Solar Powered Water Systems for Grazing Operations

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Title slide

Reasons for selecting the solar option

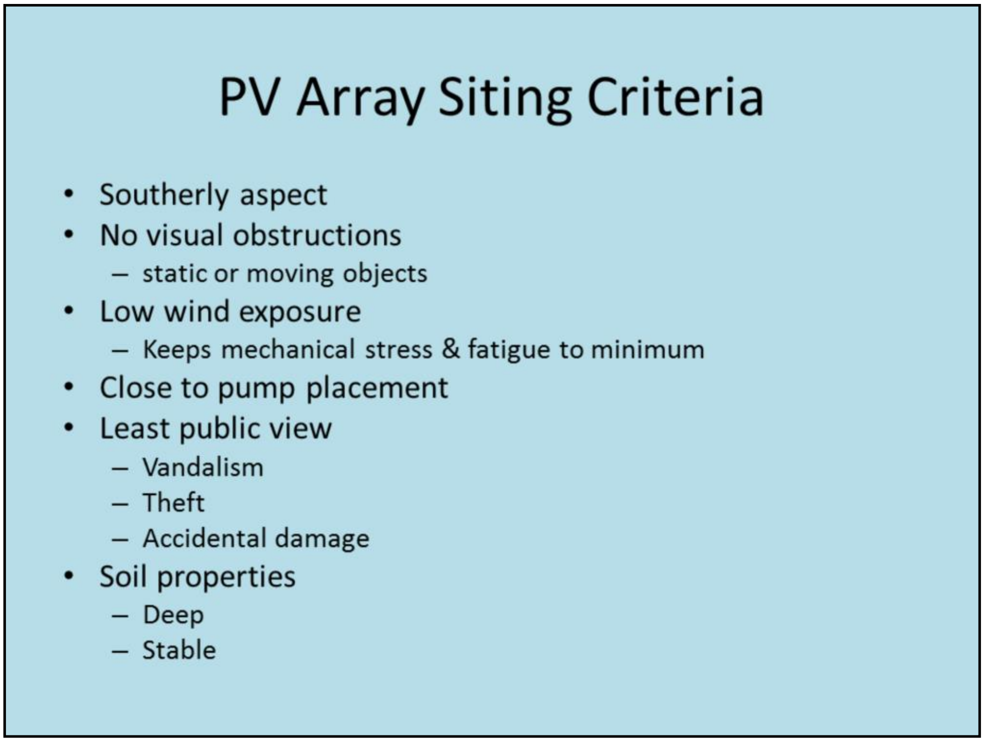
- Commercial grid not viable
  - Too far away for pump site
  - Obstruction in between SEP/SP & motor hookup
- Desire to lessen fossil fuel consumption
- Religious tenets
  - Amish

Solar powered facilities, including water pumping for livestock on pasture, are very popular. There are a variety of reasons which may compel a farmer to explore & pursue photovoltaic powered water pumping. Economics are most commonly the driving issue, but not always. Cost break point was a to ½ mile from grid back in 2004 for NY state. Depending on what the prevailing electric rate ($/kWh) of the local utility, the capital expense of conventional pumping (grid powered AC) or gravity feed option, and the cost of the solar powered alternative, a cost analysis can reveal the economics of the options available.

Key Concepts

- Solar option is normally very costly relative to more traditional means of providing water to livestock.
- Only a relative brief period each day is available to generate electricity. Make the most of that opportunity.
- Where possible, reduce reliance on solar & meet needs through less costly options.
- Solar relies heavily on technology. Murphy visitations can be more likely and have greater consequence. Have a contingency plan for those occasions.
- The type of grazing management practiced can greatly impact the design, component capacity required, and project costs.

Self explanatory.

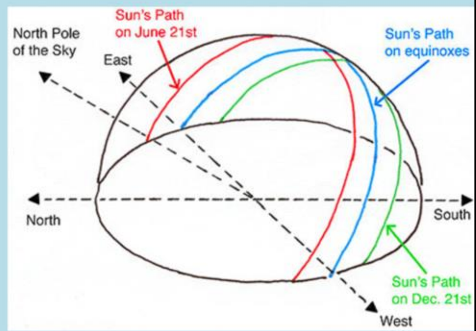


In the northern hemisphere, clear unobstructed southern exposure is essential, especially during peak sunlight period which is about 9AM to 3PM. Not only objects like buildings and trees but even poles, wires, or anything that casts a shadow onto the PV array will proportionately reduce it's output. Wind, in particular gusts, can have a long term detrimental impact on the PV array, especially the mount & trackers. Ensuring the pump is positioned in close proximity to the PV array will keep voltage drop minimal and the need to compensate with larger gauge conductors. Unfortunately, due to the required exposure and prominance of PV arrays, they become easy targets for foul play. Finally, the PV array mounts mandate solid foundation to keep proper orientation to the sun. Soil characteristics, like depth to bedrock or other restrictive layer, can make this problematic.

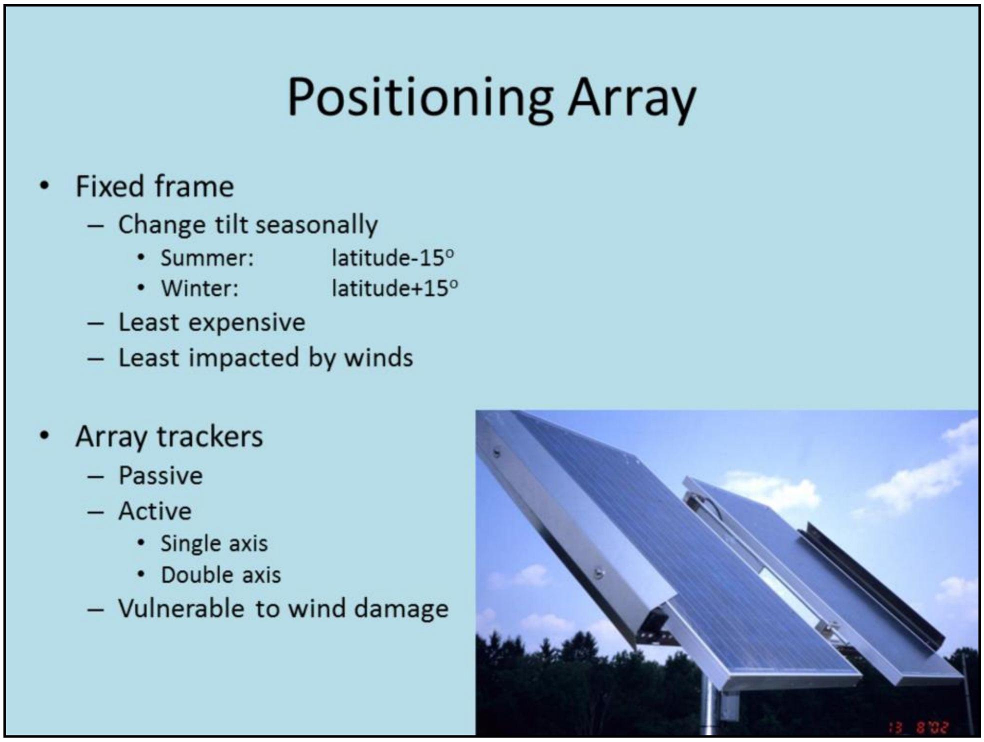
Positioning Array

Guiding principle – position surface of array perpendicular to sun as much as possible and/or practical

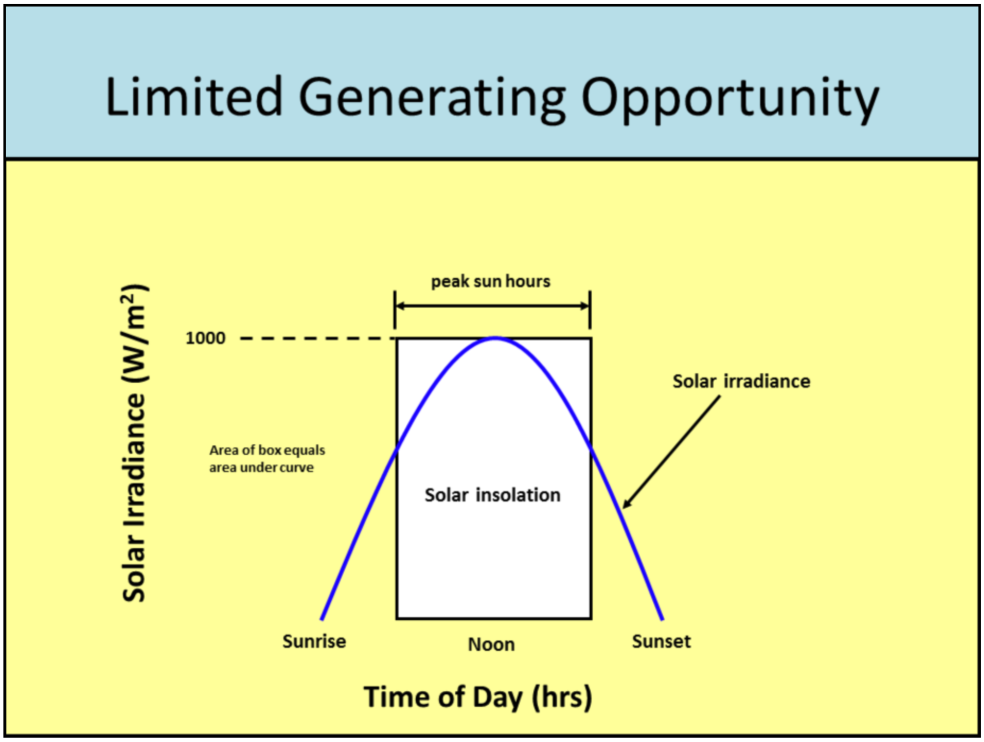
- Elevation (tilt, altitude)
- Azimuth
  (compass heading)



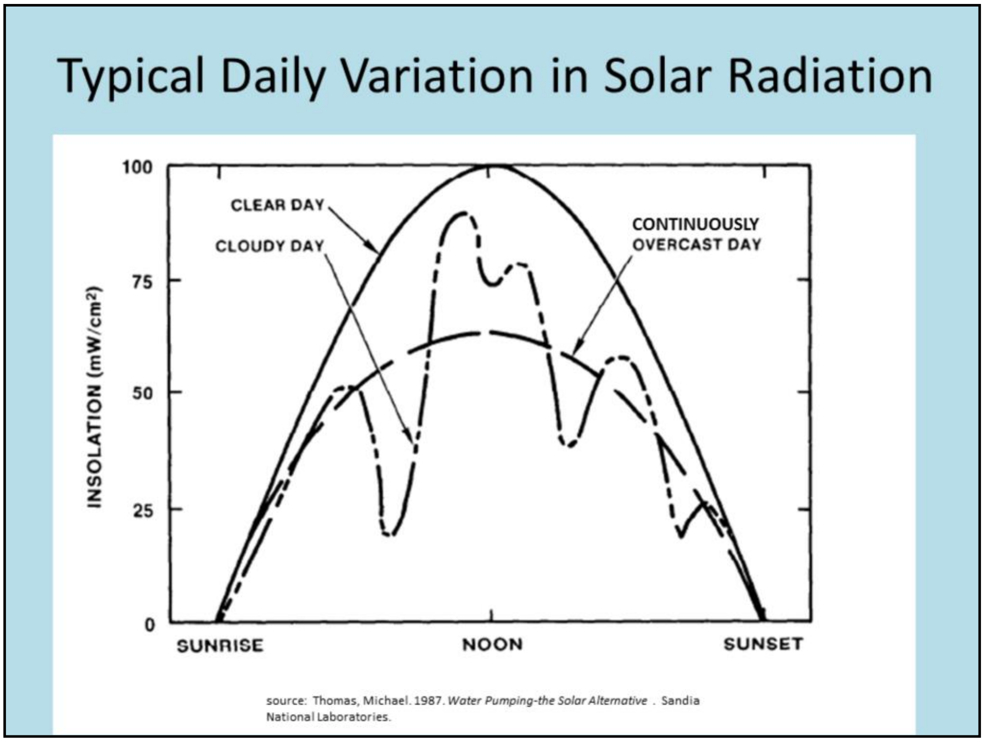
Self explanatory.



