The ISH 0306 Study
Development of Guidelines for Hydropower Environmental Impact Mitigation and Risk Management in the Lower Mekong Mainstream and Tributaries
Final Phase – Volume 5 – Final Discussion Note on Proposed Update of the Preliminary Design Guidance (PDG) and Hydropower Development Strategy (HDS)
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The Draft Final Reports constitutes 6 volumes:

**Volume 1:** Version 3.0 – Hydropower Risks and Impact Mitigation Guidelines and Recommendations

**Volume 2:** Version 3.0 – Hydropower Risks and Impact Mitigation MANUAL – Key Hydropower Risks, Impacts and Vulnerabilities and General Mitigation Options for Lower Mekong

**Volume 3:** Version 2.0 – Final Knowledge Base and Supporting Documents

**Volume 4:** Draft Case Study Report, Version 2.0 - Final Mainstream Dams Assessment Including Alternative Scheme Layouts

**Volume 5:** Discussion Note on Proposed Update of the Preliminary Design Guidance (PDG) and Hydropower Development Strategy

**Volume 6:** Final Closure Report
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PREFACE
This document is part of the Final Phase (Phase 4) Report Volumes 1 to 6 of the ISH0306 Mekong River Commission study - Development of Guidelines for Hydropower Environmental Impact Mitigation and Risk Management in the Lower Mekong Mainstream and Tributaries. It builds on the work and results from previous Phases and constitutes 6 Volumes as follows;

(i) Volume 1 - Hydropower Risks and Impact Mitigation Guidelines and Recommendations – Version 3.0
(ii) Volume 2 - Hydropower Risks and Impact Mitigation MANUAL - Key Hydropower Risks, Impacts and Vulnerabilities and General Mitigation Options for Lower Mekong – Version 3.0;
(iii) Volume 3 - Knowledge Base Report – Version 2.0 – Structure, Usage and Regional and International Practise and;
(iv) Volume 4 - Case Study Report– Version 2.0 – Modelling, Scenarios and Impact Mitigation Assessment.
(v) Volume 5 - Discussion Note on Proposed Update of the Preliminary Design Guidance (PDG) and Hydropower Development Strategy (HDS)
(vi) Volume 6 – Final Closure Report

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ABBREVIATIONS

AFP – Agriculture, Irrigation and Forestry Programme
BDP – Basin Development Plan
DG – Design Guidance
EFA – Environmental Flow Assessments
FIS – Fisheries Programme
GHG – Greenhouse Gas Emission
HDS – Hydropower Development Strategy
IDB – Inter-American Development Bank
ISH – Initiative on Sustainable Hydropower
IUCN – International Union for Conservation of Nature
IWRM – Integrated Water Resources Management
LMB – Lower Mekong Basin
MC – Member Countries
MRC – Mekong River Commission
MRCS – Mekong River Commission Secretariat
PDG – Preliminary Design Guidance
PNPCA – Procedures for Notification, Prior Consultation and Agreement
RSAT – Rapid Sustainability Assessment Tool
WCD – World Commission of Dams
WUP – Water Utilization Programme

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Cannot be referenced.
1 Introduction

1.1 Overall Context and Background

The ISH0306 study, undertaken in the period between early 2015 to early 2018, has provided detailed insight into hydropower development in the Lower Mekong Basin with special emphasis on providing Guidelines for mitigation (with focus on hydrology and flows, geomorphology and sediments, water quality, fisheries and aquatic ecology) and its related principles for engineering design and operation. The Guidelines for mitigation are thoroughly reported in Volume 1 ("The Guidelines") and with specific details in Volume 2 ("The Manual"). Specific mitigation options from the Guidelines has also been studied and tested in a Case Study focusing on the mainstream dams (ISH0306, Volume 4). Assessments reported in these ISH0306 volumes constitutes the main input to the current discussion note (ISH0306, Volume 5) on review and update of the PDG (MRC, 2009) and the Hydropower Development Strategy (MRC, 2001).

Issued back in 2009, the PDG is the most important safeguard for hydropower in the LMB for Mainstream Dams in the Lower Mekong Basin, while the Hydropower Development Strategy (HDS) was developed almost 2 decades ago in 2001. Meanwhile hydropower development has accelerated in the Mekong mainstream and tributaries (MRC, 2016) and various MRC studies, strategies and plans has been undertaken and implemented. Most importantly these are the Mekong River Commission’s Strategic Plan (2011 to 2015) and the Basin Development Plan (BDP, approved January 2011), where the focus is that the development of LMB should follow Integrated Water Resource Management (IWRM) principles. The MRC Strategic Plan as well as the BDP has now been updated for the period 2016-2020 (MRC, 2016). Within the IWRM context the need to improve the sustainability of the basin’s hydropower developments is a key Strategic Priority. With the significantly increasing scale and prevalence of this energy option, all MRC member countries are taking steps to understand and employ sustainable hydropower considerations, as the way forward. As such and update of the PDG and HDS should also be undertaken within this context.

The ISH0306 Guidelines and Recommendations with the supporting Manual seeks to enhance and expand the PDG and to provide more effective and detailed documentation of the options and methods that may be used to cover the mitigation of hydropower risks in the Mekong mainstream as well as to expand the applicability of the PDG to the tributary developments.

