LUISS UNIVERSITY

RENEWABLE ENERGY- CAN INDIA ENERGIZE ITS WAY TOWARDS A NEW FORM OF SUSTAINABLE DEVELOPMENT?

MANAS PURI

Renewable Energy - Can India energize its way towards a new form of sustainable development?

Thesis submitted towards the completion of M.Sc. in General Management at LUISS GUIDO CARLI, Rome Italy

By

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His thoughts on latecomer advantages, resource leverage and national competitive advantages have formed a basis of my research in this thesis. Much of which was taught to us by Prof. Mathews in the International Business course at LUISS GUIDO CARLI, Rome, Italy.

I greatly acknowledge the support of my friends who have been very supportive throughout and with whom I have had various constructive and positive arguments about the pros and cons of the Indian democracy and governance process.

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ABSTRACT

China and India have been hailed as the fastest growing markets in the world. Although the development of these two economies have taken a totally different path altogether, energy security and independence poses a common threat to both these gigantic nations. While China has followed a tradition pattern of economic development by transforming a largely agrarian economy to a manufacturing based economy which would ultimately lead to a service centric economy, India has managed to jump directly to a service centric economy and it is only now that its manufacturing sector is shaping up to contribute substantially to its economic growth. Energy industry and policy of both these countries will decide the future development of these nations. At present, both these economies rely on fossil fuels and coal for most of their energy needs which are growing at a hasty pace. Going forward, both these countries will have to rethink their development agenda in light of the global warming and the approaching peak oil production. Although development and increasing living standard is a right for every country, development can no longer be path independent as was previously assumed. Strategies that de link industrialisation and energy usage have to be promoted and those that depend on fossil fuels for energy need to be discouraged. China has already flagged of its very ambitions and well integrated energy policy which aims at generating 15 per cent of the country's electricity from low-carbon sources by 2020[1]. China has also been leveraging from its already established resources and capabilities in the manufacturing sector which has resulted in its becoming the world's largest producer of solar Panels. India on the other hand has so far given mixed results even though it was one of the first countries to establish a ministry of renewable energy.

The purpose of this master's thesis is to understand the process of industrialisation and the role energy plays in it. In the first part it will focus on how China and India can radically change the way we look at industrialisation and energy security. In the second part it will look at the current energy strategies and policies employed by the companies and the government of India and China. In particular, the strategies that they can employ both in short term and long

[1] http://www.ccchina.gov.cn/WebSite/CCChina/UpFile/File571.pdf

term. It would also endeavour to analyse if both these countries have advantage with respect to their latecomer status. In its third and final part, a more focussed and detailed view is taken on the Indian renewable energy sector with specific focus on bio fuels and solar energy. Also, it would attempt to formalise the strategies that India can use in order to convert the comparative advantages that they have into competitive advantages. Both these countries with their huge topography and diverse geography have an enormous potential to produce energy from various renewable sources. What remains to be seen is how these countries leverage on these resources and allocate them to develop a competitive advantage in the renewable energy industry in both short and long term. In this way they would solve the double problem of energy security and also establish a new pathway for development of underdeveloped nations such as those in Africa. It would also mean specialising and obtaining a competitive advantage in an industry which would undoubtedly be crucial for sustainable existence and development of the developed world and the developing world respectively.

Key Words: Renewable Energy, India, Late movers Advantage, development, Biofuels, Solar energy

TABLE OF CONTENT

LIST OF FIGURES

INDUSTRIALISATION, GROWTH AND ENERGY

The story of development of human civilization may as well be called his quest to locate dependable sources of energy in order to increase the living standards or climb up the value curve as far as economic development is concerned. Coal helped the UK and almost all of the western countries to move from agrarian based economies to the manufacturing economies paving way for future developments. This process was later followed by countries like Japan and Korea in Asia who followed the same trajectory of development that the west did. The question that arises is that can Africa and much of Asia follow the pattern of development that the US and Europe followed? Although there is a vast literature available on the theory of development, hardly any of them look into the role of energy in the process of development and its effect on nature and environment. India and china roughly comprise of 40% of the world's population. What is more curious is the fact that the developing world sees the United Stated as the bench mark for their future course of development. Can we really afford to have another country which consumes as much as the United States does? An average American consumes about 4000Litres of water every day. In India, on the other hand, the national policy is 40 Liters per day. If we have India or China following that trend as they grow, we would need about 2 more planets to support our population in terms of resources. Gurcharan Das the author of India Unbound rightly remarks "*Never before in recorded history have so many people been in a position to rise so quickly*". Supplying energy to 2.8 Billion people in these 2 countries in a clean and environment friendly way herculean challenge. Nevertheless, as we will see India and china are perhaps the countries poised to take on this challenge head on.

THE PROCESS OF DEVELOPMENT AND INDUSTRIALISATION

Development has traditionally been coupled with Industrialisation. As countries industrialise the employment opportunities in that country rise. The output of the country shoots up which results in an increase in the GDP which in turn is a measure of how a country is developing. Although this is the way in which most of the western world has developed where

energy is central to the process of development, it however does not scrutinise its effect on environment or the sustainability of such development trajectory. For the early movers like the UK and Europe, Industrialisation was based on the notion that an infinite amount of fossil fuels was at their disposal and that humanity was too small to have a lasting effecting on the nature and the environment. Since then, a general agreement has evolved that both these notions are not correct. Global warming and peak oil production are realities of our times. The process of development should hence be amended according to these new realisations and learnings. Under this light I propose a fundamental shift in the development process where development and Industrialisation is replaced by an inclusive *Sustainable industrialisation.*

A new course to sustainable development and industrialisation is a way to avoid the problems of energy security, economic security and environmental security which confront us today. The thing to ponder upon is the difference that will mark and bring about this change in the development process. One of the most important changes will not be technological or economic in nature. It would be a sheer change in perception of the process of development. The perception that "Develop now and clean up later" that the western world held when they made policies for their development can no longer be upheld and followed today. This is unavoidable if most of Asia and Africa wants to develop in a world which is sustainable. India and china here have a huge opportunity as well as a great challenge before them. The US and Europe did not have the constraint of pollution and global warming while they were on their way to development. This resulted in an unsustainable use of coal and later Oil in meeting their energy needs for their industrialisation and development. The notion prevailing during the 1900's was that of a fairly lateral dependence of growth and energy (Figure 1). This still holds true to a certain extent. The need to grow is inseparable from the need for energy which in turn was necessary for Development.

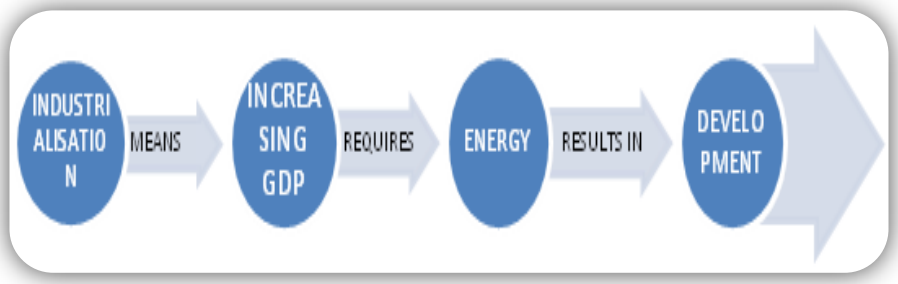


Figure 1 : Lateral relation between growth and Energy.
Source - Manas Puri

However, now we must add other parameters that effect growth. Development and progress for the sake of progress cannot be the purpose today. A sustainable growth is what we need so that it can be passed to countries in Africa and South America.

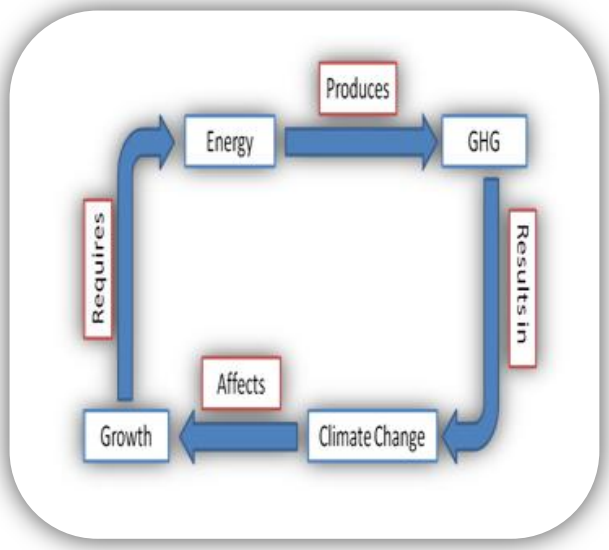


Figure 2: The New relation between Growth and Energy
Source: Manas Puri

From this lateral dependence we now have to move on to the notion that includes environment and specifically the GHG emissions into the process of development. The Stern review has demonstrated that an unstable climate will undermine the conditions necessary for economic growth in both the developed and developing country. As shown in figure 2, Growth requires energy which produces GHG which then results in Climate change and that ultimately effects growth. Hence we need to build a way to develop where the environment is not an external but an intrinsic part of this process. The growth and its dependence on energy is a cyclic relation as we now know. Growth, energy needs and green house gas emissions are interdependent now and the green development and industrialisation has to mitigate the Green house gas emitting energy production by green energy production.

Keeping this fact in mind the notion of Low carbon green growth needs to be developed. Green growth refers to sustainable growth, which helps reduce greenhouse gas emission and environment pollution. For emerging economies like India and china it also means a new development paradigm that creates new growth engines and jobs with green technology and clean energy[2].

[2]Yongsun Cho, Low carbon development and growth strategies for emerging Economies and Developing countries

Déjà Vu ALL OVER AGAIN?[3]

This industrialisation and development of economies has been a process which has been followed by various countries since England Industrialised. Continental Europe was the first oneto take the idea from Britain which was then it was quickly passed on to the US. Much later it was adopted by the war torn nations of south Asia, Japan and Korea. As is firmly established today, Industrialisation of England transformed an agrarian economy into a manufacturing economy, which created job opportunities resulting in a sharp increase in per-capita income. For England, the market for these manufactures goods was there in the form of her large empire spanning across the globe. Later at the beginning of the 19th century the economy of the United States transformed into a manufacturing economy but again the manufactured goods were mainly meant to be exported primarily to the UK and Europe. This export driven model of development and industrialisation was later followed by Japan and Korea. Both these countries we war torn and with no industry as such. Japan lay in ruins and was controlled by a foreign force. A high rate of inflation meant that the goods that were available were unaffordable. America, immediately after the war and with the looming of the cold war realised that it needed an ally in Japan and not a defeated enemy. As a result it encouraged the export driven model where, though not the first time in history, manufacturing of goods was outsourced to another country. Hence, in Japan the export boom got under way in much the same fashion as it did in America in the early 19th century. As we travel in time we see that the countries that industrialised first also climbed the value curve to meet its energy needs. Both the UK and the US that depended on coal for most of their energy needs in their early in their industrialisation phase moved to petroleum and natural gas because of greater efficiency.

So can we say that the rise of India and China will follow the same fashion? Indeed, the first factories in China were established to primarily export their products. Same goes for India where the onset of Information technology industry was primarily focused on exporting services. Moreover, in much the same way, both India and china depend heavily in coal to meet their energy needs and to fuel development and industrialisation. Are we seeing the same

[3]Title from the book, ChindiaRising,Jagdish N Sheth, Tata McGraw-Hill Publishing company Ltd. 2008

process of development that unfolded in the US and the UK? Perhaps not. What is radically different is the existence of domestic market in India and china. While the US may boast of a large consumer market now, the situation was radically different in the early 1900. It was only when immigration from Europe into United States started at an astonishing pace- about thirty million from 1820 to 1914, did the US emerge as a big market for products and services. The same is true for Japan and Korea. Both these countries had no domestic market at during the 19th century hence exporting was the way to get cash and industrialise and develop. Moreover, at the time when the UK and the US industrialised, the idea of climate change and global warming was nonexistent. In addition to this, comparing the populations of India and china to that of the UK and the US would bring forth a big difference in the way in which these countries generate electricity for their industries and population. Putting these things together, I believe that all these factors have placed India and China into a position from where they can challenge the tradition pattern of development and industrialisation and create a new model of energising the development process which would be green and sustainable. This would also mean that in future when much of Africa and central Asia develops, they would have a way of developing which is viable and sustainable.

