Turbine selection
FIGURE 9.1. Vertical hydroelectric units.

1: rotor, 2: stator, 3: runner, 4: turbine case, 5: stayring, 6: guide vanes, 7: draft tube, 8: shaft,
9: flange, 10: upper spider, 11: lower spider, 12: head cover, 13: supporting structure
2. Powerhouse of Saratov Hydro with axial-flow adjustable blade turbine
   1 — Generator; 2 — runner; 3 — draft tube; 4 — spillway; 5 — screen and gate slots; 6 — main crane.

FIGURE 9.3. Powerhouse of Nurek Hydro with radial-axial flow turbine.
   1 — Generator; 2 — runner; 3 — draft tube; 4 — ball gate; 5 — transformer; 6 — main crane.
FIGURE 9.8. Reaction turbine design, specific speed.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>K15</th>
<th>K20</th>
<th>K30</th>
<th>K40</th>
<th>K50</th>
<th>K60</th>
<th>K70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum head (m)</td>
<td>15</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Reduced speed (rpm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal $(n'_{\text{opt}})$</td>
<td>160</td>
<td>145</td>
<td>125</td>
<td>120</td>
<td>115</td>
<td>110</td>
<td>105</td>
</tr>
<tr>
<td>Average design $(n'_{\text{id}})$</td>
<td>180</td>
<td>155</td>
<td>140</td>
<td>135</td>
<td>125</td>
<td>125</td>
<td>120</td>
</tr>
<tr>
<td>Reduced flow rate maximum design flow rate $(Q'_{\text{id}} \text{, L/s})$</td>
<td>2300-1900</td>
<td>2200-1750</td>
<td>2000-1500</td>
<td>1700-1300</td>
<td>1500-1200</td>
<td>1300-1100</td>
<td>1250-1000</td>
</tr>
<tr>
<td>Cavitation coefficient $\alpha$ corresponding to $Q'<em>{\text{id}}$ and $n'</em>{\text{id}}$</td>
<td>1.4-0.9</td>
<td>1.3-0.8</td>
<td>1.0-0.65</td>
<td>0.75-0.50</td>
<td>0.55-0.40</td>
<td>0.45-0.30</td>
<td>0.4-0.28</td>
</tr>
<tr>
<td>Number of runner blades $(z_i)$</td>
<td>4</td>
<td>4</td>
<td>5-6</td>
<td>6-7</td>
<td>7-8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Relative height of wicket gate $(b_0)$</td>
<td>0.42</td>
<td>0.4</td>
<td>0.4</td>
<td>0.375</td>
<td>0.375</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Relative diameter of runner hub (case) $(\delta_{c,s})$</td>
<td>0.35</td>
<td>0.37</td>
<td>0.41</td>
<td>0.43</td>
<td>0.47</td>
<td>0.51</td>
<td>0.57</td>
</tr>
</tbody>
</table>

**FIGURE 9.6.** Basic dimensions of adjustable blade turbines. (a) Axial-flow; (b) mixed-flow.
FIGURE 9.9. Turbine specific mass factor dependence from head.
FIGURE 5.16. The dependence of reduced parameters from rated specific speed in turbines.
FIGURE 9.11. Universal characteristic of Pelton turbine. (Single-nozzle with 18 runner buckets; model diameter $D = 380 \text{ mm}$, $a_0 =$ needle shift.)
Turbine type

\[ N_q = \frac{N Q^{0.5}}{H^{0.7}} \]

- **N** = Speed (rev/min)
- **Q** = Flow (m³/s)
- **H** = Head (m)

Diagram showing different types of turbines:
- Pelton
- Francis
- Mixed-Flow
- Kaplan (Vertical)
- Kaplan (Horizontal)
- Bulb, Pit, or Tube (Horizontal)
Application range graph

Nq < 20 Pelton
Nq > 100 Axial flow turbines
Nq = 20 to 120 Francis
Consideration for turbine selection

- Environmental
- Economic
- Technical
- Operational consideration
Francis/Kaplan decision

- **Kaplan**
  - Smooth operation to low flow
  - Higher efficiency over a wide range
  - May result in a single unit instead of two Francis
  - Higher specific speed and rotational speed (smaller generator)

- **Francis**
  - Less expansive
Francis/Pelton decision

- **Pelton**
  - Less excavation cost
  - Better for erosive water
  - Better part load efficiency
  - Less sensitive to head variation
  - Wide operating range
  - Lower maintenance cost

- **Francis**
  - Higher specific speed and rotational speed (smaller generator)
  - Higher peak efficiency