COMPETITIVENESS SITUATION OF A KEY SEGMENT IN SOLAR PHOTO-VOLTAIC INDUSTRY IN INDIA: AN EXPLORATORY STUDY

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Abstract*: Solar Photovoltaic (SPV) constitutes a miniscule part in India's installed power generation capacity, prevalent as small capacity applications. The paper attempts to understand the situation related to inverters, a critical sub segment of the balance of systems (BoS). Evaluating competitiveness of Indian players in inveter segment demands first identifying key players and thereafter, assessing availability of data. Research design covering deep aspects of literature & case study research along with quantitative tools is used. This paper hints at the huge opportunities for catch-up on business and technology factors to lay sound foundations for this important low carbon emerging industry.*
To analyze the current status and trends in inverter segment of solar PV industry, SAPLAP (Situation, Actors, Process-Learning, Action, and Performance) framework has been used. Further, to depict the future scenarios of possible synergies of India's growing solar PV sector Scenario Building technique has been used.

Keywords: Solar Photo-Voltaic, Inverters, Balance of Systems, EPC, Competitiveness, Flexibility

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1. Introduction

By the year 2020, India's demand for commercial energy is expected to increase by a factor of 2.5. Also by the same year, India, presently the world's sixth largest energy consumer is expected to meet 75% of its oil and gas needs by imports (Muneer et. al., 2005). India is also world's fourth largest emitter of planet-warming greenhouse gas as coal remains the backbone of India's power sector, accounting for about 60 percent of generation (Reuters, 2009). So, it seems agreeably true that acute attention should be paid to regulate the pattern of industrialisation, especially in terms of adapting energy saving and environmentally benign technologies for sustainable development (Narayanan and Palanivel, 2003).

Stepping forward to meet the upcoming challenges, Government of India (GOI), launched Jawaharlal Nehru National Solar Mission (JNNSM) recommending the implementation in 3 stages leading up to an installed capacity of 20,000 MW by the end of the 13th Five Year Plan in 2022 (Ministry of New and Renewable Energy (MNRE), 2010). During this time, we expect many new ideas to emerge and technologies to become more efficient including both on grid and off-grid SPV technologies so that the price of solar power will attain parity with grid power at the end of the mission, enabling accelerated and large-scale expansion thereafter (Solar Conclave, MNRE, 2010).

Thus, it is imperative for researchers and technologist to understand and work out for improving the photovoltaic BOS for Indian context. In a photovoltaic BOS, ground fault detectors, charge controllers, batteries, and inverters are the components that could benefit most from developments in both technology and basic understanding (Sandia Photovoltaic). Working on these lines, the paper attempts to explore scenario of the inverter segment in India.

The major Indian players on BoS's inveter segment have been identified and thereafter, grilled on their business interest in the budding solar energy sector of the country. An in-depth analysis for a few shortlisted companies has enabled comparison of Indian players with some strong & serious foreign players in India. Further, an extensive review of the available literature has been employed to develop an understanding of the domain of solar Inverter segment in the country. To get into depth of current scenario in the sector, SAPLAP (Situation, Actors, Process-Learning, Action, and Performance) framework has been used (Sushil, 2001). Further, to outlay the future of Solar Inverter Industry in India, the powerful method of Scenario building technique is used.

2. **An Overview of Solar Inverters**

3.It is important to first understand the technological aspect of solar inverters to identify the drivers for development of the sector. The solar inverter is a critical component in a solar energy system. It performs the conversion of the variable DC output of the Photovoltaic (PV) module(s) into a clean sinusoidal 50- or 60 Hz AC current that is then applied directly to the commercial electrical grid or to a local, off-grid electrical network (Texas Instruments, USA).

Table I. Understanding Type of Solar Inverters and their Criticality

Type of Inverter	Description & Criticality in Indian Context
Stand Alone Inverters	• Used in independent solar energy systems. • Usable at remote locations viz., cabin, cottage, water pump or monitoring station and also for mobile energy stations such as boats and RVs. • Their criticality is high in Indian context.
The Grid-Tie Inverters	• Match the phase alongside a utility charged sine wave. Programmed to automatically turn it-self off during power losses to ensure safety. • Recommended for a home which is powered by a utility grid for them to take advantage of net metering. • Majorly it is a product for urban demography.
Battery Backup Inverters	• Able to supply alternating current (AC) power to selected areas which require energy during a power outage. • Incorporating batteries into the system requires more components, is more expensive, and lowers the system's overall efficiency. • For many urban homeowners who regularly outages or have critical electrical loads it is priceless.

(Source: Functionality based on description by Texas Instruments, USA)

Thus, we need first to focus on Stand Alone Inverters development first and then the others to serve the purpose of both rural and urban demography of the country.

4. Overview of International Solar Inverter Market:

The comprehensive list of solar inverter manufacturers for the world was compiled, though it could not be exhaustive ever. Strategic reports were found about them and websites of each

of these companies were visited to find out the facts for quick benchmarking. The following table summarizes the details of few prominent players in world market of solar inverters.

Table II. Summary about Global Players in Solar Inverter Market	
Company	Description
SMA Solar	It has 40% market share of the global market. SMA Solar eyes 40% of the solar inverter market in India. SMA solar has so far sold solar inverters of about 200MW in India.
Power-One	With its focus on renewable Energy and green power solutions, power-one has recently established itself as the world's second largest provider of solar inverters.
Kaco New Energy	The product portfolio offered by Kaco today is being used around the globe for rail vehicle and photovoltaic applications and is now world's second largest manufacturer of photovoltaic inverters.
Fronius International	Fronius was a top 3 player in 2009 but has seen upstarts like Power-One take more market share.
Satcon	It is strong in the US utility market and is growing its operations there but has not grown as fast nor does it have the high margins.
Schneider Electric	Got into the solar inverter market by buying up Xantrex (Canada).
General Electric	GE is trying to become an integrated player in the solar PV market supplying everything from products to services.
Sputnik Engineering	Using the European solar growth to become a reasonably big player in the solar inverter market.
Advanced Energy	AEIS which is a US semiconductor company is also a big manufacturer of solar inverters.
Siemens	The Siemens Group in India has emerged as a leading inventor, innovator and implementer of leading-edge technology enabled solutions.

Several other players' viz., Sungrow, Refu Electronik, Danfoss, Elettronica Santerno and AEG Power Solutions offers the world's most comprehensive portfolio of premium power supply and control products, systems, solutions and services.