INDIA- THE LATE–EARLY MOVER

India can lead the way for a sustainable way of development and industrialisation and in doing so establish a way for sustainable development for most of the countries in south of the world. It is not only a moral challenge that they will have to confront, its gives these two giants gigantic opportunity to develop a new market which they can create without having to worry about the protectionist policies of the west when it comes to trade. A market for renewable energy between India, china, brazil, Africa and central Asia, all of which are resource rich and have abundant potential for renewable energy generation would give a way for many of the underdeveloped economies to meet their energy needs in a sustainable way. Not to mention the kind of benefits that India and china can reap from developing and specialising in renewable energy technologies through these markets and engaging with the resource rich central Asia and Africa. All of this brings India and China into the forefront where they are positioned to be

the early movers among the developing countries of Africa, Asia and others while also possessing the late mover advantage when compared to the developed economies of the west. These dual benefits give India and china enormous opportunities to benefit from both the developing and the developed world. And indeed this is what is happening, India has been strengthening its ties with the developed world and China has been pushing its agenda with the developing economies of Africa. In November 2006, in a historic moment leaders from 48 African nations came to Beijing for a summit meeting, a meeting unprecedented in size and scope. A meeting for which *WallStreet Journal* said that it had the potential to "To eclipse Africa's historic reliance on Western Development institutes and former colonial power[4]" India on the other hand has been forging its ties with the US when it signed the Historic Civil Nuclear deal in an attempt to re energise its crumbling Energy and Power sector. Nuclear energy is India's attempt to move in a direction where the demand of energy can be met by ways which are sustainable. Both these countries have a definite late mover advantage in the renewable energy sector especially in wind and solar energy generation. A major chunk of this population lives in rural areas and yet has no access to electricity. In the western world however, electricity penetration is almost hundred percent with no substantial gap between demands and supply. India and china, instead of investing in developing infrastructure generating energy from coal and oil can invest and build their capabilities in renewable energy sector. This would benefit them in two distinct ways. The first and the obvious benefit would be that they will be able to provide electricity to the population living in these rural areas and that to in a clean low carbon way. At the same time they will be

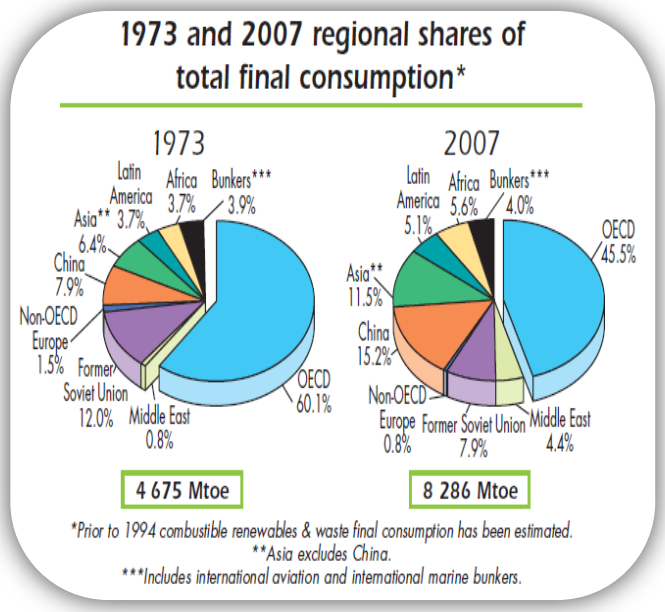


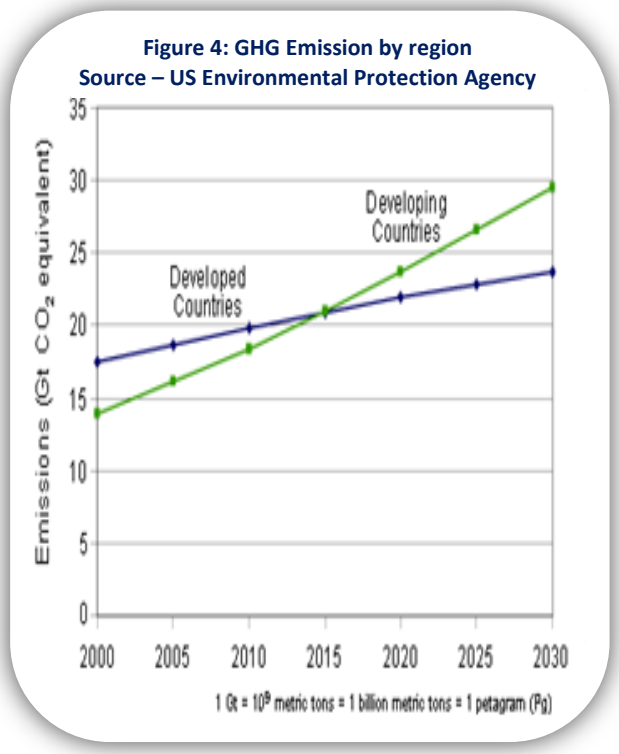
Figure 3 Global Consumption of Energy
Source- Key World Energy Statistics 2009, IEA

[4]The Quest for global resources, China Rising, Dr. JagdishSheth. 2008

specialising in technologies like solar and wind energy generation which will be a source of national competitive advantage for them. As such, the emissions from developing countries are projected to increase substantially over this century. Hence, the choices and policies these countries make can have a large effect on future carbon emissions.China, Asia and Africa on the other hand consumed just 18% of the total energy consumption.

In 2007, OECD countries were consuming about 45.5% of the total energy consumption whereas China, Asia and Africa consumed 32.3 % of the total energy. A major increase came from China and Asia where consumption level increased dramatically. The figure below gives out a clear picture about the changing consumption pattern. Taking this forward if we look at the CO_2 emissions by regions of the world, we see even astonishing change in patterns. In 1974, OECD was responsible for about 65% of the total global CO_2 emissions whereas Asia and China put together emitted about a mere 8% of the global emissions.

Figure 4: GHG Emission by region
Source – US Environmental Protection Agency



In 2007, China alone was responsible for 21% of the total CO_2 emissions and Asia about 10%. As China and India grow they will need more energy to consume and hence will also emit a lot more$CO_2$and other green house gasses. This of course will be the case if the current way of production and consumption is continued and fossil fuels dominate the global energy industry. It is unanimously accepted that the reserves of oil are limited and as we reach the peak oil production the prices will increase. This will be disastrous for countries like china and India who depend a lot on these fossil fuels to meet their energy needs. And more so for countries in Africa, central Asia and South America where energy security would play an important role. In

addition to the problem of energy security, global warming and environmental degradation is also a major international issue now. Developing countries like china and India have a active role to play in this situation. While the developed countries can use various market and financial strategies such as putting caps on emissions, doing so in India and china will hamper their economic growth. What they will have to do is play to their strength. The strengths that come from natural comparative advantages that these countries have in terms of land, geographical position, and availability of manpower. All of which are crucial for the generation of renewable energy.

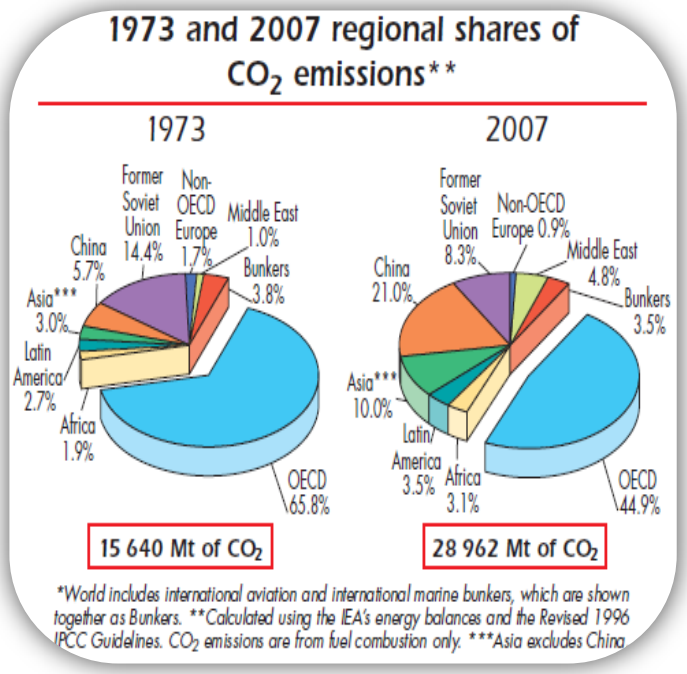


Figure 5: CO2 emission by Region
Source- Key World Energy Statistics 2009, IEA

As is shown in the figure, the countries in the OECD where the energy infrastructure is already well established still consumes a major portion of total world energy even though the population of OECD is incomparable to that of Asia and Africa. This gives a unique late comer advantage to both India and china to pioneer the development of green technology and energy production mechanism. A new development process would mean a swift transition to a resource efficient and a low- emission development pathway. This would not only provide social and economic benefit in the short run but will also create new industries, both goods and service in the long run. India and china being the factory of the world and the back office of the world are poised to do this. A new intensive renewable energy would be the way forward for these developing late industrialising countries. Later industrialised countries tend to be less resource and pollution intensive than earlier[5]. This is because firms in latecomer countries can learn from technological learning from of forms in more advanced economies. Latecomer

[5]Bernardi and Galli, 1993, Macrotullio et al., 2005)

countries can imitate and sometimes improve on existing technologies from western economies. Traditionally, latecomer countries have both an advantage and a disadvantage from their latecomer status. On one hand they can work freely and are less hampered by the institutional inertia in finding new ways of doing things[6]. On the negative side, they tend to be distanced from the international source of innovation and R&D. This traditional "negative side" does not hold anymore for China and India in this world of globalisation. In fact India with its strong service and technology sector is actually transforming into a global R&D lab. These countries no longer have to go to the world markets to get the required technology and innovation. Companies from the west are now flocking into these countries to build their R&D facilities. For a sustainable future, catching up may not just be the only viable strategy. Instead, catching up but an element of innovation in it would be the mantra for these latecomer industries.

The latecomer companies in India and China are not only catching up but also establishing their own best practices and management and business models. For example, a major player in telecom industry in china- Qualcomm's CDMA standard has been a dominant design in China which is the world's largest Cell phone market. China has already announced that it will develop its own standard for Mobile TV. Also, in August 2006 SK Telecom, South Korea's largest cell phone operator bought 6.7 percent stake in China Unicorn as part of deal to helm mainland develop its own standard for wireless networks. Renewable energy technologies, specially the more mature ones of Wind and Solar would see the same thing happening in India and China. In India, the wind industry whose Suzlon is a big global player in the wind energy business and the solar cell industry in China which is the largest solar panel production capacity in the world are bound to make impacts in design and drive innovation in future.

[6]Berkhout, F et al. Sustainability experiments in asia: innovation in shaping alternative development pathways? Environ. Scinece Policy (2010), doi:10:1016/j.envsci.2010.02.010

This innovation imperative will more than assisted by the high priority of R&D that these countries have. China in 2006 spent a whopping $136 Billion in R&D activities second only to the United States. In the late 90's less than 1 per cent of its GDP on R&D this figure is already up 1.5 and as president Hu claims, the expenditure will rise to 2.5 % by 2020. The same is happening in India. As reported by the Economic times (India)

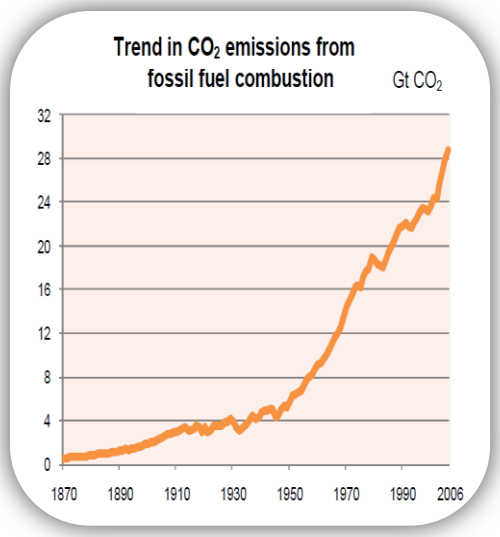


Figure 6: Global Primary energy Supply.
Source- CO^2 Emissions from fuel combustion 2009, IEA

"India's rich talent base is attracting 25 percent of fresh R&D investments". SAP Labs India is the largest development facility outside Germany, GE whose facility in Bangalore is the second largest, and Phillips whose campus in India is the largest outside Eindhoven. Intel is planning a $1 Billion in India. IBM is planning a $6 Billion investments and Microsoft a $1 Billion investment in R&D. The spill over from these R&D facilities is bound to influx a new wave of innovation in the Indian secondary and domestic industry.