Including trackers onto PV array can boost efficiency over fixed position by 40-45%. Significant increased maintenance is required for continued proper functioning and benefits. Also, as prices of PV modules decrease in cost relative to trackers, it may be more economical to simply add additional module wattage than to include trackers.



Solar radiation is light power at the earth's surface and measured in units of kilowatts per square meter (kW/m^2). Solar irradiance is light power intercepted by an object of a particular area and also expressed as kilowatt per square meter (kW/m^2). Solar insolation is the amount of solar irradiance over a given period of time. Normally it is quantified as Peak Sun Hours which equates to hours at an even solar irradiance of 1 kW/m^2. Thus it represents solar energy for that period of time. The average for the most of NY State is only a scant 2.5 hours in the winter, a short 5.5 hours in the summer, 4 hours average for the year.



At any given location, the amount of solar energy reaching the ground or a PV array on a sunny day varies uniformly in a predictable diurnal pattern. Under these conditions, maximum solar radiation is received. However, when continuous and uniform cloud cover, what would be considered overcast, filters out the full sunshine, significantly reduced radiation is received in a pattern mimicking clear days, but reduced output. On days when intermittent and scatted clouds exist, sunshine at ground level is highly variable in intensity and duration

System Approaches

Recognize key limitations of solar pumping

- Electric power only generated for small part each day at best
- At minimum, many hours separate each generating period due to diurnal nature of sunlight
- Cloud cover can further diminish daily accumulated energy reaching PV array

Basic precept is the pump can only be powered for a small portion of each day yet livestock require water constantly. Unless other means are relied upon to meet watering needs beyond peak generating hours, some form of storage is necessary.

System Approaches

Storage bridges gap between demand and service

Battery option

- Possibly reduce size of PV array & pump capacity
- Higher maintenance
- Possible safety issues (hazardous fluids, explosive gases) depending on battery type selected
- Charge controller/regulator required
- Low voltage disconnect required
- Expensive

Battery is an electric storage device which has inefficiencies and losses, even in the best system. So this is generally not the prefered approach unless gravity storage is not an option and continuous service (24 hours/day) is essential.

System Approaches

Gravity feed storage tank option

- Requires tank positioned at higher elevation relative to watering locations
- Likely need more pipe to supply storage & distribute to animals
- Possible algae growth if storage tank is not shaded
- Generally lower cost if terrain permits; sometimes mount constructed for elevated placement

Cheapest approach if viable. Water is the product which ultimately is being provided (livestock don't consume electricity to quench their thirst). Tanks could be metal, plastic, or concrete. Usually desirable to embed at least part of the storage tank in the ground and position it where it is out of sunlight.

Duration of Service

- Growing Season only
- Extended Either/Both Ends of Growing Season
- Full Year Round

Activating Pump

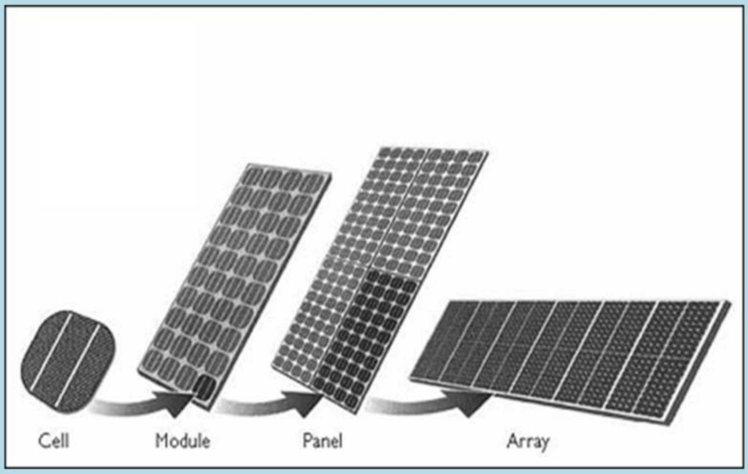
Methods to turn pump on & off as draw dictates

- Pressure switch & pressure tank

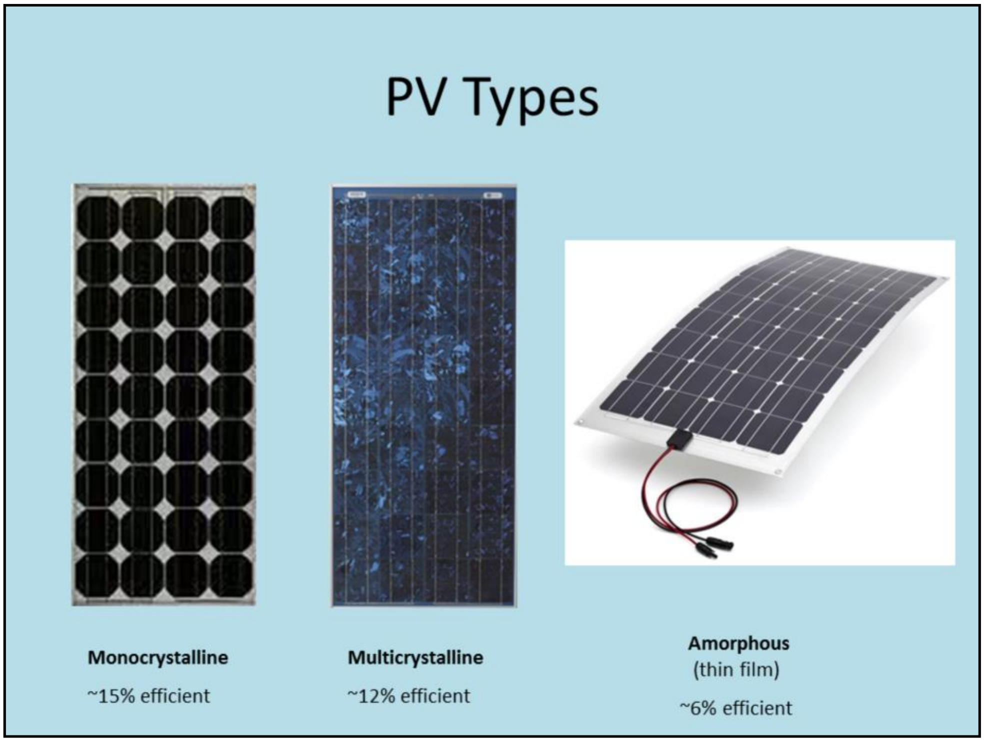
- Float switch
  (water storage tank only)

Unless the water supply has high sustained yield and excess water can be safely outleted, normally desire a means to activate pump when demand for water occurs. Conventional plumbing systems utilize a combination of pressure switches and pressure tanks to turn pump on and off as needed. However, if no other storage is included, pumping interval is will be short and may not adequately support livestock during night or very cloudy periods.

Industry Terms



The single photovoltaic cell is the fundamental building block. Almost always cells are packaged as a group and permanently secured onto a flat rectangular surface, usually rigid. This is called a module and can be purchased individually. A cluster of modules in turn comprise a panel. Finally, the completed assembly of multiple panels is called an array. For very low power needs, only one module or one panel might be required.



Three basic types of PV modules are available on the market. Monocrystaline are the most efficient in power conversion, but require extreme purity of material & ultra-clean processing to manufacture and thus highest cost.

Multicrystaline are almost as efficient, do not require as pure material, and so cost a little less.

Most pumping systems rely on either of these first two types.

Amorphous, also known as thin film, has dramatically lower efficiency. However, the cells allow for moderate flexibility so are used in portable applications. The other two types require rigid durable frames.

Industry Terms

- **Pump Controller** (a.k.a., Linear Current Booster or LCB) – interface between PV array and pump. Matches pump demand with appropriate voltage & current to maximize efficient operation.

Self explanatory.

Industry Terms

- **Disconnect Box** – weather protected switch to permit or stop output of PV array to wired components (controller, pump, etc.).
- **Surge Arrestor** – reduces damage of lightning strike by shunting impulse safely to alternative path to ground.

Self explanatory.

Motors

Alternating Current (AC)

- a.k.a. Induction motors
- High startup power
- Requires stable voltage
- Low efficiency
- Inverter needed when DC supplied
- New 3-phase versions coupled with variable frequency controller

While ubiquitous in grid powered applications, normally not selected for PV powered situations unless extenuating circumstances. These motors draw a significantly greater current when first turned on than when operating speed is reached. Generally AC motors can only function at a single RPM without damage. Another piece of electronic equipment, an inverter, is required if initial power is direct current. As electric power is converted from DC to AC, there inevitably is a loss as heat.

Motors

Direct Current (DC)

- Low startup power
- Operates under changing voltages to produce variable speed shaft rotation
- Far higher efficiency
- Brush & brushless styles
- Most widely used in PV systems

Pump Environment

Surface

- Easy access for installation, maintenance, & repair
- Vulnerable to freeze damage unless protected
- Requires shelter from livestock, wildlife, weather.
- Suction limited to about 22 feet maximum

Submersible

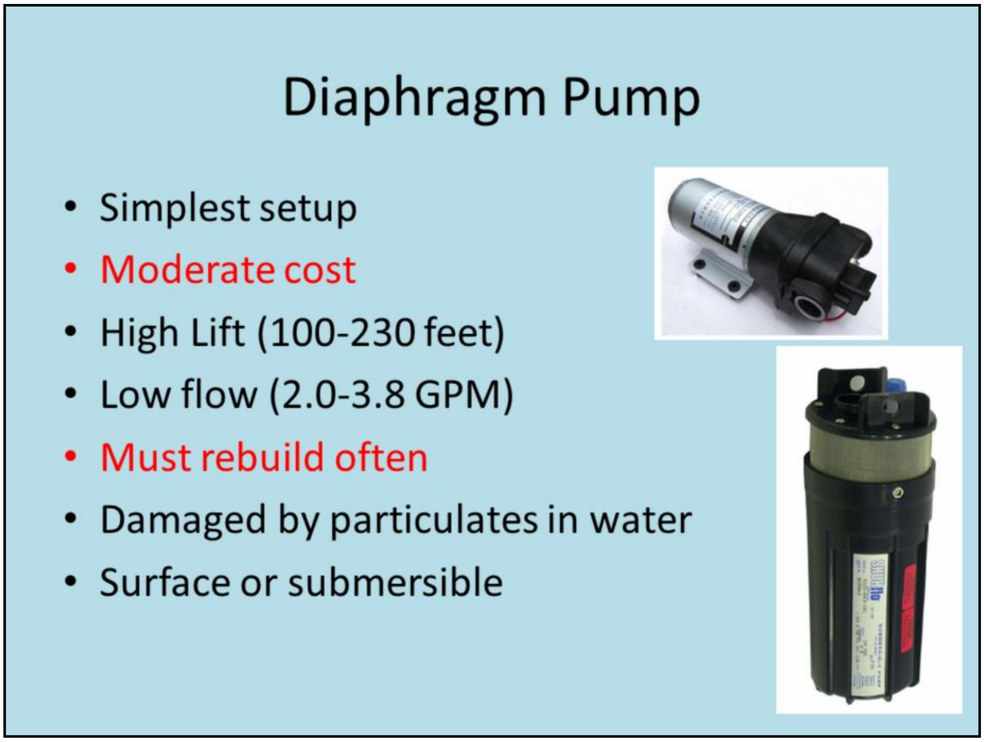
- More involved access for installation, maintenance, & repair
- Generally protected from freezing
- Due to construction & placement isolated from livestock, wildlife, weather.
- Suction not an issue; immersed in water column

Pumps differ in what kind of environment they are intended for. This influences the installation and protection they require, and how suitable they may be for winter service. Finally, since surface pumps must establish a partial vacuum on the intake port to draw water into the pump housing, there is a practical limit how much lower the water supply can be.

