thermal energy has been demonstrated at commercial scale. The research and development funding have primarily come from the government, with active participation of some electric utility companies.

### 2-1.2.1 Solar II Power Plant

Solar II was developed by the Sandia National Laboratory in USA in 1996, Constructed by the Department of Energy in partnership with the Solar II Consortium of private investors. [1]

*Solar I and Solar II* are a central thermal receiver plant, which solar energy is collected by ***thousands of sun-tracking mirrors,*** *called* 'Heliostats', that reflect the sun's energy to a single receiver atop a centrally located tower. The enormous amount of energy focused on the receiver is used to generate high temperature to melt a salt. The hot molten salt is stored in a storage tank, and is used, when needed, to generate steam and drive the turbine generator. After generating the steam, the used molten salt at low temperature is returned to the cold salt storage tank. From here it is pumped to the receiver tower to get heated again for the next thermal cycle. (Figure 1-27)

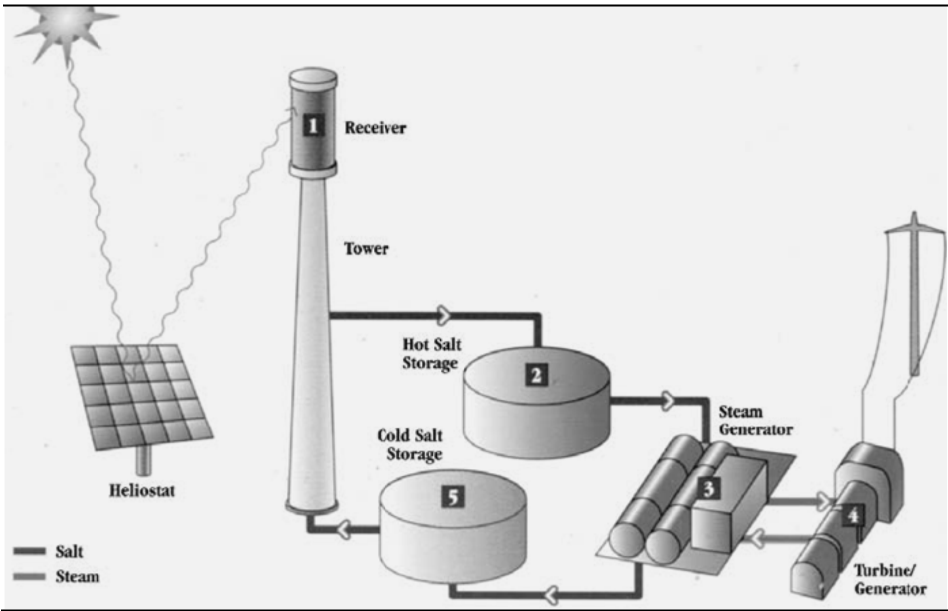



Fig. 1-27

**A Schematic of A Large-Scale Solar Thermal Power Station Developed, Designed, Built, Tested, and Operated With The U.S. Department Of Energy Funding.**

**Source: Fanchi**, R. John. *Energy: Technology and Directions for the Future, chapter 7* (Oxford, Academic Press is an imprint of Elsevier 2004) 212.

The most important feature of the Solar II design, which uses some components of *the* ***Solar I plant***, is its innovative ***energy collection*** (1,050°F) and the ***storage system***; the power generation is decoupled from the energy collection. It is connected to the grid, and has enough capacity to power 10,000 homes. The plant is designed to operate commercially for 25 to 30 years. [2]

---

[1] **Mukund,** R. Patel., *Wind and Solar Power Systems.* (New York: CRC Press LLC, 1999), 172.
[2] Data adapted and processed by the researcher from**: Mukund,** R. Patel., *Wind and Solar Power Systems*, 172. **Fanchi**, R. John. *Energy: Technology and Directions for the Future, chapter 7* (Oxford, Academic Press is an imprint of Elsevier 2004) 212-214.

### 2-1.2.2 Solar Updraft Tower

Solar updraft tower is a solar power plant, depends primarily on two factors: *the size of the Collector area and Chimney height*. With a larger collector area, more volume of air is warmed up to flow up the chimney; collector areas as large as ***7 km*** in diameter. With a larger chimney height, the pressure difference increases the ***stack effect***; chimneys designed as tall as 1000 m. Turbines are installed in a ring around the base of the tower, with a horizontal axis. Heated air can be stored inside the collector area greenhouse, to be used to warm the air later on. Water, with its relatively high specific heat capacity, can be filled in tubes placed under the collector increasing the energy storage as needed.[1] Figure 1-28)

A small-scale solar updraft tower may be an attractive option for remote regions in developing countries. Construction would be most likely in hot areas with large amounts of very low-value land, such as deserts.[2-3]

*Examples*: *Prototype in Spain 1982*, a small-scale experimental power plant was built, the project was funded by the German government. *Australian proposal*, to build a solar updraft tower station since 2001. *Namibian proposal, in mid 2008*; for the construction of a 400 MWe solar chimney called the *'Greentower'*. The tower is planned to be 1.5 km tall and 280 m in diameter, and the base will consist of a 37 km2 greenhouse in agricultural activities.[4]

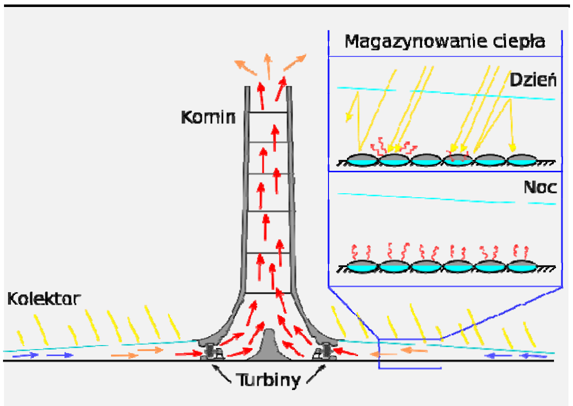



Fig. 1-28 **Schematic Presentation Of A Solar Updraft Tower.**

**Source: Cloete**, R (2008-07-25). *"Solar Tower Sheds Light on Little-Used Technology"*., Engineering News Online. Retrieved on 2008-10-17.

### 2-1.2.3 Commercial Power Plants

The commercial power plants using the solar thermal system, based on the Solar II power plant operating experience, the design studies by the National Renewable Energy Laboratory for the U.S. Department of Energy have estimated the performance parameters that are achievable for a 100 MWe commercial plant.

***Major conclusions of the studies to date are the following:***

1. *First plants as large as 100–200 MWe are possible to design and build based on the demonstrated technology to date. Future plants could be larger.*
2. *The plant capacity factors up to 65 percent are possible, including outage.*
3. *Fifteen percent annual average solar-to-electric conversion efficiency is achievable.*
4. *The energy storage feature of the technology makes possible to meet the peak demand on the utility lines.*
5. *Leveled energy cost is estimated to be 6 to 7 cents per kWh.*
6. *A 100 MWe plant with a capacity factor of 40 percent requires 1.5 square miles of land.*
7. *Solar-fossil hybrids are the next step in development of this technology.*

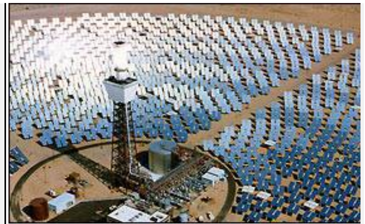
[1] **Schlaich** J, **Bergermann** R, **Schiel** W, **Weinrebe** G.*"Design of Commercial Solar Updraft Tower Systems-Utilization of Solar Induced Convective Flows for Power Generation"*, Journal of Solar Energy Engineering (2005), 127 (1): 117–124

[2] **Dai** YJ, **Huang** HB, **Wang** RZ. *"Case study of solar chimney power plants in Northwestern regions of China"*. Renewable Energy (2003). 28 (8): 1295–1304.

[3] **Onyangoa** FN, **Ochieng** RM (2000). *"The Potential of Solar Chimney for Application in Rural Areas of Developing Countries"*. Fuel.

[4] **Cloete**, R (2008-07-25). *"Solar Tower Sheds Light on Little-Used Technology"*., Engineering News Online. Retrieved on 2008-10-17.

## TABLE 1-7 Comparing of High Temperature Solar Thermal Systems.

| | | Examples | New urban Communities Application in the Desert | (x suns) Solar concentration | Hot side temp. Operation | Thermodynamic Efficiency | Figure |
|---|---|---|---|---|---|---|---|
| ***Parabolic Trough*** | ▪ The parabolic trough system is by far the most commercially matured of the three technologies. It focuses the sunlight on a glass-encapsulated tube running along the focal line of the collector. The tube carries heat absorbing liquid, usually oil, which in turn, heats water to generate steam | **USA;** 350 MW of parabolic trough capacity is operating in the California Mojave Desert.<br>**Egypt;** hybrid power plant with a total capacity of 150 MW of energy used for both natural gas and solar energy, in El-Kuraymat | - Developed as Electricity Plant.<br>- Developed to Combined Water Desalination Systems. | 100 | 300-500° c | Low | <br>**Fig.** 1-29 Parabolic Trough Plant. |
| ***Central Receiver*** | ▪ Compared to the parabolic trough, this technology produces higher concentration, and hence, higher temperature working medium, usually a salt. Consequently, it yields higher Carnot efficiency, and is well suited for utility scale power plants in tens or hundreds of megawatt capacity. | **USA**; the Mojave Desert just east of Barstow, California, for a 100 MWe.<br>**South Africa**; a 100MW solar power plant is planned with 4000 to 5000 heliostat mirrors, each having an area of 140 m²<br>**Israel ;** Negev Desert, Rotem Industrial Park, using 1,600 heliostats. | - Developed as Electricity Plant Only. | 1000 | 300-500° c | Moderate | <br>**Fig.** 1-30 **Solar II Plant Site View.** |
| ***Dish Receiver*** | ▪ In parabolic dish tracks the sun to focus heat, which drives a ***sterling heat engine-generator*** unit. This technology has applications in relatively small capacity (tens of kW). This technology is particularly attractive for small stand-alone remote applications. Because of their small size, and can be assembled in a few hundred kW to few MW capacities. | **USA**; Southern California Edison, 500-megawatt, 4,600 acre (19 km²), solar power plant to open some time after 2009<br>San Diego Gas & Electric; 300 and 900 megawatts of electricity. | - Developed as Electricity Plant Only. | With engine 3000 | 800-1200° c | High | <br>**Fig.** 1-31 **A Parabolic Solar Dish.** |
| ***Updraft Solar Tower*** | ▪ As updraft tower station would consume a significant area of land. The relatively low-tech approach could allow local resources and labor to be used for its construction and maintenance. The tower is a great source of energy, it producing enough energy to power a city during warm days<br>▪ In *Spain Proposal*. It was estimated that a 100 MW plant would require a 1000 m tower and a greenhouse of 20 km2. | **Spain** (Prototype); a small-scale experimental power plant was built, the project was funded by the German government.<br>**Namibian**,2008; for the construction of a 400 MWe solar chimney 'Greentower'. planned to be 1.5 km tall and 280 m in diameter, for Energy and agricultural activities | - Suitable for desert regions.<br>- Suitable for agriculture area for greenhouse crops.<br>- Suitable for hot and high irradiation of solar energy. | N/a | N/a | N/a | <br>**Fig.** 1-32 **A Parabolic Solar Dish.** |

Data adapted and processed from: **Mukund,** R. Patel., *Wind and Solar Power Systems.* (New York,: CRC Press LLC, 1999), 195-162, **Fanchi**, R. John. *Energy: Technology and Directions For The Future, chapter 6*(Oxford, Academic Press is an imprint of Elsevier 2004) 212-214. **http://en.wikipedia.org/wiki/Solar_thermal_energy** (2 of 25)5/11/2008, http://www.physorg.com/news98469930.html (4 of 8) 5/11/2008. **Abulfotuh** Fuad, *Workshop ; Application of Solar Energy; Solar Collectors and Photovoltaic Cells " PV Technology: Status and Prospects"*, Lecture,(Egypt: Alexandria, IGSR, October 2008).

## 2-2 *SOLAR ELECTRICAL SYSTEM; SILICON TECHNOLOGY (Photovoltaics)*

Few people have not heard of semiconductors – the materials that have helped usher in an age of high-powered microelectronic devices. The basic phenomenon underlying a semiconductor forms the basis for other technologies as well, including ***transistors*** and, the ***photovoltaic*** effect associated with ***solar power***. Here, presents the illustration of the general phenomena of these complex materials and, what semiconducting devices actually do.

### 2-2.1 *Basic Semiconductor Phenomena*

Basic semiconductor materials, such as silicon, are neither ***good conductors*** *nor* ***good insulators***, but, with the addition of small impurities called ***dopants***, they can be made to possess many fascinating electrical properties. The addition of these dopants or impurities allows electron movements to be precisely controlled.

***Silicon is the most widely used semiconducting material***, although other material types are possible. Basic semiconducting materials exhibit interesting properties when surrounding temperatures are varied. *Unlike most metals wherein increases in temperatures cause increases in resistance,* the conductivity of semiconducting materials increases with increasing temperatures. This property already makes it quite attractive for many applications.

The addition of dopants or impurities creates other conditions, the role of impurities, is affecting the flow of electrons through a material. Here again the flow is affected, but in this case in a controllable way. Silicon matrix materials are alloyed with specific concentrations of a dopant, such as boron, via a complex deposition layering procedure to form a semiconductive device. Multiple dopants of different types may be used. The specific nature of these assemblies acquires it useful electronic properties.[1]

Figure 1-33; illustrates a typical makeup of a device that consists of a junction of so-called **p** and **n** semiconductor materials (using, different dopants on silicon substrates). In the first type of material, **n**, electrons with a negative charge are predominantly present. In the second type, **p**, holes (locations of missing electrons) are primarily present resulting in a positive charge. Application of a negative charge to the **p** side causes the charges to be electrostatically attracted away from each other, creating a zone that is free of electrons. No current flows through this region. Application of a positive charge to the **p** side causes the reverse situation. Electrons flow through the barrier zone creating a current.[2]

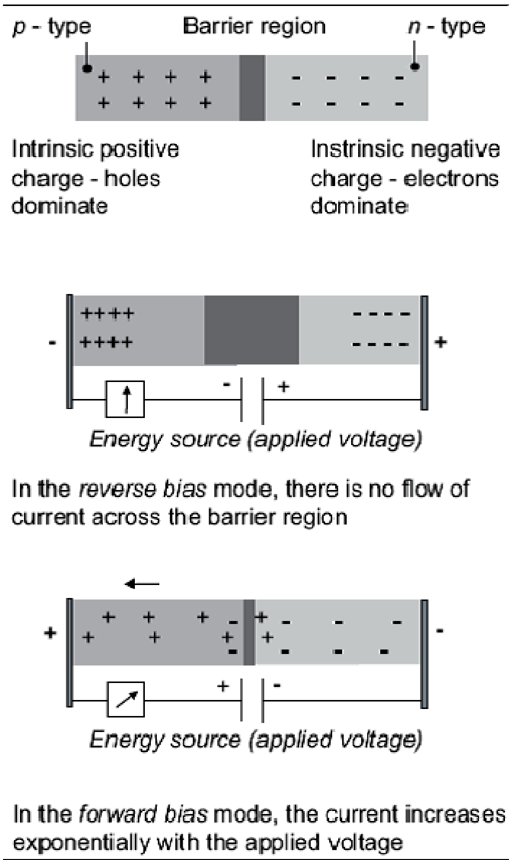



Fig. 1-33 **Basic Semiconductor Behavior.**
**Source: Addington., Schodek.**,“ Smart Materials and New Technologies” *(*Elsevier,2005*)*,101.

[1] http://en.wikipedia.org/wiki/Semiconductor_device#Semiconductor_device_fundamentals,. (9 of 19), 11/9/2008.
[2] **Addington**, Michelle., **Schodek** Daniel*.,“ Smart Materials and New Technologies For the Architecture and Design Professions”* (UK: Oxford , Elsevier,Architectural Press,2005*)* 100,101.

### 2-2.2 Photovoltaic, LEDs and Transistors

Many widely used devices have their fundamental basis in semiconductor technology (*like*, *Photovoltaic technologies*). A photovoltaic device consists primarily of a **p** and **n** junction. Instead of there being an applied voltage as described above, however, there is an incident energy *(typically solar)* that acts on the junction and provides the external energy input. In typical solar cells, the **n** layer is formed on top of the **p** layer. Incident energy impinges on the n layer. This incident energy causes a change in electron levels that in turn causes adjacent electrons to move because of electrostatic forces. This movement of electrons produces a current flow. Phototransistors are similar in that they convert radiant energy from light into a current. (Figure 1-34.a.b)

Common LEDs (light-emitting diodes) are based essentially on the converse of photovoltaic effects. An LED is a semiconductor that luminesces when a current passes through it. It is basically the opposite of a photovoltaic cell. Transistors are similarly based on semiconductor technologies. Fundamentally, a transistor can be used as a signal amplification device, or as a switching device.

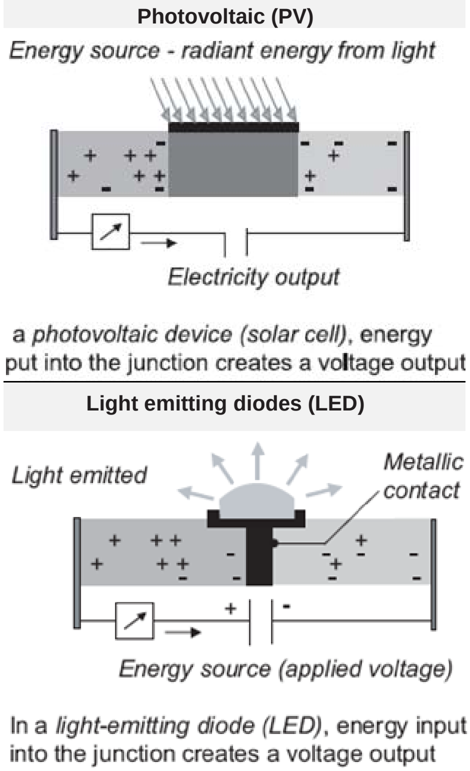



Fig. 1-34.a.b
**PV and LED Devices are Based On Semiconductor Technologies.**
**Source: Addington**., **Schodek**.,“ Smart Materials and New Technologies” *(Elsevier,2005)*,102.

### 2-2.3 Photovoltaics (PV)

*“The photovoltaic effect is the electrical potential developed between two dissimilar materials when their common junction is illuminated with radiation of photons*”.[1]

The PV effect was discovered in 1839, it remained in the laboratory until 1954, when Bell Laboratories produced the first silicon solar cell. Large-scale photovoltaic were essentially the provenance of NASA until about two decades ago, when used as generating facilities as first built, as its high power capacity as unit weight. Application has developed maturity in the space satellite. The PV technology is now spreading into the terrestrial applications ranging from powering remote sites to feeding the utility lines. [2]


Fig. 1-35 **Solar Car.**

**Source: Randall,**Thomas. , **Fordham**,Max., *“ Photovoltaics and Architecture”* (London: Spon Press,2003).p. 6

The most common PV devices at present are based on **silicon**. When the devices are exposed to the sun, direct current (DC) flows as shown in (Figure 1-35.a ). PVs respond to both direct and diffuse radiation (Figure 2.2) and their output increases with increasing sunshine or, more technically, irradiance. PVs are ubiquitous. They power calculators and navigation buoys, form the wings of satellites and solar planes, and are beginning to appear on cars.

[1] **Mukund,** R. Patel., “*Wind and Solar Power Systems”,* (New York,: CRC Press LLC, 1999), 195-162
[2] **Addington**, **Schodek**.*, “ Smart Materials and New Technologies”* (UK: Oxford , Elsevier, Press,2005*)* 181,182.

## 2-3 *PV CELL TECHNOLOGIES*

In making comparisons between alternative power technologies, the most important measure is the energy cost per kWh delivered. In PV power, this cost primarily depends on two parameters, the ***photovoltaic energy conversion efficiency***, and ***the capital cost per watt capacity***. Together, these two parameters indicate the economic competitiveness of the PV electricity. The conversion efficiency of the photovoltaic cell is defined as follows:

$$\eta = \frac{\text{electrical power output}}{\text{Solar power impinging the cell}}$$ [1]

The continuing development efforts to produce more efficient low cost cells have resulted in various types of PV technologies available in the market today. [2] Crystalline silicon solar cells exist in different forms such as *Mono-crystalline*, *Multi-crystalline*, *Rbbon* and *Sheet silicon*.[3] The major types are discussed in the following points; (Figure 1-36/ Table 1-8)

**CELL TYPE**

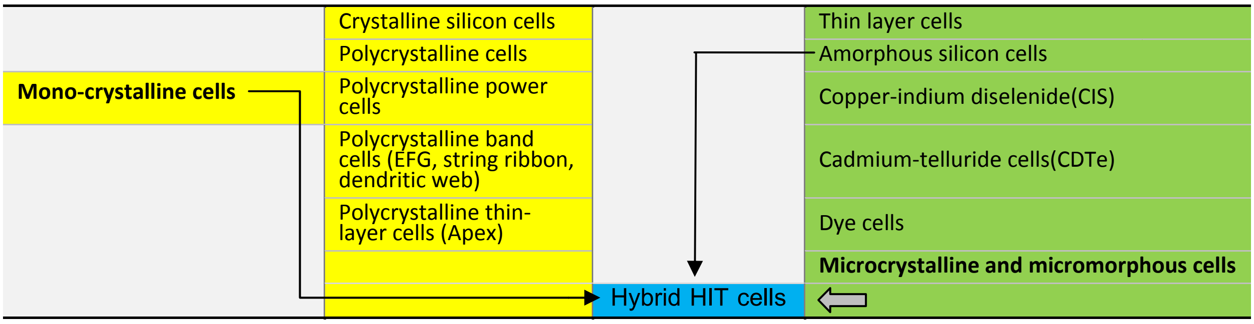



Fig. 1-36 **Cells Types and Technologies Relations**.

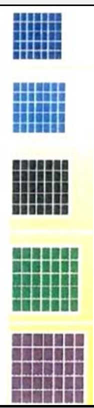
**Source: Addington**., **Schodek**.," Smart Materials and New Technologies" *(*Elsevier,2005*)*,102.

A suitable area for the PV system is agreed upon with the customer during a site visit. The checklist for the building survey includes the system specifications: orientation, tilt, available area, type of mounting, shading, cable lengths, inverter location, etc. The modules are then chosen according to the:

- *Cell Material;* mono-crystalline, polycrystalline, amorphous, CdTe or CIS, or thinfilm technology; and
- *Module Type;* standard module with/without frames, glass-glass module, PV tile, etc. (Table 1-8)

**TABLE 1-8** **PV Efficiencies and Required Area for installing the System**

| Type | Apprx.cell efficiency* % | Apprx. module efficiency* % | Required PV Areas For 1KW >> | 7 $m^2$ – 9 $m^2$ |
|---|---|---|---|---|
| Mono-crystalline silicon | 13–17 (1) | 12–15 (2) | --------------------- | 6 $m^2$ – 7 $m^2$ |
| Polycrystalline silicon | 12–15 (1) | 11–14 (2) | --------------------- | 7.5 $m^2$ – 10 $m^2$ |
| Thin-film silicon ( using amorphous silicon) | 5 (3) | 4.5–4.9 (2) | Copper-indium diselenide(CIS) | 9 $m^2$ – 11 $m^2$ |
| | | | Cadmium-telluride cells(CDTe) | 12 $m^2$ – 17 $m^2$ |
| | | | Amorphous silicon cells | 14 $m^2$ - 20 $m^2$ |



*.Efficiencies are determined under standard test conditions (STC).

**Source: Randall**,Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"* (London: Spon Press,2003).p. 7.

[1] **Mukund,** R. Patel., "*Wind and Solar Power Systems",* (New York,: CRC Press LLC, 1999), 42.

[2] **Carlson**, D. E. "*Recent Advances in Photovoltaics," 1995 Proceedings of the Intersociety Engineering, Conference on Energy Conversion,* 1995, p. 621-626.

[3] **EPIA** and Greenpeace, Department of Energy: *Energy Efficiency And Renewable Energy, 2005*PV-TRAC, 2005; U.S.

### 2-3.1 Single-Crystalline Silicon

The single crystal silicon is the widely available cell material, and has been the workhorse of the industry. In the most common method of producing this material, the silicon raw material is first melted and purified in a crucible. A seed crystal is then placed in the liquid silicon and drawn at a slow constant rate. This results in a solid, single-crystal cylindrical ingot (**Figure 1-37**). The manufacturing process is slow and energy Intensive, resulting in high raw material.[1]

The ingot is sliced using a diamond saw into thick wafers. The wafers are further cut into rectangular cells to maximize the number of cells that can be mounted together on a rectangular panel. Unfortunately, almost half of the expensive silicon ingot is wasted in slicing ingot and forming square cells. The material waste can be minimized by making the full size round cells from round ingots (**Figure 1-37**).[2]

Using such cells would be economical where the panel space is not at a premium. Another way to minimize the waste is to grow crystals on ribbons. Some U.S. companies have set up plants to draw PV ribbons, which are then cut by laser to reduce waste.[3]

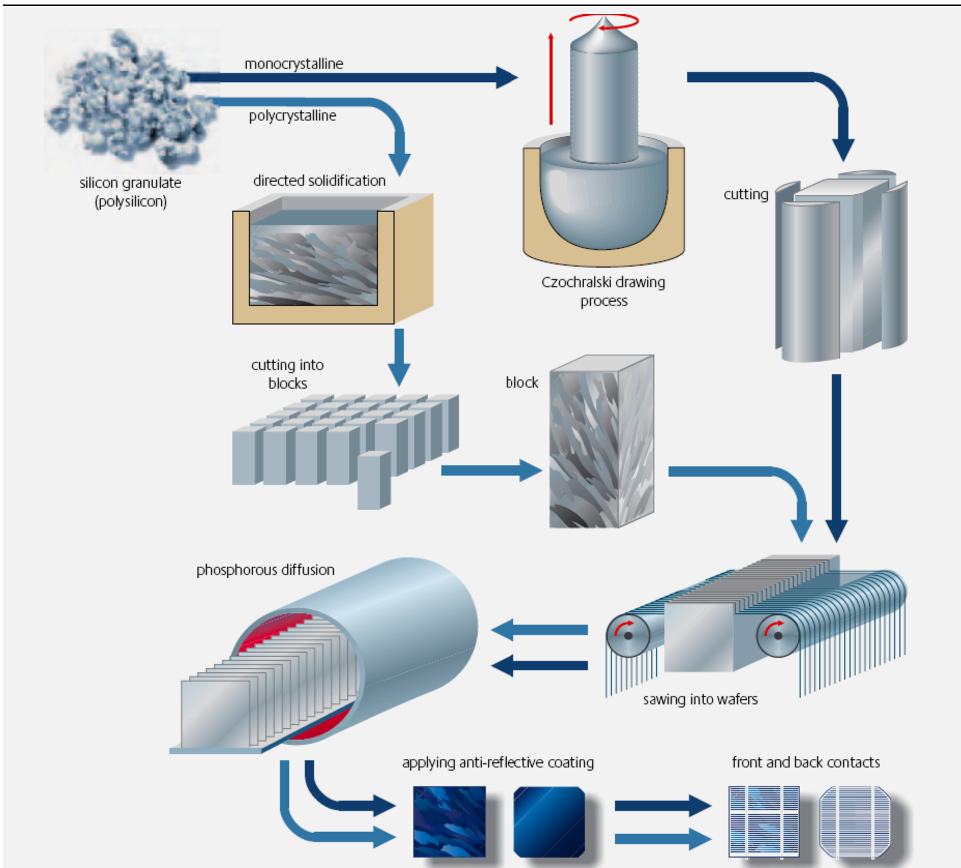
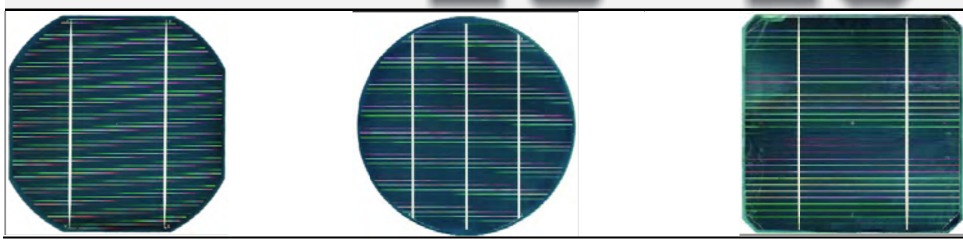



Fig. 1-37

**Technologies. Manufacturing Mono-Crystalline and Polycrystalline Solar Cells from Poly-silicon.**

**Source: The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition. (London: Earthscan, sterling,VA,2008).



**Mono-Crystalline Cells Forms.**

[2] **The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition.( London: Earthscan, Sterling,VA,2008).

[3] **Phylipsen**,G.J. **Alsema**,E.A. *"Environmental Life-Cycle Assessment of Multicrystalline Silicon Solar Cell Modules"*. 95057. Department of Science, Technology and Society, Utrecht University, 1995.

## 2-3.2 *Polycrystalline and Semi-Crystalline*

This is relatively a fast and low cost process to manufacture thick crystalline cells. Instead of drawing single crystals using seeds, the molten silicon is cast into ingots. In the process, it forms multiple crystals. The conversion efficiency is lower, but the cost is much lower, giving a net reduction in cost per watt of power.[1] [2] (Figure 1-38) Shows the forms and colures of Poly-crystalline cells for architectural uses and shows the bocks of Poly-crystalline after industrial wafering processes.

In polycrystalline cells there is a clear trend towards larger cells and, hence, more efficient module production, as well as higher module efficiency. Many manufacturers now offer 8 inch polycrystalline cells: the edge length is 8 inches (21cm). Larger cells will bring down the costs of cell and module production in future since fewer cells are needed per module. However, module manufacturers first need to adjust their production systems to accommodate the new sizes, and also develop new bypass diodes and junction boxes that are designed for the higher currents and diode temperatures. The system technology requirements are also higher (cables, inverters, etc.) since the systems have to handle higher currents.

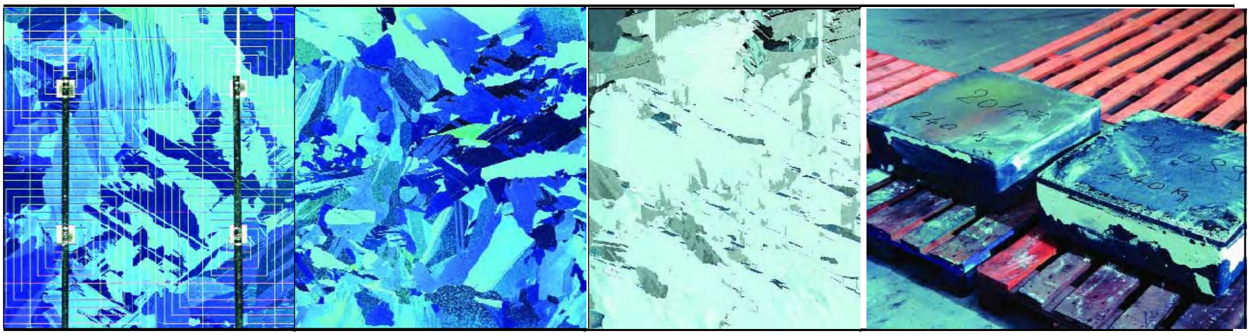


Fig. 1-38 **Polycrystalline wafer without anti-reflective coating // Polycrystalline wafer with anti-reflective coating // Polycrystalline cell with anti-reflective and contact grid lines**

**Source: The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition. (London: Earthscan, sterling,VA,2008).

## 2-3.3 *Thin Films*

The production phase is already showing improvements that will eventually be reflected in lower manufacturing costs. Firstly, the cells and the production as a whole use materials more efficiently than the crystalline silicon technology, which result in savings on the material costs. Secondly, the production shows potential for higher automation if a certain production volume is reached.[3] (Figure 1-39)

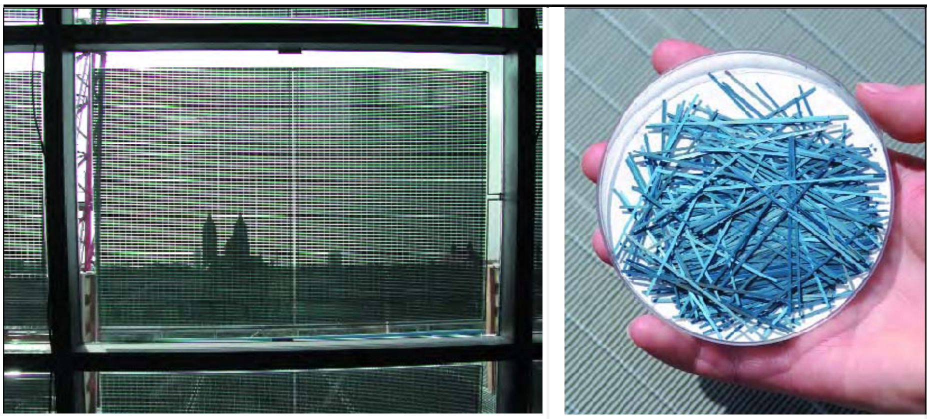


Fig. 1-39

**Semi-Transparent Thin-Film Modules Made From Amorphous Silicon With Additional Separating Steps, Interior View**

**Source: The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition. (London: Earthscan, sterling,VA,2008).

[1] **Kurokawa**. International Energy Agency (IEA); 2003; U.S. *Department Of Energy: Energy Efficiency and Renewable Energy*, 2005.
[2] **EPIA** and Greenpeace, Department of Energy: *Energy Efficiency and Renewable Energy, 2005*PV-TRAC, 2005; U.S.
[3] **Zwaan**, **Rabl**. **Surek** , *"Energy Efficiency And Renewable Energy ",*EPIA and Greenpeace, 2005 ;U.S. Dept. of Energy, 2005.

These are new types of photovoltaic entering the market. ***Copper Indium Diselenide***, ***Cadmium Telluride***, and ***Gallium Arsenide*** are all thin film materials, typically a few μm or less in thickness, directly deposited on glass, stainless steel, ceramic or other compatible substrate materials. This technology uses much less material per square area of the cell, hence, is less expensive per watt of power generated.[1]

## 2-3.4 Amorphous Silicon

Amorphous silicon differs from crystalline silicon by not having a crystal structure. This disorder results in the gradual degradation of the cell by exposure to light. Stabilized efficiencies remain low, at 6-8%.[2]

In this technology, amorphous silicon vapor is deposited on a couple of μm thick amorphous (glassy) films on stainless steel rolls, typically 2,000-feet long and 13-inches wide. Compared to the crystalline silicon, this technology uses only 1 percent of the material. Its efficiency is about one-half of the crystalline silicon at present, but the cost per watt generated is projected to be significantly lower. On this premise, two large plants to manufacture amorphous silicon panels started in the U.S.A. in 1996.[3] Figure 1-40

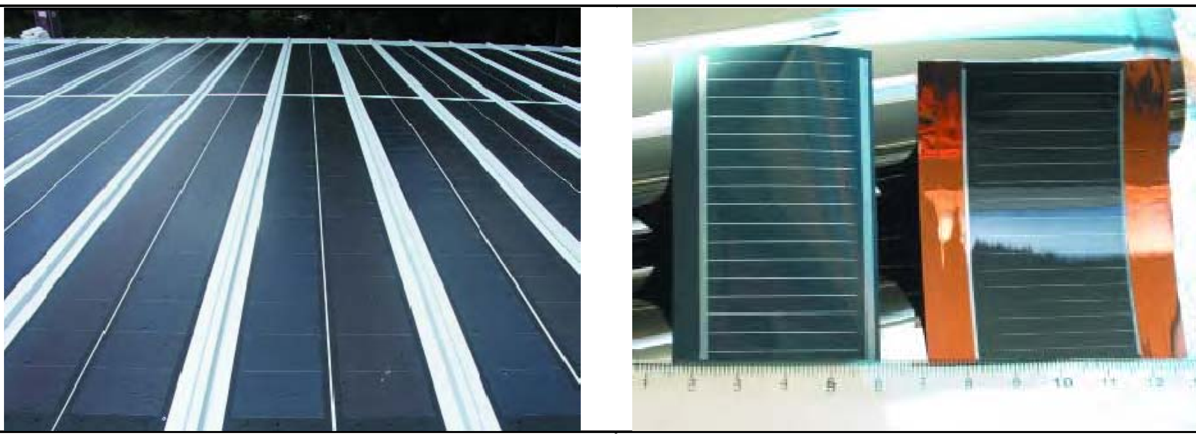


Fig. 1-40 **Flexible Amorphous Modules Based On Metallic Foils That Are Glued Onto Trapezoidal Sheet Sections**
**Source: The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition. (London: Earthscan, sterling,VA,2008).

- *Efficiency:* 9 per cent to 11 per cent module efficiency.
- *Size:* standard modules, maximum 1.2m _ 0.6m.
- *Appearance:* uniform appearance. (Figure 1-41) *Colour:* dark grey to black.

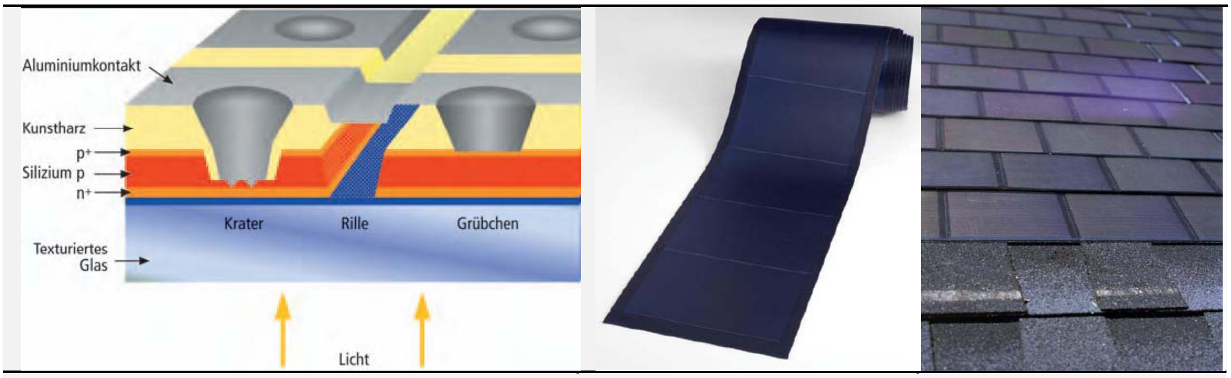



Fig. 1-41 **Structure of Amorphous Silicon Cells // Forms of Amorphous Rolls // Rolls on roof (BIPV)**
Source: **National Dong HWA University**, paper, "*Solar cells Photovoltaic Deveices, October 2006*

[1] **Oikkonen** L., J.**Paatero**, **Carlsson** T., **Lund** P., *"Photovoltaic Energy", Advanced Energy Systems*, Helsinki University of Technology, Finland, 2006, 7.
[2] **Surek**,T. "*Crystal Growth And Materials Research In Photovoltaics: Progress And Challenges"*. Journal of Crystal Growth, 2005, Vol. 275:1-2, 292-304
[3] **Oikkonen** L., *"Photovoltaic Energy"*., 8

## 2-3.5 *Spheral*

This is yet another technology that is being explored in the laboratories. The raw material is low-grade silicon crystalline beads. The beads are applied on typically 4-inch squares of thin perforated aluminum foil. In the process, the impurities are pushed to the surface, from where they are etched away. Since each sphere works independently, the individual sphere failure has negligible impact on the average performance of the bulk surface. According to a Southern California Edison Company's estimate, 100 square feet of spheral panels can generate 2,000 kWh per year in an average southern California climate.

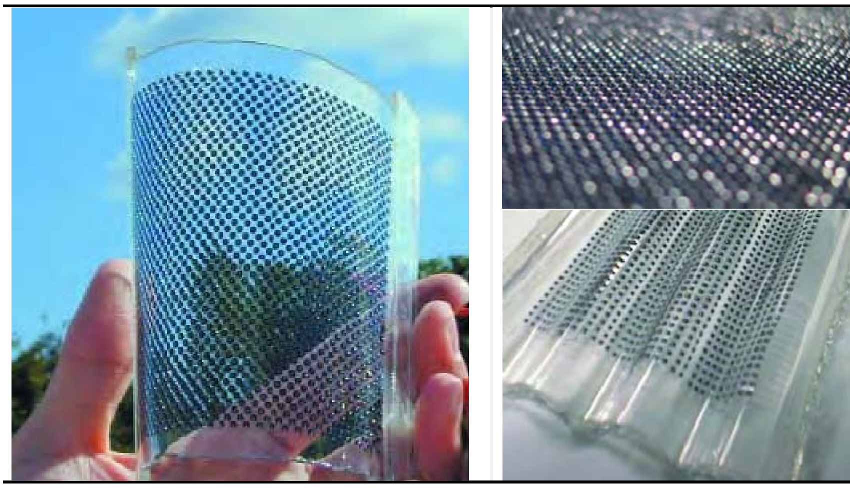


Fig. 1-42

**Spheral Spherical Solar Cell Module Made From 6-Inch Units**

**Source: The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition. (London: Earthscan, sterling,VA,2008).

## 2-3.6 *Concentrated Cells*

In an attempt to improve the conversion efficiency, the sunlight is concentrated into tens or hundreds of times the normal sun intensity by focusing on a small area using low cost lenses (Figure 1-43 ). The primary advantage is that such cells require a small fraction of area compared to the standard cells, thus significantly reducing the PV material requirement. However, the total module area remains the same to collect the required sun power.

Besides increasing the power and reducing the size or number of cells, such cells have additional advantage that the cell efficiency increases under concentrated light up to a point. Another advantage is that they can use small area cells. It is easier to produce high efficiency cells of small areas than to produce large area cells with comparable efficiency. On the other hand, the major disadvantage of the concentrator cells is that they require focusing optics adding into the cost. (Figure 1-43 )

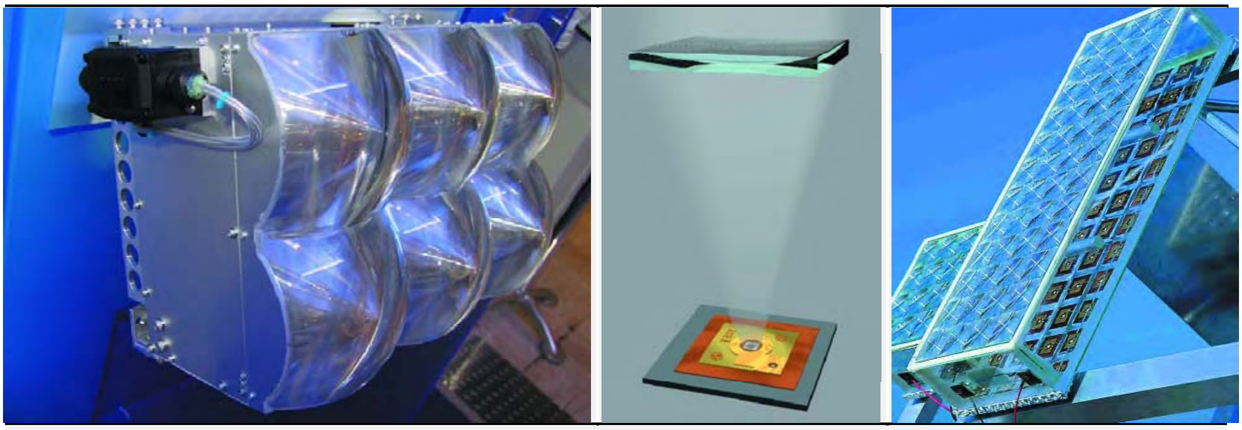


Fig. 1-43 **Lens Concentrating The Sunlight On Small Area Reduces The Need Of Active Cell Material // Theory of The Cells // Tracking Sun Panels.**

**Source**: **Cook**, G., Photovoltaic Fundamental, DOE/NREL Report DE91015001, February 1995.

## 2-4 *PV SYSTEMS COMPONENTS*

The array by itself does not constitute the PV power system. We must also have the following;(Figure 1-44)

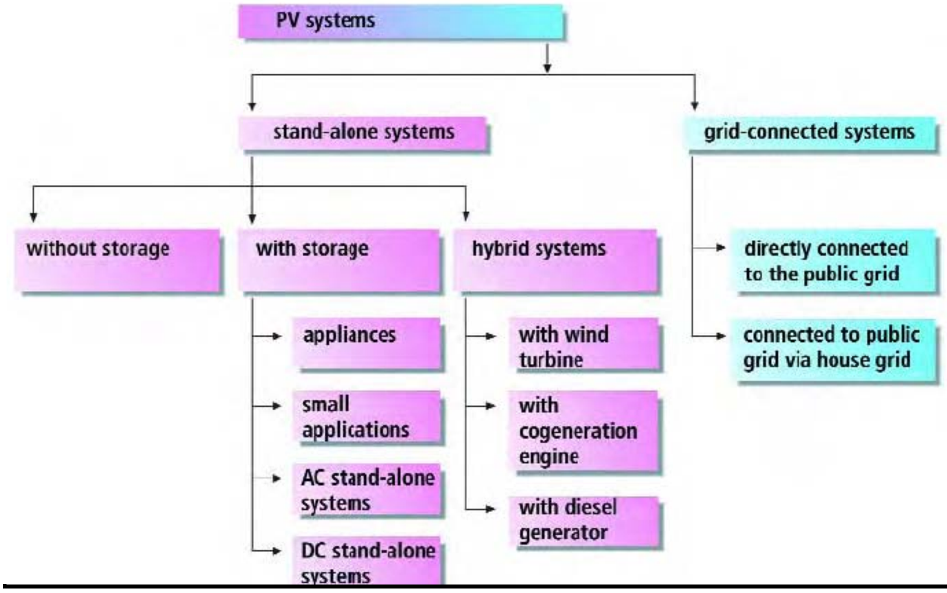



Fig. 1-44

**Classifications of PV Systems and Devices.**

**Source: The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition. (London: Earthscan, sterling,VA,2008).

a. *Stand-Alone Power System: The components include:* (Figure 1-45)

*1- A **Structure** to mount it, point to the sun.*

*2- The system needs an **inverter** to convert the DC power of the array into AC, generally at 50 or 60 Hz, if the load is AC.*

*3- **The peak power tracker** senses the voltage and current outputs of the array, if required under the given climatic conditions. To continuously adjusts the operating point to extract the maximum power.*

*4- **The battery** for night activities, battery charger is usually a DC-DC buck converter.*

*5- The battery discharge **Diode Db** is to prevent the battery from being charged when the charger is opened after a full charge. The array diode **Da** is to isolate the array from the battery, thus keeping the array from acting as load on the battery at night.*

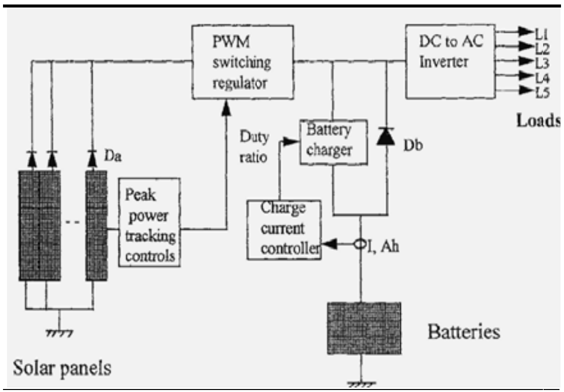



Fig. 1-45

**Shows The Necessary Components Of A Stand-Alone PV Power System.**

**Source: Mukund,** R. Patel., *"Wind and Solar Power Systems",157.*

*6- **The mode controller** is the central controller for the entire system. , keeps track of the battery state of charge by bookkeeping the charge/discharge ampere-hours, and commands the charger, discharge converter, and dump heaters on or off as needed.*[1]

b. *Grid-Connected System,*

Dump heaters are not required, as all excess power is fed to the grid lines. The battery is also eliminated, except for small critical loads, such as the start up controls and the computers. The DC power is first converted into AC by the inverter, ripples are filtered and then only the filtered power is fed into the grid lines.[2]

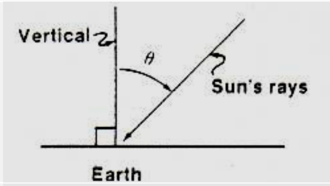
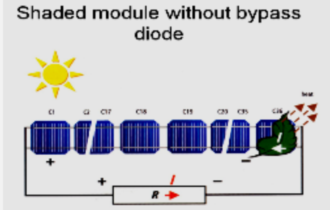
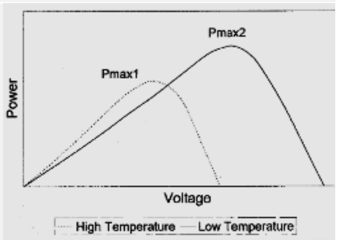
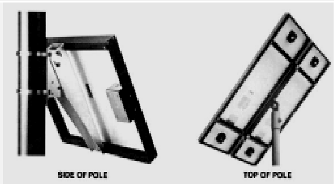
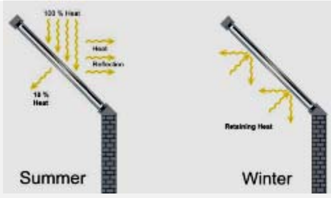
[1] **Soliman**, Moataz., *Workshop ;" Application of Solar Energy; Solar Collectors and Photovoltaic Cells " PV System Component*, Lecture,(Egypt: Alexandria, IGSR, October 2008).

[2] **Abulfotuh** Fuad, *Workshop; "Application of Solar Energy; Solar Collectors and Photovoltaic Cells" PV Technology: Status and Prospects"*, Lecture, (Egypt: Alexandria, IGSR, October 2008).

## 2-4.1 Technical Properties of the System

Table 1-9 illustrates some basic understanding about PV operation needed before the decision for installing the system is make.

**TABLE 1-9** **Most PV's Technical Properties and Problems.**

| | Illustration | Figure |
|---|---|---|
| ***Capacity Connections*** | ➢ A typical photovoltaic cell produces about 2 watts. The cells are connected in series to form modules, and the modules are connected in parallel to form arrays. Series connection is necessary to build up to an adequate operational voltage, but it is then vulnerable to any weak link in the connection. |   |
| ***Sun Angle*** | ➢ The cell output current is given by $I = I_0 \cos\theta$, where $I_0$ is the current with normal sun (reference), and $\theta$ is the angle of the sunline measured from the normal. This cosine law holds well for sun angles ranging from zero to about 50°. |   |
| ***Shadow Effect*** | ➢ Using <u>Blocking Diodes</u> are necessary to prevent PV systems from drawing electricity when they are not illuminated, perhaps due to ***shading from trees*** or ***dirt accumulation*** or in ***night-time***, but not without a penalty. The penalty is an output power loss. As a result, the efficiency of the module is approximately 20–25% (this is before one even takes the PV cell efficiency into account). |   |
| ***Temperature Effect*** | ➢ PV silicon cells are sensitive to heat such that as the cell temperature increases, the efficiency begins to drop, which in turn further increases its temperature. Their maximum efficiency occurs at 0°C and it drops to half as the cell reaches room temperature. Studies have shown that PVs directly mounted on building surfaces operate at 18°C higher than those that are standoff mounted. Thin film PVs are less sensitive to heat, but they are the least efficient to begin with. |   |
| ***Effect of Climate*** | ➢ On a partly cloudy day, the PV module can produce up to 80 percent of their full sun power. Even on an extremely overcast day, it can produce about 30 percent power. Snow does not usually collect on the modules, because they are angled to catch the sun. If snow does collect, it quickly melts. Mechanically, modules are designed to withstand golf ball size hail. |   |
| ***Sun Tracking*** | ➢ Energy is collected by the end of the day, if the Pv module is installed on a tracker, with an actuator that follows the sun like a sunflower. There are two types of sun trackers: *1- one-axis tracker, which follows the sun from east to west during the day. 2- two-axis ,tracks the sun from east to west during the day,* |   |
| ***(BIPV) Building Integrated*** | ➢ The term 'building-integrated photovoltaic (BIPV)' is now a part of every architect's vocabulary. The idea to make photovoltaics fit the building, i.e. through thin film PVs on glazing surfaces or PVs as built into roof shingles, the dilemma is, how building installations could most effectively contribute to optimal PV performance. |   |

**Data adapted and processed from**: **Soliman**," *Workshop; Photovoltaic System Component*, Lecture1, 2, 3, (Egypt: Alexandria, IGSR, October 2008), **Messenger** and **Ventre**, *Photovoltaic Systems Engineering*. 182., **Mukund,**"*Wind and Solar Power Systems"*, 152. **Addington**, "*Smart Materials and New Technologies*" *(*Elsevier, 2005*)*, 102. **National Dong HWA University**, paper, "*Solar cells Photovoltaic Deveices, October 2006*. **Eiffert** Patrina, **"**Building-Integrated Photovoltaic Designs for Commercial and Institutional Structures" http://www.doe.gov/bridge, Feb.2000.72-75, 58-62.

# 3 Computer Design Programs of PV Systems

In this section, many solar energy computer design programs that related to buildings integration of design will be discussed, This may provide the architect or planner to reviewing the design and best solutions for the integration of solar energy system on the building skin or on urban holistic system. The programs provide the followings targets and studies;

- Simple, rapid, and effective utilization of the programs for obtaining the required findings.
- Evaluation of solar energy system efficiency with relevance of building and urban adjacent design system, through taking consideration of site, climate, building design, function, and the ambient in to account.
- Providing depicted database for the system for achieving high level of simulation and efficient design.
- Providing beneficial data and findings in simple frame like charts, diagrams, figures, and data.

*The following programs will be reviewed for the study, as follows in (Table 1-10).*

**TABLE 1-10 Software programs related to PV Modeling, Studying, and Monitoring.**

| Name | Illustration | Name | Illustration |
|---|---|---|---|
| ECOTECT | ECOTECT Is an industry leading building analysis program that allows designers to work in 3D and apply tools necessary for understanding the energy use and impact that a building will have. The main related calculations are ( weather data- building analysis – control tools as shadow- scripting used LUA – visibility analysis- optimization) | PV*SOL | PVSOL Is a program for the design, planning and simulation of PV systems. The calculations are ((grid connected/stand-alone systems - PV panels number - Shading -production/consumption- costs & financial return... etc )based on an hourly data balance and results can be presented in graphic form. |
| PVCAD | PVcad is a program for optimal design of photovoltaic facades. PVcad offers a 3D view of the building to enter the generator circuit. The input is supported by databases for solar modules and inverters. The electrical data of the generator are calculated using this database and immediately available. | PVSYST | PVSYST is a PC software package for the study, sizing, simulation and data analysis of complete PV systems. It is suitable for (grid-connected, stand-alone, pumping and DC-grid (public transport) systems) and offers an extensive meteorological and PV-components database. |
| IPSE | | Sol Arch | |
| EnerCAD | | Sombrero 3,01 | |
| PV-DesignPro | | Sun Angle | |

**Ecotect**, workshop " *ECOTECT* " 2003. **Photovoltaic software**, data retrieved from *www.pvresources.com* in August 2009.

## ▪ CONCLUSION

The chapter discusses and surveys the main global issues regarding energy problems and resources, climatic changes and environmental degradations, and sustainable urban development trends, In Chapter II; IDENTIFICATION OF THE PROBLEM, the literature review discusses the potentials of renewable energy as a solution and solar energy as suitable solution and contribution in urban and architectural scales. Solar energy systems and applications are outlined through the **last chapter** of part one.

*The main outlined point concluded from the discussion in part one, was;*

***Solar Silicon Technology,*** Silicon technology demonstrates its merits to be such **more efficient semi-conductor material** for mass production manufacturing of solar photovoltaic modules, the recent efforts for developing new semi-conductor material still under **R&D stage**. Numerous scientists recommended the existence of silicon photovoltaic technology for 30-50 years at minimum, and researches for developing Nano-Silicon technology are demonstrated now.

The proposal VLS-PV recommends the utilization of **PV silicon panels** - Flat-Plate PV modules uses polycrystalline silicon technology - for developing electricity production and new sustainable communities in world's desert especially in developing countries. Consequently, through developing the local manufacture of silicon photovoltaic technology for providing technology transfer and mass production technologies, which are expected to be an economically feasible option for installing large central solar electric generation plants.

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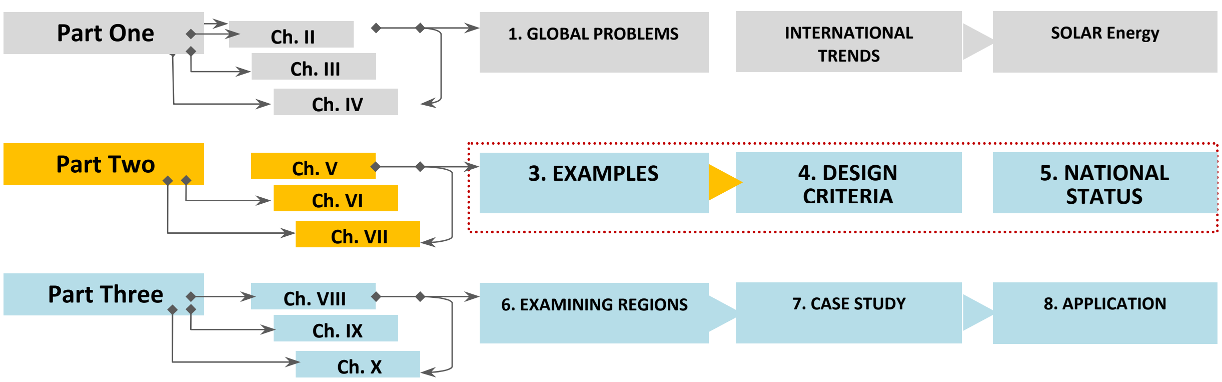
# PART TWO

## SOLAR APPLICATION IN URBAN DEVELOPMENT & THE POTENTIALS IN EGYPT

*Analytical Study*




- *In **Part Two** the research have to illustrates and analyses the principles, technology abilities, and applications of solar energy as one of the renewable energies that may be suitable for achieving the global sustainable directions on urban and architectural scale. **Chapter V;** Discusses the main principles, information, outlines, uses and applications of solar energy. **Chapter VI;** involves the most recent visions and applications for using solar energy — whether devices or systems — on urban development architectural scale. **Chapter VII;** Has to draws out the most available and suitable visions, systems, and guidelines to be the start point of the case study in Part Three; the guides that help imagine and plan the model, of silicon or solar development in the Egyptian desert.*

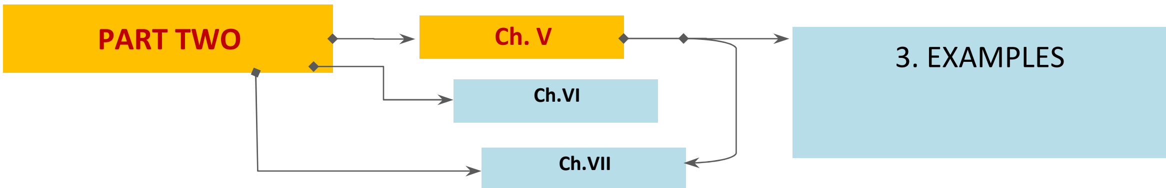
# PART 2: SOLAR APPLICATION URBAN DEVELOPMENT AND POTENTIALS IN EGYPT

*Chapter*

# CHAPTER

# V

## SOLAR ENERGY APPLICATIONS IN ARCHITECTURE & URBAN DEVELOPMENT




➢ ***This Chapter*** *presents visional, practical, and future examples of solar energy application in various levels, whether, in regional and international levels and on urban and architectural scale. However, it has to compare the practical examples to draw the main guidelines and design criteria, to examine the availability of using solar energy technologies in Egypt. The chapter contains;*

- *Discussion of the projects conditions, concept, architectural vision and achieved sustainable issues.*
- *Introduction of recent international examples uses solar energy applications and achieving sustainable design principles.*
- *Discussion and analyzing of the practical projects, and illustrate the vision, objectives, implementations stages, Energy policy, and the holistic learned lessons from every project case.*
- *Information draws out & creation of specification matrix of project's and design criteria that would extracted form case studies.*

# Chapter V. (SE) APPLICATION IN URBAN DEVELOPMENT & ARCHITECTURE

## 1 SOLAR AND PV SYSTEMS IN DESERT DEVELOPMENT

*"The way people deal with Photovoltaics in architecture differs from country to country. This depends on the scale, culture and type of financing for building projects."* [1] ***Said: Reijenga***

The interrelationship between solar applications in urban or architectural field - that should be simultaneously studied- could be addressed in the following scales of system;

### 1-1 *VERY LARGE SCALE PHOTOVOLTAIC SYSTEMS (VLS- PV)*

When you consider the future of our planet, energy problem and environmental problem will appear. The authors of this concept propose its solution, which is utilization of deserts for power plant by PV technology. 100 MW *Very Large Scale Photovoltaic Systems (*VLS-PV), which are fixed flat plate system in the world deserts and sun-tracking system in the Gohi desert are assumed and evaluated in detail by using Life Cycle Assessment. It means that the VLS-PV systems are evaluated in terms of its input and output from cradle to grave.

The proposal is try to evaluate the VLS-PV systems in world deserts, and to investigate feasibility of the system such as fixed flat plate system, tracking system and so on from economic and environmental viewpoints. As indices taken up for the evaluation, cost, energy requirement, CO2 emission of large-scale installing, toughness on hard desert condition, elucidated effect on climate and local, etc. are enumerated, and the possibility of solution to world energy and environmental problems is discussed.

Six *deserts*, which are selected to the proposal, Sahara*, **Negev, Thar, Sonoran, Great Sandy and Gobi*** are elected for installing VLS-PV system. A desert area is suitable for PV system in view of irradiation and land area. ***Gravel desert*** is elected for installing the system. Because it consists of small rocks and it is more flat and firm than sand or rock desert. Sand problems such as sand storm are seemed to be small.

