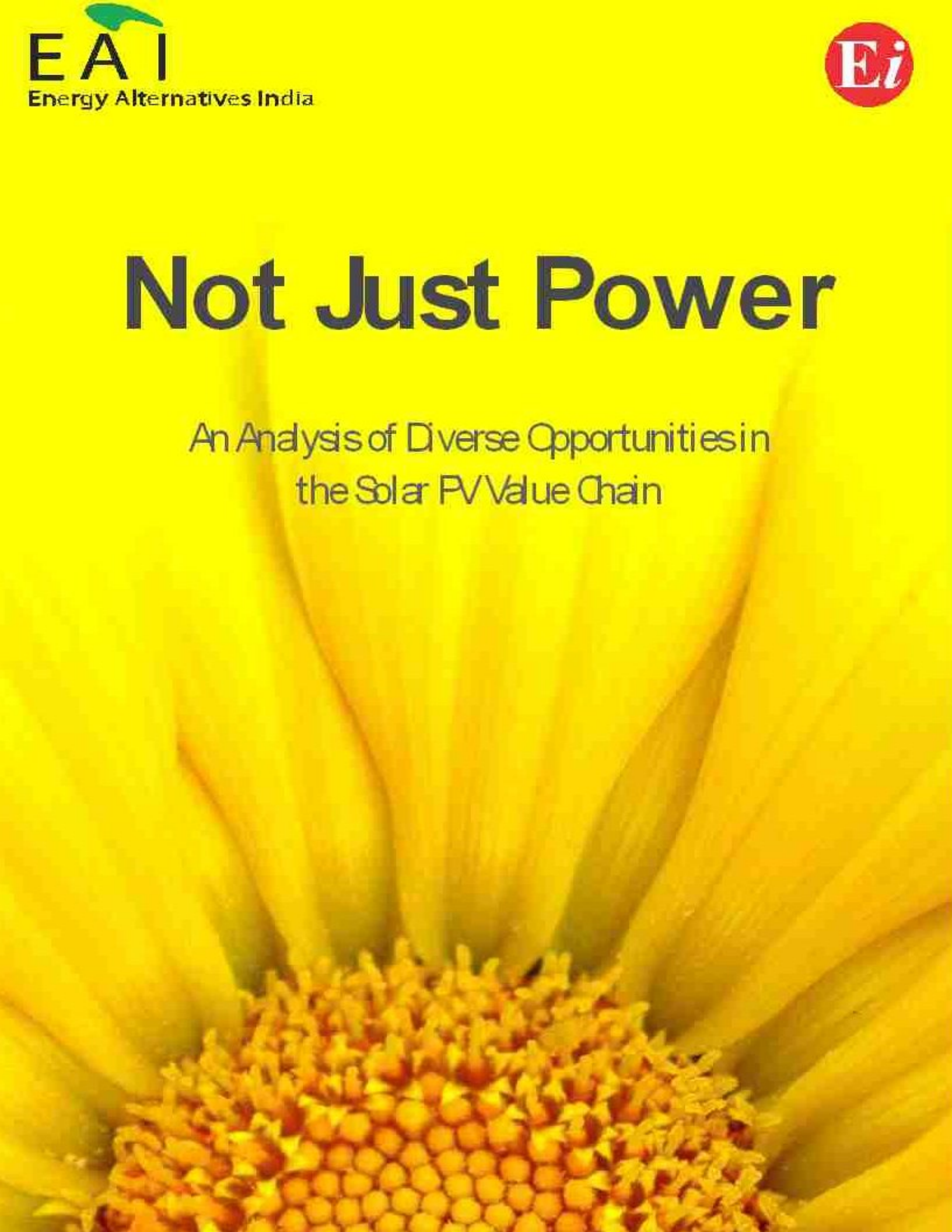


Not Just Power

An Analysis of Diverse Opportunities in
the Solar PV Value Chain



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Value Chain

Preface

As a renewable energy source, solar energy presents an exciting opportunity for India. While the current contribution of solar energy to the total India's energy needs is insignificant, in the medium and long run, it is expected that solar energy, especially solar PV will form a vital component of the country's energy mix.

The most important barrier that had stopped Solar PV from becoming a mainstream renewable energy resource is the high cost of producing power from the resource. This high cost is in turn a direct result of the high capital costs of the solar PV panels and the balance of system required.

The good news is that the capital costs for solar PV panels are expected to decrease significantly over the next 5-10 years. In addition, solar PV technology is continuously improving in terms of its efficiency. As a result of this combination of capital cost reduction and efficiency increase, by 2015, solar PV is expected to reach grid parity in some parts of the world and by 2020, in most parts of the world.

For India, the National Solar Mission and its incentives provide an additional reason for entrepreneurs and investors to explore this industry. The convergence of decrease in capital costs, increase in efficiency and significant financial support by the government is likely to result in a wide range of attractive business opportunities along the entire solar energy value chain in India.