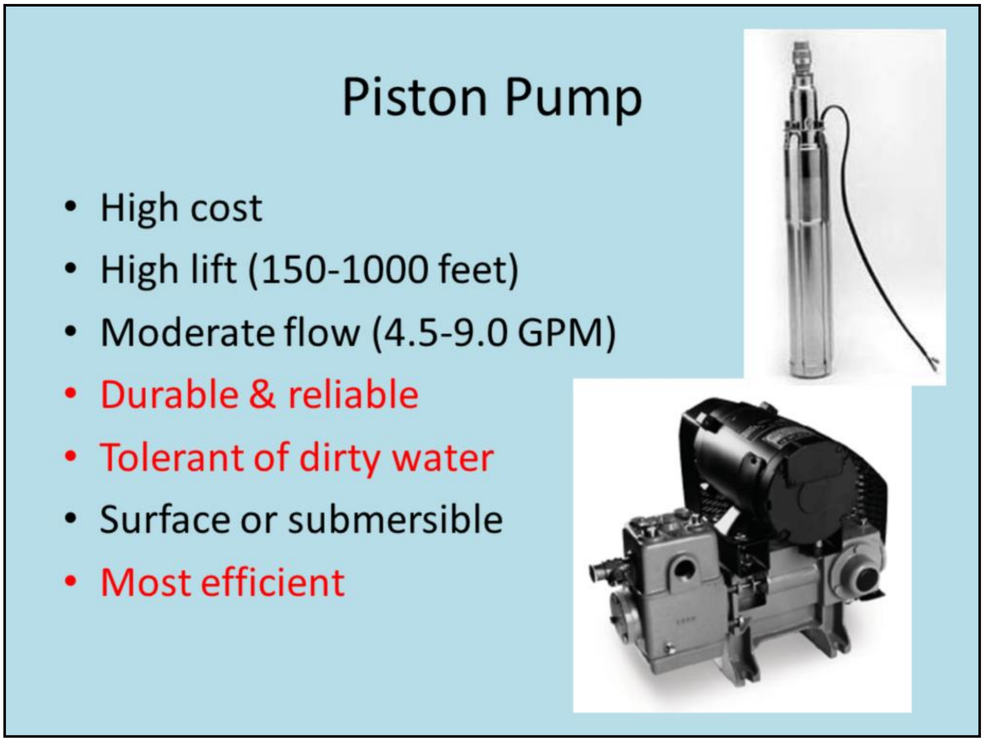
Pump Classification & Types

- Positive Displacement
  - Diaphragm
  - Piston
  - Vane
  - Helical rotor
  - Jack
- Centrifugal
  - Single stage
  - Multiple stage

Generally speaking, positive displacement pumps can achieve a relatively high THD output, but flow is low to moderate range. Centrifugal pumps are inherently suited to high flow, but only at low to moderate THD.



Relatively cheap initial cost. But with a constantly moving critical part (diaphragm), it must be changed often as it fatigues and fails. High maintenance is the downside to these units plus the paltry flow capacity.



These are tried and true pumps. They last through many years of service with few problems. Perhaps the biggest advantage is their efficiency of moving water. There is no better unit on the market to pump water with less energy.

Vane Pump

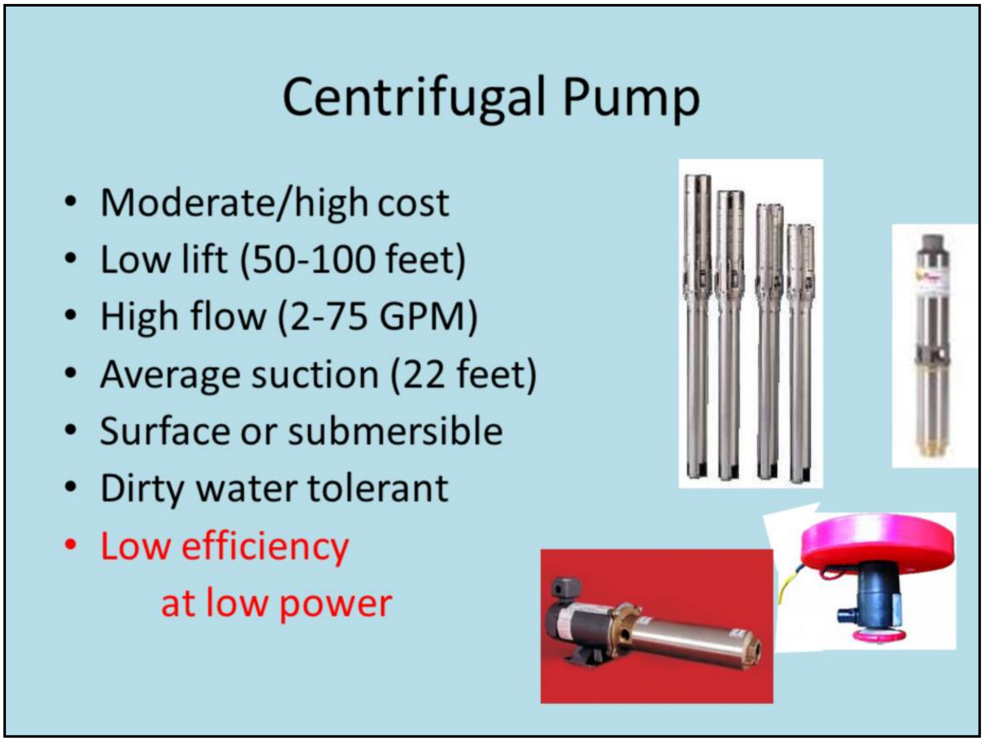
- Low cost
- High lift (560 feet)
- Low flow (0.5-4.0 GPM)
- Intolerant of dirty water
- Requires filtration
- Surface
- Operates on low power

While these pumps can continue to function under very low light situations, they do not handle particulates in the water supply. Thus a good filtration system must be incorporated into the intake plumbing. As with any filter, diligent cleaning and/or replacement of the element is essential. For farmers not willing to commit to this level of maintenance, this option should not be selected.

Helical Rotor Pump

- High cost
- High lift (165-650 feet)
- High flow (3-85 GPM)
- Submersible
- Tolerant of dirty water

Not widely utilized in grid powered applications, but have a proven record with alternative power facilities. A series of cavities filled with water is moved along the rotor shaft to the discharge port.



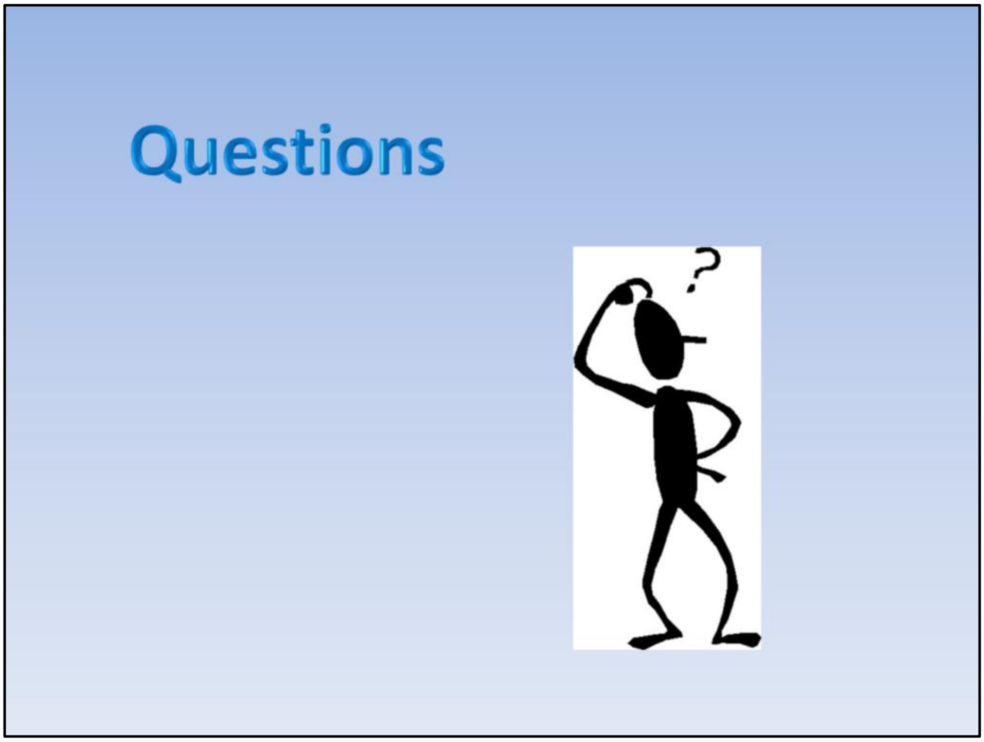
Due to the nature of how these pumps move water, they are best when they reach a consistent high RPM. Unfortunately, with solar power being variable, this is not always possible with PV setups.

Operation & Maintenance

Critical to proper & reliable functioning of any system

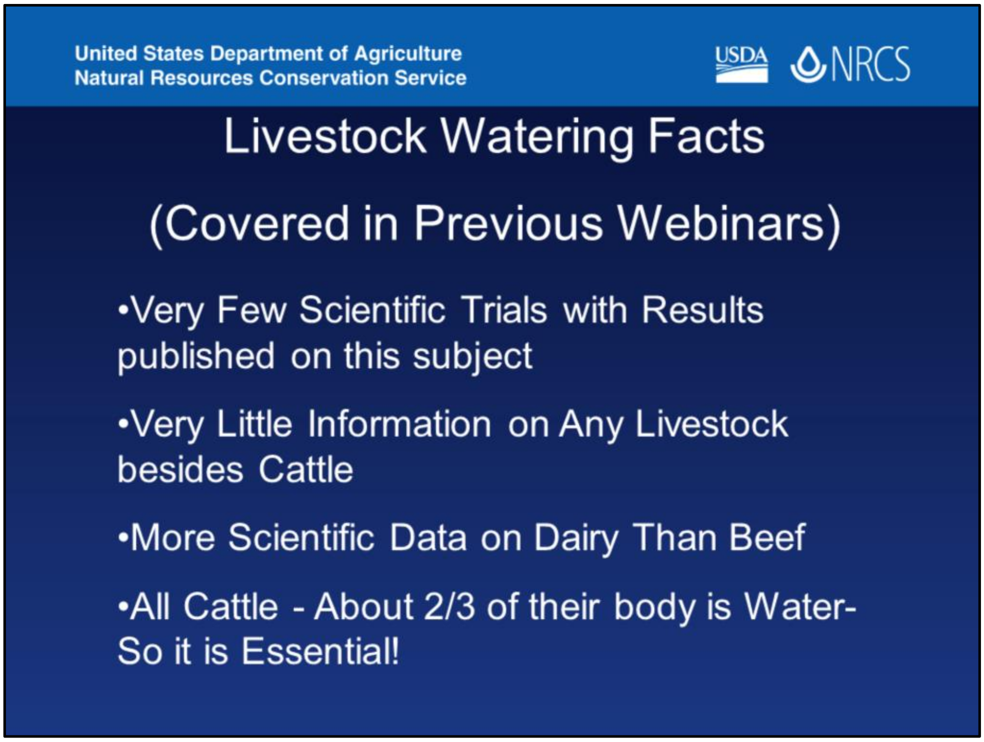
- Clean top surface of PV modules of dust, foliage, avian excreta, and other debris
- Inspect cables and wires for loose connections, damage from wildlife, corrosion, etc.
- Adjust PV array frame as necessary to optimize capturing sunlight. Check tightness of all fasteners.

Beyond typical O & M tasks associated with conventional pumping stations, there are additional requirements and considerations for photovoltaic generation. Most relate to the outdoor elements, potential weaknesses of the components, and optimizing performance.



With that we are going to take our first break for questions. Do we have any questions at this time?

Let's continue. New Slide.



