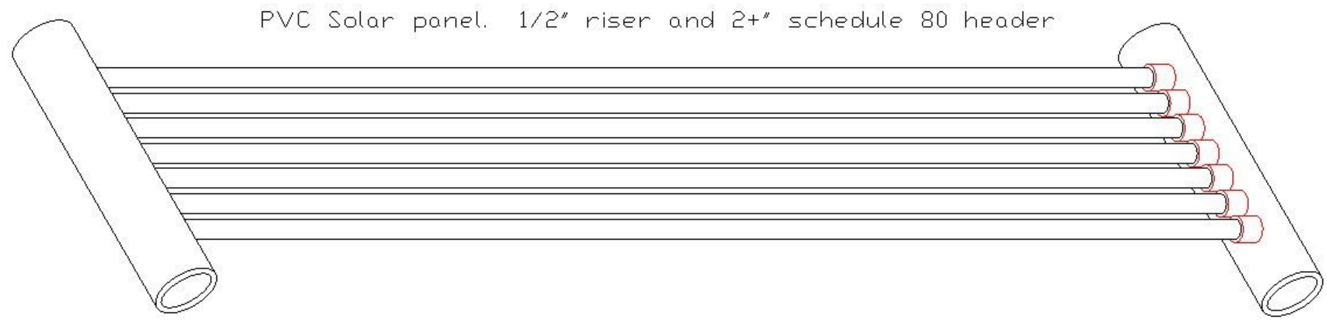
PVC Pool Heating Collector



1. **Why**

It may seem strange to some why you would build a pvc pool collector as it probably ends up being very close in money and maybe even more money then a “traditional” pool heating collector. By traditional I mean the flat plastic material mat(search fafco pool heater). Some are made of edpm and are a bit more money and some are made of polypropylene. Some homemade cheaper ones are made out or irrigation tubing.

Well to the reason. I found myself in part of the world that likes to tax foreign products. So something like a $150 pool collector could turn out to be $500 dollars. In this case you can build the pvc collector for less than the $500 and probably pretty close to the $150 for an equal sized collector. In the USA you probably can find used pool collectors very cheap if you look around and more so if you are in the southern USA (where there are many more pools).

My initial design and implementation came from lack of product locally and the lead time of 30+ days. The following pvc collector does take a bit of time but really can be made fairly easily if you take your time. I am going to go into some design considerations, then go to the actual build. Unfortunately I did not take any photos of my initial implementation but I did do some drawings. In the future I plan to make another system and as I do it I will take pictures along the way and update this document. This following system I will also do extensive data logging which be included in an updated version of this document.

2. **Design Considerations**

Here are a few things to think about.

a. **Head loss**

It may look very easy to make a big coil of irrigation hose and just pass water thru it. **IT IS**. But it is not very efficient. When you have very long lengths of tubing the amount of friction the water has to overcome to get to the other side is great. This results in very low flow rate, and/or excessive pumping power needed to make things flow. One of my first solar collectors was a big coil. Fortunately I did use large tubing diameter but it still cut down greatly on flow. The larger the tubing the less effect friction has. Some might say well just make the tubing very large. That is possible but really not the best use of resources. First large diameter tubing/pipe costs much more than small stuff. Secondly plastics are commonly made from oil. More plastic=more oil. So to remedy this design flaw of high friction larger pipes is not the best solution. It maybe a solution if you get the material for free or have extra but for everyone else there is a better way. Any easy solution is something called parallel flow. Say you were thinking of 1000 ft of 1” irrigation tubing. If it is one long loop it is called series flow as all the water flows in series. Now if you split that tubing into say 10 equal lengths (ie 100ft each) you can make 10 smaller coils 100ft each. The water flows through a large pipe and can go into any of the 10 loops. The water splits up (with good design) equally along the 10 loops/lengths. This is called parallel flow as

the water can flow parallel to itself through other channels. Say in the original 1000ft coil you wanted 5 gallons per minute to flow through. It is very easily to calculate the head loss(frictional loss). But it is very easy to imagine as well. The 5 gallons have to all flow in basically a line until they come out the other side. When there are 10 100ft sections the water splits 10 ways. Each 100ft section now only has to have 5gpm/10 = .5gpm flowing through it. Thus the frictional loss(head loss) is greatly reduced as the water meanders through the pipe, instead of racing through it as was when it was all one long piece. Also something to consider is the longer the pipe is the more friction that happens so as well as the water traveling slower in the parallel setup, it actually touches less pipe as well. When water molecule A travels series loop(1000ft) it travels the whole loop. So the whole 1000ft it is in friction with the pipe. In parallel flow molecule A only travels through 1 section of 100ft.
I will try to explain using an example of car. While no exactly the case, it is fairly accurate.

