DOE OFFICE OF INDIAN ENERGY

# Foundational Courses
# Renewable Energy Technologies
# Hydroelectric

Presented by the National Renewable Energy Laboratory



U.S. DEPARTMENT OF ENERGY | Office of Indian Energy

# Course Outline

## What we will cover…

- About the DOE Office of Indian Energy Education Initiative
- Course Introduction
- Resource Map & Project Scales
- Technology Overview:
  - Siting
  - Costs
- Successful Project Examples
- Policies Relevant to Project Development
- Additional Information & Resources

# Introduction

The U.S. Department of Energy (DOE) Office of Indian Energy Policy and Programs is responsible for assisting Tribes with energy planning and development, infrastructure, energy costs, and electrification of Indian lands and homes.

As part of this commitment and on behalf of DOE, the Office of Indian Energy is leading *education* and *capacity building* efforts in Indian Country.

# Training Program Objective & Approach

Foundational courses were created to give tribal leaders and professionals background information in renewable energy development that:

- *Present foundational information on strategic energy planning, grid basics, and renewable energy technologies;*
- *Break down the components of the project development process on the commercial and community scale; and*
- *Explain how the various financing structures can be practical for projects on tribal lands.*

# NREL Presenter on Hydroelectric Power

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Mr. Roberts graduated with a Masters of Science and Mechanical Engineering in 2007 and first worked on wind farm as a field engineer. In 2009, he began his career at the National Renewable Energy Laboratory (NREL) with modeling wind, solar, and hydropower technologies. Mr. Roberts also provides international technical assistance for energy development for rural populations including the design, analysis, and implementation of remote power systems.

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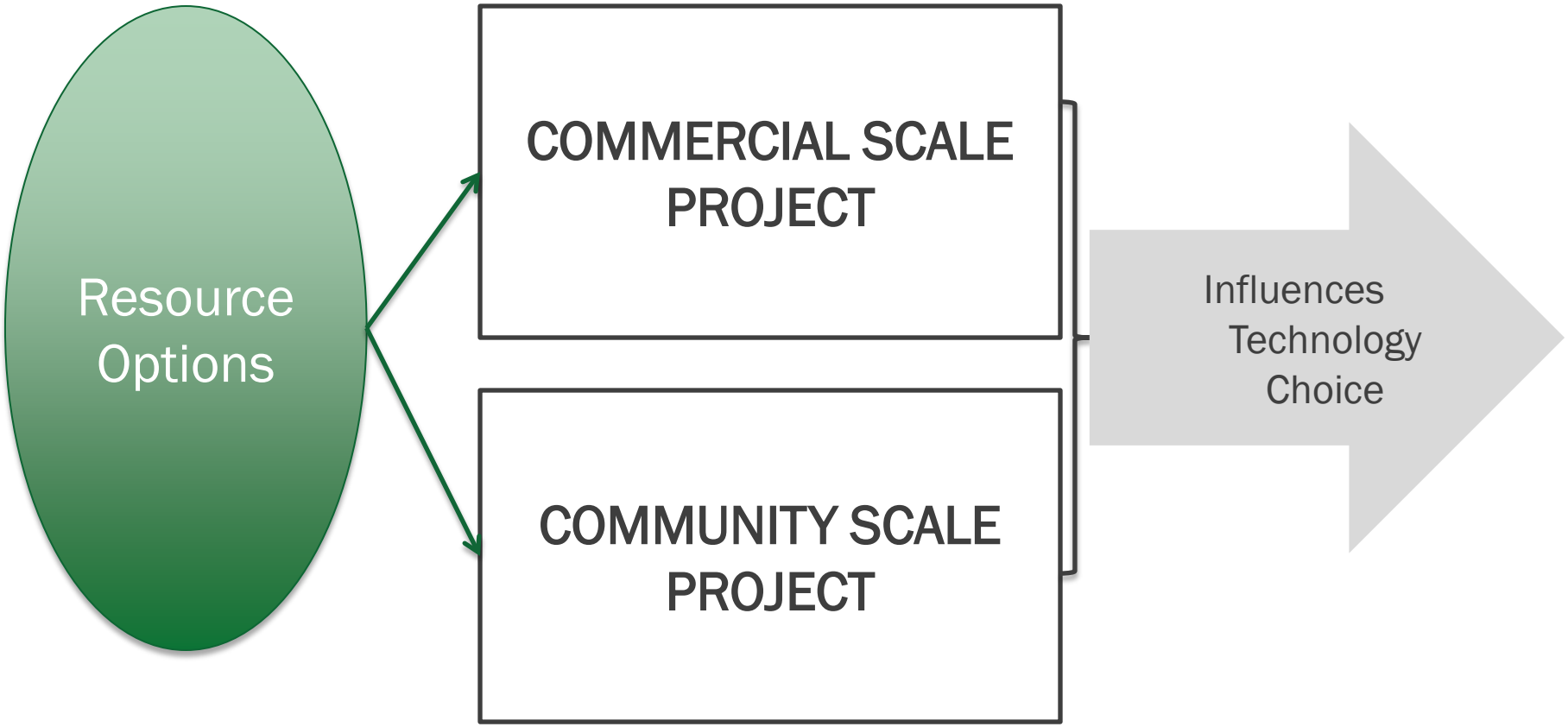
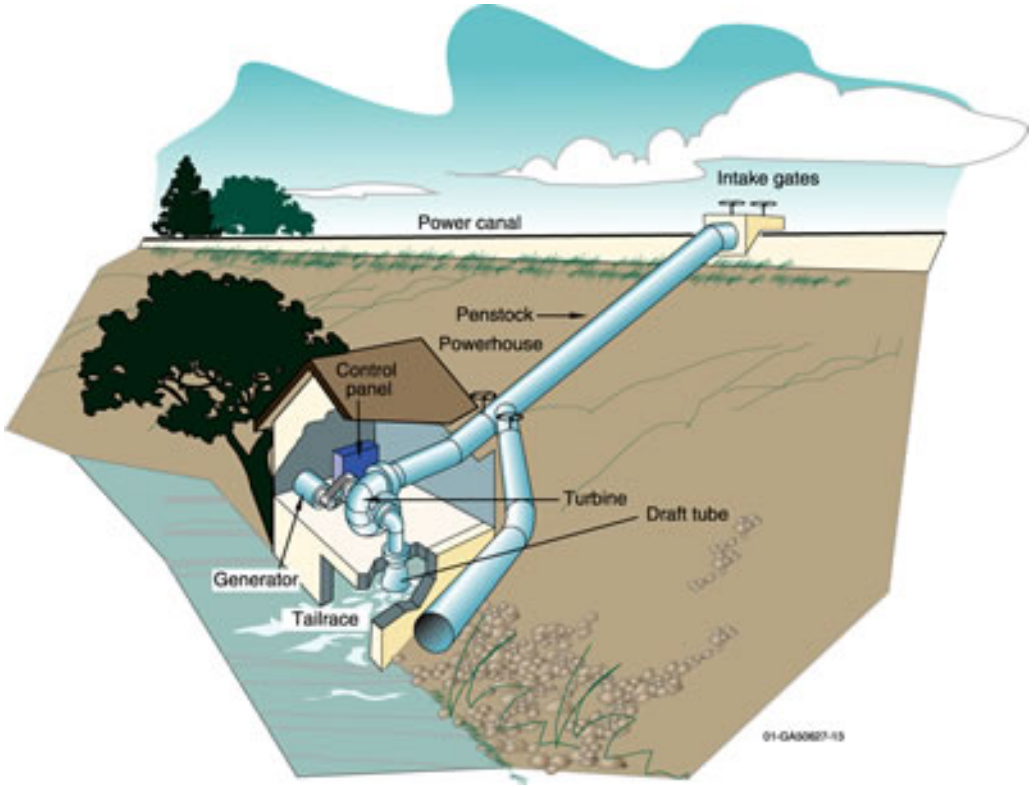
# Commercial or Community Scale?