While solar power production is the final benefit derived from solar PV, an entire ecosystem is evolving around this end "product", and this ecosystem will result in a range of opportunities for a number of industries, businesses and entrepreneurs.

This white paper titled Not Just Power provides inputs and insights on the diverse opportunities available in the Solar PV industry. This has been prepared by Energy Alternatives India (EAI), a leading consulting and research organization for the Indian renewable energy industry.

EAI is glad to be part of the 3rd Renewable Energy Hyderabad 2011 Conference which has a focus on the exciting solar PV sector. We hope that this white paper will assist Indian entrepreneurs and businesses in their efforts at exploring this sector.

EAI thanks Exhibitions India/Comet Conferences for providing the opportunity to present this white paper as part of the conference, and wishes the very best for the success of the conference.

Narasimhan Santhanam

Director

Energy Alternatives India (EAI – www.eai.in)

Chennai

List of Contents

1. Overview of the Solar PV Industry in India
 - 1.1 Introduction
 - 1.2 Status of Solar PV Technology in India
 - 1.3 Future Potential
2. Solar PV Value Chain and Businesses Opportunities
 - 2.1 Solar PV Value chain
 - 2.2 Business Opportunities in Solar PV
 - 2.2.1 Manufacturing Opportunities in Solar PV
 - 2.2.1.1 Core Products
 - 2.2.1.2 Non-core Products
 - 2.2.2 Service Opportunities
 - 2.2.3 Trading Opportunities
 - 2.3 Solar PV Power Production – Alternative Business Models
3. Summary and Inferences

1. Overview of the Solar PV Industry in India

1.1 Introduction

1.2 Status of Solar PV Technology in India

1.3 Future Potential

1.1 Introduction

PV constitutes a miniscule part in India's installed power generation capacity with grid connected solar PV generation less than 25 MWp as of Feb 2011¹. Off-grid installed capacity of solar PV power plants including street lights are 100 MWp as of Sep 2010².

Today, PV installations in India predominantly comprise of small capacity applications. These are most visibly seen in lighting applications (street lighting, and home lightning systems) in cities and towns, and in small electrification systems and solar lanterns in rural areas.

But the potential is enormous for solar PV to become a key renewable energy power source for India.

1.2 Status of Solar PV Technology in India

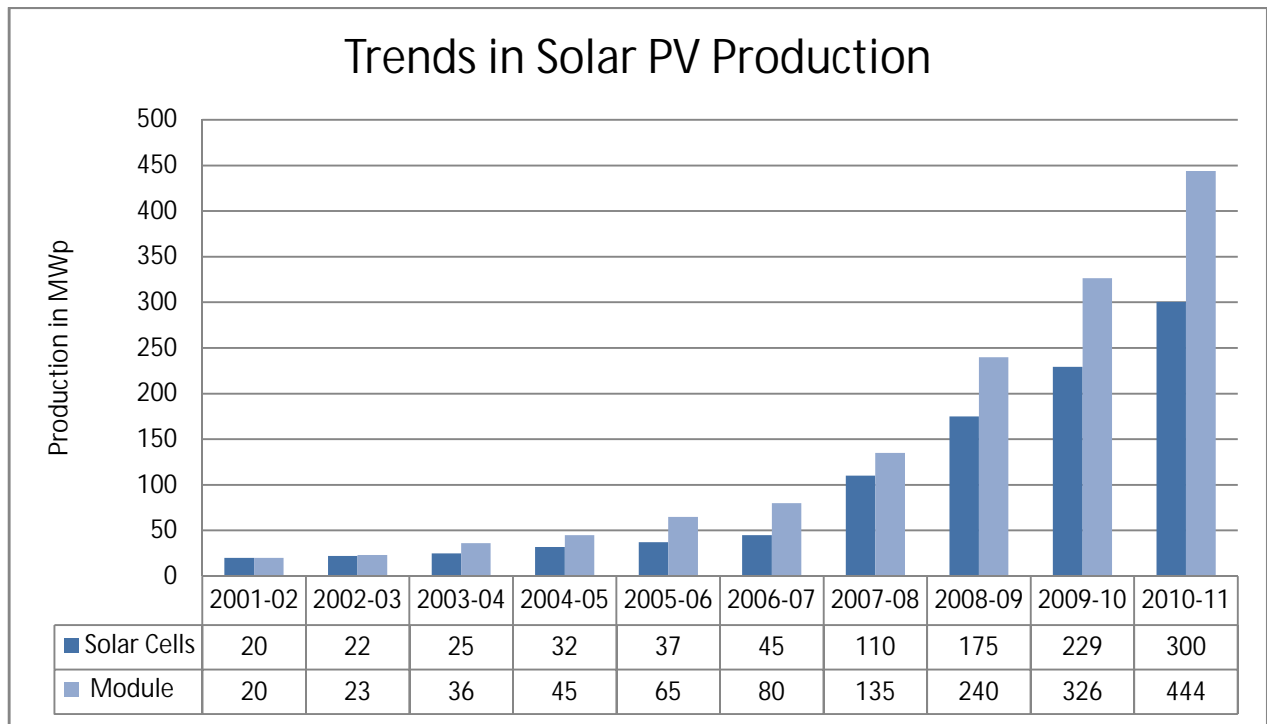
About 40 companies are actively engaged in manufacturing solar cells and panels, and many more companies produce end products such as solar lanterns, street lamps etc. The production in the country during 2009-10 is estimated to be about 230 MWp of solar cells and 325 MWp of PV modules.³ Nearly 90% of the solar modules manufactured in India use crystalline silicon C-Si technology, while only 10% of the solar modules are manufactured using thin film technology.