Series flow is like driving from NYC to LA in a 1 lane road. Ie no passing everyone is in a line and is horrible driving and takes for ever.

Parallel flow cut into 10 equal parts is now like driving on one of 10 – single lane roads with the same amount of cars that were on the single lane road. Things should speed up a lot. On top of this instead of driving 3000 miles from NYC to LA it now is only a trip of 300 miles. I do not know about you but for me driving a 300 mile trip seems much better than taking all those cars and putting them on a single 1 lane road and driving 10 times as long.

So following the analogy this will allow a much great flow rate for the water in the panel for a given pump. But if flow rate was keep the same for entire panel it would mean that the water per channel would be moving at a slower rate. Higher flow rates always collect more solar energy than slower flow rates but there is a point where the pumping at higher rates increases electricity consumed but does not significantly increase solar energy collection. On each system the balance between energy collected and energy spent is different but pool collectors are usually recommended to have .1gpm of flow per sqft of collector. So a 10sqft collector would have optimum solar collection around 1gpm. A 100 sqft collector would have a flow recommendation of 10gpm. And say a 400sqft collector would have a recommendation of 40gpm. It may sound like a lot of flow but pools are almost always flowing large volumes of water. But it should be noted a 1.5" pvc pipe header causes much greater flow restriction to 40 gpm than does 2 or 2.5" pvc piping.

Water always takes the pass of least resistance. The only benefit of series flow is that you can make sure the water flows evenly over the entire area. Once you start breaking things into pieces if not done properly more water may flow over certain pipes and very little in others thus possibly reducing efficiency. Related back to cars it would be like having 10 single lane roads but in varying length from 350miles to 250 miles. More cars would be on the 250 mile road. The idea with parallel with water is you want everything spaced out evenly.

Something to take away is the parallel flow greatly reduces head loss. It just needs a little more attention to detail. If the detail is followed great results can be had. It is the more efficient design of a system.

b. Even Flow

To make sure the water splits up equally you must make the flow resistance along the 10 loops very similar. This is done by various means. First the main distribution (header) should be much larger in diameter than any individual loop. This would be like an 8 lane highway splitting into 10 single lane roads. All heading for the same place. Traffic would split equally. If the 8 lane highway was only 2

lanes it would be harder to make the traffic spread over to 10 single lane roads.
2nd is making sure each of the 10 loops has a similar resistance. For this to happen you must take into account any fittings that maybe in such a loop. This would be like if one of your roads had construction going on. Less flow would happen. The whole loop, fitting etc gives you an idea of what has to be done to equal flow conditions between the 10 loops. In practice it can be simple if you can pay attention to a little detail.

