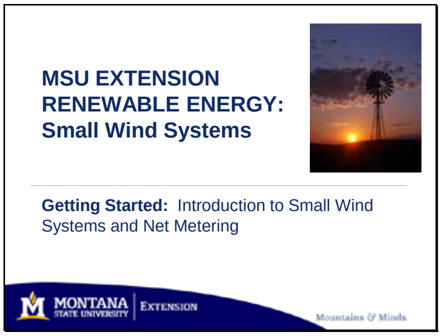
Slide 1



Introduction & Open the Session

• Welcome to MSU Extension's Renewable Energy program on small wind electrical generation systems.

• Introduce yourself, any other staff, and guest speakers and/or sponsors

• Explain workshop format (40 minute workshop as stand-alone) or part of multiple-segment training series

Tip

• Greet participants individually when they enter to create a welcoming environment

• Have this slide up on screen when they enter the room

• When you start, make clear that you have set timelines and that you need learners to help keep things on track by following instructions and paying attention to timelines when they are given.

Slide 2

Overview:

• Learning objective for this session – introduce basic concepts of wind technology and net metering.

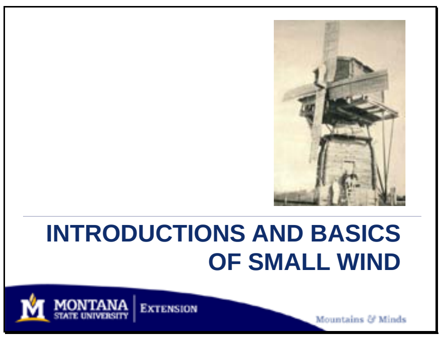
• Remind learners that MSU Extension is an unbiased resource, providing information on small wind, but not recommending or discouraging people from installing systems.

Slide 3

Reinforce Supplemental Materials:

- Online materials at www.msuextension.org/wind (Click on Small Wind)
- Each workshop has a section on the website with supplemental materials
- Website does contain information from biased sources. Content was selected because those resources explain concepts well, but MSU Extension does not endorse all sources listed on the website.

Slide 4



Activity:

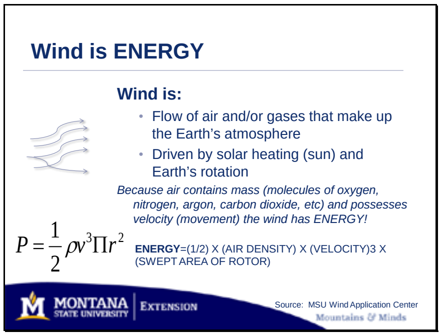
- Participants introduce themselves in TWO SENTENCES:
    - Name
    - One question they would like to have answered in these workshops

(Facilitators) – List these questions on flip charts.

Tips:

- Manage expectations – list all questions. Point out that you will not answer them now – they will be answered (most likely) as training continues. If not, contact Sarah Hamlen for additional resources
- Hold people to TWO SENTENCES on introduction. Remember that this activity will set the stage for staying on topic and on time throughout the workshops.

Slide 5



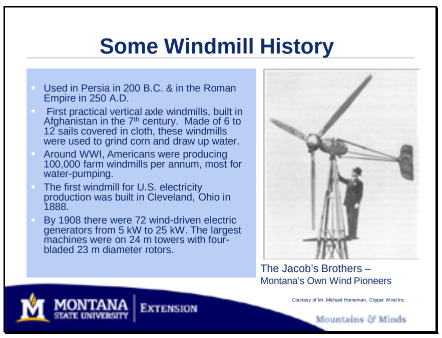
What is Wind?

• Wind is energy

• Wind turbine technology is about harnessing that energy and converting it to a usable form – power.

• If you wish to talk math - Πr2 (area of a circle – swept area of the blades); v3 (shows sensitivity to wind speed. By doubling the wind speed, you get 8 times the power because it is a cubic function)

Slide 6



Notes to Keep it Interesting:

•Small wind turbine technology is not new.