¹ From respective company websites and news

² MNRE

³ MNRE Presentation, Solar energy Conclave, Jan 2010

Trends in Production of Solar PV Cells and Modules (MWp) in India

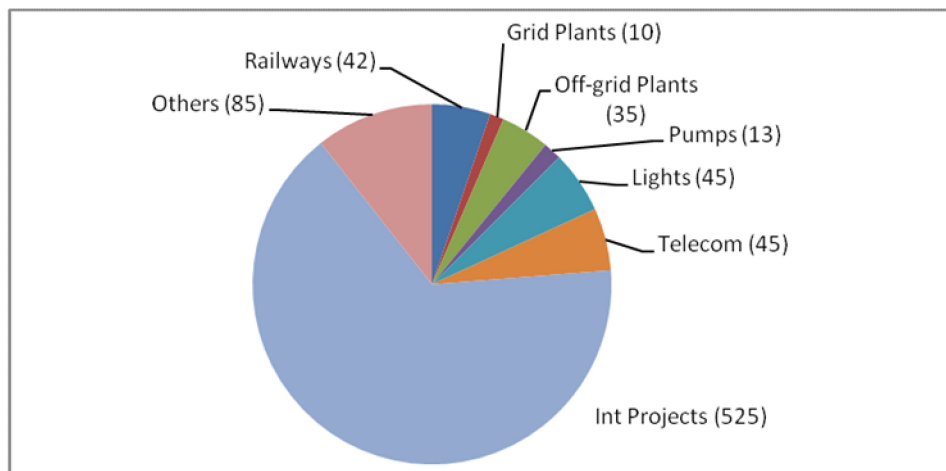


Source: MNRE Presentation, Solar energy Conclave, Jan 2010

Note: The values for 2009-10 and 2010-11 are projected/derived values and may be subject to variation.

As of end 2009, the cumulative production of solar PV cells in India has been about 800 MW. Of this total, only a small portion has been used in applications within India, while the rest have been exported. Of the total amount of solar cells cumulatively used in India, the following are the areas in which they have been applied

Application of Solar PV Cells (MW) in India – Sector wise



Source: MNRE Presentation, Solar energy Conclave, Jan 2010

1.3 Future Potential

Most experts agree that the solar PV market worldwide as well as in India will continue accelerating significantly for the foreseeable future. The global PV market is estimated to be 2.5 times its current size by 2014, based on a slowest growth scenario, while a 'production led' fast growth scenario would see annual industry revenues approach \$100 billion by 2014.⁴

Currently, the Indian Solar PV manufacturing sector is export-led, and is much larger than the country's total installed capacity. The manufacturing capacity of solar PV modules is further expected to grow at a rate of 20 to 25 percent up to 2015 from about 1000 MWp as of 2009, according to Frost & Sullivan.

In addition, the National Solar Mission's target to achieve 20 GW by 2022, of which 50% will be solar PV, and its plan to produce modules and cells domestically increases the need for significant increases in module production capacity. Many states in India are also devising their own, ambitious policies for solar PV power generation, with Gujarat being the most prominent among the states.

Thus, there exists a huge manufacturing opportunity not only for the export market but also to fulfill the NSM and state targets.

Similarly, India's off-grid market has huge potential, especially in the areas such as rural electrification, power irrigation pump sets, back-up power generation for the expanding network of cellular towers across the country, captive power generation, urban applications and highway lighting etc.

In addition to the government's initiatives such as Feed-in-Tariffs/Generation Based Incentive (GBI) as part of the NSM, the incentives under the semiconductor policy, and other expected incentives for the industry make the long-term prospects for this industry much brighter.

These targets and plans have potential to attract a variety of businesses in India, belonging to diverse segments - manufacturing, installation, operation and maintenance, training and engineering, procurement & construction (EPC) businesses, and more. The rest of this report provides more insights on the opportunities for these diverse segments.