Self-Explanatory

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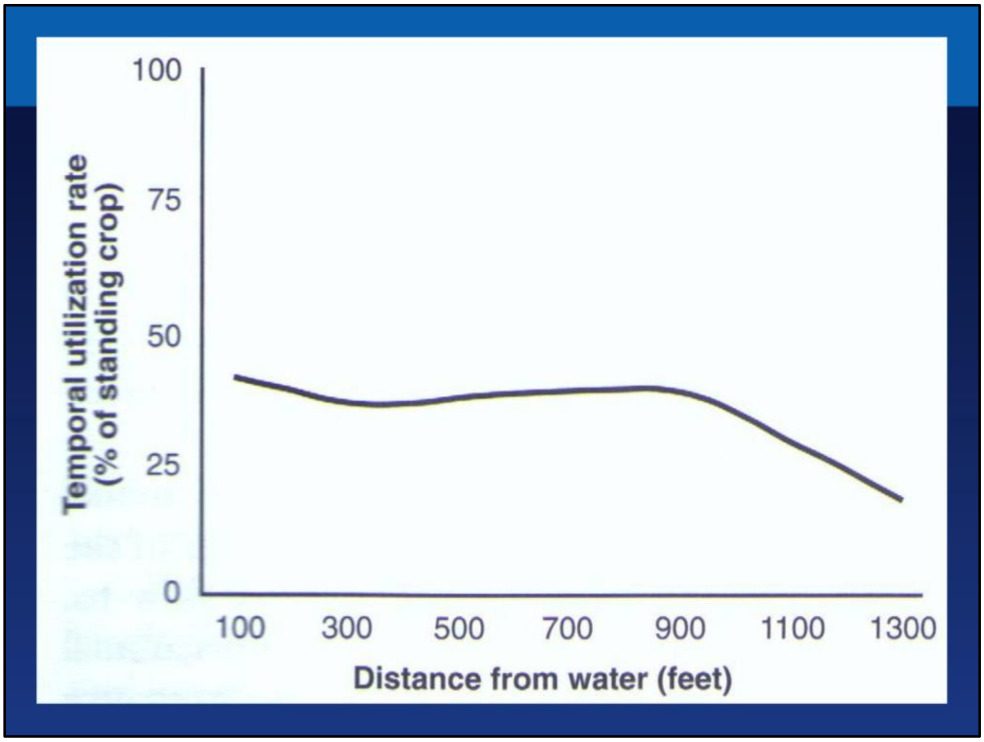
Determining Need

(Covered in Previous Webinars)

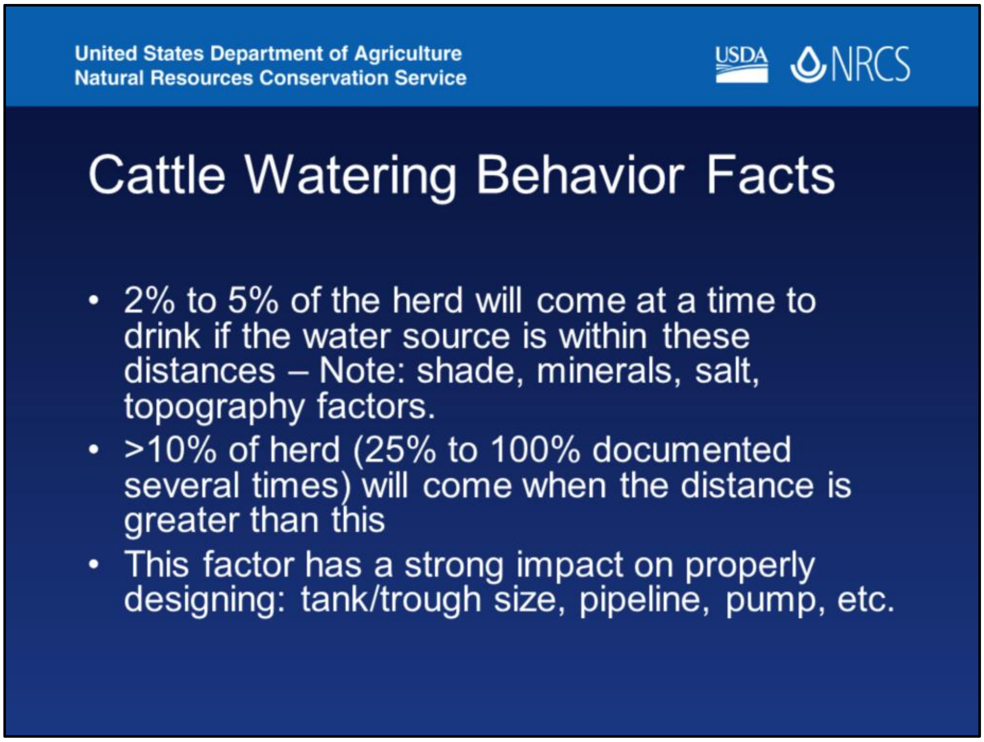
1. How Much?
2. How Fast?
3. Under what climatic conditions? The Thermal Heat Index will be reviewed briefly.
4. Animal Behavior/Management Impacts? Brief overview will be covered today.

Self-Explanatory



Source: U of Missouri research shows that **if** beef cattle travel more than 700 to 900 feet from water, utilization of the forage goes down significantly! Basically a 160 pasture only had 130 acres of pasture used. Even in the arid West, beef cattle did 77% of their grazing within 1200' of the water source in a 2000 acre "pasture". When water and shade exist in a pasture, P and K are concentrated in these areas since 90% of the P & K nutrients are recycled in the manure and urine So a **long-range goal** of all graziers should be water in every paddock.

How close should the water be to the livestock? Research in Missouri has shown that if the animals are farther than 700 - 800 feet from the water source (for beef cattle) or 600 feet (for dairy cattle) then the whole herd comes at once to drink. When the herd comes as a group to drink it is an instinctive protection mechanism. Nobody wants to be left "way out there" all alone. After the "boss" cow drinks first and is ready to go back and graze, the most submissive cows will leave with the herd without drinking! A New York (Cornell) study showed that dairy cows need water 500' or closer to avoid the "herd affect". When closer than these “best forage utilization distances, then only about 3 to 5% of the herd come at one time to drink. NRCS in New York wants water for dairy cows 300' or closer. It is better to have the water closer than farther away when in doubt. In the Midwest, the maximum distance stock should travel to water is a quarter mile.



The distance used ranges from 500 feet to 1000 feet depending on which research and which type of cattle – dairy or beef/dry dairy cows. MU research results.

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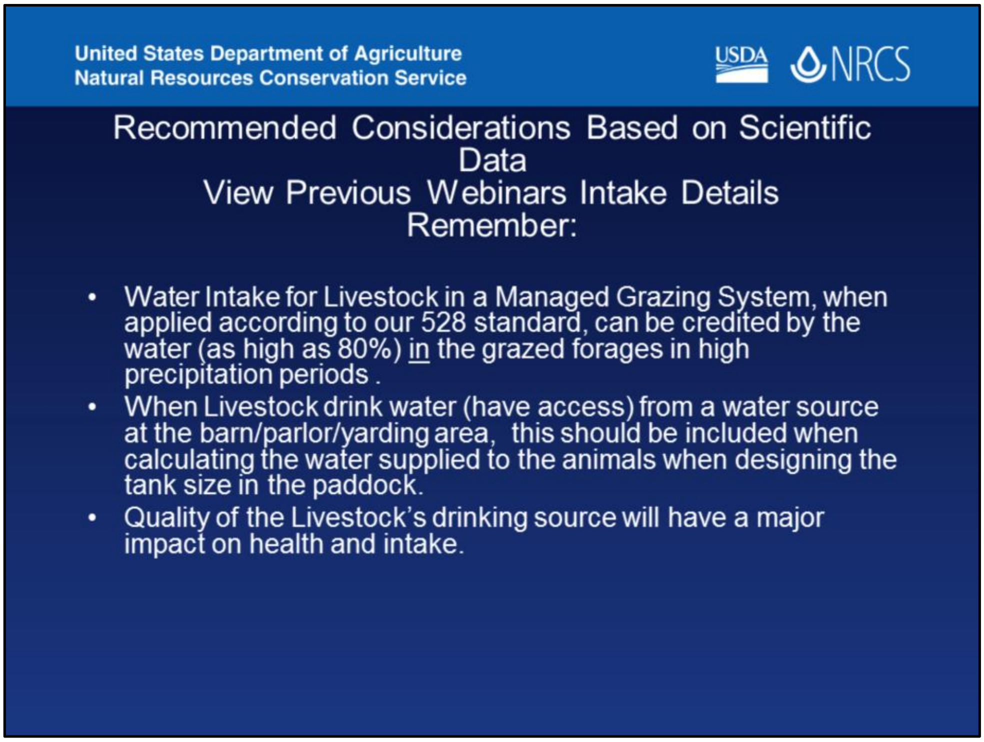
Cattle Watering Behavior Facts

- They drink 1 to 2 gallons per minute
- They drink for 2 to 3 minutes per drinking event
- So they can drink 6 gallons per drinking event per animal on ‘high side’
- 2 to 5 drinking events per day - MU

How fast do cattle drink?



Bullet 1 – Some studies show as much as 12 gallons per head per day came from water in the forage they grazed.

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Recommended Considerations Based on Scientific Data
View Heat Stress Impact on Water Intake
Remember:

- When Livestock are expected to be in 'Moderate Heat Stress' THI (or Higher) for a only a few days of the total grazing season, a contingency plan of action should be followed for those few days. We do not recommend sizing the tank for only 2% of the grazing season for example.
- When Livestock are in 'Moderate Heat Stress THI (or Higher) for several days (AL ex. - 25% or more of the Grazing Season), High Water Intake Rates should be used in the tank designs.
- Where's the Line? Using recent years weather records it has moved northward from the past. Varies by elevation, closeness to large water bodies, etc. Not just a 'north to south' determination.

Self-Explanatory

Table 5.1 Daily water intake of dairy heifers under various temperature conditions.

Air temp. (degrees F)	lb water/ lb TDN	lb TDN/ day	gal water/ day
35	4.7	10.3	5.8
50	5.2	9.2	5.7
70	7.2	9.2	7.9
80	9.0	8.8	9.5
90	22.2	6.6	17.6
95	24.8	6.4	19.0

Sources: University of Missouri researcher James R. Gerrish and Missouri NRCS specialists Maurice Davis published in a document titled “Water Requirements & Availability”.
This table shows what can happen to livestock water intake when temperatures go up. You can see that providing lots of water in hot weather to dairy heifers can have a significant impact on their health. Younger cattle also consume more water than mature cattle will. Lactating cattle consume more water than non-lactating cattle will.

In going to the THI – if we use average weather relative humidity for July (because it has the highest humidity with the highest max. air temperatures with the lowest wind speeds) the 80 degree air temperature would be in the ‘mild’ stress category and the 90 and 95 degree air temperature would be at the low and high end of the ‘moderate’ heat stress category.

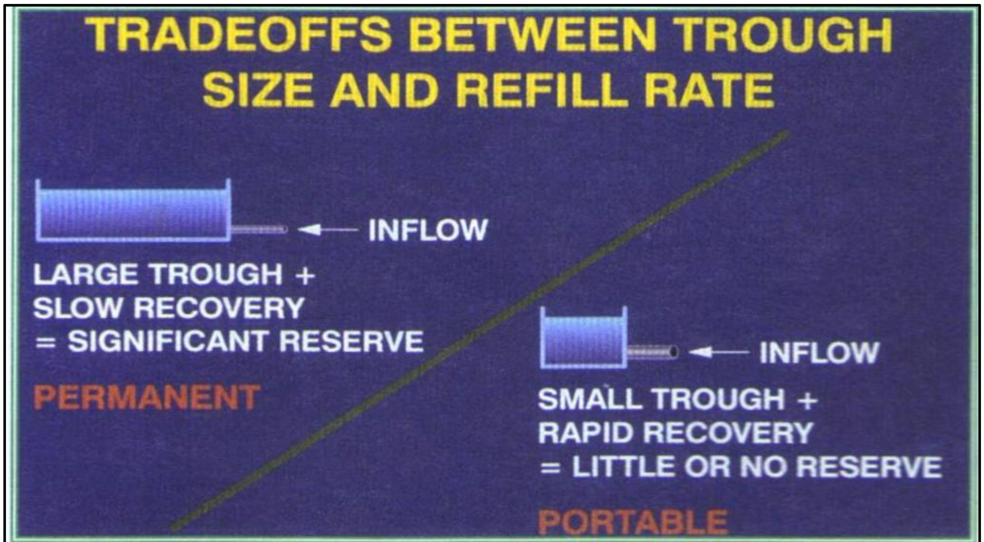


Figure 14 There are two opposite approaches to dispensing water. One is providing a large trough with a low flow of water to replenish draw down by cows. A contrasting approach is a small tough with a quick recharge capability, which allows more management flexibility due to the trough's portability.