Fig. 2-1 **Layout of Sets unit of 25MW Field in VLS-PV proposal.**
**Source**: http://en.wikipedia.org/wiki/Solar_power_plants_in_the_Mojave_Desert. Date. 1/2009.

Fig. 2-2 **Schematic View Of PLS- PV In The Desert illustrate to modular sets of 25MW unit Field.**
**Source**:http://en.wikipedia.org/wiki/Solar_power_plants_in_the_Mojave_Desert. Date. 1/2009.

[1] **Reijenga** T., ***BEAR*** Architects, "*Photovoltaic in Architecture, Gouda* ", *(*Paper 2002), 2.

### 1-1.1 *Very Large Scale PV[ VLS-PV] Case Study*

Very large scale applications of solar energy one of the most important needs that will present more utilizations of the system in expanding the application spread all over the world's energy systems, and to integrated and be combined with other conventional or renewable energy systems.

On other hand it allows more research and development ***(R&D)*** of the solar applications scale, efficiency, and materials or devices. However, Very-Large scale photovoltaics is one of leading new initiatives or proposal that has experimenting the PV's in very large-scale and in the same time in the desert, the largest abandoned land on the earth surface.

| **Project Title** | *Very Large Scale Photovoltaic – On the World Deserts.* |
|---|---|

**Fig. 2-3 The Large-Scale Concentrated Solar Collectors Plants With Electrical Generators, The Plant has Similar View With The Photovoltaics Plants, in California Desert, USA.**
**Source**: http://en.wikipedia.org/wiki/Solar_power_plants_in_the_Mojave_Desert. Date. 1/2009.

| | |
|---|---|
| **Site** | *Villages In the Vicinity of Deserts, Outskirts of Urban Areas, Vast Barren Unused Lands, World's Deserts.* |
| **Team Work** | *Main Team* : Kosuke kurokawa / Keiichi Komoto /Peter van der Vleuten / David Faiman<br>*In co-ordination with* International Energy Agency (IEA) *Photovoltaic power system program* - Task 8. |
| **General Information** | *Co-Operation Countries; Canada, Germany, Israel, Italy, Japan, Korea, Netherland, France, Magnolia.* |
| **Project Overview** | The scope of this study 'Task 8' is to examine and evaluate the potential of very large scale photovoltaic power generation (VLS-PV) systems, which have capacities ranging from several megawatts to gigawatts, and to develop practical project proposals for demonstrative research towards realizing VI.S-PV systems in the future.<br>To utilize Solar energy on a large scale, a massive land area is necessary. One third of the land surface of the ***Earth is covered by very dry desert and high-level insolation***, where there is a lot of available space. It is estimated that if a very small part of these areas, approximately 4 %, was used for installing photovoltaic (PV) systems, the resulting annual energy production would equal world energy consumption.[1] |

[1] **IEA**, **PVPS** Annual Report, *"Task 8 - Study on Very Large Scale Photovoltaic Power Generation System"*, 2007.

**Objectives**

### ✓ *Project Objectives ,*

The potential contribution of system application to global environmental protection, and renewable energy utilization in the long term.[1] It is apparent from the perspective of the global energy situation, global warming and other environmental issues that VLS-PV systems can:

- *Contribute substantially to global energy needs;*
- *Become economically and technologically feasible;*
- *Contribute considerably to the environment; and,*
- *Contribute considerably to socio-economic development, especially for the developing countries with deserts.*

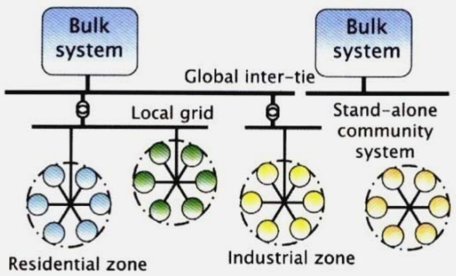



**Fig.2-4 The Global Network Image as it Studied by the Project Team.**
**Source**: Kurokawa," *Energy from the Desert: Feasibility of (VLS-PV)Systems"* , 2007.

**Project Considerations**

### ✓ *General Considerations,*

- Considering of the spread and use of the PV system and renewable energy. And raising the awareness of public, government decision-makers, and financiers of the benefits of renewable energies.
- Considering the approaches that could support the utilization of PV system in different levels, whether, from the building scale as 'Solar home system SHS' to very large-scale PV system in the desert areas.
- Considering of advantages and disadvantages of the system proposal for the environment and the world energy needs.
- Considering the studies of system form scratch with R&D stage to the practical project proposal, with considering of system's cost analysis , social-economic analysis, and live cycle assessment 'LCA ' study.

<u>The following items also should be considered at the Project proposals , depend upon the *type or stage* of the project, as:</u>

*Background and objective / Targeted capacity of VLS-PV systems/ Location / Project period / Economic aspects / Technical aspects / Social aspects / Environmental aspects, and Future perspective.*

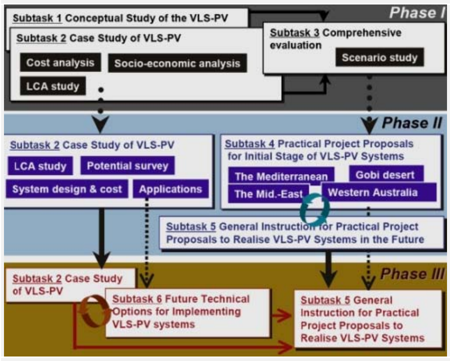



Fig.2-5 **The Task 8 Team in Front of the 450 kW PV system, Casalnoceto, Italy.**
**Source**: IEA, PVPS Annual Report,*"Task 8 - Study on VLS-PV Power Generation System"*, 2007

### ✓ *Desert Community Considerations,*

The project take into account the creation of new sustainable communities in the desert areas that includes PLS-PV plants, so the following issues are researched and investigated;

- *The possibility of utilizing VLS-PV in the desert areas,*
- *A sustainable scenario for installing the system,*
- *Modeling of sustainable society with solar PV generation and greening in the desert,*
- *The sue of solar PV generation with regard ro elemental technology/ systems for sustainable agriculture,*
- *And sustainable agriculture utilizing other regional renewable energy options.*
- *Considerations of the existence of a good groundwater supply and power grid near the community.*[2]

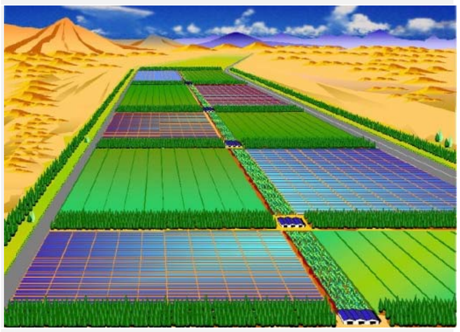


Fig.2-6 **Image of a VLS-PV System in Adesert Area as Acomplex with Planting and Tree Areas.**
**Source**: Kurokawa," *Energy from the Desert: Feasibility of (VLS-PV) Systems"*, 2007.

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[1] **Kurokawa**, K. fed," *Energy from the Desert: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems"* ,(James and James, London, 2003).

[2] **Kurokawa**, K. Keiici. Vleuten. Faiman. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems"* ,(EarthScan, London, 2007), p. 82.

**Implementation**

### ✓ *Implementation* ‘*approaches*’,

Three approaches are under consideration to encourage the spread and use of PV systems, which open the door for implementing the holistic proposal of VLS-PV Systems, as follow:

1- *Establish small scale independent PV systems;* There are *two scales* for such systems:

- *installing* ***stand-alone****, several hundred watt-class PV systems for private dwellings*, and *installing 2 to 10 kW-class systems on the* ***roofs*** *of dwellings*, ‘*used in developing countries, as the solar home system (SHS)*’,
- *and, 10 - 100 kW-class systems on office buildings and schools. ‘ used in industrialized countries’*

This seems to be used extensively in areas of short- and medium-term importance.

2- *Establish 100 to 1000 kW-class mid-scale PV systems*: on *unused land on the outskirts of urban areas*. Like it was germinated by PVPS/Task 6-8, and their number is expected to increase rapidly in the early 21st century, which, can be extended up to *multi-megawatt size*.

3- *Establish PV systems larger than 10 MW:* on vast barren, unused lands that enjoy extensive exposure to sunlight. In such areas, a total of even more than *1 GW of PV system* aggregation can be realized.

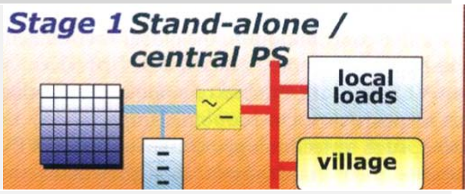


Fig. 2-7. a **Stage 1.**

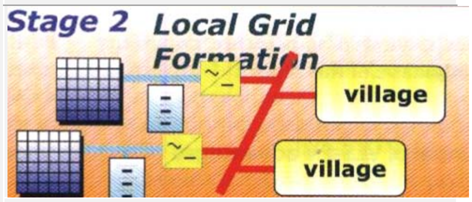


Fig. 2-7.b **Stage 2.**

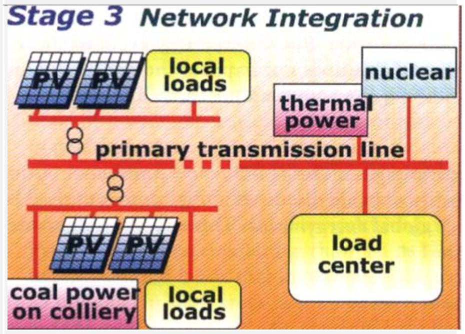


Fig. 2-7.c **Stage 3.**

### ✓ *Implementation* ‘*Stages*’,

***Stage 1:***

- A *stand-alone bulk* system is installed for surrounding villages or anti-desertification facilities in the vicinity of deserts. Figure 2-7.a

***Stage 2:***

- A Remote, *isolated networks germinate*. Plural systems are connected by a regional grid. Figure 2-7.b

***Stage 3:***

- The *regional network* is connected to a primary transmission line. Generated energy can he supplied to a load centre and industrial zone. Total use <u>combined with other power sources</u> and <u>storage,</u> for matching the demand pattern and improving the capacity factor of the transmission line. Figure 2-7.c

***Stage 4:***

- Finally, *a global network* is developed. Most of the energy consumed by human beings can supply by solar energy. Figure 2-7.d

*While*, advanced energy-transportation will be expected on a long-term basis, such as a *superconducting cable*, *flexible AC transmission system (FACTS)* or *chemical media*. Fig. d.

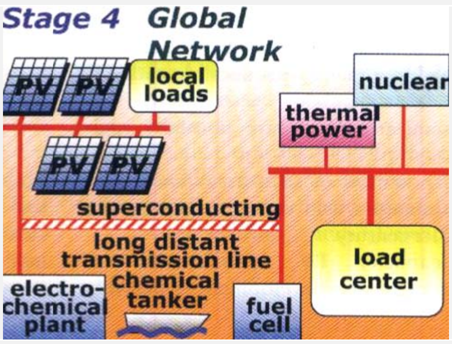


Fig. 2-7. d **Stage 4.**
**Source**: Kurokawa,” *Energy from the Desert: Feasibility of (VLS-PV) Systems”,* 2007.

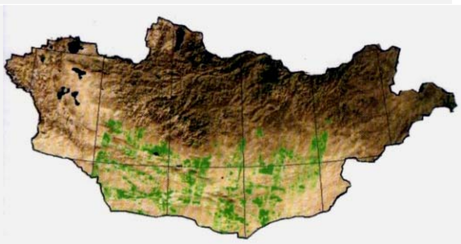


**Fig. 2-8 The Studying of Magnolia Desert for agriculture urban communities with VLS-PV.**
**Source**: Kurokawa,” *Energy from the Desert: Feasibility of (VLS-PV) Systems”,* 2007. P.83

**Energy System**

### ✓ *Energy Policy,*

The project energy policy is includes main practical approaches for make the project be realized in all levels, whether, national or international. As follows:[1]

- ***Required approaches for PV and renewable.***
- ***Establish policies for developing markets of renewables.***
- ***Expand the financing options of renewables.***
- ***Develop the capacity required of renewables.***
- ***Preliminary recommendations on a policy level for VLS-PV.***
- ***Approaches for practical project proposal.*** (As shown in **Table 1-1 )**

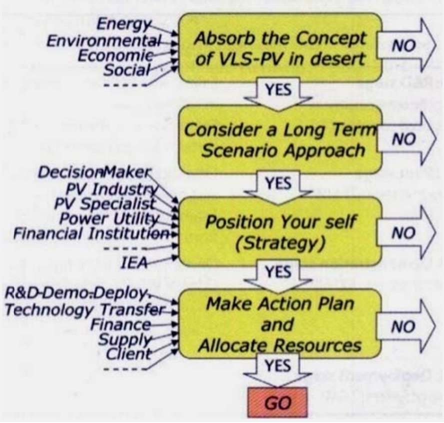



Fig. 2-9 **Check –Flow of Recommendations on a Policy level for VLS-PV.**
**Source**: Kurokawa,” *Energy from the Desert: Feasibility of (VLS-PV) Systems”*, 2007.

**TABLE 1-1** ***Summary of the scenario of VLS-PV development.***

| | Sub-stage | |
|---|---|---|
| | Technical issues | Non-technical issues |
| <u>*S-0: R&D stage*</u><br>*(may be unnecessary in advanced countries)* | ▪ Examination of the reliability of PV systems in a desert area.<br>▪ Examination of the required ability of PV systems for grid connection. | ▪ Site selection fdr VLS-PV based on conditions.<br>▪ Planning project formation, including training engineers and funding. |
| <u>*S-1: Pilot stage*</u><br>*Scale of system:* 25 *MW* | ▪ Development of the methods of operation and maintenance (0&M) for VLS-PV.<br>▪ Examination of the control of power supply from PV systems to the grid line. | ▪ Development of the area around VLS-PV in order to prevent desertification.<br>▪ Training engineers for PV module production on site |
| <u>*S-2: Demonstration stage*</u><br>*Scale of system:* 100 *MW* | ▪ Development of the technical standards for O&M of VLS-PV, including grid connection. | ▪ Training engineers for mass production of PV modules and for balance of systems (BOS) production on site.<br>▪ Preparation for industrialization by private sec. |
| <u>*S3: Deployment stage*</u><br>*Scale of system:* 1 *GW* | ▪ Developing the concept of 'solar breeder' from the viewpoint of technical and non-technical issues. | |

### ✓ *System Specifications,*

*The practical project sample was studied in Gobi desert, to create sustainable development with* One GW VLS-PV system, with studying of the *System Assumptions*

- Energy Resource: solar energy.
- Application: VLS-PV electricity generation
- PV system power targeted*: One GW VLS-PV.*
- Type of cell technology:
  - *Polycrystalline silicon PV module with 12.8% efficiency is employed; It is referred to Kyocera 120s.*
- Installation type:
  - *South-faced fixed flat array structure,*
  - *One axis* E-W *tracking array structure and foundation are designed.*
  - *Wind pressure and earthquake are also taken into account.*
- The system lifetime*: assumed to he 30 years.*[2]

Fig. 2-10 **.a Sample of the plant modules I00MW system**

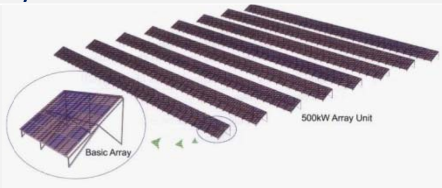



Fig. 2-10.b **The visional model of the VLS-PV plants with tree planting and grid transmission line. Source**: Ibid. p.83.

[1] **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ,” *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems”* ,(EarthScan, London, 2007), p. 4-6.
[2] **Ibid.**, 105-107.

## Installation System

### ✓ *Installation Cases,*[1]

<u>*Building Integrated system;*</u>

- Roof Cases; Installing of Solar houses system 'SHS' in villages and vicinity regions.
- Roof & Façade Cases; Installing on office buildings and schools (BIPV).

<u>*Irrigation system;*</u>

- Integration of solar PV system with the irrigation system technology for planting and trees, to avoid desertification problems of arid and semi-arid deserts.

<u>*Desalination system;*</u>

- Utilizing solar energy PV integrated with the desalination water system to provide fresh water for people and irrigation activities.

<u>*Power plant system;*</u>

- Installing of very large scale PV power plant in outskirts of urban areas, used barren lands, and deserts.

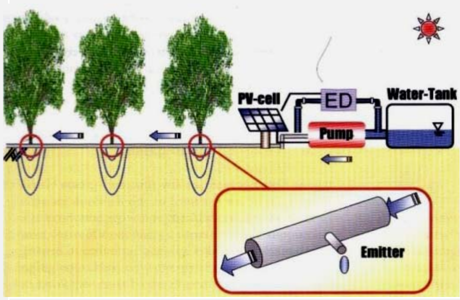



Fig. 2-11.a

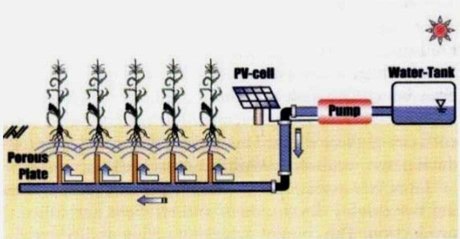



Fig. 2-11.b

### ✓ *Installing Devices,*[2]

<u>*Building Integrated system;*</u>

- Using of building integration photovoltaics 'BIPV' for installing the PV modules by using roof and façade cases.

<u>*Irrigation system;*</u>

- Using irrigation- drainage combined system + PV power. **Fig.** 2-11.a
- or, Subsurface irrigation system + PV power. Fig 2-11. b
- or, desalinated drip irrigation + PV power. Fig 2-11. c

<u>*Desalination system;*</u>

- Using of electro-dialysis desalination system with using of PV power.

<u>*Power plant system;*</u>

- Installing of very large scale PV power plant in outskirts of urban areas, used barren lands, and deserts.

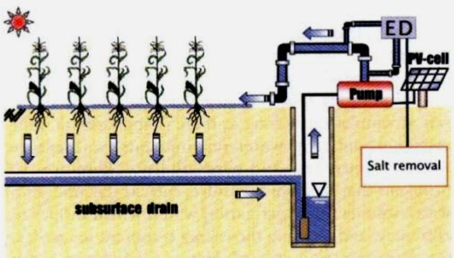



Fig. 2-11.c

Fig. 2-11 .a,b,c .

**The Irrigation System Options.**

**Source**: Kurokawa," *Energy from the Desert: Feasibility of (VLS-PV) Systems",* 2007. p.83.

## Main Issues

### ✓ *Learned Lessons,*

- The concept of VLS-PV systems in the desert areas, open new horizon for us, to investigate the resources of the deserts and the high insolation of solar energy their.
- VLS-PV projects allowed the developers and decision- makers for reviewing their vision about the deserts, not as abundant areas but as a resource of clean and renewable energy.
- The project vision, studies, analysis and realized practical proposal that spread all over the world, with the promotion of International Energy Agency 'IEA '*PVPS/Task 6-8* Tasks, make the importance for taking the project as reality of our future communities in the desert areas.
- The advantages of the project in urban, regional, national, and international level, makes it worth mentioning as a case study for the *new Urban Community in the Egyptian Deserts*.

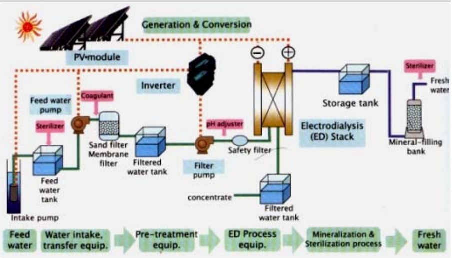



Fig. 2-12 **Using of electro-dialysis desalination system with using of PV power.**

**Source**: Kurokawa," *Energy from the Desert: Feasibility of (VLS-PV) Systems",* 2007.p.84.

[1] **Kurokawa**, K. **Keiici. Vleuten. Faiman**. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems"* ,(EarthScan, London, 2007), xliv.

[2] **Ibid.**. p. 82-94.

# 2 SOLAR & PV SYSTEMS IN URBAN DEVELOPMENT

The followings are some of the soundest international sustainable urban projects, which were started or constructed in the 21st Century. Some are in first stage of implementation and the others in the final stage. *MASDAR City*, is the most recent international initiative for applying sustainable development and renewable application especially Photovoltaic-thin cells technology, while, *Linz- Pichling* is the first implemented sustainable model of solar city in Europe, using solar passive and active systems.

## 2-1 SOLAR ENERGY IN URBAN SCALE

### 2-1.1 *Example 1*

**Project Title** — *The Masdar Development – Climate Engineering for a Carbon-Neutral City.*

Fig. 2-13 **Masdar City, Top View as it Envisaged.**

**Source:** Master Planning Phase of the World's First Carbon-Neutral City. "Report: *The Masdar Development –Climate Engineering For A Carbon-Neutral City*" , http://www.masdar.ae/. Date,12/2008.

| | |
|---|---|
| **Site** | *Abu Dhabi – The United Arab Emirates.* |
| **Team Work** | *Foster & Partner London, UK.* |
| **General Information** | *Client: Abu Dhabi Future Energy Company.* *Area: 6.5 km²*<br>*Renewable Energies: ETA - Renewable Energies, Florence, Italy.*<br>*Climate Engineers: Transsolar Energietechnik GmbH.* - Annual solar irradiation 1,000 kWh/m²a |
| **Project Overview** | The project forms part of the so-called "Masdar Initiative", the initiative that has been driven by the Abu Dhabi Future Energy Company, and will be a centre for the development of new ideas for energy production, is a new 6 million square meters, sustainable development, which uses the traditional planning principals of a walled city, together with existing technologies. To achieve a zero carbon and zero waste community. Masdar city is an ambitious project that will attract the highest levels of international expertise and commerce, providing a mixed-use, high-density city. [1] |

[1] Masdar Official Site; http://www.masdar.ae/ . "The *Masdar Initiative* "Date, 12/2008.

**Urban Considerations**

### ✓ *Project Objectives & Justifications,*

- Masdar City is one of the flagship projects of the One Planet Living™ program– a global initiative launched by WWF[1], that aims to prove that it is possible to live within ecological limits and still improve the quality of people's lives.
- It aims at maximizing the benefits of sustainable technologies, such as *photovoltaic cells* and *concentrated solar power*, through an integrated planning and design approach.
- An essential innovation for the development of the city is carbon finance. Carbon emissions reduction; that will be monetized under the Kyoto Protocol's Clean Development. [2]

**Fig**. 2-14 **Masdar City, Master Plan**. **Source**: Report: *"The Masdar Development Climate Engineering For A Carbon-Neutral City"* http://www.masdar.ae/

### ✓ *General Urban Considerations,*

- Studying of *culture background*, reflecting solutions of city planning and building designs. And using *traditional Arabic city* as source of inspirations where the person not the vehicle is paramount.
- Consideration of existing *weather data*, and use *climate engineer* for analyze the environmental and setting of the building. Also using of solar and sand protection and water collection and conservation.
- Using direct results of *computational fluid dynamic* (CFD) simulations for fluid and day light and shading analysis.
- *Excluding cars with combustion engine* from the inner city to reduce the demand for ventilation in the city.
- Using of *narrow streets* and *retractable shading courtyards* designs, differs depending on the type of building usage for better thermal comfort, will reduce outdoor temperature by as much as *20° Celsius*. Determine also the Micro-climate above the city due to high solar absorption of the Photovoltaics roofs.
- Designing of *two green parks* bands through the whole city are oriented towards the sea breeze and the cool night winds.[3]

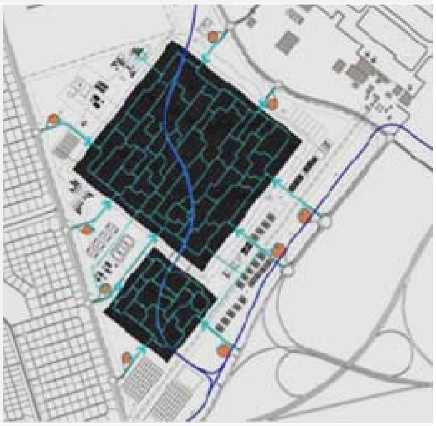


Fig.2-15 **Computaional Model of the City, Studied the Green Two Parks in the City Heart.** **Source**: Report: *"The Masdar Development Climate Engineering For A Carbon-Neutral City"* http://www.masdar.ae/.

### ✓ *Orientation,*

- In this case study, the city planning direction is related to many conditions like, *WEATHER DATA, SOLAR IRRADIATION, SAND DUST, SEA BREEZES*, and the site condition itself. The optimism orientation of these cases of study was SOUTHEAST- NORTHWEST ORIENTATION. Piazzas and streets also oriented to attract more sea wind breezes and fresh air into the city lungs
- The orientation of buildings was internal orientation, by use of courtyards and narrow streets.
- The use of Photovoltaics plants was in out of the site as *Stand-Alone* tracking systems energy plants. In addition, all city's building roofs are used as *Large-Scale Photovoltaic Plant* for the city's needs for electricity and as shading devices also for buildings.

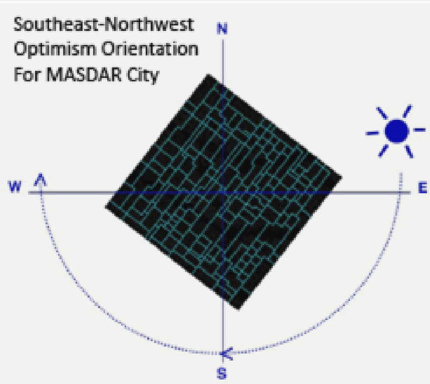



Fig.2-16 **The Optimism Orientation for City as Model Studies.** **Source**: Report: *"The Masdar Development Climate Engineering For A Carbon-Neutral City"* http://www.masdar.ae/.

[1] **WWF:** is the **W**orld **W**ide **F**und for **N**ature and the **W**orld **W**ildlife **F**und) that launched the initiative of One Planet Living™
[2] **Al Jaber**., Initiative Report, *"Abu Dhabi's MASDAR INITIATIVE; Breaks Ground On Carbon-Neutral City Of The Future"* 2008, 1.
[3] Master Planning Phase of the World's First Carbon-Neutral City. "Report: *The Masdar Development –Climate Engineering For A Carbon-Neutral City*" , http://www.masdar.ae/. Date,12/2008.

**Stages Of Implementation**

### ✓ *Planning Stage,*[1]

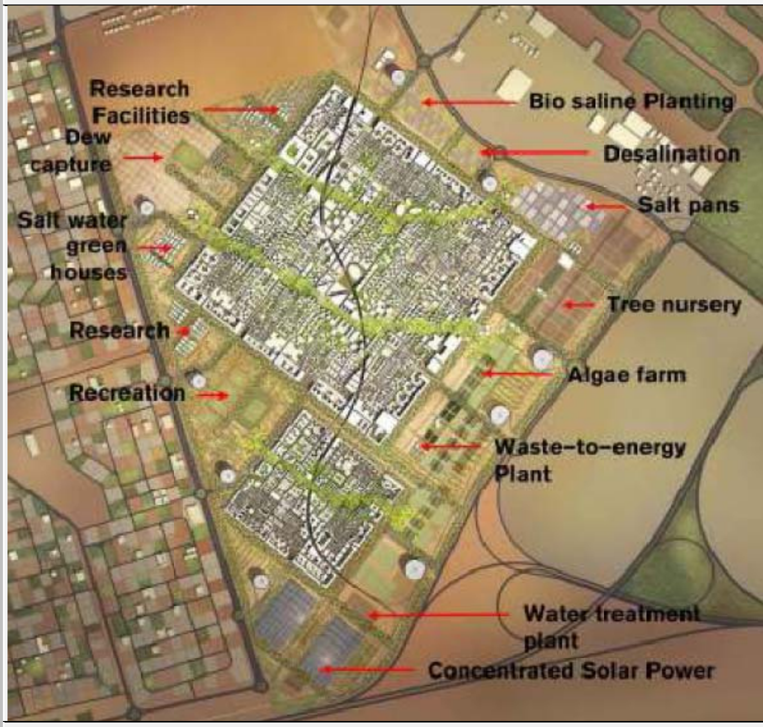
*The six-square kilometer district will have multi-use land as the followings;*

- *30 % will be zoned for housing,*
- *24 % for the business and research district,*
- *13 % for commercial purposes, including light manufacturing;*
- *6 % for the MIST,*
- *19 % for service and transportation,*
- *8 % for civic and cultural pursuits.*[2]

➢ *Plan Phases,*

- The first step in the city's ***Seven-Phase*** is the development of the *Masdar Institute of Science and Technology* (MIST), the world's first graduate university dedicated to renewable energy.

Fig.2-17 **Visionary Model of the City. Source**: Masdar Official Site; http://www.masdar.ae/ "The *Masdar Initiative* "Date, 12/2008.




Habitants No.: 500.000 inhabitants;
site on 30.665
Commuting workers: 36.166
**Site area**: 550 hectare
**Floor space**: 6.0 Million m² Density per Floor space:
2.1 m² Floor area / m² Ground area

Energy Mix:
- CSP 26%
- PV 53%
- Solar Thermal 14%
- Waste to Energy 7% = 320 MW

**total usage**, 30 KWh per capita per day energy usage (9x LESS than USA)

Fig.2-18.a **Masterplan, landscape Strategy . Source**: **Foster**, Norman., Projects, Official website,http://www.fosterandpartners.com/Practice/Default.aspx, Date,12/2008.

- **Water needs cut by more than half**; Masdar City will require around 8,000 m3 per day of desalinated water versus more than 20,000 m3 per day for traditional cities
- **Landfill area severely diminished**; a city of this size would have required millions of square meters of landfill area; Masdar City will need virtually no landfill area.
- **The City will be a home for**; 1,500 businesses and 50,000 residents and will be home to international business and top minds in the field of sustainable and alternative energy.

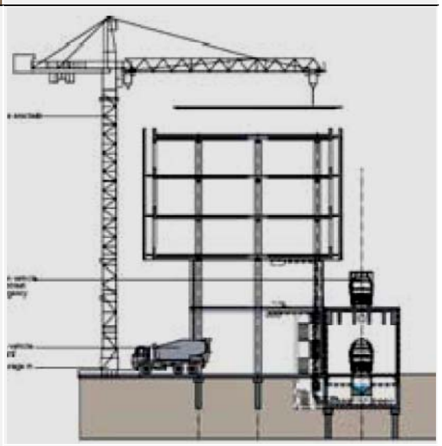


Fig.2-18.b **Structure Systems Source**: Ibid.

[1] Masdar Official Site; http://www.masdar.ae/ . "The *Masdar Initiative* "Date, 12/2008.
[2] Master Planning Phase of the World's First Carbon-Neutral City. "Report: *The Masdar Development –Climate Engineering For A Carbon-Neutral City*" , http://www.masdar.ae/. Date,12/2008.

### ✓ *Design Stage:*

- Masdar City is set to be completed in 2015. It will draw inspiration from traditional Arabic cities, where the person, not the vehicle, is paramount.
- The city will reduce the carbon footprint by developing in a compact area that allows for easy pedestrian movement and expands the comfort zone of the city through control of sun and wind to create the highest sustainable quality of life.
- Narrow, shaded streets will reduce outdoor temperatures by as much as 20 degrees Celsius, making it possible to comfortably enjoy the outdoors longer than is currently possible in Abu Dhabi's summer heat and humidity. [1]
- Carefully planned landscape and water features also aid in reducing temperatures, while enhancing the quality of the street.

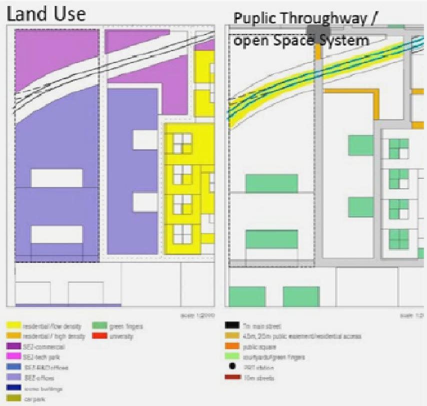



Fig.2-19 **Computaional Model Of The City, Studied Main Streets**.
**Source**: Foster., Projects, Official website, http://www.fosterandpartners.com/Practice/Default.aspx, Date,12/2008.

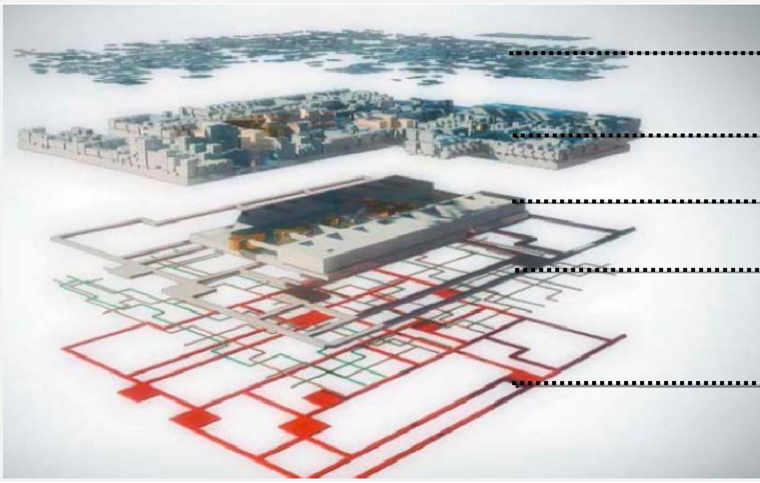



Fig.2-20 **Computaional Model of The City's Layers.** **Source**: Ibid.

**Energy Systems**

### ✓ *Energy Policy:*

- Achieving 75% percent reduction in installed power capacity; Masdar City will require approximately 200 MW of installed clean power versus more than 800 MW of installed capacity to power a similar city based on conventional design.
- *The city will minimize energy demands by deploying the **most energy efficient techniques** available,* and *that reduced demand will be met using renewable energy.*
- *New technologies, such as **Photovoltaics, concentrated solar power, waste to energy** and the opportunities of producing **Bio-fuel**. To supply 100 % of* the *energy needs. In addition, **supplying of renewable energy to the national grid** to provide regional carbon reduction benefits.* [2] - [3]

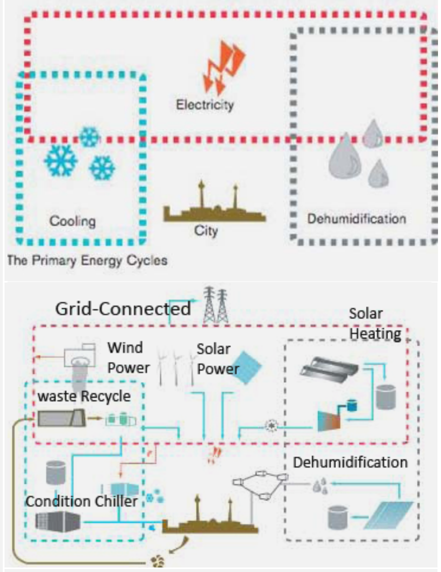



**Fig**.2-21 **Energy Cycle and Studies**.
**Source**: Report; http://www.masdar.ae/.

[1] Masdar Official Site; http://www.masdar.ae/ . "The *Masdar Initiative* "Date, 12/2008.
[2] Master Planning Phase of the World's First Carbon-Neutral City. "Report: *The Masdar Development –Climate Engineering For A Carbon-Neutral City*" , http://www.masdar.ae/. Date, 12/2008.
[3] **Foster**, Norman., Projects, Official website, http://www.fosterandpartners.com/Practice/Default.aspx, Date,12/2008.

## Installation of System

✓ ***Installation Cases,***

The planned systems that may utilized in Masdar city are;

- Use of Photovoltaics Panels (*Thin-film modules*) in out-land Plant in the fist stage of construction the city,
- And Wind power plant for the generating electricity also.
- Use Concentrated Solar Power Plant for energy generation.
- Use of Building Integrated Photovoltaics (BIPV) systems in roofs after the construction of city's main and utility buildings.
- Use of Solar Desalination Plant for clean water system.[1]

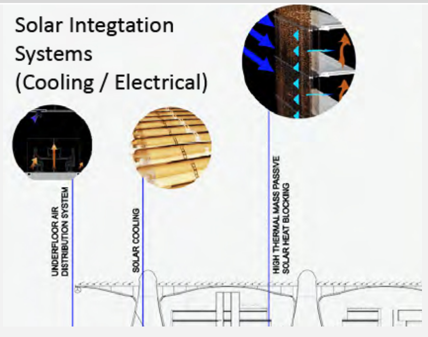



**Fig**.2-22 **Energy Cycle and Studies**. **Source**: Report; http://www.masdar.ae/.

✓ ***Integration of Systems;***

- *The city will minimize energy demands by deploying the* ***most energy efficient techniques*** *available, and that reduced demand will be met using renewable energy.*
- *New technologies, such as* ***photovoltaics, concentrated solar power****,* ***waste to energy*** *and the opportunities of producing* ***biofuel.*** *To supply 100 % of the energy needs. In addition,* ***supplying of renewable energy to the national grid*** *to provide regional carbon reduction benefits.*[2]

Fig.2-23 **Masdar Institute interiors, shaded courts by Photovoltaics devices**. **Source**: Ibid.

## Finance

✓ ***Finance;***

*The total amount of the investment represents one of the largest ever made in solar energy. It will fund a three-phased manufacturing and expansion program to produce the latest generation of thin-film photovoltaic (PV) modules.*

- ***Phase one*** *of the initiative will see an investment of $600* million, *which will fund the development of two manufacturing facilities.* ***The first*** *in Erfurt, Germany, will be operational by the third quarter of 2009, and a* ***second facility*** *in Abu Dhabi will begin initial production by the second quarter of 2010.*

*The combined annual production capacities of the two sites will be* ***210 megawatts****, which is committed to major PV system installers in Europe and for Masdar's energy needs.*

**Fig**.2-24 **Computaional model of the city, Source**: Report: *"The Masdar Development Climate Engineering For A Carbon-Neutral City"* http://www.masdar.ae/.

## Main Issues

✓ ***Learned lessons;***

- *The main policy and the planned phases of the project to make it as international Future sample for cities.*
- *Applying all sustainable principles in the concept, initiative, planning, and design in comprehensive initiative and social lifestyle.*
- *Use of new renewable energies; especially* ***solar energy****, energy efficiency technologies, zero waste system, water management, and internal public transportations, make the city as a combined integrated system to be areal sample for future cities.*

Fig.2-25 **Masdar Institute interiors, Photovoltaics devices in roofs**. **Source**: Ibid.

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[1] Initiative Report, *"Abu Dhabi's MASDAR INITIATIVE; Breaks Ground On Carbon-Neutral City Of The Future"* 2008, 2-5.

[2] Masdar Official Site; http://www.masdar.ae/ . "The *Masdar Initiative* "Date, 12/2008.

## *2-2* Example 2.

| **Project Title** | *Solar City; Pichling- Linz, Austria* |
|---|---|

Fig.2-26 **Satellite Map, Top View of Linz-Pichling, Solar City.**
**Source**: Linz-Pichling, Google Earth.

| | |
|---|---|
| **Site** | *Linz, Austria* |
| **Team Work** | *READ Group ;(Renewable Energy in Architecture and Design):**Thomas Herzog** + Partner; **Norman Foster** + Partners; **Richard Rogers** Partnership, Environmental Engineer: **Norbert Kaiser** -Germany , **Master plan**: Roland Rainer* |
| **General Information** | *Type of Project: New constructed urban area for 3500 inhabitants.*<br>*Client: municipality of Linz Financing: municipality of Linz, European Community*<br>*Construction: form 1995 - under construction in 2004*<br>*Consultant: Renzo Piano Building Workshop* |
| **Project Overview** | The aim of the project is to create ***a base for future social residential housing projects, for further projects and the development of standards in the field of passive and low energy houses,***<br>Solar City concept was subsidized by the EU and the province of Upper Austria and designed by internationally, recognized architects. The Provincial Capital of Linz has realized an urban development project that has attracted a great deal of notice. The three pillars of sustainability, namely economic growth, ecological balance and social progress, were equally and simultaneously taken into account. This succeeded only due to the exemplary co-operation of all concerned.[1]<br>*The* project *is a residential building site with **seven different big houses with 93 living-units** realized in cooperation with the apartment society. The Project is part of the solarCity Linz-Pichling and consists of 5 low energy houses, one passive house and one "almost passive house ".*[2] |

[1] **ERABUILD** *"Sustainable Construction and Operation of Buildings, Erabuild Description of Programs"* (ERABUILD Consortium: www.erabuild.net ., April 2005)
[2] **Linz- website** – Linz Pichling solar City**:** http://www.linz.at/english/life/3199.asp. Date :11/2008

**Urban Considerations**

### ✓ *Project Objectives & Justifications,*

- Being the ***largest ever settlement*** built on the basis of the tenets of ***sustainable architecture***, as basic principle underlying the project as, the desire to promote low cost building methods internationally.
- Build the new 25,000 habitant with the incorporation of extensive use of solar energy.
- Creating ***new housing development of 1,400 apartments***, using low energy construction methods and innovative methods of sewage treatment and water supply.
- *Incorporating social planning*, in a mixed social and demographic structure and the scheme, as conceived by international experts and drawing on EU subsidies.[1]
- *Use* of '*Short Cycles*[2] approach, emphasizing ecologically-efficient building layouts and technologies, integrated with the design of green spaces for ecological and amenity purposes.[3]
- ***Achieving of urban quality,*** by using of convenient public transport and considering the walking distances from the center of each node.

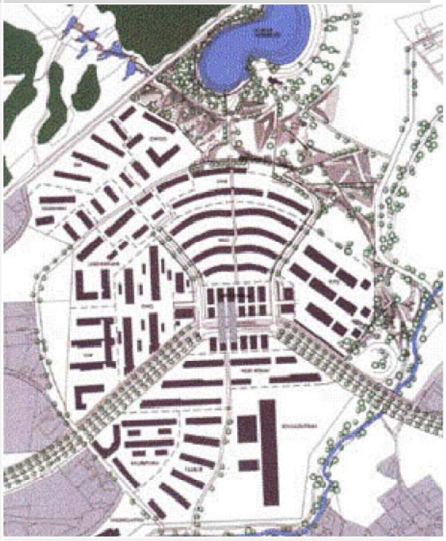

Fig.2-27 **Linz-Pichling City, Master Plan.** **Source**: Linz-website http://www.linz.at/english/life/3199.asp

### ✓ *General Urban Considerations,*

- The ***sustainability parameters***, including achievement of maximum ***possible density***, ***maximum flexibility*** of residential units' type.
- Saving and combined energy policy that integrated with the solar energy generation of the city.
- The careful studying of traffic routes to promote and facilitate ***pedestrian and cycle traffic*** - the entire settlement will be closed to motor vehicle traffic.
- *Individual homes* are built to make the most of the lie of the land, with greenhouses, winter gardens, balconies and orientations that benefit from the climate and nature surrounding them.
- Involving of the ***active participation*** on the part of future users, who will themselves take care of the development of a number of areas adjacent to the homes and certain public spaces.
- More ***efficient local use*** of natural resources and recycling, greater local economic autonomy, that so-called '***Short cycle'*** approach.
- Paying Special attention to the ***combination of different innovative components*** regarding construction and building services.[4]

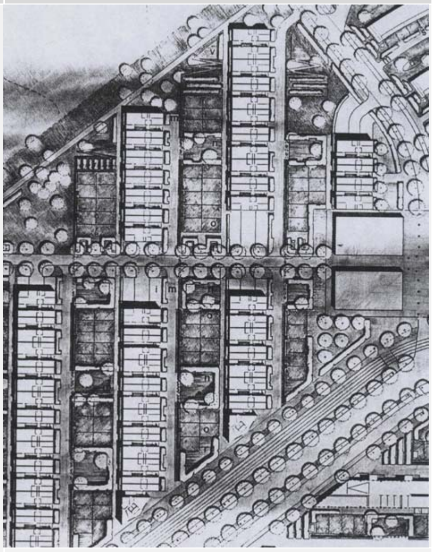

Fig.2-28 **Urban design and Planning of residential zones.** **Source**: Linz- website http://www.linz.at/english/life/3199.asp.

### ✓ *Orientation,*

- *North - South Axis;* in the northern zone of residents units, to create optimal orientation of solar gain in passive and active applications.
- *East- West Axis;* in both sides housing zones, and uses of centralized servicing, in vertical cores, with integrated heat recovery and alignment of open spaces to the sun. Parking beneath buildings.
- *Northwest- Southeast Axis*; facades have mobile blinds to protect against solar gain and heat losses. With using centralized servicing, in vertical cores, with integrated heat recovery.

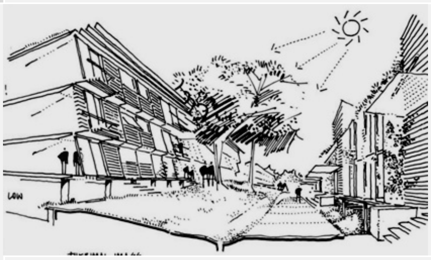

Fig.2-29 **Linz-Pichling Residential Units Oriented Roofs. Source:** Herzog, "Solar *Energy In Architecture And Urban Planning"* 190.

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[1] The **European Union** Expert Group on the Urban Environment *"Urban Design for Sustainability; Interim Report of the Expert Working Group"*, (August 2003), 31.

[2] ***Short Cycles :*** is an emphasis on achieving local environmental sustainability through more efficient local use of natural resources and recycling, greater local economic autonomy and a smaller 'ecological footprint'

[3] The European Union Expert Group on the Urban Environment, (August 2003), 29.

[4] **Herzog**, Thomas. **Kaiser**, Norbert, **Volz**, Michael., " *Solar Energy In Architecture And Urban Planning"* ; European Conference on Solar Energy in Architecture and Urban Planning (Berlin: Prestel, Second Edition,2005), 180-186.

## Stages Of Implementation

### ✓ Planning Stage,

- *In **1992**, preparation of the comprehensive regional urban planning concept of between 5.000 - 6.000 homes together with the entire infrastructure of area. By, Prof. **Roland Rainer**.*
- *In **1994**, the City of Linz together with four non-profit-making residential organizations, finance the planning and development of a model 630 low energy construction homes in the district of Pichling. With the assistance of the **READ group** and **Norbert Kaiser** (**Energy Technology Planner**), whose aim is to promote the breakthrough of low-energy construction methods at the international level.*
- *In 1995. The European Union for R& D, subsidized work with a contribution of 600.000€, and also a further eight non-profit-making construction organizations joined, with the result that the total of 1294 homes for about 25,000 people are to be built on an area of around 32 hectares.*

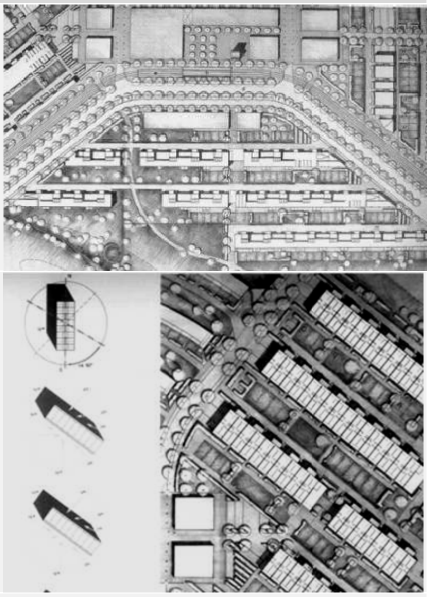

Fig.2-**30** **Planning stage and main streets In Linz-Pichling Solar City**. **Source**: Herzog, "Solar *Energy In Architecture And Urban Planning"* 186.

### ✓ Design Stage.

- *In **1996**, an architectural competition was announced for the design of more homes. The winner was the archt. **Martin Treberspurg**, a solar architecture specialist with experience in public residential construction.*
- *In **1997**, held a landscape architecture competition for controlling the anticipated high user pressure on the forest area along the Traun River. and to develop an concept for the outdoor spaces that would offer high recreational value*
- *In **1998**, other architecture competitions were held for the public infrastructure buildings, for the day nursery building, school center, and the infrastructure center.*

Fig.2-31 **Linz-Pichling Residential Units Oriented Roofs and Battaries Solar Roofs.** **Source**: Linz- website http://www.linz.at/english/life/3199.asp.

## Energy Systems

### ✓ Energy Policy;

- ***Energy policy*** is to covers the ***Energy conservation*** and the ***energy supplies***; by Co-generate its own energy with *'solar'* installations which will, in the future, make the neighbourhood completely independent and even allow it to return part of its energy surplus to the city's energy grid. [1]
- *A **Density*** and ***Mix Uses*** and ***deferent sizes of housing units***, is one of the main criteria for keeping the overall energy consumption of the city and traffic at the lowest level possible.
- ***High utilization of Solar Energy***, throughout using ***Passive Applications*** in (Thermal heating- Space Heating- Domestic water heating) and ***Active Solar Applications*** (PV for electricity generation).
- ***Integration Transport System***; Saving of energy Consumptions by using public transport from the Center of each node, reached by ***pedestrian routs***, that made more attractive distances than use of cars. To create urban Quality. [2]

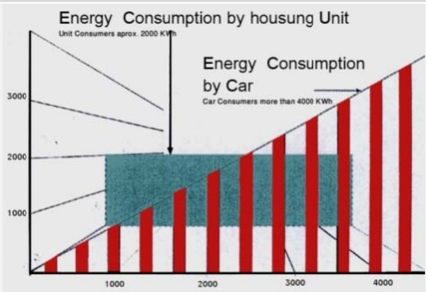


Fig.2-32 **Comparison Of Energy Consumption Of Housing And Cars**. **Source**: Herzog, "Solar *Energy In Architecture And Urban Planning"* 182.

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[1] **Ricchi**, Daria ,Article. http://www.floornature.com/articoli/articolo.php?id=433&sez=3&lang=en , 11/2008.

[2] **Herzog**, Thomas. **Kaiser**, Norbert, **Volz**, Michael., " *Solar Energy In Architecture And Urban Planning"* ; European Conference on Solar Energy in Architecture and Urban Planning (New York : Prestel, Second Edition,2005), 180-186.

## Installation Systems

### ✓ *Installation Cases,*

Roof Case;

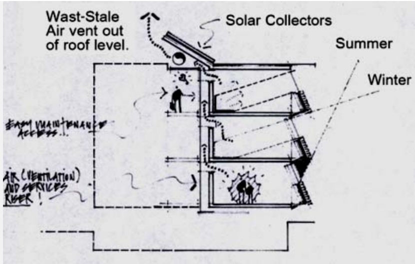
- (BIPV) Fixing of solar thermal collectors for heating domestic water for residential units,
- And installing of photovoltaics in the sloped roof of stairs battery, to southern direction.

FaÇade Case;

- Intelligent utilization of *passive systems* and high thermal capacity materials for passive solar applications.
- Using *blinds*, *louvers* and *sliding glassing* for diminishing the direct incidents solar radiation in façades, and in the same time, keeping of high ventilation velocity for spaces.

Passive systems;

- Uses of *centralized servicing*, in vertical cores, with integrated heat recovery and alignment of open spaces to the sun. Combined with the domestic heating system of the city.



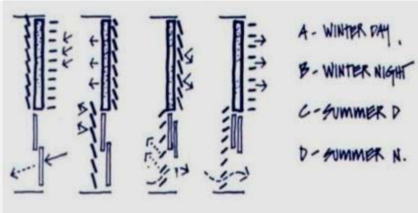




Fig.2-33 **Façade Studies of Solar gain and ventilation system. Source**: Herzog, "Solar *Energy In Architecture And Urban Planning*" 186.

### ✓ *System Specifications;*

Passive Houses; (consumed for heating: less than *15 kWh/m2/year*) or provision of another extremely low-energy consuming buildings (energy consumption: *37 kWh/m2/year*; conventional new build homes in Austria consume *65kWh/m2/year*)

There are many options of energy system for the Linz-City created by Norbert kaiser; as.

Option 3: Grid plant –> electricity + heating--> Combined heat and power plant (Gas- CHP- from sewage plant (Asten) --> returning the generated electricity to Asten + BIPV.

Option 4: CHP Unit (natural oil fired) –> electricity + heating--> heat pump + excess heat from building waste water + BIPV. [1]

Fig.2-34.a **School Solar Roof In Linz-Pichling City. Source: Linz- website** http://www.linz.at/english/life/3199.asp.

## Finance

### ✓ *Finance;*

- *Planning and Construction*: was subsidized by the EU and the province of Upper Austria.
- *The EU General Directorate* for R&D subsidized the planning work with a contribution of euro 600,000.

Fig.2-34.b **Solar Roof In Linz-Pichling.**

## Main Issues

### ✓ *Learned lessons;*

- The project is good practice example, which intended to be a model of sustainable development. For understanding and applied for other projects that have similar conditions, policies, and principles.
- Project urban stages have many guides for achieving the quality of sustainable principles. Whether it was Socially financially, Technically, or organizing of implementation stages
- The project has altered the attitudes of those involved to energy supply and town development, waste disposal and social engineering. Things are viewed and understood in perspective, leading to a step-by-step awareness of the project's good prospects.[2]

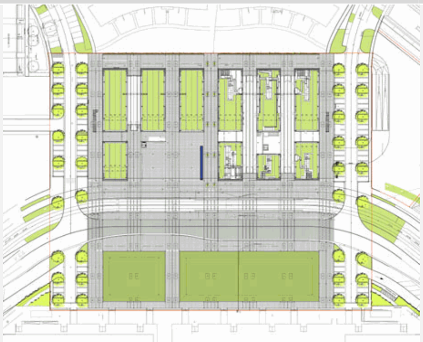


**Fig.2-35 The Center Linz-Pichling City. Source: Linz- website** http://www.linz.at/english/life/3199.asp.

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[1] **Ibid.**, 192.
[2] **IEA**, Project MEELS, Task 9; Case studies *"International Energy Agency Demand Side Management Implementing Agreement"*,2003.

## 2-3 Example 3.

| Project Title | *Solar Village at Amersfoort - Holland* |
|---|---|

Fig. 2-36 **Aerial view of houses in Nieuwland, Amersfoort.**
**Source**: **Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"* (London: Spon Press,2003),61.

| | |
|---|---|
| **Site** | *Nieuwland, Amersfoort, Netherlands.*<br>*Location: An urban extension to Amersfoort, The Netherlands* |
| **Team Work** | *National Architects, N.V. Regionale Energiemaatschappij Utrecht (REMU) Ecofys, ENEL SpA)* |
| **General Information** | Planning for the development started in 1995 and should have been finished 2002.<br>*Manufactures*: Shell *Solar, BP Solar, BRAAS* (roofing company that uses Shell Solar laminates),<br>*Hours of sunshine per year* : 1,477 h/a - 4,05 per day *Annual mean temperature*: 10 °C |
| **Project Overview** | *Solar Design on a Grand Scale,* The Dutch government and the electricity companies (REMU) the *Regional* Energy Distribution Company of Utrecht, have agreed on reductions of CO2 emissions. One result of this is a strategy for the supply of 3.2% of electricity to come from sustainable sources.[1]<br>Amersfoort is a new development in Holland about 55km from Amsterdam. However, it rises a number of initiatives; including the 1MW PV project in the Waterkwartier district (*30km east of Amsterdam*) which consists of installing more than 12,000m2 of modules on 500 houses and a crèche, a sports hall and nine school dwellings fitted with solar cells, or "photovoltaic modules" .[2] The main concept is to use the opportunity of building a completely new district to experiment with PV energy. Not only by concentrationon technical aspects, but also on availability of the technique. The builders and developers have been given the charge of demonstrating that the use of solar energy can result in architecturally sound design. They also wish to gain experience in the use of solar energy in various situations: in rented housing, owner-occupied housing and non-residential buildings.[3] |

[1] **llewelyn** - davies . English partnerships the housing corporation *"Urban Design Compendium"* www.englishpartnerships.co.uk (London, 2007)., 51
[2] **Munro,** Donna. *"PV in Urban Policies-Planning for Urban Scale PV Systems"* (PV-Upscale, Intelligent Energy, Europ, 2008 )P 32.
[3] Energie-Cités .Report,*" Solar Photovoltaic; (Amersfoort ,The Netherlands)"* ,( REMU and the City of Amersfoort, 2002) 1-4

**Urban Considerations**

### ✓ *Project Objectives & Justifications,*

*It was expected that the annual production of the village will be 1,000,000 kW, equivalent to the average electricity consumption of 300 Dutch households.*

In addition to reducing CO2 emissions the goals of the project are (1):

- To illustrate the impact of using solar power at district level.
- Reducing BIPV costs in terms of both module costs (economy of scale) and BOS-costs (through optimized integration),
- To illustrate possible management arrangements.
- To acquire know-how and experience regarding electrical engineering and architectural aspects.
- To increase the acceptance of solar-power applications by local authorities, urban development specialists, project developers, housing associations, architects, contractors and residents.
- Demonstrating the technological and architectural potential of BIPV.[1]

Fig.2-37.a **Satellite view, Layout of Amersfoort District**, **Source**: Google Earth Maps. Ordinate; 52° 11' 42.12" N 5° 23' 47.47" E

### ✓ *General Urban Considerations,*

A variety of architects were commissioned to create a range of designs, within a town plan framework that not only included roads and pavements but also waterways.

- Reduction of energy consumption.
- Using other passive application like thermal panels for heating domestic water and for space heating.
- Large streets run through axis, north–south and east–west.
- The massing units constrained to present the right and precise angles for the PV modules towards the Sun irradiations.
- Variations of incorporating methods of the PVs into the buildings, from large extrovert PV displays to subtle integration.
- Using PV also on the urban form and squares to maximize the integrations of system with the complex.[2]

Fig.2-37.b **Studies of Solar access and privacy concerns.** **Source:** *"Urban Design Compendium"* www.englishpartnerships.co.uk

### ✓ *Orientation,*

- The design in considered the precise angles and the variety of construction the dwelling units, and as a result installing the PV panels in varies integration methods on the facades and roof,
- It considered of the design of roads by axis, north–south and east–west. And the distance between dwelling units for utilization of passive solar heating and solar gain in winter.[3]

Fig.2-38 **Solar roof oriented to South for maximize solar irradiation gain.** **Source:** ,*" Solar PV; (Amersfoort ,The Netherlands)"* ,3

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[1] **IEA** PVPS Task 2 and Task 10 Educational Tool., http://www.iea-pvps.org/cases/nld_01.htm.

[2] Solar Panels On Earth Out Of Space: "*Amersfoort's Spectacular Nieuwland Solar Energy Project ,Including 1,351 MWp PV-power)*" from: http://home.hetnet.nl/~f2hbertie.joan/PVvanboven_Nieuwland.htm.

[3] **Randall,**Thomas. , **Fordham**,Max., " *Photovoltaics and Architecture*", (London: Spon Press,2003),61-68.

## Stages Of Implementation

### ✓ *Planning Stage,*

- *High Solar optimization was taken into account in the urban planning phase with the land being parcelled out to provide as many roof surfaces as possible suitable for the installation of solar panels.*
- *All the urban planners, architects and developers involved were required to co-operate in the implementation of the solar power project.*

The planning of the project was taken for implementing main five different building types, residential and utility building, using PVs:

- Three low-energy primary schools,
- Fifty rented dwellings units,
- Nineteen owner occupied homes with solar power,
- And two semi-detached "balanced **energy houses**" for energy output evaluating of the all district. [1]

Fig.2-39 **Ariel View of Amersfoort District. Showing the Urban Axis and divisions of residents units, Source:** IEA, PVPS Task 2 and Task 10 Educational Tool., http://www.iea-pvps.org/cases/nld_01.htm

### ✓ *Design Stage.*

- ***One of the three schools** in the area was fitted with, 196 - 124 solar panels on schools roof, so called 'AC modules' with using of display monitors for system evaluation, in central points in the schools, as educational data.*
- *The implementation of **The 500 solar houses**, which have on an average 20 $m^2$ of solar panels installed per house and a peak capacity of 100 $W/m^2$.*
- *Combined solar power on 50 **rented houses**. Each house has 5.6 $m^2$ of solar collectors. For valuable experience concerning management and implementation of SE on social housing.*

Fig.2-40 **Solar Panels also used in Urban tools and Shading in Amersfoort. Source**: Randall. Fordham, *"Photovoltaics and Architecture"* (London: Spon Press, 2003), 64.

- *A solar/gas combination unit, 15 kW capacity. each, has been installed in the each house*
- *Two semidetached houses **"balanced energy houses"**, with combination of systems include; solar collectors, 'normal' solar panels, double-glazed transparent panels, single-glazed transparent panels, ordinary double glazing and sunblinds. The whole panel surface is about 90 m2, providing on average. 7,500 kWh of electricity per house annually.*[2]

## Energy Systems

### ✓ *Energy Policy;*

***Energy policy***, is achieving the energy initiatives goals that were risen for generate 1 $MW_h$ form solar panels, through out the following process.

- *Generate the electricity form renewable energy (**Solar Energy**).*
- ***Integration of PV modules** on the dwellings roof and facades.*
- *There is a **mixture of private house** ownership and ownership by REMU.*
- *The PV modules are **financed and owned by REMU** who effectively sell it to the householders over **20 years** through a leasing arrangement.*
- *All the electricity generated by the PVs is credited to the owners whether or not they use it.*
- ***Maintenance and evaluation** for the PV panels and systems for conserve the capacity of energy output form the village.*

Fig.2-41 **REMU, Balance Energy House. Source**: Randall. Fordham, *"Photovoltaics and Architecture"* (London: Spon Press, 2003), 65.

[1] **Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"* (London: Spon Press,2003),65.
[2] European Sustainable Urban Development Projects " *Nieuwland Solar Energy Project"*, ( Report: Intelligent Energy) p. 3

**Installation Systems**

### ✓ *Installation Cases,*

<u>*Roof Case;*</u>

- Fixing of solar collectors for heating domestic water for residential units,
- And installing of photovoltaics in the sloped roof of stairs battery, to southern direction.