5. Overview of Indian Solar Inverter Market:

A similar approach was used to compile the list of few noticeable players in Indian Context.

Table III. Summary about Players in Solar Inverter Market in India	
Company	Description
Tilak international	Tilak international is a specialized manufacturer of solar charge controllers, solar inverters, solar lantern, solar power packs etc.
Su-Kam	Su-Kam is a manufacturer of solar sine wave inverters.
Sterling systems	It is an ISO 9001:2008 certified company, having high tech infrastructure for manufacturing professional grade systems such as UPS power systems and UPS power inverters.
Ammini Solar Pvt. Ltd.	Ammini solar is a manufacturer of solar lanterns, solar inverters, solar home systems, solar street lighting systems etc.
Novergy	Manufacturer of solar photovoltaic modules, solar water heaters, solar inverters, solar array and combiner boxes etc.
Soyo Systems	An ISO 9001:2008 certified companies engaged in manufacturing and supplying solar power equipments.
SR Electronics	Leading manufacturers, exporters and suppliers of electronic equipment like online UPS, solar inverter, digital inverter etc.
Bharat Electronics Limited	BEL is one of the eight PSUs under Ministry of Defense, Government Of India.
Corporation Limited (Webel SL Solar)	Websol Energy Systems Ltd. (formerly Webel SL Energy Systems Ltd.) is a leading manufacturer of photovoltaic monocrystalline solar cells and modules in India.
Usha India Ltd	Usha International Limited is a multi product consumer durable manufacturing, marketing and distribution company. With a diverse portfolio, they are now focusing on developing low cost solar technology.
Udhaya Semiconductors Ltd.	SL was established in the year 1984. The company manufactures Solar PV Cells, Modules and Module based systems with a capacity to produce 5 MW Cells and 10MW Modules.
TATA/BP Solar	Tata BP Solar provides complete solutions for deploying a solar power system in the often harsh conditions of an offshore rig and several remote terrains.
Moser Baer Photovoltaic	Known for CD/VCD's it ventured into Solar field and has developed high standard technology enabled plants for solar PV

	manufacturing.
Maharishi Solar Technology Pvt. Ltd	An ISO 9001:2000 Company exporting its products to countries viz. USA, Italy, Spain, France, Germany, Netherlands etc.
Indosolar Ltd	Indosolar Limited is the leading Indian manufacturer of solar photovoltaic cells. Current manufacturing capacity is 160 MWp with an average efficiency rating of 16+%, peaking at 17.2%.
Central Electronics Limited (CEL)	Largest manufacturer of SPV in India. CEL today is also a major international player in industry.
Bharat Heavy Electricals Limited (BHEL)	They are integrated power plant equipment manufacturer and one of the largest engineering and manufacturing companies in India in terms of turnover.

6. Methodology for Case Development

Understanding sources of competitiveness is utmost important for capability building. It is companies that ultimately compete by strategic decisions for capacity building and flexibility (Banwet et al., 2002). Sources of competitiveness for the firm identified have been classified & structured hierarchically. Companies for detailed case study have been carefully selected based on analysis of secondary data about competitiveness performance of the company over a period. Secondary data is collected from the company's annual report, internet/web sites, magazines etc., and is being analyzed. The company's financial performance, international performance (exports, imports, etc.), its achievements, in comparison to its competitors/industry averages etc., are being calculated and scrutinized. The leaders are being identified for best in the class benchmarking. Then some international benchmarking is in process to evaluate the performance as compared to global giants & industry. Finally, the reasons for the company's competitiveness have been extracted. Apart from all secondary sources, few informal interactions with senior executives of the national companies were held.

Relevant select factors from the following facets of competitiveness (Momaya, 2001) have been explored to develop the case studies:

i. Competitive Assets:

Including parameters like factor costs, human resources, industry infrastructure, technological factors, demand conditions, government, intangible assets and leadership.

ii. Competitive Processes:

Processes like strategic management, implementation, HR Development, Technological management, synergies, competence building, supply chain management and operations management.

iii. Competitive Performance:

It includes dimensions like productivity, Human Resources, Quality, Cost, Financial, International, Technological, Intangibles.

Each area has been grilled upon to develop cases that reveal the indicators of competitiveness, the reasons and areas of concern for competitiveness of the industry (Momaya, 1998)

7. Case Studies

Detailed case studies are being developed for two selected companies, one from overseas and one from India.

7.1.Case I: SMA Solar Technologies (International)

SMA Solar technology is the world leader in inverter segment of BOS. It has even now moved to India and is trying to make its base here. It possesses the cutting-edge competitiveness in the sector. The case study is very important as it gives a lot of hint on best practices in the field or even the lessons about hurdles in this market. Further, their intention to get established in India is an important filed of concern.

6.1.1 Indicator's of SMA Solar Technologies' Competitiveness

Competitiveness of SMA solar technologies in the field of inverters in BOS is outstanding. SMA Solar Technology AG is the worldwide market leader for solar inverters, a leading supplier of transformers and chokes, and a provider of innovative energy supply solutions for mass transit and main-line rail transportation. SMA Solar inverters are characterized by a particularly high efficiency of up to 99 %, which allows for increased electricity production. The multi award winning product range covers solar inverters for roof systems, major solar projects and off-grid systems, enabling SMA to provide a technically optimized inverter solution for all size categories and system types. The highly flexible manufacturing plants for solar inverters in Germany and North America have a capacity of approximately 11.5 GW a year. SMA Solar Technology AG is headquartered in Niestetal, near Kassel, and is

represented in 19 countries on four continents. The Group employs a staff of over 5,300 worldwide, plus a number of temporary employees which varies on a seasonal basis. In recent years, SMA has received numerous awards for its excellence as an employer and in 2011 reached first place in the federal “Great Place to Work” competition. Since 2008, the company has been listed in the Prime Standard of the Frankfurt Stock Exchange (S92), and also company’s shares have been listed in the Tec DAX. In 2010, SMA generated sales of 1.9 billion Euros. Latestly, it has been given Best Innovator Award category Renewables, by A.T. Kearney and WirtschaftsWoche.(SMA Annual Report 2010) Comparison with competitors can be good indicator of competitiveness. Table IV summarizes the financial comparison.

