Feasibility Study on Pakbeng Hydropower Project
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Part 1

Background
BACKGROUND

Pakbeng station is in upper reach of Mekong River and the first cascade of hydropower development projects on the river. The dam site is in Pakbeng district in north of Laos.
In December 2008, the Feasibility Study Report to GOL was concluded, in which the FSL was 345m mainly according to *Mekong Mainstream Run-of-River Hydropower* published by MRC in 1994.

At the same time, Initial Environmental Examination (IEE) jointly prepared by Norconsult and Earth Systems LAO was submitted.
In February 2009, GOL organized a meeting to examine the Report, and in May 2009, officially replied the Feasibility Study with the requirement of 'for the normal water level and tail water level shall be determined after completion of Optimization Study carried out by CNR' for final FSR.
In July 2009, CNR completed *Optimization Study of Mekong Mainstream Hydropower.*

In January 2010, GOL made it clear that in order not to affect Thailand, the maximum operating water level of Pak Beng Project should not exceed 340m.
After the FSL was adjusted from 345m to 340m, the reservoir inundation indicator and compensation cost would be greatly reduced, and the installed capacity would also be reduced from 1,230 MW to 855 MW accordingly.

Therefore, this presentation mainly focus on design changes after the adjustment of FSL.
Part 2
Hydrology
More hydrological data including Chiang Saen and Luangprabang Hydrological Stations were collected.

Methodology is the same as that in last version of FS report

Annual mean flow is 3,160 m$^3$/s at Pak Beng dam site (Same as the data of last version)
Hydrology

- **Design flood discharge:** 27,000 m³/s
- **Check flood discharge:** 30,200 m³/s
- Flood results is close to results of CNR or MRC

<table>
<thead>
<tr>
<th>P(%)</th>
<th>Chiang Saen (m³/s)</th>
<th>Laungprabang (m³/s)</th>
<th>Dam site (m³/s)</th>
<th>P(%)</th>
<th>Chiang Saen (m³/s)</th>
<th>Laungprabang (m³/s)</th>
<th>Dam site (m³/s)</th>
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Part 3
Adjustment of FSL
Adjustment of FSL

- Main factors for determination of FSL

  ✓ The dam crest elevation is controlled by check flood level which is 343.81m, so it is economic to raise the full supply water level below 344m.

  ✓ Topographic and geological issues are not restrictive factors.

  ✓ GOL made it clear that the construction of Pak Beng Hydropower Project could not inundate KengPhaDai, and officially advised on January 5, 2010 that its normal water level should not exceed 340m.
Adjustment of FSL

Pak Beng Reservoir is shown as followed. Mainly Sensitive objects include KengPhaDai, Nam Ing River, Nam Ngao, etc.
Generally speaking, under natural condition, the water level of this area moves from 337m to 344m with the average of 340m in flood season, and it will be from 332m to 337m with the average of 335m in dry season.
In flood season, most or even all reefs in KengPhaDai shall be submerged, and in dry season, some are exposed. When the water level remains around 337m, most reefs shall be entirely exposed.
According to water level change and reef exposing at KengPhaDai, we prepared two schemes for technical and economic comparison.

Scheme I: 340m in flood season, 335m in dry season

Scheme II: 340m in all seasons
As to the power generation benefit, operation at 340m will generate extra 370GW·h than that at 335m in dry season.

According to engineering scheme, difference between two schemes is not so obvious.
As to the impact on Nam Ngao, Nam Ing River and Chiang Khong under flood condition, it is generally same between schemes. And the water level of the aforesaid areas changes slightly (almost can be neglected) whether to build Pak Beng HPP or not:

<table>
<thead>
<tr>
<th>Item</th>
<th>P=50% (Q_m = 11600m³/s)</th>
<th>P=20% (Q_m = 14900m³/s)</th>
<th>P=10% (Q_m = 17000m³/s)</th>
<th>P=5% (Q_m = 18900m³/s)</th>
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<td>WL. without PB</td>
<td>Diff.</td>
<td>WL. with PB</td>
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<td>Ngao</td>
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<td>347.48</td>
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<td>351.29</td>
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<td><strong>0.14</strong></td>
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**Note:** WL = Water Level, PB = Pak Beng HPP.
Monthly average water level change at KengPhaDai for scheme I is similar to the natural condition, and considering of the effects on Thailand, scheme I seems better than scheme II.