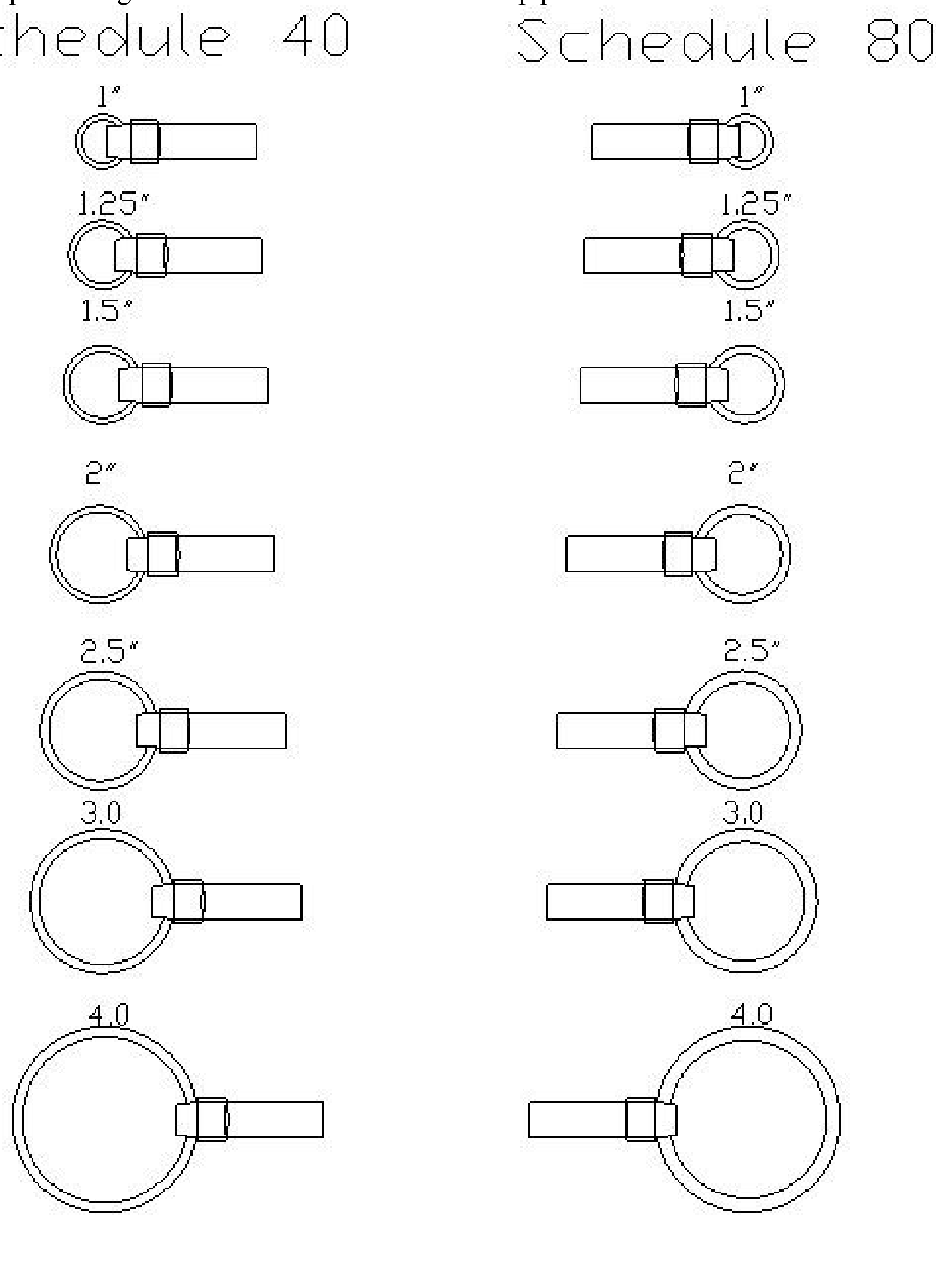
These 2 things (flow resistance and even flow) are things I think are very important to think about. You may ask your self what about coil type pool heaters just piped in parallel. This can be done and is done, but as can be seen by the photos there is more wasted space between the parallel loops and also in the center of the coils. The pvc collector does have minimal spacing between the piping but still usually utilizes space much better. More roofs are rectangular rather than rounded. During direct sunlight the sun will strike between the pvc pipes as well as hit the pvc. Once the sun starts hitting the panel at an angle instead of straight on the sun will actually hit the sides of the pvc pipes and very little will get past the pvc, but this does depending on spacing and design of the panel you decide to build.

Also one last note to think about. I have built this type of collector in a warmer climate that does not have freezing weather. PVC becomes brittle in cold weather. I am not sure what affect this will have but treatment/handling of pvc in cold weather should be more gentle/delicate. Also pvc degrades when exposed to sunlight. The whole idea of a solar collector is to receive sunlight. The pvc is painted black(optimally), or another dark color, this should provide protection to the pvc below it. How much I do not know. I do know solar pool collectors are normal plumbed with pvc and do fine for many years. Painting them should just extend this.

Now if you look at commercial pool collectors(mat style). There is a large header usually 1.5-2" and the riser(loops/pathway) are very tiny. Something like .25". Water goes rushing into the large header now a little bit goes through each tube and join back up on the other side. These little tubes use much less material, and thus is more efficient with material.

Now the pvc pool collector tries to copy the design of the traditional pool collector but with some limitations. Finding rigid pvc smaller than .5" is difficult. So instead of a .25" riser we have a .5" riser. It may seem like it is only twice as big but in reality roughly 4 times the amount of water can travel through a .5" tube vs a .25" tube. It is based on the cross sectional area of the tubing/piping not the diameter. I like to make my header bigger than 1.5-2" for this reason along with some others. I feel 2.5"-3" pvc header is really a good size, although smaller header can be used it is more difficult.