Table IV. Comparison of Financial Statements of Select Globally Leading Solar Inverter Manufacturing Companies (Figures in millions US Dollar)

	SMA Solar	Conergy	Advanced Energy	Power-One
Total Revenues	2596.9	1235.5	459.4	1047.1
Gross Profit	937.5	293.5	198.9	406.6
Total Operating Expenses	238.2	316.9	133.2	112.6
Operating Income	699.3	-23.4	65.7	294.1
Net Interest Expense	2.3	-21.5	0.5	-6.3
EBT excluding unusual items	702.3	-25.3	67.8	286.6
EBT including unusual items	700.7	-38.5	67.4	251.5
Net Income	493.7	-60.5	71.2	147.9

Source: Annual Business Report(s) & Bloomberg Business Week [Data as on 2/1/2011]

It is distinctly visible that nearest of its competitors are not even its half in size. It is the sole leader of the market, but it has to put in more efforts to be expanding and continue the legacy since other players though yet not comparable in financial terms are rapidly growing.

6.1.2 Reasons for Competitiveness of SMA Solar Technologies

SMA is technology leader and has the best system technology expertise for photovoltaics worldwide. Their ability to innovate is a major driver of competitiveness. The pursuit of top quality in both product and services is their concern. Figure 1 depicts sources and reasons of their competitiveness.

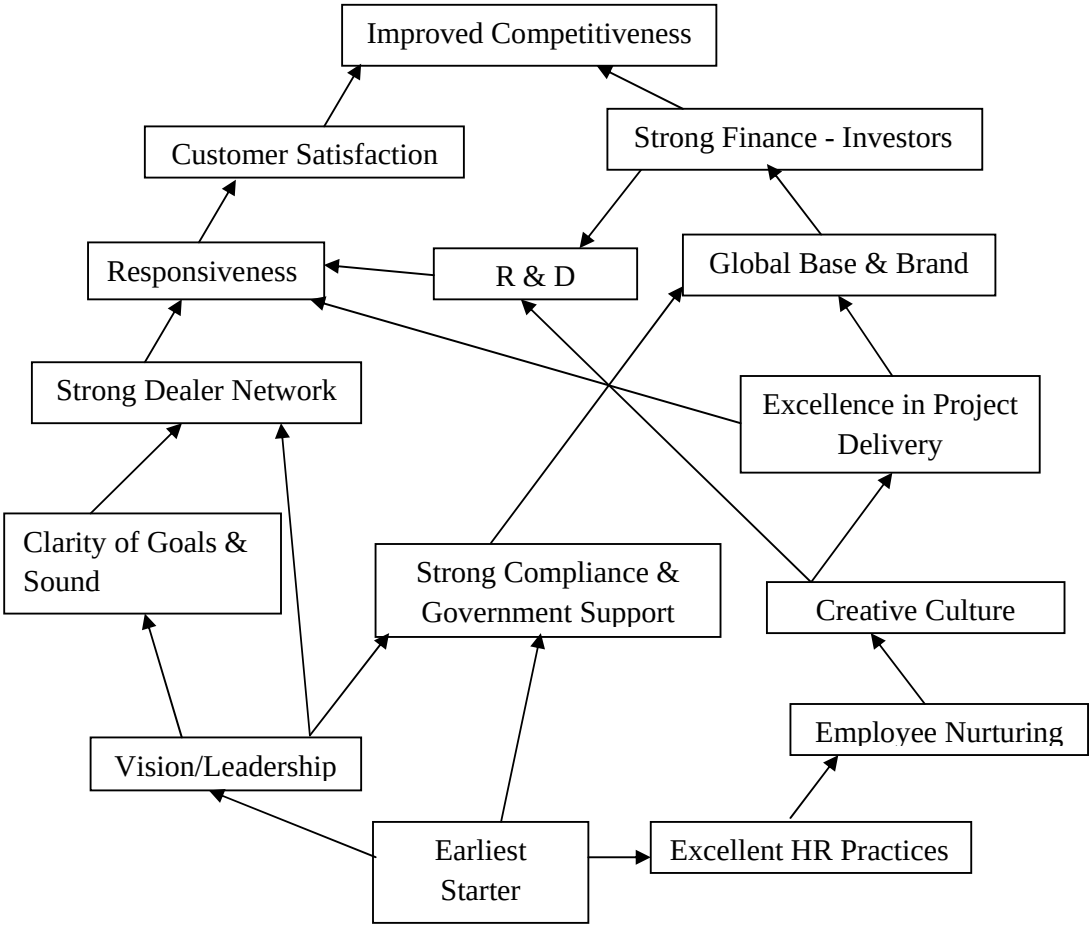


Figure I. Sources of Competitiveness for SMA Solar Technologies Global

They focus on products, worldwide service, quality and reliable delivery to meet and exceed our customers' expectations. Open employee communication on all levels, more involvement in the definition of the company goals, joint design of changes, the freedom to structure jobs self dependently, fairness, equal treatment and respect, profit-sharing, and opportunities for further training for individuals are some of the major HR competitiveness paradigm. They continually refine their products, structures and processes. SMA possesses high degree of flexibility and ability to change. Financial success is further adding to its competitiveness as

it is far ahead of any other competitor. Strong compliance with laws and other legal regulations of countries where they operate adds to their long term success. Being the earliest starter in the field it has certain accrued advantages. Factors like visionary leadership, quality orientation and spirit of entrepreneurship have been the reasons for constant growth. It is always a first mover in global expansion strategy and tries to explore new markets.

Modern ethos like corporate social responsibility helps it to get closer to society and the customer. The culture followed by it's over 5300 employees is highly innovative and full of flexibility. Being a giant it has good linkages with administration and government bodies. Strong dealer network provides the best promotion. SMA Solar Technology AG is headquartered in Niestetal, near Kassel at Germany and is represented in 19 countries on four continents exemplifying its excellence. High responsiveness and strong financial base is helping it to flourish and establish into the new markets across the globe. Further, flexibility, employee attention and technological innovation add feathers to its cap of competitiveness.

