Karnataka's Smart, New Solar Pump Policy for Irrigation

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The runaway growth in states of subsidised solar pumps, which provide quality energy at near-zero marginal cost, can pose a bigger threat of groundwater over-exploitation than free power has done so far. The best way to meet this threat is by paying farmers to "grow" solar power as a remunerative cash crop. Doing so can reduce pressure on aquifers, cut the subsidy burden on electricity companies, reduce the carbon footprint of agriculture and improve farm incomes. Karnataka's new *Surya Raitha* policy has taken a small step in this direction.

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1 The Energy-Irrigation Nexus

Solar energy, long considered ideal for home lighting uses, has suddenly become attractive for pumping irrigation water. India already has some 20,000 solar irrigation pumps (SIPs) in fields; and farmers everywhere seem happy with their performance and potential (Kishore et al 2014a; Tiwary 2012). However, providing farmers reliable energy for pumping is as much of a challenge as the availability of water. This makes SIPs important and their numbers are expected to grow at exponential rates in the coming years.

Despite inheriting the world's largest canal irrigation network in 1947, India today has become the world's biggest groundwater irrigation economy. According to the 4th Minor Irrigation Census, farmers owning 11.5 million electric and 6.7 million diesel water extraction mechanisms (WEMs) have installed some 115 gigawatt (GW) equivalent of distributed pumping capacity (MoWR 2013) to lift some 231 billion cubic metres (BCM)/year of groundwater (Planning Commission 2007: 4). These WEMs are the exclusive source of irrigation water for over 67 million ha/year of gross cropped area and a supplemental source for an additional over 16 million ha/year. The area benefited by these so-called minor irrigation schemes is over four times more than what all government canals manage to serve (Shah 2009). In effect, electric and diesel WEMs have become the engine of India's agricultural and rural economy. This groundwater juggernaut would still keep rolling but for the perverse nexus between energy and groundwater.

An energy-divide defines India's groundwater economy. Electric WEMs dominate the west-south corridor from Punjab down to Tamil Nadu while diesel WEMs are preponderant in the east-north corridor. This divide has caused perverse outcomes since, in the absence of an effective price for groundwater, the energy cost of pumping it has become the surrogate price of this resource. In the groundwater-short west-south corridor, electricity subsidies have made groundwater use excessively cheap and have caused sustained over-exploitation of aquifers. In contrast, in the groundwater-rich and flood-prone Ganga-Brahmaputra-Meghna (GBM) basin, high and rising diesel prices have made groundwater irrigation prohibitively expensive. If only eastern India could intensively used its prolific aquifers for irrigation, it can improve millions of livelihoods and, as a positive externality, reduce the intensity of recurrent floods in Bihar, Nepal Terai and Bangladesh. However, with diesel prices rising over 10 times faster than prices of agricultural commodities since 1990 (Kishore 2014b), groundwater irrigation in the GBM basin is rapidly approaching stagnation and decline (Shah et al 2009).

In western and southern India, in contrast, a long history of farm power subsidies initially made groundwater irrigation lucrative for farmers but has, over time, depleted groundwater aquifers with most of India's over-exploited blocks clustered in this corridor. Moreover, unsustainable subsidies have so bankrupted the electricity distribution companies (DISCOMs) that they have a hard time managing their rural network and supply. Frequent interruptions, low voltage and fewer hours of mostly nightly farm power supply are proving increasingly irksome for farmers in the west-south corridor.

For ideal socio-ecological outcomes, farmers in the groundwater-abundant east-north corridor should get cheap energy to accelerate groundwater irrigation, catalyse competitive groundwater markets, kick-start the region's belated green revolution and, in the process, reduce the severity of post-monsoon surface flooding. In contrast, farmers in the west-south corridor need to be weaned away from subsidised energy and incentivised to reduce groundwater as well as energy use in pumping it. With right promotional policies, SIPs can provide a one-stop solution for the energy-irrigation nexus in east-north as well as west-south corridors of India.