The reason it is more difficult to use smaller headers is the shape of the larger piping(header). I drew an example to show you the differences (following image). But basically you need an area for the riser to meet the header pipe. If the header pipe is larger, this ½ inch pvc riser where it meet the header will be flatter. If the header is smaller the area is more curved. It can still be done to within reason but little more attention needs to be made. It can also be seen that as header gets larger the 1/2" pvc fitting obviously start protruding less into the center of the header pipe.

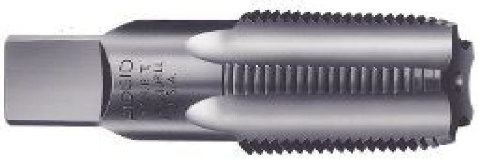


Now here is a small list of things you should need.

PVC Header - I recommend Schedule 80. It is a strong pipe that should hold up longer to the elements, as it is thicker walled. This thicker wall should help in cold weather. Also when we attach the riser to the header this extra thickness is actually a good benefit. For most designs the piping for the header is minimal and so the extra cost of schedule 80 is not a big deal.

PVC Risers- These should be 1/2" pvc. Depending on collector design you will need varying quantities. Try to find thin wall pvc for this. The plastic pipe itself is an insulator. The thinner the walls the more effective the water can be at receiving this solar energy.
Something to cut the pvc. Hack saw, pvc cutters etc.
Magic Marker to mark pvc drill spots

Drill with drill bit to drill pilot holes (45/64" or 23/32") You could possibly get away with a bit smaller as well like 11/16" We are using this on a plastic pipe so it should not a big deal. Though you will not want a bit bigger than 23/32"



½ NPT TAP- This will allow you to make threaded holes out of the pilot holes in the header pipe. Just a note about the picture the tap will look the same it is just different size. Picture is of 1" tap if you can read the lettering.

½ male npt(national Pipe Thread) pvc fittings - To connect to manifold, again based on design different quantities would be needed.

½ pvc couplings – These may or may not be needed depends on the design.

PVC -Glue, and Primer - Primer is optional buy highly recommend

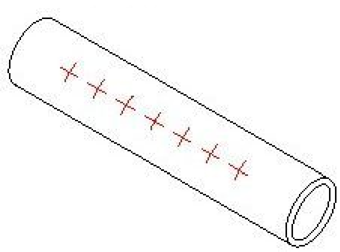
Teflon tape or just more PVC glue. Reason to be given to description of construction.

Some spray paint preferably black, but other dark colors will work to a lesser extent.

That is it. Really not much. Depending on size of the collector I would probably check with a plumbing supply house for some of the material as there is a lot of the riser material.

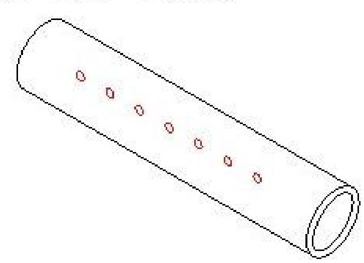
Actual construction

Below is the actual construction. It should give you the idea of how this collector is made. Once you understand the design, you can make your own collector for your individual situation. Before actual construction think about how you will implement the design and make a material list. Take a little extra time to think about quantities of materials. You still may run short on material but hopefully you will have enough.

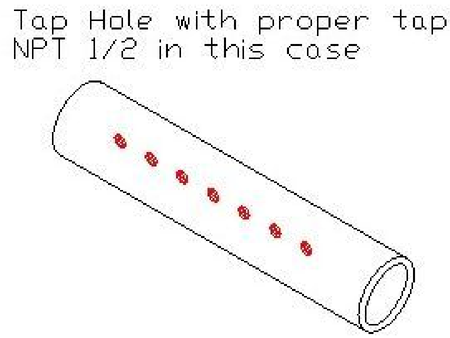


Anyway, actual construction. Cut your 2 large header pipes to desired length. Most pvc I have seen is marked(written on) you will want to use the markings on the pvc to keep a straight orientation. What you want to do is mark the header pipes with a small x. This is where the riser pipe will join the header. If you have a simple collector you may want to make that small x every 1.5" on center down the length of the pipe. You can vary the spacing but I think 1.25" is about the closest you can space the holes. Spacing will be dictated by the 1/2" male fittings. You may want to figure at minimum spacing before moving on to the next step. Maybe try this process out on a 1' piece of pipe to practice and make sure everything fits etc.