For scheme I, water level change can be shown as followed schematic maps under natural or project condition:
Comparison of two schemes

The water levels at KengPhaDai

January

Reef

Natural

Backwater

Laos

Thailand

EL. (m)

360
355
350
345
340
335
330
325
320
315
0
100
200
300
400
500

Distance (m)
Comparison of two schemes

The water levels at Nam Ngao River

January

- Backwater
- Natural

Laos

Thailand

River Bank

Distance (m)
The distribution of farmland above EL.350m in Thailand

Comparison of two schemes

The water levels at Nam Ing River
Comparison of two schemes

Both schemes can reserve most of the natural surface feature on Lao-Thai border and the scenery in KengPhaDai. But Scheme II with higher water level in dry seasons is comparatively not as good as Scheme I.

Therefore, we recommend that the proposed FSL should be 340m, and the reservoir operates at 340m in flood season and 335m in dry season.
The setting of dead water level mainly considers factors as layout of key hydraulic structures and the flexibility of reservoir operation. Once the FSL adjusted to 340m, and the water level in dry season adjusted to 335m, the dead water level shall according be adjusted to 334m.

The lowest navigable water level of upstream of the dam and dead water level are the same as 334m; Compared with values of FSL and reservoir water level corresponding to 3 years return period flood, the larger value shall be taken as the maximum navigable water level of upstream of the dam, which is 340m.
Part 4

Installed Capacity
Installed capacity

Main Factors for Finalization Installed Capacity as Follows:

- The type of water turbine, the capacity of generating unit, manufacturing level and transportation conditions;
- The characteristics of the output;
- Power supply market and load characteristics of supply area;
- Topographical and geological conditions and layout of hydraulic structures;
- Index of hydropower energy of project;
- Economy.

Six schemes of installed capacities such as 741 MW (13 × 57 MW), 798 MW (14 × 57 MW), 855 MW (15 × 57 MW), 912 MW (16 × 57 MW), 969 MW (17 × 57 MW) and 1,026 MW (18 × 57 MW) are proposed for comparison.
Selection of turbine type

- Water Head Range
  - The water head range of the power plant is changed from 13m ~ 34.7m to 7 m~ 29.7m, lead to the installed capacity changed from 1,230MW to 855MW.

- Turbine Type
  - The maximum water head less than 30m, bulb turbines are more suitable for this project
Selection of turbine type

- Single-Unit Capacity
- Scheme 1 with 14 units, scheme 2 with 15 units and scheme 3 with 16 units are preliminarily selected for consideration.

According to the unit operating flexibility, equipment manufacturing factors, transport conditions, hydro energy and layout of hydraulic structures, the scheme of 57MW (15 units) is recommended.
The characteristics of the output

According to the characteristic of the flow output, the total installed capacity may not more than 1086MW.
Comparison of other factors

Topographic and geological conditions at the dam site and layout and quantities of key hydraulic structures may not restrict the selection of installed capacity.

The power transmission pattern, voltage grade and circuits of outgoing lines applied to the aforementioned different schemes are the same.
Economically, the 855 MW is relatively good, while the other schemes are relatively poor in economic evaluation.

In general, the proposed installed capacity shall be 855MW, 15 generating units with capacity of 57MW each.

The firm output is 357MW, and annual average energy is 4846GW·h.
Part 5

Reservoir Inundation
KD has carried out comprehensive investigation on environment and social impact with Norconsult, with 1:5000 Lao PDR topographic map, in October 2008.