# Scale of Hydroelectric Power Plants




Source: http://www1.eere.energy.gov/water/hydro_plant_types.html

## Macro Hydropower

- Although definitions vary, DOE defines large hydropower as facilities that have a capacity of more than 30 megawatts (MW).

## Small Hydropower

- Although definitions vary, DOE defines small hydropower as facilities that have a capacity of 100 kilowatts (kW) to 30 MW.

## Micro Hydropower

- A micro hydropower plant has a capacity of up to 100 kW. A small or micro-hydroelectric power system can produce enough electricity for a home, farm, ranch, or village.

# Types of Hydroelectric Power

Source: NREL/PIX 17874

Marine Hydrokinetics–Wave Power

- Waterwheels, used for hundreds of years to power mills and machinery.
- Hydroelectricity, usually referring to hydroelectric dams or run-of-the-river setups.
- Damless hydro, which captures the kinetic energy in rivers, streams, and oceans.
- Tidal power, which captures energy from the tides in horizontal direction.
- Marine Hydrokinetics, which captures mechanical power from the waves and tides and uses it to directly or indirectly power a turbine and a generator.

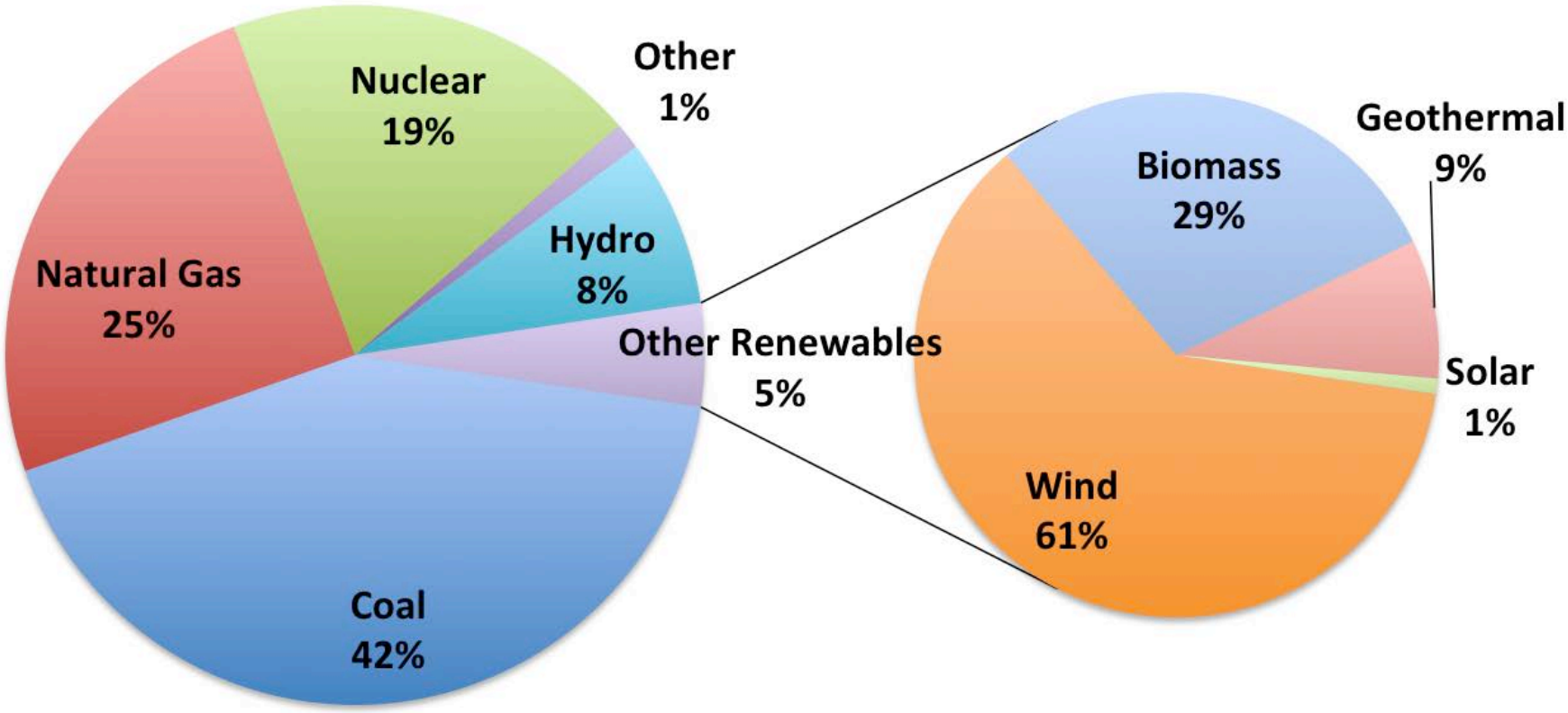
# Potential Resources


Virtual Hydropower Prospector Region Selector
http://hydropower.inel.gov/prospector/index.shtml

- Conventional hydro (low power to large hydro = 62,300 MW):
  - Capacity gains at large and small hydro = 4,300 MW
  - New small (<30 MW) and low (<1 MW) hydro = 58,000 MW
  - New hydro at existing dams = (16,700 MW included above)
  - [Efficiency gains (4%) = 3,100 MW]
- Hydrokinetic = 12,800 MW (tidal only assessed for five states, ocean current not assessed)
- Wave Energy = 10,000 to 20,000 MW
- Pump storage not assessed

**TOTAL = 85,100 to 95,100 MW**

# U.S. Electricity Generation 2012




Source: U.S. Energy Information Administration (EIA), May 29, 2012

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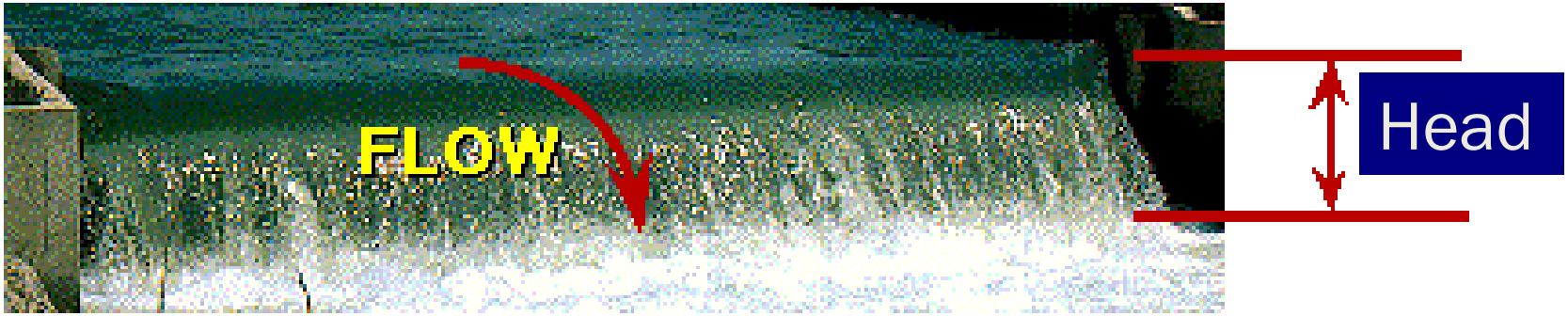
# Technology Overview