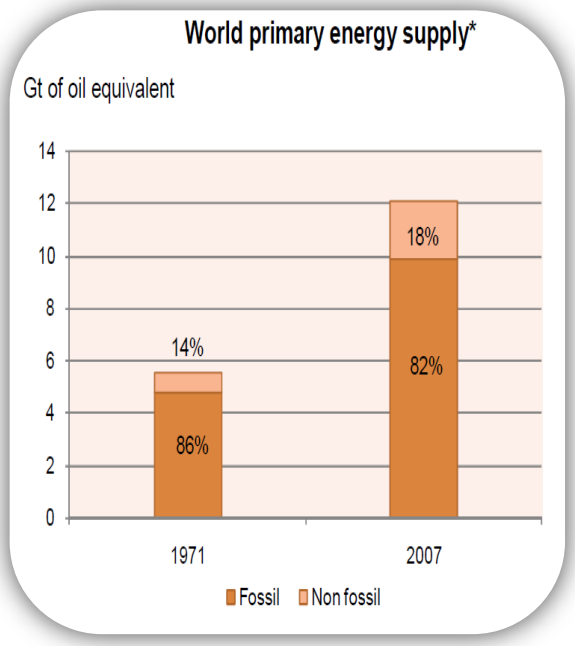


Figure 7: Co^2 Emission trend
Source- CO^2 Emissions from fuel combustion 2009, IEA

Why Move to a Green Economy

As per IEA data, the world primary energy supply is as follows. The world in 1971 supplied a total of about 6 Gt of oil equivalent. A whopping 86% of this came from fossil fuels and mere 14 came from non-fossil fuels. In 2007 the share of fossil decreased from 82% and non-fossil fuels increased to 18%.

Even though the share of fossil fuel has decreased it is still dominant in the world energy production system. Now why are fossil fuels bad? Since the industrial revolution, nations have depended on fossil fuels for meeting their energy needs and Energising the development process. The world economy is still dependant on the use of fossil fuels for energy despite of viable technologies that can replace many of the fossil fuels. The CO2 emissions from fuel combustion have risen exponentially from almost 0 in 1870 to 29Gt CO_2 in 2007[7].

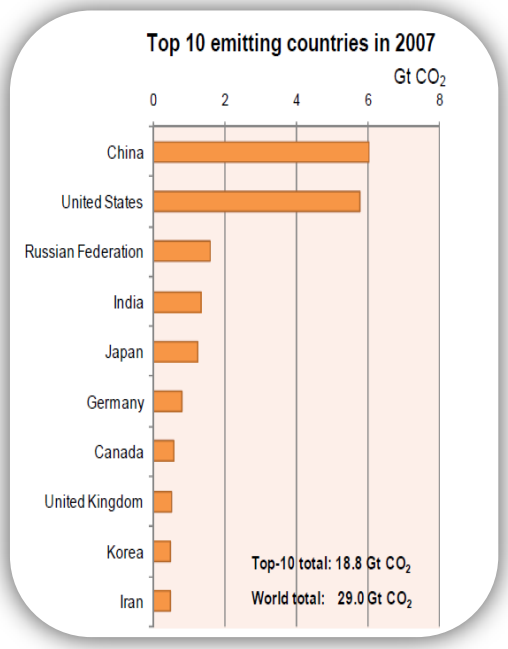


Figure 8: Top 10 Emitting Countries.
Source- CO^2 Emissions from fuel combustion

According to the world energy outlook the world energy supply will rise by 40% between 2007 and 2030. Moreover, it predicts that fossil fuels will remain at about 80% of the TPES.[8] Consequently, the CO_2 emission will also increase proportionally and will reach 40.2 Gt of CO^2 in 2030. Such an emission growth would mean, according to the IPCC report a rise in the average annual temperature between 2.5° to 6.5° C by 2100 which is disastrous.

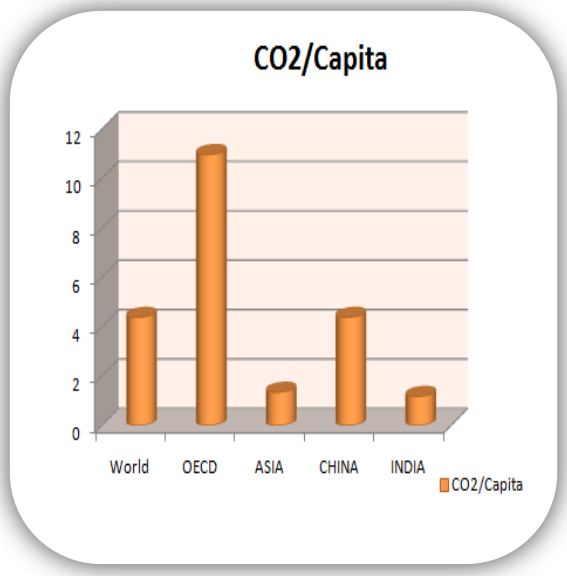


Figure 9: Per capita emission by countries
Source- CO^2 Emissions from fuel combustion

As countries industrialise, the energy consumption will rise rapidly. This is no more a theoretical hypothesis. India and China are among the top 5 polluters in the world. As these countries continue on the path to development their energy need would rise rapidly. Most of the developing countries depend on coal as their primary fuel to generate energy. The UK during

[7] CO2 combustion from fuel combustion IEA 2009 edition
[8] Total Primary Energy Supply

the industrial revolution and later the US also followed the same pattern. China and India are following the same steps. Both these countries depend on coal for most of their energy needs. Indeed, the world now sees India and China among others as the worst contributors to the climate problem. Though it is true that both India and China are among the top 5 polluters of the world, they are also probably the best positioned ones to find a solution to this. The CO_2 emissions nearly doubled for Asia between 1971 and 2007 which reflects the striking rate of economic progress in India and China. This is in contrast to the mere 15% growth which occurred in the Annex II countries of the UNFCC.[9] All of this is even when the per-capita emission of Asia (Excluding China) and in Particular India is less than the world average. As the poor in these countries move into the middle class, the consumption of these countries will rise. Although the IEA estimates that even till 2030, the consumption level in many developing countries will not be close to that of the west, even a small increase in consumption by roughly 3 Billion people of India and China would amount to a lot increasing the already huge pressure in the resources that these countries have including energy. Governments and Entrepreneurs in India, China and Brazil in particular understand better than anyone else that they cannot achieve sustainable industrialisation by simply following the west and the traditional development pattern.[10] Both India and China have a major stake and benefit in developing a green economy. This would mean meeting their energy needs and an enhanced energy security but it would also mean establishing new industries where they will have an advantage.

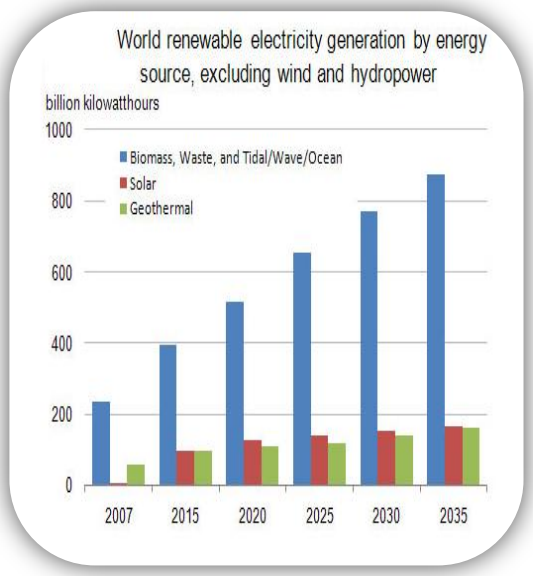


Figure 10: Present Renewable Energy Capacity
Source- International Energy Outlook 2010

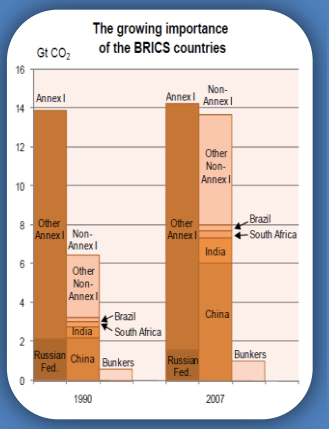
[9]Annex II countries.- Australia, Austria, Belgium, Canada, Denmark, EEC, Finland, Greece, France, Germany, Netherlands, Ireland, Iceland, Japan, Monaco,Portugal, Spain,Sweden, Switzerland, United Kingdom, United States.
[10]J.A Mathews –Can Renewable Industries be turned into a source of advantage by Developing countries?

Combining their late mover's advantage to their comparative advantages that have in Wind, Solar and hydro energy generation, they can steer ahead in developing green models for development. In addition to their latecomer advantages, these countries have a tremendous scope of resource leveraging both from their domestic industry and also from the international markets. I say this because the multinational companies of these countries that have been following a extensive and aggressive internationalisation strategy has given them the access to international resources from which they are ideally positioned to develop international capabilities. Both India and china aspire to leap frog to a global powerhouse with low poverty from their current situation. India has the largest population of poor people, even more that the sub-Saharan Africa. In China also, the gap between the rich and the poor is tremendous. Energy plays a central part in this process of transformation. Moreover, before this another transformation would need to take place for the development of these countries to be sustainable.

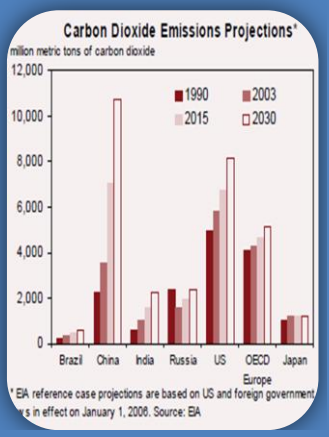
This would be Transforming a fossil fuel energy infrastructure to a renewable and low carbon energy infrastructure. As is evidenced from IEP(2006) and IEA(2007) as well as wider media coverage the focus of most of these studies is on the analysis of supply demand issues and environmental consequences without much emphasis on the process of achieving

BOX 1.

The BRICS already represent about one fourth of the worlds GDP up from 18 % in 1990. In 2007 these five countries represented 30% of the total energy use and 33% of the total emission from fuel combustion.



In China alone the share has more than doubled since 1980. The collapse of the Soviet Union led to a sharp decline in Russia's industrial base and thus emissions from energy consumption; in 2004 emissions were still just 80% of the 1992 level



such a transformation.[11] The BRICS is already a big phenomenon in the economic world today.Urbanization will remain a dominant feature in the BRICs in the decades ahead. 57% of the BRICs population now lives in urban areas, up from 42% in 1975. The urban population is projected to reach an average 68% in 2030—still lower than the current G6 average of 78%. Urbanization brings environmental issues including water and air pollution, waste disposal and traffic congestion. These challenges will be especially acute in China and India, where the urban share is projected to jump from 41% to 61% in China and from29% to 41% in India.[12]High prices of traditional fuels, emissions concerns and rising energy demand will encourage greater reliance on renewable energy sources. Global energy consumption from these sources is projected to nearly double between 2003 and 2030, though their share in total consumption is projected to rise only slightly, from 7.8% to 8.6%.

The process of development of green economy by these nations has already been started. Let us see in detail what are the advantages that these countries have and how can they build a competitive advantage under the light of preceding arguments and global situation that was outlined above. Can these countries develop a competitive advantage and change the way nation have traditionally industrialised?

[11]Bhattacharya, S.C 2010- Shaping a sustainable energy future for India: Management challenges.

[12]**WHY THE BRICS DREAM WON.T BE GREEN ,goldmansachs**

I N D I A

ENERGY OVERVIEW

With a population of 1.1 Billion people, India is the second most populous country in the world. It also ranks 4th in terms of annual consumption of energy after the US, China and Russia. With a GDP growth rate of around 8%, India is currently one of the fastest growing economies of the world. The future levels and patterns of energy use in India therefore have important implications – at the national level in terms of environmental impacts of energy use, issues of access and equity, and at the global level in terms of geopolitics of energy supply and GHG emissions related to the combustion of fossil fuels. According to World Bank estimates, around 35% of the country's population subsists below the poverty line ($1/day, 2000 PPP) and does not have access to basic amenities and clean energy forms. Even by 2001, around 44% of house-holds did not have access to electricity (Census of India, 2001). The country continues to face electricity shortages, with an overall power shortage of 8.4% and a peaking power shortage of 12.3% in 2005/06.

