ROOF-TOP SOLAR: TIPS, TRICKS & TRAPS

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Roof-top SOLAR: Tips, Tricks & Traps

This is an initiating collection of very practical tips, tricks and traps that can help you in successfully installing a roof-top solar project.

As a first-time user, the prospective residential solar buyer has a number of fears, uncertainty and doubts that plague his purchase decision. This compilation is based on actual user experiences – and some painful learnings – that can make all the difference between a failed and a successful installation.

For the users, I am building two separate sections – one for Rooftop Solar Water Heater Systems (RT SWHS) and second, for the more recent, Rooftop Solar Photo-Voltaic (RT SPV). The first harvests thermal solar energy and uses it for water heating – and hot water applications in residential households. The second – RT SPV – generates electricity that can be used to power household electrical appliances!

Finally, why do I call it "an initiating collection"? That is because there are new materials, new processes, and new jugaad getting uncovered every day. The initiating 20 tips shared here are just that – a gift to the respondents of my PhD survey. And we will be adding them to our blog for your reference below on a periodic basis. For continued update to this collection of tips, tricks and traps please follow us on the social media:

blog www.india-inspires.com category: xl-solar

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Excel in your Rooftop Solar Water Heater Installation

1. Pipe-Dreams

Harvesting solar successfully is all about minimizing losses. A typical RT SPV harvests solar heat and stores it in an insulated water tank. The water is drawn into the household from this tank via a network of feeder pipes. In Delhi NCR, somehow the average plumber/architect setup is for a GI (galvanized iron) pipe. Can you imagine what happens to the water in the iron pipe? You bet! It will be exposed to the atmosphere –and in the winter, it will cool the hot water in the pipe minimizing the user experience!
So -the first rule of the RT SWHS is to avoid the GI pipe. You should explore thermal grade KiTEC pipes or the thermal grade PU pipes. These can handle hot-water, will not corrode and will form the basis of your water inlets!

Kitec piping with Alu tape on my RT SWHS

2. Pipe Diameter – Obesity will not help!

Continuing the theme above – I have seen a gas-fired water heater installation at a premium South Delhi home where the plumber has installed 2" pipes from the gas fired heater into the home. The homeowner was tearing his hair out as he was paying for a gas cylinder every day! There were a number of reasons for this expensive water heating. But – the foremost here is that he had a 2" diameter feeder pipe. What is the volume of water that is carried in this pipe? It is calculated at

$V = \pi r^2$ x length of pipe

You can see that if you have a 2" diameter pipe vs a ½ " diameter pipe, you will be holding 4 times the water in the fatter pipe. That is the water which will cool down and which you have to feed into the gas heater continuously for maintaining the temperature! So if you use fatter pipes, you will have more heat losses!

In case of RT SWHS, fatter the pipe, more the water present in the system outside the insulated SWHS and with greater surface area over which the heat loss will take place.

Bigger is just not better here!

It is quite appropriate to use a ½" diameter pipe for your hot water feeder pipe!

3. And you need to minimize the length of pipe!

By the same reasoning, it makes sense to limit the length of the pipe! As a simple calculation, if you have a 2" pipe, then a 70-100 feet of pipe length represents a medium to large bucket of water. That is the water that may cool down overnight in the winter while in the pipe. That means the user will see as much as a bucket of cold water before he even starts to receive hot water! Talk about a poor user experience while he stands naked waiting for hot water to arrive!

As a good SWHS installer knows – you will need to ensure that you minimize the feeder pipe length. That means you should not be greedy to take the feeder pipe to too many outlets. Keep the design simple – take the SWHS hot water feed to 1, maximum 2 points – and try and make sure that you do not have excessive pipe length. Several installers recommend 10-20' pipe length.

4. And so much for sustainability!

9 out of 10 times, I bet that the cold water that comes out of the tap will go waste in the drain! Just provide for an extra bucket to take the first output of the cold water. It can be used in other applications such as watering the garden – or for selective mixing with hot water to the right temperature.

5. Insulate against losses!

It is critical to insulate your hot water feed pipes. The GI pipe I mentioned in Example 1 was not insulated and therefore the water in it cooled off faster. If you insulate the feeder pipe and, if the time between the morning use of hot water is not too delayed, the hot water in the pipe will not have significant heat losses – and the users will get more hot water from the same capacity of SWHS…and a better user experience.