2 Promise of Subsidised SIPs in Ganga Basin

Imagine, for moment, what would happen to eastern India's groundwater economy if millions of its diesel irrigation pumps were replaced overnight by SIPs of equivalent capacities. Farmers throughout the GBM basin, who have so far felt constrained by the high and rising diesel cost of pumping groundwater, will now be faced with virtually zero marginal energy cost of pumping. The same shallow tube well, which until now was pumped for barely 400-500 hours/year,[1] will now be pumped for 1,500-2,000 hours/year. The monopolistic groundwater markets operating in villages will turn highly competitive as SIP owners compete with each other to maximise their pump utilisation factor (Shah 1993). The diesel pump owner who until now sold irrigation at Rs 130-150/hour will now happily sell SIP irrigation at Rs 20-30/hour, marginal farmers and sharecroppers being the prime beneficiaries as water buyers. The proverbial Ganges Water Machine (Revelle and Lakshminarayana 1975) will get revved up pumping every year three to four times more shallow groundwater for rabi and summer irrigation and creating room in the vast porous alluvial aquifers of the Ganga plains to receive more recharge, thereby reducing the intensity of monsoon floods further east. Accelerating agricultural growth in the GBM basin will no longer need to wait for laying expensive and time-consuming rural electricity network to deliver expensive grid power to farms.

In the groundwater-abundant GBM basin, the prevailing model of promoting capital cost subsidy is appropriate because of the socio-ecological benefits of intensifying groundwater irrigation. If anything, allocations for SIP subsidies need to be drastically increased, existing restrictions on SIP capacity should be liberalised and SIP owners should also be supported to invest in buried pipe distribution system to sell irrigation service to as many farmers as they can serve. The socio-economic benefits of SIPs in this region can be maximised by catalysing competitive groundwater markets in which SIP owners as entrepreneurial irrigation service providers operate as if to achieve wider social goals by maximising the provision of affordable irrigation service.

3 SIPs' Dangers in West and South

In the west-south corridor, too, promoting SIPs can offer vast benefits. The power grid will be relieved, at one fell swoop, from the deadweight subsidy burden of Rs 35,000 crore/year (World Bank 2002). Every electric WEM refitted with a solar pump will reduce DISCOMs' losses by an average of Rs 30,000-Rs 35,000/year.[2] Farmers will have access to free, uninterrupted, day-time energy supply for pumping for six to 10 hours daily, more during winter and summer when irrigation is most needed. Electricity and diesel used in pumping groundwater emit 16-25 million mt/year of carbon, nearly 6% of India's total (Shah 2009). Solarisation will completely wipe out this carbon footprint, and transform India's "dirty" groundwater economy into a clean one.

The major risk in India's west-south corridor, however, is that solarisation will seriously aggravate aquifer depletion. Poor quality nightly grid power supply has not been without its eco-system benefits; it has helped check relentless groundwater overdraft. By replacing poor quality, nightly grid power with 2,500-3,000 hours/year of top quality day-time free power, solarisation of WEMs will intensify the race to the bottom of the aquifers in this corridor. Governments and solar companies are making light of this threat by limiting subsidy to only 1.5 to 2.5 kwp pumps and/or coupling SIP subsidy with adoption of micro-irrigation. However, these preconditions will be hard to enforce, especially as the numbers of SIPs on the ground increase.

Moreover, these preconditions will remain relevant only as long as farmers need SIP subsidies from governments. Given the reliability and convenience of solar power, it is only a matter of time before a booming non-subsidy market for SIPs emerges. Global prices of solar photo voltaic (PV) cells have fallen from $77/watt in 1977 down to $0.36/watt in 2013 and will keep falling in the times to come. As a result, the sustainability threat to groundwater from SIPs will remain real and serious with subsidies or without. The only way to meet this threat is to incentivise the farmer to grow solar power as a remunerative cash crop rather than only a fuel to pump groundwater. Karnataka's *Surya Raitha* is remarkably prescient because it intends to incentivise SIP owners to sell surplus solar power to the grid and to conserve energy and groundwater (Khajane 2014).

