Renewable Energy: Hasten Slowly

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Prime Minister Modi has talked about a "Saffron Revolution", a revolution of solar energy and power. This is a vital goal given our growing dependence on energy imports. India is short of fossil fuel resources. 75% of petroleum products consumption is based on imported crude. Natural gas consumption depends on imported gas for 15%. Even coal imports at 100 MT now account for 15% of domestic consumption. This is despite having adequate coal reserves to produce all the coal we need.

INDIA'S ENERGY NEEDS

Our total commercial energy consumption has grown from 295.49 million tonnes of oil equivalent (Mtoe) in 2000-01 to 536.59 Mtoe in 2011-12, a compound annual growth rate (CAGR) of 5.57%. During the same period the economy grew at a CAGR of 7.56%. This implies that for every 1% growth in the economy, commercial energy consumption grows by 0.74% i.e. with an elasticity of 0.74. Over the same period, electricity supply increased from 554 billion kWh to 1,052 billion kWh with a CAGR of 6.0%. The elasticity of electricity consumption w.r.t. growth of GDP is thus 0.8. If we assume that we will be more energy efficient in future, the growth rate of commercial energy may be 0.70% and of electricity consumption only 0.75% for every one percent increase in GDP. Table 1 shows projected energy and electricity needs till 2050.

TABLE 1: Projected Energy Needs for Different Growth Rates of GDP

	PRIMARY ENERGY (Mtoe)			ELECTRICITY (BkWh)		
GDP	7%	8%	9%	7%	8%	9%
2020-21	825	876	930	1618	1718	1823
2030-31	1332	1511	1713	2611	2962	3359
2040-41	2148	2606	3156	4212	5108	6187
2050-51	3466	4493	5814	6796	8809	11398

SOURCE: : Author's calculations based on elasticity of 0.7 for energy and 0.75 for electricity

As of today (without any major environmental costs added), renewable power is more expensive than coal based power and requires much larger investment upfront

Compared to 2011-12, primary commercial energy needs will be 6.5 times to 10.8 times and that of electricity 7.4 times to 12.8 times as much in 2050-51 depending on the growth rate. How can we meet these needs? Our energy resources of fossil fuels are limited. The growth rate of nuclear capacity has a limit and that limits what energy it can contribute.[1] Among renewables, solar is the only resource that has the scale to meet our needs.

STRATEGY AND POLICIES FOR SOLAR DEVELOPMENT

A number of issues arise. The pace of development and the policies to promote solar power plants in the country as well as building manufacturing capacity are all important to attain energy security in an efficient way.[2]

Desired Pace of Development of Solar Energy

Thus for India development of renewable resource is a must, the potential for it is vast. Just 20 million hectares of solar PV cells with a net efficiency of 15% can provide 30,000 billion kWh of electrical energy/year India generated, including captive plants less than 1,000 billion kWh of electricity in 2013-14. However, "the renewable energy sector in India today faces numerous financial, regulatory and supply chain barriers which impede its growth. The non-availability of low-cost, long-term finance for renewable energy projects along with the regulatory uncertainty and absence of a sustainable domestic manufacturing base have a long term impact on the growth of this sector"[3]

While a solar transition is inevitable, reckless promotion can be costly. As of today (without any major environmental costs added), renewable power is more expensive than coal based power and requires much larger investment upfront. Thus, the capital cost of a coal based power plant is Rs. 3.5 crores/megawatt but that of a solar photovoltaic plant is Rs. 5.3 Crores /MW at 2007-08 prices. Moreover, the coal based plant can be operated 70% or more of the time, a solar plant has a load factor of less than 20%. Thus the investment cost per kWh is even more for solar even when we account for the lower transmission investment for solar power. In table 2 it is seen that while the capital / output (C/O) ratio for coal based plant is Rs 9 that for solar PV is Rs. 36 for creating capacity to generate one kWh per year. Thus if we push solar too fast, less investment would be available for other sectors and the growth rate of the economy could be lowered.

We need to push solar power at measured pace with clear objectives in mind. One would have to balance higher current cost against the advantages of an early move, gains from learning by doing, benefits of economies of scale and the prospect of technical progress that will bring down cost in future.

Solar cell efficiency is likely to improve over time as many in the world are working on it. It will reduce the need for land and the cost of solar power. Still we cannot wait to begin introducing solar till new technologies are developed.

