Turbine Testing Lab at KU:
The current status and future directions

Biraj Singh Thapa, PhD
Assistant Professor,
Department of Mechanical Engineering
Kathmandu University
Dhulikhel, Nepal
bst@ku.edu.np
World: Hydropower Potential

**Developed**

Ref: Hydropower Status Report, IHA, 2016

![Pie chart showing hydropower potential distribution by region](chart)

- **South America:** 13%
- **North America:** 16%
- **Europe:** 18%
- **Asia:** 50%
- **Africa:** 2%
- **Australia / Oceania:** 1%

Total World: 1225 GW

**Planned**


![Pie chart showing hydropower potential distribution by region](chart)

- **North America:** 7%
- **South America:** 13%
- **Europe:** 3%
- **Australia / Oceania:** 0%
- **Africa:** 15%
- **Asia:** 62%

Total World: 518 GW

Asia: Hydropower history

1897, **India**
- Sidrapong Hydelpower Station
- 2*65 kW
- **2016:** 51.5 GW (61.3% of TF)

1911, **Nepal**
- Pharping Hydro Power Project
- 2*250 kW
- **2016:** 0.8 GW (1.7% of TF)

1912, **China**
- Shilongba Hydroelectric Power Station
- 2*240 kW
- **2016:** 319.4 GW (40% of TF)
# Hydropower Development Opportunities

## Nepal: Status of Hydropower Development

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Summary status of hydropower development</th>
<th>No. of projects</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Completed projects</td>
<td>59</td>
<td>886</td>
</tr>
<tr>
<td>2</td>
<td>Projects under construction</td>
<td>57</td>
<td>4935</td>
</tr>
<tr>
<td>3</td>
<td>Issued construction licenses for generation</td>
<td>124</td>
<td>3494</td>
</tr>
<tr>
<td>4</td>
<td>Issued survey licenses</td>
<td>284</td>
<td>6450</td>
</tr>
<tr>
<td>5</td>
<td>Application received for survey licenses</td>
<td>192</td>
<td>3662</td>
</tr>
<tr>
<td></td>
<td><strong>Total (2-5)</strong></td>
<td><strong>18541</strong></td>
<td></td>
</tr>
</tbody>
</table>

Ref: Department of Electricity Development, Government of Nepal, 2017

## S&SE Asia: Status of Hydropower Development

<table>
<thead>
<tr>
<th>Country</th>
<th>Tech feasible (GWh/year)</th>
<th>Installed (MW)</th>
<th>Planned (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>25000 MW</td>
<td>400</td>
<td>~500-1000</td>
</tr>
<tr>
<td>Bhutan</td>
<td>&gt;99250</td>
<td>1615</td>
<td>8530</td>
</tr>
<tr>
<td>Cambodia</td>
<td>8600 MW</td>
<td>1267</td>
<td>4378-6513</td>
</tr>
<tr>
<td>India</td>
<td>660000</td>
<td>51494</td>
<td>~10000-98500</td>
</tr>
<tr>
<td>Laos</td>
<td>20000 MW</td>
<td>4168</td>
<td>4000-17000</td>
</tr>
<tr>
<td>Lebanon</td>
<td>1500</td>
<td>221</td>
<td>200-300</td>
</tr>
<tr>
<td>Myanmar</td>
<td>39720 MW</td>
<td>3140</td>
<td>10000-17000</td>
</tr>
<tr>
<td>Pakistan</td>
<td>204000</td>
<td>7264</td>
<td>~17000-20000</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>8250</td>
<td>1624</td>
<td>&gt;267</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>71423</strong></td>
<td><strong>54975-169425</strong></td>
</tr>
</tbody>
</table>

Turbine Design Philosophy and Challenges

Operational range of Francis turbine

Velocity inside standard Francis turbine

Sediment Erosion $\propto$ Velocity

48 MW*3 Francis turbine at Kaligandaki A Hydroelectric Center, Nepal, Ref: B. Chhetri, 2013

250 MW*6 Francis turbine at Nathpa Jhakri Powerplant, India, Ref: H.K. Sharma, 2010
Turbine Manufacturing Experiences of Nepal

- 1962: First turbine manufactured in Nepal, 5 kW Propeller
- 1973: First Crossflow turbine manufactured in Nepal
- 1975: First Pelton turbine manufactured in Nepal
- 2016: Turbine manufactures 58, Unit Capacity upto 100 kW
  Total capacity 30 MW, Export 0.6 MW

Malaysia, 40 kW, 1987
Bhutan, 100 kW, 1997
Specifications:
- 30 m Open System Head
- 150 m Closed System Head
- 500 l/s Maximum Flow
- 300 kW Maximum Testing Capacity
- 300 m\(^3\) Lower Reservoir
- 100 m\(^3\) Upper Reservoir
- 5000 kg EOT Crane Capacity