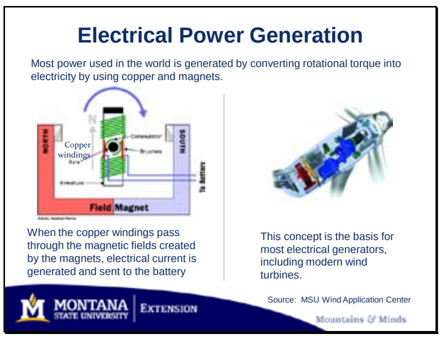
•Until the 1940's, wind turbines were a common part of the rural American landscape. Most typically, they were used for pumping water, but some installations also included home power using battery systems to store the power.

•In fact, much of the current horizontal access turbine design used today can be attributed to the pioneering efforts of the Jacob's brothers of Wolf Point, MT. Marcellus, pictured here, and his brother Joe not only designed turbines, but achieved some level of fame for successful installation of turbines in remote locations. In fact, they were written three times in National Geographic Magazine when Admiral Byrd installed their systems at the Arctic Circle and in Antarctica, as part of his Naval pioneering efforts.

•When Rural Electrification occurred in the mid-1930's, wind turbines went by the way-side for most rural Americans. Cheap electrical power from the utilities was far easier to use than turbines which required constant

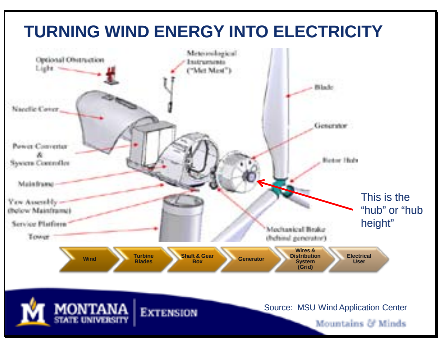
maintenance and upkeep. From the 1930's until the mid-1990's the small wind turbine industry was kept alive in many areas hobbyists and environmentalists, as well as those who used wind to live in off-grid locations.
•Small wind began re-emerging in main stream energy conversations in the mid-1990's and especially in the 2006-2008 as energy prices in the US spiked and national interest in alternative energies peaked.

Slide 7



Overview
• Technology is simple.
• Rotational torque in wind comes from wind spinning the blades - turns shaft to a gear box. Gear box turns copper windings in generator.
• Electromagnetic current carried out of the generator via wires to end user.

Slide 8



Wind Turbine from Another Angle
•Wind turns the turbine blades, which turns the copper windings within the generator, and the resulting electromagnetic current is carried down the tower in wires where the current is either consumed, transmitted, or stored in batteries.
• Some small wind turbines have a shaft and gearbox as well, but it is not common. If a turbine does have a gear box, the owners needs to consider additional budget for operation and maintenance expense. (covered in Step IX)

Interesting Notes

•Pitch function. In small wind, most blades are static, but in larger equipment (like the commercial generators of 1.5-2.5 megawatts and larger) the pitch is actually adjusted constantly to enable the machine to best capture the wind. Usually, computers adjust pitch automatically as wind speed and direction changes.

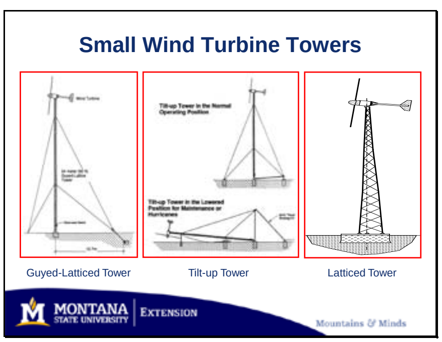
•The yaw drive and motor is also interesting in that it enables the nacelle to rotate on the tower – again to enable better capture of the wind.

• Pitch and yaw are more significant in utility scale machines.

Tip

• Be sure to point out the hub. They need to understand “hub” and “hub height” in later sessions on wind assessment and tower height.