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[1] *Planning Commission (2006), Integrated Energy Policy: Report of the Expert Committee, (Parikh Committee Report), Planning Commission, Government of India, 2006.*

[2] *Energy Security is a nuanced topic, since many RE technologies require only a one-time import (initial build), while conventional fossil fuels may require ongoing imports. However, domestic manufacturing of RE has other benefits such as employment, foreign exchange savings, etc.*

[3] *Planning Commission (2014), The final report of the Expert Group on Low Carbon Strategies for Inclusive Growth, (Parikh Committee Report), Planning Commission, Government of India, 2014.*

TABLE 2: Capital to Output (C/O) Ratios for Power Technologies in 2007-08 Prices

	1	2	3	4	5	6	7	8	9
COUNTRIES	**COAL**	**NAT GAS**	**HYDRO**	**WIND**	**SOLAR PV**	**SOLAR THERMAL**	**WOOD**	**SUPER-CRITICAL COAL**	**NUCLEAR**
Capital cost (Rs. crores/MW)	3.5	3	5	4	5.3	8	3.3	4.3	5
Associated transmission cost (Rs. crores/MW)	2	2	2	2	1	1	1	2	2
Load factor	0.7	0.7	0.35	0.2	0.2	0.2	0.7	0.7	0.75
kWh generated per MW/year (Crore kWh)	0.613	0.613	0.307	0.175	0.175	0.175	0.613	0.613	0.657
C/O ratio (Rs./kWh)	9.0	8.2	22.8	34.2	36.0	51.4	7.0	10.3	10.7
Operating cost (Rs./kWh)	1.15	1.46	0.71	0.27	0.27	0.27	1.07	1.07	1.16

SOURCE: Author's compilation

The Expert Group on Low Carbon Strategies for Inclusive Growth (LCSIG) projects a solar capacity of 110 GW by 2030, and wind capacity of 118 GW. New government targets for RE, especially solar, may accelerate the timeframes. These along with various demand side measures of energy efficient appliances, ECBC compliant commercial building, improved fuel efficiency of vehicles, longer share of railways in freight movement, greater emphasis on urban public transport and improved energy efficiency in industries along with increased sequestration through enlarged green cover, reduce India's GHG emission intensity w.r.t. tonnes of CO2/US$PPP (purchasing power parity) by 42% by 2030 compared to 2007-08.

However, this does not come free of cost. The GDP is lower compared to a scenario where these measures are not taken. The difference over 2011 to 2030 is US$ 638 billion at 2011-12 market exchange rate discounted at a real rate of 4% per year. The additional investment needed for these measures comes to US$ 396 billion discounted at 4% over the period. Of course if additional external resources are made available, or if dramatic progress in technology lowers costs, the difference would be smaller. In the absence of these, the rate of increase of renewable power has to be determined by balancing the cost and the gains in energy security and emission reduction.

POLICIES FOR SOLAR DEVELOPMENT

The primary objective of the solar mission is to make solar power cost competitive to coal power. It also recognizes that to do so we need to support the first 20,000 MW. This will create domestic capacity, experience and scale to push solar at a rapid rate when it becomes cost competitive.

A number of instruments have been used to promote development of renewable power in the country. These include:

- Accelerated depreciation (AD) for wind power
- Feed-in-tariff (FIT)
- Renewable portfolio obligation and tradable renew able energy certificates and

• Generation based incentive (GBI)

The effectiveness of these instruments varies and depends on the way they are implemented. We look at them one by one.

Reverse Bidding for FIT

Feed-in-tariff guarantees a price for every unit of electricity fed into the grid by renewables such as solar, wind, etc. This provides financial support to investors who can then set up relatively expensive renewable energy plants. Also in order that the needed financial support in the form of feed-in-tariff (FIT) decreases over time, it is competitively determined and reverse bidding for FIT can be introduced as is done in the Solar Mission. It has been successful and the demanded FIT has come down from an expected 15 Rs./kWh to around 7.5 Rs./kWh.

Tariff reductions have happened because of the fall in price of solar PV cells in the international market driven by cheap Chinese cells. It is not clear how China is able to supply PV cells at such a low price, whether it is due to economies of scale, hidden subsidies or cheap credit. While India should take advantage of the cheap cells, it has stalled the development of domestic industrial capacity to manufacture PV cells. We need to find ways to encourage domestic manufacturing in a WTO compliant manner. One could raise tariff on imports or government procurement can give a price preference to domestic manufacturers. For India to be energy secure, over the long run domestic manufacture is critical.