In the FS stage, we committed NCG (National Consulting Group, Laos) to work for environmental and social impact assessment, and trans boundary, cumulative ESIA as well. ESIA will be reported soon afterwards.
168 households, and 1010 persons are living under 340masl.
Part 6

Project Layout
PROJECT LAYOUT

- Ship lock (In future)
- Discharging & flushing sluice, Number: 2, Size: 15×23m
- Ship lock, 500t
- Concrete gravity dam, Height: 69m, Length: 894.5m
- Fishway
- Discharging & flushing sluice, Number: 12, Size: 15×23m
- Powerhouse, Turbine type: Bulb, 15×57 MW
The powerhouse is installed with 15 sets of bulb turbine units. Each unit has the capacity of 57MW and the total will be 855MW.
Design standard of navigation structure across the dam

According to the navigation agreement on Lancang-Mekong river signed by China, Laos, Myanmar and Thailand, and Preliminary Design Guidance for Proposed Mainstream Dams in the Lower Mekong Basin, the navigation structures across the dam are designed as navigation channel of class IV for watercraft of 500t level. A 500t ship can get across one time by the effective dimension of ship lock.

We adopt single line and single lock at present, and it is possible for double lines to meet the demand of shipping growth in the future.
General construction schedule

The general construction period is 63 months. The preparation period is 20 months. The period for construction of main works is 25 months. The first unit can be operated and generate power within 45 months after commencement.
Conclusions

With the adjustment of FSL from 345m to 340m, the negative effects on Thailand can be avoided, and the technical and economic indicator of Pak Beng project is still good and feasible, relatively.
Part 7

Alteration to Installed Capacity
After MOU feasibility study report, the Project had progressed in a relatively slow pace. During this period, KD conducted deeper and more detailed study on the project design. Given minor discrepancy in economic efficiency of installed capacity schemes of 798MW, 855MW and 912MW, further study was carried out. For the purpose of installed capacity of Pak Beng HPP, the same principle in MOU feasibility study is still adhered at this stage, i.e. economic comparison among different schemes. Along with deepening of the design, it can be perceived that difference between this comparison and that at MOU feasibility study stage is mainly reflected in project cost.
Economic Comparison

- Static cost
- Present value of cost

Installed capacity (MW):
- 741
- 798
- 855
- 912
- 969
- 1026

Cost in $ (10^9 $
- 1.322
- 1.324
- 1.302
- 1.294
- 1.288
- 1.291
- 1.298
- 1.373
- 1.392
- 1.408
Cost Comparison among Options Proposed at Two Stages

<table>
<thead>
<tr>
<th></th>
<th>MOU (2010)</th>
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<tr>
<td>855 MW</td>
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<tr>
<td>912 MW</td>
<td>1.358</td>
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<tr>
<td>Cost Breakdown</td>
<td>855MW</td>
<td>912MW</td>
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<td>----------------------------------------</td>
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<td>I Project complex</td>
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<td>2 Construction works</td>
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<tr>
<td>3 Environment protection &amp; water and soil conservation</td>
<td>34.3</td>
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</tr>
<tr>
<td>4 M&amp;E equipment and installation works</td>
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<td>5 Metal structure and erection works</td>
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<tr>
<td>II Land acquisition &amp; resettlement cost</td>
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<td>IV Contingency</td>
<td>118.3</td>
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<tr>
<td>V Power evacuation</td>
<td>60.8</td>
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<tr>
<td>VI Static Cost of Project</td>
<td>1291.0</td>
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</table>
Recommendation

Comparison on cost breakdowns shows M&E equipment and construction work under 912MW is remarkably less costly than 855MW and post-commissioning cost difference is narrowed. Comparing with MOU feasibility stage, post-commissioning cost difference between these two options is $16.8 \times 10^6$. 
Conclusion on Comparison of Options

Overall technical and economic comparison conducted at MOU feasibility study stage indicated all schemes are technically feasible. 855MW was most efficient economically, almost identical to 912MW.

Due to further study on project design, difference in project cost between 855MW and 912MW has been narrowed, and 912MW has shown higher economic efficiency. Therefore, it is recommended to increase installed capacity of Pak Beng HPP up to 912MW.
Analysis on Other Influential Factors

(1) With progress of manufacturing technology of turbine unit, larger capacity will be more efficient economically.

(2) Huge potential of power market is likely to trigger escalation of electricity tariff in the future. In the event that electricity tariff is increased during operation period and all energy production is absorbed, then the option with larger capacity appears to be more economic.
Final Conclusion

With reference to the latest results of analysis on installed capacity and possible impact of changes in relevant influential factors against various options, it is recommended to increase installed capacity of Pak Beng HPP up to 912MW.
THANKS FOR YOUR ATTENTION