Slide 9



Notes:

• Guyed-lattice is typically the least expensive variety. For some applications, guy-wires are not ideal. For example, public areas with pedestrian or vehicle traffic nearby may have concerns of people running into the wires.

•Tilt-up towers are more common in areas with predictable high winds, such as hurricanes, but may also be considered beneficial for system maintenance purposes.

•The latticed towers are the most expensive tower type (typically), but have the benefit of stability and the ability to climb the tower to perform maintenance.

Slide 10

Notes:

•In the case of high winds, small wind turbines are designed to protect themselves by turning up and out of the wind. The turbine blades will continue to spin, but they reduce their contact with the wind to avoid damage.

• The wind speed at which the system furls is called the “cut-out” speed.

Slide 11

Note:

•Closer look at an angle governor.

•The over-speed protection on turbines will vary by manufacturer, but usually involve a furling function in small wind.

• Turbines will usually also include a braking mechanism, which varies by machine. Quality turbines normally have a redundant system for braking (multiple brakes)

Slide 12

Note:

• Few, if any, commercially available turbines use wooden blades

Slide 13

Notes

• Metal blades do exists, especially in older turbines. They do have limitations, however (reference slide)

Slide 14

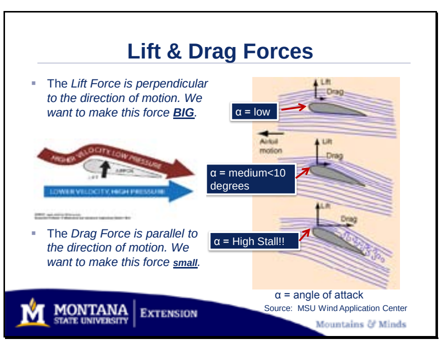
Notes:

• Most common in today's market

• Pultrusion is a process in composite manufacturing where reinforced fibers are pulled through a resin and then typically placed in a heated dye where they undergo polymerization.

• MSU Mechanical Engineering has one of the largest databases of testing and research for composite materials. This resource is highly valued by wind turbine blade designers and manufacturers.

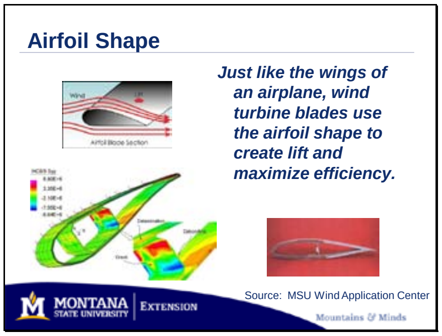
Slide 15



Notes:

• Like airplane wings, turbine blades use the forces of lift and drag to achieve motion.

Slide 16

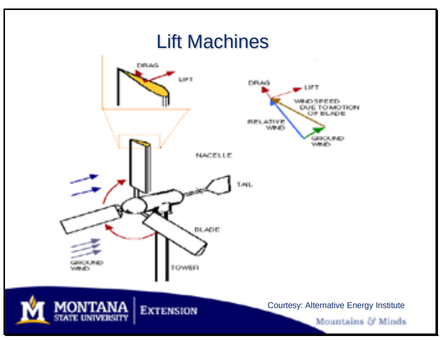


Note:

• Turbine blades will vary in shape and size, but those effective in producing electrical power operate under same principles.

• The small wind industry only began testing (on a voluntary basis) turbine designs to an industry standard in late 2009 to early 2010. This means that there have been no real "standards" on what is or is not a small wind turbine. Consumers should be aware that turbine designs that seem unconventional or do not seem to make sense given forces of lift and drag may need additional scrutiny on the part of the consumer. Other segments will address questions to ask and considerations for reviewing a turbine.

Slide 17

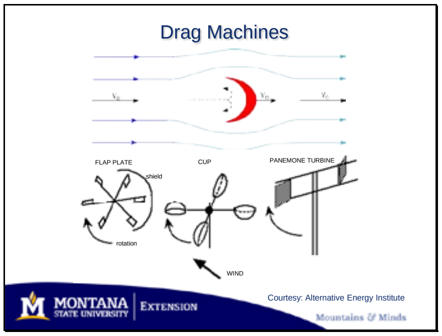


Notes:

•Lift machines seek to optimize the "lift forces".