6.1.3 Areas of Concern for Competitiveness of SMA Solar Technologies

Turning to the other side of the coin, SMA needs to focus on its weaknesses to continue its regime. The upcoming companies are expanding at a faster rate. It is due to enhanced product modulation and advertising strategies adopted by them. Also they are more innovative to launch attractive ranges. So, SMA will need to come out of the traditionalism and act to meet the ever changing needs of new customized generation. It is clearly visible that Power One is posing a stiff competition to SMA as far as competitiveness dimensions are concerned. Owing to its huge size, SMA definitely is more than double of Power-One, but, the way it has been growing in past 5 years; definitely it's an alarming situation for SMA. Very clearly visible from the facts in the table that power-one is far ahead in capital utilization factor. They have almost clinched 70% times more the value than SMA did. Even they are able to generate higher margins on the same sales. Low asset turnover ratios of SMA must be a major concern for the company management as the same is adding to the fast growth of the competitors. Power-One is gain posing a stiff competition as far as quick or current ratios are concerned. Adding to the same are total debt/equity and other ratios.

There is considerable scope for improvement in innovation and product flexibility in SMA. Though it has been in market for almost 30 years but there may be weaknesses in technology management in terms of technology transfer to develop new customer attractive designs. Managing large number of permanent and contractual employee is yet another challenge in

the process of fostering innovation throughout the company. However, with its long experience it must focus on its core strengths to improve the scenario.

Table V. Comparison of Financial Ratios of Select Globally Leading Solar Inverter Manufacturing Companies

	SMA Solar	Conergy	Advanced Energy	Power-One
Return on Assets	13.47	-9.03	9.52	23.91
Return on Capital	23.80	-15.66	13.10	44.39
Return on Equity	27.61	-154.17	15.52	49.22
Gross Margin	28.66	19.45	41.72	34.88
EBITDA Margin	19.04	-6.55	16.92	24.50
Lev. Free Cash Flow Margin	-5.83	-2.36	-0.22	0.68
SG&A Margin	7.67	10.62	14.68	7.77
Total Assets Turnover	1.3	1.5	1.1	1.7
Accounts Receivable Turnover	10.2	8.0	4.5	5.1
Fixed Assets Turnover	7.4	6.4	16.9	16.2
Inventory Turnover	4	4	4	5.1
Current Ratio	2.4	1.4	4.2	2.6
Quick Ratio	1.6	0.5	3	1.8
Total Debt/Equity	2.8	173.8	-	9.3
Total Liabilities/Total Assets	43.3	82	23.2	45.3

Source: Annual Report(s) and Bloomberg Business Week [Ratios as on 30/9/2011]

Further, looking down to the latest 1 year financial statistics of growth (Table VI); the situation looks not so favorable for SMA's growth. The total revenue generated has deflated against very high growth by Power-One and Advanced Energy. Further, sinking gross profit is again an area to be looked upon. So, there are enough areas wherein actually there is a need of change in methodology so as to get these figures right. To name a few product designs, brand awareness, innovative finishing and strengthening distribution channels are very important.

It could also look into forming strategic alliances and mergers in new markets rather than looking to set up its own base each time. Further, it needs to look more towards developing and under-developed economies wherein such products have not reached yet, so, as to almost

create new demands, tie-up with their governments; so as to continue the supremacy in the global market.

Table VI. Comparison of Growth over Prior Year of Select Globally Leading Solar Inverter Manufacturing Companies (Percentage)

	SMA Solar	Conergy	Advanced Energy	Power-One
Total Revenue	-8.11	-9.89	49.92	35.54
Tangible Book Value	13.53	-16.16	38.72	57.51
EBITDA	-42.25	-358.17	74.30	28.93
Gross Profit	-31.34	-28.26	46.28	29.15
Receivables	-8.55	-23.33	17.42	12.83
Inventory	13.67	2.72	39.18	24.57
Diluted EPS Before Extra	-47.73	-30,574.5	63.65	41.25
Capital Expenditures	6.44	23.70	173.06	97.49
Cash From Ops.	-64.84	-170.88	-966.45	-69.40
Levered Free Cash Flow	-149.04	454.33	-96.90	-94.86

Source: Annual Business Report(s) & Bloomberg Business Week [Data as on 2/1/2011]

6.1.4 Summary of Competitiveness of SMA Solar Technologies

Definitely, SMA Solar Technologies is the biggest player in the market and is also a very progressive company. The group has shown very phenomenal success in the past and is still the market leader. The group may be slightly weak on paying attention to factors focused upon by their upcoming competitors, but overall, SMA solar technologies continues to be the world leader in the field.

7.2.Case II: Amara Raja Batteries– Indian Battery Giant now in Solar Inverter Filed

The inverter segment of BOS is in its nascent stage of development in India as compared to the world. None of the Indian company stands apart, as far as financial the competitiveness of top 20 global companies of the segment is considered. However, with the increased focus of the government and launching of missions like JNNSM the sector has witnessed entry of a large number of players including renowned global and local industrial houses.

Amara Raja batteries are the domestic leaders who have now resorted in the inverter segment of BOS. It possesses the best of the people and technology in the Indian Sector. The case study is very important as it gives a lot of hint on best practices in the field in India, the

hurdles and critically highlights the situation of the Indian solar PV industry. Further, it highlights several vital issues relating to development of competitiveness of Indian solar PV industry.

6.2.1 Indicator's of Amara Raja Competitiveness

Competitiveness of SMA solar technologies in the field of inverters in BOS is making a remarkable step in the country. First prize under the discrete manufacturing category at the CII- 4th National conference and competitions on Six Sigma clearly indicate that the company is following latest techniques to achieve global benchmark. Employer Branding Institute, a premier industry body on assessment of best people practices awarded Amara Raja the following awards:

Regional round (Southern region):

- Award for ''Best HR Strategy in line with Business''
- Award for ''Continuous Innovation in HR Strategy at Work''
- Award for ''Excellence in HR through Technology''

National rounds:

- Award for ''Best HR Strategy in line with Business''
- Award for ''Continuous Innovation in HR Strategy at Work''
- The Supply Chain Leader 2011 award under the category dry cells and storage batteries by Industry 2.0 India SCM Conclave.

Thus, from the above points it becomes very clear that the company has an excellent HR policy, is innovating in nature and is at forefront in excelling in supply chain practices too, though in related categories. So, it can be spelt out that company possesses various capabilities and qualities to be a representative of India on global front in the sector. Also, the company bestows its strengths on its people and the awards in HR policy category are an indicator of the same. Only a few players of the inverter segment are listed in the stock exchanges and Amara Raja is the strongest among them.