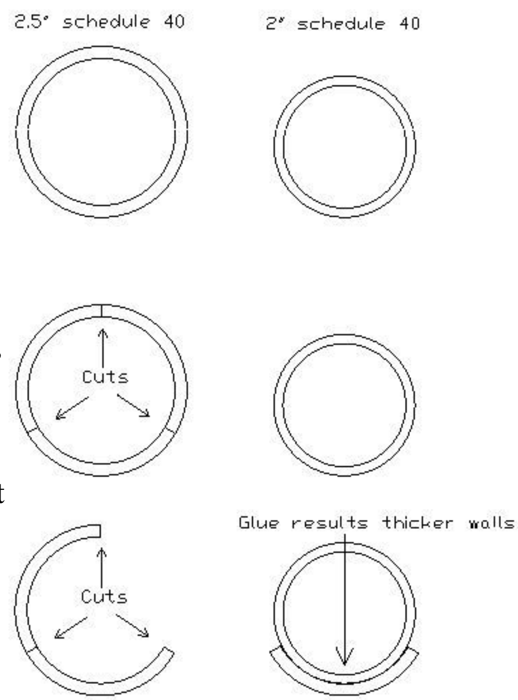
Next you will drill the center of the x with a drill bit. For a ½ npt threading you will need to use a drill bit of size between 11/16"- and 23/32". Because this is a plastic pipe it is a bit more forgiving than working on metal piping. You do not want a drill bit larger than 23/32"



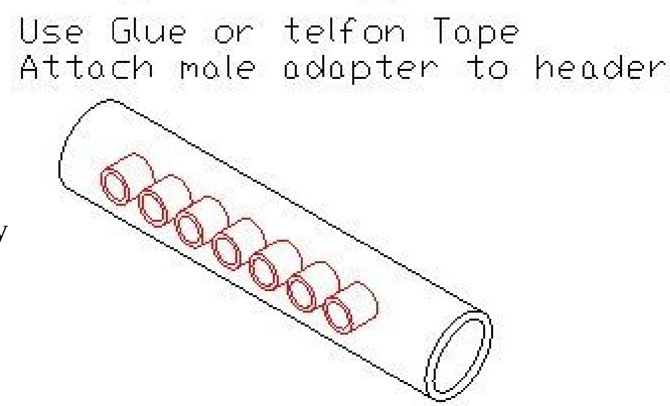
Once all the holes are drilled, now it is time to take out the tap. Basically you place the tap in the newly drilled hole. Now carefully turn the tap while pressing into the pipe. This will start to make a thread on the new hole. This is where having schedule 80 header tube is beneficial. Because the wall of the pvc is thicker it will leave more threads once done with the tap. This will ultimately leave you with a stronger product. Make sure the tap enter the hole straight and not on an angle. This can take a little practice. What I did was take a 1' section of header pipe and practice a bit until 1 got a feel for it.



Also when turning the tap it is usually recommend to not run the tap all the way through the hole but stop when the tap in ½ to 2/3 through. This is important as the tap is tapered. It is easy to visually the taper while looking at the tap. Basically what happens is as you continue tapping the whole gets bigger and bigger. If you go too far its not a big deal, just maybe need more glue or teflon tape. The panel should experience very little pressure on the fittings so not a big deal. Also another note is most manufactures of schedule 40 pipe do not recommend taping it due to the thinner wall resulting in fewer threads/less strength. I believe it is possible to use the schedule 40 **IF** you use larger diameter pipes like 2.5" or 3" The larger diameter pipes have thicker walls then small diameter. I personally would use schedule 80 if you can find it. But if you can not, 3" schedule 40 **SHOULD** work okay. If someone out there knows it does not work, let me know.