⁴ Solarbuzz.com

2. Solar PV Value Chain and Businesses Opportunities

2.1 Solar PV Value chain

2.2 Business Opportunities in Solar PV

2.2.1 Manufacturing Opportunities in Solar PV

2.2.1.1 Core Products

2.2.1.2 Non-core Products

2.2.2 Service Opportunities

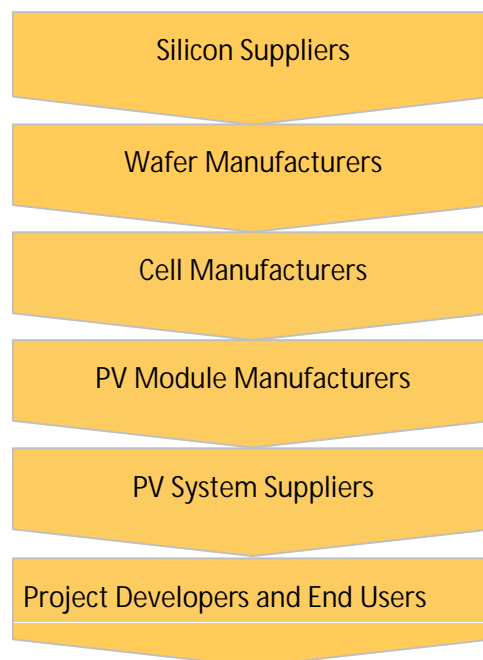
2.2.3 Trading Opportunities

2.3 Solar PV Power Production – Alternative Business Models

2.1 Solar PV Value chain

The solar PV value chain consists of a number of specific and distinct steps from the production of silicon to the end use in solar power plants or in solar panels used for distributed power generation (e.g. solar panels on residence rooftops).

The Solar PV Power Value Chain



Currently, the value chain in India starts only from cell manufacturing, but within the next couple of years, we can expect some companies to be making ingots and wafers in India. Today, Indian manufacturers depend almost entirely on import of silicon wafers or strips to make PV cells.

2.2 Business Opportunities in Solar PV

Business opportunities in solar PV are available in manufacturing, services and trading. Among these sectors, the widest range of opportunities is present in the manufacturing sector, which is followed by services.

In this white paper, an analysis of opportunities is undertaken for all three sectors viz., manufacturing, trading and services.

This analysis of business opportunities is, to a large extent, not country specific, but we have provided some notes on the Indian scenario for each of the opportunities.

2.2.1 Manufacturing Opportunities in Solar PV

Manufacturing opportunities in solar exist in the production of both core and non-core solar products and components

Core

- Polysilicon
- Ingot and Wafer
- Solar Cell
- Solar Panel
- Solar Products

Non-core

- Glass
- Electrical Components: Inverters, Wires and Transformers
- Solar PV System Manufacturing Equipments
- Chemicals for Solar PV System Production

2.2.1.1 Core Products

Polysilicon Manufacturing

The polysilicon is used to manufacture crystalline wafers for solar modules and around a quarter of the cost of a crystalline module is just for polysilicon.

The world market of polysilicon has been growing 30-40% annually since 2004, primarily from the growth in solar PV industry and around 90% of the total polysilicon market is dominated by a few companies that supply around 90% of the total polysilicon market.

No companies in India are into polysilicon manufacturing

Ingot and Wafer Manufacturing

The process of melting polysilicon into ingots and subsequently cutting them into wafers is wedged between polysilicon production and cell manufacturing.

Polysilicon → Ingots and wafers → Solar cells

Yet, it is a distinct process that does not require physical proximity to upstream or downstream processing. Consequently, some companies specialise in just doing that. Typically, ingot and wafer manufacturing are done by the same company.

The wafer industry is dominated by a few (5) companies sharing over 90% of the market, with Shin-Etsu and Sumco alone having a third each. There are however, many smaller companies fighting for share.

In India, the government has so far reportedly received seven proposals adding up to investments of about \$16 billion to set up manufacturing units for polysilicon, single and multi crystalline ingots, wafers, solar cells, photovoltaic modules, etc. Companies such as Lanco solar, Bhaskar solar are reported to be known in this sector. Lanco Solar announced in early February 2011 that it was setting up a 250 MW integrated solar PV manufacturing facility in Chhatisgarh, which presumably will include ingot and wafer production. In February 2011, Carborundum Universal also announced its interest and plans for the silicon ingot and wafer industry.

Solar Cell Manufacturing

Cell manufacturing involves creating the all-important pn-junction, coating and layering. It is an important step in the value chain responsible for about 20% of the total value addition, and it is here where significant technical differentiation is created.

Crystalline Cell Manufacturing

Worldwide, there is an ever-growing number of cell manufacturers, and the industry is not dominated by a few big players. The top 10 producers in 2008 produced just over 50% of the total. The market leader, Q-Cells, commands a market share of 10%.