•Think of this as the wind picking the blade up and "lifting" it around the rotation.

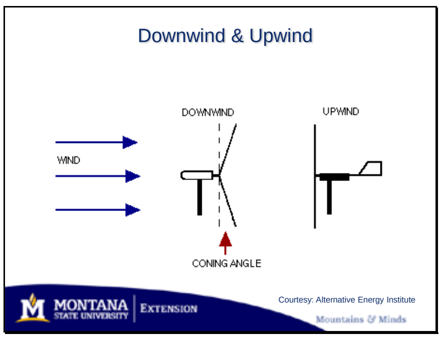
Slide 18



Notes:

• Drag machines seek to maximize the drag forces.
• Think of this as the blade acting like a cup, where the wind actually pushes the blade around its rotation.

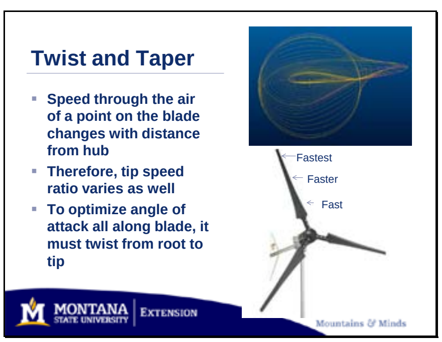
Slide 19



Notes:

• Upwind machines place the blades in direct line with the wind,
• Downwind machines place the tower and nacelle into the wind and use a coning angle on the blades.
• Most large utility-scale machines are upwind models.

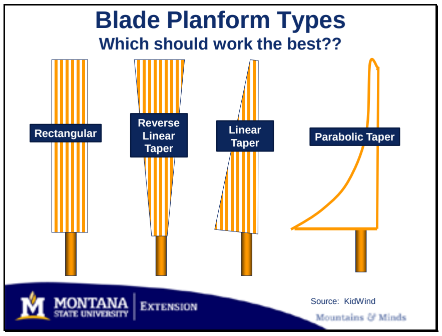
Slide 20



Notes:

• Blades "twist" from the root to the tip to optimize the angle of attack.
• In addition, the blades taper (get skinnier at the tip), which seeks to increase the speed of the blade the greater the distance from the hub.

Slide 21



Activity:

• Participants pick a partner and complete the following statement:

> "If I were going to design a wind turbine I would make the blades out of
>
> ________________________
>
> (material) and my planform type (see slide) would be ________________." Share your answers and discuss why you believe your design to be the best.

Tip:

• **Keep this activity short** – give participants one minute each to share with a partner.

Slide 22

Notes:

• Point out that there are two main types of turbine axis in wind technology – Horizontal Axis Wind Turbines (HAWT) or Vertical Axis Wind Turbines (VAWT).

•HAWTS are the most typical type of wind turbine and are usually upwind machines. The most common blade configuration on commercially available turbines is the three blade design. Over years of testing, the three blade designs have consistently demonstrated the highest amount of power output.

Slide 23

Notes:

• Further examples of blade configurations for HWAT turbines.

• The Skystream turbines are being used in the Wind For Schools projects in Montana.

Slide 24

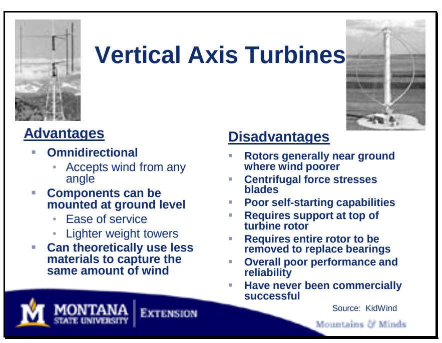
Notes to keep it interesting:

•HAWT turbines are used in utility-scale power production and continue to get larger. In the early 1990's, 250 kilowatt turbines were standard. Now installations are of 1.5 to 2.5 megawatt towers. This picture shows the largest inland turbine, which is 6 MW. 13 of these installed in Germany and Belgium as of October 2010.