We recommend Kaiflex insulation for the feeder pipes. It is a black insulating thick rubber polymer tube and will easily slip on to the feeder pipe.

6. And Protect the Insulation!!

You should note that the insulation can be damaged by exposure to sunlight (UV degradation). (You may have seen the air-conditioner insulation tubes deteriorate and fall in fluffs and parts over time)? So you need to protect the insulation. This can be done by two methods:

- Your tube vendor will give you a protective paint that can be coated on the tube to extend its life
- And the other tactic is to cover the tube itself with a reflective metal tape

Take your pick as you deem convenient or available. But protecting the insulation is key to keep your system maintenance cost low! Yes – this is one of the hidden costs that the SWHS vendor will not be talking about.

7. How to select SWHS capacity

A typical bucket will have 12-15 liters of water. That means you can get approx. 7 buckets of hot water from a 100 liters SWHS. However, this is a theoretical figure. In reality, the figure is barely half! As you draw hot water from the SWHS, the system is fed with cold water refills – and the temperature falls!

Typically, the vendors will recommend that you have a capacity which is at least twice of what your actual needs are calculated as. For a 4 member household – a requirement of 100 liters of hot waters/day in winter will translate to a minimum of 200 liters SWHS capacity.

Do NOT be conservative on your SWHS capacity – minimum 2x is the way to go!

8. 1 nos 200 liters SWHS or 2 nos 100 liters SWHS

So now that you have decided to go for a 200 liter capacity SWHS – you come across a very typical mistake by most SWHS installers. They sell you a single 200 liter capacity tank SWHS. As you draw hot water out – the cold water coming into the tank will rapidly dilute the heat – and the user experience from the system!

Actually, the right configuration to install is a 2 x 100 liters capacity SWHS. You configure this in series so that as the hot water from SWHS 1 is withdrawn, it is fed with hot water from the SWHS 2 which gets cold water at its inlet. So the water in SWHS 1 is always hotter than the water in SWHS 2 and the user gets a relatively better user experience.

9. Use of Auxiliary feed tanks

Typically, a SWHS is configured with a cold water feed tank inputting to the solar water insulated hot water tank. The difference in height of the two is recommended to be about 2-max 5' - else the resulting pressure difference will have implications on the SWHS valves and seals!

To cut costs, the installer would like to use an existing tank on a higher rooftop – but rarely do you get the right combination of heights! So the installer ends up building another platform at the installation for keeping the cold water tank at the right height.

An option to this is to provide an auxiliary tank that is having a valve system that breaks the pressure at the inlet point. In fact, many SWHS vendors provide this as an optional accessory for their systems!

10. Hard water vs Soft Water tanks

Water in Delhi NCR is hard – unlike many cities in South. Hard water corrodes the tanks and piping – and therefore necessitates use of hard water tanks. Hard water tanks have been specially treated and coated appropriately to withstand the demands of handling hard water at high temperatures!

Again – I highlight this because to save on costs, ignorant users end up installing soft water SWHS and pay a huge price within a couple of years when the tanks corrode and start leaking!

11. FPC vs ETC systems?

SWHS is available in two configurations in the market. FPC or flat plate collector systems will have a blacked radiator backplane on which a copper tube system is placed. The entire arrangement is sealed in a glass box and traps the solar heat which is transferred eventually into the water (or another solar heat evacuation fluid like glycol) in the copper tube.

ETC – Evacuated Tube System will consist of specially drawn glass tubes which act like filaments capturing solar heat and the water in them rises into the supporting solar water heater tank.

Which system would you take?

FPC systems proliferated in North India in the initial solarization phase – but were not successful. In fact, I was told by an industry leader that it was their failure – and the resulting poor word-of-mouth- that stunted the proliferation of RT SWHS in North India in that earlier era.

The reason for this failure was simple. The hard water in North India formed scales in the Copper tubing of FPC and this limited their heat capture capability over a period of just a few months.

ETC , on the other hand, have proved to be more reliable. The scale formation is a relatively slower phenomenon in the glass tubes. And can be corrected every couple of years by just taking out the tubes, drying in sun and using an appropriate cleaning brush on the dried scales.