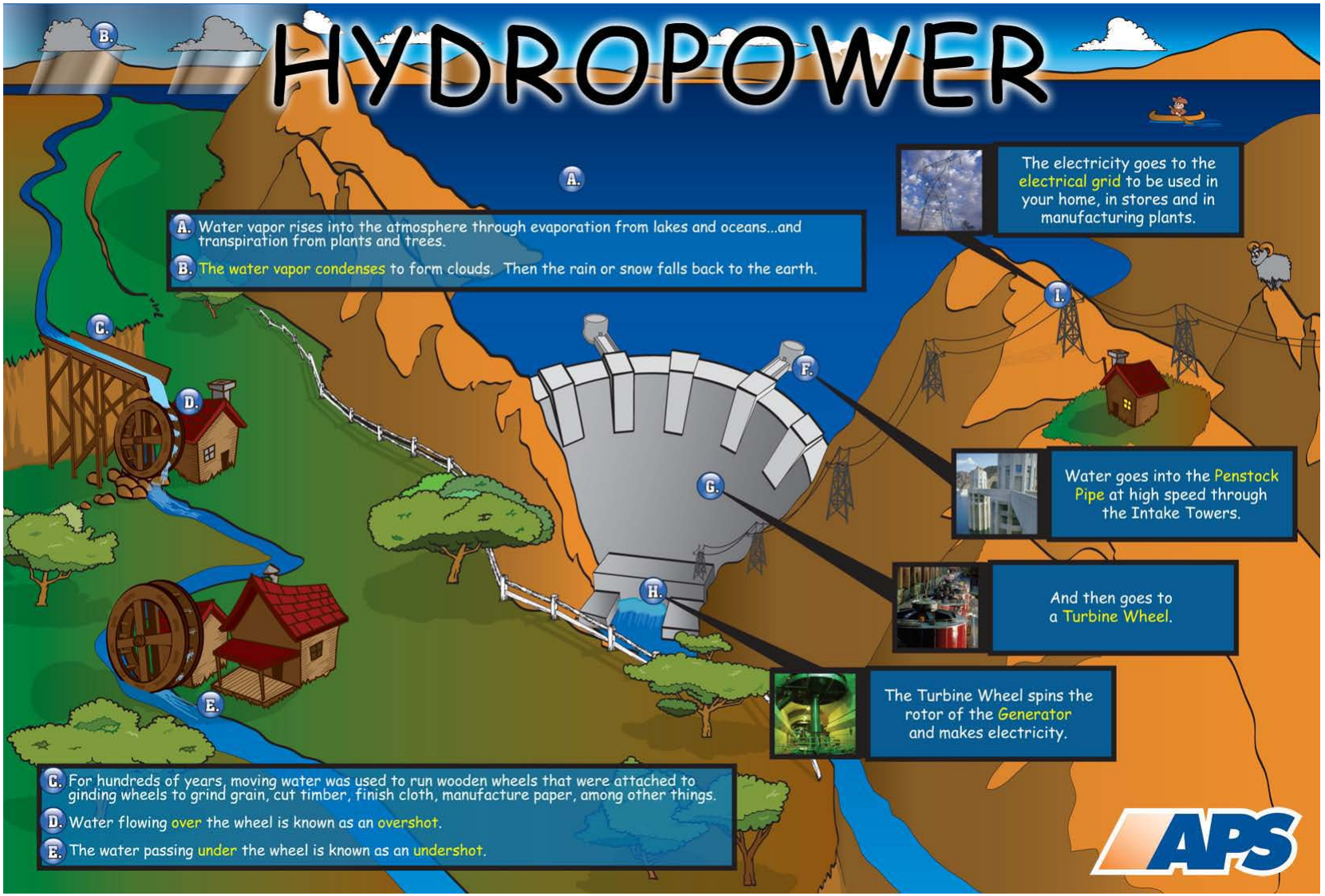



Power (kW) = 10 x Flow ($m^3/s$) x Head (m) x $\eta$

Power (kW) = Head (ft) x Flow (cfs) x $\eta$ /11.8

$\eta$= turbine-generator efficiency ~80%

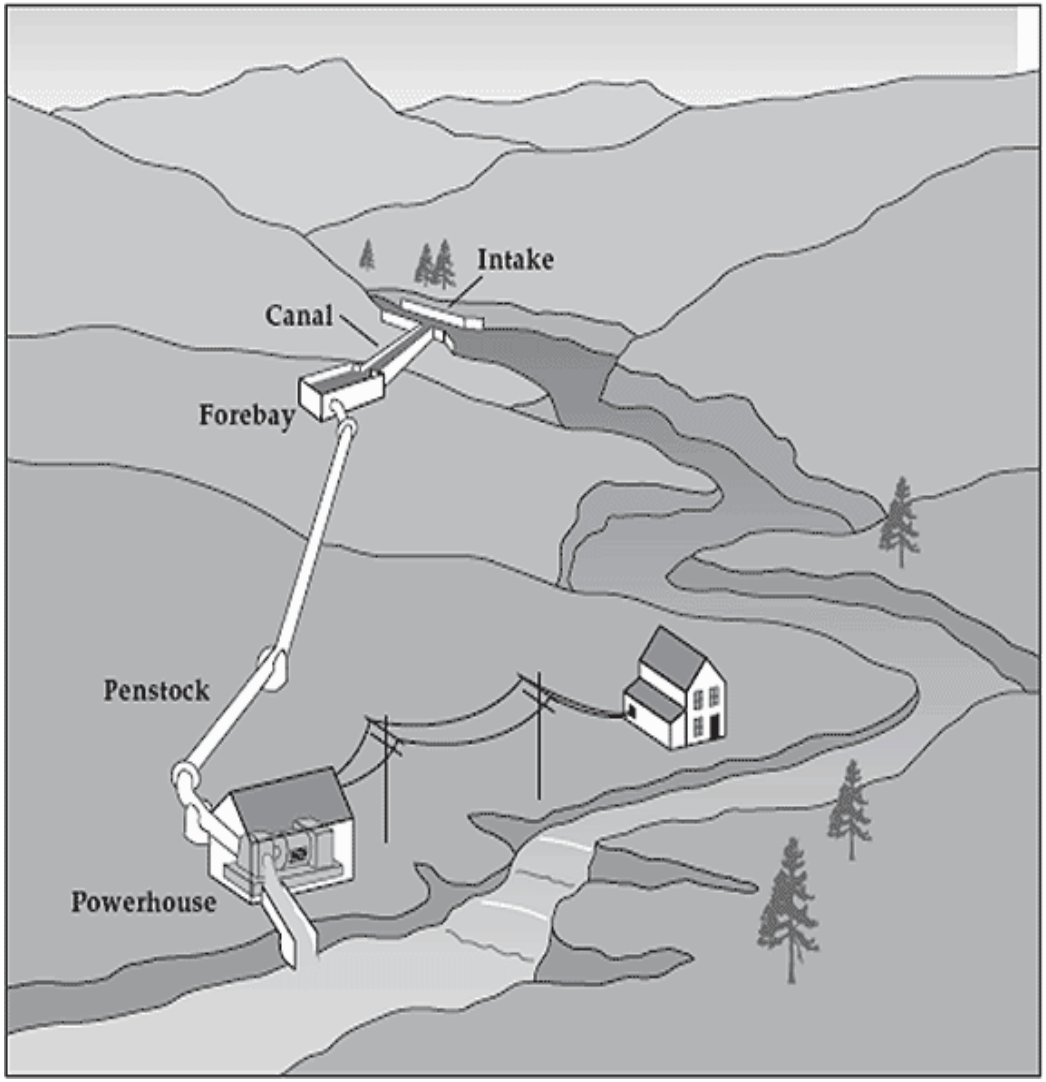