4 Perverse Subsidies

The Jawaharlal Nehru National Solar Mission (JNNSM) incentivises solar investments through two mechanisms. Solar Home Systems (SHS) are promoted through attractive capital cost subsidies. In contrast, MW-scale PV plants are incentivised by generation-linked incentives in the form of guaranteed long-term purchase contracts at an attractive Feed-in Tariff (FIT). The FIT is now hovering around Rs 7.50/kwh; in addition, generators earn tradable Renewable Energy Certificates (REC), valued at Rs 1.50/kwh in early 2014 (PTI 2014).

The two incentive mechanisms produce vastly different operating performance. The performance of SHSs – installed in homes or on community drinking water supply systems – is uniformly poor (Kumar et al 2012). Under high capital cost subsidy, "install-and-forget" is the name of the game for suppliers who have little interest in providing after-sales support but strong incentive to "gold-plate" their products. As a result, the SHS segment is neither growing as fast nor performing well as it needs to. In contrast, the MW – scale PV sector is performing very well and growing fast, having grown from next to nothing in 2010 to over 2.6 GW in 2014 (Shrimali and Nekkalapudi 2014; BTI 2014).

SIPs are best incentivised through a careful blend of capital cost subsidy and FIT. However, they are so far promoted as SHSs are, with an attractive capital cost subsidy of 86%-100%. There are several problems with this strategy: (i) high subsidy stimulates demand but the small annual fund allocation leaves a large unmet demand; (ii) high subsidy discourages the development of the non-subsidy market for SIPs as farmers wait for subsidised SIP; (iii) to reduce the threat of groundwater over-abstraction, governments allow only 1.5-2.5 kwp[3] SIPs to pump water from farm-storages where water is first pumped by electric tube wells. These SIPs thus complement – rather than replace – electric or diesel pumps on tube wells, thus defeating the key gain from solarisation, vis, of reducing fossil energy use; (iv) high prorata capital cost subsidy creates oligopolies of a few large PV supplier companies that create barriers to entry for new players; these oligopolistic suppliers strive to maximise their share in the government subsidy rather than growing the SIP market, to keep putting up the unit cost of SIP to skim the subsidy, and to use subsidy as a substitute for genuine product promotion.

The worst problem with the current subsidy schemes is that over time, they will aggravate groundwater depletion. Given the steeply falling solar PV prices, as the market for non-subsidy SIPs begins growing, it will become impossible to prevent over-exploitation of groundwater by SIP owners – except by providing them an attractive avenue to dispose of their surplus solar power.

5 Surya Raitha

Surya Raitha, Karnataka's new solar pump promotion policy does precisely this. It offers guaranteed buy-back of surplus solar power from SIP owners at an attractive FIT, as is the case with rooftop solar generators in Germany, Japan, Italy and California. Rooftop solar generation for evacuation to the grid is rapidly emerging, and is strongly advocated in India too (Gambhir et al 2012). But this is only a distributed green energy solution.

Surya Raitha will target several goals at one go: (a) improve agrarian livelihood by providing farmer cash income for "growing" solar energy as a remunerative cash crop; (b) conserve the environment through a built-in incentive to conserve groundwater and energy use in pumping; (c) enhance the quality of irrigation by providing farmers reliable, uninterrupted, daytime power supply; (d) reduce the carbon footprint of groundwater irrigation by reducing electricity and diesel use in pumping water; (e) improve finances of the power sector by liberating DISCOMs from the deadweight of farm power subsidies; (f) reduce T&D losses by replacing grid power by locally generated power.

Surya Raitha will produce these win-win outcomes by transforming perverse incentives facing the farmer in the west-south corridor where all ills of the groundwater socio-ecology are rooted in the history of free or highly subsidised farm power supply. A farmer in Tamil Nadu or Karnataka or Punjab uses some 10,000 kwh/year of power and some 60,000 m^3 of groundwater to irrigate field-crops like rice or wheat because power supply costs him little or nothing on the margin. Surya Raitha creates a mirror-image of this perverse policy. The present policy incentivises farmer to waste power and groundwater; Surya Raitha will pay them to conserve both. With a net-metered SIP with guaranteed buy-back of surplus solar power, the same farmer will now try to raise the productivity of groundwater as well as energy by investing in micro-irrigation, by choosing crops with high returns to irrigation.