1.2 Purpose and Objectives of the Review and Update of the PDG and HDS

The purpose of this discussion note is to confirm the necessity to update the PDG and the HDS. It will rely on the assessment undertaken as part of ISH0306 and conjure with the principles under the updated MRC Basin Development Strategy and Strategic Plan of 2016 (MRC, 2016). The specific objectives of the PDG and HDS update are as follows:

- **PDG review/update**: Assess necessary updates of the 2009 version of the PDG, including planning principles taking into account mitigation throughout the whole hydropower life cycle and strategic portfolio planning, additional themes for consideration, updates of existing themes, inclusion of specific engineering design principles, inclusion of tributary dams development, planning and design as well as needed updates on dam safety.
- **HDS review/update:** Assess necessary updates of the 2001 version of the Hydropower Development Strategy taking into account; recent hydropower developments in the LMB, sustainable hydropower development principles, recent plans and strategies on the LMB as well as Guidelines and results from ISH0306.
2 Review of the Preliminary Design Guidance 2009

2.1 Summary of Main Recommendations in the 2009 Version

The PDG outlines the expectations of, and an approach to, mitigation of the major risks for hydropower dams in the Mekong mainstream. For example, the PDG requires all mainstream dams to incorporate both upstream and downstream fish passage facilities, which should ensure “effective” passage (i.e. safe passage for 95% of the target species under all flow conditions). The PDG criteria have served as the compliance benchmarks in the PNPCA technical reviews of the Pak Beng, Xayaburi and the Don Sahong hydropower projects.

The Preliminary Design Guidance (PDG) for the Proposed Mainstream Dams in the Lower Mekong Basin provide developers with an overview of issues that the MRC will consider during the PNPCA process under the 1995 Mekong Agreement. With regard to existing themes the PDG provides recommendations as follows.

2.1.1 Navigation

Navigation has not been studied as part of the ISH0306 study, and as such the review of this in this discussion note will be less comprehensive than the assessment of other themes. However as a general comment to the navigation part of the PDG 2009 version is that the guidance requirements on measures to implement are much more specific than the other themes. Besides considering general requirements there are quite specific requirements/specification on; dimensions and design vessels, lockage time and availability, location and alignment of locks, construction, service life, expansion, chamber equipment as well as design operation, safety and maintenance needs.

2.1.2 Fish passages on Mainstream Dams

The PDG gives an overview of the various fish guilds (10) on the Mekong and its tributaries and the likely impacts of mainstream dams. This is followed by guidance on fish passage design and operation. Important guiding principles are as follows:

- Fish passage facilities for both upstream and downstream passage must be incorporated into all dams.
- The developers should provide for effective fish passage both upstream and downstream, defined as follows – “providing safe passage for 95% of the target species under all flow conditions”
- Where fish passage rates are unlikely to be adequate to maintain viable populations other mitigation options as part of compensation programs for lost fisheries resources must be developed.
- Fish passages and mitigation options should constitute multiple systems at each site to cater for the high number of species and high biomass.

The PDG details further biological, hydrological and hydraulic requirements for the fish passages during the various phases of the HPP project life cycle.

2.1.3 Sediment Transport and River Morphology

The PDG provides an overview of potential sediment related impacts associated with the development of hydropower projects and approaches for mitigation and management. These impacts include reservoir deposition, changes to sediment transport from inflowing tributaries (both in the reservoir
and downstream), downstream channel adjustments related to changes in hydrology and sediment loads and associated impacts on habitat distribution and quality. A summary of guiding principles for considering sediment related issues during the planning phase is provided for developers, which highlight the importance of:

- Understanding the relationships between hydraulics, river morphology and ecology;
- Assessing whether dam developments should be avoided in reaches susceptible to severe morphological change;
- Making dams transparent to sediment transport as much as possible;
- Considering sediment transport issues associated with tributary inputs.

The PDG discusses a range of sediment management options, including sediment routing, sediment bypass, sediment flushing, mechanical removal, sediment traps and sediment augmentation downstream of the reservoir. General guidance is provided with respect to site selection, modelling and monitoring of sediments into, within and downstream of the impoundment, and the inclusion of gates to enable sediment management options. Operational and ecological issues associated with the timing of sediment management are also highlighted, with an emphasis on continued monitoring over the life-cycle of the project to guide management strategies. Reactive measures, such as physical bank protection are indicated as a means of mitigating impacts which cannot be avoided through management of the project.

2.1.4 Water Quality and Aquatic Ecology
These themes are “lumped together” in the 2009 PDG version. Summary is presented and divided as follows.

2.1.4.1 Water Quality
The PDG focuses on water quality risks associated with a series of low-head dams as proposed for the mainstream Mekong in the LMB, emphasizing that larger deeper storages may promote greater changes. The water quality risks identified by the PDG include changes to physical and chemical water quality parameters which can impact on the downstream ecosystem, and geomorphology (as related to sediment concentrations).

The water quality parameters that are important to consider in hydropower developments include temperature, pH, dissolved oxygen, Biological Oxygen Demand (BOD), total nitrogen, total phosphorus and coliform bacteria. These parameters can be altered during storage within a reservoir and especially under conditions where thermal stratification can lead to the development of stagnant water at depth.