# Technology Overview






Source: APS, http://www.aps.com/_files/renewable/Hydropower.pdf

# Technology Overview – Hydroelectric Components

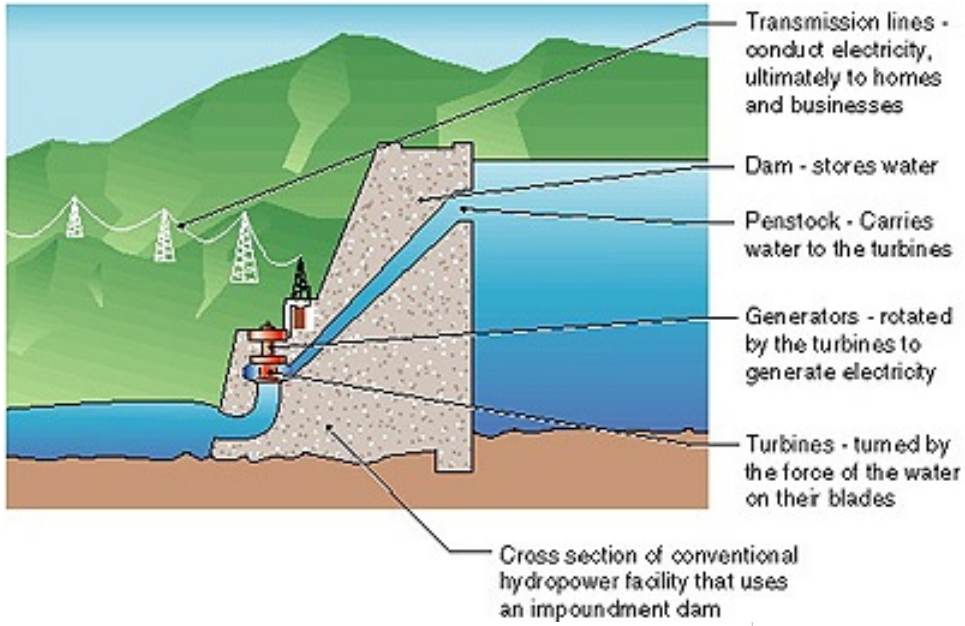



Source: NREL

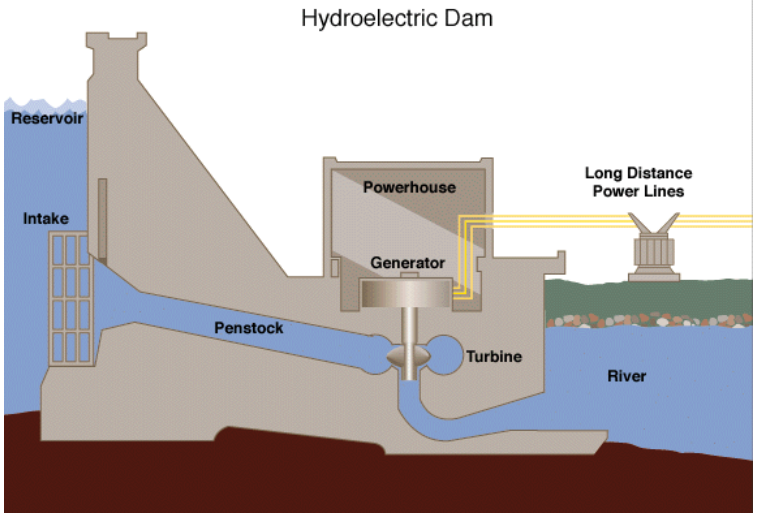
Hydropower plants are composed of three basic components:

1. A water diversion or intake system,
2. A pipeline or penstock to move the water, and
3. A powerhouse.

# Technology Overview and Siting issues – Impoundment




Cross section of conventional hydropower facility that uses an impoundment dam




- The most common type of hydroelectric power plant
- Typically a large hydropower system
- Uses a dam to store river water in a reservoir
- Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity
- Water may be released either to meet changing electricity needs or to maintain a constant reservoir level
- Significant impacts on fish, land area; potential hazard of dam breaks
- Constraints on seismic areas
- No significant installations in U.S, in past 50 years, other countries such as China and Argentina moving forward with large installations



Graphics Source: http://www1.eere.energy.gov/water/hydro_plant_types.html

# Technology Overview and Siting – Diversion Hydro

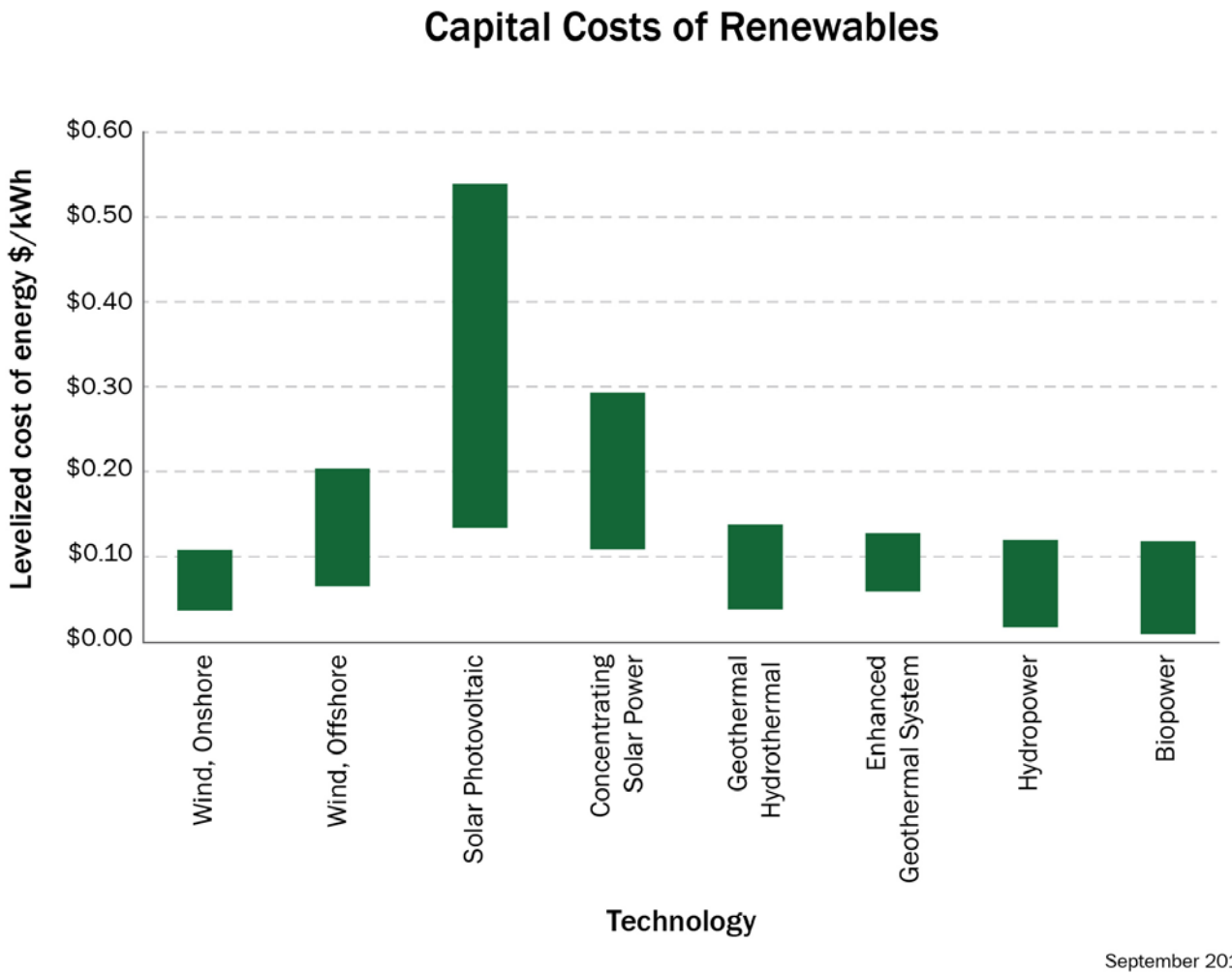

- A diversion, sometimes called run-of-river, facility channels a portion of a river through a canal or penstock
- It may not require the use of a dam
- Typically no storage opportunities as with impoundment, lower capital costs due to lack of dam
- Fewer concerns with fish and less land area impact than with impoundment



Image Sources left to right: Encyclopedia of Alternative Energy and Sustainable Living; NREL/PIX 06595