EXCEL IN YOUR ROOF-TOP SOLAR PV

12. Under the Shadow!

Minimizing losses is the critical design element even for Rooftop Solar PV. And one of the simplest loss element is the shadow that can fall on a solar PV module.

A good design stimulates shadow movement on a site across the year. Near-and-Far shading analysis is now mandated in several state rooftop programs (ex,Gujarat mandates this). There is quite a few software that permit this. These include software like Skelion – a plug-in for solar applications on sketchup program; Helioscope, Aurora to name a few. StepSolar permits a mobile app for the field practicioner. However, my favorite and recommended software is 'thesolarlabs". It gives you interface to PVSyst, options of different sources of rooftop imagery (including drone mapped images) – and 3D rooftop design.

You can get demos of these software from the vendor site.

Most software gives a limited time (1-month usage). However, your system will be locked out post that period and you may have to pay a very heavy price for the continued usage/ access to your designs.

You can also see the Skelion application view tube at the URL below. (In fact, there are several videos on YouTube that cover the full tutorial for this application)…

https://www.youtube.com/watch?v=Lu5D-4qAcsI

Why is shadow so significant in a Solar PV installation? Well -90% of the Solar PV installations are based on crystalline silicon wafers. These are solar cells that are laid in a pattern on the module backplane and 'stringed' with an electrical conductor to feed the current that is generated into the next stage. If even one of the cells is under shade, it has a higher resistance/ lower PV current – and the overall performance of the full module falls to a lower level. In fact, the overall performance of a string of modules is diluted if there is a shadow on any part of the string!

So – a good installer studies the surroundings of a given site and identifies potential sources of shadow and their likely incidence on the PV modules. A quality installation ensures placement of modules so that the shadow losses are eliminated in the golden farming hours (morning 7-8 am to evening 5-7pm).

13. Landscape vs Portrait

How would you mount your Solar PV modules? They come in the rectangular size (typically 65"x 39").

Many installers do not realize that there is a potential implication of mounting the PV modules in a portrait vs landscape mode. The PV modules typically have the solar cells laid and tabbed in the direction of the long-edge. If these modules are exposed to a shadow in the early morning or late evening, then in the portrait mode, the shadow on the edge will be enough to lower the performance of the entire module and related string.

On the other hand, if the modules are mounted in a landscape mode, then the performance may drop but not as dramatically and the module conversion efficiency will be that much better. Shared below is a site with the landscape installation…

14. Dust

Dust is the bane of a SPV installation – especially in Delhi NCR area. It can reduce the solar insolation incident on the solar PV. And it can reduce the harvesting potential by coating the solar panel surface with an increasingly opaque dirt layer.

The answer is simple…one needs to periodically clean the panels. There is no escaping the manual chore… (there are automated systems, but it is not worth it for the residential PV systems).

15. Tracking

By tracking the sun, we mean reorienting the panel to face the sun. If you had a pyranometer, you would see that keeping the panel perpendicular to the sunrays dramatically increases the PV current. You can farm up to 30% more energy if you had a good tracker. And the vendor will claim – and price – the tracker to deliver a ROI based on the additional energy harvested.

Of course, it is not practical to increase capex waiting for a ROI through a future additional savings on electricity bills.

Interestingly, a manual tracking system can achieve reasonable improvement in harvesting efficiency by fixing a couple of positions for the solar panel during the day. Of course, the manual tracker will be relevant only for smaller installations and availability of a manual labor.

There are several ideas for making a manual solar tracking system on Google Search. However, you can save yourself the trouble and get a readymade system from a mount vendor.

16. Mounting

As you would have guessed from the SWHS section, the civil work , placement, mounting frames are a key part of the site costs – and define the harvesting capability. A poor installer can reduce your high-efficiency premium quality Solar PV modules to a poor-user experience with inadequate conversion efficiency in real terms.

Use an experienced installer who has handled rooftop solar installations and civil and electrical works. To give structural stability, the foundation blocks for the mounting is fixed on the rooftop with nitro-bond epoxy adhesives – you cannot move the mounts once it is fixed…

Do note that the foundation blocks serve to provide the ballast -the dead weight that prevents the structure from damage in elemental exposure (winds etc). A good adhesive like Lords can fix the foundation block instead of letting it chip the roof surface in an extreme situation. Normally, we look at foundation blocks that are 400x400x 300 – but with a good adhesive you can get bonding strength and even look at 250 x 250 x 200 block.

