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SLIDES: Sources of Electrical Energy for Those Who Are Remote and Poor

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Sources of Electrical Energy for Those Who Are Remote and Poor

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Outline

1. Some issues to consider.
2. Some Possible Sources of Electrical Energy
 - A. Wind
 - B. Micro Hydro
 - C. Solar PV and Solar Thermal
 - D. Biomass

Note the usefulness of all these source are location dependent.
3. Some Examples

Some Requirements for Successful Projects

1. Buy in by the local population.
2. Training and an organizational structure to operate, finance and maintain the system.
3. Solve problems of getting the materials into the villages, corruption, government regulations.

Some Data From India

Reference Rural Electrification in India J.Cust,
A. Singh, Karsten Neuhoff , JEL Coeds D23,L94,Q42

1. The government has stated a goal of delivering free power to rural India and has a number of projects underway.
2. 70% of the population in India is rural and 25% of the worlds poor. 55% have some access to electricity leaving 20 million without as of 2006. Target all by 2012. (Note another reference gives 300 million with no electricity)
3. Problems , politics, economics, corruption
4. The rural population is willing to pay from 5 to 10 Rs /kWh
5. Typically grid tariffs for poor rural households range from Rs. 0-10/month for the poorest households and Rs. 0-130/month for remaining domestic customers and use about 15kwh/month
6. Roughly 50 Rs (Rubies) to \$1 US

Some Major Projects In India

Expansion of the Grid:

- A. Because of subsidies this is the cheapest power for the user.
- B. Typically grid tariffs for poor rural households range from Rs. 0-10/month for the poorest households and Rs.0-130/month for remaining domestic customers.
- C. Typically grid tariffs for poor rural households range from Rs. 0-10/month for the poorest households and Rs. 0-130/month for remaining domestic customers
- C. The grid has high losses and is unreliable with many outages.

Private Distributed Systems

- (1) Diesel Generators Common Costs
 - of Rs. 5 to 13/ kWh with fuel at Rs. 35/liter and estimated installed capacity of 10GW

Biomass Conversion

1. The electric power demand in most Indian villages lies between 20kw-100kw and the locally available surplus biomass is often sufficient to meet these power requirements (Bharadwaj and Tongia 2003).
2. Fuel sources include agriculture wastage, wood, and animal dung.
3. Current installed capacity stands at around 350 MW, with small-scale systems representing around 43MW of this, across 1800 systems.
4. Potential for many more.
5. Problems of Sustainability of fuel and competition for land use for food.
6. Past studies have put the typical cost per unit between Rs. 2.5/kWh and Rs. 7.5/kWh, with cost sensitive to load factor and fuel availability (Tripathi et al. 1997; Banerjee 2006; Nouni et al. 2007).