Source: Prescribed Grazing and Feeding Management for Lactating Dairy Cows, New York State GLCI by Sullivan (Hoffman), DeClue, Emmick

Now let's talk begin to talk about the **HOW of supplying water to livestock.**

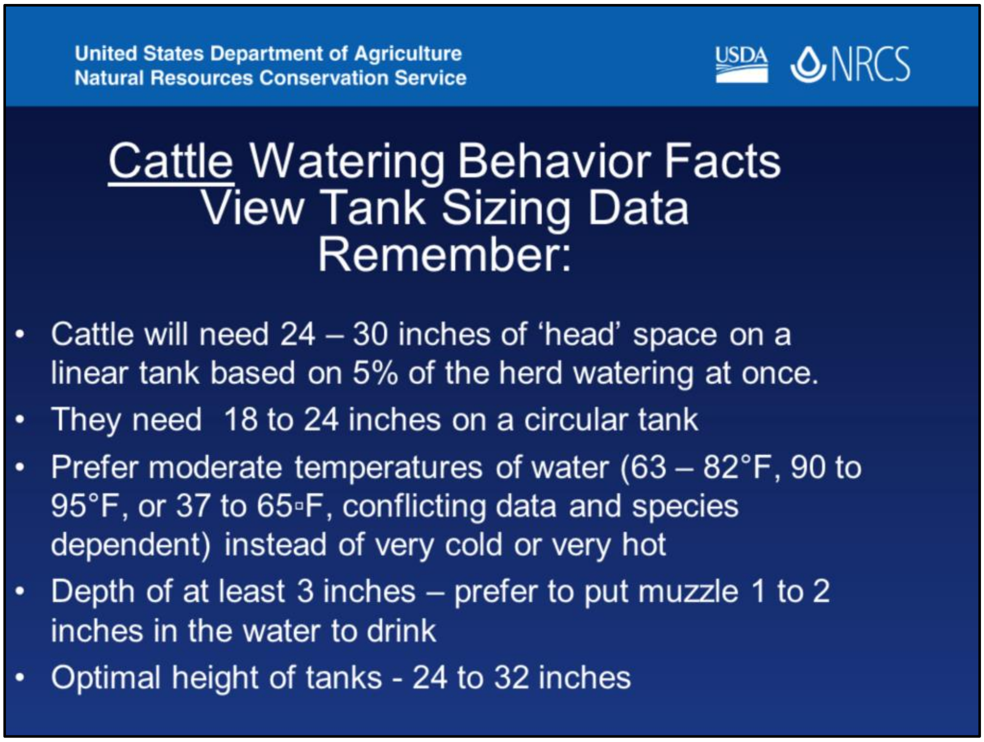
We must account for: **Animal individuality, succulent forage, instinctive herd behavior (water proximity), and quick recharge (fresh)** So we need to know:

- **How much water we need per head per day.**
- **What our water source will be.**
- **What our delivery system or distribution network will be.**
- **And the dispensing facilities or animal access facilities (tank, stream).**
- There are two schools of thought to providing water to livestock. One is to have the livestock always close to a smaller tank with a delivery system that has fast flow and can refill the tank quickly. The other is to have a large tank which can be close or farther away from the livestock with a slower flow and a slower refill time to fill the tank.

Most of the time a well with your typical electric 110 volt pump is the most reliable and lowest overall cost type of system. It is usually capable of pumping through a pipe system to a tank or tanks in every paddock. The system must be capable of lifting the water to the highest tank/trough and overcome friction by water flow in the pipe.

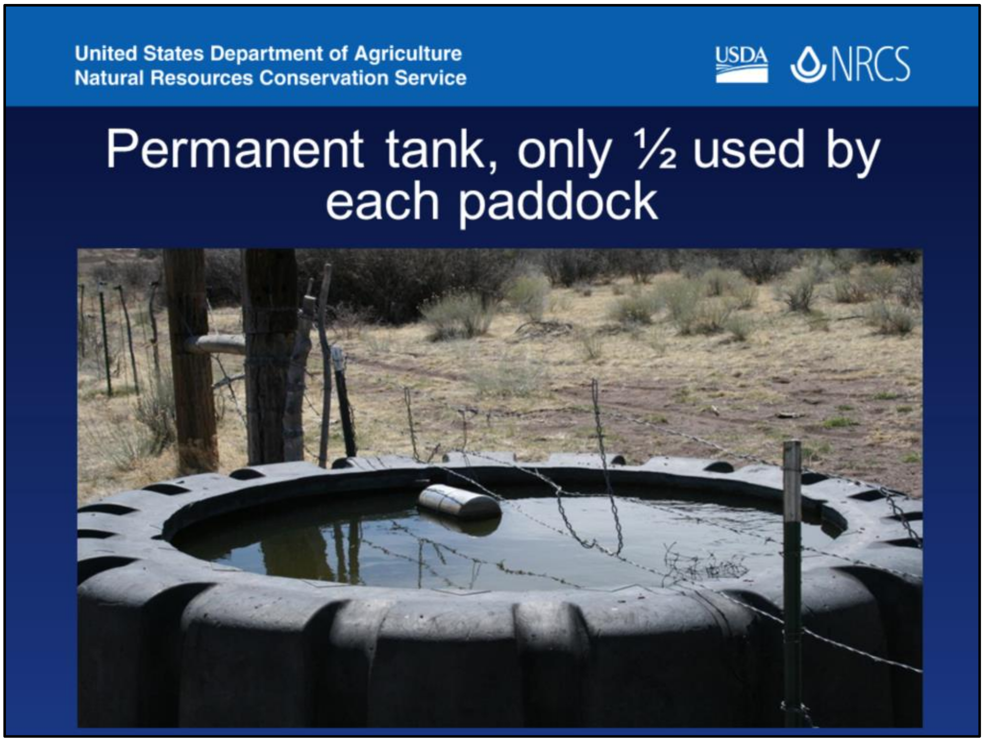
Small water tank

Self-Explanatory



Self-explanatory.

This linear oval tank can accommodate about 6 head of cattle at a time.



Read. Self explanatory.

This tank portable tank placement allows less than half of the perimeter to be effective utilized by the animals; but because of the pasture size and animal behavior the entire herd does not attempt to drink at the same time. Photo courtesy of Kevin Kaija, VT NRCS Grazing Specialist.

How many head can drink at this tank?

When planning the placement of a tank always consider how to maximize it's use. By opening and close gates this tank provides water to multiple pastures. Photo courtesy of Greg Brann, TN NRCS State Grazing Specialist.

So here is the modern day system being installed today. High Density Polyethylene (HDPE) pipe that is UV resistant is run on top of the ground along fence lines so livestock will not step on them. Full float valves are used with quick recharge like Bill talked about. Let's evaluate this set up. . . . The paddock's farthest point may be less than 600 feet to the tank. The cattle are on a 3 to 5 day duration in each paddock. What are some things that could improve in this ? Notice shade, water, mineral and fly rub are all within 50 feet of each other. If the cows had stayed here for 10 days or more this would be muddy and high in waste nutrients with a water flow path nearby.

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Management Decides If the Livestock's Water Needs are Met!

Management Determines:

- The distance livestock have to travel to water
- How much room the livestock have available to get a drink
- The quality of the water the livestock drink, at least to some degree.
- The temperature range of the water the livestock drink, at least to some degree. Intake reduces if too hot or cold, hot being worse.
- If the livestock can reach the water to drink normally
- If the livestock drinking area becomes a resource concern or not.

Self-explanatory.

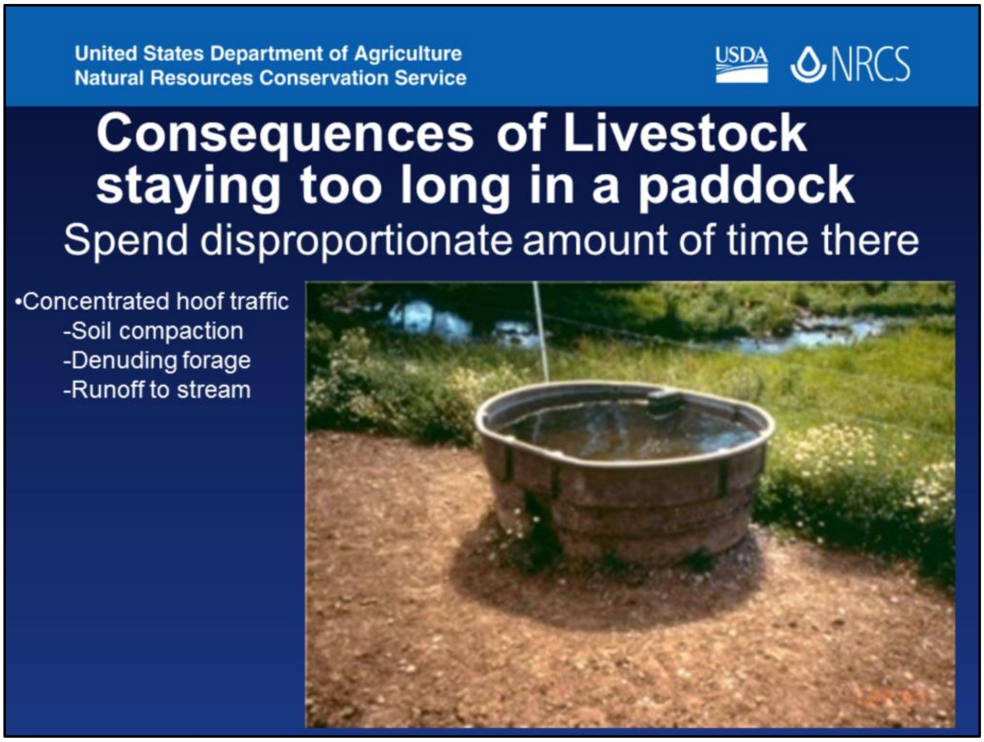
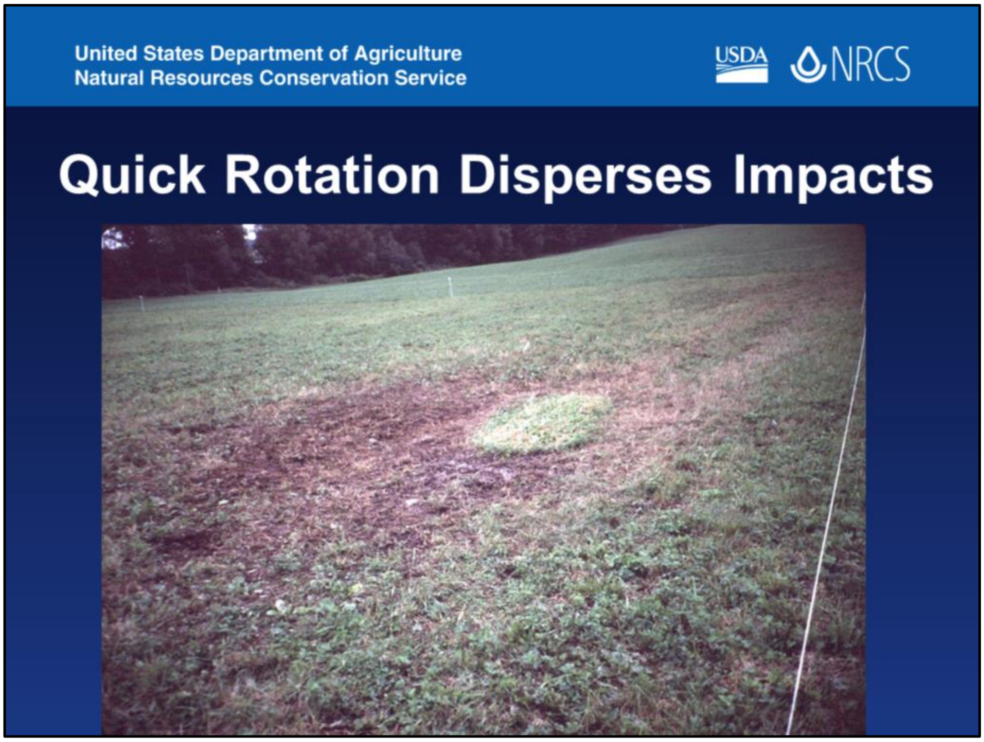


Photo courtesy of Rob DeClue, conservationist from NY.