<u>*FaÇade Case;*</u>

- Intelligent utilization of passive systems and high thermal capacity materials for passive solar applications.
- Using blinds, louvers and sliding glassing for diminishing the direct incidents solar radiation in façades, and in the same time, keeping of high ventilation velocity for spaces.

<u>*Other Case;*</u>

- Using solar panels on the elements of urban tools, like bike garage and spatial urban tools.

**Fig.2-42 Housing, Implemented Solar Cells In Roof. Source**: Randall. Fordham, *"Photovoltaics and Architecture"* (London: Spon Press, 2003), 63.

### ✓ *System Characteristics,*

- *PV system power: 1,323 kWp on 500 houses, monitoring data concern 44 houses with 2,57 kW utility-interactive*
- *Type of cell technology: multi-crystalline*
- *Module dimensions: 95 watts (27), manufacturer: Shell Solar*
- *Inverter: central 2500 watts (one per house), inverter manufacturer: Mastervolt*
- *Unforeseen Issues: In the planning stage; 5% loss due to shading and non-optimal orientation was allowed, with a tilt angle between 20 & 50 degrees. With the design as built (with a tilt angle of 70 degrees) the loss is estimated to be 16%.* [1]

**Fig. 2-43 Solar Pitched Roofs To The Sun Angle. Source**: Randall. Fordham, *"Photovoltaics and Architecture"* (London: Spon Press, 2003), 63.

### ✓ *Other Information, The Project Diagram*

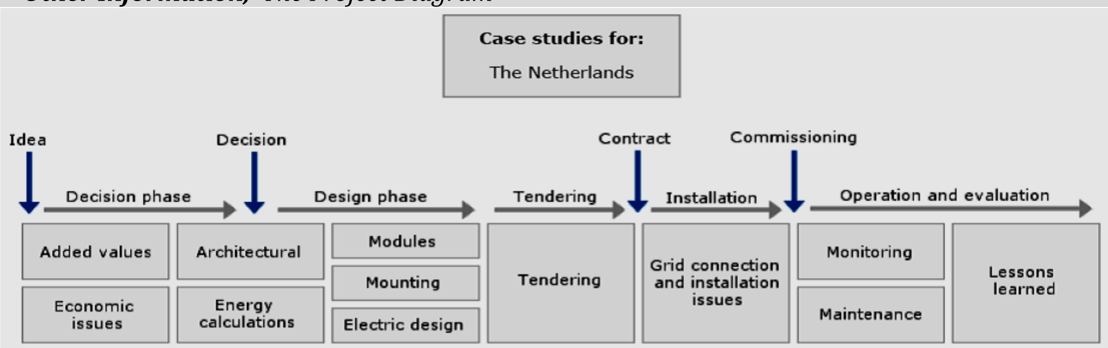


**Fig.** Main Diagram of the Project, Building Integrated PV - From Idea To Operation. **Source:** IEA PVPS Task 2 and Task 10 Educational Tool. http://www.iea-pvps.org/home.htm

**Main Issues**

### ✓ *Learned lessons;*

- Establishment of an infrastructure for future co-operation between building companies, utilities, town planners and PV industry, essential for maturing BIPV technology.
- The design review is considered to be a preparatory step for the building inspection and commissioning (That will remain an important element of quality control programmes of future PV projects).

Fig. 2-44 School With Implemented Solar Cells in the Roof. **Source:** Report " *Nieuwland Solar Energy Project* ", p. 3

[1] **Randall,**Thomas. , **Fordham,**Max., " *Photovoltaics and Architecture* " (London: Spon Press,2003),66.

# 3 SOLAR AND PV SYSTEMS IN RURAL DEVELOPMENT.

## *3-1 PHOTOVOLTAIC SYSTEMS IN RURAL & REMOTE DEVELOPMENT AREA*

Developing countries now account for about 30% of global energy use, and approximately 75% of the population of the developing world still lives without electricity. [1] An expanding population with a growing desires for basic services. However, it puts heavy pressure on local governments to keep pace with the demand for electricity. Those governments cannot afford all these economic needs, and operating new centralized power plants and their related infrastructures. [1]

On other case, people not served by a power grid often rely on imported fossil fuels like kerosene and diesel for many of their energy needs. and their use leaves economies vulnerable to global price fluctuations and disruptions in supply. Transporting these fuels to remote locations can be expensive and difficult, and their indiscriminate use can also be harmful to health and the environment. Maintenance of fossil-fuel-driven generators can also be problematic for people in these rural regions.[2]

Photovoltaics can provide everyday services for homes and communities, including water, lighting, health care, communications, and even refrigeration. Photovoltaic systems also supply electric power for many productive uses ranging from lighting in rural stores to electric fencing and roof-tile manufacture.
*The main application of PV in rural areas includes; water supplies, lighting and residential power, health facilities, community projects, productive uses, and communications.*

### *Advantages of photovoltaic systems*

- ✓ *Cost-Effective; in many instances, life-cycle costs for photovoltaic systems are low. Reliability of Photovoltaics is often the preferred power option for critical applications that require a consistent, predictable energy supply, such as for health care and emergency applications. The tech. is well established, with tens of thousands of installations in both developing and industrialized countries.*
- ✓ *Low Maintenance; Most PV systems operate with little servicing and no refueling, making them popular power sources for extremely inhospitable or isolated locations.*
- ✓ *Environmentally Benign; PV produces no gaseous emissions during operation and offers an environmentally benign alternative to fossil and nuclear sources of energy. Plus, the technology operates silently and may offer a visually pleasing alternative to miles of power conduits strung across the landscape.*
- ✓ *Free, Abundant Fuel; Of course, sunshine is free, widely available, and virtually inexhaustible - PV systems have no monthly fuel bills.*

Fig.2-45 **PV Application In Remote Regions, Mongolia.** **Source:** Volume 1 ,*"Photovoltaic Program 2002, list of projects annual reports of 2001 Officers"* NET Nowak Energy & Technology Ltd, April 2002

- ✓ *Locally Generated Power; Photovoltaics make use of a local resource - sunlight. This provides greater energy security and control of access to energy. It also reduces the dangers of transporting acid-filled batteries to recharging stations.*
- ✓ *Flexible Size; Photovoltaics can produce enough power for just about any application you can envision. Existing systems range in size from pocket calculators to multi-megawatt power plants. Their modular construction facilitates easy expansion of systems as needs demand.*
- ✓ *Transportability; as photovoltaic systems are modular in nature, they can be transported in pieces. In addition to simplifying the logistics of transport to remote areas, this feature allows for relatively easy relocation and protection from severe weather conditions.*[3]

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[1] Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2007 Global Status Report*, (Washington, DC: Worldwatch Institute, 2008), 6.

[2] 17th **European Photovoltaic Solar Energy Conference** *"Deployment Of Photovoltaic Technologies: Co-Operation With Developing Countries"* ,Task 9 of IEA PVPS, , Munich, 2001

[3] **Shepperd** W. ,**Elizabeth** H. ,*"Solar Photovoltaic PV For Development Applications"* ,( USA, Sandia National lab., August 1993),24,25.

## 3-1.1 *Example 1.*

| Project Title | *Solar Energy for Heating Water in Urban/Peri-Urban Areas, Egypt.* |
|---|---|

Fig. 2-46
**Shows the Installing of the Solar Heating System with Two Thermal Collectors and Storage Tank, Fixed Towards South Radiations. On the Houses Roof. The Client and the System Engineer Behind Solar System.**
**Source**: http://www.undp.orgtsgp , SGP Egypt,Solar Heaters Projects.Project summary, received July 2003.

| | |
|---|---|
| **Site** | *Urban And Peri-Urban Areas, El Menia, Egypt, Themes Renewable energy* |
| **Team Work** | *Implementing Organizations: Society for Community Welfare in Kom El Aghdar-Maghagha, CBO (2 projects), and Coptic Evangelical Organization for Social Services, NGO (I project)* |
| **General Information** | *Start Date: June 1998 (2 projects), and November- 2000 (I project)*<br>*Project Finance: SGP Egypt, private sector, and Non-Governmental organizations.*<br>*Hours of sunshine per day : 9-11* per day *insulation average: 1900-2600 kWh/m2* |
| **Project Overview** | Solar Energy for Heating Water , Egypt, Themes Renewable energy,<br>"Renewable Energy for Daily Life: Solar Water Heating in El Menia "<br><br>Hot water is critical to maintaining adequate sanitation and health. Often, water must be boiled in order to make it safe to drink. In poor communities in Egypt, water is normally heated using agricultural residues in a kanoun, which produces smoke and is generally unsafe. In more well- off communities, electric or gas water heaters are used, but there may be shortages of gas cylinders, or electricity costs may be high. Egypt is well endowed with solar energy. so solar- heating is a viable option; on average, the sun is shining for 9-11 hours per day, with an average insolation of 1900-2600 kWh/m2.These solar water heater projects took place in poor villages and neighborhoods surrounding El Menia, a city in Upper Egypt.[1] |

[1] SGP Egypt, "*Solar Heaters Projects*" .Report; Project summary, http://www.undp.orgtsgp , July 2003.

**Objectives**

### ✓ *Project Objectives ,*

The three solar-heat water projects (funded by SGP, Small Grants Program[1]), that are implemented in rural areas in Egypt for the following objectives;

- Raising awareness about climate change and the effects of pollution produced by traditional methods of heating water.
- To improve sanitation help, and therefore lead to health benefits for the poor residents.
- Create opportunities for youth, through Educational and training programs for using renewable energy in rural scale.
- Attracting social organizations, private sector, and community members to involve around the using of solar energy systems.
- To attract and encourage the policy-makers to support environmental activities using renewable energy.[2]

Fig.47
**Stand-Alone Solar Collector System In Roof.**
**Source**: SGP Egypt, http://www.undp.orgtsgp , July 2003.

**Urban Considerations**

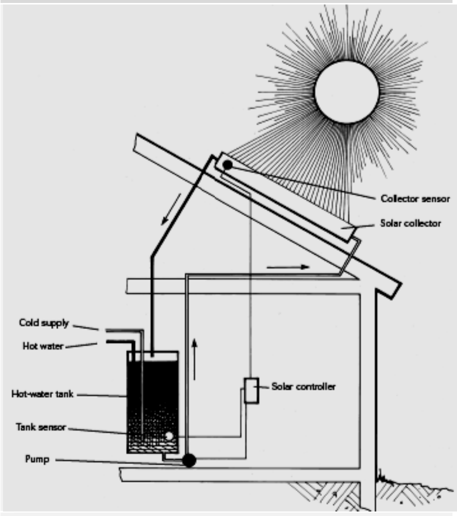
### ✓ *General Urban Considerations,*

- The Project works with the rural communities ( peri- Urban areas ) especially with poor communities which lacks to electrical or gas grid-systems.
- It also achieved to improve the quality of life and the life style in these regions by using renewable energy resources to heating water.
- It using stand-alone collection systems, to heat the water by solar energy, considering the high insulation of solar radiation in these areas in upper-Egypt.
- The project had considered the social status of these regions, especially in youth sector, to improve employments opportunities for new for them.

**Stage Of Implementation**

### ✓ *Implementation,*

- The three solar-heat water projects are installed in the poor neighborhoods of El Menia.
- It also carried out *training and education programs* for community members, regarding the installation and maintenance of solar heaters, and *how the use of solar-water heaters* is related to solving global and local environmental problems.
- Community members *contributed part of the costs* of the water heaters, which increased project ownership and allowed more water heaters to be installed.
- In addition, the projects partnered *with private sector entities* and *local governments* to improve the quality of the technology used and to sustain the effort.
- SGP has funded at least 8 projects in Egypt related to solar heaters, and it has now a good experience in this field.[1]




[1] SGP: is Small Grants Program, organized by the United Nations Development Programme, Environment and Energy section. The SGP funds, which do not exceed US$50,000, are eligible for (NGOs) and community based organizations (CBS) in recognition of the key role they play as a resource and constituency for environment and development concerns.
[2] SGP Egypt Biennial Program Review, "*Semi-Annual Progress Report, February 2001*", SGP Egypt, (Dec. 20, 2008).

**Energy System**

### ✓ *System Specification,*

- *Energy Resource*: solar energy. *Application*: water heating.
- *Technology*: solar water heaters.
- *Sector*: domestic. *Water Heater Capacity*: ISO liters.

*Number Served*: 164 solar water heaters (total for all three projects); 429 solar water heaters installed by 8 SGP-funded projects in Egypt, reaching *3,790 people*.

**Installation of System.**

### ✓ *Installation Cases,*[2]

- *Roof case:* the system is installed in planed houses roof, using light steel structure system in erection the collectors.
- Also using standard collectors type with two collector plats and one storage tank.
- *Orientation:* the system is oriented towards south with declination angle between 45-35°, *to obtain maximum sun heating radiation.*
- *Technical:* Since the projects have trained local community members to better understand, operate, install and repair solar water heaters, technical barriers to their use in this region have been reduced.
- *Capacity Development*: The first project, which installed a total of *33 water heaters*, held *10 seminars* through which *250 people* learned about the water heaters and how they relate to local and global environmental problems. The most recent of the *three projects held 8 such seminars*.*[3]

### Finance System.

SGP contribution: 3 grants, totaling $65,835: $1 1,184 June 1998-June 1999); $26,527 (June 1998 – June 2000), and $28,124 (November 2000 – November 2001); $21 1,166 for all eight SGP solar water heater grants in Egypt.[4]

*The First project*: the importance of requiring individual contributions from households to help cover the cost of water heaters. This also means that households are not paying the full cost for the heaters, and implies that access to the water-heaters would still depend upon subsidies from non-governmental organizations like those implementing these projects.

**Main Issues**

### ✓ *Learned Lessons,*

*Information/awareness:* These projects have placed great emphasis on raising awareness, educating hundreds of people about the connection between renewable energy use and global and local environmental problems. The importance of public awareness in promoting renewable energy use is another of the lessons learned from these projects.

*Policy:* According to SGP reports, these projects have encouraged policy-makers to support environmental activities and to welcome community involvement. However, no information is available about specific policy steps taken.

*Scaling Up*

In Egypt, SGP has been very active in sponsoring solar water heater projects in many regions of the country. Recent direct contact and negotiations with solar water heater suppliers may be seen as a step toward consolidating the impact of these dispersed small projects. Certainly, lessons learned in one SGP-sponsored project are being transferred to other SGP-funded projects. However, according to one source more than 25,000 household solar water heaters have been manufactured and installed in Egypt, particularly in new cities.

Fig.2-48 **Wind Energy for Water Pumping and Electricity Generation, Egypt. One of SGP and Solar Community Projects.**

**Source**: World Energy Council, 1999. *"The Challenge of Rural Energy Poverty in Developing Countries."* http://www.worldenergy.org (Dec. 20, 2008).

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[1] SGP Egypt, " Project Records EG-OP1-06,EG-OP1-05,and EG-OP2-11,SGP " , Project Database, http://www.undp.org/sgp,( Dec. 20/2008)

[2] SGP Egypt, *"The Land of the Sun."* Script for video about solar water heaters, 2003. http://www.undp.orgtsgp, (Dec. 20,2008)

[3] * It is unclear where these solar water heaters are being constructed, and whether or not these projects have helped reduce any barriers to their construction and adaptation to local needs.

[4] SGP Egypt, *"Solar Heaters Projects"* .Report; Project summary, http://www.undp.orgtsgp , July 2003.

# 4 SOLAR AND PV SYSTEMS EXAMPLES IN ARCHITECTURE

## *4-1 Building Integrated Photovoltaic Systems (BIPV)*

Definition for building integration is hard to formulate, as it concerns the physical integration of a PV system into a building, but it also covers the overall image of the PV system in the building. For the architect, the aesthetic aspect, rather than the physical integration, is the main reason for talking about building integration. The optimal situation is a physically and aesthetically well-integrated BIPV system.[1]

A large part of the future PV market will be associated with building applications, especially in Europe and Japan where the population density is high and the land is valuable[2]. Building installations are perhaps the most practical method for distributing the investment cost and for encouraging more rapid transition to solar technologies, than is likely to occur at the utility scale. *Through 'Million Solar Roofs' initiative launched in 1997*, the US Department of Energy has been encouraging, and rewarding (through tax credits), the widespread privatization of grid-connected PVs. So the term ***'Building-Integrated Photovoltaics (BIPV)'*** is now a part of every architect's vocabulary. In areas with less population, it will be possible to find land for ground mounted PV structures.[3] (Figure 2-49)

In countries where the government has little influence on house building (like developing countries), the building process is a private initiative. Integration of PV systems in buildings can be carried out by professionals but, on the smaller scale of a single-family house, the motivation must come from the private owner. In these countries, most building-integrated PV systems are found in commercial and industrial buildings where building professionals are involved.

Basically there are three locations for integrating PV systems into buildings. The main locations are the roof and façade, with all other solutions being known as ***'building components'***.

***In Roof Case***; one choice is for the integrated system to be part of the external skin and therefore be part of an impermeable layer in the construction. The other choice for roof mounting the PV system is above the impermeable layer[4]. There are also many products for small-scale use, e.g. PV shingles and tiles, that makes it very convenient for use in existing buildings. (Figure 2-50)

Fig. 2-49 **Impermeable layer Roof integration, renovation project with the Shell Solar / BOAL profiles in Leiden (NL), providing a 2.1 kWp system per house**. **Source:** Maycock P, Schoen T, Strong S, Vigotti R, Reijenga T, et al, *'Building with PV.'*, (Ten Hagen& Stam, Den Haag, 1995) 78 – 81

Fig. 2-50 **Power guard flat-roof PV system including thermal insulation at the Coastguard building in Boston,** **Source:** Eiffert P, Kiss G, *"Building-Integrated PV Designs for Commercial and Institutional Structures"* (NREL, Golden, Colerado 2000), 42-44.

Transparent PV modules used as roofing materials serve as water and sun protection as well as transmitting daylight. In glass-covered areas, such as sunrooms and atriums, sun protection in the roof is

[1] **Addington**, **Schodek**.,*" Smart Materials and New Technologies"* (UK: Oxford , Elsevier, Press,2005*)* 181,182.
[2] **Schoen** T, **Schalkwijk** M, **Prasad** D, **Toggweiler** , *"PVSEC* "( et al, Proc. 14th EC, 997) Page 359-364.
[3] **Kurokawa** K, **Kato** K, **Paletta** F, **Iliceto** A, *"PVSEC* ",( Proc. 2nd, 1998) Page 2853 – 2855.
[4] **Reijenga** T, *"Photovoltaics in Architecture in the Netherlands - An architects view"*, Program in Photovoltaics, 1996, 4.

necessary in order to avoid overheating in summer. The PV cells absorb 70 - 80% of the sun radiation. The space between the cells transmits enough diffuse daylight to achieve a pleasant lighting.[1]

The hybrid PV& thermal collector, provides warm air to the heating system in the home which, in this case, makes it cost-effective to make use of the collector.[2] Wherever also using PV modules as roof covering reduces the amount of building materials needed, which is very favorable for sustainable building and can help to reduce costs.

***In Façades Case;*** Façades is basically covered with insulation and a protective cladding, this cladding can be wood, metal sheets, panels, and glass or PV modules.[3] For luxury office buildings, which often have expensive cladding, cladding with PV modules is not more expensive than other commonly used materials, e.g. natural stone and expensive special glass. This cladding costs around $1,000/m2, comparable to the cost of today's PV module.[4] (Figure 2-51)

Structural glazing or structural facades are constructed using highly developed profile systems, which can be filled with all types of sheeting, such as glass or frameless PV modules. Facades are very suitable for all types of sunshades, louvers and canopies. There is a logical combination between shading a building in summer and producing electricity at the same time.[5] (Figure 2-52)

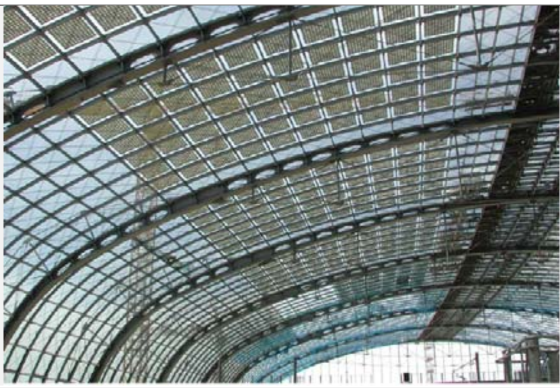

Fig. 2-51 **PV Generator with missing modules, inside view western, on the western roof end.** **Source:** *"PV façade at railroad station Lehrter Berlin"* Final Report, Thermal aid program.

Fig. 2-52 **Solar office in Doxford Sunderland (UK) with a transparent double glazing PV system integrated in the façade**. **Source:** Maycock P, Schoen T, Strong S, Vigotti R, Reijenga T, et al*, 'Building with PV.',* (Ten Hagen& Stam,,1995)

***Building-integrated, grid-connected PV systems have the following advantages:***

- ✓ There is no additional requirement for land,
- ✓ The cost of the PV wall or roof can be offset against the cost of the building element it replaces,
- ✓ Power is generated on-site and replaces electricity that would otherwise be purchased at commercial rates,
- ✓ Connecting to the grid means; high cost of storage is avoided and security of supply is ensured.[6]

***Additional benefits of public awareness are:***

- ✓ Architecturally elegant, well-integrated systems will increase market acceptance,
- ✓ BIPV systems provide building owners with a highly visible public expression of their environmental commitment.[7]

[1] Ibid., 5.
[2] **Wilk** H, IEA SHCP '*OKA-House of the Future'*, (Task -19 1997).
[3] **Hynes** K, **Pearsall** N, **Shaw** M, **Crick** F, *Proc. " Photovoltaics SEC"*( 13th EC , 2203 -2205,1995).
[4] **Reijenga** T., ***BEAR*** Architects, "*Photovoltaic in Architecture, Gouda ", (*Paper 2002), 6.
[5] **Hagemann** I, **Leppänen** J, *Proc. "Photovoltaics SEC"*(14th EC, 694 – 697, 1997).
[6] **Thomas** R, **Grainger** T, **Gething** B, **Keys** M, Report *"Photovoltaics in Buildings - A Design Guide"*, (London; ETSU, DTI, 1999).
[7] **Strong** S, **Lloyd** Jones D, "*A Renewable Future*", IEA PVPS Task7, Final Task, Feb 2001.

## *4-2 Photovoltaic as Smart Architectural Tool*

In the recent decade, photovoltaic have to play an important rule in our building than before, as it integrated with and in building component and environmental issues, that adopted the energy efficiency in the environmental agenda.

The most visible category for smart material application *(such as photovoltaic)* is in the window and façade systems area. It is in this area that architects have become most involved. There are few aspects of an '***energy systems'*** have steadily become more important as concerns regarding the '***Global Environment***' has mounted. Nevertheless, there remains much confusion as to the role that a building can or should play in the complex web of energy generation and use. [1]

Smart materials were envisioned as the ideal technology for providing all of the functions of the super facades, yet would do so simply and seamlessly. *Visions of Mike Davies'* '***Polyvalent Wall'*** – a thin skin that combined layers of ***electrochromics***, ***photovoltaics***, ***conductive glass***, ***thermal radiators***, ***micropore gas-flow*** *sheets* and more – served as the model of the ultimate facade. [2]As shown in (**Figure 2-53**)

In 1984, predictions were not far off, as an entire field devoted to the development of smart windows and façades has been premised on their contribution to energy efficiency. *Like the seminal theoretician and historian Reyner Banham' prediction*, while commenting that a ***'self-regulating and controllable glass remains little more than a promise'***, did conclude that if the real energy costs were taken into account, the new technology would prove to be economically viable. [3]

Rather *than attempting to make photovoltaics fit the building, i.e. through thin film PVs on glazing surfaces or PVs as built into roof shingles, we should perhaps ask how building installations could most effectively contribute to optimal PV performance. This requires that we collaborate with electrical engineers and power engineers to develop better solutions.* [3]

***GreenPix - Zero Energy Media Wall*** *- is a recent groundbreaking project applying sustainable and digital media technology to the curtain wall of Xicui entertainment complex in Beijing. Featuring the largest color LED display worldwide and the first photovoltaic system integrated into a glass curtain wall in China, the building performs as a self-sufficient organic system, harvesting solar energy by day and using it to illuminate the screen after dark, mirroring a day's climatic cycle.*[4] (**Figure 2-54**)

- *It is discussed in details in the* ***next chapter*** *as a case study of PV application — one of smart materials in building integration.*

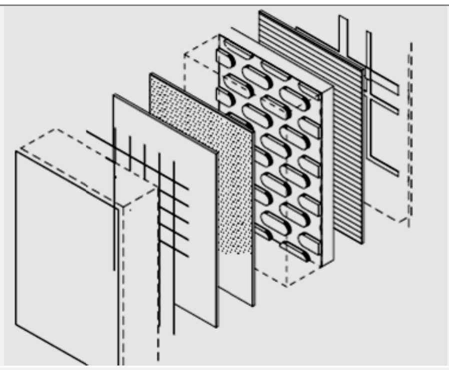

Fig. 2-53 **Schematic representation of Mike Davies' polyvalent wall. He proposed that the exterior wall could be a thin system with layers of weather skin, sensors and actuators, and photoelectric. Source: Addington, Schodek**.,*" Smart Materials and New Technologies"* (UK: Elsevier ,2005*)* 166.

Fig. 2-54 **The Largest Color LED Display Worldwide And The First Photovoltaic System Integrated Into A Glass Curtain Wall In China. The Building Performs As A Self-Sufficient Organic System**
**Source:** http://www.greenpix.org/project.php ,05/2008

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[1] **Addington**, **Schodek**.,*" Smart Materials and New Technologies"* (UK: Oxford , Elsevier, Press,2005*)* 166,167.
[2] Ibid., 166.
[3] Cited from **Reyner** Banham, "*The Architecture of the Well-Tempered Environment*", 2nd edn. (Chicago: The University of Chicago Press, 1984), 292, 293.
[4] **:** *http://www.greenpix.org/project.php* ,05/2008.

The table form in (**Figure 2-55**) 'maps' smart materials and their relevant property characteristics to current and/or defined architectural applications. With the exception of some of the glazing technologies, most of the current applications tend to be pragmatic and confined to the standard building systems: structural, mechanical and electrical.

| BUILDING SYSTEM NEEDS | RELEVANT MATERIAL OR SYSTEM CHARACTERISTICS | REPRESENTATIVE APPLICABLE SMART MATERIALS* |
|---|---|---|
| Control of solar radiation transmitting through the building envelope | Spectral absorptvity/transmission of envelope materials | Suspended particle panels<br>Liquid crystal panels<br>Photochromics<br>Electrochromics |
| | Relative position of envelope material | Louver or panel systems<br>- exterior and exterior radiation (light) sensors -- photovoltaics, photoelectrics<br>- controls/actuators -- shape memory alloys, electro- and magnetorestrictive |
| Control of conductive heat transfer through the building envelope | Thermal conductivity of envelope materials | Thermotropics, phase-change materials |
| Control of interior heat generation | Heat capacity of interior material | Phase-change materials |
| | Relative location of heat source | Thermoelectrics |
| | Lumen/watt energy conversion | Photoluminescents, electroluminescents, light-emitting diodes |
| Energy delivery | Conversion of ambient energy to electrical energy | Photovoltaics, micro- and meso energy systems (thermoelectrics, fuel cells) |
| Optimization of lighting systems | Daylight sensing<br>Illuminance measurements<br>Occupancy sensing | Photovoltaics, photoelectrics, pyroelectrics |
| | Relative size, location and color of source | Light-emitting diodes (LEDs), electroluminescents |
| Optimization of HVAC systems | Temperature sensing<br>Humidity sensing<br>Occupancy sensing<br>$CO_2$ and chemical detection | Thermoelectrics, pyroelectrics, biosensors, chemical sensors, optical MEMS |
| | Relative location of source and/or sink | Thermoelectrics, phase-change materials, heat pipes |
| Control of structural systems | Stress and deformation monitoring<br>Crack monitoring<br>Stress and deformation control<br>Vibration monitoring and control<br>Euler buckling control | Fiber-optics, piezoelectrics, electrorheologicals (ERs), magnetorheologicals, shape memory alloys |

Fig. 2-55
**Mapping Of Typical Building System Design Needs In Relation To Potentially Applicable Smart Materials**
**Source:** Addington, Schodek., *" Smart Materials and New Technologies"* (UK: Elsevier ,2005) 164.

* Many high performance materials (e.g., diochroics, view directional films, and others) may be applicable as well.

## 4-2.1 *Example 1.*

| | |
|---|---|
| **Project Title** | *GREEN PIX - Zero Energy Media Wall.* |

Fig. 2-56 **The Largest Color LED Display And The First Integrated Photovoltaic System Into Curtain Wall, China,**
**Source**: **Giostra**, Simone, **Arup**," *Green Pix- Zero Energy Media Wall"* http://www.greenpix.org. 05/2008.

| | |
|---|---|
| **Site** | *Xicui Road, Beijing, China.* |
| **Team Work** | Architect : Simone Giostra & Partners Architects - *2005- Completion 2008*<br>*Client: Mr. Zhang Yongduo, Jingya Corporation* |
| **General Information** | *Façade Engineers: Arup*<br>*Solar technology R&D: Schüco International KG - Sunways AG*<br>*Solar panel manufacturer : Suntech China*<br>*LED Manufacturer: Thorn China* |
| **Project Overview** | *The Client **JINGYA Group** is unique in China's restaurant industry. One of its objectives is the development of human societies that has always been a movement or inclination towards higher levels of civility, progress, and comfort. Green PIX, is one of JINGYA Group Initiatives and a groundbreaking project that applying sustainable and digital media technology to the curtain wall of **Xicui entertainment complex in Beijing**, near the site of the 2008 Olympics.*<br><br>*Featuring the largest color LED display worldwide and the first photovoltaic system integrated into a glass curtain wall in China, the building performs as a self-sufficient organic system, harvesting solar energy by day and using it to illuminate the screen after dark, mirroring a day's climatic cycle.*<br><br>*The project was designed and implemented by Simone Giostra & Partners, a New York-based office with a solid reputation for its innovative curtain walls in Europe and the US, with lighting design and façade engineering by Arup in London and Beijing.*[1] |

[1] **Giostra**, Simone, **Arup**," *Green Pix- Zero Energy Media Wall"* http://www.greenpix.org.. 05/2008.

**Building Considerations**

### ✓ *Project Objectives ,*

- Is to be one of the world's initiatives for integration of sustainable technology in new Chinese architecture, which use renewable energy (Photovoltaics) integrated with the entire construction system of the building.
- The main function of the project is to achieve Industrial, advertising, and pubic scopes. In the same building.
- The full integration of media/information technology with architecture in an urban context.
- Also, is to works like organic System. That works as great media wall for the previous needs, and at the same time adding dynamic component that works with the building internal environment and spaces.
- Achieving the principles of Zero-Energy building, but in the scale of the media wall that so-called 'Green-Pix, Zero-Energy media wall'.[1]

### ✓ *General Considerations,*

- The density pattern increases building's performance, allowing natural light when required by interior program, while reducing heat gain and transforming excessive solar radiation into energy for the media wall.
- The very large scale and the characteristic low resolution of the screen enhances the abstract visual qualities of the medium, providing an art-specific communication form in contrast to commercial applications of high resolution screens in conventional media façades.
- The building works as a commercial box gains ability of communication with the urban ambient through anew kind of a digital transparency.
- The full integration of media/information technology with architecture in an urban context as a new kind of communication surface devoted to unprecedented forms of art, while projecting information about the behavior and activity of the building to a wide range of distances and engaging a vast audience within the city of Beijing.[2]

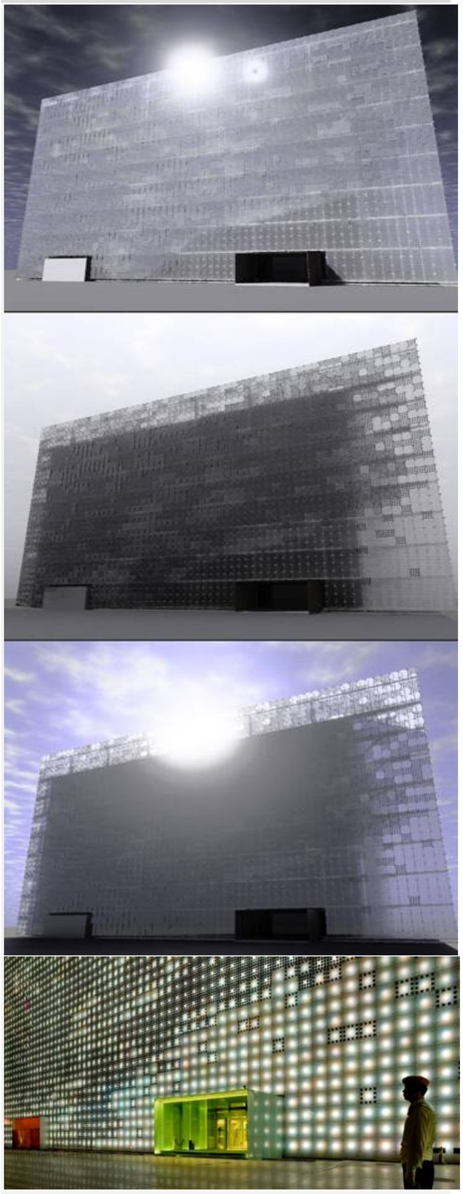

Fig.2-57 **Green-Pix, as Studied In The Various Cases Through The Day Times.**
**Source**: http://www.greenpix.org.. 2008.

### ✓ *Orientation,*

- The orientation of the media wall is related in the main to the building site, and in other case, the using of façade integration systems make the system follow the orientation and the design system of the façade itself.
- So, the design team is using Poly-Crystalline Silicon Photovoltaics modules because of its high efficiency compared with the other types of Photovoltaic cells.
- Also, because of media wall is requires low energy, the orientation of the PV wall was not consider the optimal direction to the sun radiations. Consequently, is installed in the façade as well.

Fig.2-58 **Using Poly-Crystalline Silicon Modules.**
**Source**: http://www.greenpix.org.

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[1] **Giostra**, Simone, **Arup**," *Green Pix- Zero Energy Media Wall"*, www.sgp-architects.com. 12/2008.
[2] Report;*"Green-pix, Beijing's First Zero Energy Media Wall"* http://www.greenpix.org. 12/2008.

**Stage of Implementation**

✓ *Implementation,*

- *Arup developed a new technology for laminating **photovoltaic cells in a glass curtain wall** and oversaw the production of the **first glass solar panels** by a Chinese manufacturer.*
- *The **Polycrystalline Photovoltaic Cells** are laminated within the glass of the curtain wall and placed with changing density on the former building's skin*
- *The **density pattern** increases building's performance, allowing natural light when required by interior program, while reducing heat gain and **transforming excessive solar radiation into energy** for the media wall.*
- *Green-Pix, is a large-scale display comprising of **2,292 color (RGB) LED's** light points comparable to a 24,000 sq. ft. (2.200 m2) monitor screen for dynamic content display.*
- *Xicui's, **Opaque box-like commercial building** gains the ability of communicating with its urban environs through a new kind of digital transparency.*
- *Its **intelligent skin interacts with the building interiors and the outer public spaces** using embedded, custom-designed software, transforming the building façade into a responsive environment for entertainment and public engagement.*
- *By using of **Steel structure frame** and connections to create the Media modular grid for installing the LEDs and the PV glass panels.[1] **(Figure 2-59.a.b)***

Fig.2-59.a **Steel Structure System And Cat-Walk Path For The Maintenance Works.**

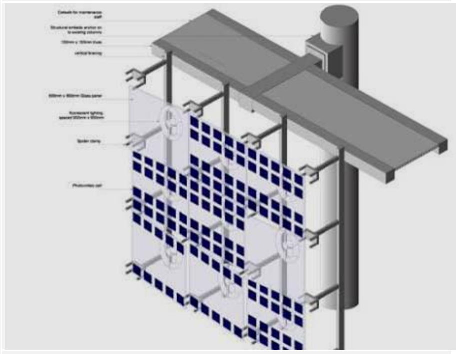


Fig.2-59.b **Isometric Model, Illustrates The Wall Steel Grid And The PV Cells.** **Source:** Giostra, **Arup**, www.sgp-architects.com.

**Energy System**

✓ *Energy Policy& Energy System,*

- *Day Cycle: Energy Production*. The photovoltaic solar cells store the solar energy that is not required to the activities in the building during the day, while acting as an affective shading device and protecting the building from excessive heat gain.
- *Night Cycle: Energy Consumption*. The *media* envelope releases the energy accumulated during the day, in form of bursting light, transforming the facade in a glowing beacon, and the building in an overwhelming visual experience within the nightscape of Beijing.[2]

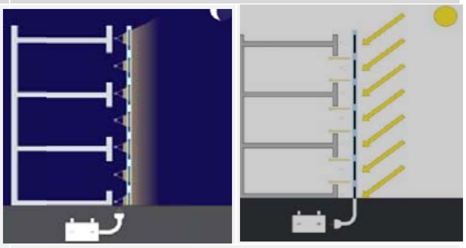


Fig. 2-60 **The Main Energy Cycle Concept of the Media wall.** **Source:** *Beijing's First Zero Energy Media Wall"* http://www.greenpix.org.

✓ *Energy System,*

- *PV system power: 2,292 glass-PV panel.*
- *Type of cell technology:*
  *Poly-Crystalline Silicon Photovoltaics modules.*
- *LEDs Type: color (RGB) LED's ( 2.200 m2) monitor screen.*

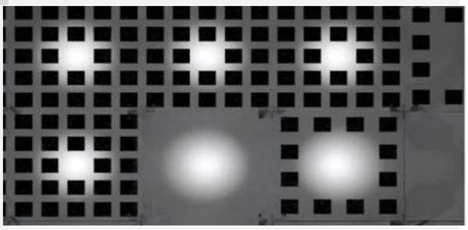


**Fig. 2-61** Illustration of The Media Wall System. **Source:** www.sgp-architects.com

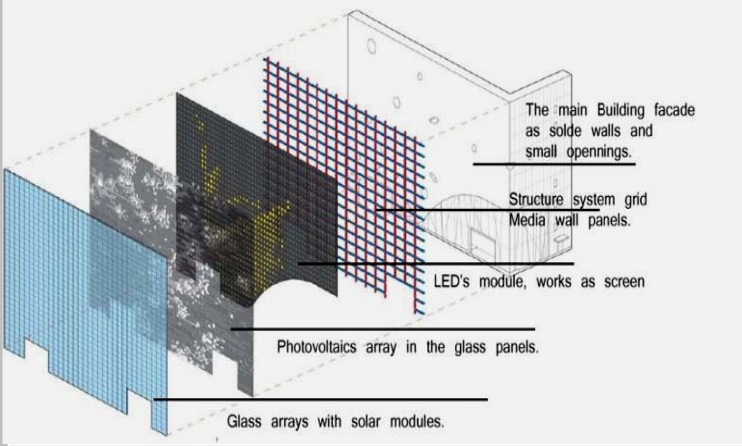
✓ *Integration System,*

*Façade Case;*

*The system in this case depends on many objectives discussed in the previous points that make the building a special case.*

[1] **Giostra**, Simone, **Arup**," *Green Pix- Zero Energy Media Wall"*, www.sgp-architects.com. 12/2008.
[2] Ibid.

**Installation Systems**




The System built up in the following respect:

- *The Building itself as a sold opaque box.*
- *Fixing of the primary steel structure grid system.*
- *Fixing of the Glass-photovoltaics arrays panels with the secondary steel structure.*
- *Fixing of the LED's as array with the former media components.*
- *Testing the media wall with its specific media program.*

Fig. 2-62 **Illustration of The Media Wall System.**
**Source:** http://www.greenpix.org.

✓ *Installing System & Devices,*

- The integration here works as; commercial media screen, transparent wall, dynamic shading system, organic energy system, and curtain wall in the same time.
- So, it works as passive and active solar system, which works with the various conditions of solar quality and excessive radiations in the same time.
- Green-Pix, is a large-scale display comprising of 2,292 color (RGB) LED's light points comparable to a 24,000 sq. ft. (2.200 m2) monitor screen for dynamic content display
- Its intelligent skin interacts with the building interiors and the outer public spaces using embedded, custom-designed software, transforming the building façade into a responsive environment for entertainment and public engagement.[1]

**Fig. 2-63 Installing The System Devices .**
**Source:** http://www.greenpix.org.

✓ *Learned Lessons,*

**Main Issues**

- Green-Pix results from the ambitious collaborative talent of architects, engineers, programmers, artists and curators.[2]
- Is how to create a full integration of media/information technology with architecture in an urban context by using high sustainable technology and renewable energy that may raises the social awareness about the international green ambitious.
- Represents a new kind of communication surface devoted to unprecedented forms of art, while projecting information about the behavior and activity of the building to a wide range of distances and engaging a vast audience within the city of Beijing.
- The *innovative use of technology and experimental approach to communication and social interaction defines new standards in the context of urban interventions worldwide, raising global interest in the integration of digital technology with architectureand reinforcing the reputation of Beijing as a centre for innovation and urban renewal.*

**Fig. 2-64 Arup, Electrical Engineer, Testing The LEDs Luminance By Panel.** **Source:** Report;*"Green-pix, Beijing's First Zero Energy Media Wall"* http://www.greenpix.org. 12/2008.

[1] Report;*"Green-pix, Beijing's First Zero Energy Media Wall"* http://www.greenpix.org. 12/2008.
[2] **Giostra**, Simone, **Arup**," *Green Pix- Zero Energy Media Wall"*, www.sgp-architects.com. 12/2008.

## 4-2.2 *Example 2.*

**Project Title** — *THE SOLAR OFFICE: Doxford International.*

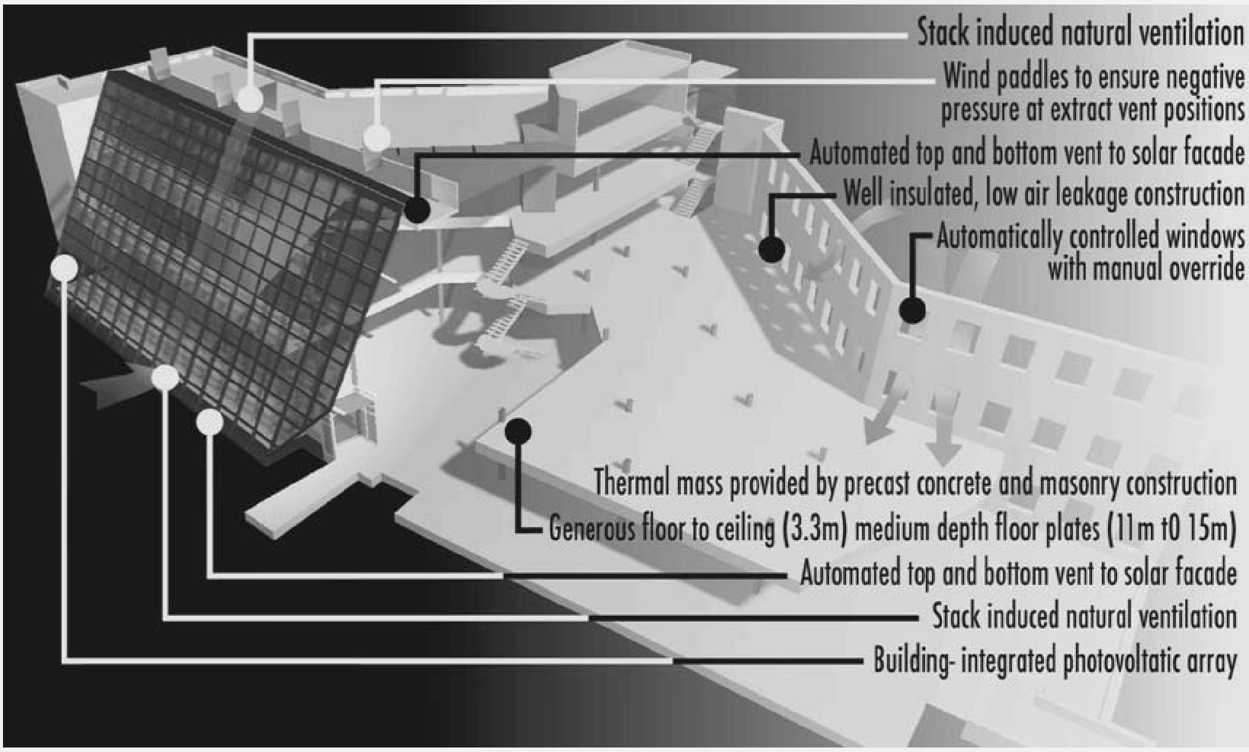



Fig. 2-65 **Illustration of The Building Dynamics, Solar Curtain Wall and Natural Ventilation System.**
**Source**: **Jones,** Lloyd**. Matson,** C. and **Pearsall,** *"The Solar Office: A Solar Powered Building With A Comprehensive Energy Strategy"* ,2nd World Conference on PV Solar Energy Conversion, Vienna, Austria, July 1998.

**Site**

*Doxford International Business Park, Sunderland, England.*

**Team Work**

*Client: Akeler PLC. Architect: Studio E Architects. Co-ordination Architects: Aukett Associates.*
*Structural Engineers: Whitby Bird and Partners. Building Services Engineers: Rybka Battle.*

**General Information**

*Value: € 4.5 million. Completion Date: 1998.*
*Main Contractors: Bowmer and Kirkland. Solar facade: Schüco International*
*PV and building monitoring: Newcastle Photovoltaics Application Centre*
*Awards: Energy Globe Award 2000, + Council Millenium Product Award 1999 + Eurosolar Award 1999.*

**Project Overview**

The Solar Office at Doxford International Business Park is a new office building designed for Akeler and located in the north east of England. It is the first speculatively constructed building (*till year 2000*) to incorporate building-integrated photovoltaics and the resulting facade was the largest assembled at the time. It is also one of only a few to adopt a holistic energy strategy.[1] It was designed to minimize the use of energy while its external fabric. This formula for energy self-sufficiency is one of the key building blocks of future global sustainability.

The PV system in this building, also contributes to the control of passive solar gain by providing shading and to the natural ventilation of the building as a result of the heat accumulation behind the façade.[2] The building has a 73-kilowatt peak rating and annual generation estimated at 55 megawatt hours. Building performance was rated 'excellent', the highest classification; in the BREEAM [3] sponsored environmental assessment program. [4]

Its performance was examined by the Energy Technical Support Unit (ETSU) on behalf of the Department of Trade and Industry in the UK, and comprises one of the tasks included in a program of financial support covering design development, testing and monitoring in respect of the project.

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[1] **Randall,**Thomas. , **Fordham**,Max., " *Photovoltaics and Architecture*", (London: Spon Press,2003),86.
[2] **Jones,** Lloyd**. Matson,** C. and **Pearsall, "***The Solar Office: a Solar Powered Building with a Comprehensive Energy Strategy*", 2nd World Conference on PV Solar Energy Conversion, Vienna, Austria, July 1998.
[3] **BREEAM** : Building Research Establishment Environmental Assessment Method.
[4] www.studioe.co.uk/doxford. , Office projects page, date 12/2008.

**Building Considerations**

### ✓ *Project Objectives :*

- Addressing of all the environmental and energy-conserving issue through the design of the building.
- Achieving of future global sustainability, by using Energy self-sufficient as a key principle for the building.
- Using of renewable energy as alternative resource for energy (using of solar energy).
- The building is designed to minimize the use of energy through its external fabric.
- The building also is achieved its targets to be the first constructed office building to incorporate building-integrated photovoltaics, and the resulting solar façade is the largest so far constructed in Europe.[1]

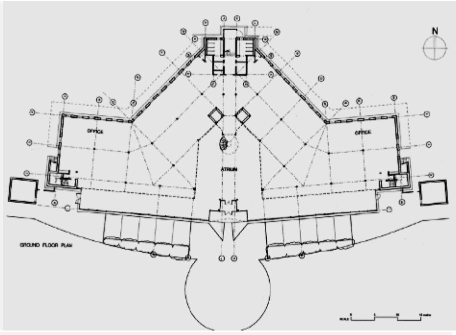

Fig.2-66 **Master plan of the solar office.** **Source:** Randall. Fordham, *"Photovoltaics and Architecture"*, p. 86.

### ✓ *General Considerations:*

- ***Energy-Consumption targets***, *reducing to 85 kWh /m [2]/ year conventional power compared with a conventional air-conditioned office of over (400 kWh/m[2]/year).*
- *Using of photovoltaic arrays (**building-integrated system**) to provide solar power to achieve the self-sufficient target.*
- *Considering of **energy loads** in the different seasons like summer season, which the **surplus energy** will be exported to the **National Grid**.*
- *Consideration of the **occupying tenants to suit there specific requirements**, with using options of low-energy "passive solar" mode or "mixed mode" operations of energy.*
- ***The building design** and functional areas has to be robust, versatile and to offer exceptional value. It can, if necessary, be divided into up to six separate tenancies.*
- ***Building Layout designed** as V-shaped in plan with the extreme ends of the "V" splayed away from each other, with semi-sold East and West sides to obviate direct solar radiations.*
- *The **inclined and sealed facade** overcame the potential problems of **dazzle and noise** from passing traffic on the adjacent trunk road.* [2]

Fig.2-67 **Main Façade And Main Entrance.** **Source:** www.studioe.co.uk/doxford.

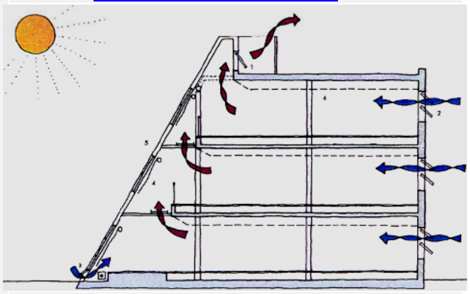

Fig.2-68 **Cross section shows the role of Southern façade as cross ventilation tool, sun shading, and solar energy device.** **Source:** Randall. Fordham, *"Photovoltaics and Architecture"*, p. 87

### ✓ *Orientation:*

- The building is designed as V-shaped in north side in plan. And photovoltaics are fixed in the southern-inclined façade that also declined 60° with horizontal axis.
- The seasonal solar angles variations are also considered in the building design, with it's PV modules, to achieve best not maximum benefiting of solar radiation with the building design concept.
- Behind the inclined southern faÇade, located a three storey atrium, that works as source of natural lighting, with shading devices, cross ventilation openings and solar radiation collector.[3]

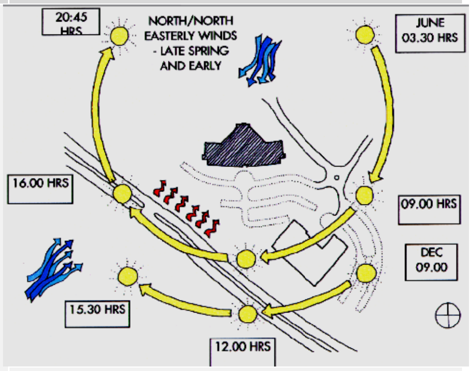


Fig.2-69 **Layout studies, shows the sun tracks in different seasons and times.** **Source:** Ibid.,88.

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[1] **Randall,**Thomas. , **Fordham,**Max., *" Photovoltaics and Architecture"*, (London: Spon Press,2003),86-87.
[2] Data is processed by the researcher from: www.studioe.co.uk/doxford. , Office projects page, date 12/2008. **Randall. Fordham,** *"Photovoltaics and Architecture"*, p. 87-88
[3] **Ibid. ,** 88.

**Stage of Implementation**

✓ *Implementation,*

<u>*Design stage:*</u>

The 4600 m$^2$ three-storey building was designed as **V-shaped** in plan with the extreme ends of the "V" splayed away from each other. A ***central core*** is located at the apex of the "V". The building incorporates a 66m-long. Behind the south-facing located a ***three storey atrium***, between the facade and the splayed wings, an internal passageway. [1]

<u>*The following principles are considered in the design stage;*</u>

- Limited depth floors (maximum 15m) with generous ceiling heights to encourage ***cross ventilation*** and ***good daylighting***.
- Secure of ***night ventilation*** in summer to provide night-time cooling, by providing ***thermal mass of building structure***.
- ***Controllable openings*** for good ventilation, glare-free daylight and solar control.
- A ***well-insulated***, impermeable building envelope to minimise heat loss in winter.

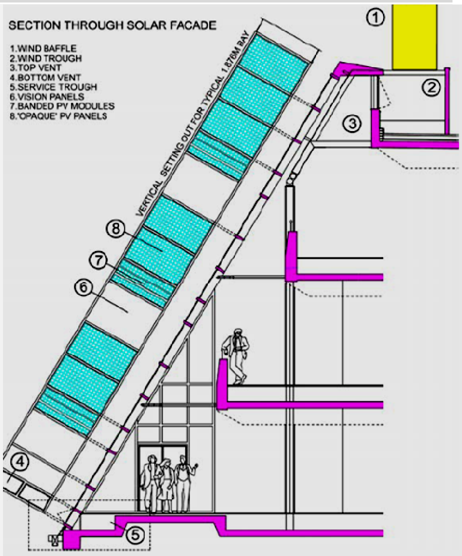


Fig.2-70.a **Detailed section through Solar façade and single bay. Source**: **Jones**, *"The Solar Office Doxford International"10.*

<u>*Construction stage:*</u>

- The Building was constructed to a "***Shell and Core***" specification. It is fitted out to suit the specific requirements of the occupying tenant.
- The whole building was designed and constructed ***over 15 months*** on a ***design-and-build basis***. This means that the contractor is required to construct it within a fixed cost to a fixed delivery date with the consultants novated to the contractor on completion of an approved scheme design.

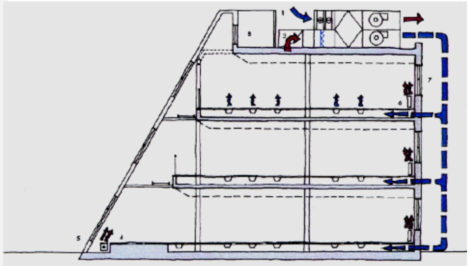

Fig.2-70.b **Dynamic Vent System in Winter.**

**Energy System**

✓ *Energy Strategy,*

*Energy strategy of the entire building is considered by the designers, to achieve its optimal performance, as the following;*

- Responsive ***thermal loads controls*** to avoid frustrating the occupants. And knowledgeable sensitive building management.
- ***Grid-connected PV installation*** was used. Compared with a self-contained installation this has several advantages:
  - ✓ Reduced installation costs, particularly the cost of batteries.
  - ✓ Ease of installation.
  - ✓ Power when the PV supply is insufficient.
  - ✓ Standard components.
  - ✓ Reduction in complexity and maintenance.
- ***Testing and Monitoring*** the output PV energy quality for constancy in voltage, and frequency and acceptable variation in harmonic distortion before the grid connection could be made.[2]

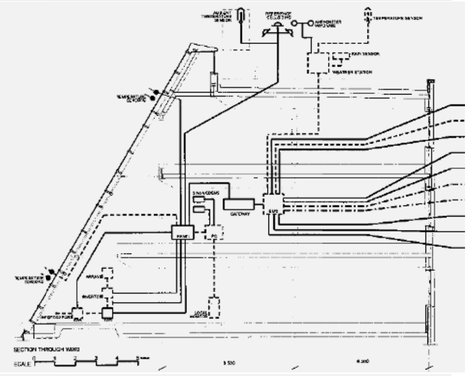

Fig.2-71 **Shop-Drawing Panels of Electrical Solar System of the Building.**
**Source**: Randall. Fordham, *"Photovoltaics and Architecture",* 96.

✓ *Energy System,*

- ***PV system power:*** 400,000 cells on 352 modular glass-PV panels each incorporating 100*100 mm cells.
- ***Glass-glass modules*** *with transparent solar cells.*
- ***Type of cell technology:*** *Poly-Crystalline Silicon Photovoltaics modules.*

Fig.2-72 **Effect on Glass-Glass Modules with Exterior. Source**: www.studioe.co.uk/doxford.

[1] **Jones**, David. **Energy Technical Support Unit**, Technical report: *"The Solar Office Doxford International"* (London: Crown, 2000). 21.

[2] Data is processed by the researcher from: www.studioe.co.uk/doxford. , Office projects page, date 12/2008. **Randall**. **Fordham**, *"Photovoltaics and Architecture"*, p. 87-88

### ✓ *How the is System Work,*

The building distinguished by its intelligent thermal, ventilation, and energy systems, which combined in the southern-façade, to work as passive and active energy system in the same time.

- *PV Electricity;* PV is generates approx. 85 kWh/$m^2$/year
- *Ventilation System;* using of mechanical vents in top and bottom of the Façade, to create cross ventilation circle.
- *PV and Stack effects*; Heating on the PV modules by the solar gain helps the well-dynamic of stack effect of worm air.
- *Thermal Capacity*; The facade glazing build-up has a U-value of 1.2 W/$m^2$K
- *Negative Pressure*; using of baffles on the end of certain wall to control the negative pressure above the building.[1]

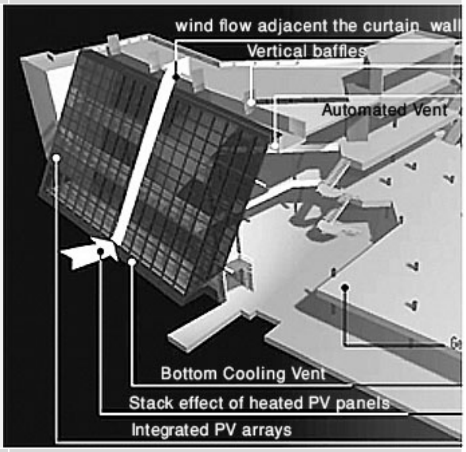


Fig.2-73.a **Illustration of Solar Curtain Wall.**
**Source:** www.studioe.co.uk/doxford.

**Installation Systems**

### ✓ *Integration System,*

Façade case;

The technical properties of the façade PV system was done as follows;

- BIPV system is utilized in the southern-façade curtain wall.
- The PV facade is basically a proprietary product, the Synergy Façade system from Schüco International.
- Use of Glass-glass modules with transparent solar cells that keep the curtain wall works as semi-shaded wall. [2]

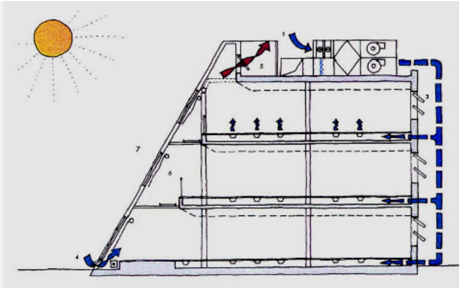

Fig.2-73.b **Dynamic Vent System in Summer's days.**

### ✓ *Installing System & Devices,*

- Façade Modules are *wired down* the mullions back to *junction boxes*, and thence to *inverters*
- The *junction boxes* and the two smaller inverters are located in a trench at the foot of the façade.
- *The two large inverters* are under the staircases at the ends of the building.
- *Bands of clear glazing* have been introduced into the façade to allow views out and ensure good internal light levels. [2]

Fig.2-73.c **Interior View**
**Source:** www.studioe.co.uk/doxford.

**Main issues**

### ✓ *Learned Lessons,*

- The project presents a readily sample model in terms of the architecture design and energy engineers fields.
- The building designer presents an intelligent design concept to utilizing photovoltaics properties, like PV over heating problem, as beneficial side as natural stack ventilation requirements.
- The Solar Office represents the coming of age of building integrated photovoltaics.
- The building's ultimate success will be judged by the manner in which it meets the demands of the commercial marketplace.
- Future projects will increasingly incorporate photovoltaics on the basis of their proven value in contributing to environmentally sound energy strategies for buildings.[3]

Fig.2-74 **Using of baffles on the building ends to control the negative pressure of outside winds, Shows integration between architects and other engineering fields.**

**Source**: Randall. Fordham, *"Photovoltaics and Architecture"*, p. 91.

[1] Data is processed by the researcher from: www.studioe.co.uk/doxford. , Office projects page, date 12/2008. **Randall**. **Fordham**, *"Photovoltaics and Architecture"*,90-92

[2] **The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition.( London: Earthscan, sterling,VA,2008) p. 294.

[3] **Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"*, (London: Spon Press,2003), p. 98.

**Example 3.**

| **Project Title** | *Parkmount Housing Complex in Belfast* |
|---|---|

Fig.2-75 **The Final Scheme of the housing complex in Belfast, Ireland.** The scheme provides high solar gain for apartments and the PV cells. The final scheme present the housing complex with gently ascending Curving arc as shown in the elevation.

**Source**: **Randall**,Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture",* (London: Spon Press,2003),71.

| | |
|---|---|
| **Site** | *Shore Road, Parkmount, Belfast. Northern Ireland.* |
| **Team Work** | *Client: The Carvill Group.*<br>*Architect: Richard Partington.* *Urban Design: Llewelyn-Davies.*<br>*Environmental Engineers: Max Fordham & Partners.* *Quantity Surveyor: The Carvill Group.* |
| **General Information** | *Completed: November 2003.* *Value: £2.9 Million.* |
| **Project Overview** | Housing is a contentious issue in Northern Ireland. Neighborhoods earmarked for redevelopment resist protecting sectarian and territorial boundaries. Private investors avoid the derelict and threatening no-go areas, and consultation processes can be long and drawn out. As a result, there has been little scope for innovation and new development has been conventional and cautious.<br><br>In 1997 The Northern Ireland Housing Executive, the main public body responsible for delivering housing established a project team to promote new ideas in housing design, with the intention of building these into a demonstration project. Their own technical team sought contributions from ***academic bodies*** and ***specialist companies***.[1]-[2]<br><br>***The site*** is a long, thin strip of derelict land, aligned on a north–south axis, two miles from the centre of Belfast. A flat area in the centre approximately ***35 metres*** wide and ***150 metres*** long provides the only useful space to build upon. The Carvill Group consultants, commissioned the holistic work to be adapted with (NIHE[3]) realistic standards. ***The project team*** with ***the consultant*** was made many sketches for achieving the scheme objectives as ***maximizing Solar gain***, and ***PV installation***, and ***other design &urban considerations***.[4] |

[1] **Randall,**Thomas. , **Fordham**,Max., " *Photovoltaics and Architecture*", (London: Spon Press,2003), p. 68.
[2] **Harvey**, Tom. Issue 25 " Constructing The Future; Getting Tough On Carbon Emissions", 2005., www.bre.co.uk Date. 2008, P. 10
[3] **NIHE** :is the (Northern *Ireland Housing Executive) Organization for housing construction affairs.*
[4] **Randall,**Thomas. , **Fordham**,Max., " *Photovoltaics and Architecture*", (London: Spon Press,2003), p. 69.

