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Human Capital And Large Scale PV Deployment

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Abstract : Energy is one of the central parameters required for human survival after food. "Knowledge is power" and renewable energy plays increasingly important role to run knowledge-based society for sustainable social and economic development. Out of these, solar photovoltaic (PV) energy system is a useful tool to run the knowledge based systems. Apart from research and development, PV systems need suitable human capital for its successful penetration into every nook and corner of the society. The main aim of the present paper is to address the quality and quantity of human capital need in future to bring the solar PV power in the world electric power budget. Analyses on the chronology of PV power systems indicated that PV would be equivalent to other conventional power sources by the year 2023. Proper implementation of PV power systems needs three levels of human capital and these are i. Skilled technicians ii. Experienced technologists and iii. Efficient executives. While the technicians would be involved in the installation, operation, maintenance and monitoring of solar PV systems, technologists need to provide the basis for the liberalization of PV systems and the executives need to develop its market, policy, planning and execution. Academic and research institutions need to develop these types of human capital to match with future demand of the PV power systems. Market and human capital are interdependent and the market for clean energy depends on issues like energy security, climate change, fossil fuel depletion, new and novel technologies and environmentally conscious consumers. The future PV market depends upon how powerful these forces are individually and collectively. Thus the PV communities need to build up human capital as well as newer market to generate demand for human resource for better dissemination of PV power.

Keywords: *PV systems, performance, grid management, human capital, PV education.*

I. INTRODUCTION

The second half of 19th century became the witness of transition from fuel wood to coal and that marked the beginning of our dependence on fossil fuels as the principal energy source. This was followed by large scale introduction of mineral oil and natural gas. Today, many argue that conventional mineral oil and gas supplies will be unable to meet anticipated demand and concomitantly will be much more expensive in the coming decades. This lies at the core of major enegy concerns.

Energy security issues arise from a combination of factors including the increased reliance of most developed and many developing countries on imported mineral oil from politically sensitive regions of the world and peak oil theories which predict that the world's supply of oil is starting to run out. In 2009, four countries, Saudi Arabia, Iran, Iraq and Kuwait accounted for 46.3% of the world's 1.333 trillion barrels of proven oil reserves. The world's largest consumer of oil at 18.6 million barrels per day (22% of the world total) - the United States - imports 66% of the oil that it refines and oil imports are only going to increase in the future. Rapidly developing economies like China and India are dependent on imported oil to fuel their economic growth. At 10.4% of the global total, China is now the world's second largest consumer of oil after the United States. China, like the United States, is a country which does not have adequate domestic oil reserves. In fact, the top four oil consuming countries are U.S., China, Japan, and India and they are the net oil importing countries. The International Energy Agency (IEA) [1] predicts that between 2008 and 2030, China and India will have average annual growth rates in oil of 3.5% and 3.9% respectively compared to the 1.0% average annual growth rate for the world due to their large population, available infrastructure and increase in supply chain. Oil supply disruptions may occur due to monopoly in pricing power or the risk of terrorist attacks in countries which hold large amounts of the world's proven oil reserves, thus causing energy vulnerability for oil importing countries [2]. One of the worst energy security scenarios is if a hostile regime seizes control of an important oil field in the Middle East and either raises the price of oil dramatically or completely cuts off the flow of oil.