Micro Turbine

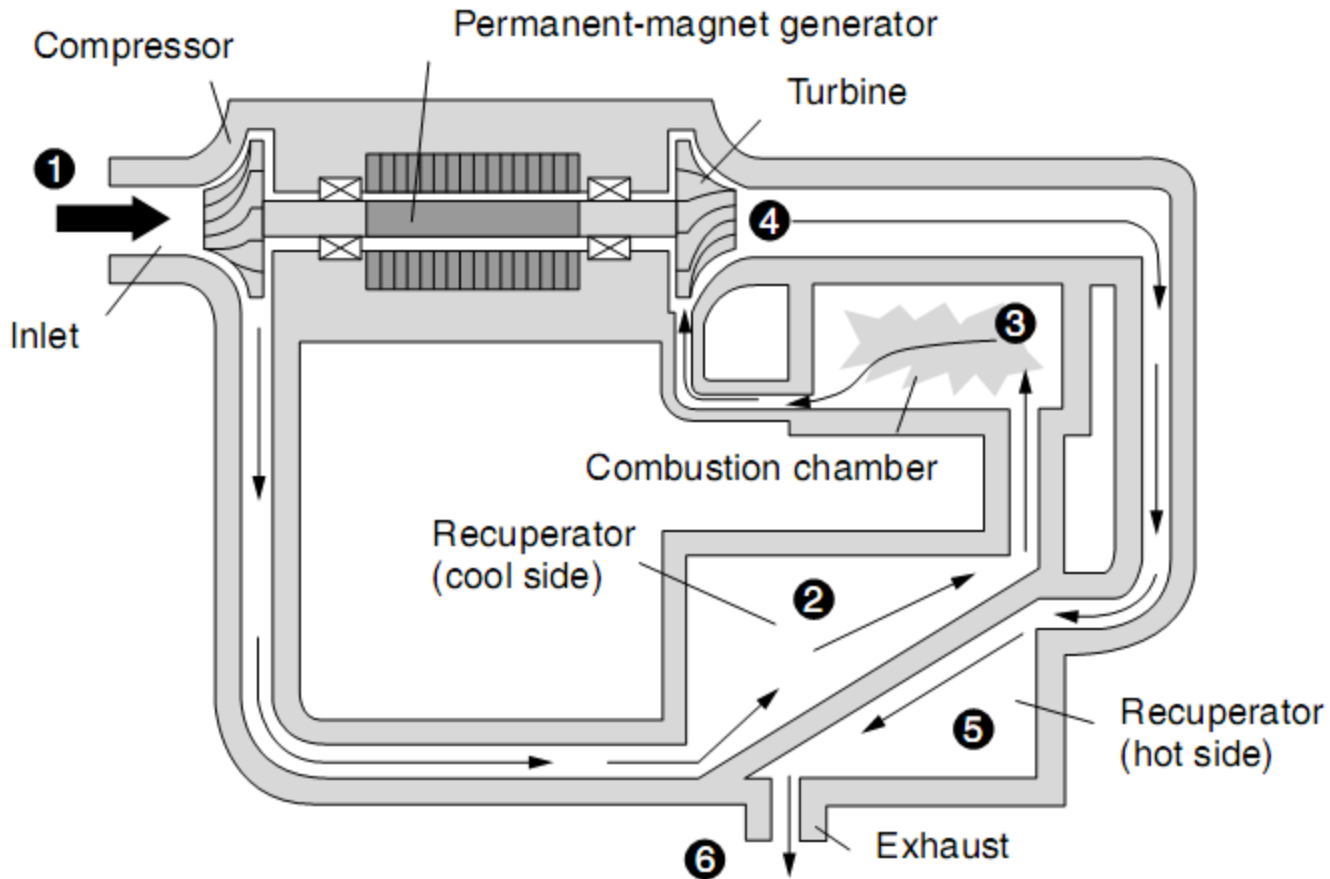


Figure 4.1 Microturbine power plant. Air is compressed (1), preheated in the recuperator (2), combusted with natural gas (3), expanded through the turbine (4), cooled in the recuperator (5), and exhausted (6). From Cler and Shepard (1996).

Micro Hydro in Colorado



- Brian Campbell, P.E., Daniel Zimmerle, Colorado State University

DROP SUB-CATEGORY	DEFINITION
Vertical Drop*	Vertical drops are structures that enable a change in elevation over a very short length of canal alignment.
Chute*	Chutes are typically used where water is conveyed over long distances and along grades that may be flatter than those for drops but steep enough to maintain supercritical velocities.
Pipeline*	A pipeline is a closed conduit structure used to convey water.
Check Drops*	Check drops are vertical drop structures with a check structure integrated on the upstream end.
Gate Drops	A gate drop incorporates a gate structure on the upstream end of the change in elevation of the canal thalweg.
Siphon	Siphons (sometimes referred to as inverted siphons) are closed conduits that convey water under existing infrastructure, usually with the headwater and tailwaer above the lowest point in the siphon alignment.
Steep Grade Change	This classification was used to identify a section of canal defined as a “steep” slope with normal depth below critical depth. Examples of this type of grade change were generally analogous to short chutes.
Engineered Drop Structure	Although all structure classifications listed above are engineered, an engineered drop structure classification is used to define a drop structure with a specific energy dissipation function, such as baffle chutes, spillways with stilling basins, and general structures that were either cast in place or constructed offsite and placed within a canal alignment.

***Definitions as listed in Site Inventory and Hydropower Energy Assessment of Reclamation Owned Conduits, 2012**

Figure 3: Vertical Drop	Figure 4: Chute
Figure 5: Pipeline	Figure 6: Check Drop
Figure 7: Gate Drop	Figure 8: Entrance to Siphon

Micro Hydro

1. Requirements a meter to few meters of vertical drop and some water flow.

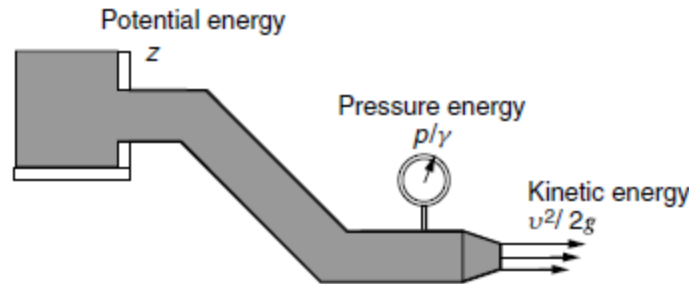


Figure 4.17 Transformations of energy from potential, to pressure, to kinetic.

$$\text{Energy head} = z + \frac{p}{\gamma} + \frac{v^2}{2g} \quad (4.3)$$

where z is the elevation above a reference height (m) or (ft), p is the pressure (N/m^2) or (lb/ft^2), γ is the specific weight (N/m^3) or (lb/ft^3), v is the average velocity (m/s) or (ft/s), and g is gravitational acceleration (9.81 m/s^2) or (32.2 ft/s^2).