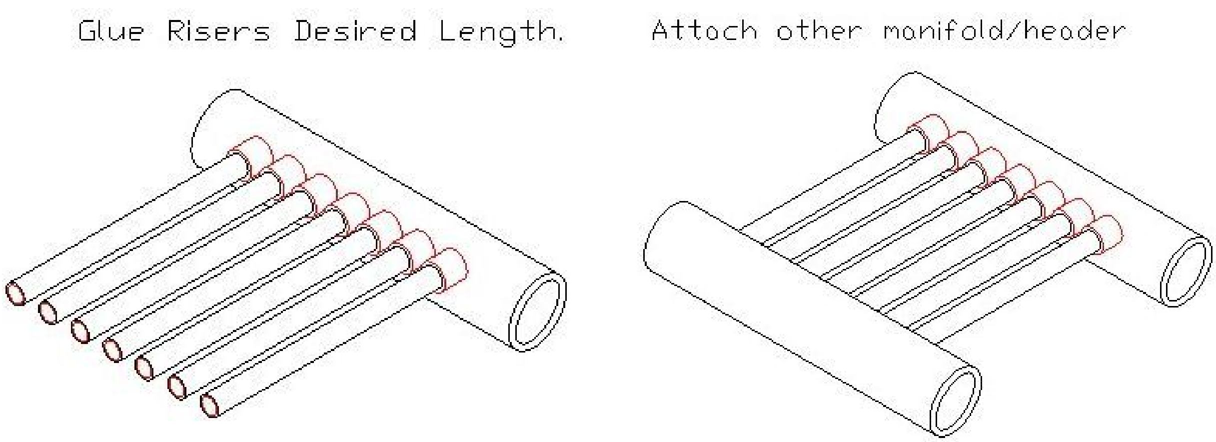


Also another trick that you may want to consider if you can not find a schedule 80 pipe is to make the schedule 40 pipe thicker. This will not work will all pvc dimensions but should work with some. You could take say 2.5" schedule 40 pipe and cut it length wise, and cut it into 3rds. Now you should be able to take one of those 3rds and glue it to a 2" pipe. I use 2 and 2.5 inches as the size is almost perfect, but using a 1.5" and 2" pipe should work as well. The point here is to make a section of pipe a good bit thicker. You will actually end up with a wall thickness a bit greater than schedule 80 if you did it this way. Obviously just buying the sch 80 first would be easier, but maybe you do not have access to it. You could glue the other 2 pieces around the header if desired, and it could possible protect the header by keeping the sun off it. I do not think it is necessary and would use more material.



Once your header has all the holes now with threads it is time to attach the pvc male fitting. Here is where you have choice of pvc glue or teflon tape. If you use glue, apply glue to the thread hole as well as the fitting. While primer is not absolutely necessary it can help. Work quickly and screw the fitting into the header. The glue dries fairly quickly, no playing around. The other possibility is to use teflon tape on the male fitting an then fit it to the header, Either way works, I particularly like the glue myself. When I first tested the panel there were 2 or 3 very small leaks where the fitting joins the header pipe. Turn off the system, drain line a bit and apply just a little bit of glue did the trick. This worked in my particular situation and should in most as the panel in most instances would have very little pressure. The only time the panel would be under higher pressure is if it was located much lower then the level of water in the pool. As height changes for ever 2.3ft there is a change in psi by 1. So if the panel is 23ft lower then the surface of the pool it would have an additional 23/2.3= 10psi This is a rare occurrence as pool panels are usually placed on roofs which usually get better lighting. When I installed my panel I also installed a pressure gauge in the system. And I found out on my system is that the psi increase because of the panel was very minimal. It was about 2psi.