Guidance for maintaining water quality includes the design and management of reservoirs which will achieve the water quality guidelines as set out in the MRC Technical Guidelines for Procedures on Water Quality. The PDG state the necessity of site-specific water quality monitoring, with the results to be interpreted within larger scale trends provided by the Water Quality Monitoring Network and Ecological Health Monitoring Network.

2.1.4.2 Environmental Flow and Aquatic Ecology
The PDG stipulates to incorporate instream flow (environmental flow) considerations appropriately at different project stages (design, implementation, operation and monitoring). The PDG states that the
developers should systematically assess the effect of a combination of flow releases from the dam to address downstream impacts at different times of the year, also taking into account the position of the dam in possible cascade series of dams. This should be done by introducing appropriate Environmental Flow Assessment (EFA) methodologies at the EIA and feasibility study stage, appropriate to the scale and significance of the flow changes, and referring to good practice techniques and methodologies. The prescribed documentations to refer are: IUCN Publication- ‘Flow: The Essentials of Environmental Flows’ and World Bank Publication- ‘Environment Flows: Concepts and Methodologies’. MRC Environment Program (2011-2015) also highlights the requirement of further development of EFA approaches.

2.1.5 Safety of Dams
The 2009 Preliminary Design Guidance (PDG) for Proposed Mainstream Dams provides a general overview of dam safety philosophy which recognises that it is a complex process covering design, construction, operation, maintenance and monitoring. A valuable commentary is provided on dam safety issues, the World Bank Operational Policy on Safety of Dams, and other publications on the safety of dams, mostly ICOLD Dam Safety Bulletins.

Since publication of the PDG in 2009 mainstream dams have started to become a reality and the practical implications of multiple mainstream dams on the Mekong are now being addressed. The complexity of the challenge is compounded by:

- The development of projects by private sector developers with different design standards and operational policies;
- Concession Agreements that typically delegate the details of project design and dam safety to the developer with only relatively high level objectives being stated;
- No established principles for design and operational interaction between projects;
- Dam safety issues created by major tributary dams.
2.2 Proposed Updates Based on ISH0306 Results

2.2.1 Project Life Cycle, Early Avoidance and Spatial Planning

The PDG for almost all themes concentrate on feasibility/design and operation phases whilst the Hydropower Mitigation Guidelines (ISH0306) covers the whole Project Life Cycle, including Concept Phases (Master Plans + Pre-feasibility) as well as construction. The update of the PDG should follow a more coherent guidance throughout the themes stating what is needed at the various lifecycles for these.

Clause 10 in the 2009 PDG states avoidance (e.g. early lifecycle planning), but this is not really sufficiently handled in the existing PDG themes (Navigation, Fish Passages, Sediment Transport and River Morphology, Water Quality and Aquatic Ecology). The necessity of early avoidance as part of spatial and system scale assessment during master, basin and pre-feasibility planning is reflected and discussed in the Hydropower Mitigation Guidelines. With inclusion of the whole life cycle, early avoidance and spatial planning in the updated PDG the last mentioned will not only be a guidance for developers but also agencies and catchment, cascade and basin developers/planners.

Furthermore, integrated hydropower planning at system/basin scale (spatial planning) is envisaged in the MRC’s Strategic Plan 2016-2020 (MRC, 2016) as part of the overall Integrated Water Resources Management approach. Such an approach, at basin and catchment level, will cater for the incorporation of sustainable planning within a spatial and temporal context allowing for the application of the full mitigation hierarchy, from avoidance through minimization, mitigation and compensation/offsets. Integrated system planning will have the possibility to reduce cumulative impacts at a basin and catchment scale (Nature Conservancy/IDB, 2013; Nature Conservancy, 2017) making this approach highly relevant for the future hydropower planning of Mekong mainstream and its tributaries. As such it would be important to emphasize this more in an update of the PDG.

When mitigating within the spatial context at basin and catchment scale, and in line with the mitigation hierarchy, the status of the LMB ecosystems will benefit from early avoidance mitigation approaches. Examples might include maintenance of intact river routes and alternative dam designs. The latter has actually been studied for Sambor, and is amongst others reported in Wild and Loucks (2015). An illustration of the original proposed Sambor Dam and the smaller alternative is shown in Figure 2.1. The latter includes a natural sediment and fish bypass channel.
Spatial hydropower portfolio planning versus traditional project planning has also been studied for the 3S basins with regard to sediment transport and hydropower production by Schmitt et al. (2017a), indicating that spatial hydropower portfolio planning can yield higher overall benefits between sediment transport or ecosystem value and hydropower production.

Figure 2.1. Map of the original proposed Sambor Dam and the smaller alternative (Source: Wild and Loucks, 2015).

Figure 2.2. Illustration of benefits from spatial scale portfolio planning in the 3S system of Mekong (from Schmitt et al. 2017b).
2.2.2 Additional themes for consideration

2.2.2.1 Hydrology and Flows
Hydrology and flows is not treated as a separate theme in the PDG of 2009, but guidance and requirements for assessment, provision and monitoring of environmental flows-downstream releases is considered under the theme Water Quality and Aquatic Ecology. Currently this is largely focused at project scale and under feasibility, design and operation phases. In the new update, requirements during construction should also be included.