•Off-shore applications are usually 5 MW turbines.

•They make the 3-15 kilowatt small wind turbines look like toys!

Slide 25



Notes:

•VAWT turbines have never been commercially successful.

• Plenty of controversy in the small wind industry over VAWTS. Selecting turbine types will be discussed more in later segments.

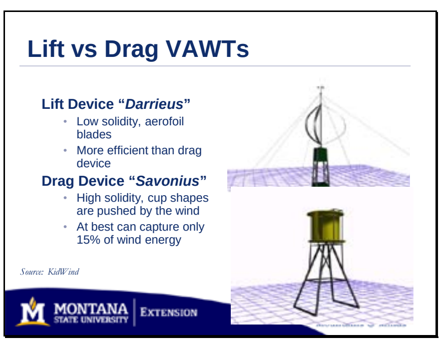
Tip:

• If a strong proponent of VAWT technology participates and wants to refute their commercial acceptance, try the following:

•Point participants to the Small

Wind Certification Council website (link on the MSU site). Mention that there have been no industry standards for HAWT or VAWT and that testing (which is voluntary) will be the best source of side-by-side comparison information in the next several years.
• Mention that MSU is an unbiased resource – the commercial, and especially utility-scale developers, have not adopted VAWTS as an industry standard because of historic performance and reliability issues.
• Remind participants that further discussion of turbine selection will take place in another segment and this discussion might best take place then.
•Contact Sarah Hamlen for additional resources prior to the next section.

Slide 26



Notes:
Here are two examples of VAWT turbines - one that maximizes lift forces (Darrieus) and one drag (Savonius)

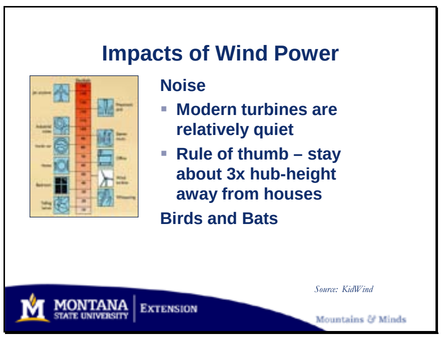
Slide 27

Notes:

•VAWT turbines can take some interesting forms

• Some are mounted on towers while some, like the Savonius, are not.

Slide 28



Notes:

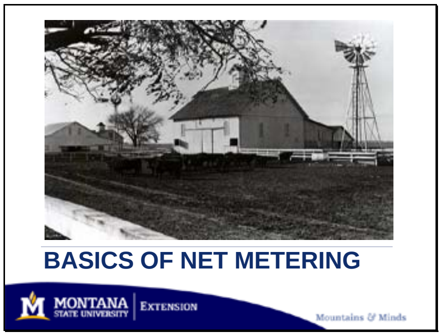
• Noise is a common concern regarding small turbines. Older models were noisy, but most newer equipment is similar to noise levels on the chart.

• Siting can impact noise – siting near a large body of water or metal building may increase noise.

• Constituents worried about noise should consider visiting an installed turbine of the model they are considering

• Bird and bat impacts for small wind has not been studied. There are occasions of bird and bat collisions with small turbines. Industry promoters argue that, statistically speaking, avian impacts are greater from house cats and automobiles than wind turbines. Siting is important - turbines sited in major flyways are more likely to have issues.

Slide 29

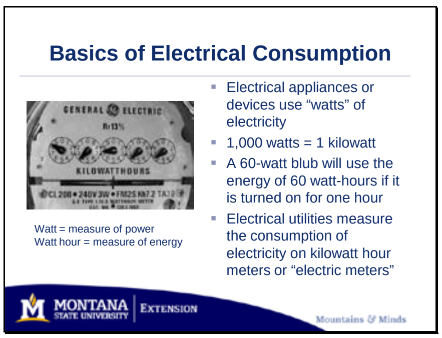


Tips:

• Call for questions on how wind works. Try to keep questions to that specific subject.

