EXPERIENCES WITH THE PRELIMINARY DESIGN GUIDELINES IN THE DESIGN OF XAYABURI HYDROELECTRIC POWER PROJECT

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CASCADE OF RUN-OF-RIVER HYDROPOWER SCHEMES

Run-of-river low head schemes are typically developed in cascades. Such cascades in long rivers are built over decades. Each design has to take reference on the other schemes built upstream and downstream.

Several Run-of-River schemes in a cascade have to closely coordinate its operation and based on the same design principles.
PROJECT LAYOUT – 5 MAIN STRUCTURES

- Upstream
- Powerhouse
- Spillway
- Intermediate Block
- Navigation Lock
- Downstream
- Left Bank Facilities
## PROJECT LAYOUT AND MAIN FEATURES

Country: Lao PDR  
Location: Xayaburi town, Approximate 80 km south of Luang Prabang  
Commercial operation: October 2019  
Owner(s): Xayaburi Power Company Limited (XPCL)

### Dam and Spillways

- **Height:** 32.6 m  
- **Length:** 820 m  
- **Type of spillway:** 7 x radial gates, 4 low level outlets  
- **Spillway capacity:** 47'500 m$^3$/s  
- **Pond Capacity:** 726 Mio m$^3$, filling time with mean Mekong flow about 50 hours  
- **Catchment area:** 272,000 km$^2$  
- **Full supply level:** 275 m a.s.l.

### Power station

- **Hydraulic rated head:** 25 m  
- **Turbines:** 7 x 175 MW Kaplan-type, 1 x 60 MW Kaplan-type, 2 x 4 MW Aux. Units  
- **Maximum capacity:** 1,285 MW  
- **Energy Production:** 7'405 GWh,  
- **Export to Thailand:** 6'985 GWh supplies electricity for 3 Mio people or 750’000 families  
- **For Lao PDR:** 420 GWh supplies electricity for 1 Mio people or 200’000 families
PROJECT IMPLEMENTATION

Main pre-construction Phases

1. Project Development Phase
   Feasibility Study -> Outline Design -> Concession Agreement
   Development up to 29th October 2010
   Basis: MRC Preliminary Design Guidance (31.08.2009) plus other MRC information

   Review of the project by MRC and Stakeholders
   Outcome:  
   - Project Review Report
   - Comments from neighbouring countries

3. GOL hires Pöyry and CNR
   - Pöyry, Compliance Report 09.08.2011
   - CNR Peer Review 30.03.2012

4. GOL instructs XPCL to implement the recommendations under the Compliance Report and Peer Review Report (06.11.2012)

5. Pöyry is assigned by GOL as GOL-E
MAIN COMMENTS DURING THE PNPCA PROCESS

1. Navigation lock:
   Re-design of the navigation facilities
   Consider the vessel in the size of 2x 500 T (109 m x 10.8 m x 2 m).

2. Fish passage:
   Improve the design for fish passage, to minimize the impact on fish migration and
   improve knowledge through the collection of additional data and studies

3. Sediment transport and Nutrient Balance:
   Mitigate the sediment trapping within the reservoir and to use low level outlets for
   sediment flushing recommended
   Phosphorus and Nitrogen might be trapped in the reservoir and by improving design of
   dam and dam operation for sediment transport and flushing

4. Water Quality and Aquatic Ecology:
   Water quality problems in the reservoir due to change of natural flow condition
   improving through the design and operation especially under flood conditions

5. Dam Safety:
   Risk evaluation of the scheme, methods of appropriate interpretation of standards and
   safe design of the main components of the project and safe operation approach.
IMPLEMENTATION OF THE PRELIMINARY DESIGN GUIDELINES AND RESULTING DESIGN ADAPTATIONS

- **Spillway**, implementation of low level outlets for sediment and nutrient transport
- **Navigation Lock**
  - Change in the hydraulic layout for safer operation
  - Implementation of fish lock facility
  - Space of a second lock system for future river transport increase
- **Fish pass facilities**
  - Substantial increase of the water flow through the fish migration system
  - Complete re-design of the upstream migration system, shorter fish ladder in combination with two fish lock towers
  - Downstream migration system and additional pumping station
  - Auxiliary powerhouse for operation of the pumping stations and reduction of energy losses (station supply)
  - Fish counting system and further changes in the mains structures to allow later adaptation in the operation
DESIGN CHANGES SPILLWAY
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Outline Design
Width 235m
10 surface spillway bays

Modified Outline Design
Width 231m
7 surface spillway bays
4 low level outlets
DESIGN CHANGES SPILLWAY

Modified Outline Design

Surface Spillway

Low level outlet
DESIGN CHANGES NAVIGATION LOCK
DESIGN CHANGES NAVIGATION LOCK

Outline Design
Length main structure & guide walls: 470m +260m

Modified Outline Design
Length main structure & guide walls: 405m +300m
Attraction flow system for fish passing during construction

Modifications guide walls
FISH PASSING FACILITIES
UP STREAM MIGRATION SYSTEMS

Attraction flow fish ladder: left bank auxiliary Powerhouse
Attraction flow at Powerhouse and Intermediate Block: Pump station 1 (dry season), gravity water supply (wet season)
90 to 200 m3/s attraction flow
2 Fish lock
1 Fish lift (optional)
DESIGN CHANGES FISH PASSING FACILITIES

Outline Design
Lower loop: 180m, 5%
Fish ladder: 610m, 4.5m
Flow about 12 m3/s

Modified Outline Design
LBAP: 8MW
Flow about 40 m3/s
Reduced water and power production losses
Fish ladder: 525m, 1.2%
Upper channel: 110m
2 fish lock, 1 fish lift (optional)
Efficiency of the fish u/s migration works has been increased significantly.
DOWN STEAM MIGRATION SYSTEM

Attraction flow u/s Powerhouse: Pump station 2 (dry season), fish d/s migration channel (wet season)

70 to 160 m³/s attraction flow

Exit chute

Fish resting area
CONCLUSIONS

Developer and planner experience with Preliminary Design Guidance and in applying mitigation measures

- The Preliminary Design Guidelines (PDG) have been valuable as a basis for the design of Mainstream Hydropower Schemes
- Xayaburi was the first (and only) successful test case of the implementation of the PDG on a mainstream project
- Xayaburi has given detailed design solutions for the various topics in the PDG
- Some of the points in the PDG are rather theoretical and should be amended to follow the successful detailed design of Xayaburi
- Some of the points are for example:
  - Fish migration detail design and new knowledge gained
  - Navigation locks used for fish migration
  - Fish Migration during construction
  - Dam Safety based on the latest knowledge
  - Coordination between the schemes along the Mekong

The main conclusion In a cascade of run-of-river schemes all plants have to follow the same design principles
THANK YOU!

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