The above figure shows a direct bonding of the structure post to the concrete roof. This is possible if one is using appropriate adhesive – but is only practical where the wind and environmental design constraints are not too demanding.

The blocks themselves can be procured ready-made or are prepared on the site using a M25 or M30 concrete mix (Cement, Sand, Aggregate mixed in ratio of 1:1:2 or 1.5:1.5:2) and molding frames. The J-anchor bolts are usually seated in the concrete mix at an appropriate depth – and are used to attach to a base plate. In fact, it is an acceptable practice to set the bolts in the base plate and then mount in the wet concrete.

It is important to realize that while solar panels have a life of ~25 years, the other components including the structure will have lower life and totally dependent on the quality of installation and environment. Typically, the structure consists of pillars mounted on foundation blocks – and rafters and purlins mounted on the pillars.

These structures (Pillars, Rafters, Purlins) are typically made of galvanized iron or aluminum. GI is more common as it is of lower cost and gives good corrosion protection at appropriate thickness. The catch is that if it is scratched, the rust starts more aggressively at that point. This requires periodic

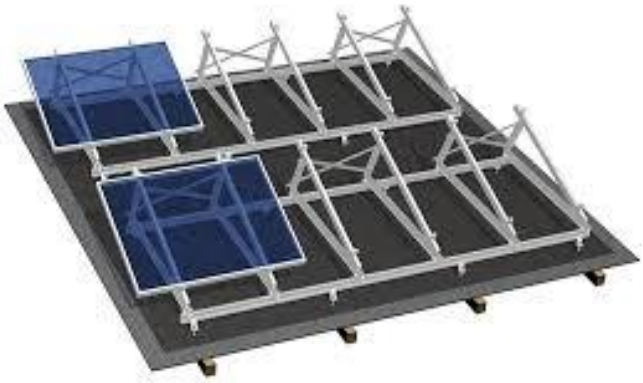
check to ensure that the zinc coat is of appropriate thickness. Some of the common mistakes that I have come across o

n the structures include:

- Use of pipes (cylindrical) for pillars. This is wrong because you will never be able to check the inside of the pipe if there is a rust there. For this reason, the recommended structures us GI angle irons.

- Another mistake is that the civil contractor drills a hole in the roof to mount the structure. This is a wrong practice as it plays with the roof integrity and potentially creates roof leaks in the rains.
- Yet another site we saw put the angles inside the concrete block while mounting. This is ostensibly for giving a strong, stable bond. Yet – it creates an issue if (when) the structure corrodes and must be replaced! The cost of disassembly – and reroofing can be prohibitively high because of a jugaad contractor.

- Depending on the site, you can also consult the adhesive specifications and explore of direct mounting of the structure on the roof with adhesive. This, of course, requires that the concrete to metal bond is strong enough to meet the site specs.



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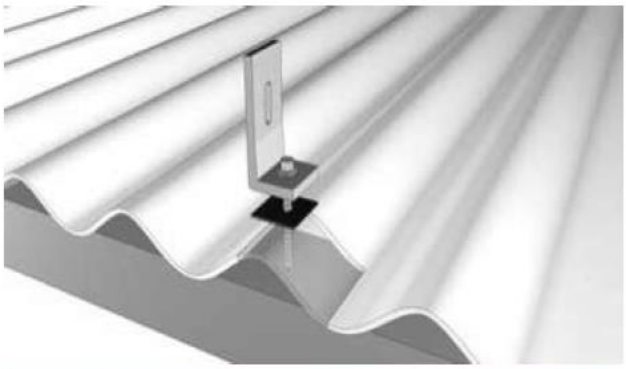
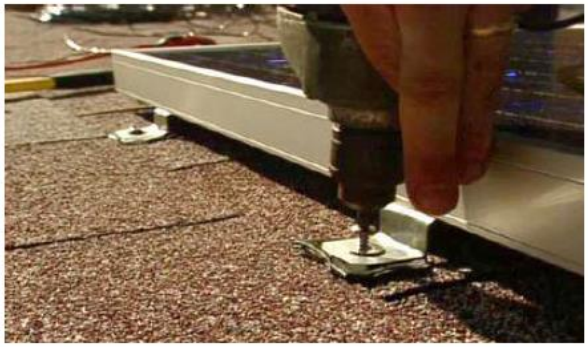
Current Method of Solar Panel Mounting:

- Currently most of the EPC contactors uses the railing system with nut bolts for mounting Solar panel on rooftop.