Pelton Turbine Aurora Power and DesignCorp.



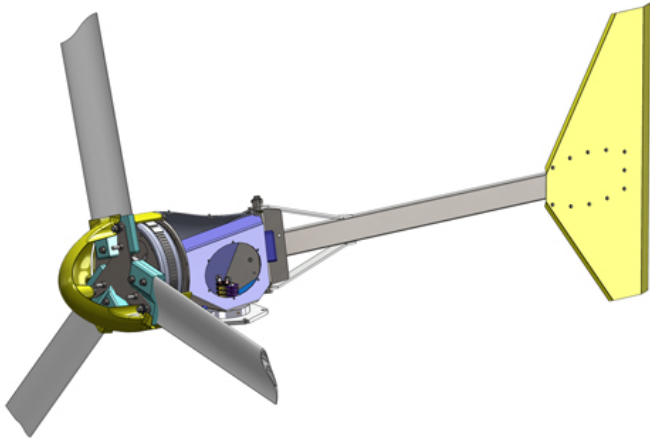
- Ruggedly built, twin nozzle, 1300W micro hydro turbine. Comes with all parts and tools for field assembly. (More pictures and Video below, scroll down!) Price \$1,250

Power Spout BE = Battery Enabled. This means it is designed to directly charge 12v 24v or 48v batteries. A good choice for off-grid installations where the turbine is within 100ft (30meters) of the battery bank. Requires a load dump [charge controller](#) to protect the battery bank.

Micro Hydro Projects

1. In India 267 projects and 210 MW and the potential for 15GW more.
2. Price from Rs. 124,310/kW to Rs. 233,335/kW as of 2003 including excavation, transmission etc.
3. This leads to costs of Rs. 3 to Rs. 9/kWh depending on location utilization.
4. Problems include variations in stream flow with season.

Wind and Wind Hybrid



Background

- Wind turbines in remote places are typically much more expensive to construct
 - Increased shipping & preparation costs
 - Difficulty finding local labor
 - Difficulty finding equipment and supplies
 - Bring everything with you
 - Crane? Some turbines can tilt up/down
- These prices may seem higher than other literature
 - That's why so many small turbine manufacturers are now bankrupt

Bergey Excel 5

- 5 kW wind turbine, made in USA
- Makes 7-12,000 kWh/year in good wind site
- Battery charging models available
- Equipment costs: \$40-60,000 (depending on options and tower height)
- Install costs (estimated): \$50-100,000
- Total up-front cost: \$90-160,000
- Service costs: \$2,500/year plus travel

Gaia 133-11kW

- 11 kW wind turbine, made in UK
- Makes 20-35,000 kWh/year in good wind site
- Battery/diesel controls extra
- Equipment costs: \$70-100,000 (turbine & tower), \$50-100,000 (battery/diesel controls)
- Install costs (estimated): \$75-150,000
- Total up-front cost: \$195-350,000
- Service costs: \$2,500/year plus travel

AOC 15/50

- 50 kW wind turbine, made in Canada
- Makes 60-100,000 kWh/year in good wind site
- Battery/diesel controls extra
- Equipment costs: \$150-200,000 (turbine & tower), \$50-100,000 (battery/diesel controls)
- Install costs (estimated): \$100-200,000
- Total up-front cost: \$300-500,000
- Service costs: \$5,000/year plus travel