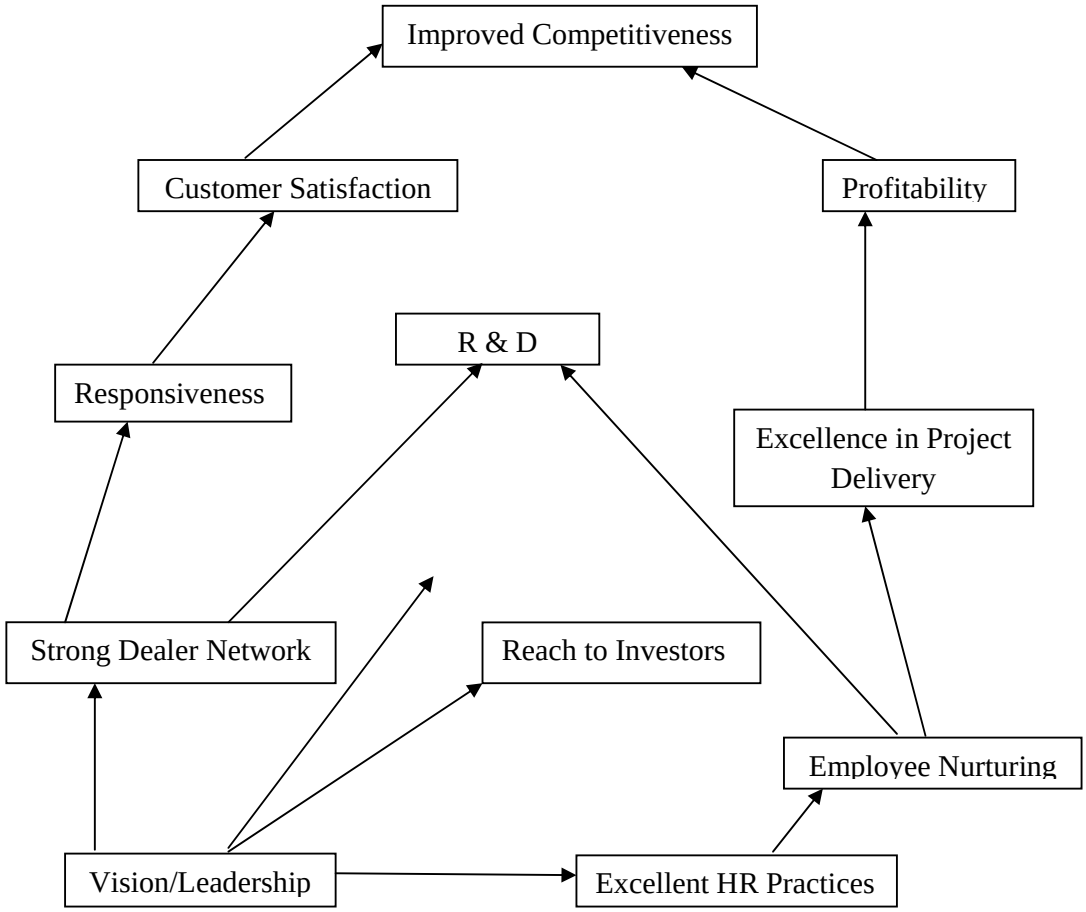


Figure II. Sources of Competitiveness for Amara Raja Batteries

6.1.2 Reasons for Competitiveness of Amara Raja Batteries

With innovative engineering, research and design, Amara Raja has grown with partnerships and information sharing with world leaders. Amara Raja is committed towards latest generation technologies by developing and manufacturing globally competitive, customer focused products of world class quality and responsibly introducing these products into relevant markets. Amara Raja focuses highly on Research and Development, Amara Raja has also built a Battery Excellence Centre – the first of its kind in Asia. This research and engineering centre has been conceived as a completely self-sufficient facility with a full range of testing equipment. As a result, Amara Raja is uniquely placed to offer substantial

benefits on sizing of batteries and electrical systems to its industrial and OEM customers and will be able to effect valuable improvements in product performance and manufacturing techniques. Furthermore, this centre will not only serve the needs of the domestic market, but alliance R& D projects.

Table V. Comparison of Major Solar Industries in India: Some Financial Interpretations

	Amara Raja Batteries	Indo Solar	USHA Industries
Fixed Assets Turnover	3.68	0.3	0.00
Inventory Turnover	8.93	2.81	0.00
Current Ratio	1.82	0.85	0.21
Total Debt/Equity	91.19	543.73	189.86
Total Liabilities/Total Assets	634.83	690.69	-51.68
Gross Profit (Cr.)	297.55	66.31	-0.03
Total Income (Cr.)	131.48	97.91	0.03

Source: Capital Line Databases and Money Control Databases

Areas on Concern for Amara Raja to Enter into Solar Inverter Segment Field

There are quite a number of domestic players having local holds on the market. However, with such strong backing it would not be too though for Amara Raja to get a hold on the local market. When we look at the bigger picture companies like SMA solar are now eyeing upon the Indian market, so, it is definitely the critical time for them to plunge strongly in the field and then capture the market. It also needs to strategies to enter into nearby markets like Sri Lanka, Nepal and other countries so that it gains enough financial backing to enter the global market. It will be very critical for the industry to have technology transfer from the leading global technology institutes. However, strong training of the work-force is essential to create global benchmarks.

7.3.Case III: Sukam Inverters– Prominent Indian Company in Solar Inverters

Su-Kam Power Systems Limited is India's one of the most admired power solutions provider, with a growing presence across India and over 70 countries worldwide. Su-Kam develops intelligent power back-up solutions, engineered to be energy efficient and thus reduce the user's carbon footprint. Working further towards a cleaner, greener planet, they have branched out towards eco-friendly inexhaustible energy solutions like solar power.

6.2.1 Indicator's of Su-Kam's Competitiveness

The company sells its products through a strong network of branch offices, channel partners, and distributors. Su-Kam awarded the prestigious Enertia Award'2011 for Technology and Innovation – Renewable Energy category in recognition of its initiatives in the field of Solar Energy.