Table 1 illustrates our argument by comparing three situations: the first is representative of the present default; the second represents wildfire spread of SIPs without any provision to buy-back surplus solar power from farmers; and third represents our recommended policy of modest capital cost subsidy but a guarantee to buy-back surplus solar power from farmers at a grid-parity price. Most numbers are hypothetical but, in our view, realistic. A representative electric tube well in west-south corridor imposes a power subsidy burden of Rs 56,000/year on the DISCOM, and emits 5,660 kg/year of carbon by burning 14,000 kwh of thermal power. If replaced by a SIP of equivalent capacity, the carbon footprint and power subsidy will be eliminated; but the average annual groundwater draft per tube well will increase significantly because of more hours and better quality of free, daytime solar power relative to the grid power. However, a SIP promoted with reduced capital cost subsidy but guaranteed buy-back of surplus solar power reduces groundwater use (by making conservation profitable), earns the farmer a net additional income of Rs 76,000 by sale of surplus solar energy and abolishes the carbon-footprint of groundwater irrigation. The DISCOM is doubly benefited through saving of Rs 56,000 in annual power subsidy and

Table 1: Pros and Cons of Alternative SIP Promotion Models in Groundwater-scarce Socio-ecologies

	Electric WEM, Western and Southern India	SIP with 90% Capital Subsidy with No Arrangement for Power Buy-back	SIP with a Subsidy of Rs 40,000/ kWp and Guaranteed Buy-back of Power at Rs 5/kWh
Nature and size of WEM	6.5 kW	6.5 kW electric+ 1.5 kWp SIP	6.5 kWp SIP
Government subsidy on capital cost of SIP	Nil	Rs 5.85 lakh	Rs 2.6 lakh
Annual hours of operation	1,500	1,800-2,000	2,200-2,500
Hours of groundwater pumping/year	1,500	1,800-2,000	900
Annual groundwater draft @ 40 m^3/hour	60,000 m^3	76,000 m^3	36,000 m^3
Farmer net income from sale of surplus solar power to the grid at Rs 5/kWh	Nil	Nil	76,375
Grid power dispatched to the WEM from generating station assuming 30% T&D losses	13,929 kWh	Nil	Nil
Farm power subsidy burden on DISCOM (Rs/electric WEM/year	Rs 55,714	Nil	Nil
Carbon footprint of groundwater irrigation (kg/year) at a carbon intensity of kWh in India assumed at 0.4062 kg (Shah 2009)	5,658 kg	Nil	Nil
Value of Renewable Energy Certificates (RECs) earned by DISCOM @ Rs 1.50/kWh	–	Rs 18,525/year	Rs 22,912/year
Value of power generation capacity released for the non-farm economy assuming investment in new thermal capacity at Rs 5 crore/MW and plant load factor at 70%.	–	Rs 56,712	Rs 56,712

earning of RECs worth Rs 23,000; indeed, compared to the present situation, the DISCOM will be gaining Rs 0.15/kwh of surplus solar power it buys from the farmer at Rs 5/unit.

6 Solar Mission Strategy

The JNNSM is trying to achieve its target of 22 GW of solar generation capacity by 2022 primarily by commissioning MW scale – or even ultra-mega – solar PV as well as solar thermal plants. However, many observers have argued in favour of the merits of small-scale distributed generation. Prayas Energy Group (Gambhir et al 2012) have argued for promoting investment in grid-connected, net-metered solar rooftop PV (RTPV) systems by incentivising high-end consumers subject to high and rising tariff for grid power to substitute solar power for grid power. Bhushan (2014) from the Centre for Science and Environment (CSE) has recently argued that for a country like India with 400 million people without access to grid power, a better alternative to large-scale solar PV plants are solar mini-grids in villages with energy storage options that can provide at least 1 kwh/day to every household. Surya Raitha is a third alternative for distributed solar power generation; it has all the advantages of Prayas as well as CSE proposals and more.