Renewable Portfolio Obligation (RPO)

RPO requires all electricity distribution companies (DISCOMs) to source a certain fraction of its electricity from renewables as specified by the state electricity regulatory commission (SERC). The DISCOMs then buy renewable power from the cheapest available source, though solar may have its own RPO target. Thus the price of renewable power is determined in a competitive market. This has also the advantage that it gives a level playing field to all renewable technologies. The disadvantage is that it introduces uncertainty. In the cases where there is no FIT, the renewable power generator does not know what price he or she would get and so financial closure becomes difficult. This uncertainty can be reduced if a minimum support price is prescribed in advance by the DISCOM which is then obligated to pay that price. It can then sell the surplus to other DISCOMs. This will require a national mechanism to compensate the DISCOMs if they are unable to sell surplus renewable power, e.g., via a national clean energy fund. This will also require that the RPO has to be enforced and a fine at the level exceeding the most expensive power available is levied on DISCOMs who do not meet their RPO obligation. The LCSIG report has elaborated on the problems and policies needed to make RPO work better.

We need to find ways to encourage domestic manufacturing in a WTO-compliant manner

The FIT regime and RPO mechanism complement and mutually reinforce each other. While the RPO is a demand creating measure for renewable energy – the FIT regime ensures developers get a fixed return on their investments for renewable power.

The RPO has the advantage that all technologies compete (though solar may have its own RPO). However, this generates lot of uncertainty about what price one would get in the future. The ability to trade may lower some risks, but the uncertainty of price and availability of buyers remains. To minimize this, we recommend the following measures:

1) ***Strict Enforcement of RPOs:*** Strong enforcement mechanisms with stringent penalty clauses should be used to scale-up the demand for renewable energy in the country, thereby creating an alternate instrument

for market based financing for this sector.

2) ***A Uniform RPO across States:*** All states should stipulate a uniform RPO level. If states are free to set their RPO, the tendency would be to set it too low, and all states would have surplus renewable capacity and no buyer. Every state utility must have some obligation, except North Eastern States since they already have high hydroelectric power generation capacity and limited power transmission capacity.

3) ***Fixing of long term RPO targets by SERCs:*** To create visibility about solar power requirement, 5-10 years of the states' RPO target should be declared at one go.

4) ***Visibility of Floor & Forbearance Price:*** A floor price should be prescribed as a minimum FIT. This would at least ensure a minimum cash flow and reduce uncertainty. A national mechanism would have to be worked out to pay for all unsold renewable power. This price should be for at least 10 years to facilitate financial closure for RE plants.It should be set at a level that provides adequate return to RE producer. A fund should be created to purchase unsold RECs at the floor price in case the total supply of RECs is greater than the demand for RECs. A forbearance price, an upper bound, should also be set. In case of short supply of RE, forced buy out at this price should be provided for. The price may be set at the highest level of other subsidized power.

5) ***Grid Linkage Obligation:*** Be it on the DISCOM, or on the plant operator, the obligation to build the required transmission line should be clearly spelled out.

6) ***Multi-time Trading and Banking of RECs:*** The trading of RECs should be allowed for more than one year and it should be multi-time tradable. Banking of RECs for a period of three years at least, should be permitted.

7) ***Requirement to Meet RPO Periodically:*** In place of the annual requirement, the RPO requirement should be met on a half yearly or quarterly basis to reduce the payment risk and the year-end rush for the RECs"[4]

Accelerated Depreciation and Generation Based Incentives (GBI)

Accelerated depreciation was provided for wind power plants as a capital subsidy, which led to rapid development of wind power capacity in the country. The problem with the capital subsidy was that investors had all the incentive to build the plant but little incentive to operate it. To overcome this, a system of generation based incentive (GBI) was introduced, which was meant to be financially equivalent. Unfortunately, the financially equivalent feed-in-tariff determined by the bureaucrats did not satisfy the investors and development of wind power slowed down.[5] Any system in which a bureaucrat determines the price is unlikely to be satisfactory. A competitive market based mechanism is best. The discount rate assumed in working out equivalence may be too low from the point of view of investors. Also investors may inflate the amount of investment to claim higher depreciation. Though this is strictly illegal, the possibility cannot be ruled out, but examining capacity growth versus support policies may be difficult due to both time delays between policy and effect and due to confounding factors.

The trading of RECs should be allowed for more than one year and it should be multi-time tradable, with banking for upto 3 years

The LCSIG report suggests "To encourage Generation Based Incentive it is important to ensure that GBI is timely paid by creating a small balancing fund which can draw upon the National Clean Energy Fund depending on the requirements. This is a classic example of complementarity in the use of policy instruments, where Feed-in-Tariffs can be combined with Generation Based Incentive, the former bid competitively, and

[4] *Planning Commission (2014), The final report of the Expert Group on Low Carbon Strategies for Inclusive Growth, (Parikh Committee Report), Planning Commission, Government of India, 2014.*

[5] *The slowdown in wind power was also due to removal of support mechanisms, such as AD and GBI.*

later made conditional on technology, region and ownership to ensure development of renewable capacity if fair and more evenly spread across the country."