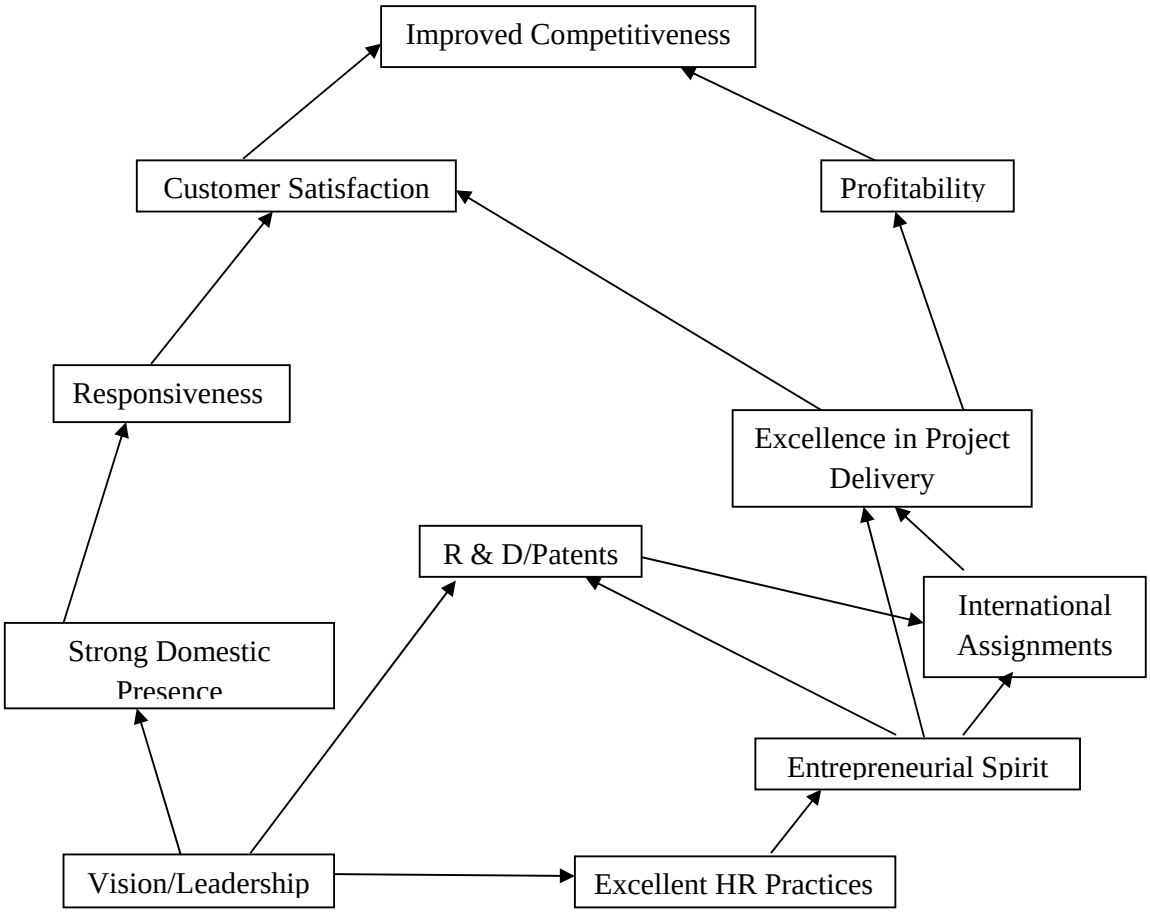


Figure III. Sources of Competitiveness for Su-Kam Batteries

The CEO, Mr. Kunwer Sachdev was among the Top 10 SME (Small & Medium Enterprises) Entrepreneurs awarded by SME Channels. Top national and multinational companies, service providers, enterprises, governments, research and educational institutions India-wide rely on Su-Kam to deliver products, services and innovative. These are customized and tailored by Su-Kam to the individual requirements of their clients in terms of their particular usages and applications

It is a pioneer to develop India's first MOSFET based inverter, India's first microcontroller based inverter, India's first plastic body inverter, India's first Home UPS which eradicated the need to buy a separate UPS for computer. It also developed India's first sine wave based inverter. It developed 5 KVA Inverter for AC & Refrigerator (500 KVA). It also developed India's first SMF batteries to be used with inverters. Thus it has number of factors to count on its domestic competitiveness.

6.3.1 Reasons for Su-Kam's Competitiveness

It exports its products to various international markets. The company is based in Gurgaon, India and has strong presence with branch offices in various cities across India. Su-Kam has been selected for the award for its continued focus on R&D and the indigenous development of several products in the solar energy sector. The company has spent over 2% of its turnover on R&D in 2010–11, making it among the top spenders on R & D in the Indian private sector. The in-house development of products like solar inverters, solar charge controllers, solar PCUs, India's first solar home UPS and more, provides further testimony to both Su-Kam's technological superiority and its commitment to green energy sources. Su - Kam has filed over 70 Patents, 80 Copyrights and 38 Trademarks. It has 53 Designs to its credit. 2 of the major investors associated with Su-Kam are the Anil Dhirubhai Ambani Group (ADAG) with a market capitalization of $ 81 billion and net assets of $ 29 billion. This name has amply proved its mettle when it comes to business acumen and vision. Temasek Holdings is the investment arm of the Government of Singapore, which manages a portfolio of $ 142 billion. It is one of the few global firms to have been awarded the highest corporate credit.