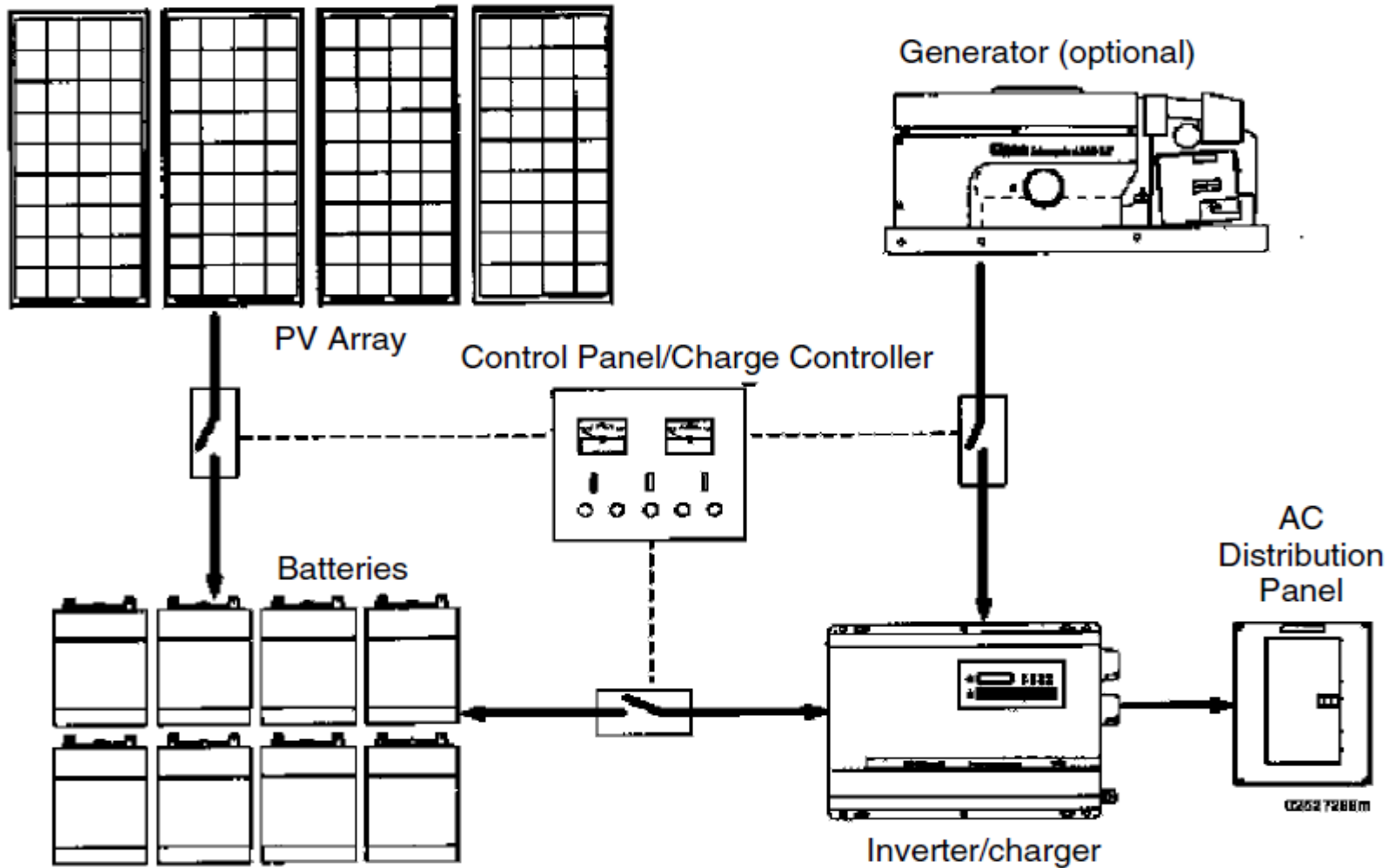
Northwind N100

- 100 kW wind turbine, made in USA
- Makes 150-250,000 kWh/year in good wind
- Battery/diesel controls extra
- Equipment costs: \$500-600,000 (turbine & tower), \$25-50,000 (battery/diesel controls)
- Install costs (estimated): \$150-300,000
- Total up-front cost: \$675-950,000
- Service costs: \$5,000/year plus travel

Wind In India

- The wind resource is generally poor in many parts of India, Hansen and Bower estimate a potential for around 45GW across 13 states (Hansen and Bower 2003).
- They show wind-hybrid systems to be viable for decentralized generation where average wind speeds exceed 4.75m/s.
- The cost estimates are highly sensitive to scale, load factor, wind resource and choice of back-up/supplementing generation.
- Diesel and increasingly biomass gasification technology are chosen to supplement wind power, with per kWh cost estimates ranging from between Rs.7/kWh and Rs.10/kWh; our fieldwork puts the estimated cost per unit around Rs8/kWh.

Typical Photo Voltaic Array



Solar Photovoltaic and Solar Thermal



Solar Powered Communications In Peru



Solar Photovoltaics in India

- India enjoys between 250-300 sunny days per year, translating to between 4-7kwh/m² (compared to an average of 2.7kwh/m² in UK and Germany).
- Capital costs of between \$3,000/kW and \$6,000/kW (Hansen and Bower 2003)
- This is low by comparison to other data of about \$10,000/kW installed.