Despite gradual urbanization, according to the last census a majority of the population live in rural areas. In 2005, a total of 412 million people in India had no access to electricity, with 380 million of them living in rural areas and 32 million in urban areas (IEA, 2007). According to recent IEA estimates, India is today 64.5% electrified, with an urban electrification rate reaching93.1% and a rural rate of only 52.5% (IEA, 2009b). The rural urban divide in India is manifest not only by the differences in the levels of energy requirement but also in the availability and choice of fuel and technologies to meet the same useful energy needs and services. Energy demands of several households, especially those in the rural areas, continue to be met primarily by inefficient traditional energy forms like fuel wood, crop residue, and animal waste. These fuels are not only inconvenient to use and cause indoor air pollution, but also adversely affect the health of women and children who are exposed to the use of these fuels.

Unlike the developed world where most of the primary energy is produced by Oil and Gas, India depends mostly on Coal to generate energy.)According to the Central Electricity Authority (CEA) of the Ministry of Power (MoP), on 31 July 2009, India's total installed capacity had reached 151 073 megawatts (MW).Thermal power accounted for 63% of total installed capacity, hydropower for 25%, nuclear power for 3%, and renewable energies including small hydro for 9 % (Central Electricity Authority, 2009a). As India continues on its path to development its energy needs are projected to grow swiftly. With an average growth rate of about 7 percent, the need for energy in India is bound to increase dramatically. An unsustainable resource usage in India is also a growing problem The World Wildlife Fund's ecological footprint. (EF) measures a country's natural resource consumption using prevailing technology and resource management schemes. Comparing these demands on nature with the country's biocapacity gives a sense of environmental sustainability. According to latest estimates, ecological footprints are twice as large as biocapacity in China and India. These are in line with high-income countries and above the world average, indicating that current resource consumption and exploitation are unsustainable. Brazil has one of the highest bio capacities in the world, almost five times its EF, with Russia relatively close behind. This risk that results from this unsustainable use of resources can be mitigated by a smarter use of the resources that are available in the country.

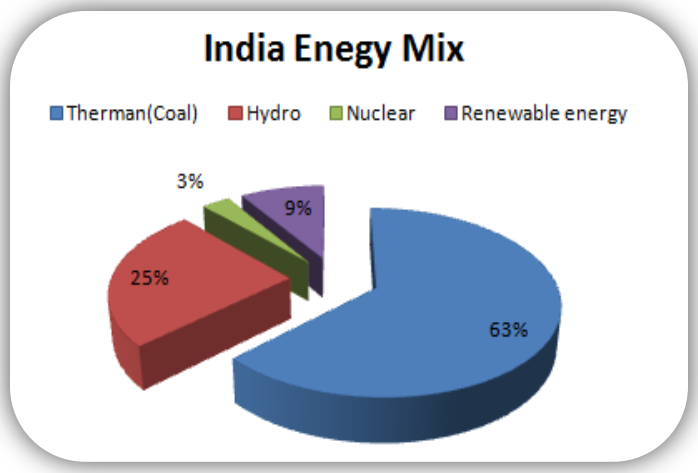


Figure 11: Energy Mix, India
Data Source – Ministry of Power, India

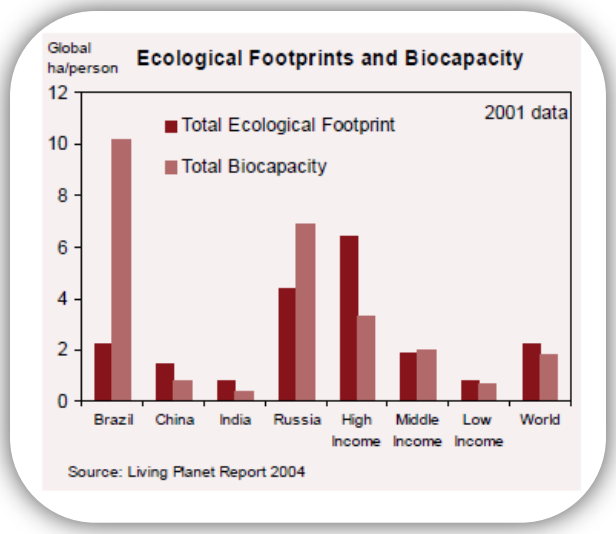


Figure 12: Ecological Footprints

Despite have a large competitive advantage over other countries, India has had mixed results as far as turning these into competitive advantage. Countries like Brazil and Argentina have had tremendous success in developing a competitive advantage in biofuels. In much the similar way India is similarly positioned (if not better) in developing its competitive advantage in Renewable energy, especially in Solar, Wind and biofuels. By capturing the latecomer advantage, India much like Brazil and Argentina can race ahead of the developed world establishing and new industry which has not only economic benefit but also social and environmental benefits.

LATE MOVERS AND MAKERS – INDIA, BRAZIL AND ARGENTINA

India is a large country with large variations in topology and climate. From the large Thar deserts in the west to fertile planes in the north India to the large coastline in the south, India is blessed with nature's beauty. In terms of these naturally occurring agents, India has a huge comparative advantage. What needs to be done is to convert these comparative advantages in competitive advantage. As stated above Brazil and Argentina have both done this before. Brazil has successfully transformed its comparative advantage in terms of agribusiness, land, sunshine and water into a thriving competitive advantage and a huge industry employing millions of people. Before we jump to what India can do or what it has been doing, it is worthwhile to briefly see what Brazil and Argentina have done before. Both these countries have a huge agricultural sector and are major producers of sugarcane and soy. On one hand Brazil leveraged upon its resources in agribusiness, specifically in Sugarcane production to establish a new industry in Ethanol, Argentina in a similar way worked its way through in leveraging on its soy production and establishing a vibrant industry in Biodiesel. Even though in Brazil, investment in ethanol dates back to the 1920, until 1970 ethanol production was still a minor industry. It wasn't until the oil crisis of the 70s which resulted in a sharp rise in oil prices threatened the military dictatorship's ability to rule. At the time 90% of the gasoline was imported, causing fuel shortages, inflation, current account deficits, and diminished hard currency reserves. By 1975, Sugar prices also fell sharply in the international Market. Brazilian imports and balance of payments accounts were strongly impacted by this oil price increase, leading the government to launch the roalcool program at the end of1975. What Brazil was doing then was capitalizing on

is comparative advantage agribusiness while at the same time also leveraging from its resources in the cane production. The purpose of the new program was to stimulate domestic fuel ethanol supply obtained from cane biomass by means of aggressive market intervention through quotas, marketing orders, price setting, and subsidized interest rates. The second oil shock of 1979 was a boon in disguise for Brazil (Joao Martines-Filho, 2006). It led to further incentives being provided by the government on ethanol use and flex fuel vehicles. The results have been sweeping. Brazil is now the world largest producer of ethanol. It almost doubled its production capacity from 225 barrels per day in 1998 to about 448 barrels per day in 2008.

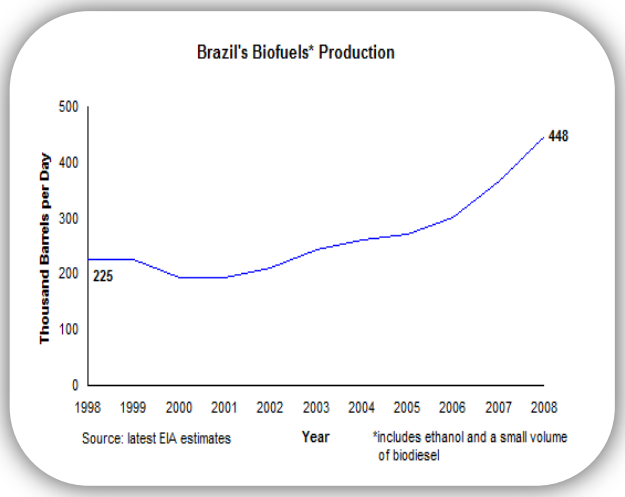


Figure 13: Bio fuel production Brazil

Similarly in Argentina who had already engineered a soy revolution in over the past 15 years is the number on exported of soy oil[13]. Following a typical latecomer strategy and extending its soy revolution to a Biodiesel revolution, much like what Brazil did years ago. The latecomer advantages, lower producing costs when combined with comparative advantages of the availability of arable land and a tropical climate have propelled both Brazil and Argentina into the foremost exporters of ethanol and biodiesel. In addition to latecomer advantages,

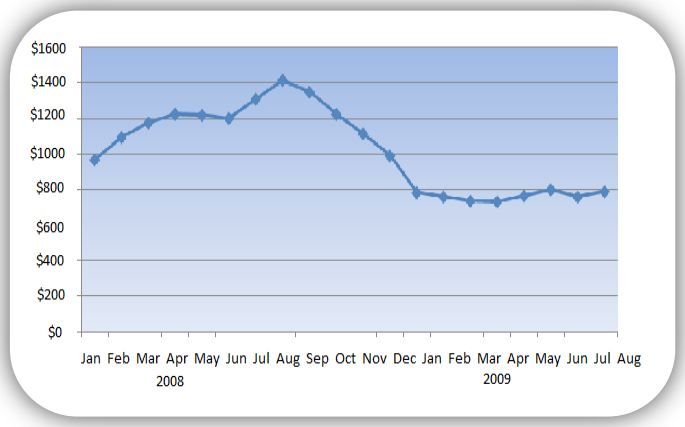


Figure 14: BioFuel prices trend in Argentina
Sources: AFIP, data CADER

[13]Capturing late comer advantages in adoption of biofuels: The case of Argentina, John A Mathews, HugoGoldsztein.

technological leapfrogging has also helped Argentina transform its comparative advantages to competitive advantages. It created a totally new soy industry based on extensive planting and large scale processing in the most technologically advanced refineries. This has been possible because of its links with large multinational firms who operate in Argentina today. The technological leapfrogging and catching up has been a major strategy primarily of which have been no-till techniques and genetically modified plant variety.[14] The same has been true for Brazil which has a thriving export industry in Ethanol. Technology has played a vital role here. In its reactors the decision to make sugar or ethanol can be taken on a daily basis. In Argentina also, the production has been increasing at an extremely fast pace. One of the results of the production is that the price of Biodiesel is going down as depicted by the graph. This has been possible because of the rapid increase in demand which has results in heavy exports be Argentina. According to the European Biodiesel Board the production of Bio Diesel in Argentina increased a whopping 433% from 2007 to 2008. The other strategy that both Brazil and Argentina employed was a deliberate industry creation. Be it in the form of Flex fuel vehicles in Brazil or a mandate to mix diesel and bio diesel. The supply side incentives have to compliment by demand side policies for a successful establishment of Industry.

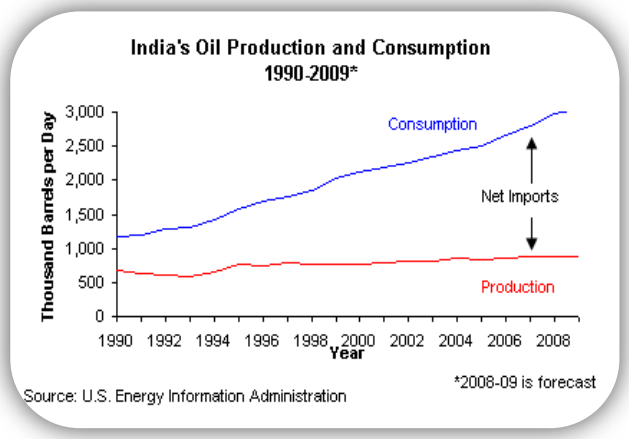


Figure 15: Oil production and consumption, India
Source - US energy Information Admin

Now let is look at how India can learn from the example of Brazil and Argentina. India is a major consumer of oil and energy. It is the 6th largest energy consumer with a power capacity of 150,323 MW. However, India's supply/demand gap on an average is 12% which is expected to rise to 15% in the coming future. Even though the energy usage per capita is amongst the lowest in the world, it is rising at a swift pace. The average energy usage is expected to rise from 632kKWh per annum to 1000 KWh by the beginning of 2013.In a recent report by McKensey India, this peak

[14]For more, see Ragauskas et al 2006

shortfall would rise to 70GW by 2017. Moreover, like Brazil in the 1970s India is a net importer of oil. About 70 % of its oil needs are met by imports from Middle East and other countries. Energy security seems to be big challenge in India. Notwithstanding these facts, we have seen, as in the case of Brazil, there are ways to convert challenges into advantages and gain import independence from oil. India needs a similar campaign to boost its own renewable energy industry which would also mean increased foreign reserves.