**Building Considerations**

### ✓ *Project Objectives ,*

The project team sought to achieve the following objectives;

- The scheme will provide ***modern***, ***energy-efficient*** and ***healthy homes*** for young and low-income households.
- A principal aim is to make ***good use of solar energy***.
- The possibilities of ***low-energy*** design in ***urban housing***;
- The connection between ***built form*** and health and ***well-being***;
- And ***flexible dwellings*** that accommodate changing patterns of use and occupation.
- It also aimed to raise public awareness of housing design, and as a preliminary application for grant funding. [1]

Fig.2-76 **The Original Site before the construction of project.**
**Source:** Randall. Fordham, *"Photovoltaics and Architecture"*, p. 69.

### ✓ *General Considerations,*

Parkmount is one of several projects underway in the city that is helping to reverse the trend, with the peace of Belfast that has been enjoyed. So, ***the consideration of the project was***;

- The scheme is developing in parallel with ***an urban design study*** that will look beyond the site boundaries,
- Considering the ***neighboring streets*** and ***public spaces*** and possible ***improvements to public transport***.
- Considering the ***publicly funded*** to promote district wider program of renewal in the area, and demonstrate the housing role as best-practice and real innovation for sale on marketing.
- A completely secure development with controlled access.
- A logical sequence for marketing and constructing the scheme in phased stages to limit the financial risk.
- plans have to be flexible to anticipate changes in work patterns and lifestyles. And creation of "place" with landscaping.
- The accommodation will consist of ***56 two-bedroom apartments*** (approx. ***60m2***) with four smaller one-bedroom apartments.
- Good design for maximizing ***solar potential with a high research and innovation*** component centred around the use of PVs.
- Attainment of the BRE Environmental Standard Award "Homes for a Greener World". [1]

Fig. 2-77 **Installing Of PV Rolls In The Building Roofing.**

**Source**: Parkmount Housing, Belfast, Richard Partington projects. www.maxfordham.com/projects .2008,

### ✓ *Orientation,*[2]

- In the final scheme the architect achieve more than 80% of the apartment have a good orientation for sunlight, plus passive gains.
- It is also a prime example of a " Solar Sculpting" strategy where ambient energy played an important role in determining building form, as shown in all of the roofs were oriented for PVs.
- As **Fig. 2-78** all roofs are oriented in the Southern direction to utilizing maximum solar gain, using Roof integration case.[3]

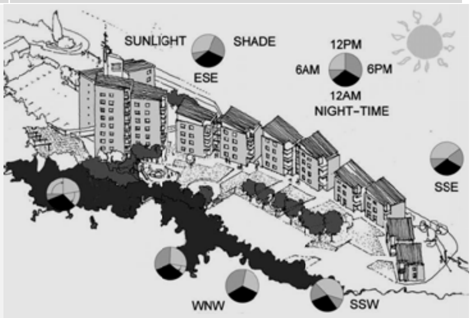


Fig. 2-78 **Layout studies, shows the sun tracks in different seasons and times.** **Source: Lewis**, Sally. *"Front To Back; a Design Agenda for Urban Housing"*, Elsevier, 2005) 22- 24.

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[1] **Background,** project Report: *"Parkmount Hosing; Civic Trust Awards 2006 "*
[2] **Lewis**, Sally. *"Front To Back; a Design Agenda for Urban Housing"* The Sustainability Agenda, (London; Elsevier, 2005) 22-24 .
[3] **Partington**, Richard. Projects Parkmount Housing, Belfast,. www.maxfordham.com/projects .2008,

## Stage of Implementation

### ✓ *Implementation,*[1]

***Sketching & Design Stage:***

*Sketch proposals* were made and reviewed and an outline design was developed. Further consultations then took place with the *planners*, *local politicians*, the *highways authority* and the *funding bodies*. The design team worked with considering the investigation of layout with maximize of solar potential, daylighting, passive solar gain and the use of PVs.

- *Courtyard Scheme*; that grouped buildings around an enclosed landscaped space, creating a haven from the busy road. Fig. 2-79.a
- *Separated Tower Scheme*; is good for solar orientation but lacking the defining of secure space. Fig. 2-79.b
- *Final scheme:* was a tall building (eight storey's) at the north end of the site with a *gently curving arc* of lower buildings starting with a *two-storey block* at the *southern end*. Fig. 2-79.c
- The *ascending heights* of the buildings ensure that each mono-pitch roof presents a large area to the southern sky for an *efficient PV installation* without overshadowing from adjacent buildings in the scheme.
- More than *80% of the apartments* have good orientation for sunlight and the inclined roof suitable for installing PV arrays.

***Construction Vision:***

The project looked expensive; because of the tower and large wall area created, but the client see, that layout makes good sense from a *commercial and marketing view*, as house builders prefer to build in phases so that early sales can fund the latter stages.[2]

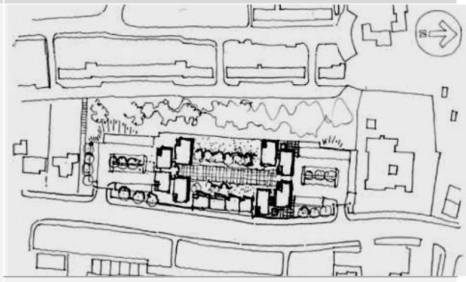


Fig. 2-79.a **Courtyard scheme.**

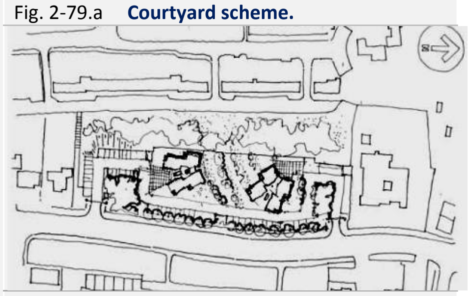


Fig. 2-79.b **Considering Orientation scheme.**

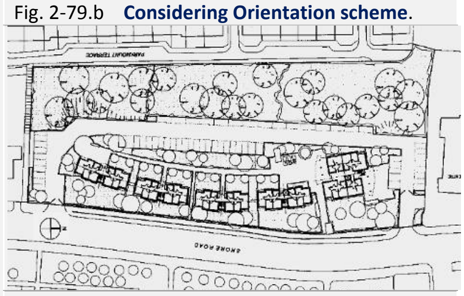


Fig. 2-79.c **Grouping with secure playing Space scheme. Source**: Randall. ,*"PV and Architecture"*, p. 70.

## Energy System

### ✓ *Energy Strategy,*

*Energy strategy of the scheme, was as the following;*

- *Installing of 10 m*$^2$ of PV array on the tower for providing energy for lighting in common areas(Lift lobby and Stairway)
- *Installing large arrays 70m*$^2$ with estimated annual *Grid-connected* output 4400kwh. The design of this roof will be applicable to all the low-rise units in the future.
- *Incorporating experimental technology*, such as rainwater recycling and a conservatory/thermal buffer device with solar mass storage.
- *Monitoring of the building energy performance*, which the Dept. of the Built Environment at Ulster University, have had.

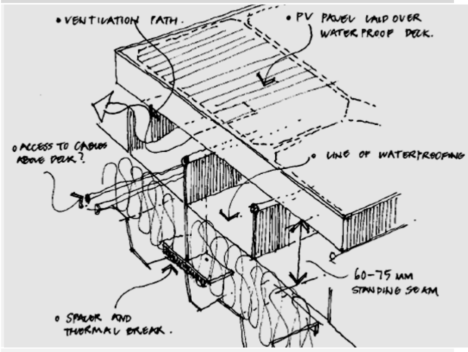



Fig. 2-80 **Studies of the Roof Components**
**Source:** Randall. Fordham, *"Photovoltaics and Architecture"*, p. 70.

### ✓ *Energy System,*

- *`PV system power:* 80m$^2$ Rolls of Amorphous (Thin film panels, BP's Millennia series- thickness: 7- 8$_{mm}$).
- *Laminated rolls (glass- sheets)*
- *Justifications:*
  1- *One-quarter of the cost* & *1/5 of efficiency compared with high efficient mono-crystal silicon panels.*
  2- *For* esthetic architectural value *of the roof boundaries if it was a bulked PV panels.* Fig. 2-81
  3- *It is adapted with using steel covering roof technology.*

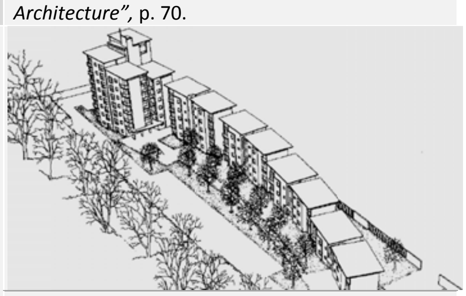


Fig. 2-81 **Final Scheme; a gently ascending curving arc. Source:** Randall. Fordham, *"Photovoltaics and Architecture"*, p. 70.

[1] **Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"*, (London: Spon Press,2003),69-72.
[2] **Ibid.,** 73.

### ✓ *How the System Works,*

*The project's team were face some questions considering the* **installation of PV** *with other* **roofing components**, *as follows;*

1- How to maintain the ***waterproof layer*** that is not compromised by the PV installation,
2- Design for ***future retrofitted panels*** without complete replacement of the roof,
3- ***Access for maintenance*** and cleaning and future installation,

After drafting the sophisticated study with using PV panels **Fig. 2-82.a**, the decision was to use bonding PV cells to the flat roof ***(Flat-roof type Single -ply membranes)*** as mentioned before. To avoid the previous technical questions for roofing components. [1]

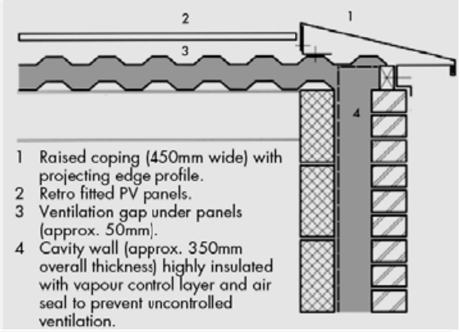



Fig.2-82 **Study of Roofing layers**. **Source:** Randall., *"Photovoltaics and Architecture",* p. 76.

## Installation Systems

### ✓ *Integration System,*

*Roof Case:*

In this case the project team studying the Integration of PV cells as roof-scape **Fig. 2-82.b** , to be treated as *"Fifth"* elevation of the buildings. So, they examined ***Two integration systems*** to achieve best solar gain with high integration with roofing surfaces as visual elevation.

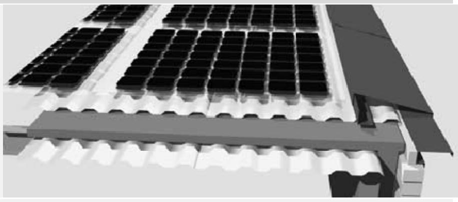


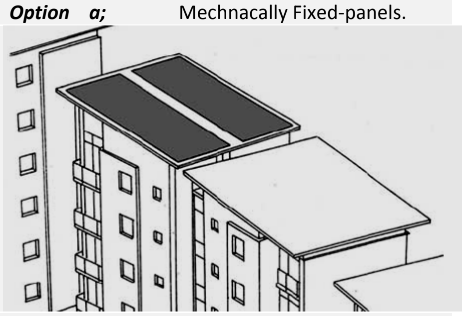
Fig. 2-83 **Studying of the integration with roof layes.**

### ✓ *Installing System & Devices,*

OPTION (a) Mechanically fixed PV panels: (Fig. 2-83.a)

- ***PV cells on glass units*** fixed to standing seam roofing system.
- Weight of PV panels and fixing mechanisms: **20kg/m$^2$**.
- Maximum PV area: **72m$^2$**.
- Central access zone for cleaning maintenance required.
- Annual output: 62kWh/m2/year. **Total: 4464kWh/year**
- Supply cables taken over roof parapet to inverters located in service core area.

***Option a;*** Mechnacally Fixed-panels.



OPTION (b) Bonded PV panels: (Fig. 2-83.b)

- PV bonded to single ply-roofing membrane rolls 1.05m wide.
- Weight of installation including roof membrane: **4kg/m$^2$**.
- Maximum PV area: **56.5m$^2$**.
- No special zones for access
- Required as membrane tolerant of light foot traffic.
- Annual output: 45–53 kWh/m$^2$/year. Total: **2552–2993 kWh / year**
- Supply cables wired to back of each panel and fed through roof deck to inverters in roof void below. [2]

***Option b; √*** Amourphos Ply-Roofing.

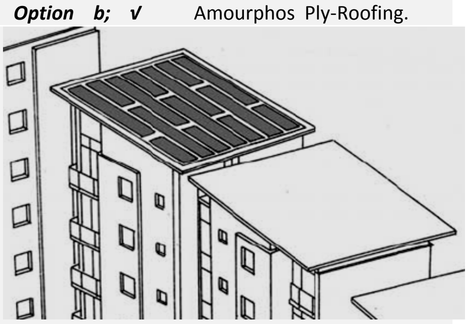


Fig.2-84
**Studying Of The Integration Options** a - b.

## Main issues

### ✓ *Learned Lessons,*

- PV required detailed considerations and co-ordination at early stage in project progress.
- The project context arises the necessary adjustment of the sequence of decision-making, especially house developers.
- PV installation has clear influence in the site strategy, layout, form and appearance of the buildings.
- In Ireland, it is considered a significant technical and visual landmark, as non-commercial standard for future speculative.

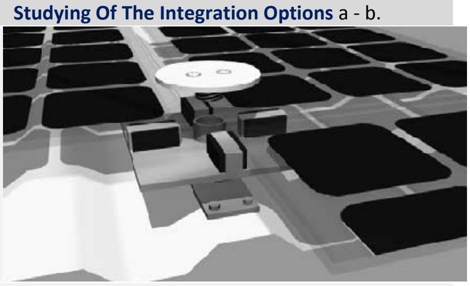


Fig.2-85 **Very Technical Study Of Roofing Connections.** **Source**: Randall. Fordham, *"Photovoltaics and Architecture",* p. 76.

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[1] **Randall,**Thomas. , **Fordham,**Max., *" Photovoltaics and Architecture",* (London: Spon Press,2003),75.
[2] Ibid., 78.

## ▪ CONCLUSION

*The Following (figure 2-86) is the Conclusion of the main international and National examples that has discussed through Chapter V;*

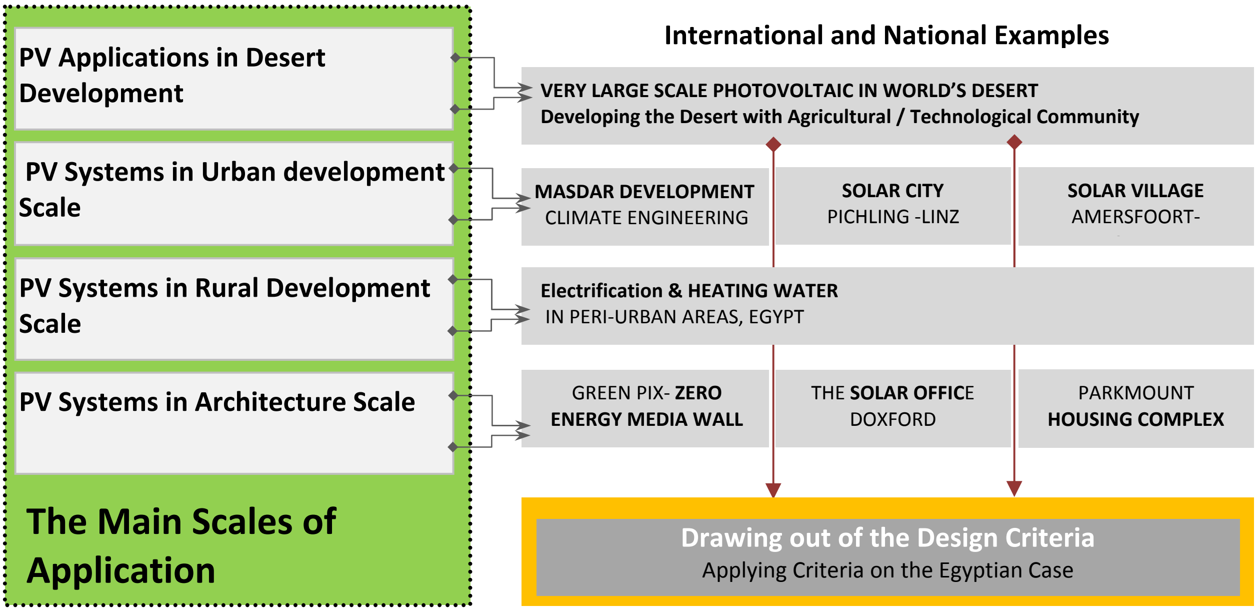



Figure: 2-86

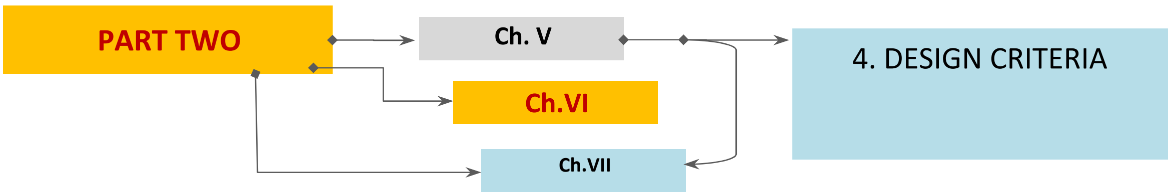
**Chapter V Diagram; Illustrates the Main Issues of Discussion**

***Solar Cities,*** The chapter presenting numerous practical, successful, and implemented examples arises the development and implementation of solar initiatives – using Building Integrated Photovoltaics (BIPV) and passive solar systems – as ; Amersfoort – solar village - and Pichling- Linz – Solar city- the projects that helps the research for draw out main objectives, urban considerations, implementation stages, energy policy, Financing mechanism , learned lessons and finally extracting the **Design Criteria.** Masdar city involves with new cohesive concept regarding the principles of sustainability and zero-Energy, which adding newest horizon for low-energy consumption to Zero. While **Rural Development**, emphasized the important role of national governmental and non- governmental organizations for supporting UNDP activities and programs in rural development concerning health and reduction of CO2 emissions.

# CHAPTER

# VI

## DESIGN GUIDELINES AND CRITERIA




- ***In Chapter VI**, the research summarize the main issues that discussed through examples in **Chapter V.** Analytical comparing is used for extracting the main design criteria of Developmental, urban, rural, and Architectural examples. These criteria would be beneficial for examining the Egyptian suitable regions or for specific sites. The chapter introduces also the key areas for developing the using of Photovoltaic technology in various scales.*

# Chapter VI. DESIGN GUIDELINE & CRITERIA

There is an additional factor to integrate into the Architectural and urban design in Photovoltaic Architecture ( PV Architecture),[1] to be more difficult than good architecture. Nonetheless, the preceding studies have shown that PVs can readily be adopted to, or even form, a starting point for *high-quality, stimulating, creative, diversified, environmentally friendly architecture*. A rapid survey of PVs indicates a number of key areas of progress:

- *Community level integration.*
- *Integrated building solutions.*
- *Development.*
- *Government support.*

Table 2-1, states the main key areas for developing the using of PV technology in different issues as; Communities, buildings, research and development, and governmental supports.

**TABLE: 2-1** **The Keys Areas for Developing the Using Photovoltaic Technology**

| KEY AREAS | ILLUSTRATION |
|---|---|
| **Communities** | Architects and planners have an especially important role to encourage the optimum use of Photovoltaics needs integrate into the planning context. Maximizing the application of solar energy through the facilities as; density of occupation, street widths, park areas, and massing of buildings of which PVs are a key element. |
| **Buildings** | It is becoming clear to more designers that PVs must be considered as part of the overall environmental design of the building. For example, reduction of the electrical energy demand through greater use of daylighting will increase the percentage of the demand that can be supplied by PVs. In the near future, designers will turn their attention to integrating PVs into the refurbishment of buildings and, particularly, their roof scapes. |
| **Development** | One report estimates that factories with annual output of 500MWp would lower PV prices to levels competitive with conventional power due to high levels of automation and economies of scale. Research and development is significant, a photovoltaic cell with a 32% efficiency has been developed using a 3-junction technology of gallium indium phosphorous/gallium arsenide/germanium. Production capacity is increasing and the world currently needs 10,000 GW. |
| **Governmental Support** | Government support varies with the country, but is on the increase. In Germany, for example, proposed new legislation guarantees that producers of PV electricity will receive a significant subsidy – six times more than the current level; support will reduce in time as PVs become more competitive. In the UK a number of initiatives are underway, including encouragement of PVs in schools and ongoing support for demonstration projects. |

Data processed by author from **: Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture"* (London: Spon Press, 2003).p 138-139. **Anon**, News. Renewable Energy World 2(6) 1999, p. 17. **Gratzel**, **M**. , Powering the planet. Nature, 403(676)2000, p. 363. **Anon**, PV – Breaking the Solar Impasse, Renewable Energy World, 2(6) 1999, p. 95.

Through the Following tables the research compare and draw out the main design criteria and illustrates the differences between the examples to understanding the specific conditions of every example's case; The Tables Are;

2-2 Comparing Between Solar -Urban Development -Examples.
2-3 Comparing Between Solar - Building Integrated - Examples.
2-4 Design Criteria for Using Solar Electrical Systems in Developmental, Urban, Rural, and Architectural Scales.

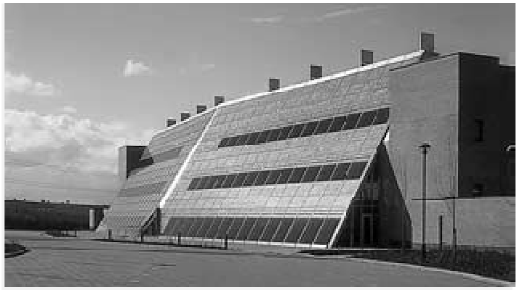
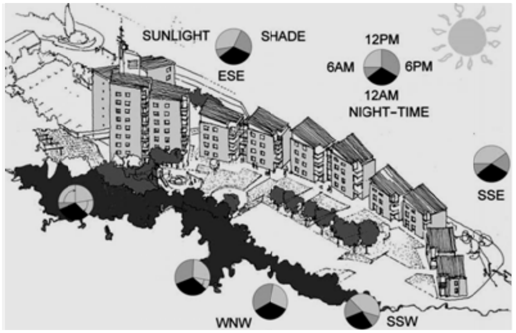
[1] **PV Architecture**: so-called by the author of book " *Photovoltaics and Architecture* " Mr. Randall Thomas

## TABLE 2-2 Comparing Between Solar -Urban Development -Examples.

| | Vision | Design | Implementation | Energy System | Installing Systems | Finance | |
|---|---|---|---|---|---|---|---|
| **Masdar City Abu-Dhabi- UAE** | - New sustainable city in abu-Dhabi to imitate a new sample for future cities.<br>- To achieve a Zero Carbon and Zero waste Community.<br>- To develop the utilization of Renewable energy, especially solar energy systems. | - The design considering the applying of all ten sustainable principles to create new form of Arabian sustainable cities.<br>- Considering all climatic conditions of the Arabian region perfectly for keeping high living style with new green Technologies & Energy.<br>- Simulating the design model for testing and studies all environmental aspects. | - Project implementation is consisting of Six-phases; the first is the (MIST) the Masdar institute for science and technology, as educational and research facility.<br>- Phase II: is the PV Energy plants and infrastructure of city.<br>- Other phases of construction depend on the investment and governmental fund. | GRID-CONNECTED<br>- Using of Photovoltaics plants outside the city to generate energy,<br>- Installing Photovoltaic cells on city's roofs.<br>- In combined with other renewable types like (Wind, Geothermal, Biofuels )<br>- To generate energy for the city and to be grid-connected with Abu-Dhabi grid. | - Very large-Scale Photovoltaic power plant.<br>- BIPV; installing PV panels in building roofs.<br>- Passive systems | - 2 Billion Dollars; The largest governmental investment in Abu-Dhabi,<br>- The investment on renewable energy and manufacture.<br>- The investment on the CO2 emission reduction.<br>- Privet investment in technology and energy development. |  |
| **Solar City- Linz Pichling – Austria** | - To create a base for the future social residential housing project.<br>- Achieving pillars of Sustainability; (economic growth-ecological balance-social progress )<br>- Achieving the principles of sustainable Architecture. | - The urban design is carried out by international Architects involves in sustainable techniques.<br>- Designing of Energy Technology planning by Norbert Kaiser.<br>- Holding an architectural competitions for developing public buildings and landscape. | - The implementation in carried out through three periods in years 1996- 1997-1998 related to financial mechanism and investment. | GRID-CONNECTED<br>- Energy conservation<br>- Energy supplying<br>- High utilization of Solar thermal systems (passive systems).<br>- Utilizing of solar electrical systems (Active systems). | - Roof Case; (BIPV) Fixing solar thermal collectors and Photovoltaic cells ,<br>- Façade Case; Intelligent utilization of passive systems and high thermal capacity materials<br>- Passive systems; Uses of centralized servicing, in vertical cores, with integrated heat | - Planning and Construction: was subsidized by the EU and the province of Upper Austria.<br>- The EU General Directorate for R&D subsidized the planning work with a contribution of euro 600,000. |  |
| **Solar Village Amersfoort- Netherland** | - Reducing of CO2 emissions, and strategy for supplying 3.2% of electricity form RE sources.<br>- To examine the impact of using solar power at district level.<br>- Demonstrating the technological and architectural potential of BIPV | The planning of the project was taken for implementing main five different Building types;<br>- Residential and utility building,<br>- Low-energy primary schools<br>- Fifty rented dwellings units,<br>- Nineteen owner occupied homes with solar power,<br>- And two semi-detached "balanced energy houses" | - Three schools with 196-124 solar panels.<br>- 500 solar houses with 20 $m^2$ solar panels.<br>- 50 rented houses.<br>- Two Balanced Energy Houses, for measuring output energy. | GRID-CONNECTED<br>Achieving of 1MW energy generation from:<br>- Solar Photovoltaic systems<br>- Solar / Gas combination unit has been installed in each house. | - Roof Case; (BIPV) Fixing solar thermal collectors and Photovoltaic cells ,<br>- Façade Case; Intelligent utilization of passive faÇade systems .<br>- Other cases; installing PV panels in Urban Tools as garages and shades. | - The PV modules are financed and owned by REMU (private Sector )<br>- Return of investment through selling PV to householders over 20 years through a leasing arrangement. |  |

**Data processed from** : **Masdar Official** Site; http://www.masdar.ae/ . "The *Masdar Initiative* "Date, 12/2008. **Foster**, Norman., Projects, Official website, http://www.fosterandpartners.com/Practice/Default.aspx, Date,12/2008. Initiative Report, *"Abu Dhabi's MASDAR INITIATIVE; Breaks Ground On Carbon-Neutral City Of The Future"* 2008, 2-5. **ERABUILD** *"Sustainable Construction and Operation of Buildings, Erabuild Description of Programs"* (ERABUILD Consortium: www.erabuild.net ., April 2005). **Linz- website** – Linz Pichling solar City: http://www.linz.at/english/life/3199.asp. Date :11/2008. **Herzog**, Thomas. **Kaiser**, Norbert, **Volz**, Michael., " *Solar Energy In Architecture And Urban Planning"* ; European Conference on Solar Energy in Architecture and Urban Planning (New York : Prestel, Second Edition,2005), 180-186. **IEA** PVPS Task 2 and Task 10 Educational Tool., http://www.iea-pvps.org/cases/nld_01.htm **Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture",* (London: Spon Press,2003),61-68.

## TABLE 2-3 Comparing Between Solar - Building Integrated - Examples.

| | Vision | Design consideration | Implementation | Energy System | Finance | |
|---|---|---|---|---|---|---|
| **Green Pix wall Zero Energy Media** | - To create new sustainable sample in architectural scale by using high and new solar LEDs technology to create Media and zero energy wall.<br>- To be one of the world's initiative for integration of sustainable technology in Architecture | - The Design aims to create Media wall so-called Green-Pix ( Zero Energy Media Wall)<br>- Considering of intelligent integration of Solar cells with the media devices( LEDs)<br>- To achieve full integration of Media / Information technology with architecture in an urban context. | - Developing technology for laminating PV cells in glass curtain.<br>- Developing of new integrated panels combines PV cells, LEDs, and isolation glass curtain.<br>- Developing and studying the steel structure frame and connection to create a modular grid. | <u>GRID-CONNECTED</u><br>FaÇade Case;<br>- PV system: 2,292 glass-PV panels.<br>- Poly-Crystalline Silicon PV modules. | - Private investment ( JINGYA Group) |  |
| **The Solar Office- Doxford- International** | - To be the first constructed office building demonstrates the utilization of BIPV techniques.<br>- Using of alternative energy sources (SE)<br>- To demonstrates self-sufficient principles. | - Considering of optimal design and orientation of southern faÇade to generate electrical energy.<br>- Considering the urban ambient and building layout design for architectural and solar installation.<br>- Considering the architectural details in plans and sections to create comfort in the building. | - It constructed as a "Shell and Core" specification. It is fitted out to the requirements of the occupying tenant.<br>- The building was designed and constructed over 15 months, to construct it within a fixed cost to a fixed delivery date with the consultants novated to the contractor on completion of an approved scheme design. | <u>GRID-CONNECTED</u><br>FaÇade Case;<br>- PV system power: 400,000 cells on 352 modular glass-PV panels each incorporating 100*100 mm cells.<br>- Type of cell technology: Poly-Crystalline Silicon Photovoltaics modules. | - European Regional Development Fund £1.35m (ERDF) to cover the major costs of the PV and some aspects of the proposed energy-efficiency measures.<br>- The client raised a £2,875,000 and the architects secured £111,000 from the Dept of Trade and Industry towards design develp. |  |
| **Parkmount Housing, Belfast - Ireland** | - To vision to achieve a modern, energy efficient, and healthy homes.<br>- To demonstrates the possibility of LOW-Energy in urban scale.<br>- Raise public awareness about utilizing of SE applications and dissemination of tech. | - Considering the publicly funded to promote district wider program of renewal in the area<br>- Good design for maximizing solar potential with a high research and innovation component centred around the use of PVs. | - It was looked expensive, because of the tower and the large wall area created. But the client see that layout makes good sense from a commercial and marketing view, as house builders prefer to build in phases so that early sales can fund the latter stages. | <u>GRID-CONNECTED</u><br>Roof Case;<br>- PV system power: 80 m2 Rolls of Amorphous (Thin film panels, BP's Millennia series- thickness: 7- 8mm).<br>- | - Private investment ( the Client) |  |

**Data processed from**: **Giostra**, Simone, **Arup**," *Green Pix- Zero Energy Media Wall"* http://www.greenpix.org.. 05/2008. Report;*"Green-pix, Beijing's First Zero Energy Media Wall"* http://www.greenpix.org. 12/2008. www.studioe.co.uk/doxford. , Office projects page, date 12/2008. **Jones**, David. **Energy Technical Support Unit**, Technical report: *"The Solar Office Doxford International"* (London: Crown, 2000). 21. **The German Energy Society** *"Planning &installing photovoltaic, guide for installers, Architects, and Engineers"* Second edition.( London: Earthscan, sterling,VA,2008) p. 294. **Partington**, Richard. Projects Parkmount Housing, Belfast,. www.maxfordham.com/projects .2008. **Lewis**, Sally. *"Front To Back; a Design Agenda for Urban Housing"* The Sustainability Agenda, (London; Elsevier, 2005) 22-24 .**Randall,**Thomas. , **Fordham**,Max., *" Photovoltaics and Architecture",* (London: Spon Press, 2003),75.

**TABLE 2-4** **Design Criteria for Using Solar Electrical Systems in Developmental scale, Urban, Rural, and Architectural Scale.**

| CRITERIA | DEVELOPMENTAL Scale | Evaluation | URBAN Scale | Evaluation | RURAL Scale | Evaluation | ARCHITECTURAL Scale | Evaluation |
|---|---|---|---|---|---|---|---|---|
| **The Site** | - Desert Village,<br>- Outskirts Urban Areas,<br>- Unused Lands,<br>- World's Deserts. | | - New Developmental Urban regions,<br>- New Communities,<br>- New Cities. | | - Rural Areas,<br>- Peri-Urban Areas,<br>- Poor Villages,<br>- Neighborhoods | | - Urban Areas,<br>- Administrative Complex,<br>- Housing Complex,<br>- Industrial Complex. | |
| **The Type** | - Industrial Development<br>- Energy Development<br>- Agricultural Development<br>- Urban Development | | - Housing and Habitation.<br>- Technological, educational, and administrative complex.<br>- Sustainable Cities (Solar Cities) | | - Housing zones,<br>- Villages,<br>- Peri-Urban Areas<br>- Mobile structures and dwellings. | | - Modern Architecture,<br>- Green Architecture,<br>- Sustainable construction,<br>- Smart Architecture. | |
| **Energy Accessibility** | - Off-Grid (Stand- alone system)<br>- Grid- Connected | | - Off-Grid (Stand- alone system)<br>- Grid- Connected | | - Off-Grid (Stand- alone system)<br>- Grid- Connected | | - Grid- Connected | |
| **Objectives** | - Sustainability to global energy needs,<br>- Economically and Technologically feasible,<br>- Environmental considerably,<br>- Considerably to socio-economic development especially Developing Countries. | | - Sustainable City,<br>- Sustainable Architectural Development,<br>- Reduction of CO2 Emissions,<br>- Achieving Quality of Life Style,<br>- Initiatives for developing RE. | | - Raising of public awareness about environment,<br>- CO2 reduction,<br>- Rural developmental Programs,<br>- Developing of socio-economic systems<br>- Providing new jobs for youth. | | - CO2 reductions.<br>- Low-Energy Consumptions,<br>- Zero-Energy Targeted.<br>- Sustainable Contribution,<br>- Future Building,<br>- An Initiative. | |
| **Climate Conditions** | - Desert Climate and Regions<br>- All Type of Climate | | - All Type of Climate with high solar insolation. | | - All Type of Climate with high solar insolation. | | - All Type of Climate with high solar insolation. | |
| **Main Considerations** | - Spread and Use of PV systems and Renewable Energies.<br>- Attracting of governmental, decision makers, public, and financer support.<br>- Advantages and disadvantages for environment and world energy.<br>- Concerning the generation of new sustainable communities in the desert. | | - Developing and studying of the holistic urban systems for maximizing the utilization of Renewable resources,<br>- Achieving a targeted power generation as 1 MW in Amersfoort village,<br>- Self-sufficient energy generation and exportation in advanced stages | | - Local Manufacturer and Maintenance,<br>- Securing financial mechanism,<br>- Providing training and educational programs,<br>- Providing maintenance training.<br>- Public involvement is necessary.<br>- Reviewing the output and benefits. | | - reviewing the Architecture design for optimal using of solar devices and systems,<br>- Considering the optimal Orientation as possible for maximizing solar insolation,<br>- Considering Layout and ambient landscape,<br>- Considering overshadowing. | |

***Continued** Table 2-4*

| | | | | |
|---|---|---|---|---|
| **Stages of Implementation** | - Stand-alone bulk system installed for surrounding Villages,<br>- Aggregation of villages connected with regional Grid,<br>- Connected to Regional Grid and developing industrial zone for power generation.<br>- Connected to global networks. | - Installing of outside power plant for generating power through stages of implementation.<br>- Integration of PV Modules on the urban and Building Context,<br>- Integration with other Renewable energy resources as wind and geothermal energy. | - Installing Domestic water Heating collector for healthy concerning,<br>- Installing solar systems in Public Building for public awareness,<br>- Utilization of Photovoltaic Cells for Electrification, communication, TV, and refrigerator. | It would use One or multi-stages as following;<br>- Installing PV Modules on façade elements,<br>- Installing PV Modules on Roofs,<br>- Installing PV Modules on landscape elements. |
| **PV Systems & Types** | - VLS-PV systems<br>- Polycrystalline Silicon PV modules with efficiency 12.8%<br>- Generation power: extended to GW VLS-PV. | - VLS-PV systems<br>- Polycrystalline Silicon PV modules on buildings.<br>- Thin film & amorphous silicon cells. | - PV power plant uses Polycrystalline Silicon modules,<br>- Polycrystalline Silicon PV modules on buildings and Batteries,<br>- Solar Collectors | - Polycrystalline Silicon PV modules on buildings and Batteries,<br>- Solar Collectors,<br>- Thin film & amorphous cells.<br>- Installing LEDs for Media and sensors for heating transfer. |
| **Types of Solar Utilization** | - In Urban system and Buildings,<br>- In Irrigation system,<br>- Water Desalination systems,<br>- Power Generation plants. | - Building integration (BIPV)<br>- Power plants,<br>- Air-conditioning,<br>- Combined techniques and systems. | - Water Heating systems,<br>- Electrification, | - Electrification,<br>- Media,<br>- Internal comfort,<br>- Shadowing. |
| **Other Integrated Systems** | - Integration with other Renewable resources;<br>- Wind Plants,<br>- Domestic Water Heating,<br>- Hydrogen power plants. | - Domestic Water headings,<br>- Wind Energy,<br>- Geothermal energy. | - Small Wind turbine for water pumping and electricity.<br>- Biomass generation for Methane gases. | - Small Wind turbine for electricity generation.<br>- Installing LEDs for Media and sensors for heating transfer.<br>- Installing cooling systems. |
| **Financing sources** | - UN Financial Programs and Developmental programs,<br>- Governmental investment,<br>- Industrial and Private Sector investment,<br>- $Co_2$ reduction Investment. | - UN Financial Programs and Developmental programs,<br>- Governmental investment,<br>- R&D Institutional investment,<br>- $Co_2$ reduction Investment. | - UN Financial Programs and Developmental programs,<br>- Governmental investment,<br>- $Co_2$ reduction Investment.<br>- Non-Governmental and public Organizations. | - R&D Institutional investment,<br>- Private Sector and the Client,<br>- Architectural Awards for sustainable construction,<br>- Industrial investment,<br>- $CO_2$ reduction Investment. |
| **Design Pattern** | N/A<br>The Urban Developmental Pattern is depending on the type of Development itself | - Conventional (Horizontal Sprawl) generate much more modular system,<br>- Compact planning,<br>- Combined planning system. | N/A<br>The Urban Pattern is depending on the type of social activities and income resources. | - Roof case,<br>- Façade case,<br>- BIPV techniques,<br>- Smart integration with curtain wall. |
| **Return of Investment** | Through the Followings:<br>- Interest rates and yearly added solar power,<br>- Electricity price after 5-22 years.<br>- Accumulation of Jobs and socio-economic development. | Through the Followings:<br>- Interest rates,<br>- Electricity price after 5-22 years.<br>- Accumulation of Jobs and socio-economic development. | Through the Followings:<br>- $CO_2$ investment<br>- Electricity price after 5-22 years.<br>- Accumulation of Jobs and socio-economic development. | Through the Followings:<br>- $CO_2$ investment,<br>- Low-Energy consumption,<br>- Awards and Prizes concerning sustainable construction, |

## ▪ *CONCLUSION*

Through the following tables the research introduces the main criteria of the examples in chapter V, the main objectives of these tables is to extract the main issues of such selected examples. In Table 2-2 and 2-3, the research compares between examples based on the Main Noted Issues of every example, which Table 2-4 illustrates the main design criteria of the examples through main points of discussion. The following diagram presents the scenario of *Chapter VI*; (Fig. 2-87)

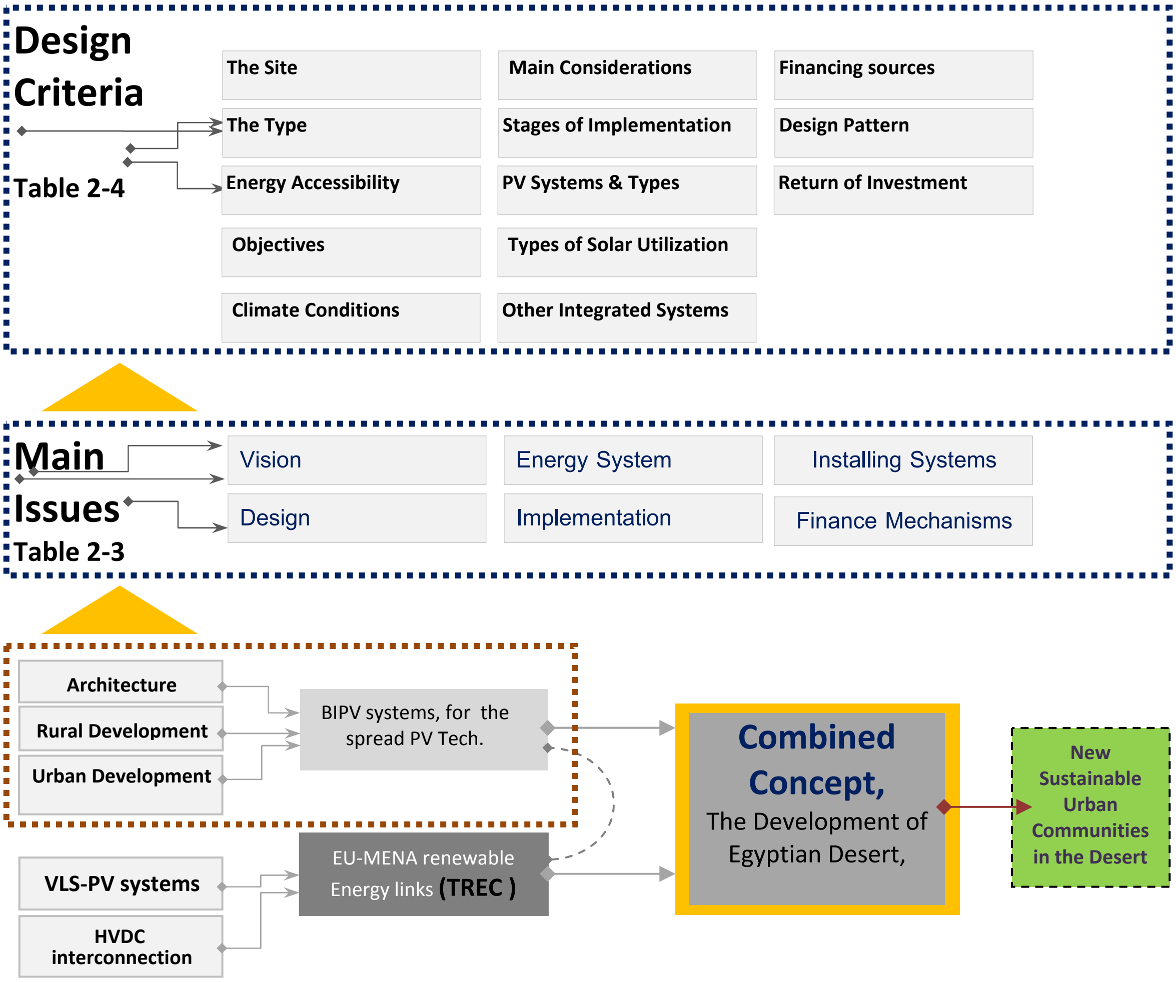


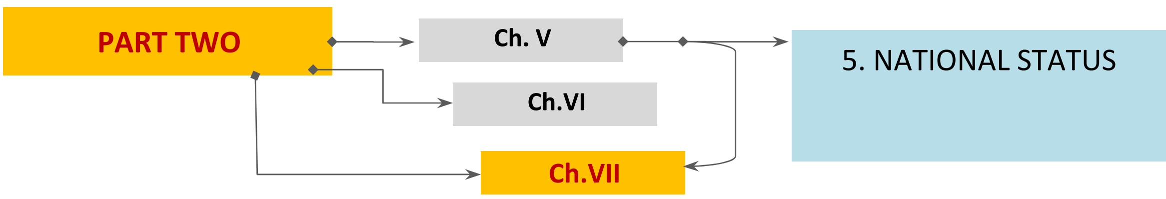

Figure: 2-87

**Chapter VI Diagram; Illustrates the Developing Stages for Extracting Design Criteria.**

# CHAPTER

# VII

## EGYPT DEVELOPMENT STATUS AND SOLAR ENERGY POTENTIALS




- *In **Chapter VI,** the research illustrates the recent Egyptian realities, energy policy, Renewable energy uses, and available applications of solar energy. The effects climatic changes and developmental plans in Egypt will discussed through introducing the reports of UNEP and other recognized research organizations concerning the Egyptian scientific studies.*

  *El-Baz scenario "**Developmental Corridor**" and Rageh scenario "**Egypt 2020**" are discussed in this chapter. Solar energy policy, applications, and status will discuss through the potentials of using solar photovoltaic applications especially Very large-scale applications. Eventually, the research introduces a summery of PV technology barriers and recommendations.*

# Chapter VII. EGYPT'S DEVELOPMENT PLANS & SOLAR POTENTIALS

Egypt is an arid country, which covers an area of about **1,000,000 km2** of which only **5%** is occupied by its population. According to the last census, the population has reached **$62x10^6$** in 1996, as it has tripled during the last 50 years, to be now about **$74 \times 10^6$** Inhabitants. By the year **2025**; it will be about **$95 \times 10^6$** of whom about **99%** are concentrated in the Nile Valley and Delta.[1] **(Fig. 2-88)**

Therefore, redistributing the population over a larger area has increasingly become a necessity. To facilitate this process, it is essential to reclaim new lands for agriculture use, create new industrial regions, build adequate services and plants, create new job opportunities, and provide adequate food for emerging communities. Meanwhile, the problem of climate change put new constrains to the anticipated development, of which desertification is considered a major threat to the bio-productive systems in the country and the entire world.

| | |
|---|---|
| **Egypt Area**: | *1,000,000 $km^2$.* |
| **Northern border**: | Mediterranean. Sea |
| **Southern border**; | Sudan |
| **Eastern border**; | The Red Sea |
| **Western border**; | Libya |

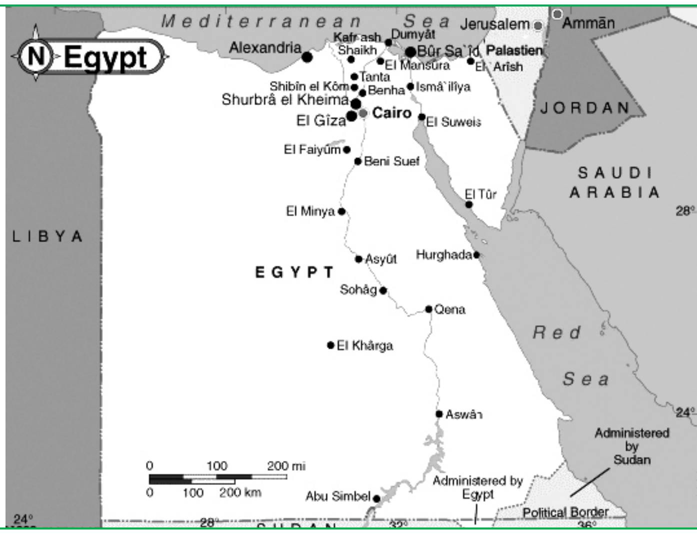



Fig. 2-88 **Egypt's Map Illustrates the Geographic Boundaries, Main Governorates, and the Countries in surround.**

**Source**: **SIS, (**Egypt State information Services), Data retrieved form http://www.sis.gov.eg in 1/2009.

## 1 Egyptian Characteristics, and Reality

According to the former illustrated studies, the utilization of eco-development strategies along with urban and desert development have become crucial issues in achieving the national strategies. In this sense, numerous studies have discussed the future scenarios.

Partially addressed as part of these studies scenarios, the desert has been focused and its obstacles analyzed; raising the following couple of questions: (1) ***could Egypt grow in the old valley alone; leaving 95% of its total area unexploited?*** and (2) ***what would happen after a quarter-century without heading towards the desert?*** Essentially, the answers will emphasize the importance of conducting R&D along with applicable studies. Recently, the vision and proposal of the *"Developmental Corridor,"* introduced by Dr. Farouk El-Baz, has emerged as a developmental ideology, that looked at the Egyptian western desert as a potential and celebrated science and youth as the way to achieve the goals.[2]

[1] **SIS, (**Egypt State information Services), http://www.sis.gov.eg . Date: 1/2009.
[2] **Rashed**, A. **Abolelah**, I.," *Second Egypt and Sustainable Future: Challenges?* "Second International Conference, SUE-MoT 2009, (Loughborough, UK, April 2009), p. 439.

# 1-1 Climatic and Geographic Characteristics

## 1-1.1 Geographic Characteristics

Egypt forms part of the great desert belt that stretches eastward from the Atlantic across the whole of north Africa onward through Arabia, and like all other lands lying within this belt, it is characterized by a warm and almost rainless climate.[1] Egypt faces global worming immediate consequences like; desertification, sea-level rising, and trough desert conditions.

Desertification is defined as *"land degradation in arid, semiarid and dry sub-humid areas resulting from climatic variations and human activities"*[1]*.* Its consequence include a set of important processes which are active in arid and semi arid environment, where water is the main limiting factor of land use performance in such ecosystem (Fig. 2-89). depicted Egypt's topography that illustrate varies combination of the geological system. Western desert have less topography in the boarders of Nile Delta side, the fact, that recognized by *Prof. El-Baz* -the international geological scientist in NASA- about the a viability of developing the western bank by many development projects.[2]

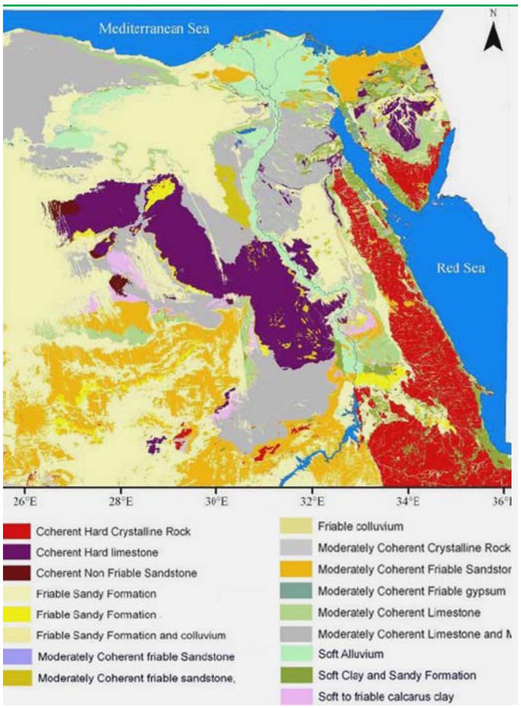



Fig. 2-89 **The Ecology and Geology of the Egypt.**

**Source**: Gad., Lotfy., *"Use of remote sensing and GIS in mapping the environmental sensitivity areas for desertification of Egyptian territory"* www.electronic-earth-discuss.net/3/41/2008

## 1-1.2 Solar Insulation Quality In Egypt

Egypt has plenty of sunshine. There are over 3400 hours per year of solar availability in the north and 3900 hours in the south. The average annual solar radiation varies between 1900 and 2600 kWh/square meter/year, from the northern to the southern parts of the country. The following is the solar Graph of Egypt. (Fig. 2-90)

The air temperature in Egypt frequently rises to over 40 degrees C in the daytime during the summer and seldom falls as low as zero degree C even during the coldest nights of winter. The average rainfall over the country as a whole is only about 10 mm a year.

Relatively strong wind regime prevails mainly along the Red Sea coast, with an annual average wing speed along the northern parts of the coast between 18 and 36 km/h (i.e. with a power flux of about 150 to 1000 watt/square meter). Winds with lower velocities (14 to 20 km/h) are encountered along the Mediterranean coast.[3]

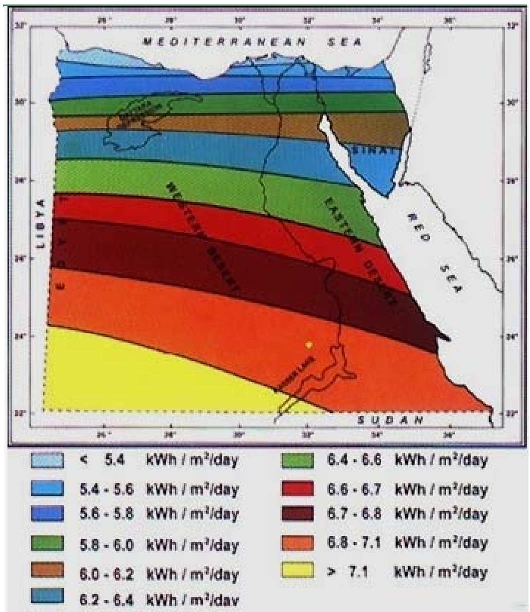



**Fig.** 2-90 **Solar Insolation Rates Graph.**

**Source:** General Organization. for Physical Planning (GOPP) www.gopp.gov.eg/

[1] **UNDP** (United Nations Development Program); Report: *"Bio-energy for Sustainable Rural Development"* Section one, 2008, p.4
[2] **Gad.**, **Lotfy**., *"Use Of Remote Sensing And GIS In Mapping The Environmental Sensitivity Areas For Desertification Of Egyptian Territory"* *Report:* www.electronic-earth-discuss.net/3/41/2008, Date: 1/2009.
[3] **UNDP** (United Nations Development Program); Report: *"Bio-energy for Sustainable Rural Development"* Section one, 2008, p.4.

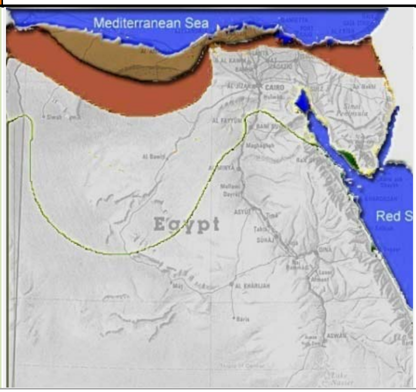
## *1-1.3 Climatic Design Zones In Egypt,*

Before examining the climatic design zones (**Table 2-5**) in Egypt, it is vital to review the factors affecting its climate in general:

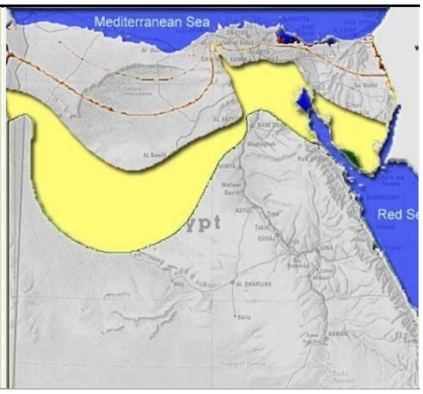
- Egypt lies between 22° and 31° N latitude; thus falls in the hot dry subtropical region - except for the northern area which is considered moderately warm. The effect of the Mediterranean Sea- lying to the north of Egypt-is limited to a coastal strip of 40 km in depth, and the effect of the Red Sea, to the east, is even more minimal due to the series of mountains and hot deserts surrounding the sea shore; isolating the coastal area from the rest of the country.
- Air temperature reaches its minimum value during January and its maximum during July. This applies to most of the country except for the northern coastal areas, where the maximum values are reached in August, due to the effect of the Mediterranean Sea.
- The daily thermal range increases when moving away from the north coast towards the southern region.[1]

**TABLE 2-5** **Egypt's Climatic Zones.**

Mediterranean Zone
**Source**:



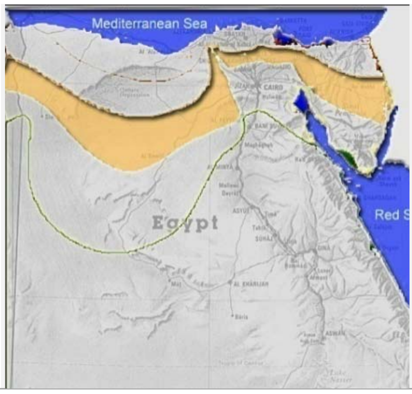

Dry Zone
**Source**: Naga, "Solar Energy and local Architecture" 1984,40



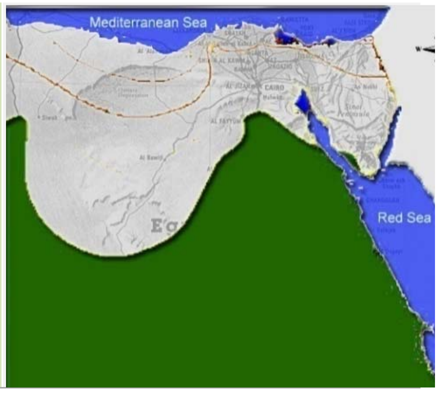

**Mediterranean-Like Zone:** This region is characterized by its high relative humidity, low daily thermal range, and relatively high amount of precipitation.

**Dry zone:** This region is distinguished by its high daily thermal range that reaches 18° in some regions with moderate percentage of relative humidity.

Semi-Dry Zone
**Source**:




Desert Zone.
**Source**:




**Semi-Dry Zone**: The relative humidity of the semi-arid zone is equal or less than some areas in the Mediterranean zone, besides, the daily thermal range exceeded the previous zone.

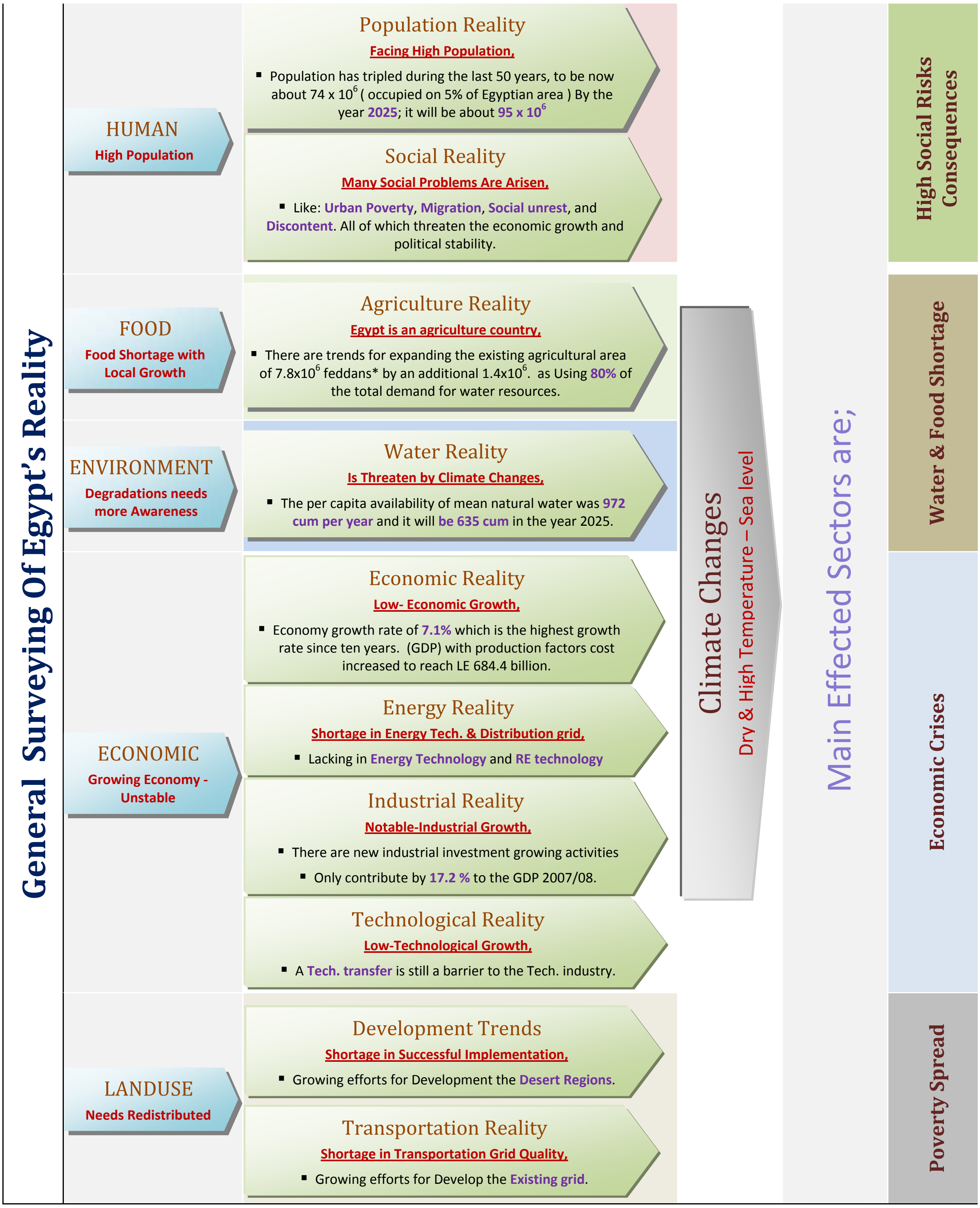
**Desert Zone**: This region is distinguished by its high thermal range that reaches 20°, and by the low percentage of relative humidity that is even less 30%, it is also characterized by very little percentage and clear sky for most of the year.

**Source**: Gad., Lotfy., *" Use of remote sensing and GIS in mapping the environmental sensitivity areas for desertification of Egyptian territory"* www.electronic-earth-discuss.net/3/41/2008

[1] **Samir** H. B. **Hosni**. "Climate *and Architecture, Volume 1"* (Cairo: Al Maaref Establishment. 1978), p. 50-55.

