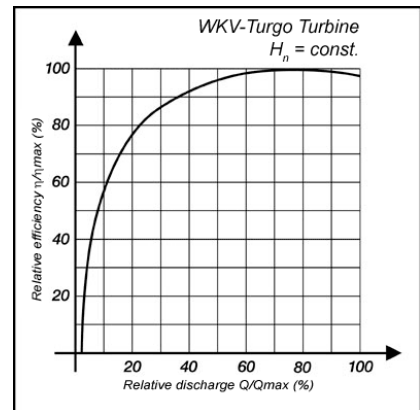


Hydroelectricity Discussion Questions  
Based on Wengenmayr and Bührke, pp. 22-25

1. What are the two types of hydroelectric power plants?
  - River power plants – primary energy production
  - Storage power plants – compensate for variations in demand
  
2. What are the two uses of storage power plants?
  - Storage power plants – collect snowmelt runoff at high elevations into a reservoir
  - Pumped storage power plants – Since energy is used to pump the water to higher elevation, no new energy is generated by pumped storage. Pump during low demand time, release during peak demand.
  
3. p. 23, first paragraph “there is no other mechanical device which attains such a high power density as a modern water turbine.” What does this mean, high power density? (Read the next sentence.) **[ANS: Power output compared to the size of the machine.]**
  
4. “How much energy a turbine can deliver depends essentially on the velocity and the amount of water that flows through it.” Let’s do some analysis. The power from the water motion (kinetic energy) is

$$\text{Power} = \rho \cdot g \cdot h \cdot Q \cdot \text{eff}$$

Efficiency  $\swarrow$   
 $\uparrow$   $\uparrow$   $\uparrow$   $\uparrow$   
 Density of water, kg/m<sup>3</sup>    9.8 m/s<sup>2</sup>    Height of water, m    Flow rate, m<sup>3</sup>/s



The variable “*h*” is referred to as “water head”. This equation gives the power available from the water. But this power must turn a turbine to become electricity. In the process some of the power is lost. The fraction of water power that turns into electricity is called the efficiency.

Try this problem: Estimate the volume flow rate needed for the 3 Gorges Dam. **[ANS: *h*=175 m, *P*=18.2 GW → 10,600 m<sup>3</sup>/s which is a 22mx22mx22m cube, also 82 miles<sup>3</sup>/year]**

5. What are some reasons why some of the power from the water never turns into electricity?  
[ANS: Some water passes through cracks, friction] How do you think the three types of turbines described in Figure 1 compare for efficiency? **[Answer depends on flow rate: Kaplan best at low flow, Pelton at very high flow rates. Francis is good from moderate to very high – and is used in 3 Gorges.]**
  
6. Compare the power output of a small-scale hydroelectric plant to a large scale plant, in particular to the largest plant in the world. **[ANS: 320 kW versus 18.2 GW]**
  
7. What seems to be the biggest challenge to implementing small-scale hydroelectric plants?  
**[ANS: High capital intensive projects require a large initial investment, which when compared to fossil fuels is a deterrent. This is in spite of the fact that hydro equipment has a very long useful life ~80 years.]**
  
8. Are hydroelectric plants CO<sub>2</sub> free? Compare the greenness of hydro vs. coal. **[ANS: Hydro is a few grams of CO<sub>2</sub> per kWh. Coal is 1 kg of CO<sub>2</sub> per kWh.]**