We suggest however that a separate theme on Hydrology and Flows is included in the PDG and that the environmental flow section is moved under this theme.

The suggested Hydrology and Flows theme in the updated PDG should also, when considering flow requirements at catchment, basin and thus spatial scale planning also include guidance on the Procedures for Maintenance of Flow on the Mainstream (PMFM). Concurrently, then the PMFM will need to be revisited since the ISH0306 Case Study (MRC, 2016) showed that the criteria proposed in the PMFM is already affected due to changes in the basin.

We further suggest that the updated PDG will need guidance on requirements for annual/inter-annual changes to flow as follows:

- Development of flow rules for catchments, cascades and individual projects (at master plan, pre-feasibility and feasibility stages)
- Development of joint operation rules for releases, especially where considering cascade development (pre-feasibility and feasibility stages). For example joint flow releases to cater for ecosystem and livelihood requirements during critical periods.
- Maintaining seasonal patterns through HP operations (operation stage)
- Mimicking natural flow regime through artificial releases and environmental flows (operation stage)

And for short-term flow fluctuations/hydro-peaking as follows:

- Development of flow rules to minimize flow changes (feasibility and design stage)
- Joint hydropeaking rules in cascades (feasibility and design stage)
- Avoidance of flow fluctuations during construction

2.2.2.2 Socio-Economics and Livelihood
This area is not covered in the current PDG, nor has it been studied in detail in the ISH0306 Hydropower Mitigation Guidelines. However it should be assessed if this is a theme that could be separately covered in the PDG update, also given that Socio-Economics and Livelihood is closely interwoven with the status of the Mekong ecosystem, hence also the other themes in the PDG. At project level this could be guidance requirements for livelihood restoration and compensation as well as mechanisms for sharing of benefits (benefit sharing) from the project development. At larger scales (catchment, basin) requirements for socio-economics and livelihood will be more closely linked to the other themes and the status of the environment as such.
### 2.2.2.3 Principles for Engineering Design and Operation

The objective of the ISH0306 Case Study in Volume 4 was to examine the effectiveness of the key mitigation options proposed in the ISH0306 guidelines on the cascade of five mainstream dams in Laos comprising Pak Beng, Luang Prabang, Xayaburi, Pak Lai, and Sanakham. A range of alternative test cases was devised to examine the effectiveness of mitigation options proposed in the guidelines to address key environmental risks and vulnerabilities. The proposed test cases are listed in Table 2.1.

#### Table 2.1 ISH0306 Case Study Options.

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Reference case</td>
<td>BDP 2030 – 20 Y (Council Study 2040)</td>
</tr>
<tr>
<td>1.1</td>
<td>5 project cascade</td>
<td>Run of river operation – no design changes (Council Study 1)</td>
</tr>
<tr>
<td>1.2</td>
<td>5 project cascade + sediment management</td>
<td>Conjunctive reservoir draw down at all schemes for sediment management options</td>
</tr>
<tr>
<td>1.3</td>
<td>Hydro peaking</td>
<td>Hydro peaking sub trials to determine acceptable amplitudes and ramp rates (Council Study 2)</td>
</tr>
<tr>
<td>1.4</td>
<td>Generation shut down</td>
<td>Reservoir draw down and station shut down during peak upstream and downstream fish migration periods</td>
</tr>
<tr>
<td>2</td>
<td>3 Project cascade</td>
<td>Pak Beng, Luang Prabang &amp; Xayaburi</td>
</tr>
<tr>
<td>3</td>
<td>4 lower dams</td>
<td>Sub divide Pak Beng, Luang Prabang, Pak Lay and Sanakham into two half height schemes with low speed bulb turbines</td>
</tr>
<tr>
<td>4</td>
<td>2 lower dams</td>
<td>Sub divide Pak Lay and Sanakham into two half height schemes with low speed bulb turbines</td>
</tr>
<tr>
<td>5</td>
<td>Revised locations (fish)</td>
<td>Relocation of projects to improve fish connectivity</td>
</tr>
<tr>
<td>6</td>
<td>Revised locations (sediment)</td>
<td>Relocation of projects to improve sediment transport</td>
</tr>
</tbody>
</table>

The broad objectives of these test cases were as follows:

**Group 1:** These test cases examine alternative operating strategies for the five scheme cascade based on all projects following the same design principles as those established at Xayaburi. The objective of the Sub Option 1.1 was to examine the impact of the cascade as a base case. Sub Option 1.2 examines how reservoir drawdown might be used to promote sediment transport through the cascade. Sub Option 1.3 examines the extent to which hydro peaking can be accepted on the cascade. Sub Option 1.4 was intended to test if generation in the cascade could be suspended and the reservoirs drawn down at critical times of the year to permit unobstructed fish migration and sediment transport.

**Group 2:** These test cases were intended to follow the same principles as Group 1 but with the two schemes downstream of Xayaburi omitted. This group is based on the recognition that Xayaburi is under construction and thus the upstream impacts are already irreversible. Whereas omission of the Pak Lay and Sanakham projects may preserve important migratory and connectivity routes downstream of Xayaburi.