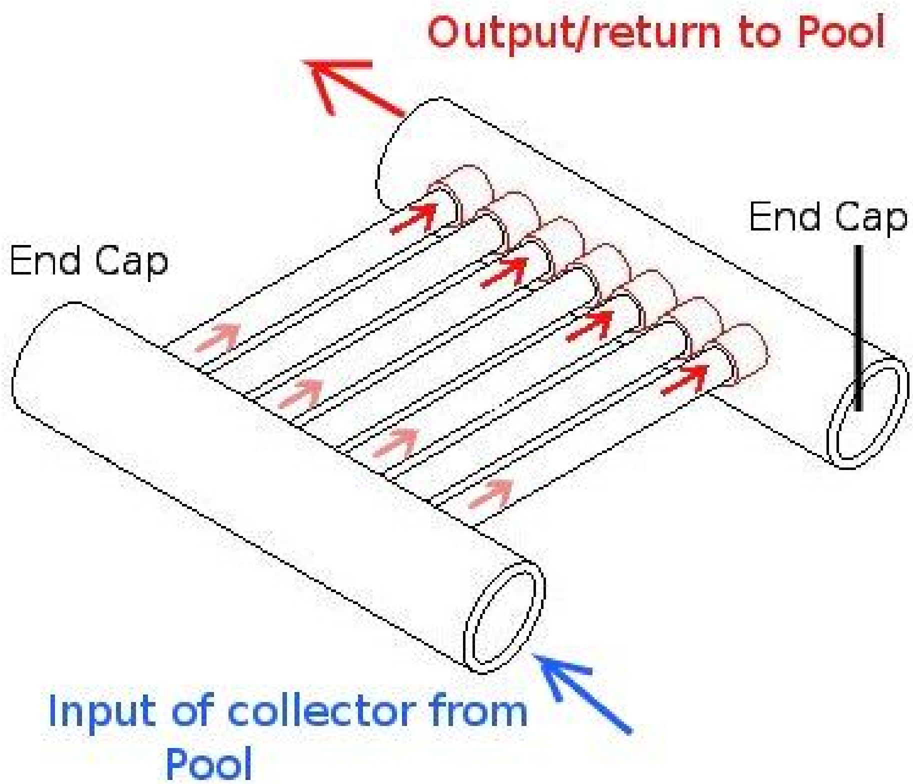
Well now you should have 2 header pipes each with male fittings attached down the length of the pipe. Now you just glue your 1/2” pvc pipes into each header. First I would recommend bring material to where it is going to be installed. It is still in small enough pieces that one person can do the job. Once risers are glued to header movement is much more challenging. Depending on the panel design you may need more than one length of piping. Here you may need to use a coupling to extend the 1/2” pvc. Some pvc manufactures include a bell end to one end of the tubing. If you plan carefully you can use that bell fitting and save the need to purchase the couplings. Also if you are skilled you can always make your own bell ends. It really depends on the budget as couplings are cheap. I will not go into detail about forming pvc as there is enough on the Internet. It is worth investigating though not so much for saving money but to give you the flexibility to be Macguyver if needed and fix something else. If you do not know who Macguyver is and you are a DIY person go find out NOW. :)



The next 2 steps (Pressure testing and painting.) are interchangeable and depending on particular situation you may want to preform one first rather than the other.
For pressure testing I really just hooked system up. When I ran it I saw there were a few water leaks. It had already been painted. So I had to take a little primer and clean off paint in areas of the leaks. Then apply a little glue. Let dry a bit and turn water on again. No leaks were detected and touched up with paint areas that were cleaned. If you are building smaller panels(portable) off site you may want to pressure test first. One thing to keep in mind with panel sizing is if you can increase the riser lengths the panel become cheaper per sqft. If the riser is 5' or 100' the header is the same construction. The only increase in cost is the riser. Another note for painting is you just want enough paint to cover the pvc.

The thicker the paint the harder it is for the heat to make it to the water. So just enough to turn collector black. If you are mounting the panel were appearances matter you may want to paint it a dark green, brown, blue etc to match a certain area. It will perform well , with a slight penalty that may make it worth painting it another color. You would not want to paint it yellow, orange etc. as those colors would make a big performance hit. If you still need to paint it a light color you would want to make the panel bigger to make up for lost performance. But it would be highly recommended a darker color and preferably black was used. One another note is you may want to very quickly talk some sand paper maybe grit 120 and apply to pvc. Not sure if it is needed but should help spray pain stick better. It maybe a think you want to test on a scrap piece of pipe first.

Once collector is done it should be feed from one corner and water should leave the opposite corner to provide even flow over the collector. Hopefully from reading this you can fully understand the idea. If you have issues I would recommend going to the yahoo group “solar heat” They can be helpful there. I check there almost every day. Some discussion is academic but there are many great opportunities to learn some practical solar stuff there. There are also other good yahoo groups that deal with solar “Simply Solar” being another one, just there is a lot of posts there and sometimes good questions can get lost in all the commotion.



Sizing solar collector for a pool.
Most would recommend at least 75% of the surface area of the pool be the amount of square feet of solar collectors.

So if you had a 12x25 foot pool that is 300 sqft. You would want at least 225 sqft of solar pool heater. If your pool is mostly in the shade increasing solar collector area to at least 100% of the area would probably be prudent. There are other guides out there, just something to think about. Increasing area further would provide more benefit, obviously larger is better .

The last note. If you are thinking about a solar pool collector make sure to get a pool cover. Pool covers can save significant amount of heat. Most heat in a pool is lost by evaporation. A cover will cut this down a lot.   This will also save chemicals and keep pool cleaner as well. The cover can be something really simple that stops water evaporation.