Very little negative effect to resources here because the tank was only in this spot for a couple of days. Photo courtesy of Rob DeClue.

If things are improperly designed, then the tank can refill too slowly, or the tank is too large for what was needed. Both can cause stagnant water and possible negative health effects on the livestock. Photo courtesy of Rob DeClue.

What Will Be Covered?

- Importance of Planning
- Understanding Solar Radiation and Configuration
- Hydraulics
  - Pumps
  - Pipe Flow
- Bringing it all together

Thank you Kevin. We have heard a lot of great information today dealing with this issue of solar powered livestock watering systems. What I would like to do during this short segment is build upon some of the concepts that have already been discussed and then bring it all together by going through a short example. I want to touch again on why it is so important to plan in all aspects of the work that we do within NRCS, but why it is particularly important when planning for livestock watering systems especially for those using alternative energy sources like solar.

I want to cover a little on the importance of evaluating a solar system and the proper configuration to maximize its performance.

I also want to touch briefly on hydraulics as one has to balance between the PV system and the pump and piping system.

ENTSC Webinars

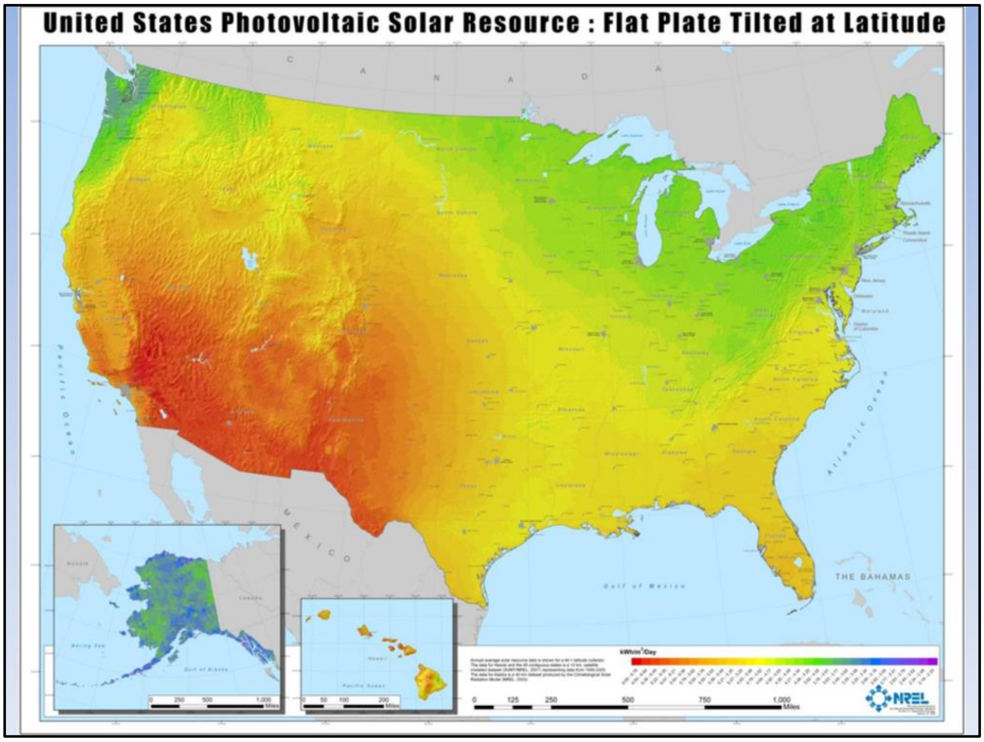
- Watering Facilities for Managed Grazing Systems by Kevin Ogles and Michael Hall
- Windmills and Water Pumps for Livestock Water by Dr. Carlos Rosencrans
- Planning and Design of Livestock Watering Systems by Bill Reck and Kevin Ogles

Just as a note to the listeners, a number of presentations on watering facilities have been made over the last few years. See the Conservationwebinars.net web-site for additional information on these presentations.

Why Plan?

- Meet Landowner's Objectives
- Water Requirement
- Water Source
- Solar Insolation
- System Layout
  - Diagram
- Water Storage
- Operational Time
- **$$**

Go though information on slide
Why do we plan? Number one, as an agency, this is who we are. We are planners. There are so many aspects that have to be considered when dealing with systems and in particular alternative technologies such as this.
It is so important to get out into the field and meet with the landowner. Get to know what that person desires out of the system.
Gather all of the necessary information so that a good plan can be developed.
Probably the biggest factor a landowner must consider is the financial obligation. And this may not be limited to only the cost of implementing or installing a practice or technology, but a person may also need to include the cost of not doing something or the cost of doing something else.



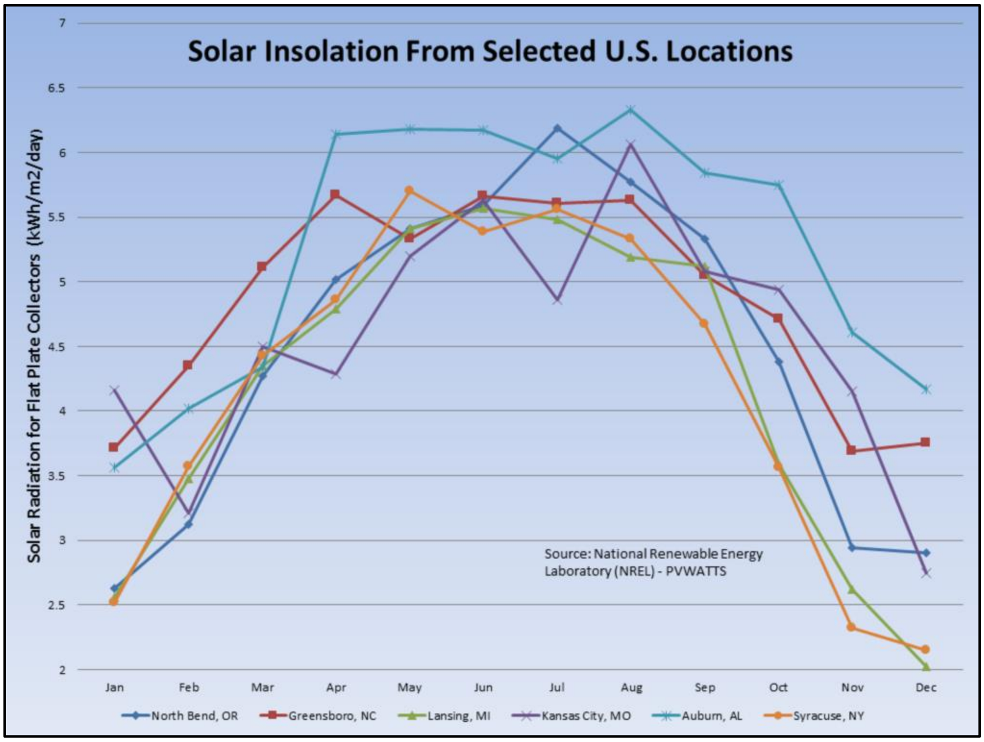
One needs to understands the limits of a system such as this. Here we see the average annual daily solar resource data for the United States. One of the things to be noted here is that as one moves to the northeast the amount of solar energy available on an annual basis decreases. This makes it more difficult to configure a PV system in this area especially if one desires to use it year round or for extended periods of time.

Solar Isolation Values

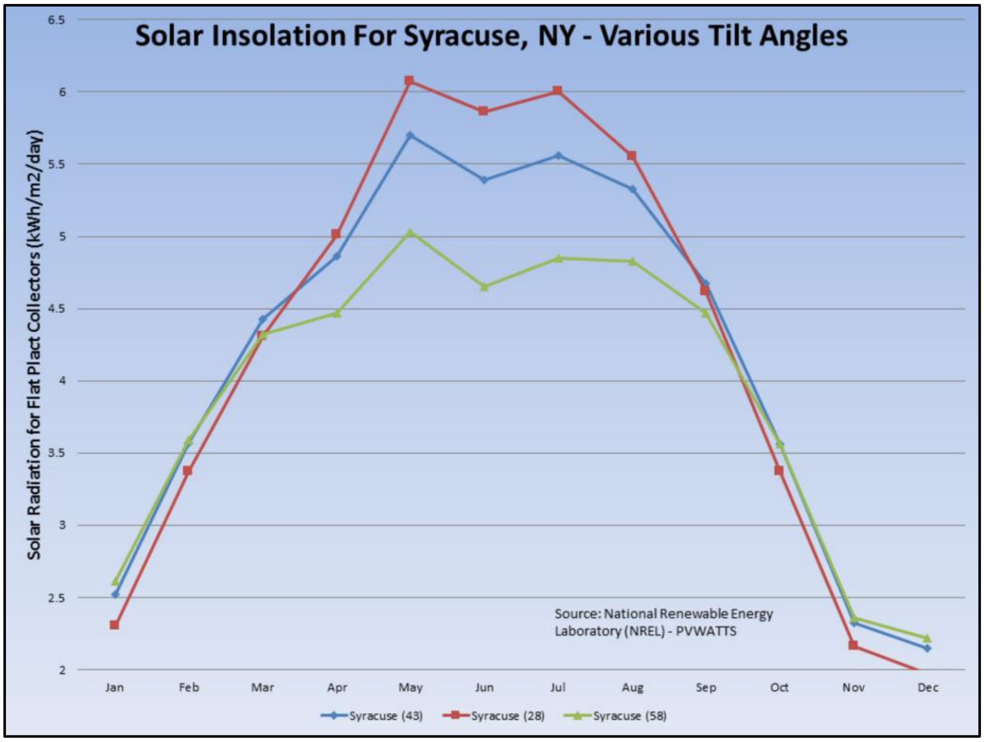
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
North Bend, OR	2.63	3.12	4.27	5.02	5.41	5.59	6.19	5.77	5.33	4.38	2.94	2.9	4.46
Greensboro, NC	3.71	4.35	5.11	5.67	5.33	5.66	5.61	5.63	5.05	4.71	3.69	3.75	4.86
Lansing, MI	2.56	3.48	4.35	4.79	5.41	5.57	5.48	5.19	5.12	3.59	2.62	2.02	4.18
Kansas City, MO	4.16	3.21	4.5	4.29	5.2	5.63	4.86	6.06	5.08	4.94	4.15	2.75	4.57
Auburn, AL	3.56	4.02	4.34	6.14	6.18	6.17	5.95	6.33	5.84	5.75	4.61	4.17	5.26
Syracuse, NY	2.52	3.57	4.43	4.86	5.7	5.39	5.56	5.33	4.67	3.56	2.32	2.15	4.17