**Group 3:** This group was intended to examine the merits of adopting lower dams, both upstream and downstream of Xayaburi. Lower dams have the potential to provide a reduced barrier to fish migration, smaller reservoirs with lower residence times to reduce water quality concerns, smaller reservoirs with lower sediment trapping efficiency, reduced reservoir footprint area and generally keeping the mainstream closer to its natural regime.
**Group 4.** This group would have the same objectives as Group 3 but applied only to the downstream dams at Pak Lay and Sanakham. This arrangement would recognise that the characteristics of the Xayaburi project cannot be changed and the upstream impacts are already irreversible.

**Group 5.** The objective of this Group was to examine if re-positioning of mainstream projects to locations upstream of major tributaries would have the potential to preserve important fish migration routes.

**Group 6.** The objective of this Group was to examine if re-positioning of mainstream projects to locations upstream of major tributaries would have the potential to preserve important sediment transport routes.

Detailed modelling of all options was beyond the scope of the ISH0306 programme and focus has been directed at the Group 1 options which do not incorporate design modifications. As such, the results primarily provide guidance on operational strategies and not the merits of alternative designs. The modelling results indicate:

- The impact of the Lao cascade on river discharge appears to be minor downstream of Pakse, on the Tonle Sap system and further down to the delta.
- Daily peaking fluctuations can be accommodated within feasible ramp rates and water level amplitude restrictions, but the commercial value of this form of operation appears to be very limited.
- Sediment flushing through the cascade is considered to provide a positive benefit downstream of the cascade but causes significant negative impact on aquatic habitat within the cascade reach. Sediment flushing results in energy loss.
- None of the Group 1 operating strategies provide mitigation to reduced water quality.
- The adoption of the complex fish passage and energy recovery arrangements at Xayaburi for upstream and downstream migration reduces the energy loss to a minor level. However it is anticipated that similar facilities on all cascade projects may result in a major decline in large migratory species in the long term although the extinction of small migratory species may be mitigated. Introduction of finer turbine intake screens would benefit larger / long lived species.
- Initial results indicate that the design of the Xayaburi gated crest spillway prevents the reservoir draw down strategy envisaged in Sub Option 1.4.

Although the modelling studies were focussed on alternative operating strategies the results provide useful guidance on the proposed revision of the PDG. The key design objectives that might be considered in the revised PGD include:

1. Adoption of lower dams so that effective fish upstream migration can take place.
2. Adoption of finer and larger power intake screens to improve fish exclusion and survival rates for downstream migration.
3. Smaller reservoirs to reduce residence time, water quality problems and sediment trap efficiency.
4. Introduce energy recovery on fish passage systems to reduce losses to commercially acceptable levels.
5. Avoid gated weir type spillways and adopt full height gated (sector) barrages (see Figure 2.3) so that the river can be retained in a natural condition during project construction and returned to natural conditions for sediment transport and fish migration.

Figure 2.3. Example of low head sector gate barrages (Source: Grant C., 2017).

2.2.3 Existing Themes Updates

2.2.3.1 Navigation

Navigation has not been covered and studied in detail by ISH0306. However it is worth noting that the text on navigation in the 2009 PDG is quite detailed and specific in its requirements, and henceforth more practical and operational than the other themes and sections in the 2009PDG. By comparison the sections on Fish Passage, Sediment Transport and Water Quality are more high level and lack specific measurable recommendations.

The ISH0306 Guidelines (MRC, 2016 – ISH0306 2nd Interim Phase, Vol. 1) do however have a few recommendations that could be considered with relation to navigation in the update of the PDG.

- Dam siting at master plan level with regard to early avoidance impact on navigation.
- Design and construction of flexible mooring structures for ports with regard to hydropeaking conditions
- Provision of environmental flows where relevant should also take into account the requirements for navigation
- Where diversion or intra-basin transfers occur maintenance of channel capacity for navigation should also be taken into consideration.

Some further comments on the navigation part is as follows:
• Clause 18 and 19 should be updated also taking into account the recent PNPCA processes for Don Sahong, Xayaburi and recently Pak Beng.
• The PNPCA process should also be reflected with the requirements/guidance discussed under Clause 26.

2.2.3.2 Fish Passage

In general, as discussed above more specific recommendations (as for navigation) should be developed for the PDG update under this theme. Results from the PNPCA processes Don Sahong, Xayaburi and Pak Beng should also be used. The background section (Section 3.1 in the 2009 PDG) should also describe more in detail the specific risks related to migration by imposing dams, as this will also cater for defining more specific fish passage requirements for upstream and downstream migration (for example dimension and type of rakes etc. for downstream migration, type of less fish harmful turbines, dimension and types of fish passages, as well as requirements of the aforementioned in cascade systems).