The production volume of the crystal silicon solar cell in 2009 was 10.7 GW —an impressive 51-percent increase from the year before.⁵

⁵ <http://bit.ly/eRqdwz>

Nine Indian companies manufacture solar cells, primarily crystalline cells (as of Nov 2010)

Thin-film solar cell manufacturing

Manufacturing thin-film modules comprises depositing photovoltaic material on a substrate, structuring it into cells to form an electric circuit and wire and frame it depending on application.

The key suppliers for the thin-film industry are chemical companies that produce high-purity metals such as CdTe, GaAs etc. The supply chain is less constrained than that for polysilicon (used in crystalline solar) and therefore much more reliable. This industry experiences a diverse mix of big-hitters (Sharp), start-up companies and universities. Companies with a long-term vision should start investing in this field.

This is a very dynamic segment with lots of startup companies, some venture-funded. There are also a number of companies that also produce crystalline technologies. Those companies tend to be in the amorphous silicon thin-film segment. The organic photovoltaics segment is mostly covered by research institutes rather than private companies.

The production volume has increased steadily as 165 MW in 2007 and 357 MW in 2008. The share of thin films is expected to increase significantly and expected to reach about 25% of total in 2013. (EPIA data)

There are a few Indian companies such as Moser Baer and HHV Solar that make thin film solar cells.

Concentrating PV

In concentrating PV (CPV), concentrators use optics to concentrate sunlight onto a small area of solar cells, thus allowing for a decrease in cell size. Because a CPV module needs less cell material than a traditional PV module, it is cost effective to use higher quality cells to increase efficiency. However, the technology makes up a very small portion of the solar industry.

CPV system manufacturers assemble the solar cells, concentrator unit and heat sink to form a module. Where applicable, companies will either integrate a tracking device or offer it as a separate product for free-standing module installations.

As a rather recent technology (being commercialized), there are many new entrants, many of whom are venture-funded.

The CPV market is estimated to reach \$266.0 million in 2014 from about \$63.9 million in 2009. There are only a few Indian companies like Square Engineering that produce concentrated solar PV systems

Solar Module Production

Module manufacturing involves putting assembling the cells into a module to form an electric circuit. This is the last manufacturing step before it is distributed to wholesalers.

Initial estimates suggest that the worldwide photovoltaic installations in 2010 were about 17.5 GW – this is an almost 140% growth over the installations that happened in 2009, which was 7.2 GW. This pace of growth is expected to continue for the near future.

There are about 40 companies in India that produce crystalline solar modules.

2.2.1.1.1 Raw Material, Machineries and Equipments for Core Products

Opportunities exist in manufacturing raw material and equipment for the following:

- Ingots
- Wafers
- Cell
- Modules

Raw Materials

A wide variety of raw materials and starting products are required for the entire solar PV value chain. This section provides inputs on the key raw materials and starting products required at each stage of the value chain. These inputs will provide the entrepreneurs excellent insights into the types of opportunities that could be most suitable for them, depending on their current line of business and their competencies.

In the tables below:

- 1) The LEFT HAND SIDE column indicates the MAIN MATERIALS required for Manufacturing
- 2) The RIGHT HAND SIDE column indicates the sub components required for each material

Table 1: Raw Materials

Ingot

Main Materials	Sub components to make the materials
Polysilicon	Modified Siemens CVD reactor, Vapor-to-Liquid deposition reactor, Fluidized bed reactor
Recycled Materials	Broken Wafer, Top/Tail of Ingot
Crucible	Quartz crucible, Graphite Crucible, Ceramic Crucible
Carbon Felt	Carbon Felt
Other	Seed Crystal

Wafer

Main Materials	Sub components to make the materials
Ingot	Monocrystalline or Polycrystalline ingot
Saw Band	Saw band
Slurry	Black Silicon Carbide, Green Silicon Carbide, Recycled cutting liquid Recycled Silicon Carbide
Saw Wire	Saw Wire
Ingot Mounting Adhesives	Adhesives
Acids	Sulfuric Acid, Hydrochloric acid

Cell

Main Materials	Sub components to make the materials
Wafers	Monocrystalline and Polycrystalline wafers
Metallization Paste	Silver Paste, Aluminum Paste
Screen	Screen
Chemicals	Isopropyl Alcohol, Ammonia, Phosphorus oxychloride, Sulfuric acid, hydrochloric acid, Potassium hydroxide, sodium hydroxide
Silane	Silane

Crystalline Modules

Main Materials	Sub components to make the materials
Ribbon	Lead ribbon, Copper Ribbon. Lead free ribbon, tin coated copper ribbon,
Glass Film	Ultra clear patterned glass, AR coated glass, TCO coated glass, BIPV glass Back sheet, EVA
Cable	Copper wires
Other	Junction Box, Connector, Frame, Sealant and tapes

Thin Film Module

Main Materials	Sub components to make the materials
Glass	Ultra clear patterned glass, TCO coated glass AR coated glass
Chemicals	Boron, Cadmium Sulfide, Copper, Alumina, Gallium, Germanium, Indium, Molybdenum, Phosphorus oxychloride, Tellurium, Tin
TCO Material	Diethyl Zinc
Oxides	Zinc Oxide, Tin oxide
Acids	Hydrochloric acid, sulfuric acid
Other	Junction Box, Connector, Cables, Frame, Sputtering Target

Machinery and Equipments

This segment covers the manufacturing of turnkey production line solutions for the thin-film and silicon module production as well as other manufacturing components such as wafers saws or analysis tools.