## 1-2 *Egyptian Reality & Climate Change Risks*

The followings are a simple survey on the Egyptian realities that have direct reciprocal effect with the Egyptian policy in different terms; as illustrated in (Figure 2-91)




* (1 feddan = 1.04 acre)

Fig. 2-91 **Conclusion of the Main Egyptian Sectors and Risks Which Threaten the Holistic Structure**

Date are processed from: **SIS, (**Egypt State information Services), http://www.sis.gov.eg . Date: 1/2009. **Otto** S., UNEP/GRID; G. **Sestini**, F.; Remote Sensing Center, Cairo; DIERCKE Weltwirtschaftsatlas

# 2 The development of Egyptian Desert: the necessity

*"Desert had received far less attention than other types of landforms in geological studies. This award will encourage more students to pursue investigation of arid lands, which constitute one-third of the land surface of our planet,"* [1] Said: El-Baz.

Climate change poses significant risks on Egypt's population, land-use and agriculture, as well as the economic activity. Throughout history, the development has been constrained along a narrow Y-shaped strip of land along the Nile and the deltaic coast. Sea level rise on the costal zone, desertification, temperature increase, and scarcity of rains calls for immediate shift of national development trends, population map, and national resources, (Figure 2-92). As mentioned above, the re-distribution of Egypt's population is an urgent need, while desert development and scenarios promotion will further require R&D, new innovative concepts, and social consciousness.


Fig. 2-92 **Coastal Inundation In The Nile Delta Under Sea Level Rise;** in 1 meter rise level
**- Today** : Population 3,800,000- Cropland (Km$^2$) 1800
**- 2050** : Population 6,100,000- Cropland (Km$^2$) 4500

**Source**: **Otto** S., UNEP/GRID; G. **Sestini**, F.; Remote Sensing Center, Cairo; DIERCKE Weltwirtschaftsatlas

## 2-1 *PROPOSED DEVELOPMENTAL SCENARIOS*

Settling the desert has long been an Egyptian dream. Besides, Egypt's rapidly increasing population has made the reclamation of vast areas of desert land for homes, agriculture, and industry as necessity. Thus, desert development has become a national goal dictated by population needs, future hopes, and a broader vision for a better life.[2] The following demonstrates the proposed highlighted scenarios of developing the Egyptian desert.

[1] **Prof. El-Baz** : is research professor and Director of the Center for Remote Sensing at Boston University. He is a renowned geologist who over the past 30 years has conducted studies in all the major deserts of the world. He is a member of the **U.S. National Academy of Engineering** and a Fellow of the American Association for the Advancement of Sciences and the Geological Society of America. The latter established the "Farouk El-Baz Award for Desert Research" to reward excellence in arid land studies.

[2] **Sheta**, Sherif., MSc. *"Earth-Sheltered Housing Design"*, (Egypt: Mansoura Uni.)1998, p. 111-112.

### 2-1.1 *Rageh Scenarios* (Egypt 2020)

Rageh Scenarios integrates with strategic governmental plans; this scenario depends on the historical reading of the Egyptian reality and its social, economic, and urban political transformation through the last 30 years.

The scenario has a holistic, national perspective through the Grid Developmental Form (GDF). The GDF combines the targeted development regions, segments, and poles of growth to create – in alignment with the strategic goals of the old valley – a holistic socio-economic and environmental development of future communities. Yet, this scenario lacks the proper use of new sustainable processes, social engagement, utilization of new sustainable technologies; while still built-up on exploiting the exhausted infrastructure of the old valley, (Figure 2-93). There are many identical issues and outlines combines the holistic vision of Regh and the proposed project of El-Baz, specially the horizontal axes pass-over the main dens cities and extended- wide to the country boards.

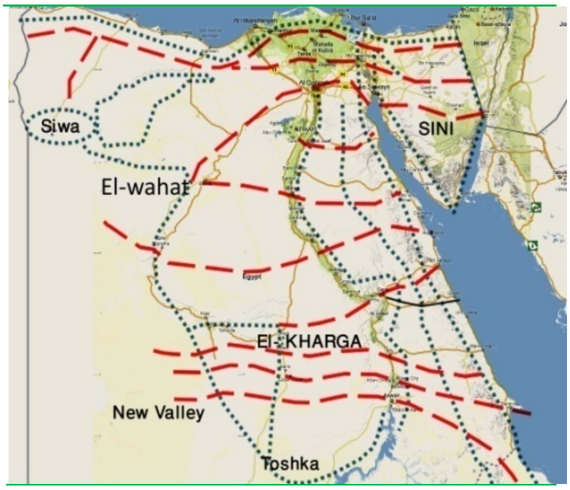



Fig. 2-93 **Rageh Proposal Egypt 2020 Developmental Axes.**
**Source: Rageh**, A., *"Egyptian Urbanism; Egypt 2020; Surveying of Egyptian Urban Development in 20 century and futuristic prediction up to 2020 -First Handbook"* (Cairo: Academic Book, 2007). A1, p. 8.

### 2-1.2 *El-Baz Scenario* (Developmental Corridor)

This scenario considered a sub-detailed project, associated with more specific and innovative concepts. It argues the potential mitigation of continued overloads on the old valley by creating the Development Corridor parallel to the Nile path. It consists of north-south super highway, modern railway, water pipeline, and electric line.

The main highway oriented in a roughly east-west direction would connect it to the main centers of population to create new productive communities in the hinterlands and deserts. The following illustrates the adaptability and feasibility of El-Baz scenario, backed with sustainable development visions of the world's deserts.[1] Figure 2-94, shows the main North-South Corridor and the twelve axes of extended from the main Delta's Cities. The next section will discuss the main concept, component, and outlines of the project, and also illustrates the pros and cons of the project through the Egyptian governmental studies.

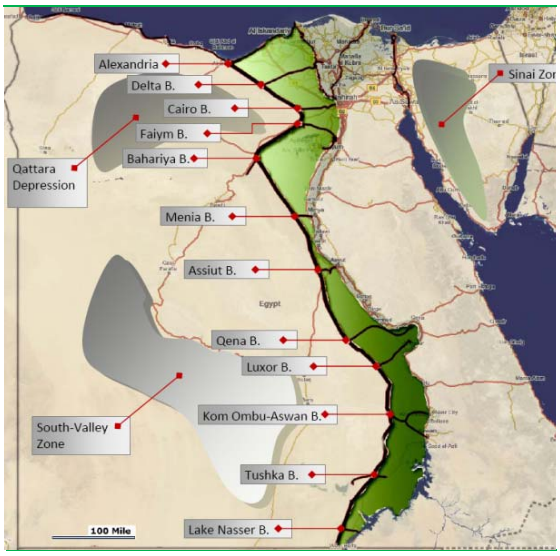



Fig. 2-94 **Developmental Corridor, The Proposal Of E-Baz for Developing the Western Desert and Securing the Future of the Next Generations**

**Source:** Processed from, **El-Baz**, F., *"Development Corridor; Securing a Better Future for Egypt"* (Cairo, El Aain publishing, 2007) p. 40.

[1] **El-Baz**, F., *"Development Corridor; Securing a Better Future for Egypt"* (Cairo, El Aain publishing, 2007) p. 40.

# 3 Egyptian Energy Policy : Solar Energy Status

In the last decades, the Egyptian policy has a different ways to develop its political, economical, agricultural, technological, and energy strategies. Renewable energy also has been endowed with some attention in the last decade with targeted using 3% of the holistic energy consumption. A general reviewing of the Egyptian in energy policy and solar technology development is discussed in the following.

## 3-1 *Energy Policy*

The Supreme Council of Energy (SCE) is the responsible for formulation of energy policy in Egypt; it consists of the ministers of ***Electricity** and **Petroleum*** and works in consultations with the parliamentary committee for industry and energy.

*The energy policy in Egypt focuses on the following:*

- Enhancement of natural gas utilization,
- Adjustment of energy prices and removal of subsidies,
- Energy *conservation* and efficient energy use,
- Promotion of renewable energy utilization. [1]

Fossil fuels, in addition to hydropower and non-commercial fuels such as firewood, agricultural wastes and dried dung; are considered as the main energy resources in Egypt. The government of Egypt realized in the early 1980s that conventional energy resources would fall short of satisfying the country's needs in the long run, thus it has taken many strides for promoting RE utilization. Accordingly, a national strategy was designed to include exploitation of the country's several renewable energy resources, particularly wind, solar, and biomass.[2]

The strategy included, among other objectives, a target for RE utilization and development. Specifically, RE was targeted to meet at least 5 % of primary energy needs by the year 2005 , because of the followings;

(*a) The country's high level of* insolation,

*(b) The economic viability of such development,*

*(c) The potential for freeing fossil fuels for export, and*

*(d) The country's desire to play a leadership role in the region.*[2]

*It is noteworthy that the final report of Energy Sector Management Assistance Program (ESMAP) for RE; considered Egypt as a well placed to take a regional lead in the development of RE resources.*

RE utilization and development has predominantly concentrated on the following applications:

- *Wind-Farms* (in which large strides have been made on the banks of the Red Sea);
- *Solar Water Heaters* (which have been developed, but not to a sufficiently large degree); and
- *Photovoltaic Cells* for special applications.[3]

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[1] **Pracad**, Jyoti. **fenhann** Jorgen,*" Implementation of Renewable Energy Technologies - Opportunities and Barriers; Summary of Country Studies"* UNEP Collaborating of Energy and Environment. Denmark, 2002.

[2] **World Bank / ESMAP** ( Energy Sector Management Assistance Program), "*Arab Republic of Egypt: Renewable Energy Strategy and Institutional Capacity Building Study*" ( Washington, D. C.: World Bank, 1996)

[3] Energy Sector Management Assistance Program (**ESMAP**), Final Report:*" Renewable Energy Potential in Selected Countries; Volume I,*" (Washington: ESMAP, The World Bank 2005),20.

National Policy, Energy Policy, and National Planning Measures are the main bases of the current Egyptian institutional framework for developing RE sources and applications, as in ( Figure 2-95),

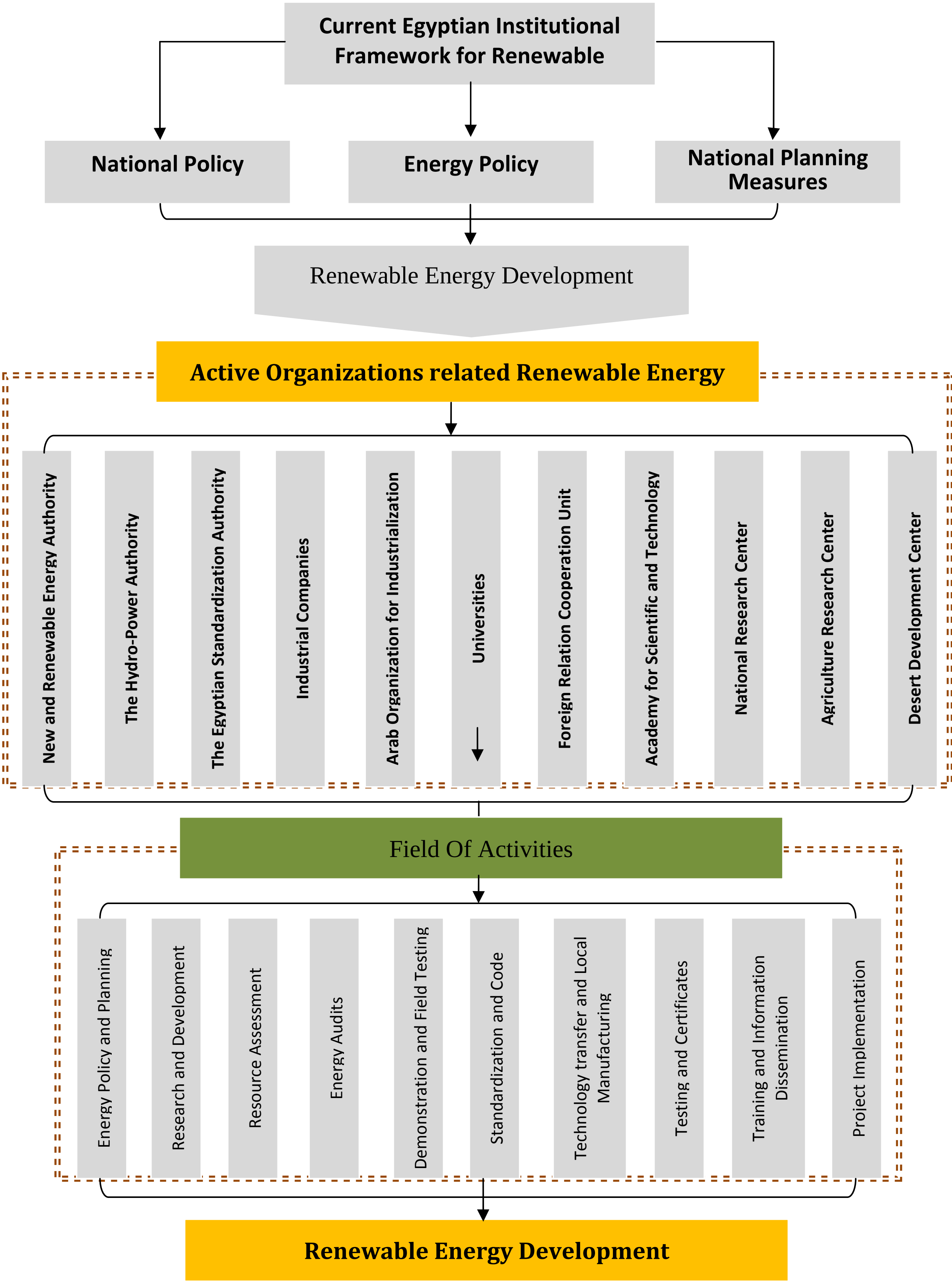


Fig. 2-95 **Summery of the Current Egyptian Institutional Framework for Renewable Energy Research & Development**

**Source: Abd-Elaal,** M. *"Sustainable Communities Depending on Renewable Energy"*, (MSc. Thesis, Cairo university, 2002), p. 197. After reviewing ( **ESCWA**, 2000, p. 62-65 )

### 3-1.1 Solar Energy Technology Feasibility in Egypt

Both industrialized and developing countries strategy in the Mediterranean region, are involved in emerging and creating a strong market for solar technology. This could lead to a decrease in production costs that, in turn, could enhance the economic viability and hence the market penetration of this technology. Depending on the outcome of prefeasibility studies and, should the countries concerned request them, the GEF and the World Bank could support further feasibility studies and investment projects in this technology.[1]

The Studies carried out by national organizations, such as Egyptian New and Renewable Energy Authority (NREA), Egyptian Solar Research Centre, Nokraschy Engineers for solar energy studies, and international associations as GEF and MEDA, have outlined the feasibility of local solar technologies, both for thermal and electrical applications. These applications are outlined in the following technologies.

#### 3-1.1.1 Thermal Technologies

Of the numerous solar thermal applications, the Egyptian government promoted the following selected technologies; identified as "*the feasible applicable systems*":

a) *Solar water heating for domestic and commercial use;*
b) *Solar Systems for industrial heating processes; and*
c) *Solar thermal Electricity.*

Recently, the Egyptian government has implemented the first solar thermal power plant uses CSP technology, through Integrated Solar Combined-Cycle System (ISCCS) plant, has been demonstrated on the Egyptian desert. The government promoted the project with assistance from the Global Environment Facility (GEF)[2] and the European Union's Mediterranean Assistance (MEDA) program. The project supported by (NREA), to be implemented as a private sector power project sited in Al-Kuraymat region.[3] (Figure 2-96)

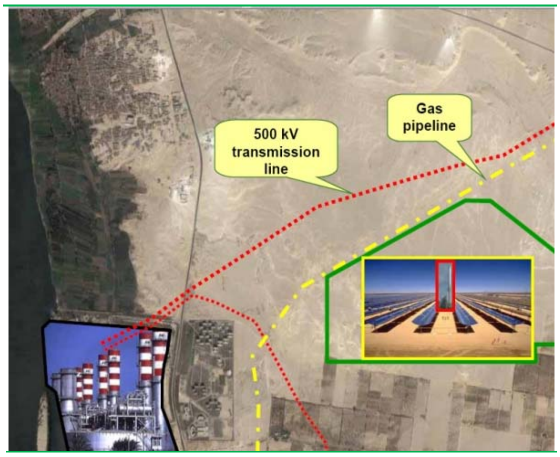

Fig. 2-96 **Al Kuraymat plant, the First Solar Thermal Power Plant Uses CSP Technology (Integrated Solar Combined-Cycle System (ISCCS).**
**Source:** **El-Zalabany**, A., *"The First Solar Thermal Power Plant in Egypt; solar thermal power and desalination symposium"* New & Renewable Energy Authority ( Cairo; Cairo University, 2007).

## National Research Activities :

In this sense, we have to note the role of private research sectors as Egyptian Solar Research Center (ESRC) and Nokrashy Engineering, for demonstrating the potentials and effective use of the Egyptian Desert to works as everlasting energy house, through utilization of solar thermal technologies to generate energy and desalinizing sea water, to secure the future needs of energy and water in Egypt by the year 2050.

[1] Energy Sector Management Assistance Program (**ESMAP**), Final Report:" *Renewable Energy Potential in Selected Countries; Volume I,*" (Washington: ESMAP, THE WORLD BANK 2005),20.
[2] **GEF** (**Global Environment Facility**): co-operated with **World Bank Financing** offering financing grant supports for sustainable and Energy development and other activities.
[3] Energy Sector Management Assistance Program (**ESMAP**), Final Report:" *Renewable Energy Potential in Selected Countries; Volume I,*" (Washington: ESMAP, THE WORLD BANK 2005),9.

## 3-1.1.2 Electrical Technologies

Solar radiation intensity is high, (at about *2,000–2,200 kWh/m2/y).* Toward ***the southern desert regions***, it reaches about 2,500–3,200 kWh/m2/y. The Resource Cost Curve (RCC), analysis shows that by 2005, 140 GW of solar energy could be installed at levelized costs of US$ 0.05/kWh. The Ministry of Electricity and Energy derived upper practicable limits of 0.7 GW of solar thermal electricity generation and 0.3 GW of photovoltaic systems.[1] (Fig. 2-97)

Solar Photovoltaic (PV) Technology is one of the Renewable Energy Technologies (RETs) actively being promoted in Egypt for use in rural and remote area. Electricity generation and groundwater pumping have been identified as two applications for PV technology in these areas. Other applications include remote services related to telecommunication, railroad and navigation, water treatment, and billboards. By 1995. total installed capacity of PV applications was estimated to around ***1 MWp***. Several projects and plans totaling more than ***I0 MWp*** are under preparation.[2]

*The following are two feasible electrical systems that are feasible for application in Egyptian regions:*

a) *Solar Photovoltaic for Rural and Remote Areas. The government promoted the use of photovoltaics in electrification systems and groundwater pumping in rural area with no access to the grid.*

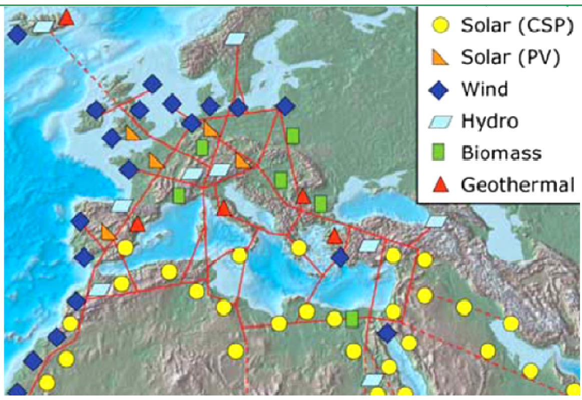


Fig. 2-97 **The Map of EUMENA-RE Energy Link**

**Source:** **TREC** (Trans- Mediterranean Renewable Energy Cooperation)- proposed by Mr. Sarkozy and Ms. Merkel - *" Clean power from desert; An Initiative of the club of Rome"* ( Mediterranean Union *2008*)

Fig. 2-98 **Modeling of VLS-PV System in Agriculture Community**

**Source:** **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems",* (London: EarthScan, 2007), p. 82.

b) *Very Large-Scale Photovoltaic Systems (VLS-PV). A practical proposal for generating energy from the world's desert by utilizing of large-scale PV plants and creation of developmental vision of the desert regions* (Fig. 2-98). *This project provides a significant relation between the required sustainable urban development in the Egyptian desert and the desired generation of an EU-MINA renewable energy links. VLS-PV research group determined numerous types of proposed community that able to collaborate on agriculture and technology, the recommended community types in Egypt desert are* ***(Collaborating on agriculture and technology, economically sustainable community, and Self-supporting community****, which has selected depending on studies for desert regions characteristics.*[3] (Fig. 2-97)

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[1] **Holding Electricity Company** (New & Renewable Energy Authority) Annual Report *"Energy In Egypt ; Solar Energy "* ( Cairo;, 2005).

[2] **Pracad**, Jyoti. **fenhann** Jorgen,*" Implementation of Renewable Energy Technologies - Opportunities and Barriers; Summary of Country Studies"* UNEP Collaborating of Energy and Environment. Denmark, 2002.

[3] **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems",* (London: EarthScan, 2007), p. 82.

## 3-1.2 *Status and Barriers for PV Technology in Egypt*

The studies carried out by UNEP collaborating centre on energy and environment - Denmark, demonstrates the remarkable Renewable Energy Technologies (RETs) notes about PV systems for electrification and remote areas as follows; (Fig. 2-99)

- *Economic and financial barriers are the first addressed important barriers;*
- *Policy barriers, indicating needs for governmental mechanism to promote PV technology;*
- *Market barriers, indicating small size of the market and limited access to international market;*
- *and, Limited **private sector** involvement, due to small size of the market.* (Table 2-6)

Some PV manufacturers even suggested the need for obligatory laws for rural electrification using PVs. While experts and users considered technical problems and availability of maintenance as an important barrier.

*Table 2-6; Highlights barriers and recommended solutions for utilization of PV technology in remote areas in Egyptian regions.*

Fig. 2-99 **Solar Heating System on Houses Roof, One of the Successful Solar Thermal Systems Installed In Upper Egypt**

**Source:** **SGP** Egypt. Retrieved in March 15, 2009, from: http://www.undp.orgtsgp.

### 3-1.2.1 Barriers of PV Systems In Remote Areas

**TABLE 2-6** **Specific Barriers Of PV Systems Disseminations In Rural Area In Egypt[1]**

| BARRIERS Issues | ILLUSTRATION |
|---|---|
| **Lack of information** | *The awareness of PV applications is very low. PV is still considered an exceptional solution in rural programs for potable water supply. despite efforts in recent years* |
| **High dissemination costs** | *Wealthy households lives in dispersed rural dwellings are the targeted group for using PV systems, therefore the transaction costs for commercial dissemination, installation and after-sales services are very high. These costs are estimated to be about 30% of the total costs of PV systems.* |
| **Unfavorable tariff system** | *Tariffs for electricity are **identical in rural and urban areas**, although the cost of supplying electricity is much higher in the countryside. This makes PV system uncompetitive with the grid electricity.*<br>*The electricity tariffs do not include external costs (**environmental costs**) due to use of fossil fuels in electricity generation. If these costs are considered in tariff setting. PV systems could be competitive with traditional electricity sources.* |
| **Taxes and duties** | - *PV considered a luxury product and charged high import duty in Egypt.*<br>- *Import of equipment and materials is also a problem due to foreign exchange constraints, and the components that are produced locally (such as charge regulators, and batteries)*<br>- *Sometimes, tax exemptions may be available for equipment imports for a public or NGO project.* |
| **High capital costs of the PV** | *The capital cost of PV systems is very high and people in the remote (rural) areas are not able to afford it, because of their **low income**. In addition, there is no suitable **financing mechanism** to support them.* |

Data processed from: **Soliman**,*" Workshop; Photovoltaic System Component*, Lecture1, 2, 3., **Abulfotuh** Fuad, *Workshop; "Application of Solar Energy; Solar Collectors and Photovoltaic Cells" PV Technology: Status and Prospects"* (Egypt: Alexandria, IGSR, October 2008).

[1] **Pracad**, Jyoti. **fenhann** Jorgen,*" Implementation of Renewable Energy Technologies - Opportunities and Barriers; Summary of Country Studies"* UNEP Collaborating of Energy and Environment. (Denmark, 2002.) p. 24

### 3-1.2.2 Actions to Overcome the PV Barriers[1]

The solar PV systems still have opportunities and potential for contribution to the *rural development programs.* These include the following:

- Solar radiation is high in Egypt, making solar PV system operation quite reliable and attractive.
- Small villages with no access to the grid (High potential area), specially through he governmental policy and plans to electrify all small villages and attachments provides an opportunity.
- Technical and technological experiences are available.

*The Actions to Overcome the Barriers Include the Following;*

- *Awareness campaigns* need to be launched on regular basis to bring out the potential merits of PV systems and applications.
- *Financial schemes* need to be designed to support buyers.
- *Manufacturers*, *suppliers*, and *agents* should have their representatives and centers near the consumers,
- *Since* the *PV* program is in initial stage*, government supported market* incentives needs to be designed to encourage commercial development and deployment.
- PV *rural electrification projects* can be integrated with other development programs.
- *Integration of various PV rural electrification projects* can help sharing of experiences in barrier removal. (Figure 2-100)

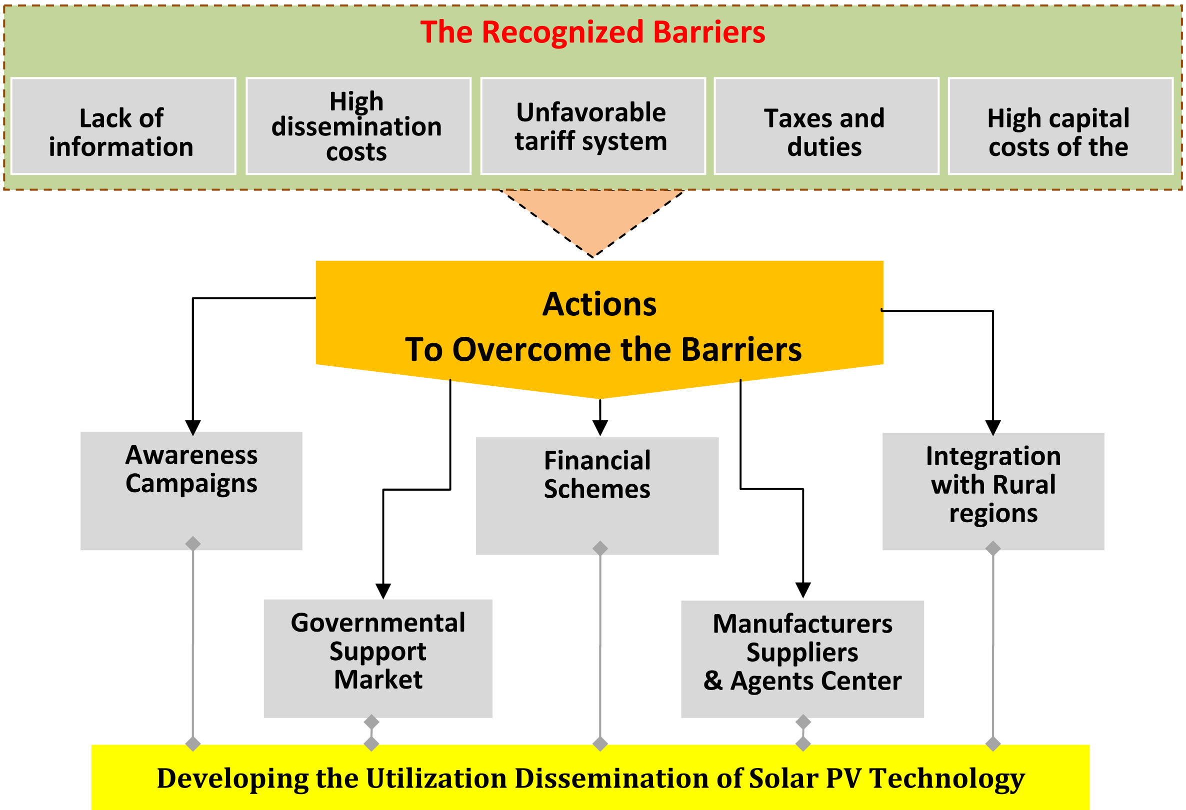



Fig. 2-100 **Summery of the Current Recognized Barriers & the Recommended Actions to Overcome the Issues**

**Source: Data processed by the author from ( ESMAP** final report" *Renewable Energy Potential in Selected Countries"* - UNEP *"Implementation of Renewable Energy Technologies" p.24).*

[1] Data processed form: (**ESMAP**), Final Report:" *Renewable Energy Potential in Selected Countries; Volume I,*" 28. **Pracad**, Jyoti. **fenhann** Jorgen," *Implementation of Renewable Energy Technologies - Opportunities and Barriers; Summary of Country Studies*" UNEP Collaborating of Energy and Environment. (Denmark, 2002.) p. 24

## ▪ *CONCLUSION*

The goal for RE utilization and development, as set by the Egyptian authorities, is for RE to supply 5 percent of the country's primary energy needs by 2005 and 10% in 2010. In general, the objectives for RE development should be in line with the government's energy sector objectives, which are to move systematically to a market-oriented economy, specifically by giving the public sector greater autonomy and by increasing private sector participation in energy ownership and operations. In line with the energy sector objectives, specific RE objectives should be to:

- *Maximize the contribution of RE to the Egyptian energy balance and to ensure RE has a significant impact on the economy and environmentally beneficial;*
- *take appropriate measures to **develop renewable technologies** and to implement applications that are approaching technical maturity, and encourage local participation; strengthen and transform the NREA into a commercially oriented entity;*
- *identify and mobilize innovative **financing mechanisms** to support RE projects and programs;*
- *pursue **private sector** involvement in RE project development and operations;*
- *benefit from **periodic training** and development on RE project management and operations; and*
- ***Strengthen local manufacturing** capabilities in the field of RE utilization and development.*[1]

While dissemination of BIPV systems – extended with the use of VLS-PV – is hypothesized to form the combined strategic vision for developing the Egyptian desert, (Figure 2-101).

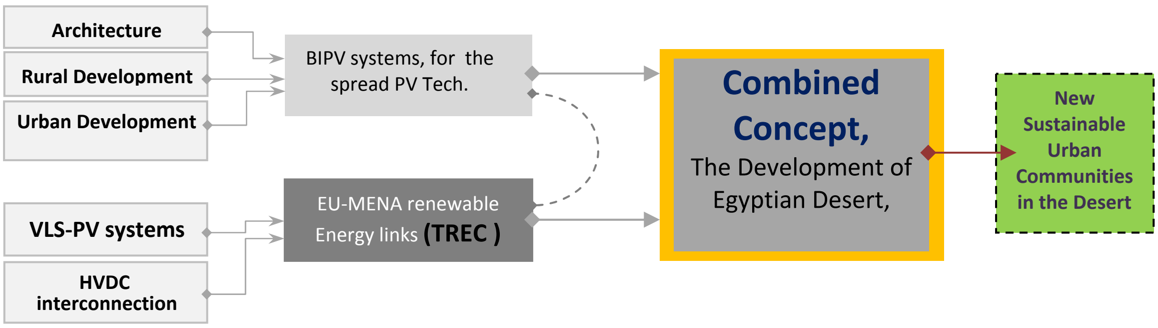



Figure: 2-101

**Developing the Desert by Use of BIPV and VLS-PV, a Proposed Scenario.**

### NREA Role in Egypt;

One particular problem for the dissemination of RE projects is the weakness of the existing institutional structure. The NREA is a policy setter as well as a project's implement. If the present pilot and demonstration projects are to be carried forward as large-scale commercial projects, the NREA needs institutional capacity for project-oriented task assessment, evaluation, analysis, financial modeling, risk-analysis, and so on. In the short to medium term, international experience suggests that the NREA should take over the responsibility of owning and operating RE power plants. In the long run, the NREA can divest itself of its operational responsibilities and concentrate on promoting the RE industry in Egypt

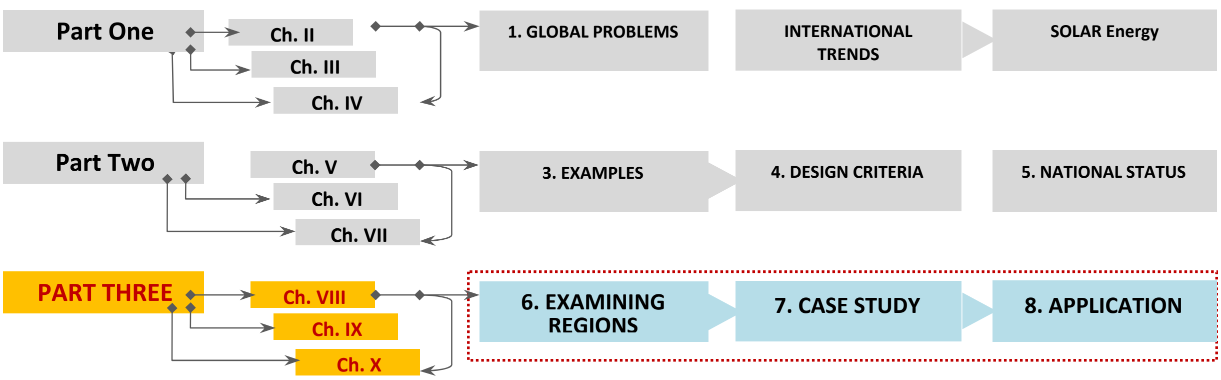
[1] **(ESMAP)**, Final Report:" *Renewable Energy Potential in Selected Countries; Volume I,*" 28. **Pracad**, Jyoti. **fenhann** Jorgen," *Implementation of Renewable Energy Technologies - Opportunities and Barriers; Summary of Country Studies*" UNEP Collaborating of Energy and Environment. (Denmark, 2002.) p. 28

# PART THREE

## APPLICATION;

## EGYPTIAN DESERT DEVELOPMENT BY SILICON TECHNOLOGY

CASE STUDY




- *The Objective of **Part Three** is to examine the Egyptian regions to select the suitable regions for using and applying solar energy system and photovoltaic silicon technology in the specific and selection of sites that has a high priority of national development and potentials of use VLS-PV proposal*

  *This is envisaged to be achieved by contributing the following: 1) analytical study of selected regions and sites and examining the design criteria of PV technology applications, uses energy system, devices, energy output, and suitable infrastructure if we installed PV Silicon cells on roofs. 2) Developing an application to embody the potentials of PV integration with the developmental trends of desert through new sustainable communities.*

# PART 3: APPLICATION; EGYPTIAN DESERT DEVELOPMENT BY SILICON TECHNOLOGY.

*Chapter*

## *VIII. DEVELOPMENT CRITERIA AND SITE SELECTION*



## *IX. APPLICATION OF VLS-PV IN THE EGYPTIAN DESERT*



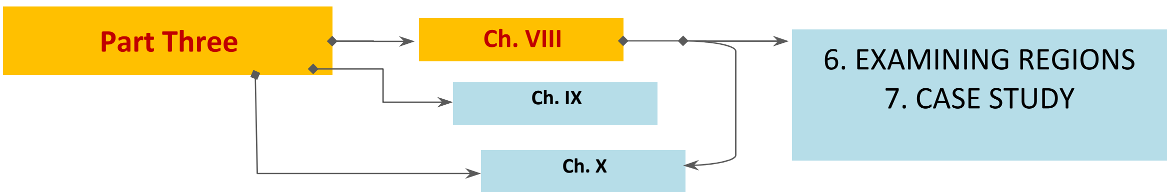
## *X. CONCLUSION & RECOMMENDATIONS*

## *Appendices*

# CHAPTER

# VIII

## DEVELOPMENT CRITERIA
## & SITE SELECTION



# Chapter VIII: DEVELOPMENT CRITERIA & SITE SELECTION

This chapter address the main Conditions on which site selection for using solar energy applications especially Photovoltaics technology in Egypt is based, it has been emphasized that Photovoltaics applications may yield the favorable results when applied especially to remote or new developmental regions with no access to grid utilities.

These regions or sites are selected through specific consideration of the design criteria discussed in Chapter VI and adapted to the Egyptian Governmental policy and trends that introduced through Chapter VII.

## 1 Development Criteria

The criteria drawn-out in chapter VI have to be developed through the Egyptian national conditions, it could be stated that PV architecture may yield a success in some certain locations in Egypt , yet may not be beneficial if applied to others. In addition, each choice, i.e., setting desert locations, will require more studies to be taken to overcome the main potentials problems. (Figure 3-1)

### 1-1 *EXAMINING OF MAIN RESEARCH ISSUES*

Figure 3-1 illustrates the main issues that has discussed through the former parts and the needed new approach for developing the Egyptian desert. The issues embody the international trends towards wide utilization of RE, which solar energy considered one of the most promising application that may integrate with the recent national developmental trends in general and the project developmental corridor in specific.

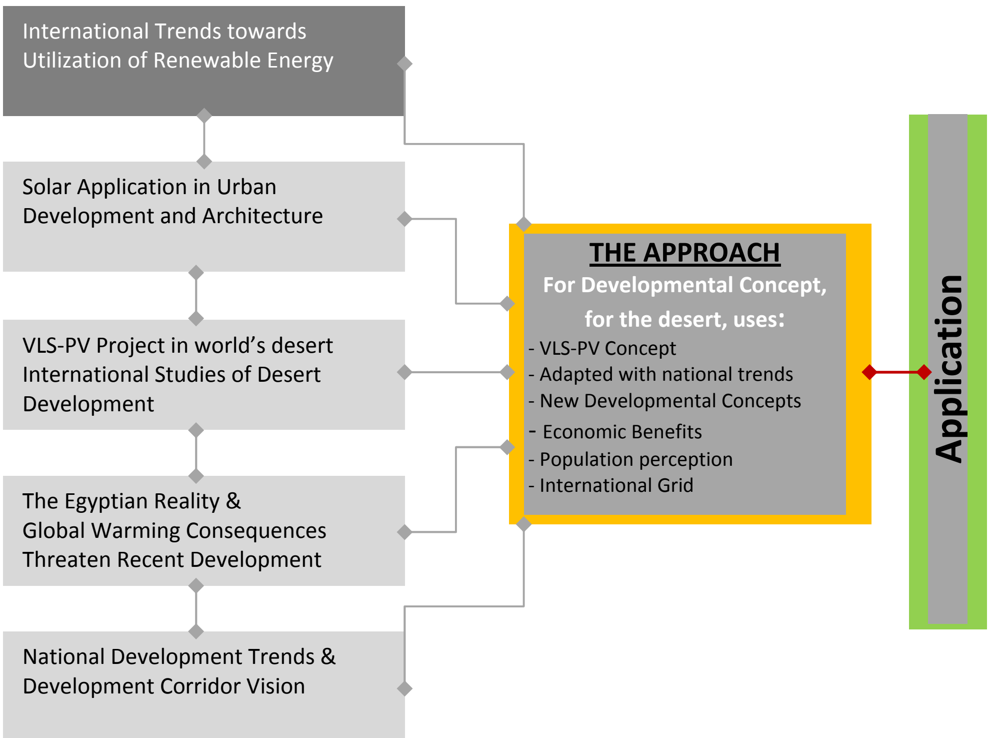



Figure: 3-1

**Diagram Illustrates the Main Issues that has Discussed through the Research Structure.** (**Source**: the Author)

## 1-2 APPROACHING THE DEVELOPMENT CRITERIA

The following points are sub-detailed criteria for examining the suitable regions for using solar energy application in Egypt and adapted to the national developmental trends of the deserts.

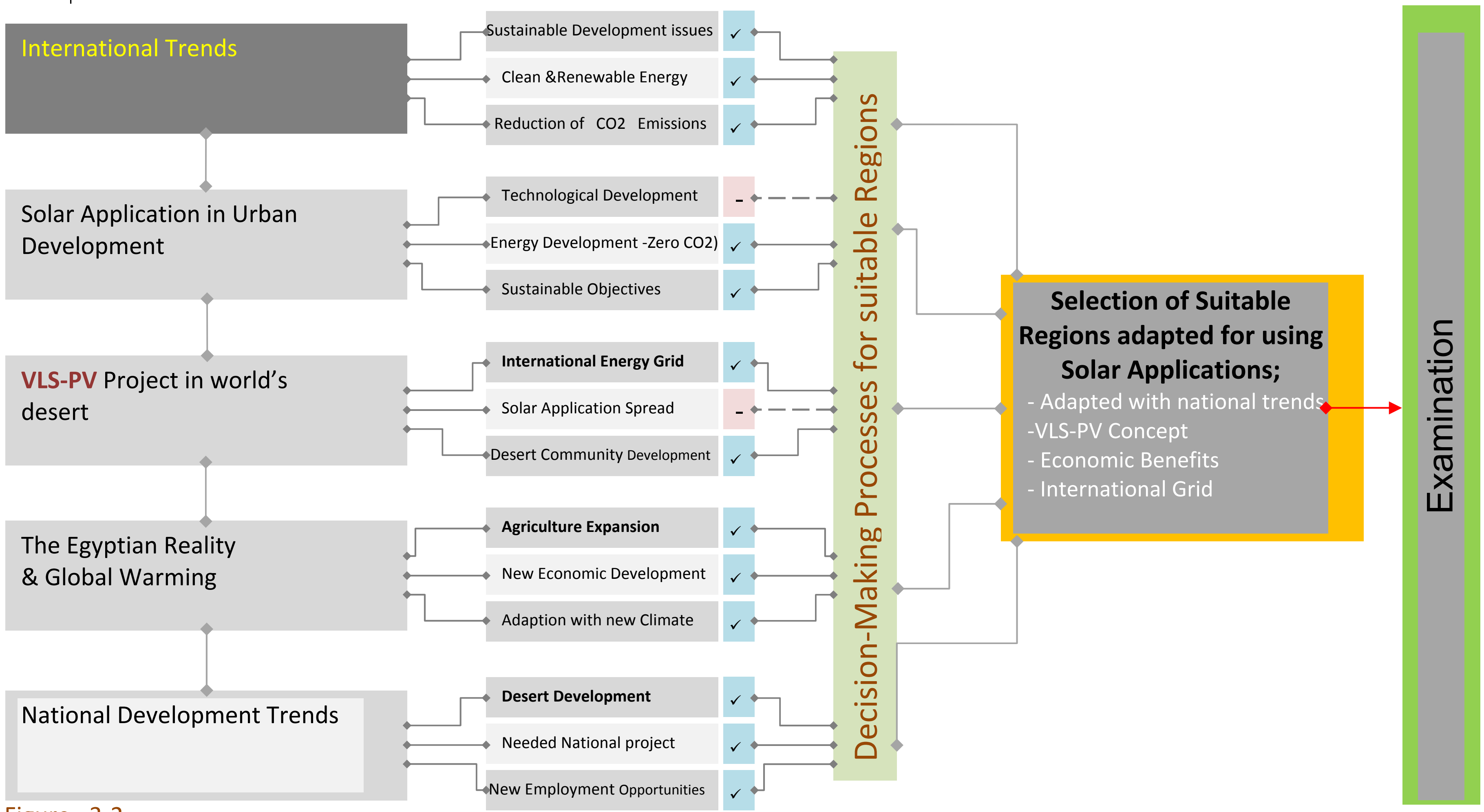



Figure: 3-2

**Diagram Approaching Research's Criteria for Regions Selection Adapted to Solar PV Applications in Egypt.** (Source: the Author)

## *1-3 REGIONS EXAMINATION CRITERIA*

In Figure 3-3 There are five stages for examining the expected developmental regions in Egypt, the final stage is examining the criteria through a case study in real site and developing an application through the proposed new communities in the Egyptian desert utilizing VLS-PV systems.

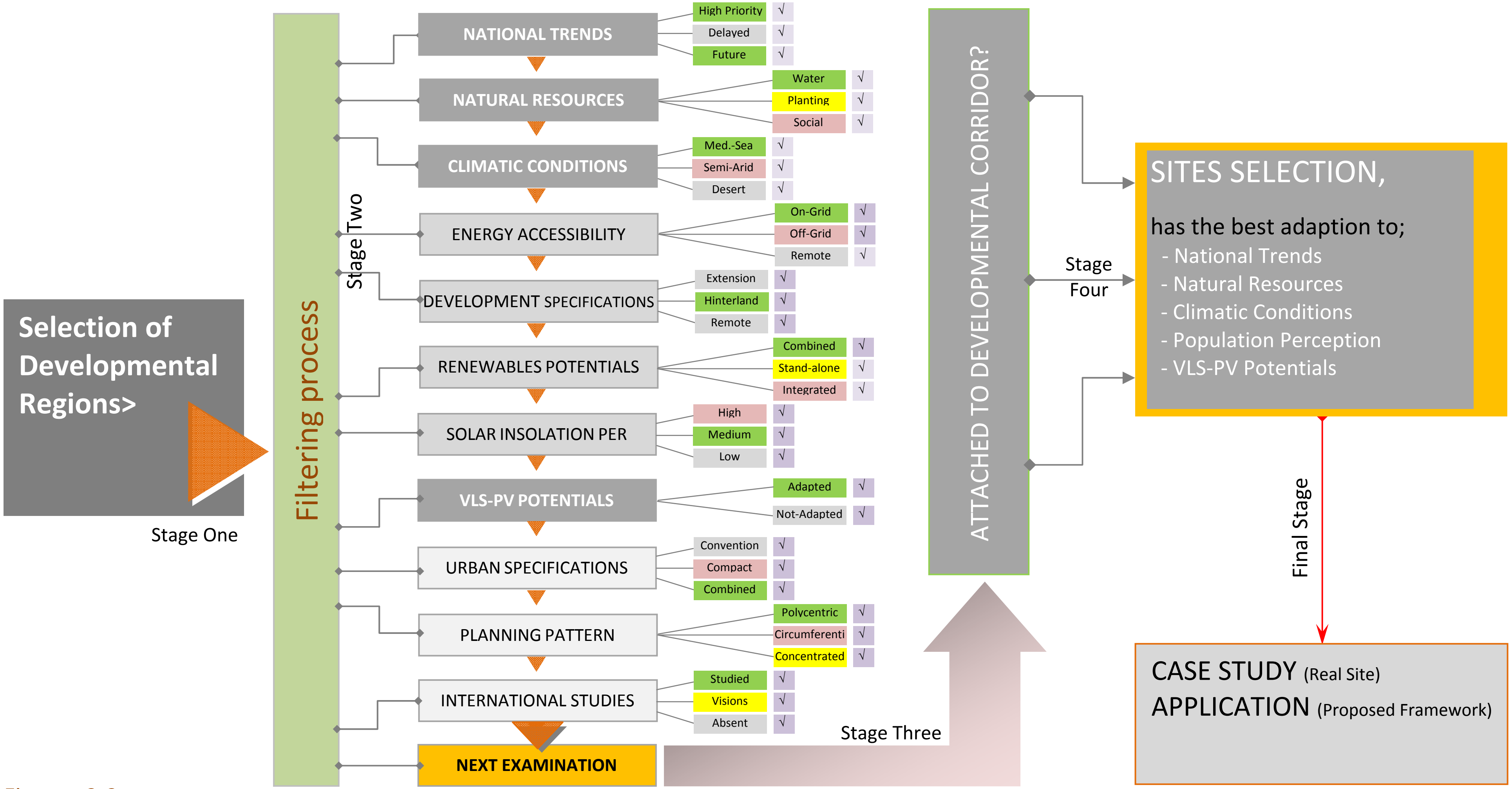
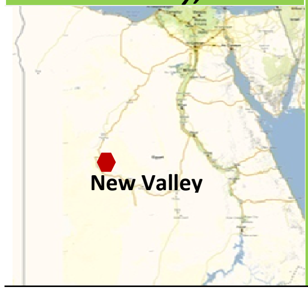



Figure: 3-3

**Regions Examination Criteria Diagram, to Select the Specific Sites for Using Silicon Photovoltaic Technology.** ( **Source**: the Author)

## TABLE 3-1 Examination of Solar Energy Application Potentials For Egyptian Developmental Regions

| | NATIONAL AVAILABILITY | | | | | RENEWABLES & VLS-PV | | | PLANNING STUDIES | | | | DECISION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Location** | National Trends | Natural Resources | Climatic Conditions | Energy Accessibility | Development Specification | Renewable potentials | Solar insolation | VLS-PV potentials | Urban Specification | Planning Pattern | International Studies | Development Corridor | |
| ***1. Al-Alamain,***   | **Delayed,**<br>- The region is Considered to Touristic development and a memorial site (World's War II). | **Medium,**<br>- Under-ground water.<br>- Natural Environment<br>- Planting<br>- Off-Grid (Stand-alone system) | **Mediterranean –Zone,**<br>- Moderate solar insolation | **Grid-Connected,**<br>- Connected to the New Coastal Gridline | **Extension,**<br>- Development of Coastal Axis | **High**<br>- Wind energy potentials-<br>- Solar energy. | **Medium**<br>- Solar Insolation, | **Adapted to VLS-PV**<br>- New Community-<br>- Export Site for Global Grid | **N/A**<br>- Original habitats are Bedouin | **N/A** | -Studied as an international memorial and touristic center, | **Attached,**<br>**High Priority**<br>- Developed to play an exportation point for energy and gods (international port) | **Al-Alamain is Considered an important region in the advanced stage of Implementation of developmental activities for desert.** |
| ***2. Qattara Depression,***   | **Future,** | **Low,**<br>Suitable for agricultural activities | **Arid –Zone,**<br>Hard Climate as a desert macro-Climate | **Remote,** | **Remote,** | **Wind** energy-<br>**Solar** Energy-<br>**Geo-thermal** | **High Solar** Insolation, | **Not-Adapted to VLS-PV ,**<br>- New Community | **N/A** | **N/A** | -Studied as Futuristic Develop. Region,<br>-Seventh Oasis | **Not-Attached,**<br>**Future** | **Qattara depression still have a very technical problems about the development activities and methodology** |
| ***3. New Valley,***   | **High Priority,**<br>- The region endowed with a natural resources as planting and natural environment. | **Social, Water and planting,**<br>- Have strides steps towards Social and agricultural development. | **Desert – Zone,**<br>- High temperature and solar insolation in noon times and cold in night times. | **Remote,**<br>**Grid-Connected,**<br>- There are remote areas in the region. | **Remote,**<br>- Internal Regional Development trends. | **High ,**<br>- Solar energy.<br>- Wind energy potentials | **High Solar** Insolation<br>- High priority for using Solar thermal systems | **Not-Adapted to VLS-PV**<br>**Future**<br>- New local manufacture | **Convention**<br>- Original habitats are agricultural neighborhoods' and Bedouin. | **Concentra-ted** | -the region Studied to be a promising site for solar thermal systems plants. **(Nockrashy engineers )** | **Not-Attached,**<br>In advanced stage of development | **New valley in and exist region for agricultural development** The high potentials for using **solar Thermal Plants still under R&D** stage. |

| *Continued,*<br>**Location** | NATIONAL AVAILABILITY | | | | | RENEWABLES & VLS-PV | | | PLANNING STUDIES | | | | DECISION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **National Trends** | Natural Resources | Climatic Conditions | Energy Accessibility | Development Specification | Renewable potentials | Solar insolation | **VLS-PV potentials** | Urban Specification | Planning Pattern | International Studies | **Development Corridor** | |
| ***4. Sinai & Canal,***<br> | **High Priority**<br>-The region endowed with a natural resources as planting , Ports, industrial , and Trading. | **Social, Planting,**<br>-Watering of region through El-Salam Canal,<br>-Solar desalination systems. | **Mediterranean –Zone,**<br>-Moderate climate for conventional urban development activities. | **Grid-Connected,**<br>-Western-Side specially<br>-Endowed with Gas resources and industries, | **Extension, Hinterland, Remote,**<br>-Extension for Cairo axes.<br>-Hinterlands to canal governorates<br>-Remote sites in Sinai peninsula. | **Wind** energy-<br>**Solar** Energy-<br>**Geo-thermal** Energy,<br>**Biomass** Energy | **Medium** Insolation, | **Adapted to VLS-PV** Community, | **Convention** | **Poly-Concentric** | **The region is Studied to be a promising site for solar Photovoltaic applications and industries and power plants.** | **Not-Attached,**<br>In advanced stage of development through coastal axes. | **The region exists as an important site for using and developing of RE and Solar energy specially Silicon PV Technology.** |
| ***5. Eastern Bank,***<br> | **High Priority**<br>-The region endowed with a natural resources as touristic sites and rich Minerals. | **Social,**<br>- Social develop-ment in weak.<br>-Only tourism activities and natural Environment | **Mediterranean – arid in South,**<br>-Moderate climate,<br>-High temperature and solar insolation in noon times | **Remote, Grid-Connected,**<br>-Endowed with Gas resources and industries, | **Extension, Remote,**<br>-Extension for upper Egypt governorates<br>-Remote sites. | **Wind** energy-<br>**Solar** Energy-<br>**Geo-thermal** Energy, | **High** Insolation, | **Not-Adapted to VLS-PV**<br>**Future**<br>New local manufacture | **Convention** | **Poly-Concentric** | The region has a natural resources and site suited the tourism activities and develop. | **Not-Attached,** | **The region is suitable for industrial and mining activities. SE would attached in urban context due to remote conditions.** |
| ***6. Toshka Region,***<br> | **High Priority,**<br>-The region endowed with a natural resources as planting and natural environment. | **Social, Water and planting,**<br>- Has strides steps towards Social and agricultural development. | **Desert – Zone,**<br>-High temperature and solar insolation in noon times and cold in night times. | **Remote, Grid-Connected,**<br>-There are remote areas in the region. | **Remote,**<br>-Internal Regional Development trends. | **High ,**<br>-Solar energy.<br>-**Thermal Solar systems.** | **High Solar** Insolation<br>-High priority for using Solar thermal systems | **Adapted to VLS-PV,**<br>-For power generation and Agricultural community | **Convention**<br>-Original habitats are agricultural neighborhoods' and Bedouin. | **Poly-Concentric,**<br>Adapted to the Agricultural y urban system. | -The region Studied to be a promising site for solar thermal systems plants.<br>**(Nockrashy engineers )** | **Attached,**<br>**Start point** for Development al Corridor Implementa-tions. | **Toshka is considered a promising site for solar energy applications, specially throug the advanced stages of development depending of multi-activities and resources.** |

**Source**: Data processed by author from: **Planning Ministry**, 2005 & **SIS**, 2006. **Abd-Elaal,** M. *"Sustainable Communities Depending on Renewable Energy"*, (MSc. Thesis, Cairo University, 2002), P.170. **MED** (Ministry of Economic Development-Egypt ), report*" Developmental Corridor Project: Initial Studies* ", Cairo, retrieved April 15, 2009, from http://www.mop.gov.eg/under.html.

## 1-4 SELECTED REGIONS

The Examination of Egyptian Regions emphasizes the potentials for using solar energy applications in some regions and exclusion of other regions for specific conditions. Suez Canal and Developmental Corridor Regions have highlighted ranking in the Examination of solar energy potential specially PV Silicon Technology. The followings are the Studying of these selected regions and PV technology potential (Figure 3-4).

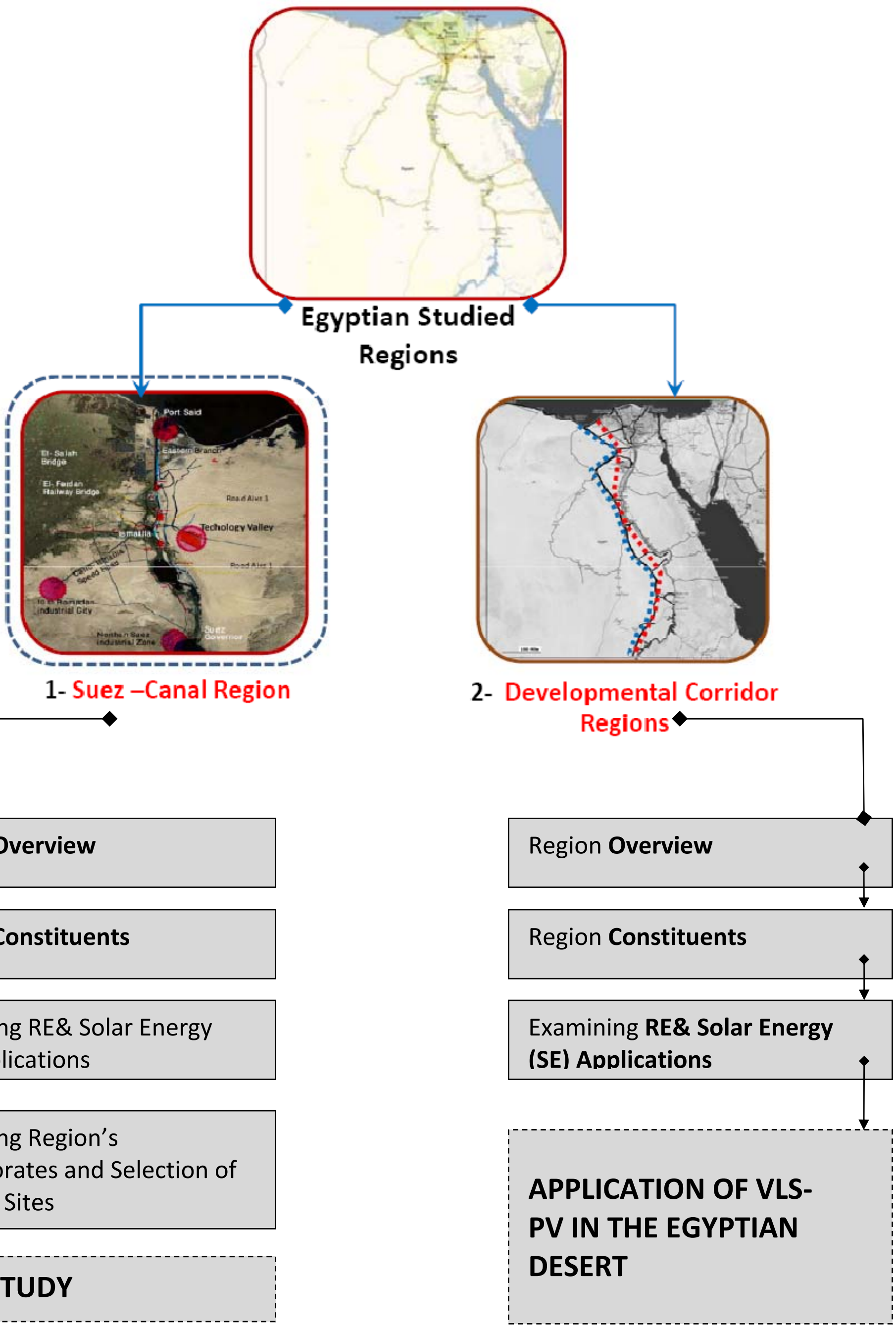



Figure: 3-4

**Selected Regions for Developing the Utilization of PV & VLS-PV systems.**

( **Source**: the Author)

# 2 SUEZ-CANAL REGION

## 2-1 *OVERVIEW*

Suez Canal region placed the east north corner of Egypt, as a part of the third region and consists of *three governorates* of the canal beside the two governments of Sinai and El-Sharkia. It takes a rectangular shape from 28° 55' to 30° 10 north and from 31° 45' to 33° east and its area is about 15890 Km$^2$ ( about 22% of the total area of the third region). [1] (Figure 3-5)

### 2-1.1 Region Overview

According to the Planning Ministry, national estimations report in 1999, the population of this region is 1,602,200 with a general growth rate 2.55%. Also, it has a general density 100.8 P/Km$^2$ and a net urban density 150 p/km2 but it is remarkable that this density varies between about 6539.9 P/ Km$^2$ in port Said and 45.4 p/Km$^2$ in Ismailia. The importance of this region is that it's -with its three governorates - the key bridge for carrying the development pivot's to Sinai beside its local resources, which forming a good base for its future development.[2]

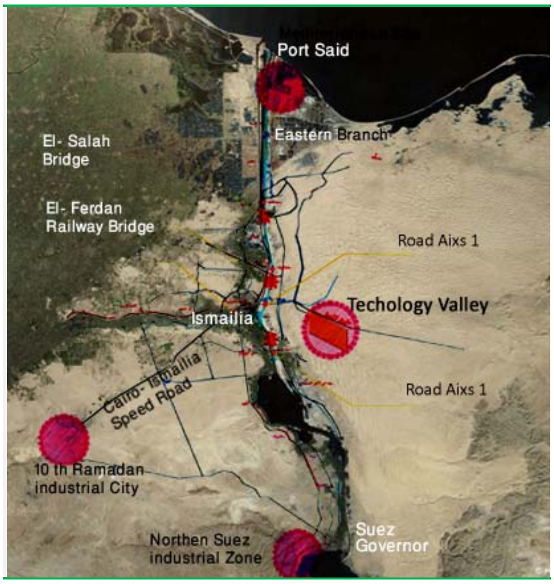



Fig. 3-5 **Suez Canal Region Main Project and Transportation Network.**

**Data Retrieved and processed March 15, 2009 by the author, from:** http://www.ismailia.gov.eg/TechValley/

Canal region depends on many activities for facing the employment force needs, mainly on agriculture (16.3% of the employment force), industry and power (14.3%), trading and tourism (13.2%) and transportation and storage (12.4%) beside the social services (29.6%). In general, the region's unemployment rate is about 8.4% and it will increase during the few next years due to the economical changes in the region, specially in Port Said after cancelling its free-zone.[3] (Table 3-2)

**TABLE 3-2** **The Relative Distribution of Employment According to the Activities**

| ACTIVITY | Port Said (%) | Ismailia (%) | Suez (%) | Total (%) |
|---|---|---|---|---|
| **Agriculture** | 9.1 | 26.9 | 7.6 | **16.3 %** |
| **Mining** | 0.4 | 0.2 | 1.9 | **0.7 %** |
| **Industry \ Electricity \ Gas** | 11.3 | 11.3 | 23 | **14.3 %** |
| **Construction** | 5.1 | 9.9 | 10.4 | **8.5 %** |
| **Trading \ Tourism** | 17.1 | 10.4 | 13.1 | **13.2 %** |
| **Transportation \ Storage** | 15.5 | 9.5 | 13.4 | **12.4 %** |
| **Financing \ Insurance** | 5.2 | 3.7 | 3.8 | **4.2 %** |
| **Social services** | 35.4 | 27.3 | 25.8 | **29.6 %** |
| **Others** | 0.9 | 0.8 | 0.9 | **0.8 %** |
| **Total** | 100 | 100 | 100 | **100 %** |

**Source: Planning Ministry 1999,**

[1] **Planning Ministry** 1999, p. 20
[2] **Abd-Elaal,** M. "*Sustainable Communities Depending on Renewable Energy*", (MSc. Thesis, Cairo University, 2002), p.197.
[3] Ibid, p. 198.