• For questions about safety, icing, lightening, etc., refer them to the MSU Extension website.

Slide 30



Notes:

• Wind workshops focused on process called net metering (hand out net metering guide).

• In today's market, net metering is the most common application of small wind technology.

• Off-grid installations become much more complicated as issues such as the home's electrical wiring, battery storage, and other factors must be considered.

• Much of what will be covered in these workshops will also apply to off-grid installations, but if considering off-grid, seek out an experienced off-grid system designer and consultant to help you through the process.

• Review of how energy consumption is measured:

 • To keep things simple, we'll discuss home energy consumption, but the same principles apply to farm or ranch applications.

 • Each time you flip on the lights or turn on an electrical appliance, you consume electricity.

 • Most of us are connected to

electrical utilities such as NorthWestern Energy, a cooperative, or MDU. These electricity providers ensure that electrical current is flowing to our homes and when we use electrical power, that usage is measured by an electrical meter.

• Most of our appliances consume energy in “watts”, which is a measure of energy conversion.

• Every 1,000 watts equals one kilowatt.

•The electrical meter, which is also called a kilowatt hour meter, tracks our electrical consumption and we are billed each month by the utility for the number of kilowatt hours we used in that billing period.

• In simple terms a “watt” is a measure of power, while a “watt-hour” is a measure of energy.

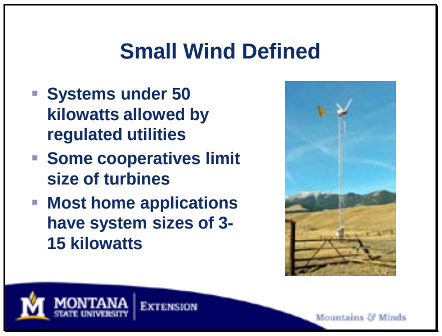
• A light bulb with a power rating of 60 watts will use the energy of 60 watt-hours if it is turned on for one hour.

• In the case of renewable energy generators, the power generator is measured in terms of its power, or kilowatts, but its actual generation is measured in kilowatt hours.

• A kilowatt-hour is the amount of energy equivalent to a steady power of 1 kilowatt running for one hour.

• According to the US Department of Energy, the average Montana household consumed 843 kilowatt hours per month, or 10,116 kilowatt hours in the year 2008.

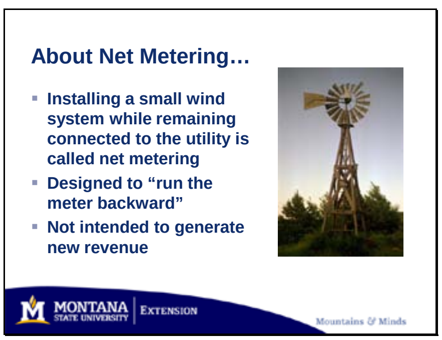
Slide 31



Notes:

- Regulated utilities in MT (NWE and MDU) are required to allow systems up to 50 kw on a net meter basis. (Remind participants not to confuse these with the utility-scale machines which are 1.5-2.5 MEGAwatts)
- Most home systems are between 3-15 kw.
- Most utilities in MT have accepted the 50 kw standard, but the utility should be contacted early in the exploration process with regard to their net metering policy. Policies can be found on the MSU Extension website. If the utility did not have online access to their policy, their contact information is listed.