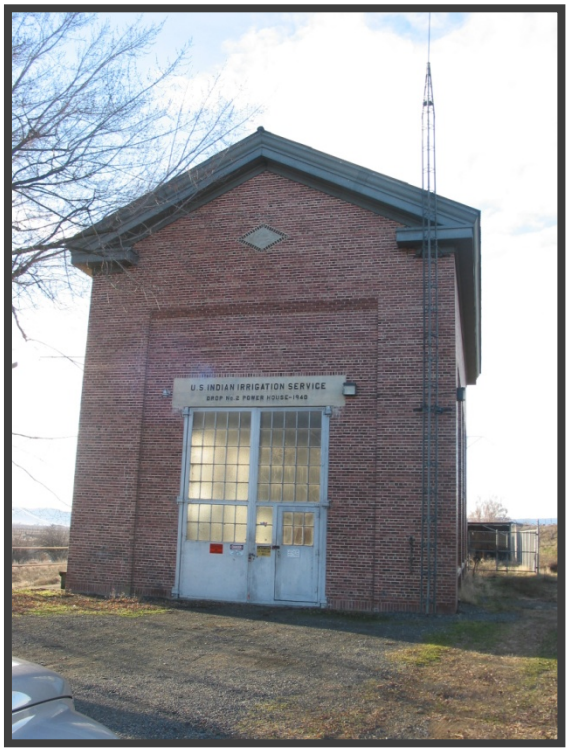
# Costs

- High capital costs for hydroelectric projects in general, but typically much higher capacity factors resulting in lower levelized cost of energy (LCOE).