### 2-1.1.1 Local Resources

This area enjoys a moderate climate, land resources, mineral wealth, and tourist attracting features, besides to its unique location on an international navigation artery;

- Abundance of vast reclaimable and cultivable land of about **one million acres**, mostly in Sinai Peninsula.
- Availability of **water sources**, as all governorates within this region overlooks sea, gulf coasts and waterways.
- Abundance of **mining resources**, which constitute an essential base for a variety of industries.
- A large numbers of **industrial estates and free zones** with necessary services and utilities that have been already built in this area.
- Availability of **transport**, **communications**, **electricity**, **public utilities** and **infrastructure networks.**[1]

The region of the Canal and Sinai contains a number of mega-projects, which are under implementation. *On top of these the projects are the following;* (Figure 3-6)

1- Developing north of Sinai that aims at ***reclaiming 400,000 feddans*** to be irrigated from Nile water through El-Salam Canal;

2- the project of ***reclaiming 200,000 feddans*** on the west Side of Suez Canal,;

3- the projects of east Port Said and northwest Suez Gulf aiming at ***establishing two new harbors*** that represent a new addition to the Egyptian maritime transport networks;

4- the related ***free economic zones*** within these projects that enhance the Egyptian industrial production and exportation;

5- the ***valley of technology project*** that under implementation, aims at erecting a high-technology industrial zone, to enhance the transfer of these kind of technology.[2]

These projects aims at creating ***new population-attracting communities*** to accommodate about ***2.5 million citizens***, exploiting available natural resources and establishing an industrial free zone, an international hub-port and about ***200 major factories***, as well as providing about ***246,000 job opportunities***.

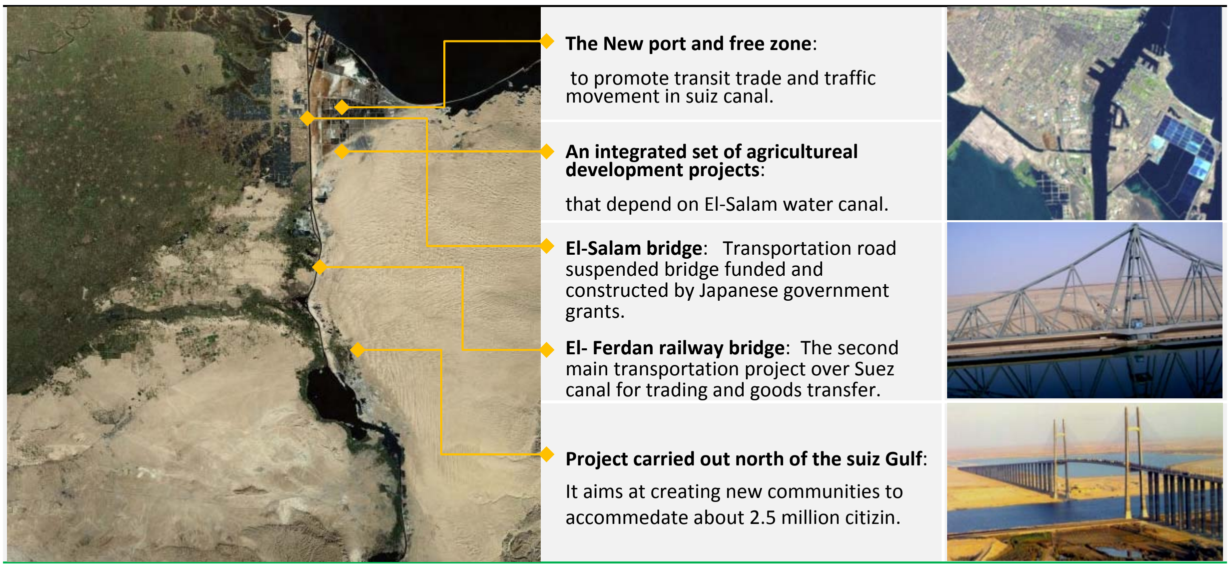



Fig. 3-6 **The Main Mega Projects for the Development in Suez Canal Region.**

**Source**: Data processed by author from: **Planning Ministry**, 2005 & SIS, 2006.

[1] Data processed from; **Planning Ministry,** Report, 1999, p.20**.** – **Egypt State information Services** (SIS), Retrieved March 15, 2009, from: http://www.sis.gov.eg/

[2] **Abd-Elaal,** M. "*Sustainable Communities Depending on Renewable Energy*", (MSc. Thesis, Cairo University, 2002), p.199.

### 2-1.1.2 Technology Constituents & Infrastructures

The former information about Suez Canal's trading activities, social structure, industrial and technology development, and agricultural development, makes it have a remarkable potentials to form an integrated technology zone depending of the former infrastructure. One of the distinguished projects was the project of Technology Valley – for industrial manufacturing of technological tools- in Ismailia's eastern bank.

Technology Valley had initiated and has implemented its first phase in 1994 still adopted by the Egyptian government as national trends, although the frequent barriers that project has faced. Project's total area is approximately 16500 acres, has been divided into six sectors phase, have already been working in the primary sector *(immediate phase) total* 3021 acres, *and have been extended with infrastructure (roads - water - electricity - sewage), and services (ambulance building - fire - Gallery – Central).*[1] (Figure 3-7)

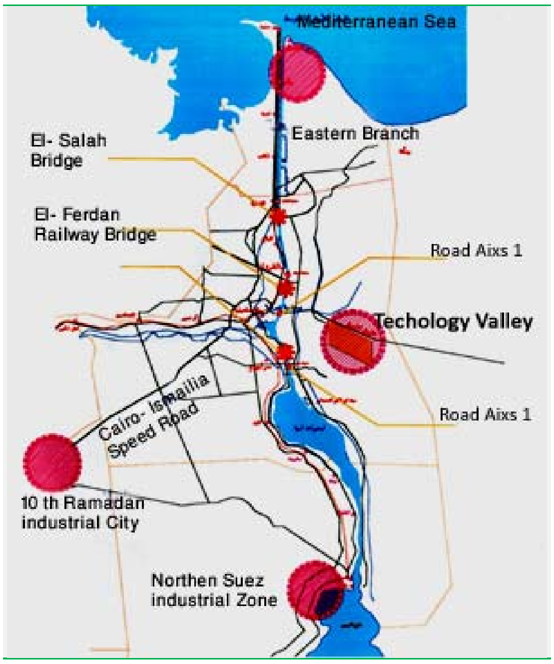



Fig. 3-7 **Suez Canal Region Main Project and Transportation Network.**

**Source:** Data Retrieved and processed March 15, 2009 by author, from: http://www.ismailia.gov.eg/TechValley/

### *a. Project location*

The Project was implemented in the eastern bank of the Suez Canal with a strategic place, its distance from Ismailia center is approximately 10 km, and the industrial zone with distance of 35 km east, with a total area 16500 acres. (Figure 3-8)

### *b. Project Investment*

- Marketing: National and International marketing are targeted.
- Investment: National investment (30 %) - Private investment (70 %).
- Budget: 5,000,000 L.E for infrastructure.

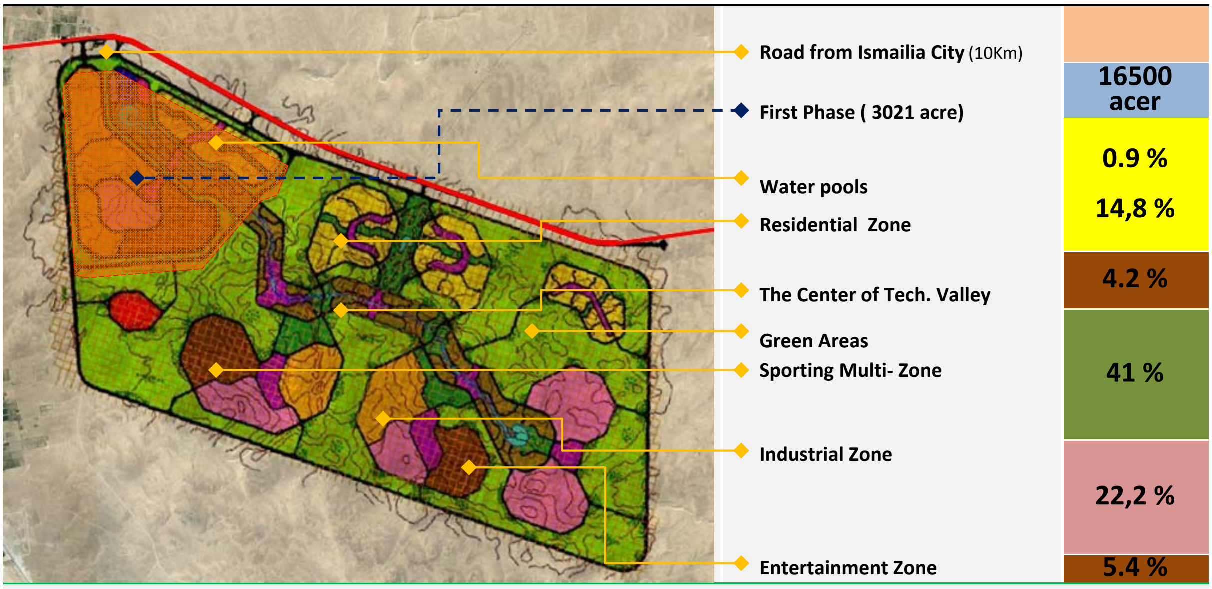



Fig. 3-8 **The Master Plan of Technology Valley.**

**Data Retrieved and processed March 15, 2009 by author, from:** http://www.ismailia.gov.eg/TechValley/

[1] **Ismailia Governorate**, Official website, " *Technology Valley Project*",( Ismailia Governorate, 2009), Retrieved 15 March, 2009, from: http://www.ismailia.gov.eg/TechValley/

### *c. Project Objectives*

The project has two main targeted objectives:

1- It aims at creating new urban society in the Eastern bank of canal, relies mainly on technological industries of high electronics tools and devices.

2- To makes, Egypt has the abilities and applications of electronics industry to be as producer and exporter in the future of like this new technology, through an industrial urban community frame, titled "**technology valley or Silicon valley** ", similar to the recent technology valleys in USA, China, and India. [1] (Table 3-3) (Figure 3-9)

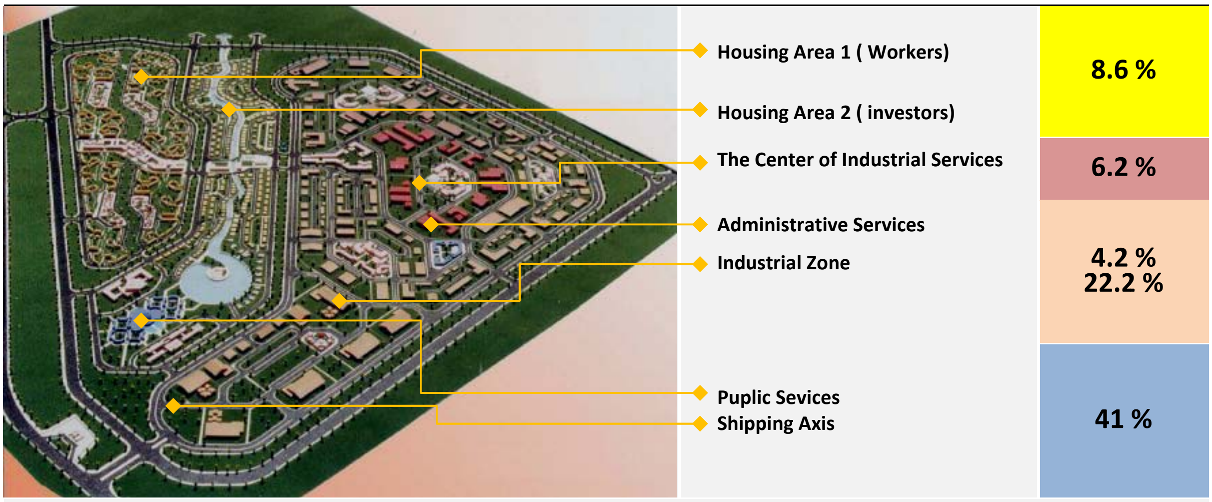



Figure : 3-9 **The Component of Technology Valley in Ismailia (First Phase) as planned in this Model.**
**Source**: Retrieved 15 March, 2009, from: **Retrieved March 15, 2009, from:** http://www.ismailia.gov.eg/TechValley/

Table 3-3 shows the Main components and areas of the technology valley.

**TABLE 3-3** — **The Component of Technology Valley in Ismailia** [2]

| **ACTIVITY** | **The Total Area** (Feddan) | **Percentage** (%) |
|---|---|---|
| **International Trade Center and Exhibition** | 25.0 | **0.2 %** |
| **Housing Area 1 ( Workers)** | 1394 | **8.6** % |
| **Housing Area 2 ( investors)** | 1015.2 | **6.2** % |
| **High Technological Industry** | 1431.2 | **8.8** % |
| **Integrated Industry** | 781.4 | **4.8** % |
| **Small Industry** | 1392.2 | **8.6** % |
| **High Technology University** | 78.5 | **0.5** % |
| **Multi- Sporting Zones** | 205.6 | **1.2** % |
| **Open Green Zones** | 6674.4 | **41** % |
| **Entertainment Zones** | 548.3 | **4.3** % |
| **Shipping Services Zones** | 127.9 | **0.8** % |
| **Administrative Services** | 16.5 | **0.1** % |
| **Trading and Management Services** | 569.7 | **3.5** % |
| **Water pools** | 142.1 | **0.9** % |
| **Circulation and Roads** | 1877.5 | **11.4** % |
| **Total** | **16279** Feddan | **100** % |

**Data Retrieved and processed by the author on; March 15, 2009 by author, from:** http://www.ismailia.gov.eg/TechValley/

[1] **Ismailia Governorate**, Official website, " *Technology Valley Project*",( Ismailia Governorate,2009), Retrieved 15 March, 2009, from: http://www.ismailia.gov.eg/TechValley/

[2] **Technology Valley**, Official website, " *Technology Valley Project Components*", Retrieved 15 March, 2009, from: http://www.ismailia.gov.eg/TechValley/

## *2-2 EXAMINING RE & SOLAR ENERGY (SE) APPLICATIONS*

Suez Canal region has noticed feasibility for applying renewable energy applications, as it has a wide range of its types, especially, from the wind and solar energy. (Figure 3-10)

*The region's has the following feasibility, summarized as:*

- Solar energy application,
  - Solar pond application ( by using salty land and sea water for solar pond plants)
  - Photovoltaics application ( whether using BIPV on cities or VLS-PV plants)
- Wind Energy applications,
  - The Two wind power plants in El- Zhafrana ( wind speed 10meter/ second)
  - The project of Wind Turbine industry by (The Arab Organization for Industrialization- AOI)
- Biomass applications,
  - Duo to the extended agricultural activities and the noticed new small agriculture communities in west Ismailia and Suez governorates through the development axis of Cairo-Ismailia road, In addition to the agricultural development in the eastern canal side.[1]

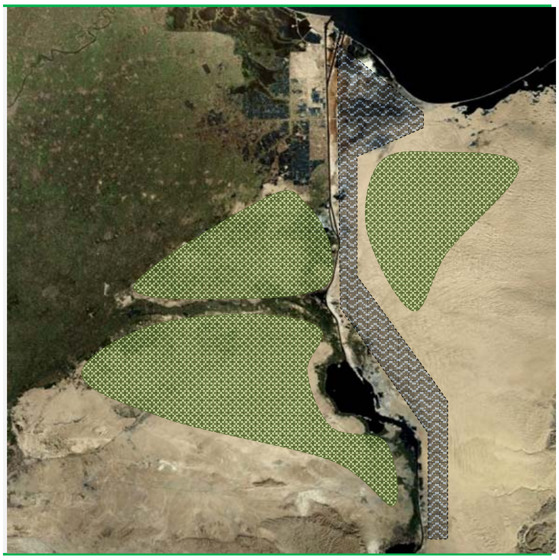


Fig. 3-10 **Renewable Energy Potentials In Suez Canal Region**

**Source**: Data processed by the author from ( Planning Ministry 2005 & SIS, 2006)and Google Earth (Ordinates : 32.219296 ,30.599518 )

| | |
|---|---|
| | **Biomass resources ( Agricultural activities)** |
| | **Solar Pond resources ( salt Sea water )** |
| | **PV Application ( High solar insolation in open areas)** |

### 2-2.1 ( SE ) Applications in General

Concluded that through the former overview and studies, it could be Suez Canal region has attached to many studies for developing using of solar energy technology, whether, industrialization or utilization of technology through its urban context. Proposed Solar applications for the region are;

#### a. Thermal Applications

- High Temperature applications: Thermal Solar Plants for Electricity Generation.
- Medium Temperature: for industrial process.
- Low Temperature: utilization solar pond technology for Electricity Generation.

#### b. Electrical Applications

- Photovoltaic technology industrialization: by developing the industry of electronic and Silicon technology by utilizing the natural resources of Silicon sands.
- VLS-PV Applications: using VLS-PV proposal for developing new sustainable agricultural communities in Sinai Peninsula for agriculture, technology, and energy production.

The virginity of this regions especially Sinai or eastern bank of Suez Canal provides a certain chance for developing the proposal; VLS-PV community –it will discussed through the Application in Chapter IX.

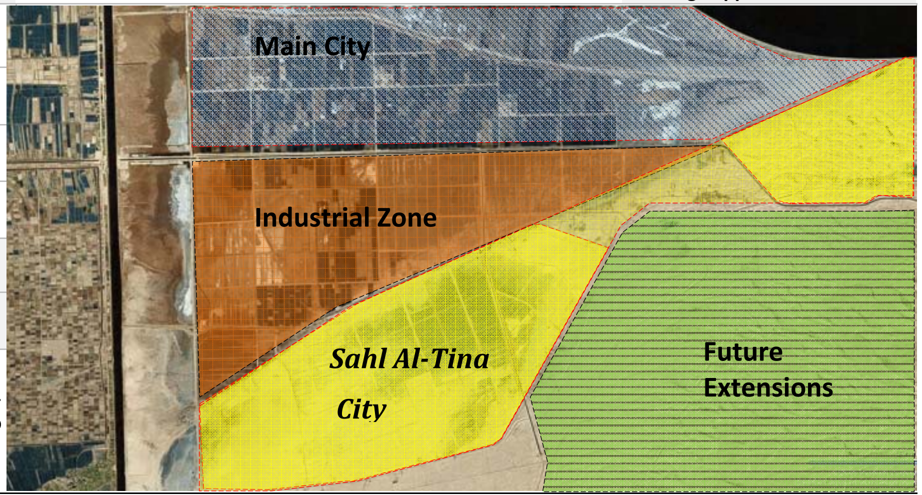
<u>Table 3-4 examining the governorates of Suez Canal region for the applications of PV and VLS-PV Technology.</u>

[1] Data processed from; **Egyptian Electricity Holding Company,** *Annual report 2005*, **Egyptian Gas Holding Company**, *Annual report 2004*, **Egyptian general Organization of Petroleum,** *Annual report 2003/2004.*

## TABLE 3-4 Examining of PV & VLS-PV Applications in Suez Canal Governorates.

| PORT SAID | NATIONAL AVAILABILITY | | | PLANNING STUDIES | | RENEWABLES & VLS-PV | | | | DECISION |
|---|---|---|---|---|---|---|---|---|---|---|
| | Local Activities | Development Trends | Energy Accessibility | Planning Pattern | Urban Specification | Renewable potentials | Solar insolation | Feasibility of Solar Applications | VLS-PV potentials | |
| ***General Profile*** | - **Trading**<br>- **Tourism**<br>- **Industrial**<br>- **Agricultural** | - **Extension,**<br>- Development of Eastern Canal Bank | **Grid-Connected,**<br>Depending on Plenty of **Natural GAS** Resources | - **Existing City**<br>- **New Eastern: Communities : in SINAI Desert**<br>**( Polycentric )** | - **N/A**<br>- **Regular Urban patterns**<br>**(Grid-Conventional)** | - **Wind energy**<br>- **Solar energy** (Thermal – Electrical ) | **Medium** Solar Insolation, | - Domestic water heating<br>- **PV**- on Houses<br>- **PV** -Plants.<br>- **Solar pond**<br>- **Solar thermal** Concentrators plants<br>- **Industrial** processes | - **Adapted to VLS-PV Applications**<br>- As an Export Site for Global Grid | - **Plenty of Natural gas and petroleum resources would delay the applications of solar energy in large scale.**<br>- **VLS-PV applications would be available exclusively through the exportation processes.** |
| *Urban Site 1:*<br>***Sahl Al-Tina Community,*** | - **Trading**<br>- **Industrial**<br>- **Agricultural** | **New industrial Communities** extended to Northern SINAI peninsula | **Grid-Connected,**<br>Depending on **Natural GAS** Resources | **Industrial Community** | - **Grid System**<br>Conventional-Horizontal spread | - **Solar energy** | - **Medium**<br>Suitable for Medium Thermal applications | - **PV**- on Houses<br>- **PV** -Plants.<br>- **Domestic water Heating**<br>- **Solar pond**<br>- Industrial processes | - **Not feasible** according to the abundance of Gas resources | - **Sahl Al-Tina City as a new industrial community is available for small PV applications.**<br>- **The urban, social and economic, context makes it adapted to PV applications small and in future extension to large applications.** |

| DATA | Urban Densities | Legend |
|---|---|---|
| Population (1000) | 471.5 | **Existing City** |
| The Total Area (Km2) | 1351.14 | **New Communities** |
| The general density (Person/ Km2) | 349 | **Industrial Zone** |
| The Existing Urban Area (Km2) | 72.1 | **Future Extension** |
| The net density (Person/ Km2) | 6539.5 | |
| **Other** | <u>Development Pivot</u>; extends from Port Said in the north to Suez in the South. Development efforts will help boosting port and free zones activities in addition to promoting transit trade and traffic movement in Suez Canal. | |



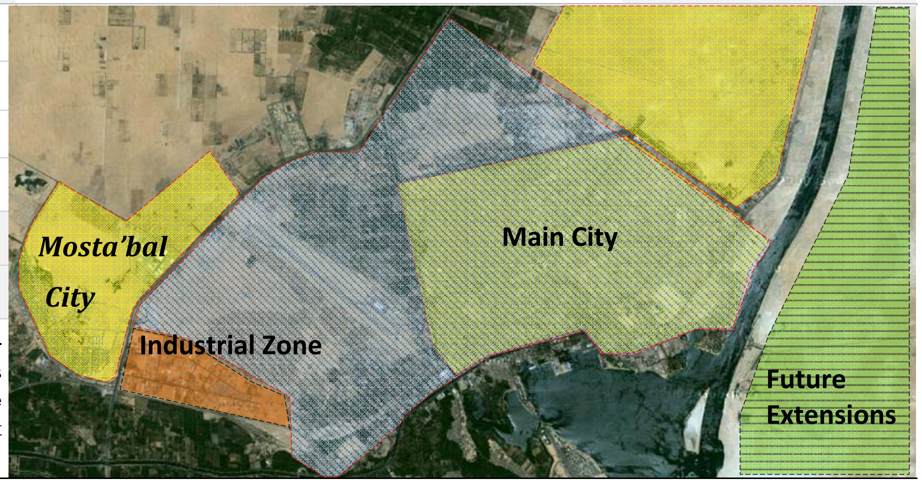
*Continued,*
*Table 3-4*

| ISMAILIA | NATIONAL AVAILABILITY | | | PLANNING STUDIES | | RENEWABLES & VLS-PV | | | | DECISION |
|---|---|---|---|---|---|---|---|---|---|---|
| | Local Activities | Development Trends | Energy Accessibility | Planning Pattern | Urban Specification | Renewable potentials | Solar insolation | Feasibility of Solar Applications | VLS-PV potentials | |
| ***General Profile*** | - **Industrial**<br>- **Agricultural**<br>- **Tourism** | - **Extension,**<br>Development to North of the City<br>& Eastern Canal Bank | **Grid-Connected,** | - **Existing City**<br>- **New Eastern: Communities : in SINAI Desert**<br>( **Polycentric** ) | - **N/A**<br>- **Regular Urban patterns**<br>( **Combined** ) | - **Wind energy**<br>- **Solar energy** (Thermal – Electrical )<br>- **Biomass energy** | **Medium** Solar Insolation, | - Domestic water Heating<br>- **PV**- on Houses<br>- **PV** -Plants.<br>- **Solar pond**<br>- **Solar thermal** Concentrators plants<br>- **Industrial** processes | - **High Feasibility to VLS-PV Applications**<br>- As a producer of Electrical power | - **The recent Industrial, Technological and agricultural communities will make it feasible to Solar energy applications.**<br>- **Ismailia is considering one of the best governors available to PV and VLS-PV applications.** |
| *Urban Site 2:*<br>***Mosta'bal City,***<br>*(Future City)* | - **Industrial**<br>- **Agricultural** | **New industrial Community**<br>extended to North-West Ismailia City | **Grid-Connected,**<br>Depending on **National Grid** | **Industrial Community**<br>Combined-(Horizontal spread) | - **Grid System**<br>Numerous habitat patterns | - **Solar energy** | - **Medium**<br>Suitable for Medium **Thermal** applications and **PV applications** | - **PV**- on Houses<br>- **PV** -Plants.<br>- **Domestic water Heating**<br>- Industrial processes | - **High Feasibility**<br>- according to its urban and industrial integrated activities | - **El Mosta'bal City is one of noticed available new industrial community for PV applications.**<br>- **The urban, social and economic, Educational Context makes it adapted to PV small and large applications** |

| DATA | Urban Densities | | |
|---|---|---|---|
| Population (1000) | 713.9 | **Existing City** | |
| The Total Area (Km2) | 4482.8 | **New Communities** | |
| The general density (Person/ Km2) | 159.3 | **Industrial Zone** | |
| The Existing Urban Area (Km2) | 1441.59 | **Future Extension** | |
| The net density (Person/ Km2) | 495.2 | | |

**Other**

Development Pivot; Extends along Suez Canal in the east, from south **Sahl El-Tinah** to north **Oyoun- Moussa** on the Suez Gulf. The main activity in this area is agriculture on water carried through Ismailia and Suez water channels to irrigate 100,000 feddans. In addition, this area comprises the valley of technology project that provides high-technology industries and services.

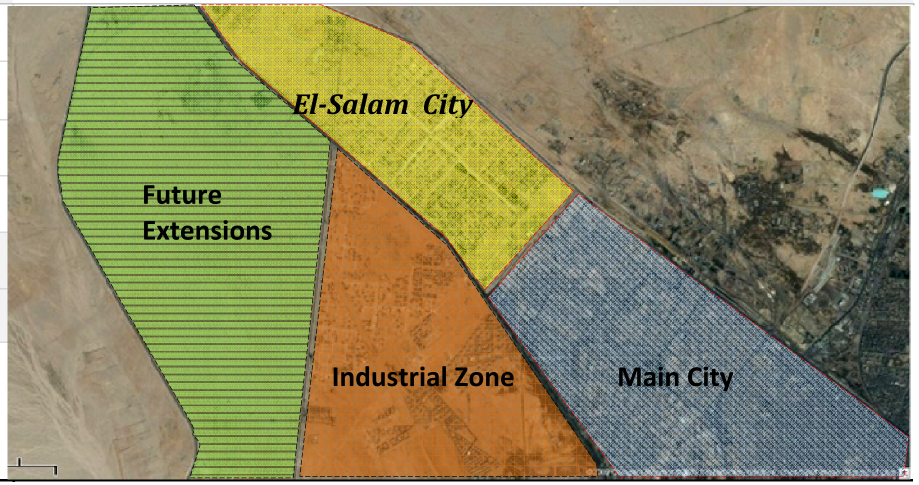


*Continued,*
*Table 3-4*

| SUEZ | NATIONAL AVAILABILITY | | | PLANNING STUDIES | | RENEWABLES & VLS-PV | | | | DECISION |
|---|---|---|---|---|---|---|---|---|---|---|
| | Local Activities | Development Trends | Energy Accessibility | Planning Pattern | Urban Specification | Renewable potentials | Solar insolation | Feasibility of Solar Applications | VLS-PV potentials | |
| ***General Profile*** | - **Industrial**<br>- **Trading**<br>- **Agricultural**<br>- **Tourism** | - **Extension,**<br>Development to North-West of the City<br>& Eastern<br>Canal Bank | **Grid-Connected,**<br>Depending on Plenty of **Natural GAS- and Petroleum** Resources | - **Existing City**<br>- **New Urban Communities in city's North-west <u>(Polycentric)</u>** | - **N/A**<br>- **Regular Urban patterns**<br>**<u>(Grid-Conventional)</u>** | - **Wind energy**<br>- **Solar energy** (Thermal – Electrical ) | **High** Solar Insolation, | - Domestic water Heating<br>- **PV**- on Houses<br>- **PV** -Plants.<br>- **Solar pond**<br>- **Solar thermal** Concentrators plants<br>- **Industrial** processes | - **Adapted to VLS-PV Applications**<br>- As a producer Site for Electrical power | **Plenty of Natural gas and petroleum resources would delay the applications of solar energy in large scale.**<br>**VLS-PV applications would be available exclusively through the industrial applications.**<br>- |
| *Urban Site 3:*<br>***El-Salam City***<br>*(North-west Suez)* | - **Industrial** | **New industrial Communities** | **Grid-Connected,**<br>Depending on **Natural GAS& Petroleum** resources | **Industrial Community**<br>Combined-(Horizontal spread) | - **Grid System**<br>Numerous habitat patterns | - **Solar energy** | - **High**<br>Suitable for Medium **Thermal** applications & **PV** | - **PV**- on Houses<br>- **PV** -Plants.<br>- **Domestic water Heating**<br>- Industrial processes | - **Not feasible** according to the abundance of Conventional (Gas-petroleum) resources | - **Suez new city, as a new industrial community, is available for small PV applications.**<br>- **The urban, social and economic, Context makes it adapted to PV applications small and large applications.** |

| **DATA** | **Urban Densities** |
|---|---|
| Population (1000) | 416.3 |
| The Total Area (Km2) | 10056.43 |
| The general density (Person/ Km2) | 41.4 |
| The Existing Urban Area (Km2) | 9171.09 |
| The net density (Person/ Km2) | 45.4 |

| Legend | |
|---|---|
| **Existing City** | |
| **New Communities** | |
| **Industrial Zone** | |
| **Future Extension** | |




**Other**

<u>Development Pivot</u>; The western-southern pivot; extends from Oyoun-Moussa in Suez governorate to El-Tour town on the Suez Gulf in South Sinai governorate. Its main activity is tourism and extracting activities.

**Source:** Data processed from ( **Planning Ministry**)and **Google Earth**; (Ordinates : 32.219296 ,30.599518). **Abd-Elaal,** M. *"Sustainable Communities Depending on Renewable Energy"*, (MSc. Thesis, Cairo University, 2002), p. 190. **MED** (Ministry of Economic Development-Egypt ), report*" Developmental Corridor Project: Initial Studies* ", Cairo, retrieved April 15, 2009, from <u>http://www.mop.gov.eg/under.html.</u>

## *2-3 CASE STUDY ( El Mosta'bal City- Ismailia )*

The objective of this study to examine the ability for using PV cells to fulfill the electricity needs in the near future — through the period 20-50 year — which most of cities may use solar energy as a main source of energy after the finite of fossil fuels resources. (Figure 3-13.b)

(Figure 3-11) illustrates the site component, the ambient, and main circulation road connected to the site. The new city is considering the new extension for Ismailia city and settles the surplus and new population that related to the new industrial zones and the free zone.

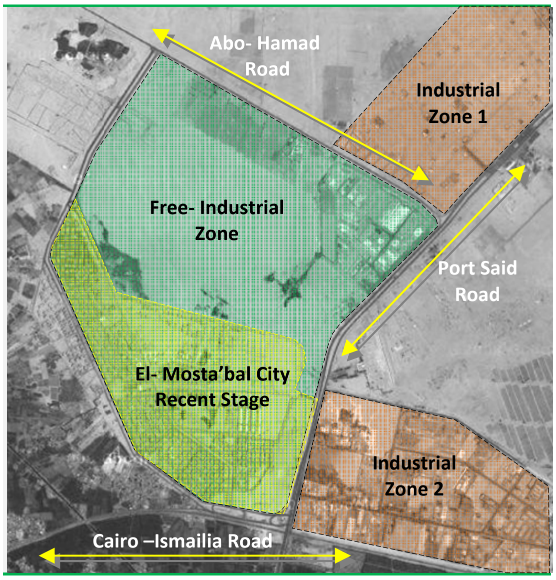



Fig. 3-11 **El-Mosta'bal City Borders.**
**Source:** Data processed by author from ( Planning Ministry)and Google Earth;
(Ordinates : 32.219296 ,30.599518 )

*The city contains the following Components:*

1- Economic Housing – level (2) - Zone A
2- Housing – level (2) - Zone A"
3- Economic Housing – level (3) - Zone B
4- Housing – level (2) - Zone B"
5- Housing – High level (1) - Zone C
6- Economic Housing – level (3) - Zone E
7- The Main wholesale Center - Zone D

*Advantages of Site:*

The city considered a suitable site for studying solar energy application as new urban community, and an example for the governmental housing models of the industrial communities in Egypt.

### 2-3.1 Case Study Assumptions,

The examination of site for installation photovoltaic cells depending on the following assumptions and requirements: (Figure 3-12)

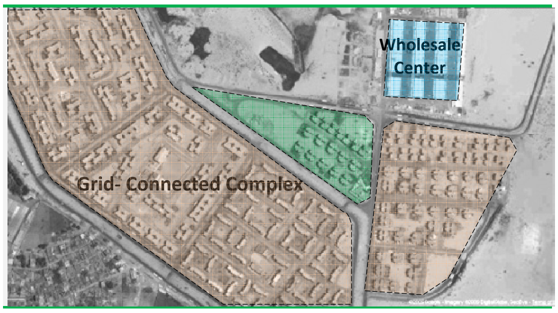



Fig. 3-12 **Analytical Study of El-Mosta'bal Site.**
**Source:** Data processed by author from ( Planning Ministry)and Google Earth;
(Ordinates : 32.219296 ,30.599518

**The Community**

1- The new community consists of educated habitants, whether good or medium educated.
2- There is a technical group from the community, responsible for the maintenances processes and checking the system performance.

**The System**

1- Using of Grid-Connected system – to avoid The use of Batteries.
2- Using of high or medium efficiency *(Mono crystalline 24 %- poly crystalline 13%)* of Solar cells for producing maximum electrical power- depending on the exporting the energy for the national grid.
3- Subtract (25%) of the roof total area —as specified in the Egyptian Building standards — for the other habitant's equipments as, ( Dishes- water Tanks).

According to **Chapter VI** recommended Design Criteria, the following are the Examination of El-Mosta'bal City urban system; Table 3-5

**TABLE 3-5** — **Examining of Design Criteria on El-Mosta'bal City Urban Context with using of Solar Photovoltaics.**

| CRITERIA | URBAN Scale | Evaluation | |
|---|---|---|---|
| **The Site** | - New Developmental Urban region, | √ | - New Agricultural and technological community |
| | - New Community, | √ | |
| | - New City. | √ | |
| **The Urban Type** | - Housing and Habitation. | √ | - Urban Development |
| **Energy Accessibility** | - Grid- Connected | √ | - Stable Electricity |
| **Objectives** | - Sustainable City, | N.A. | - Achieving the principles of sustainable community for conserving the high sensitive nature of desert environment |
| | - Sustainable Architectural Development, | N.A. | |
| | - Reduction of CO2 Emissions, | √ | |
| | - Achieving Quality of Life Style, | √ | |
| | - Initiatives for developing RE uses. | √ | |
| **Climate Conditions** | - Moderate Climate condition ( Moderate Solar Insolation) | √ | - Needs an architectural passive technique |
| **Main Considerations** | - Developing and studying of the holistic urban systems for maximizing the utilization of Renewable resources, | √ | - Using of VLS-PV systems make the availability of self-sufficient concept possible, with prospected exportation of energy. |
| | - Achieving a targeted power generation as 1 MW in Amersfoort village, | N.A. | |
| | - Self-sufficient energy generation and exportation through advanced stages | N.A. | |
| **Stages of Implementation** | - Installing of outside power plant for generating power through stages of implementation. | N.A. | - Identical to VLS-PV implementation stages |
| | - Integration of PV Modules on the urban and Building Context, | √ | |
| | - Integration of other Renewable energy resources, as wind and geothermal energy. | N.A. | |
| **PV Systems & Types** | - VLS-PV systems | X | - Identical to VLS-PV recommended panels (Silicon Technology) |
| | - Polycrystalline Silicon PV modules on buildings. | √ | |
| | - Thin film & amorphous silicon cells. | X | |
| **Types of Solar Utilization** | - Building integration (BIPV) | √ | - Using BIPV and integration of other RE systems |
| | - Power plants, | X | |
| | - Air-conditioning, | X | |
| | - Combined techniques and systems. | X | |
| **Other Integrated Systems** | - Domestic Water headings, | √ | - All systems are attached |
| | - Wind Energy, | X | |
| | - Geothermal energy. | X | |
| **Financing sources** | - UN Financial Programs and Developmental programs, | √ | - All financial resources would available |
| | - Governmental investment, | √ | |
| | - R&D Institutional investment, | √ | |
| | - Co2 reduction Investment. | √ | |
| **Design Pattern** | - Conventional (Horizontal Sprawl) generate more energy | √ | - Modular system<br>- (Poly-centric urban patterns) |
| | - modular system, | √ | |
| | - Compact planning, | X | |
| | - Combined planning system. | X | |
| **Return of Investment** | - Through the Followings: | | - All resources would available |
| | - Interest rates, | √ | |
| | - Electricity price after 5-22 years. | √ | |
| | - Accumulation of Jobs and socio-economic development. | √ | |

**Source**: Design Criteria –**Chapter IV**

## 2-3.2 Studying the Installation of PV Models,

The followings are the studying of site components and classification of housing units, to determine the suitable orientated units for installing PV modules on roofs.


Fig 3-13.a **Analytical Study of El-Mosta'bal Units and Zones.**

**Source:** Data processed by author from ( Planning Ministry)and Google Earth (Ordinates : 32.219296 ,30.599518 )

| | Installing potentials of PV Modules | | |
|---|---|---|---|
| Zone A-A" | ( 0 $^0$) Optimal Orientation for PV Cells - Wide Zone – Urban Design is effective to PV Sys. | 25 % | √ |
| Zone B-B" | ( 24 $^0$) Suitable Orientation for PV Cells - Wide Zone – Urban Design is effective to PV Sys. | 50 % | √ |
| Zone C | ( 24 $^0$) Suitable Orientation for PV Cells - Small Zone – Urban Design is Not effective to PV Sys. | 10 % | - |
| Zone D | ( 0 $^0$) Optimal Orientation for PV Cells - Small Zone – Roof Design is Effective to PV Sys. | 5 % | √ |
| Zone E | ( 55 $^0$) Suitable Orientation for PV Cells - Small Zone- Urban Design is Not effective to PV Sys. | 10 % | - |

### 2-3.3 System Specifications

The former context of the city presents the feasibility for studying solar energy in "El Mosta'bal City" that sets in the Western side of Ismailia City. The main zones of study is shown in (Figure 3-13.b)

*The main sides of the study were as followings:*

1- Studying the percentage of Net Roof Area /Block related to the Number of Dwellings in the block, and calculating the percentage of full-covered units by PV electricity.

2- Studying the efficiency of City's Blocks by shape for using PV Cells on Roof, and the efficiency of roof area to cover maximum number of dwelling units.

3- Studying the needed area to cover the total energy of the city and recommended needed place for erecting this PV Areas.

4- Using medium efficiency *(Poly-crystalline Silicon 13%)* of Solar cells for producing maximum electrical power.

5- Using of PV Modules with area (module (1.2*.33) output power 47,0 watt )

6- The Study calculated the needed power per Unit level per day(Figure 3-13.b), related to the (Table 3-6);

- Level (1) needs= 7935 w/h/day ( For Unit = 26 $m^2$ = 66 module= 7935 W/h/day )
- Level (2) needs= 7478 w/h/day ( For Unit = 25 $m^2$ = 63 module= 7478 W/h/day )
- Level (3) needs= 6066 w/h/day ( For Unit = 20 $m^2$ = 51 module= 6066 W/h/ day)

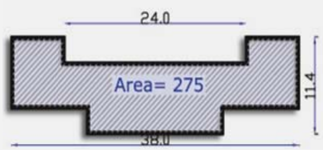
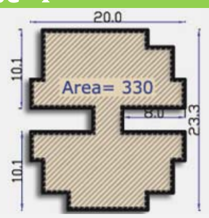
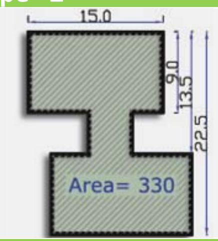
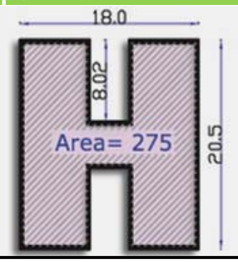

Fig 3-13-b. **Classification of El-Mosta'bal Zones by Life-Level.**

**Source:** Data processed by author from:Google Earth (Ordinates : 32.219296 ,30.599518 )

*** All Calculations Related To The Energy Demands Per Units: In Full Details In The APPENDIX 2 PAGE 162.

| TABLE 3-6 | Classification of Block's Life-Level and Needed Power/ Unit. | | | | |
|---|---|---|---|---|---|
| **Component** | Rated Wattage | Adjustment Factor 1.0 For Dc | Adjusted Wattage | Hours Per Day Use | Energy Per Day |
| **5** Lights | 150 | 0.85 | 176 | 2 | 353 |
| Refrigerator | 500 | 0.85 | 588 | 5 | 2941 |
| **3** Ceiling Fans | 125 | 0.85 | 159 | 8 | 1272 |
| Dishwasher/other | 600 | 0.85 | 706 | 2 | 1413 |
| Washer | 1500 | 0.85 | 1765 | 0.85 | 1500 |
| Toaster/ H. Iron | 1500 | 0.85 | 1765 | 0.25 | 441 |
| **Total Energy** (Watt-Hours/day) | **High LEVEL (1)** | All Utilities | | | **7935** W/h/ day |
| | **LEVEL (2) Blocks** | Without (Dishwasher) | | | **7478** W/h/day |
| | **LEVEL (3) Blocks** | Without (Dishwasher + Toaster) | | | **6066** W/h/ day |

**TABLE 3-7** **Main Information of PV Cell System , Block s Forms, and Dimensions.**

| El Mosta'bal Units | BLOCKS Main Data: Blocks Total Numbers | Orientation | Roof Area | TOTAL NET AREA - PV: Net Roof Area | Total PV Area | Number of PV Modules | Total Energy demand / day: For 1 Unit | For 1 Block | For all Block | ENERGY OUTPUT: Covered Units | Un-Covered units | Evaluation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shape U<br> | 60 block Zone E | 55 ⁰ Form axis N-S | 275 m² - | 206 m² | 12375 m² | 12375/ 0.4 m² = 4950 module (1.2*.33) | - For Unit = 25 m² = 63 module = 7478 W/h/day | 119648 w/h | 7178880 w/h | 8 | 8 | 51 % |
| Shape I<br> | 45 block Zone A" | 24 ⁰ Form axis N-S | 330 m² | 248 m² | 16088 m² | 6435 module (1.2*.33) | - For Unit = 20 m² = 51 module = 6066 W/h/ day | 97056 w/h | 6308640 w/h | 12 | 4 | 77 % |
| | 20 block Zone B" | 24 ⁰ Form axis N-S | | | | | | | | | | |
| Shape Z<br> | 30 block Zone E | 24 ⁰ Form axis N-S | 330 m² | 248 m² | 46035 m² | 18414 module (1.2*.33) | - For Unit = 20 m² = 51 module = 6066 W/h/ day | 97056 w/h | 18052416 w/h | 12 | 4 | 62 % |
| | 156 block Zone B" | 24 ⁰ Form axis N-S | | | | | | | | | | |
| Shape H<br> | 97 block Zone A | 12 ⁰ Form axis N-S | 275 m² | 206 m² | 26194 m² 5400 m² | 10478 module (1.2*.33) | - For Unit = 20 m² = 51 module = 6066 W/h/ day | 97056 w/h | 12326112 w/h | 10 | 6 | 77 % |
| | 30 block Zone A" | 12 ⁰ Form axis N-S | | | | | | | | | | |

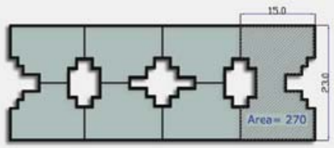
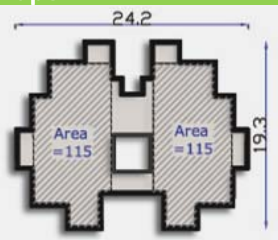
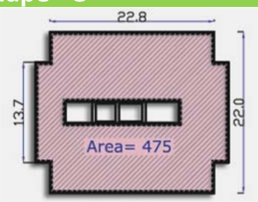
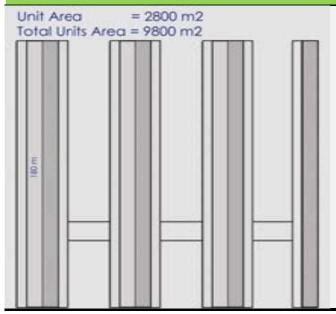
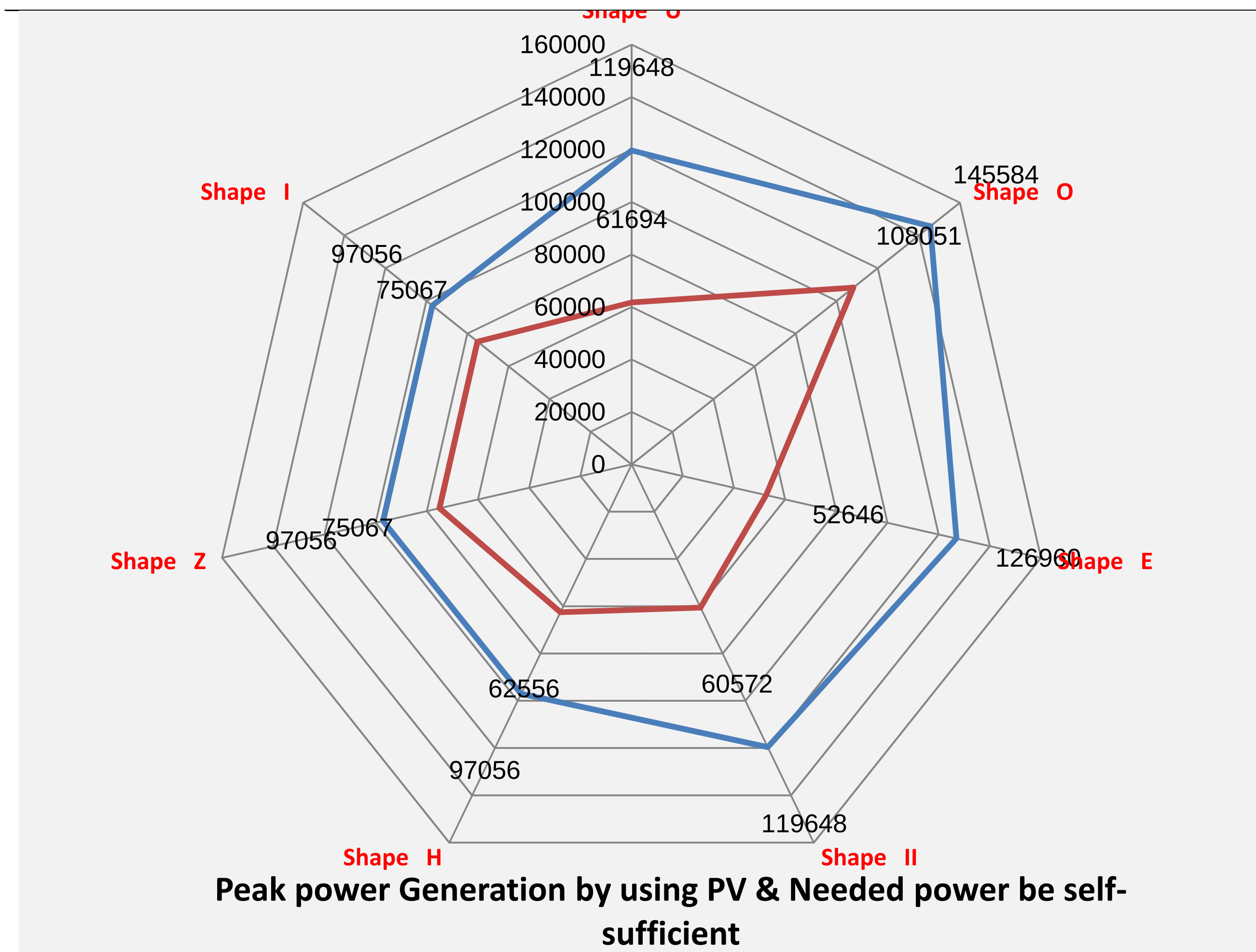
| *Continued,* **Table 3-7** | Total Numbers | Orientation | Roof Area | Net Roof Area- **PV** | Total **PV** Area | Number of **PV** Modules | For 1 Unit | For 1 Block | For all Block | Covered Units | Un-Covered units | **Evaluation** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shape II**<br> | **75 block** Zone **B**<br>**30 unit** Zone **E** | **24** $^{0}$ Form axis **N-S**<br>**55** $^{0}$ Form axis **N-S** | **270** $m^2$ | **203** $m^2$ | **21263** $m^2$ | **8505** module (1.2*.33) | - **For Unit = 25 $m^2$** = **63** module = **7478** W/h/day | **119648** w/h | **12563040** w/h | **8** | **8** | **64 %** |
| **Shape E**<br> | **84 block** Zone **C** | **24** $^{0}$ Form axis **N-S** | **230** $m^2$ | **173** $m^2$ | **14490** $m^2$ | **5796** module (1.2*.33) | - **For Unit = 26 $m^2$** = **66** module = **7935** W/h/ day | **126960** w/h | **10664640** w/h | **7** | **9** | **51 %** |
| **Shape O**<br> | **28 block** Zone **B"** | **24** $^{0}$ Form axis **N-S** | **475** $m^2$ | **356** $m^2$ | **9975** $m^2$ | **3990** module (1.2*.33) | - **For Unit = 20 $m^2$** = **51** module = **6066** W/h/ day | **145584** w/h | **4076352** w/h | **18** | **6** | **41.5 %** |
| **Wholesale Center**<br> | **3.5 unit** Zone **D** | **0** $^{0}$ Form axis **N-S** | **2800** $m^2$ | **1866** $m^2$ | **6531** $m^2$ | **466,5** module (1.2*.33) | - **For Unit = 26 $m^2$** = **66** module = **7935** W/h/ day | **-** | **-** | **-** | **-** | **74 %** |

Table 3-8; Illustrates the calculation of the generated power using PV cells on roof of City's blocks depending on block type and shape. The final columen aggragate the percentage of power generated by evey block shape .

**TABLE 3-8** **Peak Power Generation by Using PV & Needed Power for Self-Sufficient.**

| Blocks Shape | Blocks Total Numbers | Orientation | Roof Area | Net Roof Area | Covered Units | Un-Covered units | Covered units/City | Un-Covered units/ City | Total PV Area( all Blocks) | Number of PV Modules | Total Energy demand / Unit/ day | Needed Power/ Block | Produced Power | Extra power for Self-sufficient Level | Percentage % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shape U** | 60 | **55** Form axis N-S | 275 | 206.25 | **8** | **8** | 495 | 465 | 12375 | 4950 | 7478 w/h | 119648 | 61694 | -57955 | **51 %** |
| **Shape I** | 45 | **24** Form axis N-S | 330 | 247.5 | **12** | **4** | 557 | 163 | 11137.5 | 4455 | 6066 w/h | 97056 | 75067 | -21989 | **77 %** |
| **Shape I** | 20 | **24** Form axis N-S | 330 | 247.5 | **12** | **4** | 248 | 73 | 4950 | 1980 | 6066 w/h | 97056 | 75067 | -21989 | **77 %** |
| **Shape Z** | 30 | **24** Form axis N-S | 330 | 247.5 | **10** | **6** | 297 | 183 | 7425 | 2970 | 7478 w/h | 119648 | 74032 | -45616 | **62 %** |
| **Shape Z** | 156 | **24** Form axis N-S | 330 | 247.5 | **12** | **4** | 1931 | 566 | 38610 | 15444 | 6066 w/h | 97056 | 75067 | -21989 | **77 %** |
| **Shape H** | 97 | **12** Form axis N-S | 275 | 206.25 | **10** | **6** | 1000 | 552 | 20006 | 8002 | 6066 w/h | 97056 | 62556 | -34500 | **64 %** |
| **Shape H** | 30 | **12** Form axis N-S | 275 | 206.25 | **10** | **6** | 309 | 171 | 6187.5 | 2475 | 6066 w/h | 97056 | 62556 | -34500 | **64 %** |
| **Shape II** | 75 | **24** Form axis N-S | 270 | 202.5 | **8** | **8** | 608 | 593 | 15187.5 | 6075 | 7478 w/h | 119648 | 60572 | -59076 | **51 %** |
| **Shape II** | 30 | **55** Form axis N-S | 270 | 202.5 | **8** | **8** | 243 | 237 | 6075 | 2430 | 7478 w/h | 119648 | 60572 | -59076 | **51 %** |
| **Shape E** | 84 | **24** Form axis N-S | 230 | 172.5 | **7** | **9** | 557 | 787 | 14490 | 5796 | 7935 w/h | 126960 | 52646 | -74314 | **41.5 %** |
| **Shape o** | 28 | **24** Form axis N-S | 475 | 356.25 | **18** | **6** | 499 | 173 | 9975 | 3990 | 6066 w/h | 145584 | 108051 | -37533 | **74 %** |
| | 10704 | | | | **117** | **67** | **6743** | **3961** | | | watt/h | | | **- 468539** | |
| | | | | | | | **63.00 %** | **37.00 %** | Extra Needed Area of PV For Self- Sufficiency = **99,025 $m^2$** | | | | | | |

Figure 3-14; Illustrates The final columen aggragate the percentage of power generated by evey block shape .



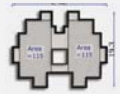
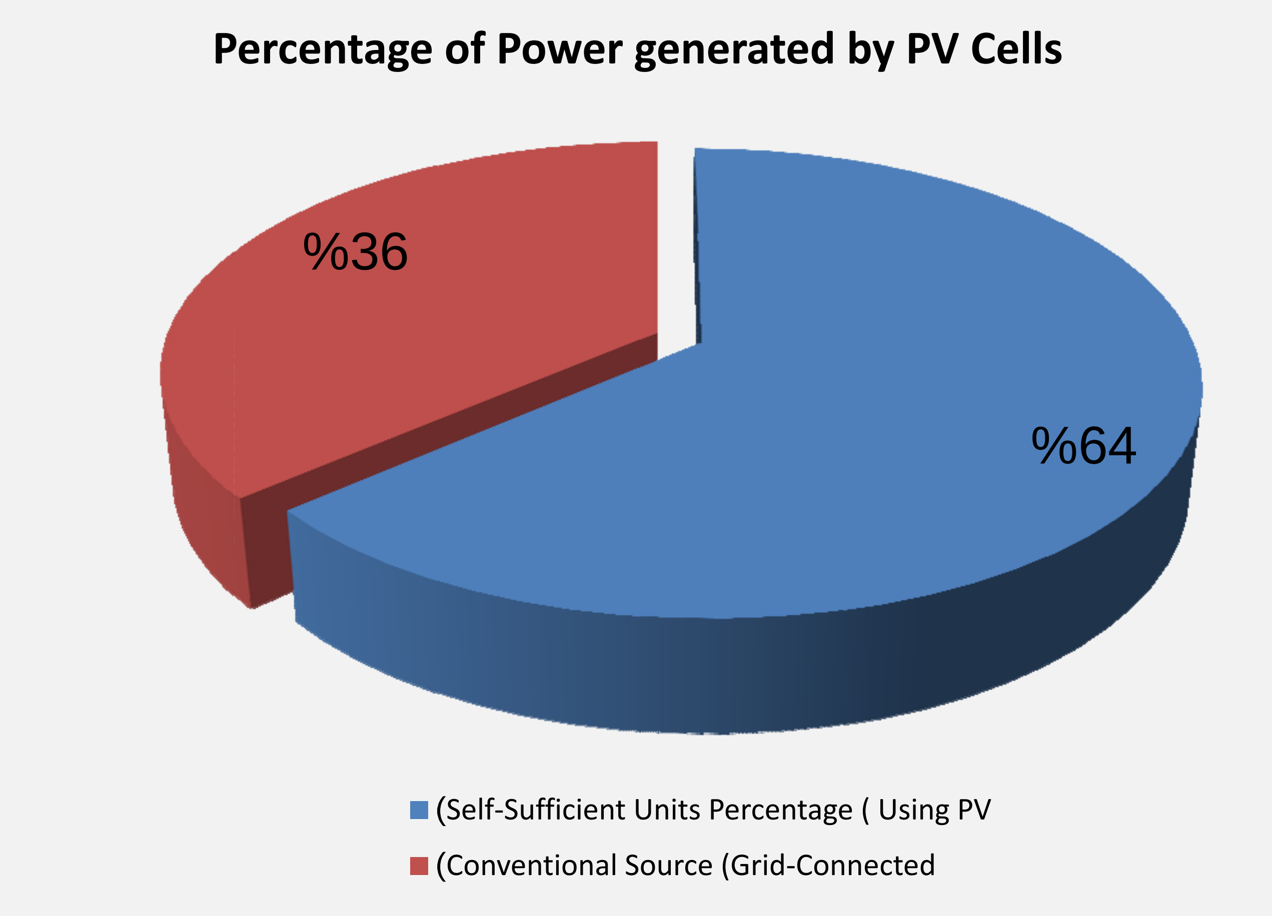

| Shape | | Power Percentage |
|---|---|---|
| Shape U |  | 51 % |
| Shape I |  | 77 % |
| Shape Z |  | 62 % |
| Shape H |  | 64 % |
| Shape II |  | 51 % |
| Shape E |  | 41.5 % |
| Shape O |  | 74 % |
| | | |

Fig. 3-14 **Percentage of Produced Power by Unit Shape**

Figure 3-15; introduces the percentage of generated power by PV cells IF THE HOLE PLANNING SYSTEM OF THE CITY'S BLOCKS HAVE NORTH-SOUTH ORIENTATION.




| Covered Blocks | Un-Covered Blocks |
|---|---|
| 495 | 465 |
| 557 | 163 |
| 248 | 73 |
| 297 | 183 |
| 1931 | 566 |
| 1000 | 552 |
| 309 | 171 |
| 608 | 593 |
| 243 | 237 |
| 557 | 787 |
| 499 | 173 |
| **6743** | **3961** |
| **63.00%** | **37.00%** |

Fig. 3-15 **Percentage of Power generated by PV Cells**

## 2-3.4 *CASE STUDY'S* Findings

The Studies regarding Al Mosta'bal City in Ismailia Governorates helps the research to understanding the potential of installing PV cells in roof and its capacity for covering the dwelling's needed electricity per block, and number of covered dwellings also, if we use PV Cells as a main source of energy for such these units.

### *The main Findings of the Study were:*

1- **Extra-Needed PV Area** for accessible 100% Self-Sufficiency = **99,025 m$^2$**.

2- The former needed PV area is equivalent to **37 % of area of central Services ( Zone D )** — its Area is (267242 m$^2$)—

3- Through **Figure 3-15**; the pilot study for using optimism orientation of Block — **North-South Axis**— emphasize the shortage of roof area per block, to cover its needs electricity. The fact, that it requires installing **stand-Alone PV plant** or **Installing Extra-PV Cells on other roof** in the City, as (**The Central services buildings**), to cover the needed percentage — **36 %** — to be Self-Sufficient city.

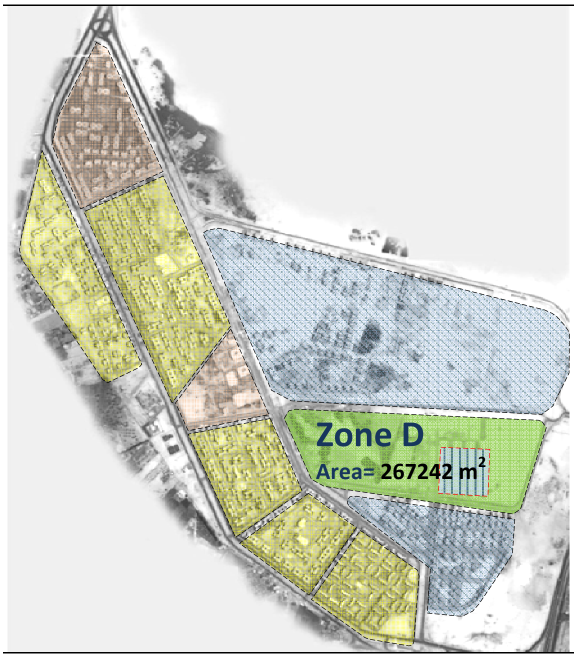



Fig 3-13-c. **Recommended Zone for Using Extra PV Plant with area** (99,025 m$^2$.)
**Source:** Data processed by author from: Google Earth (Ordinates : 32.219296 ,30.599518 )

### *Recommendations;*

Through the study, there are numerous points of recommendation for using PV Cells in the future, these points regarding the following scales;

### A. URBAN SCALE:

The following considerations are required;

1- Using optimal orientation — North-south Facing — as possible for reducing the shortage of Electricity output.

