What are we talking about?

Overview on „small-scale hydropower“ SHP

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Content of the presentation

- Main components of a hydropower plant
- Various classifications of hydropower plants
- Crucial differences between micro, mini and small hydro
- Some words about costs
Main components of a (runoff river) hydropower plant

- Channel for diverted water
- Diversion weir and intake
- Forebay tank
- Pressure pipe feeding turbine (penstock)
- Turbine
Main components, plan view
## Classification applied in the current context

<table>
<thead>
<tr>
<th>Term</th>
<th>Power output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pico hydropower</td>
<td>&lt; 5 kW</td>
</tr>
<tr>
<td>Micro hydropower</td>
<td>5 - 100 kW</td>
</tr>
<tr>
<td>Mini hydropower (MHP)</td>
<td>100 – 1 000 kW (=1 MW)</td>
</tr>
<tr>
<td>Small hydropower (normally “SHP”)</td>
<td>1 MW - 30 MW (!)</td>
</tr>
<tr>
<td>Full scale (large) hydropower</td>
<td>&gt; 30 MW</td>
</tr>
</tbody>
</table>
Estimation of the power potential (simplified)

\[ P = Q \times h \times 7 \]

- \( P \): electric Power [kW]
- \( Q \): Available flow [m\(^3\)/s]
- \( h \): Available head [m]
- \( 7 \): constant [m/s\(^2\)], based on the gravity constant and the efficiencies of the equipment
Classification by design head

Most literature recommends the following general limits:

- low-head plants \( H < 15 \text{ m} \)
- medium-head plants \( H = 15 \text{ to } 50 \text{ m} \)
- high-head plants \( H > 50 \text{ m} \)
Low head
High head
Classification by design type

- run-of-the river schemes
- storage schemes
Run-of-the-river

- Most common type in the context of mini and micro hydropower
- Diversion weir installed in the river causes a minimum impact to the river as it has no impact on the seasonal flow pattern downstream of this structure.
- In some cases enlarged forebay serves as daily storage to cover daily peak demands. These schemes also count to the run-of-river-type.
Storage system

- Not commonly used in the context of mini and micro (complex design and expensive to implement, more frequent for small and large hydro)
- Causes large accumulation of water by flooding the valley upstream of it → large impact on the river ecology
- Seasonal storage and flood prevention (regulation of river flow).
- Common problem with large dams is accumulation of silt.
- Disruption of river flow renders shipping, rafting of timber and fish migration impossible
Multipurpose plants

Use of hydropower potential in:

- drinking water supply systems
- irrigation systems
- Waste water systems

often economically viable!
Classification by grid type / destination of supply

- **off-grid** / captive generation
  - The SHP supplies an island / isolated grid, not interconnected with the national grid
  - Hybrid-operation is also possible (supply from various sources to the micro-grid)

- **on-grid**
  - The SHP directly supplies electricity to (usually) the national utility.
Crucial differences between pico, micro, mini and small hydro

The “order of magnitude” has an impact on:

- Required components and their technical standards
- (specific) investment and O&M costs
- Potential project owners and managers
- Environmental (and social) impact
Pico hydropower (< 5 kW)

- Power supply for single or few households
- Cost start at about 200 US$ per unit
- Only suitable for isolated operation
- Depending on type of installation usually very maintenance intense and less cost efficient than larger community-based systems
- Productive use not possible
Pico hydropower (< 5 kW)

- normally owned and operated by private individuals or small communities
- Technical standards mainly to protect the users
- Almost no civil works required
- Can be installed by local population (with some external support)
- Normally no negative environmental and social impact
**Micro hydropower (5 - 100 kW)**

- Power supply for up to several hundred households
- Cost start at about 2,000 US$ per kW installed capacity
- Mostly used for isolated micro grids in the context of rural electrification
- Grid connection possible
- Normally no or no significant negative environmental & social impact
Micro hydropower (5 - 20 kW)

- Can be owned and operated by community or private individual
- Certain technical standards increase lifetime and reduce O&M cost
- Components can be cheap and simple → high local content (earth channel, manual control, one-phase generator etc.)
- Productive use often with “direct drive”
- High community contribution increases feeling of ownership
Micro hydropower *(20 - 100 kW)*

- Can be owned and operated by community or private individual
- Bigger size / higher investment often only justified in combination with productive use / factory etc.
- Higher technical standards (civil works and EM equipment, control system etc.) are obligatory for long lifetime
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Micro hydropower *(20 - 100 kW)*

- Often transformation to medium voltage required (customers more widespread)
Design mistakes or inaccurate hydrological analysis can already have serious consequences!
Mini hydropower (100 – 1000 kW)

- Since several thousand households are required to justify investment, normally difficult as purely “community based scheme” → would need more support for institutional set-up for proper management
- Promising potential on smaller rivers
- Normally grid-connected to achieve reasonable load factor!
- Can substantially contribute to stabilization of grid, especially at end-points
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**Mini hydropower** *(100 – 1000 kW)*

- Larger-scale productive use possible (e.g. tea factories, ice factory…)
- Technical standards obligatory (safety regulations!)
- Requires involvement of experienced designers and construction companies
- Environmental and social impact have to be considered
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Small hydropower (1 - 30 MW)

- Power supply for up to several ten thousand households → always grid-connected!
- Due to economies of scale, specific investment per kW often lower
- Much more profitable than isolated smaller plants → interesting for commercial investment / independent power producers → requires suitable legal framework (feed-in rules…)

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Small hydropower *(1 - 30 MW)*

- Promising potential on medium sized rivers
- Can contribute to stabilization of grid
- Has to fulfill international technical standards and requires very professional planning and implementation
- Detailed hydrological analysis required!
- Detailed assessment of environmental and social impact required → mitigation measures
Large hydropower (> 30 MW)

- Power supply for municipalities of large cities and supply to national grids
- Is not considered in the present workshop context
Some words about the costs…

- Economy of scale: The larger a power plant, the lower the specific costs (Investment costs per kW installed)
- For large, high head hydropower plants starting from about USD 2,000 per kW
- For low head micro hydro systems USD 15,000 per kW or even more!
- Strong dependence on local costs and head
Some words about the costs…

- Civil
- e/m equipment
- Electrical equipment
- Penstock

The graph shows the cost share [%] against the head [m] for different types of equipment.
Possible conflicts of interest

- Fishery
- Irrigation
- Shipping
- Environmental Impacts
- Aquatic Wildlife
- Water use for human activities, like washing, bathing, sport, ...
Thank you!