Source: http://en.openei.org/apps/TCDB/

# Wapato Hydropower Project: Successful Example

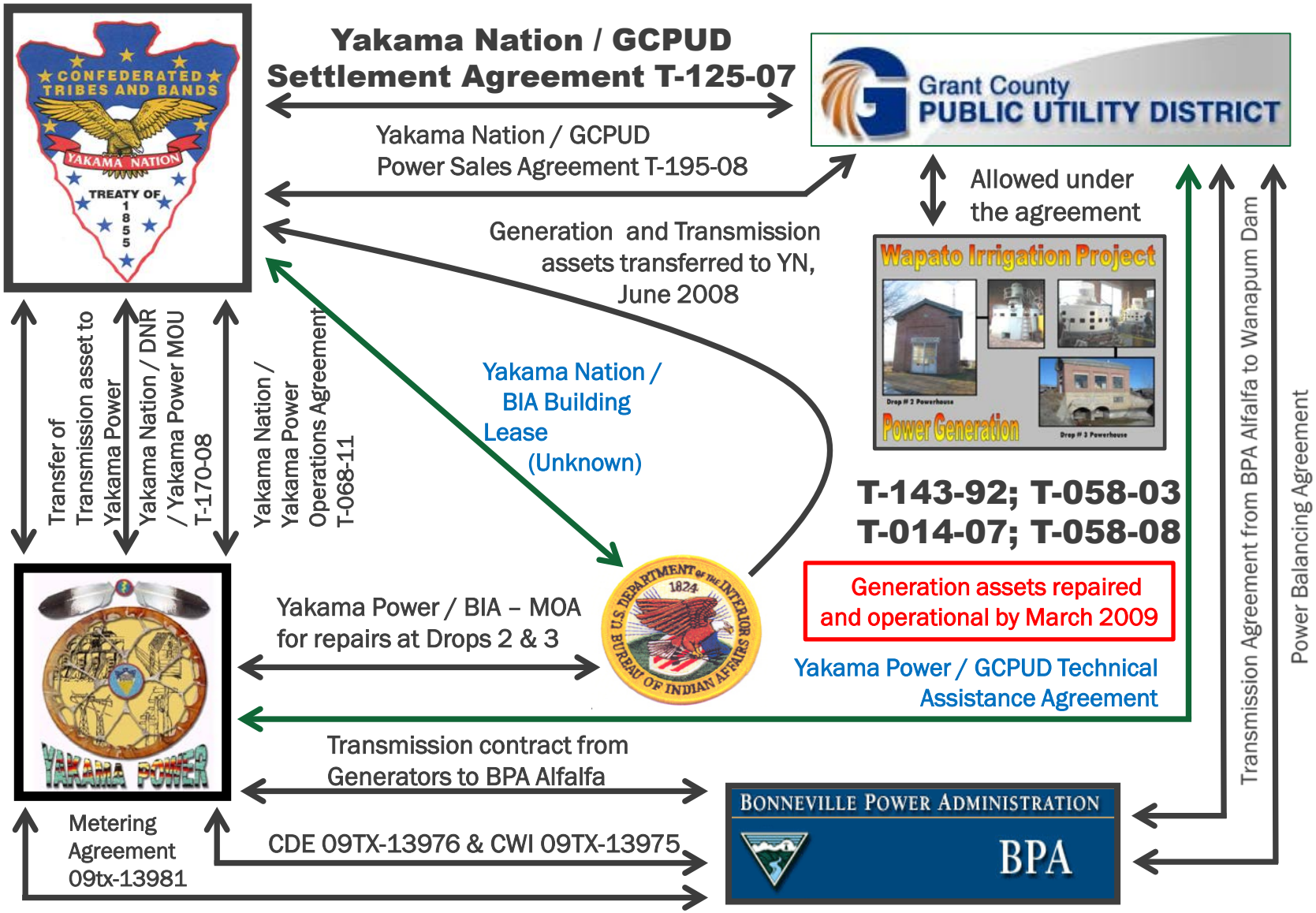



Drop Site 2 Powerhouse

YAKAMA POWER

Source: Yakama Power

# Wapato Hydropower Project Continued



# Traditional Dinner for Hydro Project Opening – 2009

Source: Yakama Power

# Wapato Drop 2 Opening Ceremony

Source: Yakama Power

# Hydro Equipment – Expensive but Lasting Investment

Source: NREL/PIX 12811

# Hydro Equipment Endures for Decades




Source: Yakama Power

# More Tribal Hydropower Information

- http://nhd.usgs.gov/
- http://www.prism.oregonstate.edu/
- http://www.yakamapower.com/generation.php
- http://apps1.eere.energy.gov/tribalenergy/projects_detail.cfm/project_id=168
- http://apps1.eere.energy.gov/tribalenergy/projects_technology.cfm#Hydropower

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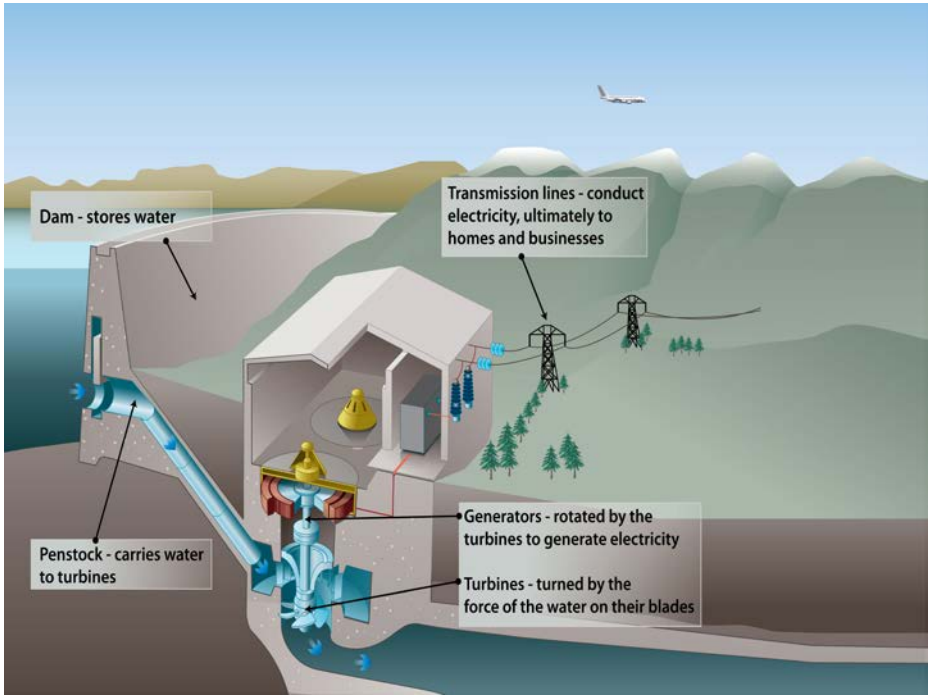
# Policy: Federal Energy Regulatory Commission (FERC)




The Commission's responsibilities include:

- Issuance of licenses for the construction of a new project
- Issuance of licenses for the continuance of an existing project (relicensing) and new projects
- Oversight of all ongoing project operations, including dam safety inspections and environmental monitoring

http://ferc.gov/industries/hydropower.asp

Photo: NREL/PIX 13518; Graphic: NREL

# What we covered…

| | |
|---|---|
| ▪ About the DOE Office of Indian Energy Education Initiative | √ |
| ▪ Course Introduction (Takeaways) | √ |
| ▪ Resource Map & Project Scales | √ |