2- Using of **Maximum Possible Density of Blocks** for erecting shadow area in between and installing Extra-area of PV cells for un-covered units, without neglecting the minimum distance between block in the New Urban Cities in Hinterlands Areas.

3- Neglecting the needed area for **Roof Services** — (**25%**) for Dish and water tanks, as specified in the **Egyptian Building standards** — and replacing theses area by **Using Central Services**, and maximizing the roof area for installing PV Cells in Block's roof.

### B. Architectural SCALE:

4- Using of high-efficient PC cell as (Mono-Crystalline cells with efficiency 24%) for maximizing the energy output — if these technologies have lower cost through this time.

5- The advantage for using more **number of Block shape** (O – H – Z – I) for its efficiency and balance between **Units number and needed roof area per/unit**.

6- The ability for using (**Pitched Roofs**) in other cases for maximizing the electricity output from PV.

7- Necessity for using upon roof area per block for installing PV cells, to minimize the quantities and distances of wiring cables to avoid energy looses through wiring.

# 3 DEVELOPMENTAL CORRIDOR REGIONS

The "Developmental corridor" proposal, which was mentioned above, represents a new national development strategy for developing the Egyptian desert in parallel with the valley path. It also presents new development techniques depending on mitigation the overloaded valley activities, through attracting these activities in horizontal axes connected to the main overloaded cities of every governorate across the hinterlands and desert lands extended in 30-80 Km distance from the main centers of population in twelve branches. (Figure 3-16)

The North- south highway will connect the twelve branches to form new axis parallel to the Nile valley and creating new development zones in between, it extended 120 km distance and contains the main infrastructure of fresh water resources, the mode railway, electricity line, and the highway.[1]

The Egyptian government considered the project and has been studying its projects specifications and related activities, which were presented through the preliminary studies, as appears in the following findings at the next points.[2]

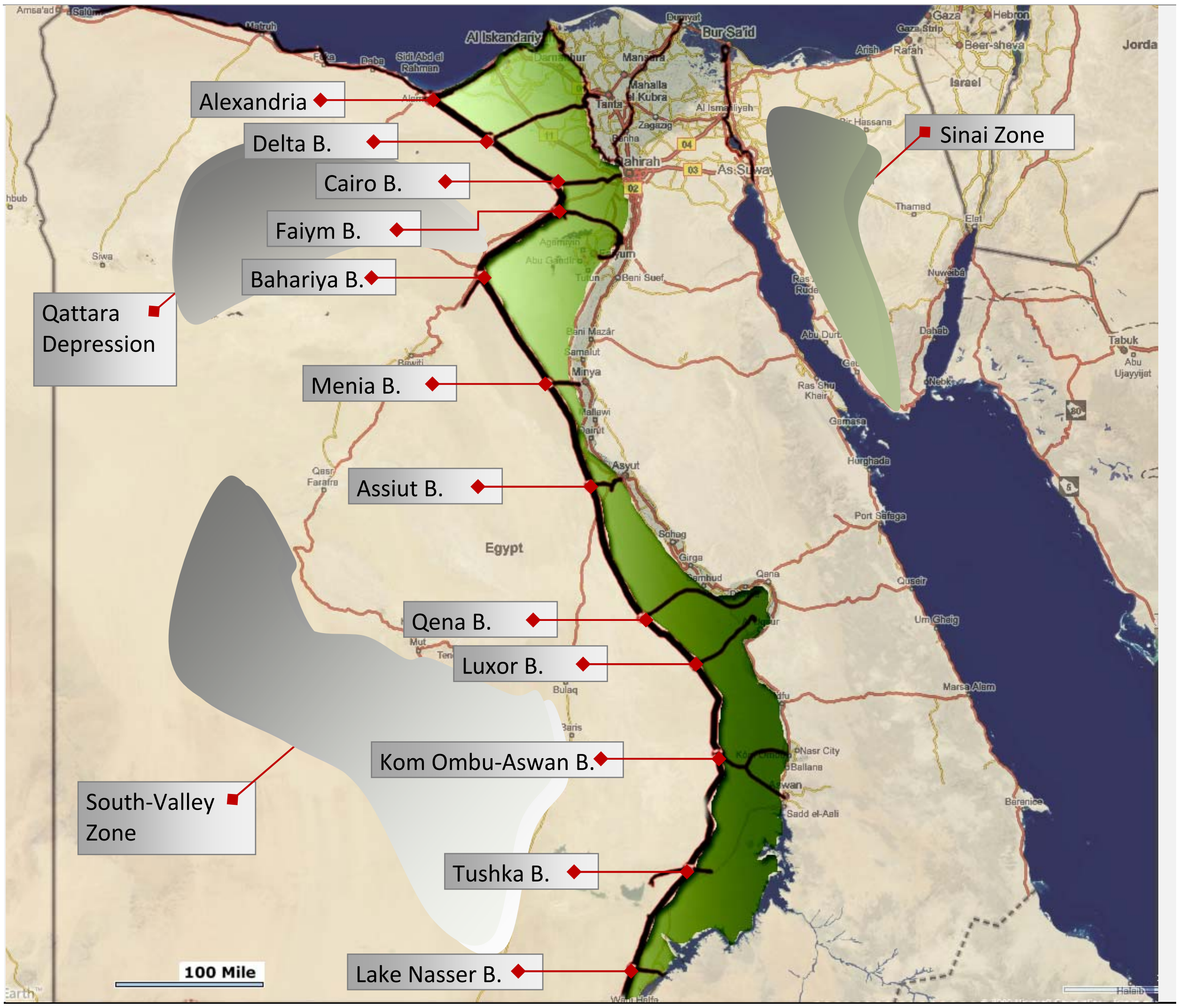



Fig: 3-16 **Main Development Corridor Branches and other Selected Sites.**

**Source:** Data Processed form: **Google Maps**, **El-Baz**. " *Development Corridor, Securing a better Future for Egypt*" ( Cairo, El Aain publishing, 2007).

[1] El-Baz. " *Development Corridor; Securing a Better Future for Egypt* " ( Cairo, El Aain publishing, 2007).

[2] **Ministry of Economic Development**, Annual Reports "*Development Corridor*" December 2008.

## 3-1 OVERVIEW

This concept presented by the significant geological scientist Prof. Farouk El Baz, advances the case for a proposed superhighway west of the Nile from the Mediterranean Sea coastline to Lake Nasser. The proposal would provide numerous opportunities for the development of new communities, agriculture, industry, trade and tourism around a 2,000 km strip of the Western Desert; it represents the best possible use of one of Egypt's natural resources, (Figure 3-17)

### 3-1.1 Proposal Specification

#### a. North-South Highway,

The main highway runs parallel to the Nile River from Egypt's Mediterranean Sea coastline to its border with Sudan. Its distance from the Western scarp of the Nile Valley varies from 30 to 80 kilometers, based on the nature of the crossed land. It begins at a point between Alexandria and El-Alamein. The proposal also suggests an advanced port to serve future needs of import and export, as well as increased trade with Europe and the expansion of maritime transport worldwide. In the meantime, the northern branch of the superhighway extends to Alexandria and its present port and airport and eastward through the Nile Delta coastal highway to Rosetta and Damietta.[1]

Near the terminal point, branches extend to Lake Nasser, Abu Simbel, and the Tushka depression, all regions that have promise in development of fisheries, tourism and agriculture, respectively. (Figure 3-17)

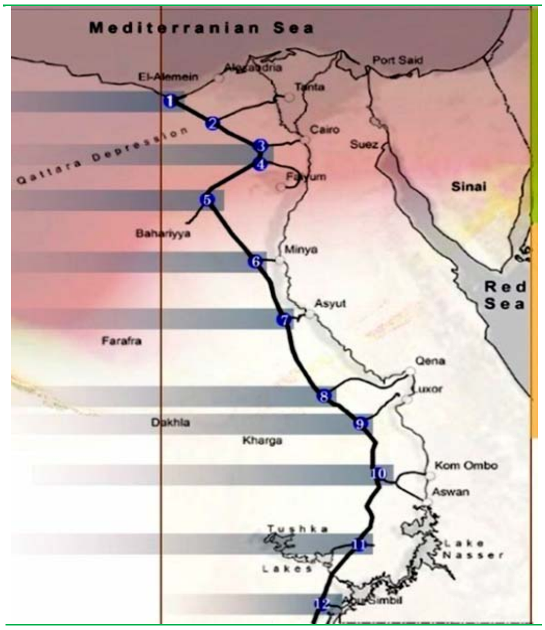



Fig. 3-17 **Developmental Corridor axes and the twelve connection roads to dens centres**
**Source:** Processed from**, El-Baz**, F., "*Development Corridor; Securing a Better Future for Egypt*" (Cairo, El Aain publishing, 2007) p. 40.

#### b. Modern Railway,

Egypt's railroads are very old and their tracks are laid on relatively soft soils that do not allow fast movement by heavy loads. Thus, the need exists for an advanced railroad system to serve present and future requirements of development. A rail- track parallel to the superhighway would serve that purpose. If deemed necessary, connecting tracks could be establishing along some of the east-west road branches in the future. The railway could serve many existing projects. For Example, the aluminum manufacturing plant at Nag Hammadi -west of Qena- that needs the new railway to abbreviate the process of row material and production transition form and to the Alexandria.[2]

The superhighway ends at the southern border of Egypt. But, the railroad that connects Wadi Halfa to the rest of eastern Sudan would facilitate transport between Egypt and the main cities and towns of Sudan to allow better positive ground links impact on the economies of both countries.[3]

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[1] Processed from**, El-Baz**, F., "*Development Corridor; Securing a Better Future for Egypt*"(Cairo, El Aain publishing, 2007) p. 8.
[2] Ibid, p.9
[3] **MED** , report" *Developmental Corridor Project: Initial Studies* ", Cairo, retrieved April 15, 2009, from http://www.mop.gov.eg/under.html

## c. Water Pipeline,

No development could be assured without the presence of freshwater. Even though several areas along the path of the superhighway promise the existence of groundwater, a pipeline of fresh water from the Toshka Canal is required to run the length of the superhighway. (Figure 3-18)

The length of the required pipeline is about 1,100 km and 1 meter in diameter. It would provide the necessary resources for human consumption during the early phases of the project. This is of-course less than half that of the Great Man-Made River system in Libya -with a total length of more than 2,000 km- using complicated network system. [1]

*Prof. El Baz suggest:s* using of the nature topographic gradient of Egypt's land – that declined towards north- to pumping the water from the Toshka canal up to the plateau for approximately 300 meters, and let water flow-down in the pipeline without any need for energy, but might be usable to produce mechanical energy that can be converted to electricity. *Agricultural and industrial* development activities would be supplied either by groundwater resources or subsidiary canals from the Nile.

* Needed Water quantity and resources, has been the main barrier for the project viability. The research proposed the using of renewable energy systems, particularly solar energy to supply fresh water by using desalination and pumping systems for irrigation activities.

## d. Electricity Line,

Initial phases of the proposed project require energy for lighting, and refrigeration. Therefore, a line to supply electricity is one of the requirements of the project. The required power can be supplied by any one of the generation plants along the Nile Valley as deemed appropriate.

Urban communities, industrial plants and agricultural farms to be initiated along the east- west branches should be encouraged to utilize solar and/or wind energy resources as much as possible. This encouragement can be in the form of tax breaks or grants from the Egyptian Government or international environmental agencies. (Figure 3-18).

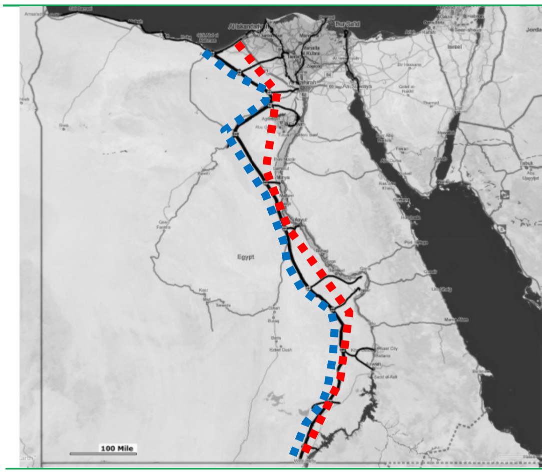



Fig. 3-18 **Identical visions for developing the Western Desert through erecting high speed Modern Railway**

**Source:** **Rageh**, A., *"Egyptian Urbanism; Egypt 2020; Surveying of Egyptian Urban Development in 20 century and futuristic prediction up to 2020 -First Handbook"* (Cairo: Academic Book, 2007). Annex 2, p. 19.

The Egyptian government delayed the implementation of the electricity line for long-term stages, as a result its high costs. This case makes the potential of using Solar Energy applications more available in the future.[2]

## e. East-West Connectors,[3]

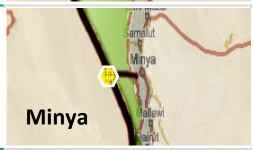
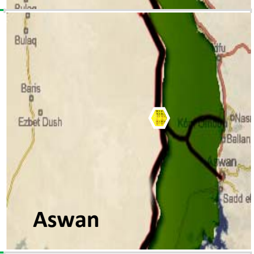
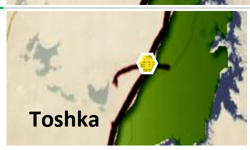
Branches of the main highway oriented in a roughly east-west direction would connect it to the main centers of population. They assure easy transport between the main cities of Egypt and between the main production areas and the outside world. Such branches may include the following in (Table 3-9 )

[1] Processed from, **El-Baz**, F., "*Development Corridor; Securing a Better Future for Egypt*"(Cairo, El Aain publishing, 2007) p. 10.

[2] **MED** (Ministry of Economic Development-Egypt ), report" *Developmental Corridor Project: Initial Studies* ", Cairo, retrieved April 15, 2009, from http://www.mop.gov.eg/under.html

[3] Ibid, p.12.

**TABLE 3-9** — **Proposed Activities in the Twelve Axes in 2050.**

| AXES Names | NOTES | Zone |
|---|---|---|
| **Alexandria** Axis | *This branch connects the main N-S highway to the road leading to Alexandria, and leading to the northern cities and towns of the Nile Delta coastal zone.* |  |
| **Tanta (Delta)** Axis | *This connects the superhighway with the heart of the Nile Delta, to diminish the transmitted density inside Tanta and limit encroachment in the fertile land of delta. This would assure better links between the Delta and the rest of Egypt and the outside world.* |  |
| **Cairo** Axis | *This branch connects the superhighway with the Cairo-Alexandria road. It is envisioned to link it with upgraded roads leading to Maadi and eastward to Suez. This would allow the use of cargo land transport between Alexandria and Suez.* |  |
| **Al-Faiyum** Axis | *This connector would allow the development of the desert north of the Faiyum depression by establishing sites for tourism, new communities, agricultural areas, and industries.* |  |
| **El Wahat El Bahariya** Axis | *This branch improves the existing road to the Bahariya Oasis as a northern link to the New Valley Province to the south. It would also allow further development of the natural resources of the Bahariya depression including the iron ore deposits.* |  |
| **Al Minya** Axis | *The city of Minya has been one of the major population centers from ancient times. Minya has a university and can generate numerous avenues for local and regional development if it is better connected to the national market.* |  |
| **Assuit** Axis | *This case is identical to that of Minya in all aspects. In addition, Assiut has an airport that could be upgraded for civilian transport. There are also a viability to upgrade the roads that connected to New Valley Governorate, and connecting the Nile Valley and the oases of Darfur in northwestern Sudan.* |  |
| **Qena** Axis | *This connector would open for agricultural development a vast area south of the Nile. This plain represents fan deposits of streams during wetter climates in the past; therefore, groundwater resources would potentially underlie it.* |  |
| **Luxor** Axis | *This branch would allow unlimited growth of tourism and recreation on the plateau that overlooks the largest concentration of ancient Egyptian archaeological sites.* |  |
| **Kom Ombu-Aswan** Axis | *Like the Qena Branch, the Kom Ombu segment opens up a vast tract of fertile land west of the Nile for reclamation. The region once hosted the channel of the Nile, it revealed by radar images from space. This makes it an excellent location for the expansion of agriculture the west. The Aswan segment; connects the superhighway to the city's transport of products with the holistic region. It provides the expansion of winter recreation resorts and tourism near the many archaeological sites.* |  |
| **Toshka** Axis | *The superhighway goes through the northeastern edge of the Toshka depression, where a canal from Lake Nasser has created several lakes. The superhighway would provide all necessary mechanisms to transport people, material and products to and from the Toshka region.* |  |
| **Abo-Simple** (Lake Nasser) Axis | *This branch would develop the plentiful fishing activities of Lake Nasser and transported via the railroad to distribution centers throughout Egypt. The branch might also increase the potential use of Lake Nasser for eco-tourism.* |  |

Data Processed from, **El-Baz**, F., "*Development Corridor; Securing a Better Future for Egypt"* (Cairo, El Aain publishing, 2007) p. 20.

### 3-1.2 Project Benefits and Constituent

In of the present proposal, it is difficult to predict the drawbacks the environmental or socioeconomic points of view. This question can only be answered by feasibility studies. But, In the meantime, it is possible to list the benefits and the most highlighted criticism of the project, as appears in Table 3-10.

| TABLE 3-10 | | Project's Potential Benefits. |
|---|---|---|
| **Social Sector,** | | ▪ Creating hundreds of thousands of new jobs for Egyptian labor.<br>▪ Involving the population at large in the development of the country.<br>▪ Giving people, particularly the young, some hope for a better future.<br>▪ Focusing people's energy on productive and everlasting things to do. |
| **Economic Sectors,** | **Agriculture** | ▪ Opening new land for desert reclamation and the production of food.<br>▪ Planting and production of new organic Vegetation. |
| | **Industrial** | ▪ Establishing new areas for urban and industrial growth near large cities.<br>▪ Opening the door for new industries like Minerals industry, agriculture new irrigation technologies.<br>▪ Expansion in agricultural industries and Bio-Fuels industry. |
| | **Technological** | ▪ Using new technologies of renewable energy like Solar and wind energy.<br>▪ With mass-production of RE technology it provides technology transfer of Silicon technologies of Photovoltaic panels.<br>▪ Utilizing sustainable technologies for water desalination and heating systems. |
| **Development Sector,** | | ▪ It affords unlimited potential for new schools and training centers, industrial zones, trade centers, tourism; providing virgin territory for development initiatives in every field.<br>▪ Creating a physical environment for economic projects by the private sector.<br>▪ Connecting the Toshka region and its projects with the rest of the country.<br>▪ Creating new communities that absorbing the high-density centers population.<br>▪ Adoption of new RE project like VLS-PV proposal, solar community initiative, Zero-Energy sustainable Development. |
| **Environmental Sector,** | | ▪ Ending urban encroachment on agricultural land in the Nile Valley. Arresting environmental deterioration throughout the Nile Valley.<br>▪ Observing the desertification threats over the outskirts of Nile Delta.<br>▪ Agriculture activities could support the ECO-System of the desert. |
| **Energy Sector,** | | ▪ It adapted quietly with VLS-PV project proposal for Developing the Desert and generates Energy.<br>▪ Creating new energy plant fields for supporting the development rising.<br>▪ Utilization of renewable energy for electricity generate for remote areas. |
| **Tourism Sector,** | | ▪ Initiating new ventures in tourism and eco-tourism in the Western Desert. |
| **Services Sector,** | | ▪ Relieving the existing road network from heavy and dangerous transport.<br>▪ Creating facilitating new high standard transport Services Branch throughout Egypt. |
| | | **Points of Critique** |
| **Water Resources** | | ▪ In terms of water adequacy for the project compared with the water capacity of the River Nile.<br>▪ Using of strategic underground storage of water in the Western Desert. |
| **Feasibility Methodology** | | ▪ The methodology of implementation still facing the project confidence.<br>▪ Climatic barriers faced the new urban communities. |
| **Other** | | ▪ Project's environmental impacts on the desert sensitive nature. |

**Data processed by the researcher from: El-Baz.** Farouk, **Rashed**, Ahmed.,*" Development Corridor ; 2st Workshop"* ,Dept. of architecture, Mansoura University, Egypt.

## 3-1.2.1 Local Resources

The corridor enjoys a diverse land resources, mineral wealth, and tourist attracting features, besides to its unique locations beside every Egyptian Cities in the Nile valley, so it has combine various local resources by branch activities.[1] The local resources can be concluded as followings in (Table 3-11 );

**TABLE 3-11** **Supposed Economic Development Activities per Axis**

| AXES NAME | ACTIVITIES | (SE) Feasibility |
|---|---|---|
| **Alexandria** Axis | Agricultural activities ( fruits plants ) | - |
| **Tanta (Delta)** Axis | Agricultural expansion and domestic animals production | √ |
| **Al-Faiyum** Axis | Urban development, military activities, and Medical valley | √ |
| **El Wahat El Bahariya** Axis | Construction materials Industry, tourism, and urban Development | √ |
| **Al Minya** Axis | Industrial and agricultural Activities | √ |
| **Assuit** Axis | Agricultural and urban extensions | √ |
| **Qena** Axis | Agricultural and urban extensions | √ |
| **Luxor** Axis | International tourism development | - |
| **Kom Ombu- Aswan** Axis | Agricultural development based on ground water | - |
| **Toshka** Axis | Developing and completing recent Toshka project components | √ |
| **Abo-Simple** (Lake Nasser) Axis | Tourism Development and fishing resources ( Lake Nasser) | - |

*__Egyptian Government Studies:__*

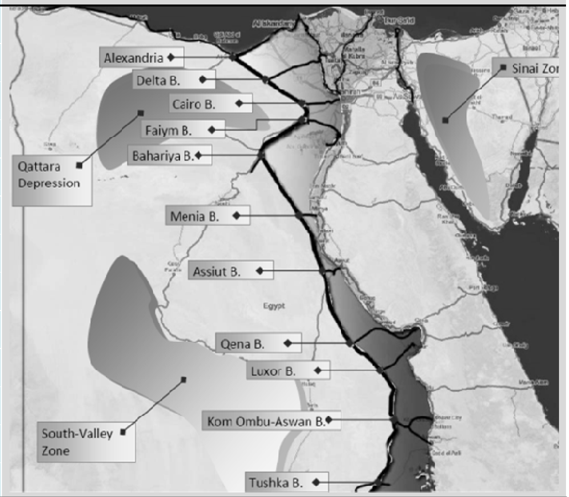
The studies that has been adopted by the council of Ministers, and carried out by The Ministry of Economic Development with the participation of (Urbanism and Housing, Tourism, Culture, and Irrigation ministry with the organization of new urban communities), presents the preliminary findings -without the total investment of the project — in a report that consists of 307 pages.

It is accepted the project feasibility with some modifications, especially on some horizontal axis road paths, and emphasized the feasibility of numerous industrial, agricultural activities with estimated investment 243, 8 billion pound, in addition with viability of 1,6 million acre for agricultural activities.[2] (Table 3-12).

**TABLE 3-12** **Studied Developmental Activities in Axes ( 2050).**

| AXES NAME | Industry | Agricultural& Reclamation | Total % |
|---|---|---|---|
| **Alexandria** Axis | 20,4 | 3,5 | 23,9 |
| **Tanta (Delta)** Axis | 7,2 | 9,3 | 16,5 |
| **Al-Faiyum** Axis | 20,5 | - | 20,5 |
| **Cairo** Axis | 12,0 | 3,1 | 15,1 |
| **El Wahat El Bahariya** | 28,2 | 0,7 | 28,9 |
| **Al Minya** Axis | 10,8 | - | 10,8 |
| **Assuit** Axis | 20,7 | 1,9 | 22,6 |
| **Qena** Axis | 17,5 | 1,4 | 18,9 |
| **Luxor** Axis | 10,7 | - | 10,7 |
| **Kom Ombu- Aswan** | 21,3 | 10,3 | 31,6 |
| Toshka Axis | 11,0 | 11,0 | 22,0 |
| **Abo-Simple** -Nasser | 22,3 | - | 22,3 |
| **Total** | 202,6 | 41,2 | 243,8 |
| **Percentage** | **83 %** | **17 %** | **100 %** |

**The Developmental Corridor Path**




[1] **MED** (Ministry of Economic Development-Egypt ), report" *Developmental Corridor Project: Initial Studies* ", Cairo, retrieved April 15, 2009, from http://www.mop.gov.eg/under.html

[2] Ibid.

## 3-1.3 *Method of Execution*

After thinking about the costs and feasibility studies, it has to mention the role of the *National supports*, the main motivate of every decision, it requires involves of scientists, young, university students, high-school students in the study, evaluation aspects, and processes of it as a "National Project". The project's scope and the variety of its benefits suggest that it can best be accomplished by the private sector- local, regional and international investors. That would not represent a burden to the Egyptian Government. Naturally, this would require a vigorous and well though-out marketing campaign. (Figure 3-19)

A private sector organization could afford the former characteristics of the superhighway, to manage the road and its maintenance. It would be responsible for operating the toll stations, providing emergency services, and maintaining the utility of the superhighway. Naturally, such an organization requires a specific mandate and clear laws and regulations by the Egyptian Parliament to assure the safety and utility of the highway while placing limits on excessive government regulations or company profits.[1]

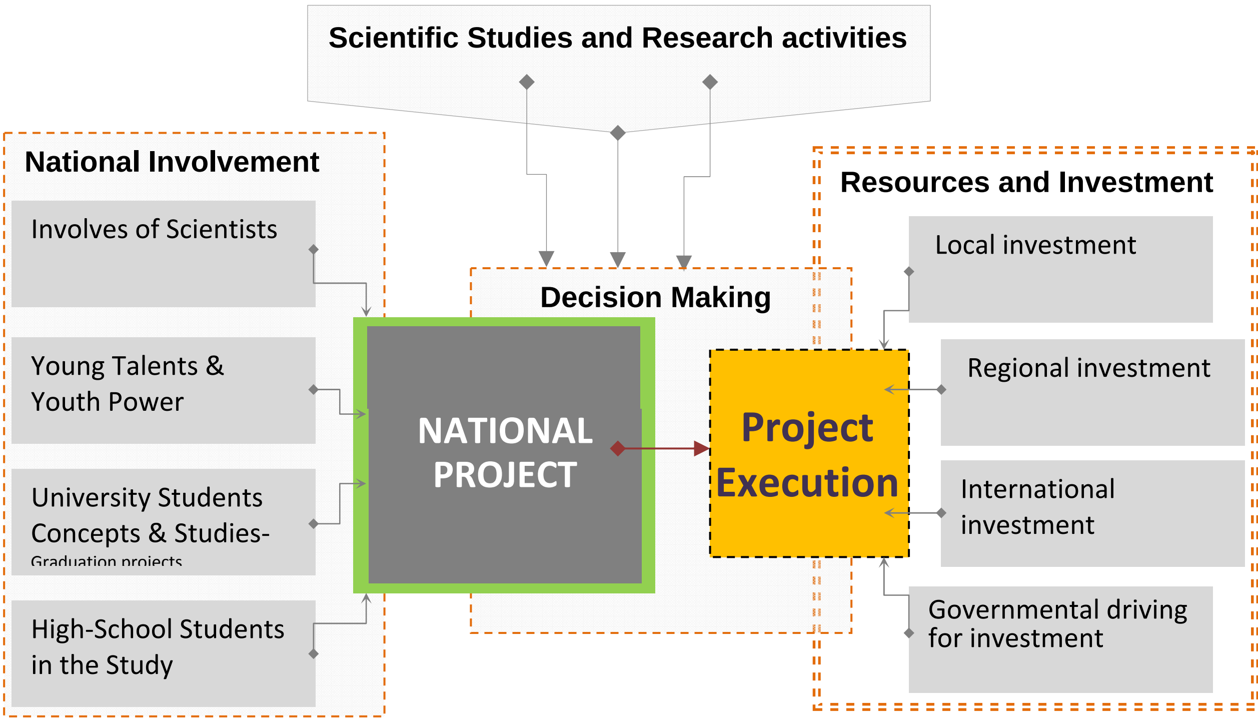



Fig. 3-19 **The Desired National Involvement for Making El Baz's Proposal as a "National Project" and Supporting The Project Execution Through Local, Regional, and International Investment. Source**: data processed by the Author from: **El-Baz**, F., *"Development Corridor; Securing a Better Future for Egypt"* p. 50.

***Architecture Department of Mansoura:*** Institutional Initiative

It is worth mentioning the initiative of the Department of Architectural Engineering at Mansoura University, which adopted studies through the title "Egypt, the Future" which was the main theme under which numerous **Graduation Projects** have been produced since the Academic Year 2005/2006, and the "Developmental Corridor" through the academic year 2006 to 2008. As a parallel effort in R&D, the **ESU 95% Lab** (Egyptian 95% Sustainable Urbanism Laboratory) was launched as a scientific research group. They helped develop the findings and data and share the results and outputs with interested governmental parties and private sectors that showed interest in Dr. El-Baz proposal.

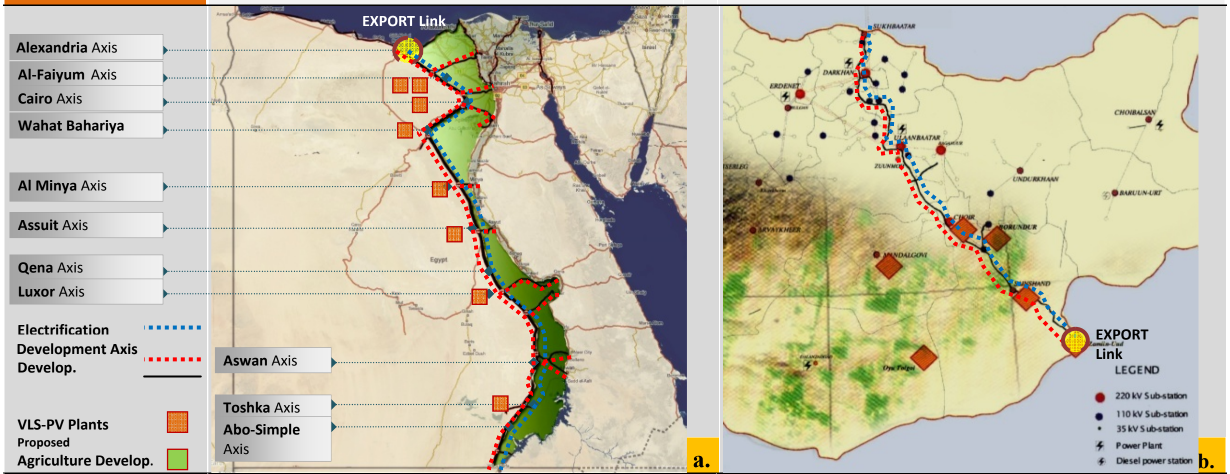
[1] Processed from, **El-Baz**, F., "*Development Corridor; Securing a Better Future for Egypt*"(Cairo, El Aain publishing, 2007) p. 50.

## 3-2 *EXAMINING SOLAR ENERGY APPLICATIONS ( VLS-PV)*

**Table 3-13**, discusses the identical components of the Egyptian Development Corridor and the structure of recent VLS-PV utilization in magnolia desert (Table 3-11.b). This experiment indicates the feasibility of the Egyptian strategic vision of combining the VLS-PV concept with methodology for developing the proposed agriculture desert regions in the Development Corridor.

**TABLE 3-13** **Identical Issues of the Proposed VLS-PV Project in Mangole Desert and Developmental Corridor in Egypt.**

| ANALYTICAL STUDY | The Egyptian Case **"Developmental Corridor"** | The Mangole Case **The Proposed VLS-PV Project** |
|---|---|---|




| ANALYTICAL STUDY | The Egyptian Case "Developmental Corridor" | The Mangole Case The Proposed VLS-PV Project |
|---|---|---|
| **Desert Nature** | ▪ Consists of multi-type of deserts (plain- depression- valleys- Great sandy desert ) | ▪ Consists of vast semi-desert and desert plains, mountains, and the Gobi desert. |
| **Climate** | ▪ Formed multi-type of climates (Mediterranean zone- semi-arid – arid – desert zone) | ▪ Desert climate, continental (large daily and seasonal temperature ranges), and cool and dry. |
| **Population** | ▪ Prospected to attract 25% of the Egypt's population; approximately 17-20 million | ▪ Recently; is approx. **2,5 million in 2003**, with **1,5 million** in settled urban areas |
| **Transmission line** | ▪ Through ***railway*** or ***North-south highway***; the main feed for the corridor developmental axes | ▪ Through ***Railway***, that plays a very important role in Magnolia economy |
| **Activities (GDP)** | ▪ ***Studied activities***: Agricultural expansion and domestic animals production, Urban development, military activities, Medical valley, Construction materials Industry, urban Development, International tourism, fishing resources | ▪ Wholesale and retail trade; agriculture, hunting and forestry; transport, storage and communication, mining and quarrying; and manufacturing. |
| **Energy** | ▪ ***Electrification***: the proposed expansion of North-South national grid, natural gas resources, and renewable energies. | ▪ ***Electrification***: beside the main power grid (1/3 Exported from Russia) utilization of VLS-PV electrification system |
| **Rural Areas** | ▪ Rural areas not connected with these energy systems have publicly operated diesel power stations | ▪ Rural areas not connected with these energy systems have publicly operated diesel power stations |
| **Agricultural land** | ▪ Viability of ***1,6 million*** acre for reclamation and agricultural activities | ▪ The research group detected vast agriculture activities areas using satellite mapping |

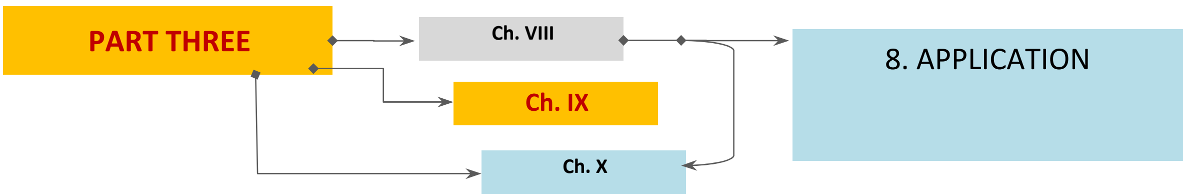
Data processed by the author from: **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems",* (London: EarthScan, 2007), p. 85. Egyptian government, **Ministry of Economic;** Report " *Developmental Corridor*"

# CHAPTER

# IX

**APPLICATION** OF **VLS-PV**

IN THE EGYPTIAN DESERT



# Chapter IX: APPLICATION OF VLS-PV IN THE EGYPTIAN DESERT

Through Chapter IX, the proposal "Developing the Egyptian Desert by Silicon Technology " introduced through the main aim of the research for developing the Egyptian desert with new communities utilizing and producing energy from solar technologies — VLS-PV systems using Silicon Technology — integrated with other available local renewable energies. Through *THE APPENDICES* the author introduces the proposal "Green **Mines Community -GrMC**" as part of other research activities regarding the application, the proposal still under research and development, and highlighted to improve value of the research application through a specific research theme with Architecture Dept.'s Unit **" ESU 95% "**.

The proposal "**DESERT REGION COMMUNITY DEVELOPMENT**" has been discussed by the research group of the project (VLS-PV) and introduced it through the book "**Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems**". The following issues are researched and investigated by the VLS-PV's research team for developing and constructing a new concept of integrated renewable energy technology and photovoltaic (PV) generation, installed in arid regions or desert with agricultural technology.[1]

- The possibility of utilizing VLS-PV in desert areas;
- A sustainable scenario for installing VLS-PV systems;
- Modeling of a sustainable society with solar photovoltaic generation and greening in the desert.
- The use of solar PV generation with regard to element technology/system for sustainable agriculture;
- Sustainable agriculture utilizing other regional renewable energy options;
- Desertification issues;
- The effects of VLS-PV in the location environment.

## 1 VLS-PV FRAMEWORK

The VLS-PV scheme recommended the sustainable development criteria for any proposed community in desert using the project vision.

Figure 3-20; shows a recommended Diagram for achieving sustainability in the Egyptian new urban desert communities. The diagram is processed by the author, for adapting the aims of developing a new desert community in the Egyptian Desert, and discusses the main issues to form a cohesive community adapted with the desert conditions.

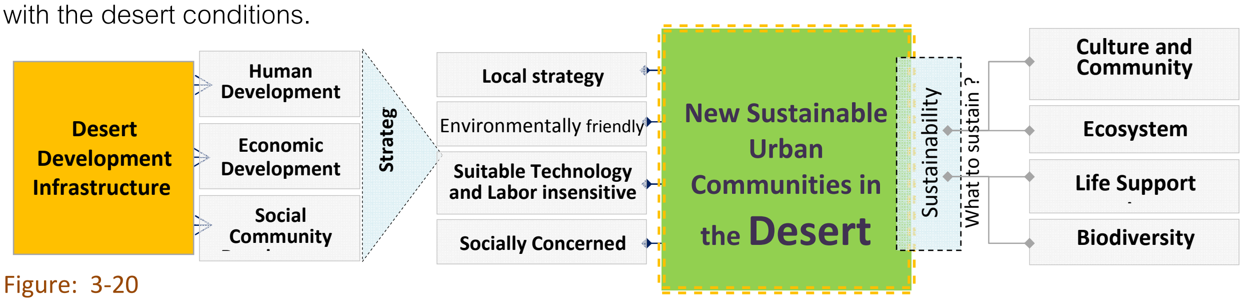



Figure: 3-20

**Targeted Points for Achieving Sustainability within application VLS-PV in the Egyptian Desert.**

**Source:** data Processed by author from; **Hitchcock**, D., *"Transition to Sustainable Development: is this about planning?"* Proceedings of the American Planning Association conference, 1997.

[1] **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems"*, (London: EarthScan, 2007), p. 85.

Based on national studies conducted to determine the successful community models for Egypt, numerous types of proposed community that are able to collaborate on agriculture and technology have been recommended. The following types are particularly recommended by the VLS-PV Research Group - Tokyo University of agriculture and Technology- for the deserts, and the research selected the following types of community as convenient cases for the Egyptian cases.[1] (Table 3-14)

**TABLE 3-14** **Summery of Community Proposed through VLS-PV Studies**

| AXES NAME | RE | Battery | Agriculture; greening | Grid-connected | Stable electricity | Salt-damage land | Ground water | Living people | Electricity Demand |
|---|---|---|---|---|---|---|---|---|---|
| *Collaborating On Agriculture &Technology* | A | A | A | A | A | **N.A.** | A | A | Community ;City |
| *Economically Sustainable Community;* | A | **N.A.** | A | A | A | **N.A.** | A | A | Community ;City |
| *Self-Supporting Community*. | A | **N.A.** | A | A | **N.A.** | **N.A.** | A | A | Community ;City |

Data processed from : **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems",* (London: EarthScan, 2007), p. 85.

## 2 PROPOSED DESERT COMMUNITY STRUCTURE

The application "*VLS-PV in the Egyptian Desert*" discusses the development of the desert by utilizing the potentials of reclamation for regions located on the Delta's borders, hinterlands, and suitable desert sites for agricultural activities, which the fertile lands in desert zones, and through the regions in Developmental Corridor axes. (Figure 3- 21)

*The concept was built upon the following themes;*

(1) Development of reclamation regions in the desert;

(2) Agricultural-based development;

(3) Combined utilization of renewable energy (bio-fuels and solar energy in particular);

(4) Adoption of VLS-PV systems in the holistic design; and

(5) Creation of new self-sufficient community in the desert with electrical export potentials.[2]

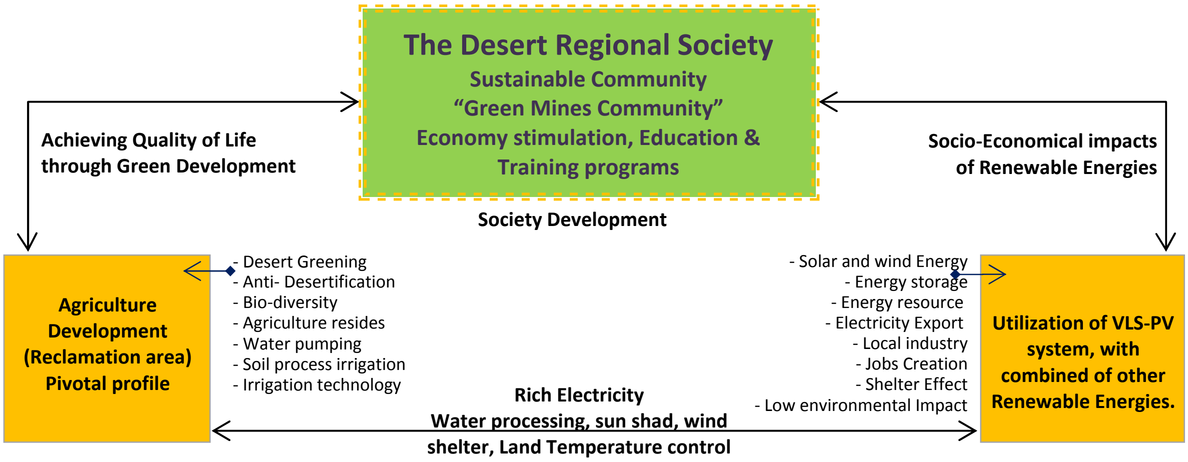



Figure: 3-21

**Framework of Egyptian desert development; adapted to VLS-PV research studies.**

[1] **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ," *Energy from the Desert: Practical Proposal for Very Large Scale Photovoltaic Systems",* (London: EarthScan, 2007), p. 85.

[2] **Sudany**, M. Research Project " ESU 95% Lab; Green Mines Community" (ESU Lab., Mansoura University, Egypt, 2008 )retrieved May 1, 2009, from: http://dsites.mansouraarc.net/

# 3 GUIDELINES TO DESERT STUDIES

TABLE 3-15 introduces an analytical study for *VLS-PV Application in the Egypt*, throughout the Desert's types, site, and climatic conditions. It also forms the design concept and main guidelines of a self-sufficient dwelling, as part of utilization of solar Photovoltaics technology and integrating with the proposed desert community using VLS-PV application.

**TABLE 3-15** **Analytical Study for Desert Regions and Decision –Making Processes to Form the Dwelling Concept.**

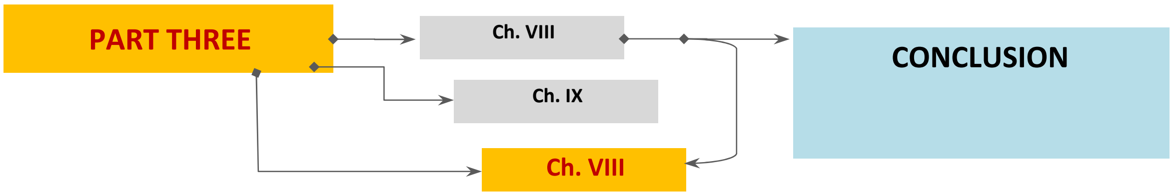
| ANALYTICAL STUDY | Development Types | Strategy | |
|---|---|---|---|
| **Desert Development** | ✓ *Desert hinterland regions* | ▪ *Extension spaces for agriculture activities and urban development.* | |
| | ✓ *Remote Areas* | ▪ *Problems > transportation- high Energy coast- low tech- hard climate- low population- lacking of social services.* | |
| **Desert Climate** | ✓ *Arid Desert* | | |
| | ✓ *These climate prevails on the western sides of land masses 'between 20-25° N and S (extremes 15-30 °N and S) -Two seasons; hot and some what cooler period - Vegetation extremely sparse cactus* | | |
| | ✓ *Semi-arid deserts* | | |
| | ✓ *Long dry season and a short rainy season during summer. As rain is in hottest months when evaporation is at maximum it is not very effective for plant growth.* ✓ *Variable annual rainfall In winter months which Is more, effective for plant growth.* | | |
| *** Temp.-Humidity - Rain –Sky - wind** | *Temp. 45°-50° in shade in summer and 20-30 ° in winter- Night; 25 ° in summer and 10-20 ° in winter - Humidity is low ,RH is 20%in afternoon &40% in night- Rains are few – sky without cloud – high solar irradiation- storms.* | | |
| **Kinds of Desert** | ▪ Sand Desert ▪ Rock Desert | ✓ *Gravel Desert* | ▪ Salt Desert |
| | *Gravel desert >> is consist of small rocks, a few plants exist. Also is the hest area to install PV systems and agriculture activities, because lowest sand dune and sand storm cause minimum damage,* | | |
| **THE PROJECT VISION** | | | |
| **The Site** | ✓ *Desert hinterland regions >* | ✓ *Combined with On-Grid urban systems* | ✓ *Expansion of agriculture and urban capitals* |
| | ✓ *Remote System (Stand-alone >* | ✓ *Rural development regions* | ✓ *New community* |
| **The Activities** | ✓ *Agriculture activities* | ✓ *Housing and Urban Develop.* | ✓ *Industrial Activities* |
| | ✓ *Energy Industries (PV sys.)* | ✓ *Tourist activities* | ✓ *Camps for research act.* |
| **Energy type** | ✓ *Solar energy > for industrial, Agriculture, energy industry, Housing, and Urban development act.* | ✓ *Biomass energy > for Agriculture activities.* | ✓ *Wind energy > for energy generating activities.* |
| **Energy system** | ✓ *for > Desert Hinterland Regions* | ✓ Solar energy units | ✓ *Biomass* energy |
| | ✓ *for > Remote systems* | ✓ PV - *thermal* gen. Fields & units. ✓ *Wind gen.* *fields*. | ✓ *Biomass* ***energy*** > for *Agriculture* activities. |
| **Building analysis** | ✓ *Outer Envelop* | ✓ ***high*** *resistance* with hard conditions | ✓ *Harmony* with ambient |
| | ✓ *Inner Envelop* | ✓ *Passive* Cooling tools | ✓ *Energy* Saving |
| | ✓ *Construction system* | ✓ *Earth*-Sheltered const. Technique | ✓ *Recycled* and recyclable materials |
| | ✓ *SELF- SUFFICIENT UNITS* | ✓ Energy generation | ✓ *Smart construction* Unit. |

**Source:** **Kurokawa**, K. **Keiici**. **Vleuten**. **Faiman**. ," *Energy from the Desert", appendix A, p.* 120. **Al-Hagla ,K.** " *Sustainable Development in Desert Settlements, an Ecological Approach*" PhD.( Alexandria, 2000) p. 5-5. **Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009.

# CHAPTER

# X

## CONCLUSION & RECOMMENDATIONS



# Chapter X CONCLUSION& RECOMMENDATIONS

It is evident that the means of sustainability affects in different ways in our thinking and recent global trends. in this sense, sustainable development is one of the main issues related the achievement of sustainability principles. The scope of this research is to discuss one of the globalized issues that are “Energy” and “sustainable development”, these issues has a crucial relationship and effects dramatically at all on Earth Environment. Energy is clearly linked to economic development and environmental quality, it is central to world economy, providing the power needed for industrial production, agriculture, transportation, and increasingly urbanization.

Urban development, Urbanization and the rapid expansion of cities throughout the late 19th and the 20th centuries was a direct outcome of the fossil fuel economy. Today, the growth and operation of cities and urbanized areas absorbs roughly ***three-quarters*** of the world's fossil fuel production. This is a staggering amount given that fossil fuels supply 85% of total global commercial energy use – and their use is increasing at a rapid rate. Economic regions, nations and cities worldwide will soon be under great pressure to find alternative sources.[1]

***Renewable Energy*** forecasting scenarios of energy in entire twenty-first century; was not only the main guide for the recent global trends towards renewable energy, the fact that the depletion of fossil fuels and its environmental consequences is also considered. The last summit of the greatest eight industrialized countries in July 2009; recommends the rapid development and utilizations of renewable energy’s Researching and Development (R&D) and its applications regarding the reduction of CO2 emissions to 50% by the year 2020. Consequently, Egypt announced immediately, promotion and developing ***new thousand acres for renewable energy*** applications in Suez Canal region, In additions, the projected solar Photovoltaic plant uses efficient PV modules( Concentrator Tech.) in western desert . Hereby, it demonstrates ***the serious strides towards the development and utilization of RE in Egypt***.

***Solar Silicon Technology,*** Silicon technology demonstrates its merits to be such **more efficient semi-conductor material** for mass production manufacturing of solar photovoltaic modules, the recent efforts for developing new semi-conductor material still under **R&D stage**. Numerous scientists recommended the existence of silicon photovoltaic technology for 30-50 years at minimum, and researches for developing Nano-Silicon technology are demonstrated now.

The proposal VLS-PV recommends the utilization of **PV silicon panels** - Flat-Plate PV modules uses polycrystalline silicon technology - for developing electricity production and new sustainable communities in world’s desert especially in developing countries. Consequently, through developing the local manufacture of silicon photovoltaic technology for providing technology transfer and mass production technologies, which are expected to be an economically feasible option for installing large central solar electric generation plants.

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[1] **Droege**, P. *Renewable Energy and the City: Urban life in an age of fossil fuel depletion and climate change*, (Japan: Institute for Global Environmental Strategies, 2002),1.

The fact, which demonstrates also the availability ***for developing and urbanizing the Egyptian Desert by Silicon Technology***, of course without neglecting the importance for developing industrial, economic, institutional, and social infrastructure and constituents in selected region in Egypt.

***Solar Cities,*** the research presenting numerous practical, successful, and implemented examples arises the development and implementation of solar initiatives – using Building Integrated Photovoltaics (BIPV) and passive solar systems – as ; Amersfoort – solar village - and Pichling- Linz – Solar city- the projects that helps the research for draw out main objectives, urban considerations, implementation stages, energy policy, Financing mechanism , learned lessons and finally extracting the **Design Criteria.** Masdar city involves with new cohesive concept regarding the principles of sustainability and zero-Energy, which adding newest horizon for low-energy consumption to Zero. While **Rural Development**, emphasized the important role of national governmental and non- governmental organizations for supporting UNDP activities and programs in rural development concerning health and reduction of CO2 emissions.

Accordingly, the research concludes the ***availability for programs, experiences, and Financing mechanisms*** for developing the utilization of Solar Photovoltaic technology in rural and remote area in Egypt.

***Egyptian Desert development,*** Settling the desert has long been an Egyptian dream. Dictated by the population needs, future hopes, and a broader vision for a better life, desert development has widely been considered a national goal. Redistribution of population over 95% of abandons desert lands still existed. But, developmental scenarios and activities needs also to new visions, concepts, approaching and new developmental ideology. Farouk El-Baz proposal "***Developmental Corridor***" provides such these principles and the project introduces new horizons for studying and developing it, through impressive national framework attaching the importance of national scientific studies, which is the thesis considered one of these scientific research efforts. As in **(Fig 3-19/ page 142)**

The research demonstrates the potentials for using VLS-PV – as practical project- in the Egyptian developmental activities and scenarios, through the discussion and **identical study of VLS-PV Project in Mangole Desert and Developmental Corridor in Egyptian case**.

***Case Study,*** Examining the potentials for applying solar energy Photovoltaic technology in the Egyptian regions demonstrates the availability of using it whether, through the proposal VLS-PV in the Egyptian desert or in new urban communities as the new urban sites of Suez Canal regions. The Examination of Sues Canal region and the selection of ***El-Mosta'ble City as a case study***, provides a scientific study for examining the efficiency and potentials for developing such these existed social complex to be sustainable, healthy, Self- dependence on clean energy, friendly to the environment, and Zero-emission and energy in the Future.

The findings of the study demonstrates the importance for considering and combining of such these future sustainable applications and energy systems ***through the recent developmental, Urbanize, architectural, and Design processes***, to permit the effective integrations and installations of Photovoltaic systems through the Medium/Long-term for developing such these regions by using renewable energy.

***The Application of VLS-PV in the Egyptian Desert,*** introduced as an applicable framework for developing the Egyptian desert through new Agricultural –technological communities. The integration of VLS-PV proposal and BIPV systems in new community and through the developmental scenario *"Developmental Corridor"* emphasis the strategic role of solar applications for adding new horizon for Egyptian desert development. (Fig 3-21/ page 146)

The proposal VLS-PV community, offers new concept for integrate and supporting the Egyptian developmental scenarios with technological, developmental, urban, and architectural studies discussing the using of renewable energy for developing the ***new agricultural desert regions to be socio-economic, self-sufficient, sustainable, and producer of energy***.

# RECOMMENDATIONS

A cohesive concept combining the international visions for developing the desert with the corresponding national strategic plan is presented. The proposal VLS-PV Community is a visional and feasible community — still in the R&D stages — a model that embodies the authors' vision structure, functions, and resources. The key finding and recommendations of the research are as follows:

- Utilization of renewable energy and solar energy in particular, whether in large or small scale, provides sustainable frame for the new urban communities in the desert.
- Developing the Egyptian desert needs more innovative visions, studies, and developing of creative thoughts and concepts to make it possible.
- The integration between architectural and developmental visions is a necessity to create sustainable communities in desert regions.
- Obstacles for developing the Egyptian desert can be overcome by fulfillment of the scientific methodology, developmental; not conquering thinking, and national, provincial, political, economic, commercial, cultural and societal ambitions.
- The importance of achieving the vision of VLS-PV system within the overall developmental, urban, and architectural framework, to insure the feasibility and dissemination of PV technology; especially for desert communities.
- Sustaining VLS-PV vision with urban and architectural studies will make the proposal more available to as many architects and developers as possible. Therefore, they will be able to pose sustainable and futuristic visions of VLS-PV upon the future designated communities.

# FURTHER STUDIES

Studying the using solar energy applications in the world's desert, provides a wide-range of studies related this hole issue. Through the research numerous of this issues has discussed — whether in details or through overview — the further studies of the research will discuss the following issues;

- *Discussing the visions of the futuristic urban communities in world's desert;*
- *Discussing the framework, structure, and form of future solar cities' planning systems, construction methods, techniques, and environmental design.*
- *Studying and modeling of solar dwellings placed in the desert regions.*

On other hand, the author will study the proposal "Green Mines Community (GrMC)" through further activities and funded research projects for examining the availability of such concept for developing new forms of desert communities, and embody the findings of the thesis through scientific and practical model. The following issues will also consider through the next studies;

- *GrMC planning & Infrastructure.*
- *GrMC's Unit Details and Materials.*

# APPENDICES

**Appendix 1: Sizing Stand-alone Housing Unit; using PV System.**

**Appendix 2: The Proposal** “Green Mines Community” (GrMC)
for Desert Development.

# APPENDIX 1

## The Proposal "Green Mines Community "(GrMC) for Desert Development.

**The Proposal** is determined to study the major potential approaches for developing the Egyptian desert. In collaborative effort with research team of ESU 95% LAB , this study mainly stems from theoretical studies carried out by the author through the *Thesis,* conducted *academic research,* and *submitted entries* at several environmental architectural competitions. Through all these contributions, solar energy applications in urban development have been mainly focused, and major international experiments studied to draw out practical criteria to pave the way for the Egyptian desert to be home to new communities and future generations.

The application GrMC, offers new concept for integrate and supporting the Egyptian developmental scenarios with technological, developmental, urban, and architectural studies discussing the using of renewable energy for developing the *new agricultural desert regions to be socio-economic, self-sufficient, sustainable, and producer of energy*.

The proposal Green Mines Community (GrMC) introduced as an applicable proposal for developing the Egyptian desert through new Agricultural –technological communities. The integrations of VLS-PV proposal and BIPV systems in GrMC proposal and through the developmental scenario " *Developmental Corridor*" emphasis the strategic role of solar applications for adding new horizon for Egyptian desert development.

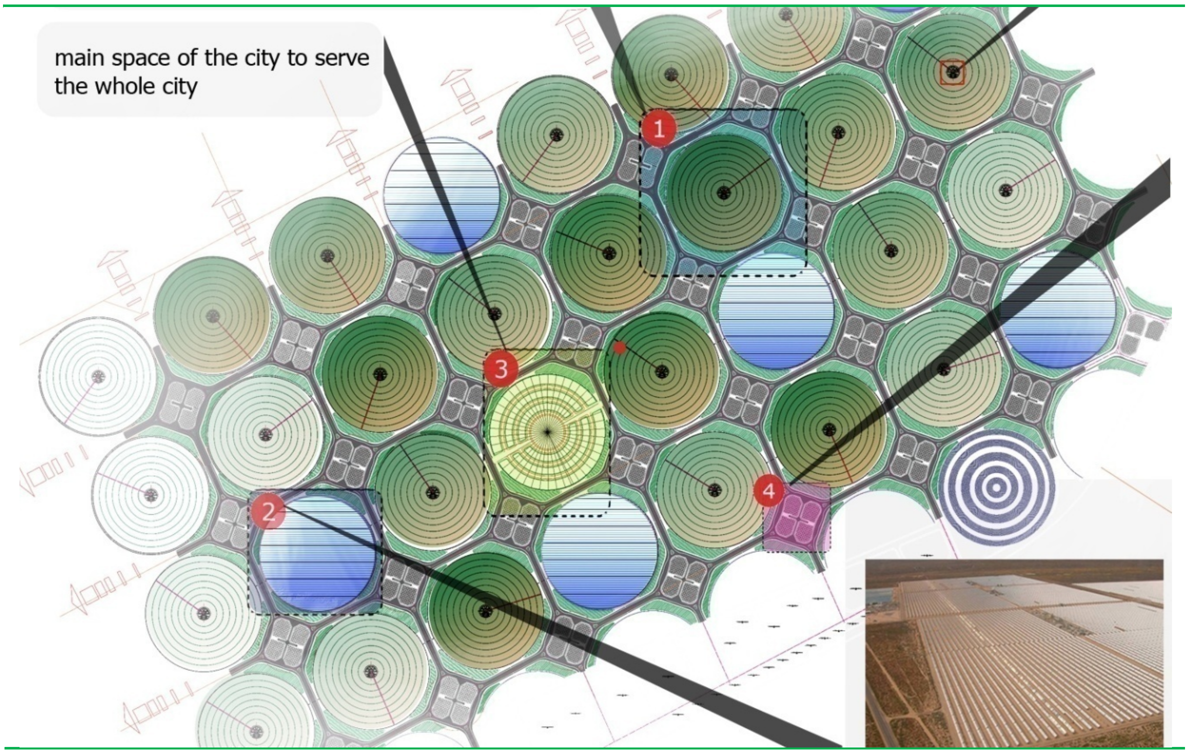



Fig. A1-1 **Visional form of GrMC.**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009

## *1. EXAMINING GrMC DESIGN CRITERIA,*

According to **Chapter VI** recommended Design Criteria, the following are the Examination of GrMC urban system; Table A1-1.

| **TABLE A1-1** | **Examining of Design Criteria on Green Mines Community's Urban Context with using of Solar Photovoltaics and VLS-PV.** | | |
|---|---|---|---|
| **CRITERIA** | **URBAN Scale** | **Evaluation** | **Notes** |
| **The Site** | - New Developmental Urban region, | √ | - New Agricultural and technological community |
| | - New Community, | √ | |
| | - New City. | x | |
| **The Urban Type** | - Housing and Habitation. | √ | - Urban Development |
| **Energy Accessibility** | - Grid- Connected | √ | - Grid-connected make electricity exportation to regional network is promising. |
| | - Off- Grid (**Remote**) | √ | |
| **Objectives** | - Sustainable City, | √ | - Achieving the principles of sustainable community for conserving the high sensitive nature of desert environment |
| | - Sustainable Architectural Development, | √ | |
| | - Reduction of CO2 Emissions, | √ | |
| | - Achieving Quality of Life Style, | √ | |
| | - Initiatives for developing RE uses. | √ | |
| **Climate Conditions** | - Desert Climate condition ( **Harsh Climate**) | √ | - Needs an architectural passive technique |
| **Main Considerations** | - Developing and studying of the holistic urban systems for maximizing the utilization of Renewable resources, | √ | - Using of VLS-PV systems make the availability of self-sufficient concept possible, with prospected exportation of energy. |
| | - Achieving a targeted power generation as 1 MW in Amersfoort village, | √ | |
| | - Self-sufficient energy generation and exportation through advanced stages | √ | |
| **Stages of Implementation** | - Installing of outside power plant for generating power through stages of implementation. | √ | - Identical to VLS-PV implementation stages |
| | - Integration of PV Modules on the urban and Building Context, | √ | |
| | - Integration of other Renewable energy resources, as wind and geothermal energy. | √ | |
| **PV Systems & Types** | - VLS-PV systems | √ | - Identical to VLS-PV recommended panels (Silicon Technology) |
| | - Polycrystalline Silicon PV modules on buildings. | √ | |
| | - Thin film & amorphous silicon cells. | **N.A.** | |
| **Types of Solar Utilization** | - Building integration (BIPV) | √ | - Using **BIPV** and integration of other **RE** systems |
| | - Power plants, | √ | |
| | - Air-conditioning, | x | |
| | - Combined techniques and systems. | √ | |
| **Other Integrated Systems** | - Domestic Water headings, | √ | - All systems are attached |
| | - Wind Energy, | √ | |
| | - Geothermal energy. | √ | |
| **Financing sources** | - UN Financial Programs and Developmental programs, | √ | - All financial resources would available |
| | - Governmental investment, | √ | |
| | - R&D Institutional investment, | √ | |
| | - $Co_2$ - reduction Investment. | √ | |
| **Design Pattern** | - Conventional (Horizontal Sprawl) | x | - Modular system (Poly-centric urban patterns) |
| | - modular system, | √ | |
| | - Compact planning, | x | |
| | - Combined planning system. | x | |
| **Return of Investment** | - Through the Followings: - Interest rates, | √ | - All resources would available |
| | - Electricity price after 5-22 years. | √ | |
| | - Accumulation of Jobs and socio-economic development. | √ | |

**Source**: Design Criteria –**Chapter IV**

## *2. PROJECT'S PROPOSED UNIT,*

The proposed name "Green Mine Unit" - inspired from the "*Mine Unit*" expression used in Word War II – is determined to serve newly reclaimed regions by working as a wide-range dwelling in the centre of agriculture pivotal unit system. The unit is recognized as a dwelling and initial storage for the daily agricultural activities. It has a biomass sub-tank, recycle system, technical room for PV batteries, and other services. (Figure A1-2)

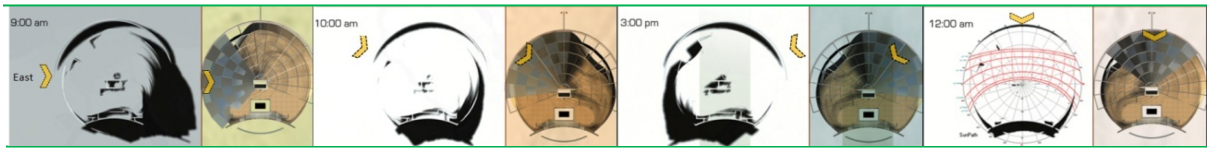



Fig. A1-2 **Studies for PV Tracking System with Time, Installed on Units.**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009

Solar energy and biogas are the main energy sources for the unit. Solar tracking system is used to provide shadows for the unit's south-facing surface ( Figure A1-3-4 ), decrease the direct solar gain, and convert it into electricity. Besides, agriculture residues are utilized to draw bio-fuels. Earth-sheltered building techniques are used to keep the integration between the unit and harsh climatic conditions in the desert, and creation of trained local inhabitants to manufacture their own materials and build their own units.