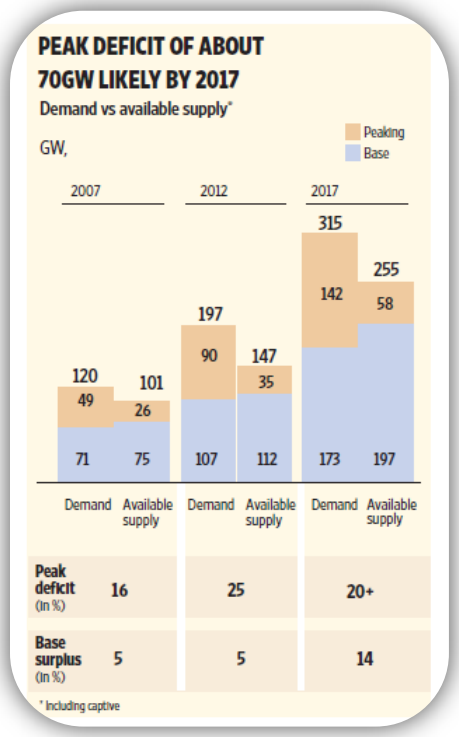


Figure 16: Electricity deficit, India
Source- Powering India, McKinsey &Co

Being a tropical country and located near to the tropic of cancer and having a long cost line it has a huge potential for both solar and wind energy, not to mention that potential for Biofuels. With these comparative advantages, India has all the chances of becoming a leader in the renewable energy sector in the future. A lot depends on the policies that the Indian Government declares to seriously take up renewable energy both as a source of energy security and also a massive domestic and export industry. Since India is a late comer nation in terms of industrialization, it possesses advantage that the advanced nations do not. First and foremost for me is that learning that one gets from the developed nations and not repeating those mistakes again the basic infrastructure for policymaking already seems to be in place. The ministry for new and renewable energy is the premier body implementing policies and encouraging entrepreneurship in the country. The potential for generating renewable energy in India is huge. The Table below gives the potential generation of energy from renewable sources as on 31 December 2009.

Source	Estimated Potential	Cumulative Achievement
Bio Mass (Agro Residue)	16811 MW	834.50 MW
Wind Power	48500MW	10925MW

Small Hydro Power	15000MW	2558.92MW
Cogeneration-bagasse	5000MW	1302MW
Waste to Energy	2700MW	65.01MW
Solar Power	50 MW/Sq.km	6MW
TOTAL	**88,081 MW**	**15691.43 MW**

Hence we see that India is endowed with lot of potential to generate renewable energy from these sources. Another challenge that it faces is the rise of the number of people owning automobiles, the demand for oil is only expected to rise. Although the transportation sector accounts for only 9% of its CO^2 emissions, de la Rue du Can et al (2009) reports that vehicle ownership is growing fast. By 2040, one in five Indians is expected to own a car as against one in 100[15] now. For a country that already imports 70% of its oil, an increase in oil demand will translate into a greater dependence of oil imports. Biofuels are perhaps the only viable answer to these problems that India faces. India as in Brazil and Argentina has a tremendous potential to produce biofuels. In India the agriculture industry accounts for about 19% of the Indian GDP and about 60 % of the population depend on agriculture for their subsistence. With a large availability of Arable land and cheap labor, the production of crops for biofuels is viable and an economical alternative.

BIOFUELS IN INDIA

ETHANOL PRODUCTION

India is one of the largest producers of sugarcane and sugar. Sugar molasses, which is a by-product of the sugar industry, is used for production ethanol for fuel. Due to the cyclical nature of sugarcane and sugar production in India, sugarcane farmers and the processing industry experience periodic market fluctuations of sugarcane, sugar and molasses production which in turn impacts the prices.

[15] Anon., More of everything.*The Economist*, 14 September 200

As mentioned above, the cyclic nature of the Sugarcane industry in India means that the supply if ethanol is also not constant. The government of India thought started its Petrol blended with ethanol program in 2003 through the ministry of petroleum and natural gas that mandated blending of five percent ethanol in gasoline in some states and union territories in India. The program showed mixed results because of unavailability of ethanol from the sugar industry for petroleum companies. This was due to a decline in sugarcane/sugar production in sugar marketing years 2003/04 and 2004/05. Ethanol supplies available to oil companies came to a virtual halt by September 2004. In 2005-06 again due to a strong recovery in the sugar and molasses production only to decline again in 2007-08 when the production of ethanol was reportedly stopped dues to the low yield sugarcane that year. In the present form, the EBP is unsustainable. India cannot afford to blend ethanol if the supply is not there. Sugarcane and Sugar production in India follows a 6 to 8 year cycle where a 3 to 4 of high productivity is followed by a 2 to 3 years of low productivity. The present policy of ethanol blended petrol would only prove to be a success if the government of India initiates some production stabilizing measures. Also, unlike Brazil and Argentina, India has no scheme to provide any direct financial assistance or tax incentives or tax benefits for production of ethanol. However, the government of India offers a subsidized load from government held Sugarcane development fund to sugar mills for setting up an ethanol production unit in addition to the R&D that it does of ethanol production by both public and private organizations. These half measures have stopped India from executing its policy on ethanol whereas the ethanol blend was to be raised from 5% to 10% from October 2008.

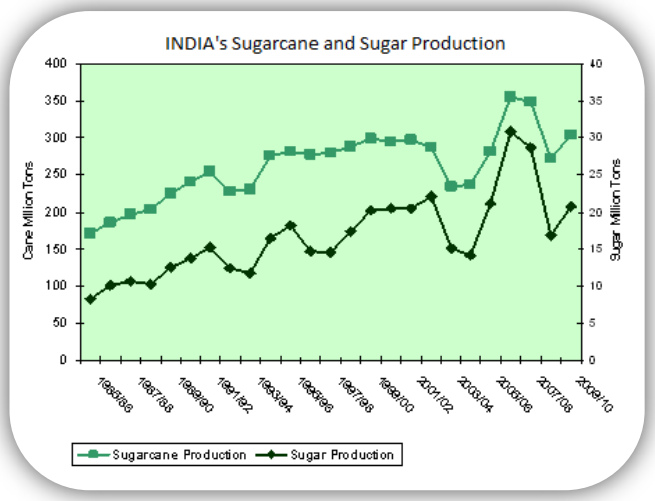


Figure 17: Sugar production, India.
Source- India; Biofuels Annual, GAIN Report No. IN9080

Another problem in India is the huge population that it has to feed. It is not possible to meet even the 5% of ethanol–gasoline blending by using molasses only as a resource for ethanol production in coming years. The area under sugarcane cultivation has increased only by nearly 2.5 times since 1950–1951 and also both area and yield has stagnated in recent years. Thus, to raise the mandate to try blending targets and to meet the subsequent demand at competitive cost it would be necessary to use the sugarcane juice and other available alternative feedstock such as sweet sorghum, sugar beet and cellulosic raw materials. It is possible to make ethanol from these grain based feedstock, but it is constrained from the point of view of food security due to India's large population. The trick here could be manufacturing ethanol using primary sugarcane juice or secondary sugarcane juice. But the major problem in adopting this option is the use of sugarcane as raw material by sugar industry. India is among the world's largest producer and consumer of sugar and this has put additional pressure on the ethanol industry. In case of the large sugar deficit owing to some unfavorable condition as in2003–2004 would result in high sugar prices and subsequently cane-based ethanol production would be discouraged[16].

RESOURCE LEVERAGE

These problems have left India with two options. First could be to import more ethanol from countries like Brazil and which it already does to an extent, and second to find ways to efficiently use the resources that it has. India has a booming Biotechnology industry with a lot of research going on in this field. Pharmaceuticals and Biotechnology are being hailed as the next industries following the Boom that IT industry created in India. With ample of qualified people, India is already one of the leaders in biotechnology. In India, sweet sorghum and tropical sugar beet could be grown as cost-effective feedstock crops instead of sugarcane (Gonsalves, 2006). However, the most promising source would be cellulosic ethanol. Advances in biotechnology enabled enzymatic saccharification and fermentation of readily available cellulosic material such as wood and crop residue for ethanol production. This breakthrough

[16]Internationalexperiencesofethanolastransportfuel:Policyimplications for India SanjibPohit, PradipKumarBiswas, RajeshKumar, JayaJha

technology is yet to be commercialized on a large scale because of its high costs of production. Keeping in view the high potential of the cellulosic ethanol, India should make collaborative research on this area with other countries like Canada that have made substantial advances in cellulosic technology. Presently Canada is the only country running vehicles on cellulosic ethanol (Sanjib Pohit, 2009). India is ideally placed to leverage from its biotechnology industry and pursue research in this direction. What it will require however are a set of proactive policies by the Indian Government which unfortunately, it has failed to provide as far as Bio Fuels are concerned. It is evident that in the field of Ethanol production, India needs to be more competitive at an international level. What India needs to do is import sugar cultivating techniques from Brazil and provide more financial and tax incentives to encourage the production of ethanol. Also, for better utilization of capacity, states should allow not only interstate movement of molasses but also direct use of sugarcane juice into ethanol, particularly when sugar demand is low (Sanjib Pohit, 2009). The problem here has been the lack of an integrated and a consistent policy towards the ethanol production. India needs a two pronged strategy which should first cover the area of sugarcane production. This would mean making the cultivation of sugarcane more productive. Under this, it would need to import irrigation and distillation techniques from Brazil. Also, the concept of no till farming that proved to be a major success in Argentina should also be employed to as to increase the efficiency of production and water usage. Availability of technologically advanced Biorefineries is also a major bottleneck. Hence, firstly India will have to make sure that it has the sufficient supplies of Sugarcane so that the supplies towards the production of ethanol are not hampered. Also, as Pramod Chaudhari, the chairman of the National Biofuels committee says, there is an over dependence on molasses is the primary feedstock. Almost 90% of ethanol (for beverage/industrial/fuel) is based on cane molasses. There is overdependence on one single feedstock, and hence there are issues of allocation, pricing and availability for fuel ethanol.

Secondly, it will have to provide a favorable atmosphere for entrepreneurs, farmers and distillery owners to take up ethanol products. This can be in the form of financial assistance, tax benefits and assisting R&D. Also, as mentioned earlier, India will have to make sure that a stable supply of sugarcane s maintained. The problem of volatile production of ethanol is not

only I India. In Brazil ethanol production started in the late 1980s when due to high world prices of sugar, distillers began diverting sugarcane for sugar production rather than ethanol production. Eventually, the entire ethanol programme collapsed. In January 2001, as a result of high world sugar prices, Brazil again faced ethanol shortage and had to import ethanol from the USA. In response, the government introduced a tax on sugar exports whenever ethanol production falls short of domestic demand. Consequently, there has been no supply shortage in recent years. Hence policies like this can help India play a more active role in the world ethanol market and at the same time solving its own problem of domestic fossil fuel shortage.

BIO DIESEL IN INDIA

The possibilities of production of biodiesel from edible oil resources in India is almost impossible, as primary need is to first meet the demand of edible oil that is already imported. India accounts for 9.3% of the world's total oil seed production and is the fourth largest edible oil producing country. Even then, about 46% of edible oil is imported for catering the domestic needs. Hence it is not possible to divert the resources that we have in Edible oil for Bio Diesel production. It was in 2003 that the Government of India launched the National Mission on Bio Diesel that identified Jatropha as the most suitable oil seed for production of Bio Diesel. The Planning commission calculated that 11.2 to 13.4 Million hectare of land is to be planned with Jatropha by 2012 in order to produce sufficient bio Diesel to blend at 20% with Petro-Diesel. India has a lot of comparative advantages for such plantation and productions. As per Government of India survey, out of total land area, 60Mha are classified as waste and degraded land. India has third largest road network in Asia having length about 3 million km the sides of which can be used for growing the Jatropha and Karanjia crops and oil can be converted into biodiesel. India has a railway network of 63,140 km and land along the track can be easily used for cultivation of Jatropha curcas to check the soil erosion and to improve fertility in addition to oil production. Extrapolating the data, the future demand of Biodiesel is given in the table below. It is estimated that by the year 2012 about 13.38 MT of Diesel could be saved if Bio Diesel blended Diesel is used. This would result in a decrease in imports of oil which in turn will

have a positive impact on the trade balances and foreign reserves. Not to mention the benefits that India can reap in establishing an export industry in the form of Bio Diesel like that in Brazil and Argentina. Moreover, since Jatropha is a non-edible seed plant, hence there is no scope for a food vs. Fuel debate. The cultivation of Jatropha is also a way to alleviate poverty and to provide some sort of earning ability to millions of poor farm less people who live in the rural India. India has the largest population of poor people in the world. Most of these live in the rural area and depend on agriculture for their subsistence. The cultivation and ultimate refining

Biodiesel demand in India

S. No	Year	Diesel demand (MT)	5% blend (MT)	Area (Mha)	10% blend (MT)	Area (Mha)	20% blend (MT)	Area (Mha)
1	2006–2007	52.33	2.62	2.19	5.23	4.38	10.47	8.76
2	2011–2012	66.40	3.35	2.79	6.69	5.58	13.38	11.19

of this plant has a potential to generate jobs at all stages. Right from its agricultural cultivation to its processing into fuels it can create huge opportunities for millions of people living in the rural areas in India. Most of the biodiesel producing countries use readily available edible oilseeds as feedstock, for example sunflower and rapeseed in Europe, soybean in the USA, palm oil in Malaysia, and coconut in Philippines. The same approach cannot be adopted in India. As mentioned above doing that would mean endangering the food supplies to more than a Billion people in India. Nor can it, for the same reason, afford to produce more oilseeds by cultivating oilseeds in more areas as that would imply a shift in cropping pattern in terms of substituting land use from food grains to non-food grains.