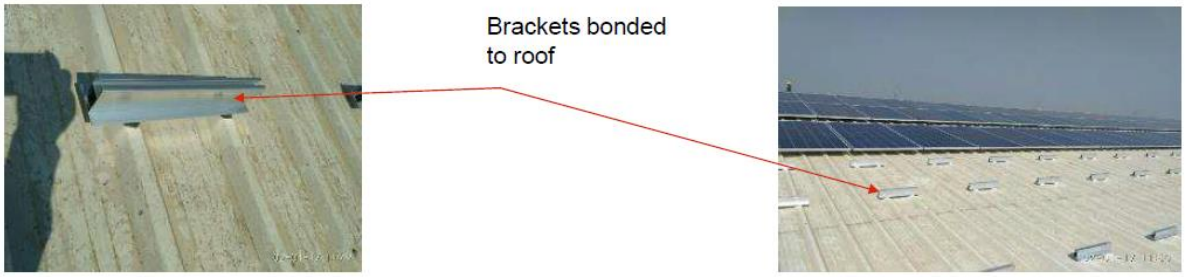




The other type of roof that one encounters in India will typically be a factory roof – an inclined metal roof. Typically, here one is mounting the structure on the metal roof and quite a few contracts do so by riveting the structure to the roof by drilling a hole in the roof! They use an epoxy to fill the hole but the moment you drill a hole in a roof structure – as shared before – you destroy the roof integrity. If the roof site is covered by another civil contractor's warranty, he will void the warranty or review it subject to the roofing work done by the PV contractor.

A more appropriate and effective way to do so is by using a metal-to-metal adhesive for bonding the metal roof with a mounting bracket. Typically, you will be using an acrylic adhesive that meets the bonding specification. The cost of adhesive bonding for a 10KW site is estimated at Rs.3500/- (as of March2020, for Lord's Acrylic adhesive) -or barely Rs.350/- per KW. Cheaper adhesives could lower it marginally, but the aim should be to get a good quality roof work not cut corners on costs!

Solar Plant of 1.3MW – Fiat Chrysler, Ranjangaon, India



Another key element to take care while working on roof – especially, inclined metal roofs is to ensure that the workers are having appropriate personal protective equipment, are properly anchored using appropriate body harness and cables – and full OSHA standard practices are followed to prevent any personnel related accidents. Read full post on the A-B-C-D-E of PV roof-top safety on my Blog www.india-inspires.com under the category solar-xl.

Unsafe, unsecured roof workers at a PV installation site

17. WYPIWIG

Finally, you will get the solar PV modules in a wide range of efficiencies and wattage (265 w thru >300 watts and rising …). A good thumb rule in solar is that 'what you pay for is what you get'…

With higher efficiency solar panels, your harvesting capability for a limited solar rooftop space is maximized. With good brands, you will have stable products and warranty. If you buy a cheap brand, the panel performance may degrade over a period (potential induced degradation effects) leading to overall losses because of incrementally poor material. Finally, a good brand ensures that the product has warranty and the service is ensured for its lifetime (~25 years)!
Abound Solar – a US based Cd-Te TF vendor – sold into the Punj Lloyd, Phalodi solar farm in 2011 timeframe. Then it went bankrupt…can you imagine the plight of the 10 MW solar developer? That was a $10mln installation!

There are cheap Chinese PV modules that keep coming into the country which are nothing more than rejects from the manufacturing lines. You need to be careful and critical of overtly aggressively priced solar panel vendors.

Finally, Brand will matter!

18. Earthing

It is critical to earth the SPV structure to safely bypass energy from an unbalanced circuit or a lightning strike. A proper earthing in a residential SPV will enable not more than 1-ohm earth resistance at the earthing point. Again, several, several crude executions are done in real life.

- Please do not dump charcoal blindly in the earthing pit. Depending on the nature of the earth you will need to use bentonite earthing mix or a finer grade graphite earthing mix.
- Use of a 1m + copper earthing rod is recommended. Cheaper rods will not give the required resistance. Again, depending on the earth (dry, moist etc.) you may have to design an appropriate earthing strategy. It is recommended that you have two earthing pits in parallel to improve your earth resistance (lower it).
- Workmanship matters. Please provide for an earthing pit cover on your earthing rod site so that you can access it subsequently for safety audits and repairs.