Some further comments with regard to the background sections are as follows:

• Clause 51 (incorrectly numbered between 58 and 59) states ladders only work for heights up to 6 m and lifts and locks are not proven. This means there are no proven fish passage solutions for the mainstream dams. Either this advice needs to be revised or there is no point in providing fish passages. This statement is also contradictory to the review of fish passage systems under the ISH0306, that has been reported thoroughly in specifically the Manual (MRC, 2016 – ISH0306 2nd Interim Report, Vol. 2), where different types of systems and their potential success on Mekong is discussed. The cumulative benefits/impacts of Xayaburi type fish passage systems in the upstream Lao mainstream cascade (Pak Beng, Luang Prabang, Xayaburi, Pak Lay and Sanakham) has also been thoroughly investigated in the ISH0306 Case Study (MRC, 2016 – ISH0306 2nd Interim Phase, Vol. 4). Hence the statement in Clause 51 is incorrect. There are many examples of functional fish passes exceeding 6m in height (e.g. 14m in the Danube). It is only true that successful examples for large tropical rivers are missing. However, the goals for restoring connectivity are clearly given in the PDG.

• Clause 61 suggests effective fish passage is 95% of target species under all flow conditions. This requirement requires clarification. Does 95% refer to one transit of one dam in one direction? Or does it mean 95% of target species population can navigate the entire cascade in both directions for all the critical years of their breeding life. This has high relevance to the results from the Case Study mentioned above, which indicated for example that even with a downstream migration mortality of only 2% through 1 dam would cumulatively add up to 10% for the cascade of 5 dams, e.g. well below the 95% target.

• Clause 61: “The success rate for fish passage both upstream and downstream necessary to ensure continued population variability can be refined for the particular species concerned, based on its life history and the number of dams the species may have to pass to complete its life cycle.” This paragraph refers to Halls & Kshatriya (2009) which indicated that no large species are predicted to persist if three or more dams have to be passed. To fulfil this clause, detailed knowledge on large species (i.e. migratory range, spawning areas, number of barriers to be passed before reaching spawning grounds and passage rate of those dams) is necessary. If the data collection predict that an additional dam could endanger the continued existence of this species, it should be considered not build it.
In Clause 61 target species should also be defined, and given the 3 different main migration systems on the Mekong discussed in detail in the ISH0306 Manual, it should be considered if the different target species should reflect these systems spatially. The selection of target species should not be “in the competence” of the developers to ensure a sound selection. Under clause 66 (footnote 9) it is stated that the “The Mekong Fisheries Programme is currently defining a list of target species”. This list needs to be provided and considered by dam developers.

Clause 62: “Where fish passage rates are unlikely to be adequate to maintain viable populations, the developers should develop and propose mitigation options as one element of compensation programs for lost fisheries resources”. This paragraph is in conflict with clause 61, which states that the success rate in both directions have to “ensure continued population viability”.

Clause 65, commenting on best international practise for fish passage design can be derived from the ISH0306 Manual and MRC Technical Paper no. 48 (MRC, 2015 – Review of existing research on fish passage through large dams and its applicability to Mekong mainstream dams).

Clause 71 on direct and indirect mortality of upstream and downstream migration (should be less than 5%) reflects the same issue as discussed under Clause 61, hence the same comments will endure. Furthermore it should also be specified if this includes also the reservoir and not only the dam (for example in relation to larval mortality in the impoundment).

Clause 80 – Fish friendly turbines, or “less fish harmful” are discussed in detail in the ISH0306 Manual and reference could be made to it, or some key requirements can be lifted into the updated PDG. Reference is also made to - Review of existing knowledge on the effectiveness and economics of fish-friendly turbines” MRC technical paper no 57 (2015).

Clause 89 “Developers should set aside contingency funds for modification of the fishway facilities, which may be identified as necessary based on the results of the monitoring programme...”. The following clause “the contingency fund is 20 percent of the initial cost of building the fishways” should be removed. Subsequent adaptations can be very expensive and should not be limited to a money amount but the aims stated above (i.e. successful passage for fish). By removing this, the developers are also motivated to build a functional fish pass in the first place.

Furthermore, the ISH0306 Guidelines do have some recommendations that could be considered with relation to Fish Passage in the update of the PDG as follows:

- Dam siting in master plans to avoid risks and impacts in fish migratory hotspot areas. Waiver of planned projects if they are in very sensitive locations and mitigation of negative effects cannot be ensured.
- Consideration of cumulative effects (not only single effects per dam).
- Develop joint operation rules for flow releases, in periods important for migration, including maintaining seasonal patterns, artificial releases and environmental flows (including joint flow releases in critical migration periods).
- Operating rules to minimize flow changes and management of re-regulation weirs to provide appropriate downstream flows
• Consider alternative hydropower designs to minimize impact on connectivity (See also section 2.2.2.3)
• Design measures for fish protection, e.g. suitable trash racks, adapted turbines, guidance systems, alternative spillway gate design, etc.
• Ensure fish passage and connectivity during all phases of the project (incl. construction)
• Avoid high retention time in reservoirs and plan and implement large bypass systems where possible
• Reduce reservoir size to improve flow conditions (e.g. for supporting passive drift of eggs and larvae)

### 2.2.3.3 Sediment Transport and River Morphology

In general, also for this theme more specific recommendations should be developed for the PDG update, and results from the PNPCA processes Don Sahong, Xayaburi and Pak Beng should also be used. The background section (Section 4.1 in the 2009 PDG) could also here describe more in detail the specific risks related to sediment transport and geomorphology by imposing dams, as this will also cater for defining more specific requirements for this theme.