Hence, the focus of the India government has been on degraded forestland and un-utilized public land, field boundaries and fallow lands of farmers where non- edible oil-seeds can be grown. The extent of wasteland in India is enormous, hence, leveraging that resource which has been laying unproductive gives India a great way to utilize its wastelands, generate employment and also curb its increasing oil imports. Although the Biodiesel program in India is much more focused that the ethanol program, the results have not yet matched the expectations. In spite of having world class Biotechnology research institutes like the

Department of Biotechnology, the Aditya Biotech Research Centre (Raipur), the Indira Gandhi Agriculture University (Raipur) and the Bhabha Atomic Research Centre (Trombay) who were entrusted the task of finding a high yield variety of this plant, there has not been any major success. If we go back a little, we did see that this was one of the most important things that Argentina did. It genetically modified the soy seed to improve yields. India on the other hand has been slow in doing that. Also, cultivating techniques like no till techniques that both Brazil and Argentina managed to defuse commercially has not happened in India.

CAPTURING LATECOMER ADVANTAGES

As in Argentina, the late comer advantage was developed in the form of soy revolution. India needs a revolution in Jatropha plantation which has a great future. As we have observed above, India does have the comparative advantages for the production and ultimate process of Jatropha seed in Biodiesel.

What it needs to do is to actively engage in converting these comparative advantages in terms of the availability of wastelands into a competitive advantage. This would mean combining the cost advantage that it has in terms of cheap labour, low production cost to comparative advantages like, climate and agribusiness. The government will also have to play a very important role in terms of policies and financial subsidies. The most important aspect of the biodiesel policy is the pricing and subsidy. It may be seen in the figure that cost of production of biodiesel in India is relatively lower ($0.40/l) as compared to United States ($0.50/l) and European Union ($0.62/l). However, as evident from Table below, the production cost of biodiesel in India is slightly higher than that of petro diesel. There has to be differential tax/tax rebates/subsidies to equate the prices of the two fuels. It has also to be seen whether the cost of production of the seeds exceeds Rs. 5 a kg. If so the farmers are also to be subsidised at the time of procurement. In fact state subsidies are to given at various stages, such as cultivation, processing, engine modification and in R&D in various stages, provided that the industry has a long term viability (Pradip Kumar Biswas, 2009). This would however be not enough. Technological advantages would have to be developed in order to further reduce costs

and improve yields. These models have propelled countries like Brazil and Argentina into a global player in the biofuels market. However, there are certain points for which both Argentina and Brazil have been criticized. In recent years, both these countries have observed a swift pace of deforestation. Especially in Brazil, where the encroachment into the Amazon forest is a big problem now.

In India however, the plantation of Jatropha does not give rise to any such problem. In fact India has a definite advantage in plantation of this shrub in that it does not need a very fertile land to grow. Therefore, in addition to developing a huge industry in Biodiesel, it would also mean utilizing the land which now seems unusable and unfit for cultivation of regular crops.

However, the policies that Brazil and Argentina followed cannot be applied to India in its entirety. Indeed, both these countries have done wonders in biofuels industry there is a essential difference between them and India. Whereas in Brazil and Argentina, there has been large scale farming of sugarcane and soy respectively, India would have take up small scale farming, due to various restrictions that it has. Although, according to official estimates, the wastelands in India are apparently more than adequate, but in reality these lands may not be available for growing Jatropha since these are already occupied or are being used by villagers in some way or other, as indicated by TERI (2005). In India where millions of landless families and floating populations exist, most of these lands will be occupied in some form or the other. Most common form of use of the land by the poorest parts of the population is for cattle husbandry (Altenburg et al., 2009). This would surely be in conflict with Jatropha cultivation as it would remove the only source of livelihood of this section of people. Hence, taking this land away from the poor and the homeless would certainly brew up resentment among the people. Moreover, unlike in china where the state can acquire land

iodiesel costs of production in India and other countries.
Source: Planning Commission (2003) and Kojima and Johnson (2005).

Fuel	Country	Feedstock	Cost (US$/l)
Biodiesel	India (2005)	Jatropha	0.40
	USA (2002)	Oilseeds	0.50
	European Union (2002)	Oilseeds	0.62

through coercion, in the Democratic setup like the one in India, the state cannot afford to take away land like this. Similar to china, Brazil, the most successful country in ethanol production for running vehicle, the military Government forced a large number of farmers to transfer lands to corporate for cultivating sugarcane that would be used to produce alcohol. State coercion enabled the corporate to acquire and consolidate millions of hectares of land at nominal rates.

What India can do however is that it can include these people who as it is have no permanent source of income into the biodiesel program. The land on which these people reside is a low productivity land. Hence it would be rather easy for the government to convince them to grow Jatropha for higher earnings. Moreover, training the, will not be much of a problem as people in rural India almost always have experience in farming and agriculture. Notwithstanding these arguments, necessary information, campaign and support would be needed by the government. Unlike the large scale farming of sugarcane in Brazil or corn in the US for ethanol, in India an effective mode of growing Jatropha would be based on small scale farming. The state has to play a proactive role in motivating and organizing these farmers to cultivate Jatropha. Even on the processing side, a more decentralized approach might work for India. One of the problem , as noted in UNCTAD (Gonsalves, 2006, p. 23), hampering the rapid growth of feedstock market for biodiesel is that, on the one hand, farmers do not want to shift their production to Jatropha in the absence of processing facilities, and on the other hand, investors are hesitant to build processing facilities before feedstock become available. Here again the long gestation lag in Jatropha cultivation may be partly responsible for the emergence of this ‘‘chicken and egg situation’’. Engaging local entrepreneurs could be a potential solution to this problem. This would enable a sort of coordination and trust between the farmer and the processors, while also giving rise to various job opportunities at the local rural level

CONCLUSION

As we saw earlier, Brazil and Argentina opened up a plethora of opportunities for farmers and organizations to benefit from the ethanol and Biodiesel programs, India can initiate and ultimately develop its own biodiesel industry. India does have a glut of opportunities and

comparative advantages for developing this industry. The government of India has to play a very vital role in this. As in Brazil where the state laid a major thrust on ethanol industry during the early 1970s, India will have to do the same. The state had made the use of ethanol mandatory in official government vehicles, mandated blending requirements, provided assistance in setting up processing plants, R&D assistance in sugarcane production and

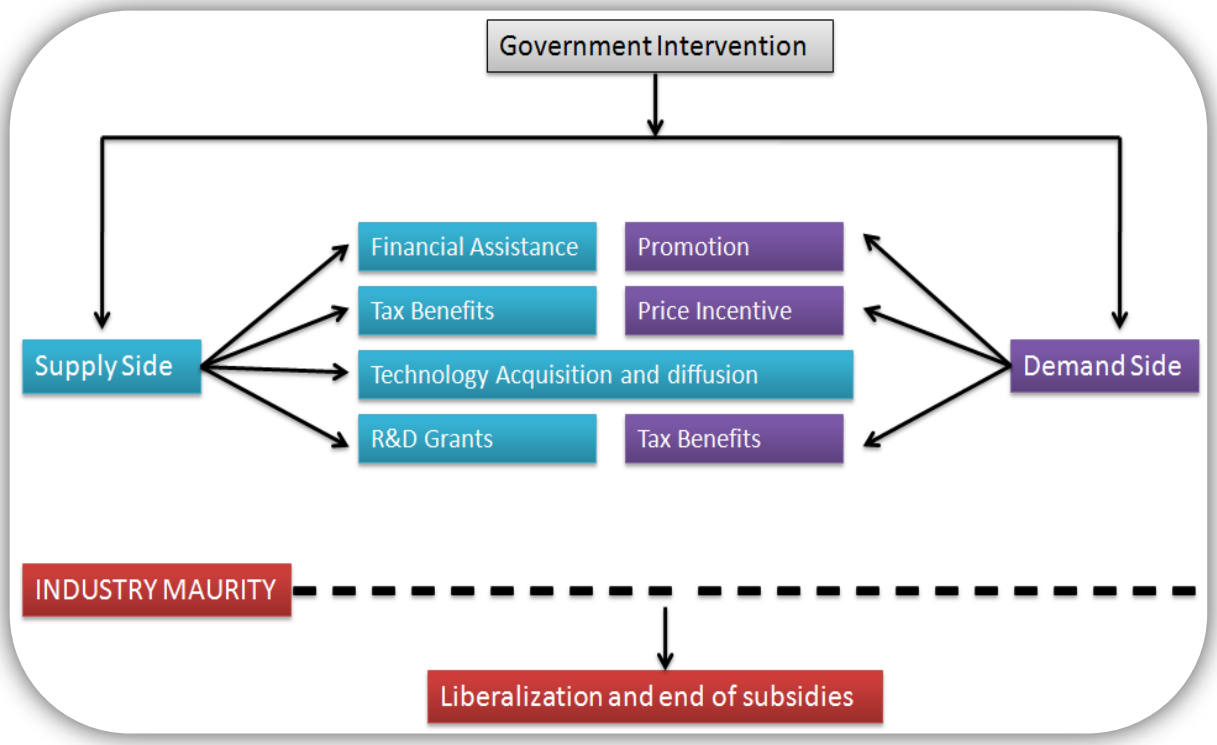


Figure 18: Deliberate Industry Establishment
Source: Manas Puri

designing of cars suitable for ethanol fuel, provided subsidies on ethanol and tax concessions for ethanol-fuelled cars, and levied taxes on gasoline for maintaining parity in the mileage costs of these two fuels (Pradip KumarBiswas, 2009). India will have to follow suit. In the figure below, I have tried to draw the kind of government intervention that would be required toward both the supply and demand side to actually get this industry up and going. In addition to these incentives, it will have to device larger, social integration initiative which would reach out to small farmers and people living on wastelands and motivate them to grow Jatropha. This decentralization of Jatropha plantation would generate local employment opportunities.

This may well involve including NGO's, corporation and various ministries in the government. The government will have to actually nurture this industry till it get matured and then liberalize it so that market forces can take care of the supply, demand and the pricing issues. There is no reason why India, with all its advantages cannot do so. What remains to be seen is if India actually does it.