Slide 32



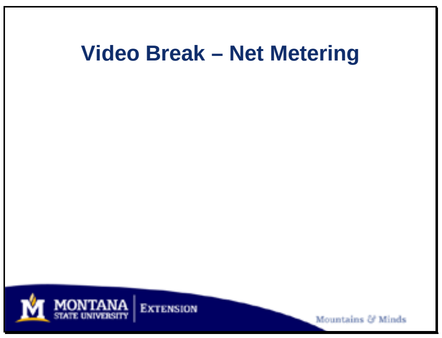
Notes:

- Installing a small wind system while remaining connected to the electrical utility or "grid" is called net metering.
- When the wind turbine is generating electricity, the meter spins "backward" and credits the homeowner's kilowatt hour meter, which reduces the amount of consumption for which the consumer will be billed.
- When the homeowner consumes more electricity than is generated by the wind turbine, electricity is provided by the utility and tracked on the meter. The homeowner then pays the "difference" between the amount generated and the amount consumed (the "net") at the end of each billing period.

Tips:

- Handout "Net Metering in Montana" Montguide.

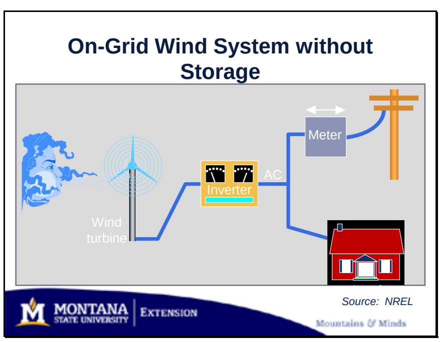
Slide 33



Notes:
• Show Mick Sagrillo video called Electrical Meter.

Tips:
• Download and install this video on your hard drive prior to the workshop.
• Be sure to use speakers to project sound

Slide 34



Notes:
• Simple schematic shows how a wind turbine is connected to the utility grid in a residential net metering application.
• When wind-generated power exceeds the power consumption of the home, the excess power flows back to the utility.
• At other times, power flows from the utility to supplement the wind-generated power.
• An inverter delivers electricity to the home at the same voltage and frequency as the utility grid. It also must turn off automatically if the utility

grid goes down. When that happens, the home is without power.

Slide 35

Some Common Issues

Myth	Reality
• I will get paid for any excess electrical generation	• Net metering in Montana does not pay for excess production
• One turbine will off-set all electrical consumption on my property	• This is only true if all electrical consumption is tied to one meter (one turbine per meter)
• I will run my electrical system seasonally, and then use several months of wind generation to credit that account for a smaller total utility bill	• This will depend on the billing period used by your utility
•I can use my existing kilowatt hour meter	•Most meters will have to be converted for a net metering application. Some utilities will provide this meter, others will ask you to pick up the expense. Ask your utility.

Notes:

- In Montana, utilities do not pay for excess electrical generation for net metered applications. If you produce more than you consume, you will donate the excess to the utility. This means that you need to purchase a system that is sufficient to meet your needs, but do not oversize the system.
- Rural residents often have multiple electrical meters on their properties (home, shop, irrigation meters, etc). In many situations, those meters cannot be tied together. In a net metering application, you can only install one turbine for one meter. So, if you have five meters that cannot be consolidated, you would have to install five wind turbines to off-set all of your meters. However, in many cases one meter will have a higher load than the others.
- For seasonal applications, such as irrigation, it would seem that an irrigator could accumulate a large number of kilowatt hours over the summer and then use the wind turbine generation in the off-season to credit the account. In many situations this is possible, but you need to check with

your electrical utility. Some utilities have a monthly "true up" or billing period which makes seasonal applications difficult when net metering.

- Most meters will need to be changed when installing a net metering application. Sometimes, the utility provides these meters. Other utilities ask you to pick up that cost. Check with your utility about their expectations early in the process.

Slide 36

Notes:
- Show video from IPTV

Activity:
- Have participants watch video and use note cards to write down one thing about the video that surprised them or made them want to ask a question.
- Facilitators – ask participants to share their notes with the class or in small groups (depending on group size).

Tips:
- Download video content prior to session.

Slide 37

Any Questions?

Next Segment –

- **Your Objectives & Consumption**
- **Assessing Your Small Wind Resource**

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Mountains & Minds