Under clause 112 to 115 in the 2009 PDG sediment augmentation is discussed as a solution for mitigating downstream sediment starvation. It is questionable though if this is at all practical on the mainstream Mekong and the dams planned and under construction there.

Management of sediments in a cascade of dams are discussed under Clause 116 to 119 in the 2009 PDG. This has been thoroughly modelled and investigated in the ISH0306 Case Study, and reference could be made to it, or some key requirements for management strategies can be lifted into the updated PDG.

Furthermore, the ISH0306 Guidelines do have some recommendations that could be considered with relation to sediment transport and river morphology in the update of the PDG as follows:

• Dam siting in master plans with regard to avoid sediment transport and river morphology hotspot areas (for example studied by Schmitt et al. 2017 in the 3S system).
• Coordinated and joint flushing and sluicing in cascades in mainstream and tributaries, and together where they are closely connected.
• Design multiple large gated spillways/outlets at multiple levels, and low level sediment outlets
• Design sediment bypass channels.
• Under operation implement annual sediment sluicing to maintain seasonal pulse.
• Undertake riverbank stabilization works during construction.
• Introduction of annual sediments downstream of impoundments (however practically questionable on mainstream Mekong).
• Minimize sediment runoff through design of access roads and seasonal work schedules.
• Find mechanisms to support or implement catchment management measures to reduce sediment inputs.
• Limit rate of water level drop to prevent slope instability

Some specific recommendations with respect to sediments include:
**Lack of catchment context of project:** In general, the PDG provides clear guidance on the types of information and modelling that should be provided for the Prior Consultation process. However, the geographic extent that should be included in the investigations is not well described, and there is a lack of emphasis on considering the development in the ‘bigger’ catchment context. This could be improved by including some specific requirements about ‘setting the scene’ for the project.

One approach would be to:

- Include a requirement to provide a summary of large scale hydrologic and sediment transport processes occurring in the region proposed for hydropower development as part of the Prior Consultation submission. This should be at a much larger scale than the ‘project’ scale. The upstream extent should be far enough upstream to account for all major inflows reporting to the project, and the downstream extent should be defined where the flow regulated by the project contributes for example <25% of the flow in the mainstream in both the wet and dry seasons. The following information should be recommended for inclusion:
  - Geomorphic and hydraulic characteristics of the channel in the area to be inundated and in the area downstream of the project. This should include the distribution of bedrock, alluvial and mixed areas, and the locations of features such as deep pools, rapids and confluences with major tributaries;
  - A flow balance on a monthly time-step without the proposed project
  - A description of how flows are modified by other HPs (or irrigation dams) in the area, e.g., hydropeaking in tributary dams, daily run of river operations in mainstream, etc.
  - A description of how flows will be further modified within the area with the project in place;
  - A sediment balance without the proposed project that includes estimates of existing sediment trapping in mainstream or tributary HPs, and describes sediment mitigation and management approaches used at other HPs. This should include a list of the types of sediment management infrastructure included in dams downstream of the project, and justification should be given as to how the proposed project will not reduce the effectiveness of sediment mitigation at these other sites, e.g. due to having compatible or ‘better’ infrastructure or other sediment passage system;
  - A description of the grain-size distribution of suspended and bedload sediment on a seasonal basis at the upstream extent of the proposed head pond, at the proposed dam site and downstream of every major tributary entering in the downstream area as defined above. A greater emphasis should be included in the PDG to address sediment mitigation by grain-size. Passing 80% of the silt will not maintain channel stability if only 2% of the sand is getting through the impoundment;
  - A description of how sediment transport will change with implementation of the project, including:
    - Sediment budget by grain size into, through and downstream of the impoundment;
    - Sediment mitigation measures to be implemented, including timing of sediment releases and associated flow releases;

This ‘big picture’ should be used as the context for the more detailed project description.
Background regarding siting of project: Clause 124 in the PDG deals with the siting of projects, but it is unclear at what scale this assessment should be completed. Ideally dams are sited during the Master Plan phase where sediment management is considered. Following then from the catchment description, an additional clause to 124 requesting justification of the dam location on a catchment scale, with respect to sediment management, would provide the developer the opportunity to present the background as to how the dam location was initially identified.

Data quality: A second area where the PDG does not provide extensive guidance is defining the types and quality of data that are appropriate for inclusion in the Prior Consultation documentation and for use in modelling exercises. The source of all flow and sediment data used in the above ‘big-picture’ and in the subsequent project description should be thoroughly documented and provided as annexes. If based on modelled results, detailed information about the models used and model calibrations should be provided. In all cases, data should be compared to the existing MRC databases and any differences should be identified, and justified.

Promoting ‘joint operations’ with other HPs: The PDG could provide more guidance as to how HPs should coordinate operations with respect to sediment and flow management. It is difficult to address this issue at the pre-feasibility stage, but a ‘guidance’ to identify what power stations will coordinate operations, and at least a description of how communication and cooperation will be managed would be useful.