Farmers have a strong comparative advantage in solar power generation and, in principle, could accept lower levelled FIT to sell solar energy than MW scale plants do. Solar PV arrays need land; and farmers own half of India's land. MW-scale solar plants will mean acquisition of more than 50,000 ha of land for panels. SIPs would require no land acquisition. Moreover, unlike MW-scale solar plants, SIPs have little or no land footprint since farmers can grow high value vegetable crops under the PV arrays that act somewhat like a makeshift green house. In Japan, entire farms are covered by such "solar sharing" in which farmers earn from the crops as well as from solar energy. Through SIPs, India can generate many times more solar energy without removing any land from existing uses, by retiring some 115 GW equivalent of conventional generation capacity currently deployed to run 21 million electric and diesel pumps.

7 Devil in the Detail

The basic idea of Surya Raitha – combining capital cost subsidy with guaranteed buy-back of surplus solar power – for promoting SIP makes it smart. But the devil lies in the detail of actual design and implementation. Surya Raitha intends to give priority to farmers without grid connection for allocating subsidised SIP (Khajane 2014). However, it should also give priority to farmers who are willing to surrender their grid connection in lieu of a subsidised SIP because solarising grid-connected irrigation pumps is the best way of reducing the subsidy burden on DISCOMs. Government should also significantly enhance the annual funds allocation for Surya Raitha given its potentially beneficial impacts on the DISCOM finances. Then, the incentives presently offered are unrealistically high and will make the policy unsustainable: like Bihar, it offers 90% capital cost subsidy and on top of that guaranteed FIT of Rs 7.20/kwh (Rs 9.56/kwh if the farmer has not taken a subsidy).

In our view, the capital cost subsidy should be lower and flat at Rs 40,000 per kwp (instead of prorata as per cent of the gold-plated unit cost) to encourage high-volume-low-margin business strategy among SIP suppliers. A lower flat subsidy will also make it possible to reach out to over twice as many farmers with the given subsidy budget. We also believe that the FIT should be pegged at around Rs 4.5-5/kwh for subsidised SIPs, as the Delhi Electricity Regulator has just announced in its new policy for rooftop PV owners (Verma 2014). A much higher FIT will distort farmer incentives: many farmers will use their PV plant just to sell power to the grid and irrigate with diesel or electric pump. One can also not rule out farmers feeding grid power (or power produced with a diesel genset!) back to the grid to claim high FIT.

Tamperproof net-metering, preferably time-of-the-day, of surplus power evacuated to the grid will be absolutely critical. Installing three-way switches can help stem malpractice. We must not forget that all the present ills of the electricity-groundwater nexus in India have their root in metering problems on tube wells back in the 1970s which led to the birth of flat tariffs and then to free power. As farmers realise the lucrative gains from feeding solar energy into the grid, the chances of malpractices will multiply. Surya Raitha should focus on minimising room for malpractice. In doing so, it will also be helpful to organise SIP owners into a SIP owners' cooperative or the Joint Liability Groups (JLG) which can vouch for honest dealing by members and collectively evacuate surplus solar power at a single point which is easy for the DISCOM to monitor on a real-time basis. Penalties for malpractices will have to be high enough to serve as deterrent; and vigilance will need to be vigorous from the beginning. Buying energy from small, decentralised generators is a big and growing business around the world. But a smart solar pump promotion strategy will need careful running in and implementation.

NOTES

1 Based on data on operating hours of diesel pumps from Bihar and West Bengal from Minor Irrigation Census 2006.

2 In Karnataka, for example, 2013 farm power subsidy to 1.99 million irrigation pumps was Rs 7,200 crore with an average subsidy/pump at Rs 36,183/year.

3 kWp refers to peaking kilo Watt. Solar PV cells produce maximum power when solar insolation is at its peak; the actual power delivered varies according to the time of the day, cloud cover, temperature and other factors.

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