At current global production rates, there is 46 years of oil remaining in the world [3]. While expectedly, the world will never completely run out of oil, the cost of extraction is likely to increase across time as oil becomes scarcer. Resource depletion issues arise from the fact that most of the easily accessible oil deposits are being depleted faster than new ones being found. Historic data shows that global oil discovery peaked in 1966. Oil production peaked in the U.S. in the early 1970s and global oil production is forecast to peak sometime around 2010 - 2020 [4]. In fact the IEA now expects global oil production to peak around 2020. Moreover, as reported in ref. [1] there are even some indications that oil production from Saudi Arabia, the country that holds 20% of the world's proven oil reserves, will soon reach at the peak. Peak oil theories suggest that it is imperative to find an alternative to oil before the peak in oil production. Others, like [2] are even more concerned about the future of the global economy as peak oil ushers in an era of ever rising oil prices. Researchers are now concerned about the emergence of economic globalization that can build upon the availability of cheap oil. Cheap oil keeps transportation costs down. As a result, a whole new production process has expanded to assemble finished products made from components sourced in different parts of the world. Once oil prices start to pass $150 per barrel, it no longer makes economic sense to ship goods from halfway around the world. The rising energy costs will more than offset the low labour costs that are typically found in emerging economies.

Climate change is now recognized as one of the biggest threats to society [5]. Indian Ocean experiments (INDOEX) indicated that climate changes such as rising temperatures, rising sea levels, altered rain fall patterns, and greater variability in weather patterns, have the potential to seriously disrupt business activity. In particular, climate change can affect business activity through industry specific risk like regulatory and physical risks and company specific risks like reputation, litigation and competitive risks [6]. According to the World Resources Institute, 61.4% of global GHG emissions come from the energy sector which means that any serious attempt to control greenhouse gas emissions will have to reduce fossil fuel consumption and increase renewable energy consumption. This implies putting a price on carbon either through taxes on carbon intensive products or a cap and trade system with the result that carbon based energy products like oil will increase in price [7]. Pricing carbon will raise the price of carbon intensive energy products and help to encourage a replacement by low carbon energy sources.

Technological development is often cited as an important driver behind renewable energy because many renewable energy projects are capital intensive to build and the sources of renewable energy are often long distances from their usage. Bringing down the costs of producing renewable energy is one of the biggest challenges for the widespread adoption of renewable energy and technological improvements are vital for this to happen. Renewable energy policy can affect the development of new energy technologies and it is important to achieve the right mix of policy.

Environmentally conscious consumers are now demanding products that have less of an impact on the environment. As individuals become wealthier they show concern not just for the quality of life that they have but also for the quality of life of their children. Environmentally conscious consumers as a driver of renewable energy get mentioned more in developed economies than emerging economies which is not surprising since consumers in developed economies have higher incomes and often have a greater preference for environmental sustainability. Higher income individuals are often the first adopters of new renewable energy products.

The above discussions indicate that renewable energy technologies hold the promise of addressing these security and environmental concerns; this has been characterized as moving from hunting and gathering fossil resources to farming renewable resources. However, many challenges must be met successfully if a renewable energy transition is to be accelerated appreciably. The scale-up required for an appreciable renewable contribution is two to three orders of magnitude. Cost reduction is essential for large scale deployment. These call for development of proper human capital for successful exploitation of renewable energy technologies.

Engineering and technical education in the south Asian countries has undergone a boost due to the privatization of technical education. After completion of the first undergraduate degree a good number of students are absorbed in the information technology (IT) sectors while many leave the country for advanced studies in applied sciences, management or IT sciences in USA or Europe. Studies indicated that every year about 21–22% students are flying to USA, about 11-12% to UK, 9-10% to Germany, 8-9% to France and 6-7% to Australia from south Asian countries. However, very few of them are aspiring for taking education and training on PV engineering and technologies. Moreover, there are few institutions around the globe those are offering dedicated courses on PV power engineering and the program is not attractive to the students due to lack of attractive job offers after completion of the program as PV still has very limited market to offer high quality jobs.