Values are $kW/m^2/day$

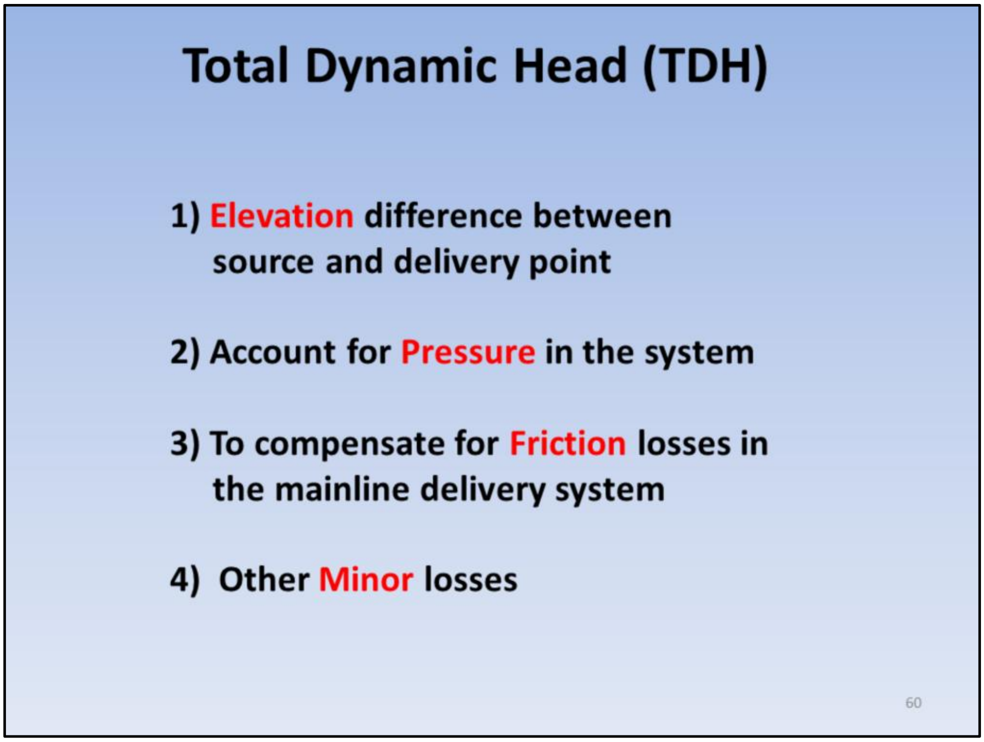
Here I have chosen a few cities from across the country to show how the energy availability not only between different parts of the country, but also how it varies from month to month within a given area. Take for example Syracuse, NY; the number varies from 2.15 kW/m2/day in December up to 5.7 in May. It would likely be difficult to operate a system year round in this location, but it would likely be more feasible to look at a PV system that functions from April to September or maybe March through October. Let's take a look at this information graphically.



I know this slide is a little busy with all of the lines. But as we take the tabular data and show it in this graphical display, I believe that you can see some of the difficulties in putting together a good PV design, especially in the northeast and northwest corner. As we can see from this graph, on the average from April until September the isolation values do not vary as much as throughout the rest of the year. This really shows the importance of planning. Now there are some things that can be done to help improve the performance and let's take a look at one.



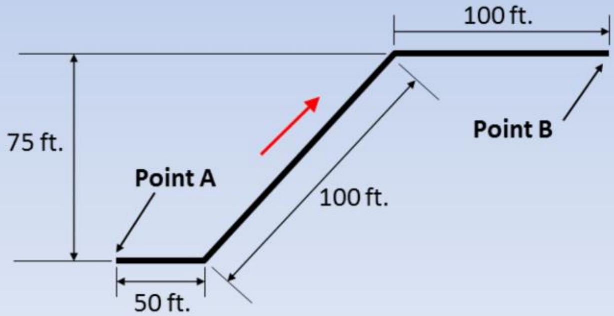
I've taken the Syracuse, NY site and manipulated the fixed flat plate collector by changing the tilt angle. As has been mentioned a good starting point for the tilt angle is to set it at the locations latitude that would be the blue line on this graph. Notice by decreasing the angle by 15 degrees (red line), the solar insolation values increase during the summer months, but decrease during the winter months. Consequently, one could increase the tilt angle by 15 degrees (green line) for the winter months to increase solar capture during that time, but would sacrifice efficiency in the summer. Solar tracking systems could be incorporated, but these add expense along with additional operation and maintenance issues.



Once we get an idea of the solar values and time intervals we will be working with, we can then move to the area of hydraulics looking at pump and pipe sizing. To tackle this, we have to look at the pressure requirements for system operation. One of the things we need to determine is what is called the Total Dynamic Head. Basically this is looking at what it takes to move water from point “A” to point “B”. The four main items are listed here. Discuss each briefly. The presentation given by Bill Reck and Kevin Ogles covers this in much greater detail.

Elevation & Distance

- Elevation Difference
- Distance

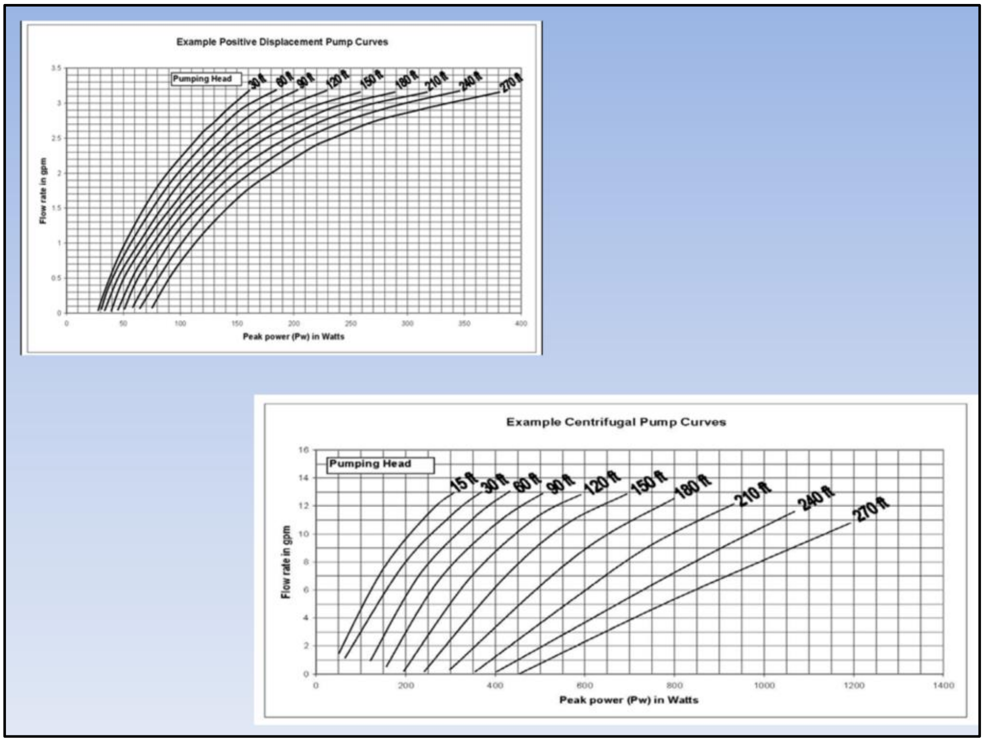


Discuss the two items

Friction Loss

- Velocity
- Pipe size
- Pipe type
- Pipe Length
- Fittings/Valves

Impacts in loss and total dynamic head

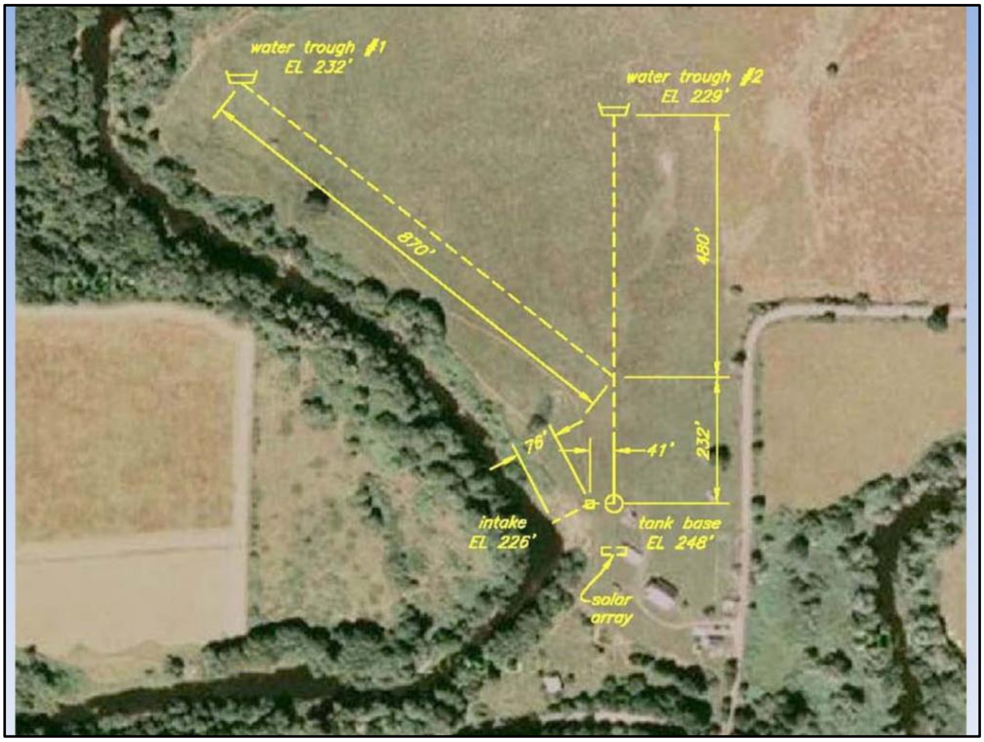


From the animal water requirements, flow rates can be determined. Once one knows the flow rates and the total dynamic head, pumping curves such as these can be used to determine which pump will work best for the system. So now we have the basics, what do we do with it? Good question, let's take a look.

Example Problem

- 100 head beef cattle operation
- Livestock currently have stream access for water supply
- Will fence cattle out of stream – need new water supply
- Location: Syracuse, NY (Latitude 43 N)
- 4 – 500 gallon watering troughs (currently available to landowner)
- Gravity feed from storage tank – if possible
- Will Solar work for this site?

This example is provided as one approach of planning, evaluating and designing a PV watering system.
Review some of the parameters.

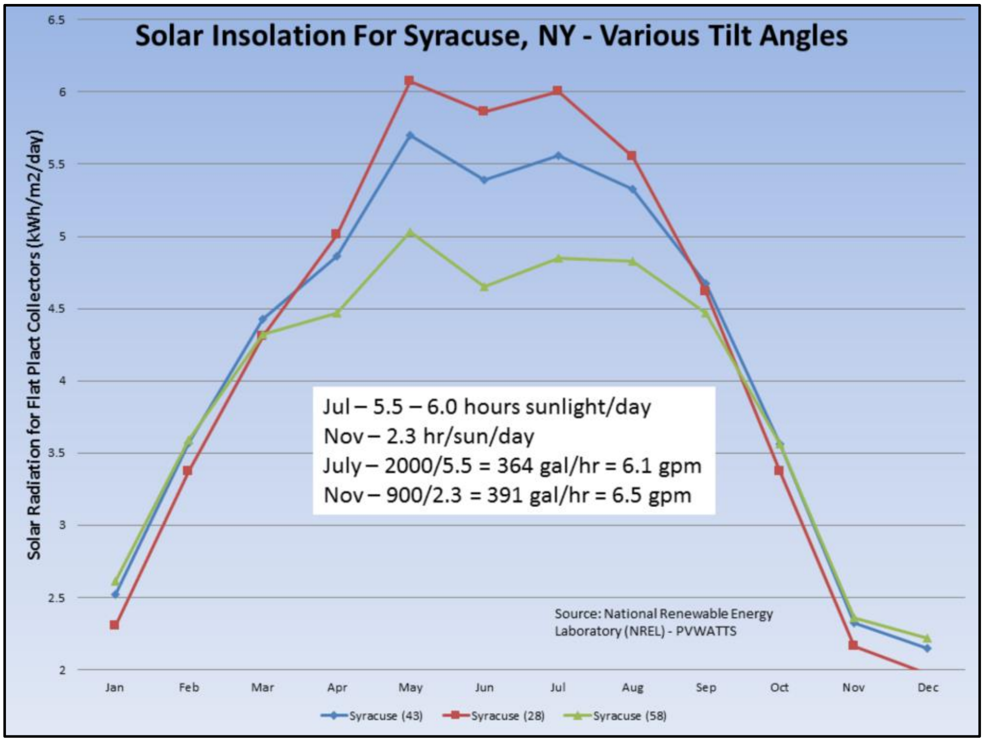


As we look at this site, this show the location of the water source, storage tank and two of the watering troughs. Information obtained from a diagram such as this is invaluable when planning a livestock watering system.