The top global machinery and turnkey solution providers for the various stages are Oerlikon Solar, Applied Materials and Ulvac Solar. There are also other players in the market, including Roth & Rau, Centrotherm, Spire Solar, Anwell Technologies and Leybold Optics.

Indian companies are yet to make serious forays into machinery and equipment manufacturing for the solar PV industry. A detailed list of machineries and equipments required for the various processes all along the solar PV value chain is provided below.

In the tables below:

- 1) The LEFT HAND SIDE indicates the process involved
- 2) The RIGHT HAND SIDE indicates the equipments involved in each process

Table 2: Machineries and Equipments

Ingots

Process involved	Equipments involved in each process
Inspecting/Testing	Life time Analyser, Ingot vision inspector, Resistivity Inspector, Material Property Analyser, Polysilicon Tester
Cutting & grinding	Ingot Cutting Machine, Ingot Grinding Machine
Crystalline ingot growing	MCZ process equipment, DSS process equipment, CZ process equipment
Others	Ingot Transportation and Storage Cart, Granular Feeder

Wafers

Process involved	Equipments involved in each process
Cutting	Cutting Equipment, Wire Saws, Band Saws, Silicon Recovery System Slurry Recovery System
Cleaning	Ultrasonic Wafer Cleaner
Inspecting/Testing	Life time Analyser, Wafer vision inspector, Resistivity Inspector, Material Property Analyser, Wafer Sorter, Wafer Counter, Wafer Tester
Polishing and grinding	Wafer Grinding equipment, Wafer Polishing Machine
Others	Wafer Handling System, Conveyor, Automatic Water Loading Machine Cassette, Water Separation Equipment

Cell

Process involved	Equipments involved in each process
Etching	Laser Etching Equipment, Plasma Etching Equipment, Wet etching equipment, Texturing Equipment, Power system and gas/Liquid Flow Management System
Diffusion	Diffusion Furnace, Waste gas Abatement system, Doping Equipment Vacuum Pump for Diffusion, PreDiffusion Sprayer
Coating/Deposition	Cell Coating Equipment, Cell Sputtering, Coating Control System Cell PECVD system, Cell MOCVD, Cell CVD, Cell PVD, Cell AR coating system.
Screen Printing	Screen Printer
Furnaces	Drying Furnace, Firing Furnace
Inspecting/Testing	Cell sorter, Cell Tester, Cell vision inspector, Cell coating inspector
Others	Cell Plating system, Cell handling system, conveyor cassette

Crystalline Silicon Modules

Process involved	Equipments involved in each process
Inspecting/Testing	Panel Solar Simulator, Environment Simulating Tester, Panel Cell Position, String Measurement Equipment
Cleaning	Glass Cleaner
Tabbing/Stringing	Stringer, Tabber, Soldering Equipment
Laminating	Laminator, Curing Furnace
Cutting/Scribbling	Cell Laser Scribber, Cell Laser Cutter
Framing	Framing Machine
Others	Ribbon Cutter, Lay up station, Film Cutter, Silicone Dispenser, Ribbon Flux Furnace, Panel Handling System.

Thin Film Modules

Process involved	Equipments involved in each process
Inspecting/Testing	Thin Film Solar Simulator, Thin Film Optical Inspection System, Thin Film Thickness Measurer, Thin Film Time Analyser
Coating/Deposition	Thin Film PECVD system, Thin Film Sputtering, Thin Film CVD, Thin Film PVD, Thin Film AR coating system
Cutting/Scribbling	Thin Film Laser Scribber, Thin Film Mechanical Scribber
Cleaning	Ultrasonic Thin Film Cleaner
Etching	Thin Film Laser Etching Equipment, Thin Film Plasma Etching Equipment, Thin Film Wet etching equipment, Thin Film Texturing Equipment

Source: ENF.cn, <http://www.enf.cn/database/equipment.html>

The above tables provide a glimpse of the range of components, subcomponents and equipments required to make the key products along the solar PV value chain. The list provided is by no means exhaustive but is intended to make entrepreneurs acquainted with the diverse opportunities.

Solar PV Products and Tailored Solutions

Apart from power production and manufacturing cells and modules, other business opportunities using solar PV include the installation and maintenance of stand-alone/off-grid systems for different sectors, and manufacturing solar PV based appliances.