II. MARKET FOR PV

There are many projections for the PV market and during the last five years, PV market has improved reasonably. However, major applications of PV happened in four major distinct areas and these are:

- Consumer applications, having a market of 17-18%
- Off grid industrial, having a market share of 8-9%
- Off grid residential, having market share 7-8%
- On grid, having the market share 40-65%

The consumer applications are mainly restricted to small scale products that started from the inceptions of terrestrial applications of PV. In most of the developing countries the mobile phone towers are run by diesel generator and the individual mobile phones are charged by the PV charging systems. Moreover, the automobile industry has immense potential to be an emerging market for PV. In most urban areas, especially in tropical countries, the car roof as well as its metal body get overheated during the prolonged summer and becomes very uncomfortable for the user at the end of the day. These can, therefore, be integrated with PV systems installed on their roof to reduce the heat load of the car while they are parked in urban open space. This, in turn, will help to reduce the cooling load as well as the load of the storage battery of the car.

Remote mobile phone towers need quality electric power for generating proper connectivity and in many developing countries there is scarcity of such power and the towers are run by additional diesel generators to charge the storage batteries. The power demand capacity of a tower is in the range of 1-1.25 kW_P and PV power station can serve the need for supplying quality power to these towers. If such power stations are adopted, a demand of 1.5-2.0 GW_P PV power for supporting the rural mobile power stations can be met. This is one of the future demand areas for the off-grid industrial market.

Power supply to the off -grid residential has started in the late 80's but storage problems and limited time of power supply brought stagnations in the market. On the other hand small power pack up for individual residential house took a leap in the market.

On-grid supply or the grid integrated PV systems captures a major market share as it became a successful commercial venture. The carbon emitting industries took a special interest in this market as the systems can fetch carbon sequestering certificate that can earn additional value in this venture.

While in the past, consumer products and remote industrial applications used to be the main cause for turnover in PV, in recent years the driving forces are more pronounced in the grid-connected systems and by installations in developing countries. For the promotion of rural electrification combined with the creation of local business and employment, suitable measures are proposed in the context of the PV product value chain.

The competitiveness of grid-connected systems is addressed, where electricity generating costs for PV are projected to start to compete with conventional utility peak power quite early between 2010 and 2020 if time-dependent electricity tariffs different for bulk and peak power are assumed. The most effective current-pulling force for grid-connected systems is Indian Government's recently declared Jawaharlal Nehru National Solar Mission (JNNSM) with reasonable feed-in tariff where the generating companies are focusing on yield, performance and long-life of the power plants.

III. NEED FOR HUMAN CAPITAL

As already mentioned, engineering and technical education in the south Asian countries has witnessed a significant boost due to the opening of private funding in education sector. Dissemination of knowledge is now a commodity rather than service. Due to the entry of large number of engineering and technical institutions, there is an inclination for emerging technical subjects over conventional subjects. After completing the undergraduate degree courses in engineering or applied sciences, majority of the students are preferring information technology (IT) and allied jobs for higher salary structure compared to manufacturing related jobs. Studies also indicated that students opting for advanced studies are in favour of pursuing these in USA or Europe in applied sciences, management and information sciences. Very few of them are aspiring for taking up studies on renewable energy technologies as till date job potential in this sector in South-Asian region is meager. As a result there is paucity of manpower in the renewable energy sectors which is another constraint in renewable energy deployment in general and PV in particular.

To overcome this constraint there is an urgent need of integration between educational institutions, industries, engineering-procurement-construction (EPC) companies, Government agencies, bank and financial institutions. From pedagogic point of view, three types of courses appear to be necessitated and these have been conceived as i. Skilled Technician level course, ii. Efficient technologist level program and iii. Skilled executive level program.

Input for first course should have first degree and the duration will be for sixteen weeks. The course should cover fundamentals of electricity and methodologies for conversion of mechanical energy into electrical energy. It should also cover basics of electronics and their possible failure modes. Finally, it needs to train students in the whole gamut of PV cells to systems - assembling, installation, operation, maintenance and monitoring.

The second program is comparatively a higher one where the input will be graduate engineering or applied science. Duration of the course should be for fifty two weeks. The course may comprise of two semesters with the odd semester offering fundamentals related to sun and solar power, methodologies for conversion, solar PV effect, materials and technologies for conversion of solar energy into electricity, technologies from PV cell to systems, system designing and integration procedures, industry related aspects, related to testing and procedure for technical backup. The even semester shall educate students on preparing a PV related project work and internship in the PV industries or the PV balance of system (BOS) related industries.