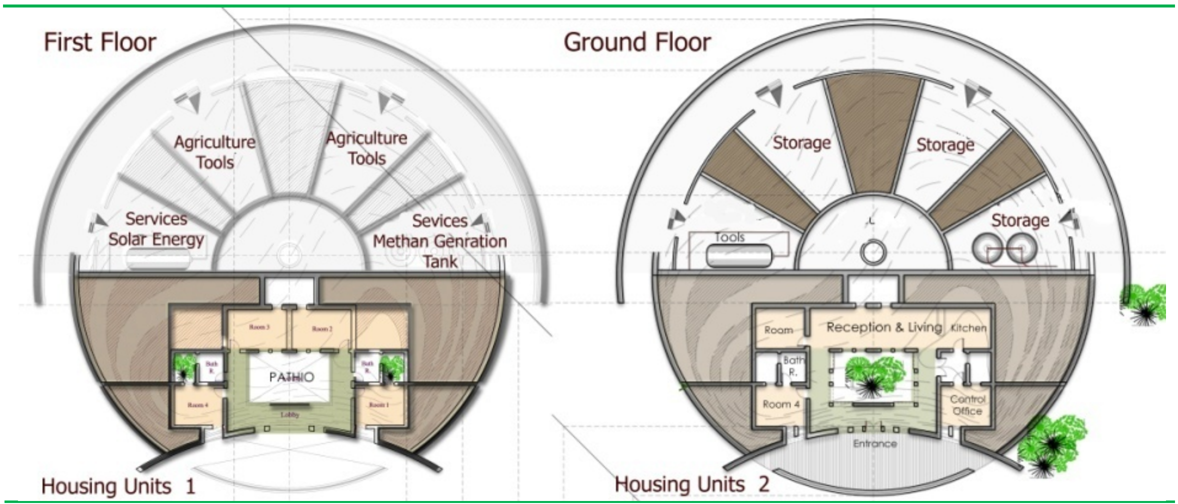


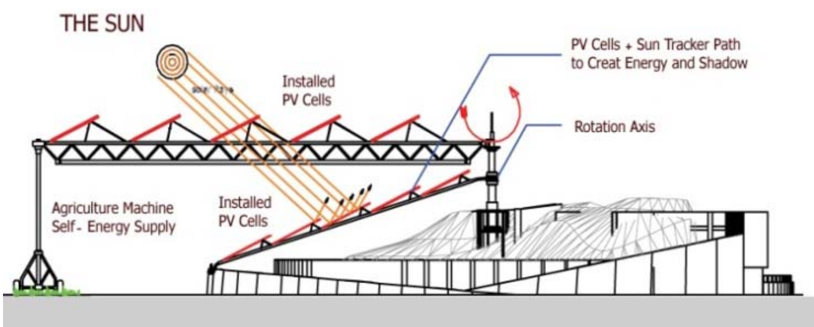

Fig. A1-3 **Plans of the GrMC Unit, Illustrating The Dwelling Components.**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009

Fig. A1-4

**Installation of PV Cells on the Units.**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009



## 3. FARM AND UNITS CONTEXT,

With bringing forth aggregated units in hundreds and thousands, a small self-sufficient community will be created, where electrical energy and bio-fuels for the daily human and agricultural activities will be locally produced. The uniform shape category will be dictated by specific urban planning criteria, the irrigated agricultural landscape, the social structure, and the aesthetic value to be determined. The planning is neatly structured to ensure the most efficient use of land; using simple natural materials and the earth sheltering technique to provide comfort in a thermal and physical sense.[1] (Figure A1-5)

Fig. A1-5

**The Initial Form of the Community Farms.**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009

*Economic performance and Compatibility*

The idea of forming G-mine societies is based on many steps and procedures. The most important one being its self sufficiency in small scale living units resulting in self sufficiency at large, depending on renewable solar energy and sustainable agriculture, and each unit using recyclable agricultural waste, bio- thermal and biomass for energy. (Figure A1-6)

Phase 1 : governments and NGOs financing infrastructure and irrigation, Further, finding solar collectors for living units.

Phase 2: improving the agriculture, watering and the main services depending on income from crops.

Phase 3: Improving solar energy usage and locally planting new cells and electricity fields for solar energy, using excessive energy for export.

Phase 4: forming an industry whether based on agriculture or silicon sand solar cells.

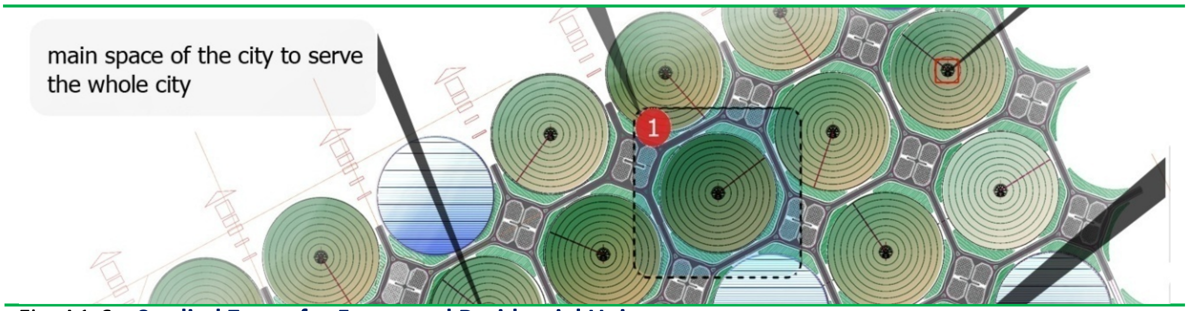



Fig. A1-6 **Studied Zones for Farms and Residential Units**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009

[1] **Sheta**, Sh., MSc. *"Earth-Sheltered Housing Design"*, (Egypt: Mansoura University, unpublished, 2000), p. 111-112.

## 4. *IRRIGATION SYSTEMS,*

Central pivotal systems are proposed initially for the GrMC framework, the selected system has benefits for the proposed community especially through the integration with VLS-PV, which PV panels can be integrated with the structure system of the Pivotal system to generate its needed electricity through the work times. Movable system of Pivotal system makes it more advantage to the proposal to improve the sustainability and reduction of initial cost of system **(Fig. A1-7-8).** It is noteworthy to emphasize the long Egyptian experience of using such these systems through numerous developmental projects in Egypt.

Fig. A1-7 **Central Pivotal Irrigation System.**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009

The advantage of Pivotal irrigation systems are;

- Flexible, movable, and applicable system for developing desert sites.
- The ability for covering large agricultural area with lower efforts especially for dens plants.
- It can be controlled automatically through using electronic devices.
- A built-up system combines the agricultural chemicals and irrigation control panel.
- Unused area in between the circular irrigation areas can use it as a services and residential zones simply to form a sustainable and self-sufficient community.[1]

Disadvantages of the system are a technically, financially, and limits to the dens planting.[2]

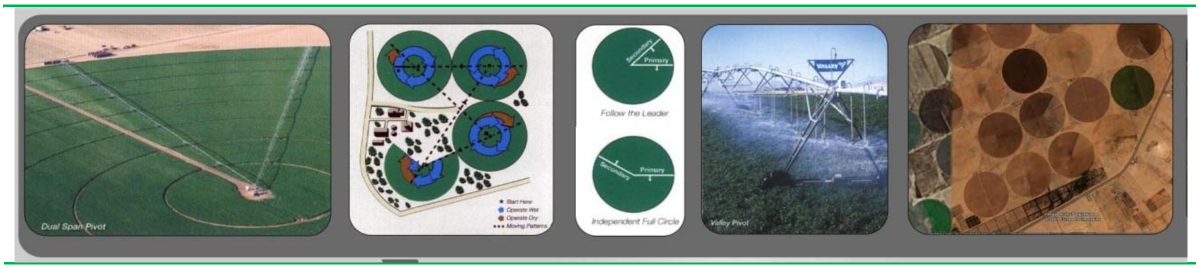



Fig. A1-8 **Flexibility and the Technical Component of Central Pivotal Irrigation System.**

**Source: Sudany**, M. **Report** "ESU 95% Lab; Green Mines Community" (ESU, Mansoura Uni. , Egypt, 2008 ) retrieved 1 May, 2009.

[1] Maher, M., Lecture *"Irrigation System; Central Pivot"* (August 2009).p. 2-5.
[2] Ibid. p 5-6.

# APPENDIX 2

## Sizing Stand-Alone Home Unit; Using PV system 5 Miles from Utility Line

**LOCATION**: Tallahassee, FL **LATITUDE**: 30.38° North

### *1. LOADS:*

(A I) : Inverter efficiency (decimal). This quantity is used as a power adjustment factor when current is changed from dc to ac. The efficiency of the inverter selected for this application is assumed to be 0.85.

(A 2) : Battery bus voltage. This is the nominal operating voltage of the battery. The battery bus voltage for this application is 24 volts, which corresponds to the required input voltage for the dc side of the inverter.

(A 3): Inverter ac voltage. The output voltage of the inverter selected for this application is 110 volts.

The components (appliances) that the system will power are:

- 5 Lights (30W ea.), combined rated wattage 150, used 2 hrs/day.
- Refrigerator, rated wattage 500, used 5 lirs/day.
- 3 Ceiling Fans (45W ea.), combined rated wattage 135, used 8 hrs/day.
- Dishwasher, rated wattage 600, used 2 hrs/day.
- Washer, rated wattage 1500, used 6 hrs/wk or 0.86 hrs/day.
- Toaster, rated wattage 1500, used 0.25 hrs/day.

The Components Are Listed Under The Column Heading Component.

(A4): The rated wattage is listed for each component in column (A4).

**TABLE A2-1** **(A4): The Rated Wattage is Listed for Each Component in Column.**

| Component | (A4) Rated Wattage | (A5) Adjustment Factor 1.0 For Dc | (A6) Adjusted Watt ( A4 / A5) | (A7) Hours Per Day Use | (A8) Energy Per Day (A6 * A7) |
|---|---|---|---|---|---|
| 5 Lights | 150 | 0.85 | 176 | 2 | 353 |
| Refrigerator | 500 | 0.85 | 588 | 5 | 2941 |
| 3 Ceiling Fans | 125 | 0.85 | 159 | 8 | 1272 |
| Dishwasher/other | 600 | 0.85 | 706 | 2 | 1413 |
| Washer | 1500 | 0.85 | 1765 | 0.85 | 1500 |
| Toaster/ H. Iron | 1500 | 0.85 | 1765 | 0.25 | 441 |

**Soliman**, Moataz., *Workshop ;" Application of Solar Energy; Solar Collectors and Photovoltaic Cells " PV System Component*, Lecture,(Egypt: Alexandria, IGSR, October 2008).

(A5): Adjustment factor. The adjustment factor Increases wattage to compensate for wattage loss due to the inefficiency of the inverter. For ac loads the value (A1) is inserted in column (A5). For this application the adjustment factor is 0.85.

(A6): Adjusted wattage. Dividing rated wattage (A4) by the adjustment factor (A5) adjusts the wattage to compensate for the wattage loss due to inverter inefficiency. (A4)/(A5).

(A8): Energy per day. The amount of energy each component requires per day is determined by multiplying each component's adjusted wattage (A6) by the number of hours it is used per day (A7). (A6) x (A7).

(A7): Hours per day used. The number of hours each component is used per day is listed in column (A7).

(A9): Total energy demand per day. The sum of the quantities in column (A8) determines the total energy demand required by the components per day. For this application the local energy demand per day is 7935 wart-hours.

(A10): Total amp-hour demand per day. The battery storage subsystem is sized independently of the photovoltaic array. En order to size the battery bank the total electrical load is convened from watt-hours to amp-hours. Amp-hours are determined by dividing the total energy demand per day (A9) by the battery bus voltage (A2). (A9) / (A2).

**7935 watt-hours / 24 volts = 331 amp-hours.**

(A11): Peak ac power requirement. The sum of the rated wattages (A4) for all components is equal to 4385 watts. Note that this is the maximum continuous power required and does not include surge requirements.

(A12): Peak dc power requirement The sum of the adjusted wattages (A6) for ail components is equal to 5159 W

## 2. B. BATTERY SIZING

**TABLE A2-2 Battery Sizing.**

| STEPS | PROCESSES | Calculation |
|---|---|---|
| | Design Temperature | **25°** Degree |
| B 1 | Days of storage desired/required | **7** Days |
| B 2 | Allowable depth-of-discharge limit (decimal) | **0.80** |
| B 3 | Required battery capacity (A10 x BI/B2) | **2317/0.8** = **2896** amp-hours |
| B 4 | Amp-hour capacity of selected battery * | = **478** amp-hours |
| B 5 | Number of batteries in parallel (B3/B4) | **2896/ 478 =** **6** Battery P |
| B 6 | Number of batteries in series (A2/battery voltage) | **24 volt/ 12 volt =** **2** Battery S |
| B 7 | Total number of batteries (B3 x B6) | **6 * 2 =** **12** Battery |
| B 8 | Total battery amp-hour capacity (B5 x 84) | **6 * 478 =** **2868** amp-hours |
| B 9 | Total battery kilowatt-hour capacity (B8 x. A2/I000) | **2868 * 24 / 1000 =** **68.8** Kilowatt-hours |
| B 10 | Average daily depth of discharge (0.75 x A10/B8) | **0.75 * 331 / 2868 =** **0.90** |

* Use amp-hour capacity at a rate of discharge corresponding 10 the total storage period, B1

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## 3. PHOTOVOLTAIC ARRAY SIZING

**TABLE A2-3 Photovoltaic Array Sizing.**

| STEPS | PROCESSES | Calculation |
|---|---|---|
| | Design Tilt **40 °** | Design Month…………… |
| C 1 | Total energy demand per day (A 9) | **7935** Watt-hours |
| C 2 | Battery round-trip efficiency (0.70 – 0.85) | 0.85 |
| C 3 | Required array output per day (C 1 / C 2) | 7935 / 0.85 = 9335 Watt-hours |
| C 4 | Selected PV module max power voltage at STC x 0.85 | **16.0 * 0.85= 13.6** Volts |
| C 5 | Selected PV module guaranteed power output at STC | **42.3** Watt |
| C 6 | Peak sun hours at design tilt for design month | **3.77** hours |
| C 7 | Energy output per module per day (C 5 x C 6) | **42.3 * 3.77 = 159.5** Watt-hours |
| C 8 | Module energy output at operating temperature. Use derating factor, DF =0.80 for hot climates and critical applications; DF = 0.90 for moderate climates and non-critical applications (DF x C7) | **0.90 * 159.5 = 143.6** Watt-hours |
| C 9 | Number of modules required to meet energy requirements (C3/C8) | **9335 / 143.6 = 65** Modules |
| C 10 | Number of modules required per string (A 2/C 4) rounded to next higher integer | **24 / 13.6 = 1.6** Modules |
| C 11 | Number of strings in parallel (C 9/C 10) rounded to next higher integer | **65 /2 = 32.5 rounded to 33** Strings |
| C 12 | Number of modules to be purchased (C 10 xC 11) | **2 * 33 = 66** Modules |
| C 13 | Nominal rated PV module output | **47** Watt |
| C 14 | Nominal rated array output (C 13 x C 12) | 66 modules * **47** watt = **3102** Watts |
| **AREA** | **Module unit Area =**<br>**Modules Area = (C12) * 0.4 $m^2$ = 66 * 0.4 $m^2$ =** | **26 $m^2$** |

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## D. Balance-of-system (BOS) Requirements

1. A voltage regulator is recommended unless array output current (at 1000 W/m* condition), less any continuous load current, is less than 5% of the selected battery bank capacity (at the 8-hour discharge rate).
2. Wiring should be adequate to ensure that losses are less than 1% of the energy produced.
3. In low voltage (i.e., less than 50 volts) systems, germanium or Schottky blocking diodes are preferred over silicon diodes.
4. Fuses, fuse holders, switches, and other components should be selected to satisfy- both voltage and current requirements.
5. All battery series branches should contain fuses.
6. Fused disconnects are strongly recommended to isolate the battery bank from the rest of the system.

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# ABSTRACT

Settling the desert has long been an Egyptian dream. Dictated by the population needs, future hopes, and a broader vision for a better life, desert development has widely been considered a national goal. Numerous scenarios tackled the future development of Egyptian desert such as *"Egypt 2020"* by Rageh, and "*The Development Corridor*" by Farouk El-Baz. Studying the international trends related to sustainable development and renewable energies utilization has shown a gap between the entire national trends and the relevant international strategies that call for an optimum utilization of the "Very Large Scale Photovoltaics" (VLS-PV) in the worlds' deserts. Such new visions may help create new productive sustainable communities in the desert while providing for new desert development scenarios.

The thesis suggests an integrated approach to practical utilization of VLS-PV, guided with the national visions of the future of prospected desert communities in Egypt. In this regard, the "*Application of VLS-PV in the Egyptian Desert* " is developed as a sustainable planning and design proposal to provide optimum utilization of photovoltaics in new desert communities. It presents a model for the integration of photovoltaic system within future communities in the Egyptian desert, whether through the "*Development Corridor*" scenario, or the desert development framework in general. The conclusion illustrates a number of recommended actions steps that may possibly make recent development projects more adaptive with the use of solar energy applications; mainly with the VLS-PV systems.

***Keywords***: *Egyptian Desert- Solar Energy- Sustainable Community- VLS-PV systems.*

## AIMS OF THE RESEARCH

This study aims at approaching the following:

- Discussion, analysis, and development of the existing scenarios dealing with the developmental concepts for the Egyptian desert and creation of new urban communities.
- Emphasizing the role of renewable energies (solar energy in particular), handling the implementation of self-sufficient/productive housing units, and fostering the effective role of architecture in disseminating and developing sustainability strategies for desert settlements and regional communities at large.
- Promoting the major governmental projects, implemented in desert hinterlands by expanding the body of knowledge to a larger scale of sustainable photovoltaic application in the local urban communities.
- Proposing some urban and architectural design guidelines for discussion, debate, and further input.

## HYPOTHESIS OF THE STUDY

The use of solar energy applications on the urban scale, regarding an economic development - especially in developing countries - would offer suitable solutions for energy and environmental problems. This hypothesis is to be examined through the Egyptian reality by developing its desert, and exploiting the available local resources, mainly the silicon, as a principal means to achieve sustainable development.

## STRUCTURE OF THE THESIS

Beyond the introductory chapter, the thesis has been organized into three broad parts: One- Literature review, Two- Analytical study, and three – the application study. Each part is separated into individual chapters, which may in turn be divided into subdivisions.

Part One, literature review, presents three chapters. ***Chapter II*** discusses the identification of recent world's problems, as problem of Energy, resources depletion, pollution, environmental degradations and the role of Renewable energy as a solution. ***Chapter III*** presents the forecasting scenarios of energy and the needs for developing solar energy utilization trough the world's energy. Finally ***Chapter IV;*** discusses and illustrates the main outlines of solar energy systems, applications, uses, and devices and compares the electrical and thermal application for developing its uses in Egyptian case through the application in Part Three.

In *Part Two* the research have to illustrates and analyses the principles, technology abilities, and applications of solar energy as one of the renewable energies that may be suitable for achieving the global sustainable directions on urban and architectural scale. *Chapter V* Discusses the main principles, information, outlines, uses and applications of solar energy. *Chapter VI* involves the most recent visions and applications for using solar energy — whether devices or systems — on urban development architectural scale. *Chapter VII* Has to draws out the most available and suitable visions, systems, and guidelines to be the start point of the case study in Part Three; the guides that help imagine and plan the model, of silicon or solar development in the Egyptian desert.

The Objective of *Part Three* is to examine the Egyptian regions to select the suitable regions for using and applying solar energy system and photovoltaic silicon technology in the specific and selected sites that has a higher priority of national development and potentials of using VLS-PV proposal. This is envisaged to be achieved by *Chapter VIII*, which introduces analytical study of selected regions and sites and examines the design criteria of PV technology applications, uses energy system, devices, energy output, and suitable infrastructure when applying PV Silicon cells to roofs. *Chapter IX;* Develops an application for embodying the potentials of PV integration with the developmental trends of desert through new sustainable communities in Egypt.

## RESEARCH METHODOLOGY

The Research is determined to study the major potential approaches for developing the Egyptian desert. this study mainly stems from theoretical studies carried out by the author through the thesis, conducted academic research, and submitted entries at several environmental architectural competitions. Through all these contributions, solar energy applications in urban development have mainly been focused, and major international experiments studied to draw out practical criteria to pave the way for the Egyptian desert to be home to new communities and future generations. The methodology can be summarized the following;

### Theoretical Study;

- Indentifying of research problem as; global energy crisis, climatic changes, and the environmental degradations, and discussing the abilities of renewable energy as a solution.
- presenting the forecasting scenarios of energy through the 21st Century and the role of RE,
- Studying solar energy theories, systems, and applications and discussing of photovoltaic technology with special mention of the Silicon technology.

### Analytical study;

- Analytical study of solar energy applications — whether thermal or electrical — and comparing its uses and relations to urban or architectural fields,
- Analytical Study of solar energy applications through examples in a number of subdivision to discuss the world's energy development, urban development, rural development, and architecture,
- Studying the principles and design criteria, if solar energy applications are integrated with developmental, urban, rural and architectural applications,
- Drawing out the design criteria from the former examples for examining the potentials of SE through the Egyptian regions,
- Studying the Egyptian reality, desert developmental trends, and RE statements and policy,
- Examining the SE design criteria on the Egyptian regions, sites, and desert regions in particular,
- Conducting a case study, on installing PV cells on one of the selected or suitable sites, to draw out specifications, design notes, achievable design criteria through the urban and architectural scale, learned lessons, and recommendations,
- Creating a study model or application specified the utilization and integration of PV technology in different scales through the Egyptian desert development and new communities.

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قســــم الهندســــة المعمارية,
كليـــة الهندســـة,
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# تطبيقات الطاقة الشمسية في التنمية العمرانية

تنمية صحراء مصر بتكنولوجيا السيلكون

# Solar Energy Applications in Urban Development

Developing of the Egyptian Desert by Silicon Technology

بحث مقدم الى

**قسم الهندسة المعمارية**

كجزء من المتطلبات للحصول على

**درجة الماجستير فى الهندسة المعمارية**

(تخطيط عمرانى)

الباحث

**مؤمن محمود السوداني**

معيد بقسم الهندسة المعمارية

August
**2009**

عنوان الرسالة : تطبيقات الطاقة الشمسية فى التنمية العمرانية
تنمية صحراء مصر بتكنولوجيا السيلكون

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عميد الكلية وكيل الكلية رئيس القسم

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عميد الكلية وكيل الكلية رئيس القسم

# تقـــــديم

تمثل انبعاثات ثانى اكسيد الكربون ثلثى العوامل التى تسبب مشكلة الاحتباس الحرارى بعالمنا اليوم طبقا لتقارير الامم المتحدة (برنامج الامم المتحدة للتنمية, اتفاقية الامم المتحدة لتغيرات المناخ **UNFCCC** – برنامج الامم المتحدة للبيئة **UNEP)** ويعتبر ثانى اكسيد الكربون من احد الغازات المسببة لنظرية الصوبة الزجاجية للغلاف الجوى للارض. فنجد فى الدول الصناعية الكبرى والمتقدمة ان قطاع المبانى سواء قطاعات الانشاء او الاستهلاك العقارى من اكبر القطاعات غير المباشرة والمسببة للانبعاثات ثانى اكسيد الكربون بالغلاف الجوى نتيجة حرق مشتقات الوقود الاحفورى( النفط ) فى محطات الكهرباء المركزية. فنجد انها تمثل على الاقل خمسون بالمائة من العوامل المسببة للانبعاثات ثانى اكسيد الكربون . انشطة الانسان تحتاج لان تتجه بصورة اكبر نحو ترشيد استخدام النفط لمسبب للانبعاثات والاتجاه نحو للاعتماد على استخدام الطاقات المتجددة والنظيفة. وكلما زداد دور الطاقات المتجددة كمصدر رئيسيى للطاقة ذلك قريبا كلما كان افضل , والابتعاد عن الاستهلاك المفرط لمصادر الطاقة التقليدية غير المتجددة وانظمتها التى تهدد النظام الكونى لعالمنا.

فنجد تزايد مطرد فى مبادرات مدن الطاقة الشمسية الاهتمام بالدراسات والمشروعات المتعلقة لهذة المبادرات لتقليل انبعاثات ثانى اكسيد الكربون وتاكيد استخدام مبادئ التنمية والعمران المستدام, وذلك من خلال المجتمعات العمرانية الحالية والمستقبلية. ولتحقيق هذا الهدف ينبغى علينا تعجيل التحول من استخدام الوقود الاحفورى الى استخدام الطاقات المتجددة لدعم البيئة العمرانية بالطاقة للازمة, فنجد توجهه عالمى ملحوظ لترسيخ ونشر مبادئ ترشيد استهلاك الطاقة وتوليدها من مصادر نظيفة وتحافظ على البيئة وكذلك اعداد دراسات الاثر البيئى للمشروعات التنموية الجديدة المقترحة. وعلى هذا الاساس فان مراعاه الاعتبارات التخطيطية والبيئية والعمرانية وايضا القوانين الملزمة من اهم العوامل لتحقيق مثل هذة الاهداف السابقة. ومن وجهه النظر المعمارية, فنجد ان الاهتمام بتكامل مثل هذه الانظمة المتجددة فى المبانى وعلى الاخص تكامل انظمة الطاقة الشمسية الكهربية ( **الخلايا الشمسية** ) اثبتت دور المعماريين فى ترسيخ مثل هذة التوجهات للحفاظ على البيئة والمسؤلية فى المساهمة لحل احد اهم القضايا العالمية فى يومنا هذا.

وعلى هذا الاساس, فان الرسالة البحثية قد شكلت لتناقش دور الطاقة الشمسية كاحد الطاقات المتجددة فى التنمية العمرانية , كاحدى السبل الفعالة لتنمية مجتمعات عمرانية جديدة ومستدامة بشكل عام ودراسة دورها فى انشاء هذة المجتمعات فى المناطق الصحراوية على وجهه الاخص. واثراء تمكين الانسان من فهم ومراعاة العوامل البيئة المحيطة به والحفاظ على استدامتها فى ظل احتياجاته للتنمية والتعمير.

ولذلك , فان دور الرساله البحثية هو دراسة وتحديث ورصد للمجهودات الحالية والمعلومات عن نظم استغلال الطاقة الشمسية فى التنمية العمرانية, وبالتالى, تقييم امكانية استخدام هذه التطبيقات والانظمة من خلال توجهات التنمية العمرانية للصحراء المصرية خلال المدى المتوسط والبعيد نحو تنمية مجتمعات جديدة على ارض تمثل 95% من مساحة مصر غير مستغله بكفاءة لان معظمها اراضى صحراوية.

<u>وفى ضوء ما سبق</u>, فان الدور المؤسسى الريادى الذى يقوم به قسم الهندسة المعمارية بجامعه المنصورة من خلال النشاط الاكاديميى لسنة **2005** حتى سنة **2008** والذى تبنى من خلال البرامج الدراسية فكرة دراسة **" مصر المستقبل"** والتى رسخها الاستاذ الدكتور احمد راشد فى النظام الاكاديمى بالقسم , والذى تكامل مع المشروع التنموى المقترح من العالم العالمى المصرى فاروق الباز تحت اسم " ممر التعمير" المشروع الذى تم دراستة ايضا بقسم العمارة من خلال مشروعات التخرج للطلاب خلال الاعوام الدراسية حتى **2008**, وبالتوازى مع مجهودات البحث والتطوير من خلال الانشطة البحثية لوحدة Lab **ESU 95%** التى تم انشائها بقسم العمارة كاحد المجموعات البحثية لتبنى مشروعات بحثية متخصصة على مستوى الدراسات العليا والابحاث العلمية الهندسية , وتضم نخبة من الباحثين والاساتذة والطلاب والخرجين بالقسم تحت اسم (**Egyptian 95% Sustainable Urbanism Laboratory)** لتبادل

الخبرات والمعلومات والمخرجات البحثية التى تتكامل مع الخطط الحكومية والهيئات البحثية المحلية والعالمية التى تهتم بدراسات التنمية العمرانية المستدامة بمصر.

والبحث يعتبر احد نتائج المشروعات البحثية لمعمل **ESU 95% Lab** والذى يهدف الى دراسة امكانية تنمية وتعمير الصحراء المصرية من خلال استغلال تطبيقات الطاقه الشمسية. فنجد ان الاستخدام واسع النطاق لانظمة الخلايا الشمسية جاء ليحقق امكانية استغلال انظمة الطاقه المتجددة على مقاييس واسعه فى انشاء مجتمعات عمرانية جديدة ومنتجة تحقق معايير الاستدامه داخل الصحراء المصرية.

*وانا ممتنٌ لفرصة اكتسابى التجارب والخبرات في مجالات التنمية والانشاء العمرانى المستدام, و اتقدم بالشكر للسيد الاستاذ الدكتور/* ***احمد يحيى راشد*** *- والاستاذ المساعد دكتور/* ***شريف احمد شتا.*** *فلولا خبراتهم ودعمهم وتعاونهم المخلص, لما كان العمل البحثى ان يكون على هذه الصورة.*

*وامتنان لا نهائى يتوجهه للسيد الاستاذ الدكتور/* ***محمد مؤمن عفيفى*** *- وللسيد الاستاذ الدكتور /* ***اسامه على فرج*** *, على دعمهم لجودة البحث خلال مراحلة المختلفة.*

*وانا مدين ايضا بالشكر والجميل لكل باحث , عالم, مؤسسه, منظمات , وجمعيات داخل او خارج مصر ,خصوصاً وكالة الطاقةِ الدوليةِ* ***(IEA)*** *برنامج نظمِ الخلايا الشمسية* ***(PVPS)*** *- برنامج إدارةِ قطاع طاقة* ***(ESMAP)***، *هيئة الطاقة الجديدة والمتجددة بمصر* ***(NREA)***- *التي جَعلتْ هذا العملِ جدّدَ بوسائلِهم ومعلوماتِهم المتميزة.*

الباحث

**مؤمن السودانى**

يوليو 2009

# ملخص البحث

تعمير الصحراء مازال أحد أهم الأهداف المصرية نتيجة النمو المتزايد لعدد السكان ونمو احتياجاتهم الحالية والمستقبلية منها , ولتحقيق رؤية شاملة لتنمية مستدامة فى شكل مجتمعات جديده بها, لذا فان تنميه الصحراء التى تمثل 95% من مساحه مصر تعتبر من الأهداف القومية المراد تحقيقها. هناك دراسات متعدده ناقشت مستقبل تنمية الصحراء المصرية من أهمها حاليا **"مصر 2020"** للعالم أبو زيد راجح , ومشروع **"ممر التعمير"** للعالم العالمى فاروق الباز. فمن خلال دراسة الأبحاث والتوجهات العالمية التى تتبنى فكر التنمية المستدامة وتفعيل استخدام أنظمة الطاقة المتجددة فى مشروعات التنمية, أظهرت فقدان حلقة ربط بين منهجية الدراسات القومية وهذه التوجهات العالمية التى تنادى بالاستغلال الأمثل لتقنيات الطاقات المتجددة ومن أهمها " تطبيقات الخلايا الشمسية واسعه النطاق داخل صحراء العالم **(VLS-PV) "** مثل هذه التوجهات ساعدت فى طرح سيناريو جديد لتحقيق التنمية المستدامة فى الصحارى على شكل مجتمعات تنمويه جديدة مكتفية ذاتيا ومنتجة ومصدر للطاقة وتتكامل مع تقنيات التنمية الزراعية فى النطاقات الصالحة للزراعة.

البحث يتناول هذا السيناريو كمدخل جديد لاستغلال تقنيات الطاقة الشمسية واسعة النطاق داخل الخطط القومية الحالية منها والمستقبلية لتحقيق إنشاء مجتمعات مستدامة داخل الصحراء المصرية والمساعدة على تنميتها لاستيعاب الزيادة السكانية. وذلك بعرض المعايير التصميمية والاعتبارات العمرانية والمعمارية للاهم الامثلة والمدن العالمية وللاستفادة من هذه التجارب. وكذلك عرض المنهجية العلمية للمشروع التطبيقى **(VLS-PV)** والهيكل المطروح لتنمية الصحراء العالمية عمرانيا ,من خلال مشروعات تنمية الطاقة الكهربية والتنمية الزراعية. والاستفادة منها فى تحقيق استغلال الطاقه الشمسية فى تنمية مجتمعات عمرانية بالصحراء المصرية

***الكلمات المفتاحية*** :

الطاقة - نظم الاستفادة من مصادر الطاقة المتجددة فى البيئة العمرانية – دور الطاقة الشمسية فى التنمية العمرانية

## الهدف من البحث:

تهدف الدراسة الى تناول النقاط التالية:

- مناقشة وتحليل ودراسة المقترحات التنموية الحالية الهادفة إلى تنمية الصحراء المصرية بإنشاء مجتمعات عمرانية جديدة بداخلها تحقق معايير الاستدامة وتشكل نطاقات منتجة ومكتفية ذاتيا.
- تأكيد دور الطاقات المتجددة بشكل عام والطاقة الشمسية على وجه الخصوص كأحد السبل لانشاء مجتمعات ووحدات عمرانية مكتفية ذاتيا/ منتجة, و إبراز الدور العمرانى والمعمارى فى نشر وترسيخ مبادئ التنمية المستدامة من خلال مقترحات التنمية العمرانية للصحراء والتنمية المحلية داخلها.
- دراسة المشروعات والبرامج الحكومية التى تتبنى تنمية استخدام مصادر الطاقة المتجددة من خلال الدعم المعرفى والعلمى لإمكانية تكامل أنظمة وتطبيقات الطاقة الشمسية واسعه النطاق داخل الاقتراحات المطروحة لتنمية الصحراء المصرية.
- تقديم عدد من المحددات والمعايير العمرانية والمعمارية الجديدة التى استحدثت من خلال تجارب عالمية تهدف الى تأكيد أهمية تكامل أنظمة الطاقة المتجددة داخل النسيج العمرانى والمعمارى.

## الفرضية البحثية:

إن استخدام تطبيقات الطاقة الشمسية كأحد الطاقات المتجددة والنظيفة داخل المقياس العمرانى بهدف تحقيق تنمية عمرانية واجتماعية واقتصادية - خاصة بالدول النامية, من الممكن أن يمثل أحد الحلول المناسبة لمشكلات الطاقة والبيئية والتغيرات المناخية. ومناقشة هذه الفرضية من خلال الواقع المصرى وأهداف التنمية العمرانية للصحراء المصرية وإمكانية تنمية المصادر المحلية مثل رمال السيليكون على سبيل المثال كأحد الوسائل لتحقيق تنمية عمرانية مستدامة بصحراء مصر.

## هيكل الدراسة البحثية :

بعد التقديم البحثى خلال الفصل التمهيدى تم تقسيم البحث إلى ثلاثة أبواب رئيسية **الاول منها**: يتناول المراجعه العلمية للمشكله البحثية, و**الباب الثانى**: يتناول الدراسة التحليلية لأنظمة الطاقة الشمسية , و**الباب الثالث**: يتناول دراسة الحالة وتقديم الدراسة التطبيقية. كل باب ينقسم تبعيا الى عدد من الفصول.

**الباب الاول**: يتناول الباب الخلفية النظرية وعرض للمشكلة البحثية, حيث يقدم **الفصل الثانى** عرض ومناقشة المشكلات الحالية التى يواجهها العالم ومن أهمها مشكلات الطاقة , نقص الموارد الطبيعية , التلوث الجوى , تدهور البيئة والتعديات عليها , وكذلك عرض الدور التى تقدمه الطاقات المتجددة النظيفة والصديقة للبيئة كأحد الحلول لهذة المشكلات الناتجة فى الأساس عن توليد الطاقة من المصادر النفطية غير المتجددة, وذلك من خلال عرض أنواع وخصائص الطاقات المتجددة والامكانيات التى تقدمها لحل المشكلات السابقة

. بينما يتناول **الفصل الثالث** عرضا للسيناريوهات المقترحة من علماء وباحثين عالميين فى مجالات الطاقة و رصد التنبؤات من خلال عدد من الرسوم البيانية وشرح مكوناتها , وتظهر التنبؤات النمو المتزايد نحو استغلال الطاقات المتجددة وعلى الأخص نمو استخدام الطاقة الشمسية على المدى القريب والبعيد حتى 2100 . وتظهر البدائل المقترحة لدور الطاقات المتجددة لتكون هى الطاقة الرئيسية للعالم مستقبلا

. ويختتم الباب الاول **بالفصل الرابع** الذى يناقش مبررات اختيار الطاقة الشمسية كأحد الطاقات المتجددة لتناولها على وجه الأخص خلال البحث ومدى تزايد التوجهات لتنمية استغلال أنظمة الطاقة الشمسية وخاصة الكهربية منها فى مشروعات التنمية العمرانية بالعالم وخاصة فى الدول النامية. ويشرح الفصل الأسس والنظريات العلمية عن إمكانيات الطاقة الشمسية وكذلك شرح للأنواع التحولات الرئيسية للاشعاع والطاقه الشمسية فى كوكب الارض , وأنواع الأنظمة الشمسية سواء الأنظمة الحرارية أو الكهربية وشرح مفصل للتطبيقات, الاستخدامات, الأدوات والتكنولوجيا المستخدمة والخاصة بكل نظام (خاصة تكنولوجيا السيلكون المستخدمة فى تصنيع الخلايا الشمسية ) وإمكانية تكامل هذة الأنظمة فى مشروعات التنمية العمرانية التى سيتناولها الباب الثالث لدراسة التطبيقات الشمسية داخل مصر.

**الباب الثانى**: يختص هذا الباب بتحليل وشرح تطبيقات الطاقة الشمسية من خلال الأمثلة المحلية والعالمية وذلك على مقاييس التنمية للصحراء , التنمية العمرانية الاقليمية, والتنمية المحلية والقروية, وكذلك على المقياس المعمارى.

ويقدم **الفصل الخامس** شرح لمقترح استخدام تطبيقات الطاقة الشمسية واسعه النطاق **(VLS-PV)** داخل صحارى العالم لتنميتها بمجتمعات عمرانية زراعية جديدة منتجة للطاقة الكهربية وتتكامل مع النسيج العمرانى بها , وشرح لسيناريو تطبيق هذا المقترح المدعم من وكالة الطاقة الدولية... كذلك يقدم الفصل عرضا لأمثلة استخدام تطبيقات الطاقة الشمسية فى مشروعات ومبادرات التنمية العمرانية مثل مشروع " المدينة الشمسية" بالنمسا ومشروع مدينة "مصدر" بأبوظبى وقرية " اميرزفورد" بهولندا وذلك من خلال تحليل المشروعات واستخلاص الأهداف والمعايير والدروس المستفادة منها. ويدرس الفصل أيضا تطبيقات الطاقة الشمسية فى تحسين البيئة العمرانية والصحية للمجتمعات القروية أو العشوائية المعزولة عن الخدمات الرئيسية وتوضيح دور برامج الأمم المتحدة للتنمية ودور المؤسسات الحكومية وغير الحكومية فى تنمية هذه المشروعات وتحقيقها. وفى نهاية الفصل يتناول أساليب تكامل أنظمة الطاقة الشمسية الكهربية مع العمارة والتى يطلق عليها اختصار **(BIPV)** وأساليب تثبيت أنظمة الخلايا الشمسية وتكاملها مع عنصر المبانى سواء لتحقيق الاكتفاء الذاتى أو تحقيق مبادئ المبانى الذكية أو المبانى الموفرة للطاقة.

**<u>الفصل السادس</u>** يتناول مقارنات وتحليل لكل الأمثلة السابق ذكرها فى الفصل الخامس لاستخلاص المعايير والأسس و الدروس المستفادة من هذه الأمثلة مع اختلاف ظروفها على كل من مقياس التنمية العمرانية أو المقياس المعمارى. ويقدم الفصل تحليل واستخلاص للمعايير والأسس التصميمية لكيفية استخدام نظم الطاقة الشمسية وخاصة النظم الكهربية منها على عدة مقاييس سواء للتنمية الاقليمية أو العمرانية أو المحلية أو التصميم المعمارى.

ويتنهى الباب الثانى بمناقشة للواقع المصرى من خلال **<u>الفصل السابع</u>** الذى يقدم عرضا ملخصا للواقع المصرى بكل أبعاده سواء اجتماعى, اقتصادى , بيئى,أو المصادر المحلية المتاحة. ويعرض الاهتمام المحلى فى تفادى تبعيات وأخطار التغيرات المناخية على التنمية المحلية بمصر , ويعرض التوجهات المصرية للإعداد لمواجهه هذه المخاطر. ويقدم الفصل عرضا عاما أن الخواص المناخية والجغرافية لمصر , وسياسات الطاقة بمصر والدور الحكومى الذى تقدمه فى تبنى وتنمية استخدام الطاقات المتجددة داخل هيكل الطاقة بمصر لتساهم بنسبة 10% خلال عام 2020 من مصادر الطاقة بمصر وعرض لسيناريوهات تنمية الصحراء المصرية لكل من العالم أبو زيد راجح بمقترح*"مصر 2020"* ومقترح مشروع*" ممر التعمير"* للعالم فاروق الباز. وكذلك شرح للأنظمة الحرارية والكهربية للطاقة الشمسية التى تتبنى الحكومة عملية تنميتها وتطويرها بمصر.

**الباب الثالث**: يقدم ملخص للنقاط الرئيسية التى تناولها البحث خلال الباب الأول والثانى ويفصل هذه النقاط فى شكل معايير وأهداف رئيسية من الممكن استخدامها عن اختبار امكانية استخدام أنظمة الطاقة الشمسية الكهربية على وجه الخصوص داخل النطاق المصرى لتأكيد امكانية استخدام تكنولوجيا الخلايا الشمسية ( تكنولوجيا السيليكون) واسعه النطاق فى تنمية مجتمعات داخل الصحراء المصرية.

يتناول **<u>الفصل الثامن</u>** تحليلا للنطاقات الصحراوية المقترح تنميتها داخل القطر المصرى ومدى تكاملها مع أهداف التنمية المحلية للحكومة المصرية وملائمتها مع استخدام تطبيقات الطاقة الشمسية الكهربية واسعه النطاق **(VLS-PV)** المستخدمة لتكنولوجيا السيلكون , وذلك فى سيناريو جديد لتنمية مجتمعات طاقه جديدة على صحراء مصر. وينقسم الفصل ليعرض ويناقش إمكانيات استخدام تطبيقات الطاقة الشمسية داخل نطاقين رئيسيين تم اختيارها على الأسس والمعايير السابقة, وهو نطاق محافظات قناه السويس و نطاق محاور مشروع ممر التعمير . وفى نهاية الفصل يتناول **<u>دراسة حالة</u>** لأحد المدن التى تم اختيارها على الأسس والمعايير السابقة وهى " *مدينة المستقبل – بمحافظة الاسماعيلية* " , واختبار مدى فاعلية وامكانية استخدام تطبيقات الطاقة الشمسية الكهربية وتكنولوجيا خلايا السيلكون فى تحقيق وفر للطاقة او لتحقيق اكتفاء ذاتى بها . وتكون أحد الأمثلة لتطبيق معايير الاستدامه واستخدام الطاقة المتجددة فى المدن الجديدة.

**<u>الفصل التاسع</u>** يأتى فى نهاية الباب الثالث ليقدم **نموذج تطبيقى** يعبر عن الفكرة الرئيسية للبحث, لتجسيد فكرة استخدام تطبيقات الطاقة الشمسية فى التنمية العمرانية للصحراء المصرية باستخدام تكنولوجيا الخلايا الشمسية ( تكنولوجيا السيلكون ) من خلال الهيكل العلمى والبحثى الذى يتناوله مقترح استخدام تطبيقات الطاقة الشمسية الكهربية واسعه النطاق داخل صحارى العالم **(VLS-PV)**. والهيكل التطبيقى بعنوان **" Application of VLS-PV In the Egyptian Desert"** والذى يجسد فكرة إنشاء مجتمع جديد مستدام داخل الصحراء المصرية يتناسب مع السيناريوهات التنموية المقترحة للعلماء والحكومة المصرية وذلك من خلال مجتمع طاقة زراعى يستخدم ويصنع تقنيات الخلايا الشمسية لإنشاء محطات لإنتاج الطاقة الكهربية تتكامل مع التنمية الزراعية للصحراء فى النطاقات الصالحة للزراعه , ويكون مجتمع مكتفى ذاتيا ومنتج للكهرباء ومصدر لها.

## المنهجية البحثية :

يعد البحث دراسة شاملة لأهم الامكانيات والمداخل لتنمية الصحراء المصرية بمجتمعات عمرانية مستدامة. والدراسة ناتجة عن دراسة بحثية نظرية وتحليلية وتجارب تم مناقشتها بواسطه الباحث من خلال الرسال البحثية , النشاط البحثى الاكاديمى , والمشاركة فى مسابقات معمارية تتناول أفكار التنمية المستدامة والعمارة البيئية. ومن خلال كل هذه المجهودات والمساهمات, فقد تم تناول امكانيات استخدام تطبيقات الطاقة الشمسية فى التنمية العمرانية بصورة مباشرة ومركزة, والاستفادة من التجارب العالمية من خلال دراستها واستخلاص النقاط والمعايير العملية لتمهيد امكانية أن تكون الصحراء المصرية نموذج لمثل هذة المقترحات التنموية الحديثة وتعميرها بمجتمعات عمرانية حديثة ومتقدمة. والمنهجية البحثية تم مناقشتها خلال النقاط التالية:

**<u>الدراسة النظرية</u> :**

- من خلال تعريف المشكلة البحثية وأهمها: أزمة الطاقة عالميا, التغيرات المناخية, التدهور البيئى , و مناقشة الحلول التى تقدمها استخدام الطاقات المتجددة وامكانياتها.
- عرض نظرى للتنبؤات العلمية المتعلقة بسيناريوهات الطاقة خلال القرن الواحد والعشرين والدور الذى تحتله أنظمة الطاقة المتجددة خلال هذه السيناريوهات.
- دراسة نظريات الطاقة الشمسية , الأسس العلمية, أنظمتها التطبيقية, ومناقشة تنمية تكنولوجيا الخلايا الشمسية وخاصة تكنولوجيا السيليكون فى الاستغلال واسع النطاق للنظم الكهربية للطاقة الشمسية.

**<u>الدراسة التحليلية والتطبيقية</u> :**

- دراسة تحليلية لتطبيقات الطاقة الشمسية سواء الحرارية أو الكهربية منها ومقارنه ملائمة استخدامها مع مشروعات التنمية العمرانية والمعمارية.
- دراسة تحليلية لتطبيقات الطاقة الشمسية من خلال أمثلة عالمية مقسمة على مقاييس: التنمية الاقليمية للصحراء, التنمية العمرانية , التنمية المحلية , والمقاييس المعمارية للمبانى.
- دراسة الأسس والمعايير التصميمية فى حال استخدام أنظمة الطاقة الشمسية خلال المقاييس السابق ذكرها.
- استخلاص المعايير التصميمية والدروس المستفادة من الأمثلة العالمية, لاستخدامها فى اختبار إمكانية استخدام التطبيقات الشمسية من خلال البيئة المصرية.
- دراسة وتحليل الواقع المصرى والتوجهات الحالية لتنمية الصحراء المصرية وكذلك رصد لسياسيات الطاقة المتجددة بمصر.
- اختبار المعايير التخطيطية والتصميمية والأهداف المحلية على النطاقات التنموية بمصر.
- دراسة حالة لأحد المواقع أو المدن داخل مصر, ودراسة إمكانية استخدام وتكامل أنظمة الطاقة الشمسية الكهربية بها واستخلاص النتائج ومراعاة المعايير التخطيطية والتصميمية لتحقيق أقصى كفاءة للاستغلال الطاقة الشمسية الكهربية.
- تقديم نموذج ابتكارى أو تطبيقى يرسخ إمكانية تكامل أنظمة الطاقة الشمسية الكهربية سواء التطبيقات المصغرة أو واسعه النطاق, من خلال المشروعات التنموية للصحراء المصرية واقتراح شكل مجتمع جديد بها.

# الخلاصة والتوصيات

الاندماج الملحوظ لفكر التنمية المستدامة فى كل المجالات أثر تبعياً على التوجهات العالمية العلمية منها والعملية, ومن هذا المنطلق فإن التنمية المستدامة تعتبر واحدة من أهم القضايا الرئيسية المتعلقة بتطبيق فكر الاستدامة. الهدف من البحث هو مناقشة قضايا " الطاقة" وعلاقتها ب " التنمية العمرانية " كأحد أهم هذه القضايا التى يواجهها العالم, وهذه القضايا ذات علاقة وثيقة ومؤثرة على معظم التغيرات البيئية التى يشهدها كوكبنا هذا من مشكلات. فالارتباط الوثيق بين قطاع الطاقة والتنمية العمرانية والاقتصادية وأيضا جودة البيئة الطبيعية, يعتبر عصب الأساس للاقتصاد العالمى الذى يمنحها القدرة على تلبية احتياجات الانتاج الصناعي , الزراعى, النقل والمواصلات , وأخيرا النمو العمرانى.

خلال كلا من القرن التاسع عشر والقرن العشرين نجد أن التنمية العمرانية والامتداد السريع للمدن خلال هذه الحقبة يعتمد اعتمادا أساسيا على الناتج المباشر لمشتقات الوقود الأحفورى أو النفط. وفى يومنا هذا , نجد أن الطاقة المطلوبة لنمو المدن ونظم تشغيلها تستغل قرابة ثلثين الانتاج العالمى من طاقة المصادر النفطية الأمر الذى يؤكد الدور المؤثر لاستهلاك الطاقة خلال القطاع العمرانى فقط, والنفط حاليا يمثل 85% من إجمالى التجارة والتبادل والنمو الاقتصادى العالمي. ومنه فإنه من المؤكد أن وقت ما سوف يأتى لتتعرض فيه القطاعات الاقتصادية الإقليمية والعمرانية بالعالم لأزمة طاقة كبرى قد تهدد بانهيار حضارتها إن لم يتم الاعتماد على مصادر طاقة اخرى.

**الطاقة المتجددة:** لم تكن فقط التنبؤات العلمية لقضية الطاقة العالمية فى أوائل القرن العشرين هى المحرك الرئيسيى للتوجه العالمى نحو تنمية استخدام الطاقات المتجددة. لكن مشكلة نقص وفناء مصادر الطاقة التقليدية والأثر السلبى لها على البيئة بكوكبنا هم العامل الرئيسي لهذه السياسات العالمية . القمة الدولية الاخيرة للدول الثمان الصناعية الكبرى فى يوليو 2009 رصدت استثمارات ودعم اضافى على تطوير وتنمية وأبحاث استخدامات تطبيقات الطاقات المتجددة فى خطوة غير مسبوقة بهدف تقليل نسب الانبعاثات لغاز ثانى أكسيد الكربون الى 50% بحلول عام 2020, وحضور مصر كدولة فى هذه القمة أثر تبعيا وبصورة سريعه على القرار الرئاسى بتبنى تنمية وزيادة آلاف الأفدنة من الأراضى لاستغلالها فى تنمية تطبيقات الطاقة المتجددة فى إحدى الأقاليم بمصر وهو إقليم قناه السويس. بالاضافة إلى الدراسات الموجهه نحو إنشاء مشروع محطات لتوليد الطاقه الكهربية من الخلايا الشمسية باستخدام تقنية ( الخلايا المركزة) فى نطاق الصحراء الغربية.

*ومنه فإن هذه التوجهات بالاضافة إلى السياسات الحكومية المصرية السابقة والحالية لتنمية التطبيقات المتجددة خاصة طاقة الرياح وتطبيقات الطاقة الشمسية بأنواعها يؤكد الخطوات الجدية للسياسات المصرية نحو تنمية استخدام الطاقات المتجددة داخل نطاقات أوسع ومن أهمها داخل قطاعات التنمية العمرانية.*

**تكنولوجيا خلايا السيليكون:** من خلال البحث والدراسات عن أنواع الخلايا الشمسية والتنبؤات العلمية للباحثين والعلماء العالميين أثبتت أن مادة السليكون والتكنولوجيا الخاصه بها فى تصنيع الخلايا الشمسية تحتل أعلى كفاءه كمادة من بين أشباه الموصلات الأخرى خاصة خلال مراحل التصنيع الكمى للخلايا الشمسية على الرغم من ظهور مواد أخرى أعلى كفاءة ولكن معملية فقط وليس تصنيعية وهى مازالت فى مرحلة البحث و التطوير (**R&D**). وأكدت الدراسات العلمية بقاء مكانة وكفاءة مادة السيليكون على الأقل لمدة قد تصل 30-50 عاما, والآن تشهد تطورات تكنولوجيا النانو- سيليكون مراحل متقدمة من البحث والتطوير لرفع كفاءة مادة السيليكون أكثر دون الاستغناء عنه تماما بأى مواد أخرى.

المشروع العالمى الخاص بتنمية الاستخدام واسعة النطاق لتطبيقات الخلايا الشمسية فى صحراء العالم, أوصت باستخدام خلايا السليكون الشمسية فى هذا المشروع العملاق ( مستخدمين ألواح الخلايا الشمسية المسطحة المصنعه بتقنية بولى- سيليكون تكنولوجى ) وذلك لتنمية إنتاج الطاقة العالمى من الطاقة الشمسية النظيفة وتبعيا استغلال هذه المشروعات فى تنمية مجتمعات عمرانية جديدة فى الصحراء العالمية وخاصة بالدول النامية. الأمر الذى يحتم ضرورة تنمية التصنيع المحلى لهذه الخلايا الشمسية داخل هذه الدول (كما أوصت الدراسة لمشروع VLS-PV ) لنقل هذه التكنولوجيا والتصنيع الكمى لها الأمر الذى يساعد على تنمية استخدام الطاقات النظيفة وتقليل تكلفتها مقارنه بالطاقات التقليدية الحالية, ولتكون متاحه اقتصاديا للانشاء محطات توليد كبرى للطاقة الكهربية ودمجها مع مشروعات الربط الكهربى العالمى وأهمها الربط الكهربى لدول حوض البحر المتوسط على سبيل المثال.

*وبالتالى , فإنه يدعم صحه الفرضية البحثية للرسالة فى امكانية تنمية مجتمعات عمرانية جديدة داخل الصحراء المصرية من خلال تطبيقات الطاقة الشمسية واسعه النطاق التى تستخدم تكنولوجيا السيلكون ( سواء بتصنيعها أو استخدامها ) كأساس للتنمية. ولكن دون إغفال أهمية تجهيز واعداد مقومات البنية الأساسية الاجتماعية, العلمية , الاقتصادية, المؤسسية, والصناعية داخل النطاقات الملائمة لاستخدامات الطاقة الشمسية بمصر.*

**مدن الطاقة الشمسية:** خلال البحث تم عرض عدد من الامثلة العملية الرائدة عالميا تستخدم وتتبنى مبادرات تنمية واستغلال الطاقة الشمسية داخل النسيج العمرانى, وتستخدم تطبيقات الطاقة الشمسية المتكاملة مع المبانى (BIPV) والتطبيقات السلبية للطاقة الشمسية وأهمها الامثلة العمرانية مثل مشروع " المدينة الشمسية" بالنمسا ومشروع مدينة "مصدر" بأبوظبى وقرية " اميرزفورد" بهولندا وتم تحليل المشروعات واستخلاص الأهداف والمعايير والدروس المستفادة منها. فنجد أن مشروع مدينة " مصدر" قد قدم آفاق جديدة فيما يتعلق بتطبيق أسس الاستدامة وتطوير فكرة (zero-Energy) والانتقال من فكرة تقليل الطاقة إلى وصولها لمعدل صفر.

بينما استخدام تطبيقات الطاقة الشمسية داخل مقياس مشروعات التنمية المحلية والقروية أكدت أهمية الدور الفعال للمؤسسات الحكومية والغير حكومية فى تنمية وتبنى تطبيق مشروعات وبرامج الأمم المتحدة الرامية للتنمية المحلية لرفع المستوى الصحى وتقليل انبعاثات ثانى أكسيد الكربون نتيجة حرق مشتقات النفط فى الاحتياجات المنزلية.

*ومن خلال ماسبق من دراسة, فإن البحث استخلاص إمكانية تنمية برامج, دعم مؤسسى , خبرات, وآليات تمويلية لتنمية استخدام تطبيقات الطاقة الشمسية وخاصة الخلايا الشمسية فى تنمية عمرانية ومحلية بمصر وخاصة بمجتمعات جديدة بالصحراء.*

**تنمية الصحراء المصرية:** تعمير الصحراء مازال أحد أهم الأهداف المصرية نتيجة النمو المتزايد لعدد السكان ونمو احتياجاتهم الحالية والمستقبلية منها , ولتحقيق رؤية شاملة لتنمية مستدامة فى شكل مجتمعات جديده بها, لذا فإن تنميه الصحراء التى تمثل 95% من مساحه مصر تعتبر من أحد أهم الأهداف القومية المراد تحقيقها. وتحقيقها هذا, يحتاج الى رؤى جديدة, أفكار, ومداخل تنمية فكرية مختلفة. المشروع المقترح من العالم فاروق الباز بعنوان " ممر التعمير" يتيح تطبيق مثل هذه الاسس والمطالب, ويقدم المشروع آفاق جديده نحو الدراسة والتنمية للمشروع وذلك من خلال إطار قومى يؤكد دور الدراسات البحثية المحلية, حيث يعتبر هذا البحث جزء من هذه المجهودات البحثية.

*والدراسة البحثية للرساله توضح امكانية استغلال تطبيقات الطاقة الشمسية الكهربية واسعه النطاق (VLS-PV) كنموذج ومشروع عملى مدعم من الامم المتحدة. وتكامل المشروع ليكون جزء من المجهودات والسيناريوهات التنموية للصحراء المصرية, وذلك كما ظهر خلال مناقشة التطابق فى كثير من مقومات استغلال مشروع VLS-PV فى منغوليا مع مشروع ممر التعمير المصرى.*

**دراسة الحالة:** الدراسة التى تمت للاختبار امكانية استخدام تكنولوجيا الخلايا الشمسية داخل عدد من النطاقات التنموية بمصر, أثبتت امكانية استخدامها, سواء من خلال الهيكل المقترح لمشروع VLS-PV أو خلال سياق عمرانى جديد مثال النطاقات والمواقع العمرانية بإقليم قناه السويس. من خلال اختبار إقليم قناه السويس واختيار مدينة " المستقبل" بمحافظة الاسماعيلية كحالة دراسية, يتيح دراسه عملية لمدى كفاءة استخدام مثل هذه المجتمعات العمرانية القائمة على أرض الواقع لتطبيق أسس الاستدامة, رفع المستوى الصحى, والاكتفاء الذاتى للطاقة عن طريق استخدام الطاقات النظيفة والصديقة للبيئة وتقليل انبعاثات ثانى اكسيد الكربون لتصل الى الصفر لتكون مصدر الطاقة الرئيسى فى المستقبل.

وقدمت المخرجات من دراسة الحالة لمدنية المستقبل, أهمية دراسة الاعتبارات العامة لامكانية تكامل مثل هذه التطبيقات المستدامة وأنظمة الطاقة الشمسية, خلال مرحل وعمليات التطوير والتخطيط والتصميم المعمارى لها. لكى يمكن من زيادة كفاءة تكامل واستخدام تطبيقات الخلايا الشمسية على المدى المتوسط أو البعيد لتنمية مثل هذه الاقاليم باستخدام تطبيقات الطاقة المتجددة.

**التطبيق " Application of VLS-PV In the Egyptian Desert":** الدراسة التطبيقية تم تقديمها كنموزج تطبيقى لامكانية تنمية الصحراء المصرية من خلال مجتمعات طاقة تكنولوجية/ زراعية فى المناطق الصالحة للزرعة. والتكامل بين هيكل مشروع VLS-PV وأنظمة الخلايا الشمسية (BIPV) داخل الهيكل الرئيسى للنموذج التطبيقى, من خلال السيناريو التنموى " ممر التعمير" يؤكد الدور الاستراتيجى لتطبيقات الطاقة الشمسية للاضافة آفاق جديدة لتنمية الصحراء المصرية.

*النموزج يعرض فكر جديد لتكامل ودعم السيناريوهات التنموية المصرية بأفكار تطويرية, تكنولوجية, عمرانية, ودراسات معمارية تناقش استخدام الطاقات المتجددة لتنمية مجتمعات صحراوية زراعية جديدة ذات مبادئ اجتماعية- اقتصادية وتحقق اكتفاء ذاتى ,استدامة, ومنتجة للطاقة فى نفس الوقت لتسهم فى أحد أهم المشكلات العالمية وهى " الطاقة" من خلال دور محلى.*

# ARABIC SUMMARY

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