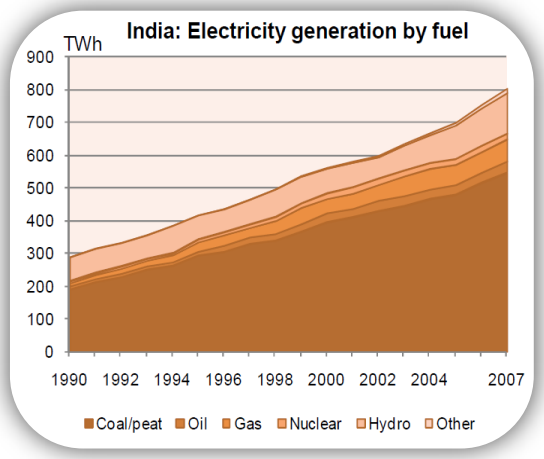


Figure 19: Electricity generation breakdown, India
Source- CO^2 Emissions from fuel combustion 2009, IEA

SOLAR ENERGY

SOLAR ENERGY OVERVIEW

India has the fifth largest power generation capacity in the world with an installed capacity of 152 GW as on 30 September2009, which is about 4 percent of global power generation. The top four countries, viz., US, Japan, Chinaand Russia together consume about 49 percent of the total power generated globally. The average per capita consumption of electricity in India is estimated to be 704kWh during 2008-09. However, this is fairly low when compared to that of some of the developed and emerging nations such as US (~15,000 kWh) and China (~1,800 kWh).India is heavily dependent on coal for power generation

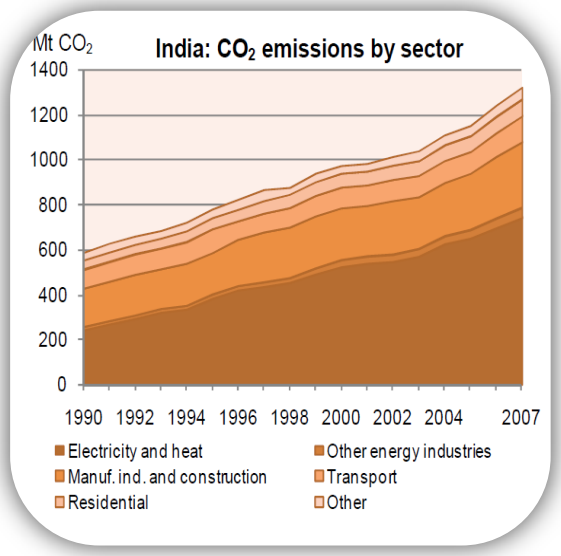


Figure 20:CO^2 emission breakdown, India
Source- CO^2 Emissions from fuel combustion 2009, IEA

and is a matter of serious concern for the Indian government now. In 2007, 68% of the energy generation came from coal. Consequently, the electricity and heat sector is the biggest contributor toward the total CO2 emissions representing 56% in 2007 up from 42% in 1991[17]. Although India has the third largest reserves of coal, with the current technological knowhow, the extraction has been difficult. This has resulted in India becoming the fourth largest importer of hard coal after Japan, Korea and Taipei. This has resulted in added pressure on the overall trade balance in India, not to mention the environment degradation that the production of energy from coal causes. Moreover, a large percentage of the population lives in rural areas where there is no access to electric grid, resulting in large areas without electricity. According to UNDP in 2008, 70.8% of India's total population lived in rural areas, progressively migrating to urban areas at an annual rate of2.3%, a rate which is below that of many other countries. In 2005, a total of 412 million people in India had no access to electricity, with 380 million of them living in rural areas and 32 million in urban areas (IEA, 2007). According to recent IEA estimates, India is today 64.5% electrified, with an urban electrification rate reaching93.1% and a rural rate of only 52.5% (IEA, 2009b).Under these circumstances, there are 2 possibilities that India can ponder upon. The first would be the obvious which is to extend the electrical grid and provide electricity from traditional sources. This however, will only burden the Indian financials as well as its environment. The second would be to invest in providing energy to these places through developing and employing renewable sources of energy. The challenge however is not limited to providing dependable energy to rural India. *The urban India comprises of about 30% (285.35 million people, 2001 census) of the Indian population. In post-independence era while population of India has grown three times, the urban population has grown five times. Urban areas are heavily dependent on fossil fuels (often imported), for the maintenance of essential public services, for powering homes, transport systems, infrastructure, industry and commerce. The fossil fuels are increasingly becoming more expensive due to scarcity of fuel and increase in demand. In addition to this, the environmental and social impacts of the consumption of fossil fuels are increasingly becoming a concern. These impacts include air pollution, global warming, waste disposal problems, land degradation and the depletion of natural resources.*(Government

[17]CO2 emissions from Fuel combustion, IEA, 2009 Edition

of India, 2008). The solar energy may be the answer to the above said problems. The government of India seems to think so. Dr. Manmohan Singh, India's current Prime minister had

> *"In this (India's) strategy, the sun occupies centre stage, as it should being literally the original source of energy. We will pool all our scientific, technical, and managerial talents, with financial resources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people. Our success in this endeavor will change the face of India"*

this to say[18] while releasing the national action plan on Climate change.

This clearly indicates the level of confidence that this government has in the solar energy systems and why not? With the kind of comparative advantage that it has, it would be really disappointing of India did not head forward to turn them into a competitively placed industry providing solution not only to India's problems but to the world's. Let us have a look in a more detailed fashion as to from where does India derive it comparative advantages.

COMPARATIVE ADVANTAGE TO COMPETITIVE ADVANTAGE

The potential to generate electricity from solar energy in India is huge. India lies in the sunny belt of the world. The scope for generating power and thermal applications using solar energy is huge. Most parts of India get 300 days of sunshine a year, which makes the country a very promising place for solar energy utilization[19]. As far as the natural enablers are concerned, India has the natural advantage in abundance. The daily average solar energy incident over India varies from 4 to 7 kW h/m^2 with the sunshine hours ranging between 2300 and 3200 per year, depending upon location[20]. The technical potential of solar energy in India is huge. The country receives enough solar energy to generate more than 500,000 TW h per year of electricity, assuming 10% conversion efficiency for PV modules. It is three orders of magnitude

[18] **Jawaharlal Nehru National Solar Mission Document,** *mnre.gov.in/pdf/**mission**-**document**-JNNSM.pdf*
[19] TERI, India
[20] Ministry of new and renewable energy report, 2001

greater than the likely electricity demand for India by the year 2015.This in fact is far more than current total energy consumption. For example, even assuming 10% conversion efficiency for PV modules, it will still be thousand times greater than the likely electricity demand in India by the year 2015. Moreover, with the existence of a vast skilled pool and low level of salaries, India can transform itself into a giant in the manufacturing and using solar energy systems. Furthermore, with uniquely positioned business enablers offer a huge market for firms operating in the solar energy sector. As mentioned before, a huge number of people in India live off grid. This constitutes a huge market for the solar PV industry in India. In addition to this, in India already has an emerging semiconductor industry which can be leveraged in order to boost the PV industry. This would also be beneficial for the Semiconductor industry in general which has been trailing behind the semiconductor industries of other south East Asian countries.

The Indian government seems to have realised these comparative advantages can make India the world largest market for solar PV energy and has put in place policies that aim to convert these comparative advantages into solid competitive advantages. In June 2008, the Indian government announced its National Action Plan on Climate Change (NAPCC); which incorporates India's vision of sustainable development and steps to be taken to implement its (GOI, 2008).The NAPCC itself is made up of eight distinct national missions. On 11 January 2009, the Jawaharlal Nehru National Solar Mission (JNNSM) aims to create an enabling policy framework for the deployment of 20,000MW of solar power by 2022 (MNRE, 2010). It will create favorable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership and promote programs for off grid applications, reaching 1000MW by 2017 and 2000 MW by 2022.Other mandates of the JNNSM include achieving 15 million m^2 solar thermal collector area by 2017 and 20 million by 2022 and deploying 20 million solar lighting systems for rural areas by 2022 (MNRE, 2010). The JNNSM aims at 1000 MW grid-connected solar power generation within 3 years– by 2013; an additional 3000MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff. This capacity can be more than doubled– reaching 10,000MW installed power by 2017 or more, based on the enhanced and enabled international finance and

technology transfer. The ambitious target for 2022 of 20,000 MW or more will be dependent on the 'learning' of the first two phases, which if successful, could lead to conditions of grid-competitive solar power. These initiatives will the put India on a low-carbon path way while simultaneously reducing its greenhouse gas emissions. The transition could be appropriately upscale, based on availability of international finance and technology. Hence, there are ample of opportunities in India for solar power generation. The right steps have been taken as far as the government policies are concerned. The latecomer advantages in terms of land are crucial for India for solar thermal power plants. India seems to have realized that this comparative advantage needs to be converted into competitive advantage soon.

After the announcement of the policies, the solar industry is now being hailed as the Sunshine industry of India.According to the International Energy Agency forecasts –the Indian solar mission will make India the producer of almost three-quarters of the world's total solar energy output in the next decade. Although, India always had the advantages in terms of its position on the solar belt, ample of land in states like Rajasthan, Gujarat, due to the lack of government policies there was no Business model as such.Now, India has business-friendly policies and regulations in place to make the venturing into this industry self-sustainable. Rakesh Singh, co-founder and chief operating officer of Staten Solar remarks "*The solar power tariff for plants that start before March 31, 2012 is Rs 18.43, which will go down to Rs 17.91 for units that start before March 31, 2013. The tariff will go down to Rs 13, and then stabilise for some time. And as the tariff pact is for 25 years, investing now will translate into high returns*."[21].

DEVELOPING RESOURCES AND CAPABILITIES

The Indian PV industry has been around for a long time now. The first PV cell manufacturers in India were the "Public Sector" enterprise and government research laboratories. These organisations have been in the solar cell industry in India since the mid 1970's. However, due to lack of interest by the government resulting in absolutely no policy framework, India did not progress much in developing its solar industry

[21]http://www.indianexpress.com/news/-Now-is-the-time-to-invest-in-solar-power-sector-/632825/

. What the Indian government has done now is that it has started developing its resources which has resulted in a fairly swift increase in manufacturing capabilities. From the graph above we see that in the 2007 India almost quadrupled its PV manufacturing capabilities. This was not a case of a sudden unplanned increase.

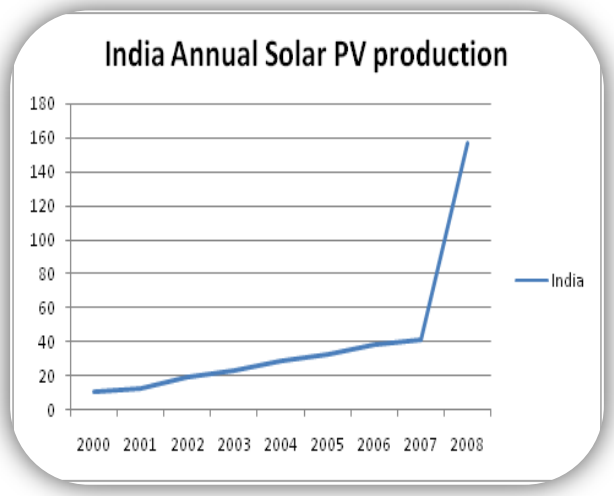


Figure 22: Annual Solar PV production, India
Source: data compiled from Prometheus Institute and Greentech Media

The resources that India has always had were not being translated into capabilities before the year 2007 because of lack of policy regulation. In 2007 India announced a special incentive package scheme and the semiconductor policy that apply to solar cell and module manufacturing in the country. Following the SIP the manufacturers of solar PV and modules in India have substantially expanded their output. The national scenario however is a little different than what it may seem from the supply side. Even with a potentially huge market, the demand of solar energy systems has not been huge. This is evident if you look at the composition of the total manufacturing that has been happening in India. About 75% of the total manufactured capacity is exported to mainly developed countries. However, since 2008, the demand of solar energy in India has been increasing at a astonishing pace.In July 2009 Dr.Farooq Abdulla, the minister for New and renewable energy inaugurated the world's largest system for solar thermal steam cooking, in Shirdi, Maharashtra. The system will generate the steam required in cooking food

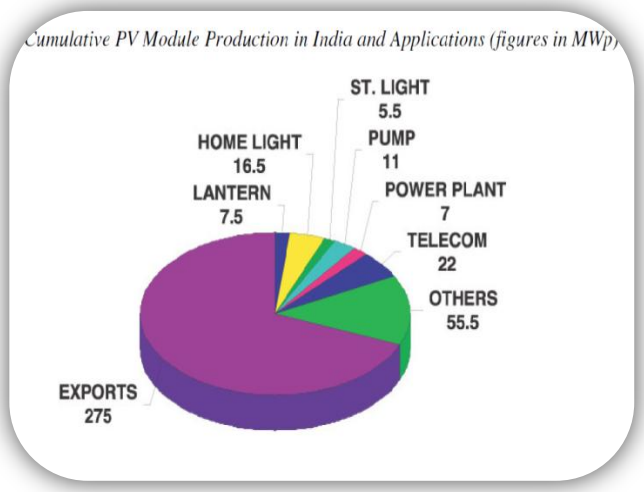


Figure 21: PV consumption Breakdown, India
Source: PV group White paper- The solar pv landscape in India

for 20,000 pilgrims twice a day. More recently, Moser Baer Photo voltaic Ltd commissioned its largest ever thin film solar farm of 1MW in Chandrapur, Maharashtra in April 2010. In addition to this, a 3,000MW project has been planned in the western state of Gujarat which would be the largest solar power facility in the world. The project may be developed on 10,000 ha of land spread across three locations within an area of 150 sq. km in Gujarat. The Gujarat government, headed by chief minister Narendra Modi, has taken the lead among Indian states in promoting solar power. It has allotted 716MW of solar generation capacity to 34 Indian and international developers, apart from this huge solar plant which is being facilitated by Clinton foundation.