19. Safety

Safety is an oft neglected feature both for the installation contractor and for the user. It is relevant to note that a typical residential RT SPV can have DC voltages of several hundred if not ~1000 volts at its terminal points. And Electric energy could be stored in the circuit – say, at the battery – even if the mains is switched off. It is important that appropriate Lock-Out Tag-Out (LOTO) procedures are carried out while servicing or installing the SPV system.

Also, OSHA type rooftop safety procedures are recommended if the worker is working at a height of greater than 6 ft. Full safety procedures cover multiple inspectors to record the potential hazards, define appropriate anchors, proved for body harness, cables (connectors and carbiners), deceleration devices and emergency procedures.

For more details – please refer to my blog www.india-inspires.com.

20. Thin Film vs CSi Panels

As in SWHS, there are number of technologies trading blows in the market on the Solar PV modules. TF or Thin Film modules emerged as an option in the initial solar PV era because they operated on the premise that they would deliver a competitive cost/watt of generated energy. They did this by using alternative solar PV material like cd-Te coatings which generated a photo-voltaic effect, albeit at an efficiency lower than the costlier Crystalline Silicon (cSi) cells. cSi solar cells offer the best efficiency (reaching ~24% in labs and ~20 % in commercial sites).

However, poly-silicon – the input material for cSi cells – has fallen in prices from $75/kg in May 2011 to ~$16 in Dec 2016. It is trading at $9.50 or lower in Feb 2020 and is predicted to ship below $7 in another ~2-3 years.

In fact, the market is evolving to mono-crystalline Cells. This material innovation coupled with module designs leveraging half-cut cells and bifacial harvesting techniques are pushing the envelope on the module wattage higher every year!

The dramatic price shift forced the economics of the TF solar PV manufacturers. Many of them have been wiped out in the last 5 years. Some of them are making unusual claims – not backed in reality – to sell their products.

I would put my money on a good brand (local or global) of cSi panels any time, as of now!

MISC, INCLUDING HOW TO GET THE GOVERNMENT GRANT

21. What to look for in a Rooftop solar installer

Most vendors have tantalizing ROI in their marketing sheets. And they will offer different models including

- Wholly owned RT Solar PV installation (you pay for the full project)
- RESCO installation (Renewable services contract – you pay part upfront but mostly enter into a feed-in tariff for the energy generated and consumed by you).

Investigate both contracts carefully. The shortlisted installer should have appropriate qualifications (ESSCI certified Solar Integrator or NABCEP/PVA USA), government accreditation and prior experience.

After all, you do not wish to be the guinea pig for someone new.

22. How to get the Government Grants

I am a SWHS user –and have 400 liters of SWHS installed across my 1000 sq. yards plot. Yes, it was economical and though there were some surprises on the way – I have definitely recovered my installation

investment to date. Did I get my government grant? Yes – I did, albeit after 4 months of sending in my applications. It was delayed because of elections.

Did I have to pay anything for getting my grant cheque? NO – I am proud to say that the Haryana Renewable Energy Development Agency supervisors were very professional. Their supervisor told me clearly that he did not want any bribe – just that I complete the simple form correctly, give a date that was mutually convenient – and when he/ his staff visits us for the site inspection – we treat them with respect without asking them at the gate to go away and come on a future date!

Respect, basic courtesy and following due process and maintaining appropriate behavior are simple lessons in life that apply here as well!

What about a loan from the bank? Solar renewable is a priority sector for banks – and they should give loans and subsidized interest for the same. Unfortunately, I did not have any luck with the Punjab National Bank even though I knew the bank manager. I tried to take the loan as a pilot – but he was just not interested in supporting a single site (or frankly, even if I had half-a-dozen sites) …I was later told that the situation was a lot better in some cooperative banks…

For all the trials and tribulations – I found my solar adventure great fun and a good learning experience. I know it works , found that I could get my government grant without any stress and discovered a number of harvesting hacks – some of which I have penned here. For more practical tips, stay in touch with me on my solar blog… www.india-inspires.com category Solar-XL

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