A whole range of solar PV products is emerging in the off-grid sector. Some of the prominent ones are solar lanterns, solar street lamps and solar powered water pumps. Other less known ones are solar pool covers and pool heaters, solar fencings, solar candles, solar LED signals and road studs etc.

While for many of these products the current market sizes are small, the growth rates are expected to be high as larger sections of unelectrified India start yearning for the fruits of electricity and the costs of solar panels decrease at a fast clip. Companies such as Tata BP Solar, Selco, d.Light Designs are already developing innovative products for specific markets.

In addition, companies provide custom made solar solution for various sectors like, bank, telecom, rural development, education and roads & highways. Some of these segments, where installation services can be done in relatively small scale are:

Telecommunication Sector - BTS (Base Transceiver Station) sites require constant and uninterrupted power for the safe operation of the network. Solar panels can be installed to generate the required power.

Solar Water Pumps - Solar water pumping systems can be uses in a wide range of applications from livestock watering to remote home or village water supply and irrigation.

Captive Power Generation – Diesel-based captive power generation is used extensively in the country today to bridge power supply deficits and to overcome supply quality problems in industrial, commercial and domestic applications. These can be replaced with solar power.

2.2.1.2 Non-core Solar Products

In addition to the core business opportunities in manufacturing available along the solar PV value chain, there are non-core opportunities for entrepreneurs and investors in this industry. We list the prominent non-core manufacturing opportunities below.

Solar Glasses

For crystalline cells, solar glass is used for protection and performance enhancement. In the case of thin films, glass is used as a substrate.

Worldwide, in 2007, 138 million tons of glass was produced. Of this, 50 million tons were flat glass, which is used in solar modules and reflectors. The flat glass market is worth €21 billion annually but, only four companies namely NSG Group, AGC, Saint-Gobain and Guardian Industries produce around 60% of the world's high quality float glass.

Few companies in India currently make glasses for solar cells, and Saint Gobain is one of them; the Indian arm of the French glass giant is making serious efforts at extending its glass products to cater to the demand of solar panels sector. Recently, Gujarat Borosil launched solar grade glasses in Dec 2010.

Electrical Components: Inverters, Wires and Transformers

The manufacturing of inverters, charge controllers, wires and transformers is largely a commodities business.

In the case of inverters, efficiencies of these devices are already relatively high, offering only limited room for technical differentiation. There are exceptions - for instance, Steca Solar of Germany provides a solution to the problem of partial shading when solar modules become as inefficient as under full shading. The global leaders in inverters are SMA Solar Technologies, Kaco and Fronius.

In India, the transformer and wires are sourced locally. Inverter manufacturers like Su-kam, Luminous and Numeric are yet to fully start producing inverters for grid connected power plants; hence, as of Feb 2011, the inverters for MW scale solar PV power plants are mostly being imported.

Manufacturing Chemicals for Solar Industry

The manufacturing of photovoltaic modules, thermal receivers and reflectors requires a number of chemicals and materials such as coatings, laminates, photovoltaic materials and solar glass. Some of these chemicals have been listed in Table 1 under Cells.

Production of many of these chemicals also offers opportunities to Indian companies already in the chemicals industry.

2.2.2 Service Opportunities

Significant opportunities exist in the service sector as well, and these could benefit entrepreneurs with diverse skill sets. We provide a list of service opportunities here.

- Financing Support
- EPC
 - Project Development Support
 - Design and Engineering Support
 - Construction and Commissioning Support
 - Operation and Maintenance
- Training Support
- Others

Financing Support

Due to high capital requirements for solar power generation, few large projects are financed by the sponsor's balance sheet. Instead, tailor-made financing is achieved through project finance. Support from the relevant finance experts will be required at this stage.

EPC (Engineering Procurement and Construction) Services

EPC contractors can provide the following services and supports:

Project Development Support

This phase consists of

- Assessment of the customer's needs and objectives;
- Identifying potential sites for a solar farm, acquiring land and securing the rights to use the site for the generation of solar electricity.
- Securing permits to construct, connect, integrate and operate the plant.

In most instances, project developers will also be involved in arranging financing as well as design and construction.

Design & Engineering Support

Every site has its own specific characteristics including geographic location and solar radiation level, site topography, local regulations and requirements for grid connectivity. During the Design & Engineering phase, the optimal structure and choice of components will be determined, based on all input factors. This will require support from specialized experts.

Construction & Commissioning Support

The physical construction begins after the design phase and ends with the act of commissioning when the facility is handed over to the operator, which is in most instances a different organization. Construction companies will find opportunities in this phase.