Water Requirements

- July – 20 gallons/day/animal
- November – 9 gallons/day/animal
- Hot/high humidity – 6 gallons/animal/event (2-5 events/day)
- 10 animals can gather around watering troughs
- 20 gal/day*100 animals = 2000 gal/day (Jul)
- 9 gal/day*100 animals = 900 gal/day (Nov)
- Design for 3 days storage – 4000 tank required (4- 500 gallon troughs available)

It was determined for this operation that these would be the water requirements for the cattle.
Note the differences between the water requirements for July and November. Also note the water intake requirements for very hot and humid days. All of these things need to be taken into consideration when preparing a design.



Note the flow rate requirement for November is greater than July even though the water usage is less than ½ of that required in July. This is because of the limited amount of solar radiation that is available for energy generation. These higher flow rates may could have an impact on the type of pump that can be used for this operation.

Determine Pump Requirements
Flow Rate = 6.1 gpm
(Storage Tank is 11 ft tall)
Elevation = 248+11-226=33'
Pressure = 0 (tank not pressurized)
Pipe length = 200' (add 10% for minor losses)
Use 1" pipe Schedule 40 PVC pipe
Friction loss 220'*2.36'/100'= 5.2 ft
TDH = 33 + 5.2 = 38.2' – use 40 ft

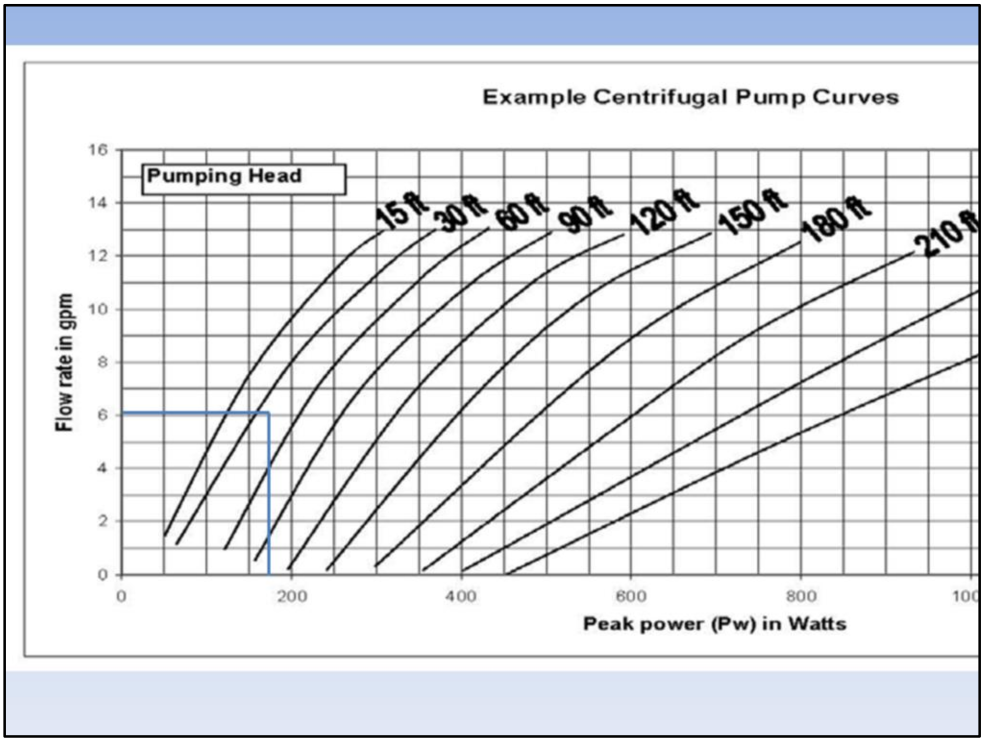
Let's take a look at the pump requirements. Using the previously computed flow rate for July and the other parameters, one can determine the total dynamic head so the appropriate pump can be selected.

Tank base is elevation 248 and the 4,000 gallon storage tank is 11 feet tall. Subtract the intake elevation (water level) to determine the elevation requirement and in this case it is 33 feet.

For this example, the tank will not be pressurized so the pressure component is zero when looking at the total dynamic head.

The total pipe length is estimated to be 200 feet. Minor losses could have been computed, but for simplicity purposes, I chose to add 10%. Here the total dynamic head is calculated to be approximately 40 feet. With this information we can now select the pump for this operation.

I want to emphasize that it is not as important to know all of these numbers and specific equations as it is to understand the process.



6.1 gpm with a pumping head of 40 feet – and from this we find that the PV power requirements for this system is about 170 watts.

PV Selection

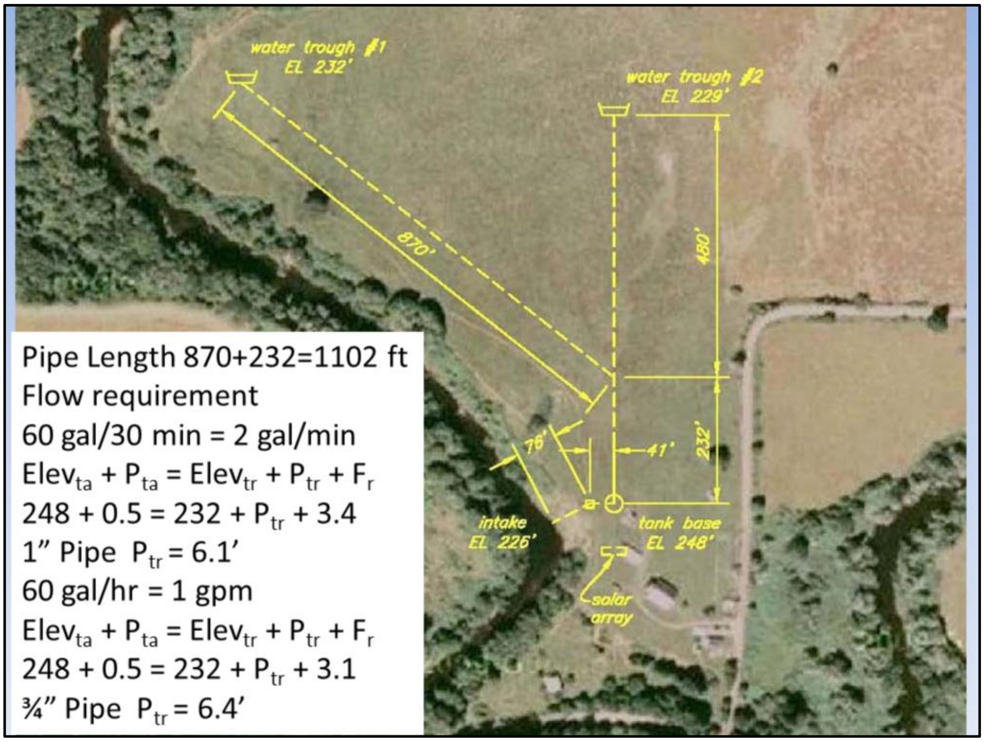
- From Pump Chart – 170 watts required
- Add 25% for other factors
- PV requirement – 215 watts
- Work with supplier to meet demand

To deal with environmental factors such as dust and wear over time it is recommended to add 25% to the computed value. This brings the PV array requirement to 215 watts. The landowner needs to work with the supplier for the size and configuration to meet the PV specifications.

Gravity Flow to Trough

- Peak water requirement
  - 10 animals at trough
  - 6 gallons/animal/event
  - 60 gallons/event
  - Landowner desires to have replenished in 30 minutes to ensure demand is met
  - Float requires a minimum of 2 psi to operate properly (4.6’)

The system has now been designed up to the storage tank. Since the tank is located on a hill, the landowner would like to distribute the water to the troughs by gravity. This will have to be evaluated. With the high temperatures and humidity during July, the landowner has also determined that during peak water usage events the cattle would consume 60 gallons. It is desired to replenish this amount of water within 30 minutes to ensure that adequate water is available for the animals. Another item to consider is that the floats in the troughs require a minimum of 2 psi to operate properly.



The calculations on this slide make it look very busy, but again I am using this information to help us understand the process that one goes through when designing a system.

Flow requirement – 2gpm (replenish rate) – Float pressure – 2 psi

To determine the pipe size we will basically use the total dynamic head (or Bernoulli’s equation) at both the storage tank and most distant watering trough.

Pta – 0.5 feet of water in tank – conservative estimate

Ptr - will be solved for in this equation – value needs to be at least 4.6 feet which is equivalent to 2 psi.

1” pipe required – ¾” introduced too much friction and would not work by gravity system

Increase delivery time to 60 gal/hr decreases pipe flow to 1 gpm

If reduced flow is acceptable then ¾” pipe will meet the pressure requirements for the float valves.

So, as you can see there is much more planning required than just sizing the PV system.

If you would like more information on this process please see the document entitled – Design of Small Photovoltaic (PV) Solar-Powered Water Pump Systems – included in the handout materials.

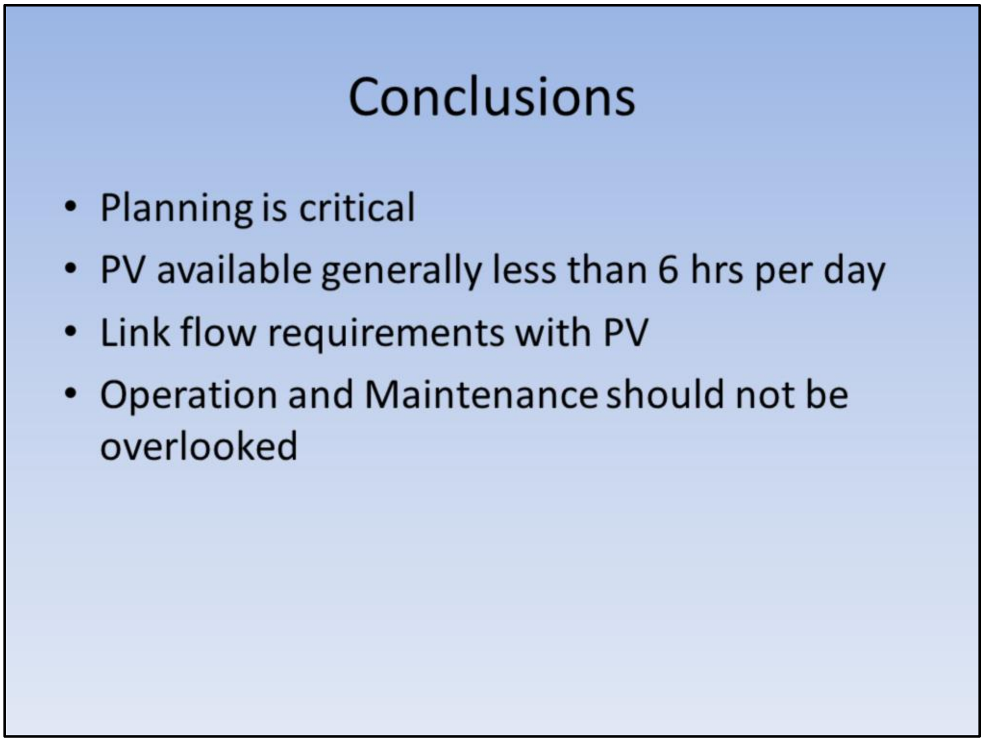
REFERENCES

AgPipe (Located at the National Design, Construction and Soil Mechanics Center): http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/ndcsmc/?cid=stelprdb1042198

Photo Voltaic Watts (PVWatts)Calculator http://pvwatts.nrel.gov/

Couple of references
AgPipe – NRCS – Need to have IT to load the software – Non-governmental folks can download directly
Many states have spreadsheets for designing pipelines
Engineering Field Tools – eventually will have a pipeline component – waiting for funding to complete the work

PVWatts – general information on solar isolation for areas across the country



As we being this presentation to a close, I would like to summarize some of the things that have been covered. Review conclusions

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Kevin, with that I will return control to you. Questions.