6.3.3 Areas of Concern for Su-Kam's Competitiveness

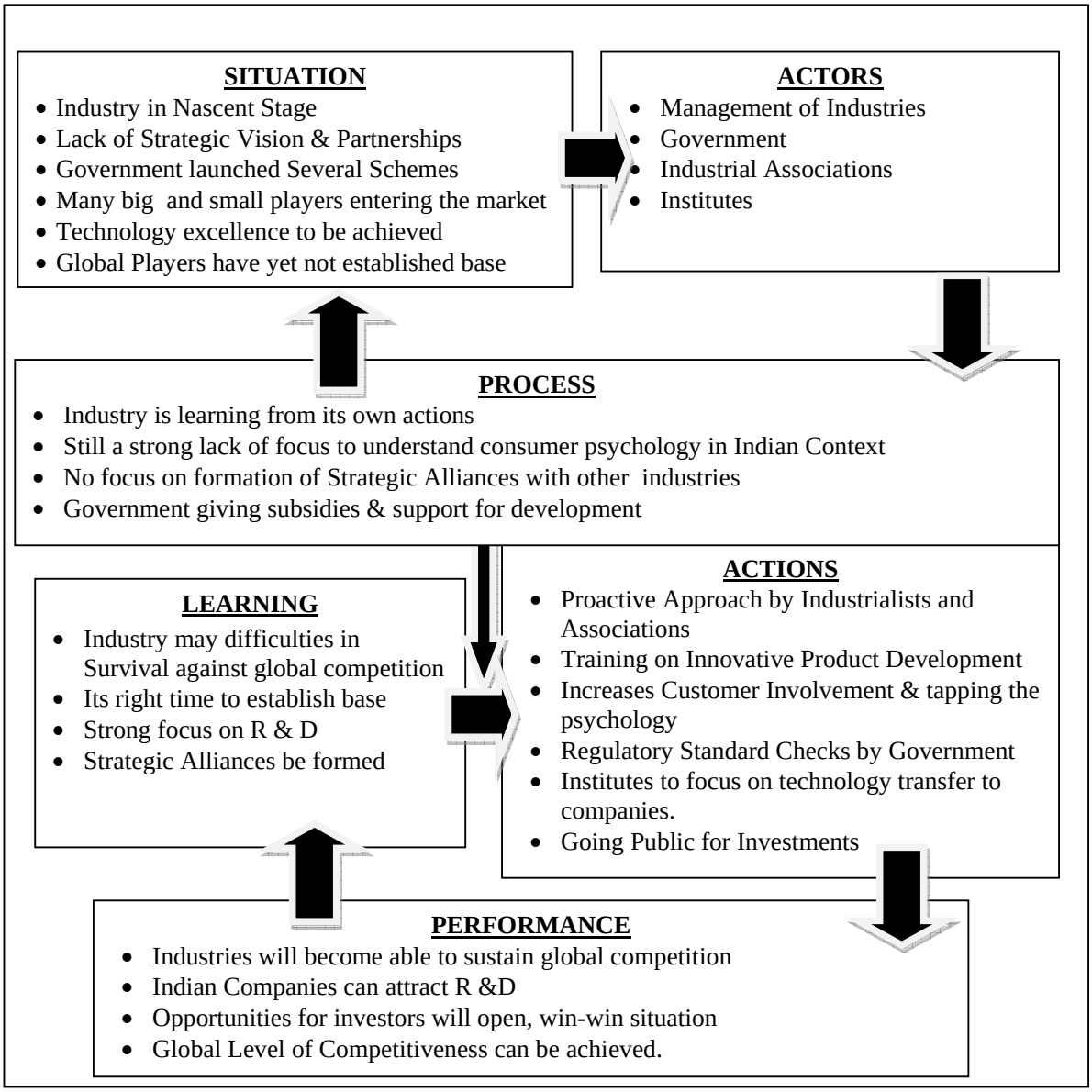
Though, Sukam has high number of credits to count on its domestic excellence but to mark a presence on international fore front it will have to strengthen its financial and technological base manifolds. In comparison to global giants like SMA solar technologies or emerging one's like power-one its financials reservoirs stand below 20 percent. So, the company may not be able to withstand the competition posed by international competitors even in domestic market in upcoming years. Also, it may problems with depreciation of Indian currency as it has significant trade deficit (difference between imports and exports). There needs to be a strong focus on talent acquisition and nurturing the work-force with global technology. It needs to form strategic alliances with global leaders of the field for technology acquisition.

Also, it may count upon the domestic technology institutes and organizations to work for technology transfer.

Development of SAP-LAP Framework for Indian Solar Inverter Industry:

SAP-LAP is a holistic framework that aids the process of analysis to generate models for managerial enquiry and problem solving (Sushil, 2001).

(Figure IV: SAP-LAP Framework for Solar Inverter Industries in India)



The Situation, Actor, and Process comprise of the SAP framework where the freedom of choice lies with the Actor. A synthesis of SAP leads to LAP which deals with Learning, Action, and Performance. Thus, it is highly important for the stated actors to focus on the

learning to do the action so that the sector may give the desired performance. It is very important to understand that through a strategic vision and appropriate R & D the Indian companies may find their sustainability in the sector. Available data and interactions with industry professionals hint at huge opportunity for scale-up in capabilities for Indian players, before the international giants set-up bases to dominate. Ongoing research on competitiveness of industries in India (e.g. Auto Components, Engineering Construction and Telecommunications; Momaya, 2001) hints that the regaining competitiveness and market shares from established international giants is very difficult. For instance, despite massive growth in domestic market, firms in India entered vicious cycles (incl. technological competitiveness (e.g. Mittal et al., 2009) that they are finding so difficult to break. Solar PV can provide opportunities for employment and low carbon development, if key stakeholders learn from past and implement flexible strategies to build capabilities and leverage them for international markets.

8. Scenario building for the Inverter Segment of Indian Solar PV Sector

Introduction to the Scenario Building Technique

'Scenario Building 'is an important management technique used in strategy planning and policy formulation (Nasim & Momaya, 2007). Although the concept of scenario was first introduced by Berger in1964,(Berger,1964) the word 'scenario' was reportedly first used by Herman Kahn in 1967.(Kahn,1967).A scenario is basically the description of a future situation based on sequence of events leading from the present situation to the future situation (Nasim and Momaya, 2006). Scenarios are not projections, predictions or preferences, but alternative futures. It is a story that describes a possible future, identifying some significant events, the main actors ,helping people explore what the future might look like and the likely challenges of living in it. (Watt and Davis, 2003).There exist various methods of scenario building ranging from quantitative simulations to highly creative methods. To name a few are System Dynamics simulations (Forrester, 1961), Harva method, Storytelling etc (Maira et al, 1997).

4.2 Scenario Building - the Methodology

A mix of Harva method and the Shell's method for scenario building is used. The steps undertaken to arrive at the potential scenarios may be broadly enumerated as follows:

i. Decision on the key question to be answered by the analysis

Given the context of the paper, the key question is "What are the actions to be taken to develop the competitiveness of Domestic players in Solar PV Segment in India?" this key question however was finalized after extensive data search and brainstorming reviews

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ii. Setting the time and scope of analysis

A usual timeframe of 9-11 years has been considered.

iii. Identification of major stakeholders

Although there may be a number of stakeholders, but the major ones considered are Solar PV industries, Government Bodies and Technology research organizations and institutes.

iv. Mapping basic trends and driving forces

Forces driving changes in these sectors are identified and trends are mapped to for an in depth understanding of the context. SAPLAP analysis of the sector has given important dimensions.

v. Finding key uncertainties

Key uncertainties refer to those driving forces which are important and uncertain (less predictable). In our context, the basic uncertainty lies whether domestic industry progresses due to Sustained Efforts and will be able to capture considerable share of Global Market.

vi. Identify & Description of the potential scenarios by mapping the uncertainty

Mapping the uncertainty identified above on xy axis helps identify the future potential scenario. For our context, four potential scenarios identified (Preferred, Positive, Pessimistic, and Worst scenario) are further explained in detail and represented in the Fig. 3. Each Scenario has been described to develop further understanding.

vii. Recommend actions for the stakeholders to achieve the preferred scenario

Having identified the preferred scenario for the future, the next logical step is to identify what needs to be done. For this actions are recommended for the stakeholders, to help preferred scenario come true in the future.