The third program will be mainly for the professionals and it can be implemented after the office hours, preferably in evening hours. The duration of the program may also be for fifty two weeks. The course shaould cover marketing and management aspects of all types of power systems in general and PV in particular. Commercial project preparation, management, financial and market analyses will be the major thrust areas of this program. Impact on environment, pollution auditing and risk factors of all the power plants are proposed to be covered in this program.

IV. JOB POTENTIAL

It has been observed that implementation of renewable energy systems create a large no. of jobs per mega watt of installed capacity. Available data and estimates are the suggestive of the future job potential in the renewable energy sectors. It was reported that about 20,000 people are directly involved in PV business and nearly 100,000 people are indirectly involved in PV power generation, distribution and planning in the USA. Reasonable calculations indicate that nearly 150,000 people will be involved in PV power business by the year 2020. About 25-30 persons are already involved in every MW_P of PV power installed in Europe and additionally, 10-15 more persons are indirectly involved in this business. Germany employed 40,000-42,000 people in PV industries. This is more than total employment in nuclear industries. In India, the European trend of green job opportunities is reflected. But it is a pity to observe that there is still a deficit of good designers, landscapers and skilled technicians for planning and installing MW_P level solar PV power projects. Inquiries and speculations suggest that worldwide there are possibilities of creating 10 million jobs by 2030. These figures justified the need for human capital in PV domain in the coming days.

V. EXPERIENCES IN RUNNING SUCH PROGRAM

The three distinct academic programs mentioned earlier have been formulated at Jadavpur University, India and studies on inputs and outputs were carried out. The first program is a certificate course while the second and third programs are post graduate diploma courses. The first type of program i.e. the ‘Skilled Technician level course’ has been successfully running for several years and post graduate diploma program in categories second and third are also continuing for quite some time. At the inception stage of energy studies, sixteen weeks program was implemented to develop technicians. The post graduate program in “Energy Science & Technology” was implemented in the year 1995and post graduate diploma program in “Energy Management & Audit” is also running during the evening hours. The post graduate program in Energy Science & Technology covers all aspects of energy technologies with special emphasis on renewable energy. The post graduate diploma program is joined mainly by professionals and are conducted during the evening hours. In both the programs, the participants learn PV technologies in details. Experiences reveal that there is a possibility of further enhancement of the above courses through the following improvisations:

i. Development of attractive teaching methodologies and ii. Involvement of the PV industries for offering internship for developing experiences on the product manufacturing and vend services. Teaching and learning methodologies on clean energy need both in-house and outreach modes and this may include: i. Where **it** comes from ii. Making **it** available iii. Better ways to use **it** iv. Impact on people and the planet, and v. Making the choices.

The courses need internship to involve the industries actively in partnership with institutions for mutual benefit and growth. The industries can have fresh brains to enhance products and improve processes while identifying future human resources and man-power for their organizations. The students can get hands-on experiences and learn about the industrial environment which help them in decision making in their future profession. This close association between industry and institutes involving products, process and services has the potential to attract future generation for large scale PV deployment. Successful implementation of above aspects will create better prospective jobs to the degree holder and simultaneously can meet the demand for industries for exploration of PV market.

VI. CONCLUDING REMARKS

It is evident from the above discussions that there is need for appropriately trained human capital to promote PV technologies in the larger interest of sustainable energy solutions. Market and human capital are interrelated and complementary to each other. The present paper focused on four types of existing markets as well as some potential market, which has also been projected in the text. Studies also indicate that in reality, human capital is a function and market is a variable. Thus effective interaction of market and human capital can make efficient and wholesome integration for the PV technologies in future and trigger wider applications throughout the world.

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