All these examples stated above bring out a important inference about the Indian solar energy strategy. Even though the deployment of solar energy till now has been miniscule, the industry as such has been swiftly increasing the manufacturing capacity. Until now, the strategy was to develop capabilities in manufacturing to drive the costs down so that the technology can be adopted by the price sensitive market such as India. Post NSM, the focus of the government is to adopt the technology and make it competitive in the market. This is virtually the same 3 pronged strategy that Brazil employed for its biofuels program. The first phase was aimed at introducing biofuels by mandating blending of ethanol and encouraging local production. Second was to drive the cost down and increase capacity and the third was the social goal. Similarly in India, the solar program has a three pronged strategy for the adoption of solar power for the ultimate goal of providing energy to the masses, specially the poor, with reliable self-sustaining, clean energy. However, developing capabilities is process that can realise through various means. Leapfrogging is a typical latecomer strategy, India has a history with. Is this strategy viable for solar energy industry in India? In all possibilities; Yes.

LEAPFROGGING

The shift from fossil fuels to renewable like solar and wind is a classic case of leapfrogging by a developing, latecomer nation such as India. Instead of investing heavily into centralised power plants based on fossil fuels, India is moving towards energising its some 80,000 villages with no electricity through decentralised, renewable energy plant such as solar power. This is not the first time when India has leveraged the strategy of leapfrogging. With the

resources ain terms of trained manpower and a vibrant IT industry, India leapfrogged to mobile phones rather than using landlines. This telecom revolution brought phone connectivity to the remotest part of India where landlines would have taken ages to reach. A similar story is unfolding in the solar energy sector. The availability of ample of sunshine throughout the year in India coupled with the chronic problem of electricity shortage has forced India to leapfrog its way to sustainable development. Moreover, leapfrogging is not all about technology alone. It is more about infrastructure or a time the lack of it. Leapfrog technologies are largely those that do not require a existing grid. This was the case in telecommunication, wireless communication and distributed power supply like solar power. While one can argue that leapfrogging to mobiles was only possible because of the advanced technology like wireless data transfer, yet it was largely possible because of standalone decentralized units which did not require being connected to the traditional grid and cables. In addition to this, there isn't a single path to leapfrogging. Regions adopt technologies that fit their needs and resources. Leapfrogging can happen accidentally when the only systems around for adoption are better; it can happen because a particular setting limits options, like decentralised communication for inaccessible rural areas; or it can happen deliberately, where government develops targeted policies, like promoting the installation of Wi-Fi (ie 'wireless fidelity') and free computers in poor urban areas.Solar industry in India is well on its path to leapfrog and become the next telecom industry in India. Solar energy in India is a combination of the second and the third point mentioned above. The problem of lack of grid connected electric systems has forced the government to deliberately develop policies targeting this particular industry. Moreover, leapfrogging also requires adequate manpower that is skilled and equipped to assist this

Local adaptation and innovation is also paving way for rapid diffusion of solar energy in India.
The Airports Authority of India (AAI) is going to install solar panels on the roof of the new terminal that will be used to generate about 100kw and use that to heat up water.

This heated water-chemical mix will be circulated through coils in air handling units where big fans will be installed. Like a normal AC, the air will get heated after passing through the coils with hot water and help keep the terminal temperature comfortably high in the cold desert capital's airport.

transition. The government of India having realized this has made conscious efforts to make sure that the required skilled manpower needed to make the national solar mission is available. Following this, the government has tied up with the Australian ministry of energy, resources and tourism which will prove training to Indian engineers to handle and maintain the solar array and panels. This skill development from an advanced country like Australia would mean a faster catch up as far as the R&D that is going in the developed country. A National Clean Energy Fund is to be set up to fund research and innovative projects in clean energy technologies. The fund will be fed by an energy cess of Rs 50 on every tonne of coal produced. In addition to this training, the government is also involving premier engineering colleges, ITIs and IITs to develop specialised courses in solar technology. Both undergraduate and postgraduate courses, as well as doctoral studies, will be financially assisted by the government, as part of the national solar mission. Also, a fellowship programme will be offered to 100 selected engineers and scientists who will be trained in solar energy in world-class institutions abroad, an official in the new and renewable energy ministry said. The fellowships will be available both at the research and post-graduation levels. The government believes that the country will need at least 100,000 trained personnel in engineering, management, and research & development functions to fully implement the solar mission. The government also plans to set up research centres for both solar photovoltaic and solar thermal technologies at the IITs. A national centre for photovoltaic research and education is already under way at IIT Mumbai. Some other IITs and engineering colleges have also planned similar centres[22].

CONCLUSION

The solar energy in India is on a threshold now. With comparative advantages like very few countries have and the interest that the central government is showing India is poised to become the world's largest market for solar energy. National Solar Mission will add 20,000 MW of generation capacity by 2020 and make it as cheap as electricity from conventional sources. The outlay will be with Rs.10,130 crore in the current Five Year Plan (ending 2012), Rs.22,515 crore in the 2012-2017 second phase, and Rs.11,921 crore in the 2017-2020 third phase.

[22]http://www.mydigitalfc.com/power/govt-rope-institutes-solar-mission-success-376

The plan is to raise this by taxing fossil fuels, mainly coal. The objectives of the programme include:

- 20,000 MW of installed solar generation capacity by 2020 and 100,000 MW by 2030; 200,000 MW by 2050
- Solar power cost reduction to achieve grid tariff parity by 2020
- Achieve parity with coal-based thermal power generation by 2030
- 4-5 GW of installed solar manufacturing capacity by 2017.

The policies by the Indian government seem to be in place. The main bottleneck that prevents the large deployment of solar energy systems in India is its high upfront cost. As a solution to this problem, the national solar mission in its first phase will aim to reduce the cost of solar panels by indigenising them. A rapid scale up program has been set in place to drive down costs, to spur domestic manufacturing and to validate the technological and economic viability of different solar applications. This will be done through promotion of commercial scale solar utility plants, mandated deployment of solar rooftop or on-site solar PV (photovoltaic) applications in government and public sector undertaking buildings, promotion of these applications in other commercial buildings, and mandating that at least five percent of power generating capacity being added every year will be through solar sources. Vacant land in existing power plants will be used for this purpose, and anybody who produces solar power at home or office will be able to sell the excess back to the power distributor. Policies like this will definitely have a positive impact on both the supply side and the demand side. The Union Ministry of New and Renewable Energy is working with the Union Ministry of Telecommunications in India on a project to convert all cell phone towers into “green towers” by tapping in solar energy for powering the towers instead of diesel generators. At present, India has around 250,000 cell phone towers which consume between 3-5 KW of power depending on the number of operators using the towers. Around 2 billion litres of diesel is consumed by these towers yearly. The introduction of solar powered cell phone towers would not only save billions of dollars in terms of resource saving but would also significantly cut down the Co^2 emissions.

India seems to have finally woken up to realise its full potential in solar energy. Combining its unique late mover's advantage and the comparative advantages, India is poised to become one of the largest producers and consumer of solar energy. While the policies and the incentives seem to be in place, only time will tell if these are executed robustly and efficiently. India has everything to gain by incorporating solar energy in its energy mix. Notwithstanding the advantages that India has due to its industrialisation, it cannot afford to do the switching from conventional to fossil fuels in leisurely. The latecomer strategy is not the one that can be leveraged forever. India will have to seize the opportunity and swiftly develop its capabilities in renewable energy from the resources it already has. This will have to be done before the developed world manages to shake itself out of the fossil fuel dependence. This will ensure that the latecomer advantages that India has now can be sustained in the form of early movers advantage when the rest of the world follows suit.

FINAL REMARKS

The traditional development model did not explicitly take into consideration the limited fossil fuel reserves and the environmental impacts that industrialisation will have in the long run. With the emergence of a unanimous consent on the seriousness of global environmental degradation, the renewable energy industry has finally arrived on the global scene. Although, it is evident that a consumerstic driven society coupled with inappropriate regulations during the past century has been a major cause of the present environmental and climatic conditions, we cannot afford to cling on this notion forever. What is needed is a global solution to, what is a global problem. The countries of the south, most of which were colonised and exploited by the western capitalism are now poised better than anyone else to come forth and provide a viable solution to this global menace. Energy was arguably the single most important thing for the early industrial revolution of the west. However, the path that the developed countries set on was and still is an unsustainable path for responsible development. The idea "develop now and clean later" is no more a feasible option because late may be just a little too late for developing countries. Notwithstanding this, there are other viable options that the emerging countries are better poised to take on. Especially for a country like India which is the early mover among the

late countries can benefit from both these characteristic. Being a late mover among the industrialised countries of the west, it has advantages in land, geographical location, a large skilled but cheap work force, access to latest technology and a greater say in global affairs. On the other hand it also has an advantage in terms of its early mover status when compared to countries in Africa, central Asia and other countries in South America. Unlike the emergence of the west and its capitalistic strategy of exploitation and suppression, the Indian capitalism which evolved as a complex mix of socialistic ideas adapted and re adapted by democratic institutions with a colonial legacy lingering on them is more inclusive. Adaptation of renewable energy by India will bring with itself benefits not just for India but may as well give new lease of life for underdeveloped countries to develop sustainably.

The gains to be made by switching to a green economy by adaptation of renewable energy are enormous for India. Apart from the economic benefits of energy security and emergence of a export industry, it will have social benefits that will encompass the rich and poor alike. First and foremost would be that of generating jobs where they are needed the most. India has the largest population of poor people in the world. Renewable energy industry would also translate into more jobs for rural India. Renewable energy technologies generate more jobs per megawatt of installed capacity, per unit of energy produced, and per dollar of investment, than fossil fuel based energy sector.[23] The PV industry in United States today directly employs 20,000 people and indirectly supports 100,000 jobs. The ministry of new and renewable energy predicts that the PV industry alone would create 100,000 jobs by 2020. Industry sources however are of the opinion that this is a conservative estimate and the actual employment generation would be much more than this figure.

Two of the most important sector contributing to greenhouse gas emission in India are transport and power sector. India has alternatives for both these industries in the form of biofuels, solar energy and wind energy among others. In addition to this, India has comparative advantages to develop all these industries into competitively advanced industries. As far as the bio fuel industry is concerned, India has to do a lot more for its ethanol industry. Even though

[23]Opportunities for greenhouse gas reduction: how many jobs can clean energy industry generate, Daneal M Kammen, University if California.

the demand side policies are in place, the supply side policies are not apt for the ethanol production in the country. The Biodiesel industry on the other hand has had a major push by the government with right policies in place. This promises to make the biodiesel industry a competitively strong industry in the coming years. Much like Brazil and Argentina, India is endowed with natural comparative advantages and it also benefits from typical late comer advantages. It remains to be seen if India can follow Brazil in what it did in the biofuels industry.

In solar energy industry, India seems to be advancing with a incredible pace. The Jawaharlal Nehru solar mission is the world largest program for harnessing solar energy. The policies that the union government has formulated have already started bearing fruits. However, financing would be the main bottleneck. In addition to this now technology is a major bottleneck in the solar industry in India. Though India's rising power demand and high irradiation levels make it ideal for harnessing solar energy, the country is highly dependent on imports of critical raw materials including silicon wafer used for solar cells and panels. India is a manufacturer of solar concentrator collectors for another type of solar infrastructure -- solar thermal energy. But its industry is underdeveloped in terms of technology. Nevertheless, coming forth of foundations like Clinton foundation to assist the Indian government are good signs of international cooperation. Rather than waiting for the west to drive down the costs of solar energy, India has initiated an aggressive program to accelerate the diffusion of solar energy into its energy mix. With the apt supply side and demand side policies in place, the price of solar energy in India is going down at a fast pace. Yet, a major portion of its supplies is exported. However, with the emergence of a strong domestic demand, competition is bound to rise. This would result in an increase in private R&D with companies wanting to differentiate their products. This coupled with government incentives both towards supply and demand side will boost the production and consumption of solar energy. India's biggest photovoltaic solar power plant, capable of generating 3 MW, at Yalesandra village in Kolar district of Karnataka, was inaugurated formally on 17th of June, and has been integrated with the state power grid.

Clearly, the renewable energy industry in India is now on a threshold. With proactive government participation and policies, India is ideally placed to establish a low carbon

development process, exploiting its comparative advantage and efficiently coupling them with its latecomer strategies to develop a green economy which is stable, at the same time proving an alternative for underdeveloped nations to develop responsibly.

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