| ▪ Technology Overview: | √ |
| - Siting | √ |
| - Costs | √ |
| ▪ Successful Project Examples | √ |
| ▪ Policies Relevant to Project Development | √ |
| ▪ Additional Information & Resources | |

# Useful Resources

| | |
|---|---|
| **RESOURCE** | NREL Geographic Information System (GIS) Maps<br>www.nrel.gov/gis/maps.html |
| **TECHNOLOGY** | Virtual Hydropower Prospector<br>http://hydropower.inel.gov/prospector/index.shtml |
| **POLICY** | Federal Energy Regulatory Commission (FERC)<br>http://ferc.gov/industries/hydropower.asp |

# Thank You & Contact Information

For Technical Assistance:
IndianEnergy@hq.doe.gov

DOE Office of Indian Energy Website:
www.energy.gov/indianenergy

NREL Technology Websites:
www.nrel.gov/learning/re_basics.html

**Joseph "Owen" Roberts**
**Joseph.roberts@nrel.gov**

# INFORMATION ON THE CURRICULUM PROGRAM & OFFERINGS

# Curriculum Structure & Offerings

**Foundational Courses**

- Overview of foundational information on renewable energy technologies, strategic energy planning, and grid basics

**Leadership & Professional Courses**

- Covers the components of the project development process and existing project financing structures

# Foundational Courses

## Energy Basics

- Assessing Energy Needs and Resources
- Electricity Grid Basics
- Strategic Energy Planning

## Renewable Energy Technology Options

- Biomass
- Building Heat & Hot Water
- Geothermal
- Hydroelectric
- Solar
- Wind

All courses are presented as 40-minute Webinars online at
www.energy.gov/indianenergy