Creating Domestic Manufacturing Capacity & Securing Long Term Supply Chain

Policy measures like FIT, GBI and RPO/REC will create a market for renewable power. However, policies are required to facilitate the development of manufacturing industries. Domestic manufacturing industry needs to be encouraged if energy security based on solar and wind power is to be realized. The country should not aim to go from import dependence for oil and coal to import dependence for solar and wind equipment and its components.

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While the solar sector in India is poised to grow in the near future, the Indian photovoltaic and solar thermal equipment industry is facing challenges from global players, who have overcapacity, have far lower interest costs and higher incentives or subsidies as compared to the Indian photovoltaic and thermal equipment manufacturers. Several solar equipment manufacturing industries in India are either operating at sub-optimal capacity and/or have shut down production. In order to achieve JNNSM objectives, the industry needs a level playing field where the government ensures a balance between indigenous manufacturing capacity and imports. A higher value add in the indigenous supply chain would lead to increased investment, job creation, reduce foreign exchange outflow and sustain long term growth of this sector.

The following list of recommendations can help domestic solar and wind plant manufacturers by providing a level playing field, and creating a sustainable, reliable and long term demand for the domestic renewable industry.

1) ***Capex Support for Solar Manufacturing:*** National Manufacturing Policy has identified solar as a sector of strategic importance. Sectors of strategic importance should be given special thrust in terms of capex support in the form of long term, low interest non-recourse loans.

2) ***Technology Upgradation Schemes for Solar Manufacturers &Suppliers:*** A technology up-gradation scheme for the solar energy sector should be introduced to promote induction of state-of-the-art or near-state-of-the art technology. Such a scheme can be supported through the National Clean Energy Fund (NCEF) to support technological upgradation and productivity enhancement in the solar energy industry.

3) ***Tax and Duty Rationalisation:*** The inverted duty structure for the solar photovoltaic sector has been a matter of grave concern for this sector. There is an urgent need to rationalise taxes and duties along the solar thermal and solar photovoltaic value chain to restore the level playing field for the Indian solar manufacturing industry.

Decentralized Development of Solar Power

One great advantage of solar power is that it could be generated near the point of demand. Thus decentralized microgrids at village level can be set up to bring electricity quickly to villages not connected to grid or to villages connected but not supplied power. Grid connected solar plants distributed across the country can reduce transmission cost and increase availability, the probability of cloud cover for all plants may be smaller than for one large plant. However, the enthusiasm for village level solar grids needs to be moderated. A village level grid will need back up and so the costs would be higher.

For remote villages where cost of grid connection can be very large, such local generation makes economic sense. However most villages would prefer to have reliable grid connected power. Villages are reluctant to declare

themselves as remote villages if it precludes grid connection. A strong argument can be made for grid connected power. It is lot cheaper. India has already connected more than 95% of villages to grids. Gujarat has shown that providing 24x7 power to villages is feasible. The inability of many states to provide reliable power to consumers, urban and rural, is a problem that can be and must be tackled up front. One cannot imagine a country in which villagers get limited power through local solar grid for few hours every day and the rest of the country has a power system supplying unstable and unreliable power. The argument for such village level solar or renewable based grids is that the normal grid will take a long time to reach all and that even where grid connections are given, power does not flow. This unfortunately is the experience in many states. However, this need not be so. Gujarat's model of 24x7 electricity to all villages was accomplished in two and a half years. Our aim should be to replicate it all over.

The village level solar power systems operated by dedicated NGOs often provide power for few hours at night, limited to basic household needs. Power for productive activities is rarely provided by such grids. Also the cost of electricity would be many more times the rate charged to households in urban areas. A village grid has to be financially viable and would require that power is available for productive purposes. This would not be viable for electricity supplied for few hours at night, even though such power does provide an enormous improvement in quality of life compared to no supply at all.

We need entrepreneurs / managers who can run a micro-grid, having ability to manage, maintain, collect charges and make a successful business enterprise out of it

Covering the lakhs of villages with such local micro-grids poses huge challenges apart from cost. We need entrepreneurs, managers who can run such a micro-grid, having ability to manage, maintain, collect charges and make a successful business enterprise out of it. A person with such skills is unlikely to find it worthwhile as one might not get enough of an income from operating a single village level micro grid. It may be possible to attract such a person if one were given a charge of a cluster of villages to set up microgrids with an assurance that once the grid comes, the power can be fed into the grid at an agreed rate.