- **Small Installations** - Small installations for residential rooftop applications are implemented by local installers and electricians directly. Module manufacturers and distributors often maintain lists of certified installers nationwide. This is a very fragmented segment of the value chain with very few companies that operate at national level, let alone globally.
- **Large Installations** - Big projects undergo various stages of development even before construction can begin. Generally, this is a high-margin segment with some companies that are operating globally.

Operation & Maintenance

This stage begins after the construction phase. Operation & maintenance includes activities such as facility monitoring, cleaning solar glass, breakdown management, repair work and warranty management.

Training and Support

MNRE has estimated that in order to achieve the target of 20 GW by 2022, over 1, 00,000 skilled solar professionals will be required, comprising multiple skill sets. This presents a significant opportunity for businesses that can impart skill sets at various levels such as system design, project management, installation and maintenance.

Other Service Opportunities in Solar PV

Software: A number of software companies offer solutions specifically tailored to the solar market. There are three main categories

- **Forecasting Tools:** Mainly for planning purposes, simulation software applications can assist both upstream and downstream players as well as end-customers.
- **Manufacturing Support:** Enterprise tools like SAP offer PV-manufacturing components to help manufacturers optimize their business processes.
- **System Control:** Software that helps measure and monitor the solar generating system, the output of which can be used to optimize the facility. Photovoltaic system monitoring is a combination of hardware (dataloggers) and software tools. Yield analysis is usually also part/task of such monitoring system. Standard options are local or remote monitoring (via web for example). In India, companies such as HCL Technologies and Wipro Eco-energy have already developed embedded software for solar power plant monitoring.

2.2.3 Trading Opportunities

Significant trading opportunities exist for retail solar products such as solar lanterns and other solar based lighting products for the mass market. This sector currently small, but growing fast. Attractive market segments for these are in the rural and semi-urban areas (smaller towns and cities) where there are more regular and long-duration electricity cuts. Trading of solar street lamps could be considered as business opportunities for those who have prior experience in selling to governments and municipalities.

In the context of solar PV power production, trading opportunities currently exist primarily for trading of solar panels and balance of systems for the retail market. Currently, this trading market is not well structured due to the nascent stage of the industry, but in the near future it is expected that there will be opportunities for wholesalers and retailers to target the institutional and retail markets for solar PV panels/systems.

2.3 Solar PV Power Production – Alternative Business Models

Evolving Business Models

While new energy technologies come up all the time, technology is not the driver of the energy industry. The driver is the business model: how you get it financed and how you apply traditional risk-management methods to solar and wind and biomass.

- Jigar Shah, Founder of SunEdison

Within solar power production, there are many business models coming up, and third party ownership is one of the business models that appear to hold good promise for the future. In such a business model, a third party will be responsible for designing and installing solar panels on the rooftop of the host (the host can either be an individual or community), whose rooftops are leased to install panels. In turn, these hosts sign a power purchase agreement with the third party for certain years.

Another model that has potential is the BOT (Build Operate Transfer) model in which the service provider takes care of implementation, operations and maintenance of a rooftop solar power plant for a determined period, after which the asset is transferred to the owner of the rooftop.

SunEdison's solar Service Model and Community Solar Power Model are some of the examples of this interesting model. You can get to know more about this model from <http://www.sunedison.com>.

Currently these models are not followed in India, but with the possibility of attaining grid parity in a few years time, these models could be an exciting business opportunity.

3. Summary and Inferences

This white paper was developed in order to highlight the diverse opportunities available for entrepreneurs and businesses in the solar PV industry.

The following are the key inferences:

- Solar PV power production represents the most prominent opportunity segment. But while the grid connected power production is in the limelight most times, attractive opportunities are emerging for entrepreneurs in the off-grid segment as well
- Some emerging models in solar power production could considerably reduce the risk of adoption and be a win-win for all parties involved.
- Significant opportunities exist beyond power production, in which companies in all sectors – manufacturing, trading and services – could play a role.
- Opportunities along the solar PV value chain exist for all sizes of businesses – small, medium and large.
- Specific industries that could benefit from these diverse opportunities include electrical, chemical, software, construction/EPC service providers with equipment installation and maintenance capabilities, and engineering and design firms.

It is imperative that the Indian entrepreneur analyzes these opportunities before making an investment into the fast growing solar PV industry in India. In addition, we recommend that the entrepreneur gets updated on the emerging trends and case studies in other countries, especially Germany, Spain, Italy, Japan and the US.

All the Best!

For more details on each of the above opportunities and how your company can benefit from these, please talk to:

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About



EAI is the foremost research and Consulting Company for Renewable Energy Industry in India.

We are unique in focus on market strategy and research for the Indian Renewable Energy Sector.

Our team has assisted business large and small on a variety of Renewable Energy projects.

Our expertise has been sought by Fortune 100 companies.

Our team comprises professionals from premier institutes such as IITs and IIMs.

The cumulative wisdom of our team, derived from extensive research and hands-on consulting, has provided us with deep insights about the industry which few, if any, have.

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