Potential Scenarios for Solar PV Industries in India

Figure V shows the potential scenarios for the sector and it depends on 2 uncertainties:

a. Progress of Domestic Industry due to Sustained Efforts
b. Large Share of Global Market Captured by Indian Industries

Description of the potential Scenarios…2020

As evident from the Figure V, four scenarios are described as follows:

Preferred Scenario-2020*:* India- Global Hub of Quality Solar Inverters

There has been a sustained progress of domestic Industry due to high efforts put in by all the actors viz government, industries, technology institutes and now the large share of global market has been captured by Indian Industries .Backed by strong R & D and very competent ethos and networks the industry is adding to the competitiveness of the country.

Positive Scenario-2020: Flourished Domestic Inverter Segment in the Country

There has been a appropriate progress of domestic Industry due to high efforts put in by all the actors viz government, industries, technology institutes and however still the major share of global market has not been captured by Indian Industries .Still the sector is competent enough to survive in the front of global competition and exploring in under-developed and developing markets. With time its heading to attain global benchmarks.

Pessimistic Scenario-2020: India- Domestic Players Facing Stiff Competition

There could not be appropriate progress of domestic Industry due to entry of strong global competitors who have used the advantage of capital to eat up the market, still due to various efforts put over time industry is surviving but the scenario is too though for their expansion as it needs lot of monetary investment which is being attracted by opponents.

Worst Scenario-2020: India-Domestic Players lost the battle to Foreign Companies

The Indian inveter industry almost collapsed due to its archaic methodology. The plans and efforts were only on paper. The global players have established strong base in the country. The monopoly developed by them almost kills any local player entering the market. Even government subsidies could not attract the quality work force and methodology to be infused into the sector.

Potential Scenarios 2020

Future of Inverter Segment of Solar PV Industry in India

Progress of Domestic Industry due to Sustained Efforts

Positive Scenario

Flourished Domestic Inverter Segment

Small Share of Global Market Captured by India

Preferred Scenario

Indian –Global Hub of Quality Solar Inverters

Large Share of Global Market Captured by India

Worst Scenario

Domestic Players lost the battle to Foreign Companies

Pessimistic Scenario

Domestic Players Facing Stiff Competition

Domestic Industry did not catch-up to Competitive Level

Figure V Potential Scenario of Inverter Segment of Indian Solar PV Industry in 2020

Actions Recommended for the Preferred Scenario

i. Management of Inverter Industries & Industrial Associations:

- They must try to figure out their core strengths.
- Encourage their research teams to work on product differentiation.
- Must involve customer to have the development of user-friendly products.
- Must focus on chap procurement sources.
- Try to form Strategic alliances with certain bigger and smaller partners.

ii. Government

- Stress on deploying more Industrial R & D.
- Try to get international collaborations for the sector.
- Must provide subsidies to the bigger domestic houses entering the field.
- Put a check on foreign industries trying to eat up the domestic sector.
- Put strict qualitative checks on the industries.
- Try to give them position in Special Economic Zones (SEZs).

iii. Academic & Research Institutes

- Conduct Training on Best Practices of the Sector.
- Focus on Technology Transfer to Industries.
- Help the sector in goal setting and benchmarking for the industry.
- Foster best project management techniques to industries.

9. Concluding Remarks

The solar PV inverter segment in India is still at an inception stage. Global giants have rich experiences and are keen to leverage markets in India for growth. However, the domestic industry still has an opportunity to flourish, if it can act fast before the domestic markets are fully captured by global giants. The role of government and research institutions is indispensible for the same. The sector needs to understand the global practices and methodology to develop new definitions of flexibility for growth. Developing competitiveness to a higher stage, may be possible, if indigenous firms catch up through sustained efforts in right direction, for which the critical time has arrived.

Road Ahead for the work

Among the long list given above, we plan to carefully select few polar cases that are open to interactions and sharing data and further benchmark the industries to develop industry specific competitiveness facets. Reluctance of the firms to share data and poor availability or access to quality data are posing major barriers to research, but we are working on alternatives.

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Financial Databases
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Annual Report of Amara Raja Batteries accessed via Money Control through their database at
"http://www.moneycontrol.com/annual-report/indosolar/directors-report/I03".
Bloomberg Business Week, Internet Financial Research Database accessible on their website at "http://investing.businessweek.com/research/company/overview/overview.asp"

List of Websites Being Referred (except above)

To get the financial and other information about companies to benchmark their competitiveness:

Company	Website
Tilak international	www.tilaksolar.com
Sterling systems	www.sterlingsystems.com
Ammini Solar Pvt. Ltd.	www.ammini.com
Novergy	www.novergy.co.in
Soyo Systems	www.soyosystems.co.in
SR Electronics	www.srelectronics.in
Bharat Electronics Limited	www.bel-india.com

Corporation Limited (Webel SL Solar)	http://www.webelsolar.com/
Udhaya Semiconductors Ltd.	http://www.uslsolar.com/
TATA/BP Solar	http://www.tatabpsolar.com/
Moser Baer Photovoltaic	http://www.moserbaersolar.com/index.asp
Maharishi Solar Technology Pvt. Ltd	http://www.maharishisolar.com/
Indosolar Ltd	http://www.indosolar.co.in/
Central Electronics Limited (CEL)	http://www.celindia.co.in/
Bharat Heavy Electricals Limited (BHEL)	http://www.bhel.com/home.php
Kaco New Energy	www.kaco-newenergy.com/
Fronius International	www.fronius.com/
Satcon	www.satcon.com/
Schneider Electric	www.schneider-electric.com/
General Electric	www.ge.com/in/
Sputnik Engineering	www.solarmax.com/
Siemens	www.powergeneration.siemens.com/