I strongly believe that India must go for 24x7 power supply to all. This does not mean that solar power has no role. The grid power can be from grid connected solar plants.

Roof-Top Solar

Germany has expanded solar generating capacity rapidly with roof-top solar plants with a Feed-in-Tariff (FIT). There are days in the year where the majority of generation is met through RE.

There seems to be lot of enthusiasm in India for promoting roof-top solar plants with net metering. MNRE is even giving a subsidy for installation of roof-top solar systems, which some states augment.

India should move cautiously in pushing roof-top solar with subsidy. This is a regressive subsidy as only the relatively well off would have their own roofs. If the rich consumers go out of the DISCOMs, their financial viability, which is already in a precarious condition, will worsen. Their ability to serve their poorer consumers will be worsened.

In Germany the cost of residential electricity is $0.34/kWh (around 20 Rs./kWh) of this $0.07/kWh (around 4.2 Rs./kWh) goes to subsidize renewable energy. The high cost of residential electricity reportedly lead to shutting off of electricity for some 300,000 poorer families as they cannot afford to pay their electricity bills.

What is ironic is that Germany's carbon emissions from power plants are increasing.[6] Roof-top solar plants have increased the variability of power required from the grid and the high price of natural gas makes gas powered plants uneconomic for peaking purpose. Also since Germany shuns nuclear power, it has to rely more on coal based plants at least for few years (may be a decade) where renewable energy fills the gap left by nuclear power.

While the situation in India would be not as bad as in Germany, where the plant factor of solar plants is around one half that of India, the consequences could be similar. If India is to support roof-top power, it should be without subsidy and the price paid for feeding surplus electricity into grid should be carefully determined taking into account the system wide repercussions.

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CONCLUSIONS

Solar Imperative

• India's limited fossil fuel resource and its vast solar potential make solar (and other green power) inevitable in not too distant a future.

• The National Solar Mission (NSM) has the correct objective of making solar cost competitive to coal.

• Setting up 20,000 MW of solar capacity under the NSM (or vastly more, as per recent announcements) is a means to realize the objective. Competitive reverse bidding for FIT is the right approach and has led to rapid reduction in cost of solar power.

• However, this has not yet led to domestic manufacturing capacity as desired. WTO compliant measures need to be taken to protect them from cheaper imports. These could be higher tariff on imports or price preference for government procurement.

Pace of Development

• The up-front investment required for renewable is still more than coal power. When the low plant factor of solar is taken into account, the capital cost for solar PV for building capacity to generate one kWh of electricity per year is measurably more than that of a coal based plant.

• Thus development of renewable power plants diverts investments from other sectors and could result in lower growth rate of the economy.

• Thus the pace of development of renewable power should be carefully determined to balance the need for domestic capacity creations against loss in GDP.

• There is also another reason to moderate the growth rate of renewable capacity. Significant efforts of R&D around the world are going on to increase efficiency and reduce cost of solar PV cells as well as of storage technologies. One can expect success in a decade (or less). Solar would then be an economically preferred alternative requiring no sacrifice of GDP.

Decentralized Development

• Solar power's advantage that it could be set up near the consumers has opened up the possibility of decentralized development. However, the enthusiasm for village level solar grids needs to be tempered with more planning for reliability and cost-effectiveness.

• A village grid has to be financially viable and would require that power is available for productive purposes. This would not be viable for electricity supplied few hours at night.

[6] *Carlyle Ryan (2013), "Should Other Nations Follow Germany's Lead on Promoting Solar Power?" Forbes, October 4, 2013, http://www.forbes.com/sites/quora/2013/10/04/should-other-nations-follow-germanys-lead-on-promoting-solar-power/*

• A manager to maintain the plant and distribution networks and to collect bills may not find it worthwhile for her skills in terms of income she could earn.

• What may be feasible is for such an entrepreneur to set up a cluster of such village grids with an assurance that once the grid reaches the villages, power can be fed into grid at prescribed tariff.

• The argument for such village level solar or renewable based grids is that the normal grid will take a long time to reach all and that even where grid connections are given power does not flow. This unfortunately is the experience in many states. However, this need not be so. Gujarat's model of 24x7 electricity to all villages was accomplished in two and a half years. Our aim should be to replicate it all over.

Roof-top Solar

• Roof-top-solar should not be promoted with subsidy. It is a regressive subsidy as only the relatively rich would have a roof. Also taking such paying consumers off the DISCOMs' customer base would worsen their financial health and delay supply of electricity to the poorer citizens.

• The price paid to consumers for surplus power from their roof-top plant fed into the grid, should be carefully determined taking into account system wide repercussions.