Major Objectives:
- Performance Testing of Hydraulic Machines
- Development of New Turbines
- Education and Training
- Applied Research to Solve Problems of Hydropower Industry

Inaugurated on 10 November, 2011
Kickoff Francis Turbine R&D at TTL, 2012

Development of 2 kW Francis Runner
A milestone for Francis Turbine Manufacturing, 2013

Development of 92 kW Francis Turbine

Hydraulic Design and Optimization

CAD Model

Stay ring with stay vane

Spiral Casing Sections

Casted Runner Blades

Turbine in test rig at TTL

Complete runner

Assembly of the runner blades

Guide vanes
TTL Activities and Achievements

Academic activities:

<table>
<thead>
<tr>
<th>Activities</th>
<th>Completed</th>
<th>Ongoing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>MS by research</td>
<td>5</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Masters Thesis</td>
<td>17</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Undergraduates thesis</td>
<td>51</td>
<td>8</td>
<td>59</td>
</tr>
<tr>
<td>Journal Publications</td>
<td>35</td>
<td>5</td>
<td>40</td>
</tr>
</tbody>
</table>

Test Facilities:

- 5 kW Crossflow turbine test rig and procedures, *KETEP, 2013*
- 20 kW Crossflow turbine test rig and procedures, *AEPC, 2014*
- 22 kW Pelton turbine test rig and procedures, *AEPC, 2014*
- 92 kW Francis turbine test rig and procedures, *EnergizeNepal, 2016*

Certification and Services:

<table>
<thead>
<tr>
<th>Activities</th>
<th>Client</th>
<th>year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test certification of 1 kW Pico-propeller turbine</td>
<td>PEEDA</td>
<td>2012</td>
</tr>
<tr>
<td>Design validation of 100 kW Crossflow turbine</td>
<td>UTS</td>
<td>2013</td>
</tr>
<tr>
<td>Detail study of root crack in 12 MW Pelton runner</td>
<td>HPL</td>
<td>2014</td>
</tr>
<tr>
<td>Design and analysis of penstock bifurcation for 6 MW HPP</td>
<td>Daraudi HPP</td>
<td>2014</td>
</tr>
<tr>
<td>Detail design of 200 kW Francis turbine</td>
<td>IPS</td>
<td>2017</td>
</tr>
</tbody>
</table>
Future Direction: *Technology for Entrepreneurship*

Center of Excellence at TTL
CoE at TTL for Hydropower Development

**Aim:** *Initiate a new business in Hydropower market with the innovative technology for reducing sediment erosion in turbines by a collaborative effort of Universities and Industries.*

<table>
<thead>
<tr>
<th>Components</th>
<th>Goals</th>
<th>Vision 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Testing</td>
<td>Establish IEC standard Francis turbine test facilities serving at the regional level.</td>
<td>Model test of commercial projects, at least one, at each national and regional level.</td>
</tr>
<tr>
<td>Turbine Design and Manufacturing</td>
<td>Initiate turbine manufacturing in Nepal with the new design technology for reducing sediment erosion.</td>
<td>System design of electromechanical components with 5 MW unit size Francis turbine manufactured in Nepal.</td>
</tr>
<tr>
<td>Services and Training</td>
<td>Provide technical services and trainings for repair, maintenance and operation of turbines in sediment-laden projects.</td>
<td>Third party quality control of turbine repair. Services for efficient power plant operation. Training packages for different target groups.</td>
</tr>
</tbody>
</table>
Proposed Models for Business Development

- Both model were focused to develop technical competence in University and transfer it to Industry.
- University was in leading role to initiate new business, which was not successful.
The Lesson Learned for Turbine Manufacturing

• Leading role for the business development should be taken by the Industry.

• Supply of complete ‘water-to-wire’ electromechanical components, with turbine designed and manufactured locally, needs be the scope of business.

• There is a big technical gap between manufacturing industries and universities in Nepal, which should be addressed in some ways.
Need of Sustainable Partnership

Manufacture and supply of turbine and other components as per drawings.

Detail design of turbine. Manufacturing drawings. Support for manufacturing and commissioning.

Manufacture or supply of other components and axillaries as per order.

Maintain cash flow as per need of project.

Fulfill relevant regulations and procedures (PPA, EIA etc)

Deliver complete water-to-wire inhouse solution.

Coordination for design, installation and commission of relevant components.

Provide technical and non-technical service as per need.
The Good Questions

• Can we develop technology for our specific needs?

• Shall we dare to dream 1000% progress in one life time?

• Will TTL be able to develop resources for national interest?

• Is University allowed to intervene the business development?
Thank you for your interest!