2.2.3.4 Water Quality and Aquatic Ecology
In general, also for this theme more specific recommendations should be developed for the PDG update, and results from the PNPCA processes Don Sahong, Xayaburi and Pak Beng should also be used. The background section (Section 5.1 in the 2009 PDG) could also here describe more in detail the specific risks related to water quality and aquatic ecology by imposing dams, as this will also cater for defining more specific requirements for this theme.

In general this theme should also discuss catchment management issues and recommendations with regard to water quality and floodplain and wetland issues with regard to aquatic ecology (including dam siting and joint flow releases to cater for these). Environmental flow considerations and recommendations should be considered to be moved under hydrology and flows if the last-mentioned is included as a theme in the update of the PDG. The reason for this is that environmental flows measures will benefit/impact various themes and not only water quality and aquatic ecology.

Furthermore, the ISH0306 Guidelines do have some recommendations that could be considered with relation to water quality and aquatic ecology in the update of the PDG as follows:

Water Quality
- Design of aeration and re-regulation weirs
- Provision of environmental flows mimicking the natural flow regime
- Use of high/low level outlets to mimic seasonal temperature and manage dissolved oxygen
- Avoid high retention time in reservoirs
- Implement site specific (spatial level) water quality standards (e.g. TSS, oxygen, temperature)
- Plan and implement catchment management measures to reduce pollutants inputs
Aquatic Ecology

- Dam siting during master plans to avoid impacts on aquatic, wetlands and floodplain habitat hotspots, including assessment of sections sensible to river fragmentation and important habitats (no-go areas)
- Consideration of cumulative effects (not only single effects per dam)
- Assessment of requirements and distribution of migratory aquatic species
- Assess and implement suitable turbidity thresholds with regard to natural floods for aquatic species
- Mimic natural flow regime through artificial releases and environmental flows
- Maintain seasonal patterns through HP operations
- Reconnecting floodplains and ensure connectivity during construction
- Creation of offsets of residual impacted areas and habitats
- Floodplain and wetland rehabilitation
- Implement river bank stabilization works
- Implement habitat improvement in head of impoundment

2.2.3.5 Safety of Dams

The background on the Safety of Dams in the 2009 PDG was presented in Chapter 2.1. The following is a review of the needs to update this section.

Published guidelines & regulations

There is a requirement for a review and update of the PDG to incorporate guidance provided by the most recent ICOLD publications on dam safety. These publications provide guidance based on best current practice but are, by necessity, high level and international in outlook. There is therefore an additional requirement for regional guidance and legislation to be reflected in the updated PDG document. For example, the Lao Electric Power Technical Standards define legislative requirements for critical dam safety parameters such as design flood magnitude and freeboard. These requirements differ from other standards adopted in the region and are mandatory in Laos. Similar Electric Power Technical Standards are published by other national authorities in the region. The updated PDG should provide guidance on how differing national legislative design requirements can be accommodated consistently on a basin wide, transboundary basis.

Basin-wide Risk Analysis

As river basins are developed it is no longer adequate to base design flood assessment on natural hydrology. The updated PDG should define a process where existing and planned structures are examined for their potential to generate flood risk to structures downstream. Gated spillways clearly have the potential to release flood peaks many times greater than the natural inflow. River diversion structures adopted during project construction are typically designed for much lower flood return periods than the completed works. The risk created by these temporary conditions should be examined.

Dam break analysis should form part of the risk analysis. Upstream structures should be reviewed for their potential to be overtopped or fail as a result of design or operational problems. Catastrophic failure of an upstream structure may create a risk for much larger downstream structures with a corresponding increase in the potential for damage and loss of life.
In the operating stage data from a catchment wide hydrometric network should be obtained on a real time basis to assist with flood forecasting. Agreed flood management strategies should be established by all project operators in the river basin so that the cumulative effect of flood management is understood and is not detrimental.

**Spillway design**

Dam failure is very rare. Statistics (ICOLD Bulletin No 99. Dam Failure – Statistical Analysis) indicate that the 3 most common causes of failure are:

- Over topping;
- Foundation defects; and
- Internal erosion.

In the case of mainstream dams the risk of overtopping will be mostly a function of limited reservoir storage to attenuate floods, ultimate spillway capacity, gate response time and reliability of spillway gates. The 2009 PDG mentions some of these issues but it would be valuable to provide more detailed guidance on the design standards that should be adopted and how these risks can be effectively mitigated. The required minimum flood return periods for the design and check floods, and associated freeboards, should be specified so that a consistent approach is adopted on all mainstream projects. The requirement for redundancy of gates should be fixed with an n-1 criteria for the design event.

It will be a characteristic of the mainstream dams that the powerhouses will be designed to turbine very large discharges. In the event of a line fault or full station trip, this discharge must immediately be transferred to an operational spillway otherwise unsafe variations in upstream and downstream water level will occur. Minimum response times for spillway gates should therefore be specified in terms of maximum acceptable changes, and rates of change, in upstream and downstream water level.

Redundancy of power supply and reliability of operation is a critical dam safety issue where gated spillways are adopted. The updated PDG should provide detailed guidance on the levels of power supply redundancy that are required. The PDG should additionally require 100% duty and standby hydraulic systems, and manual intervention systems, to ensure that the gates can always be opened when required. Finally, outline guidance should be provided on required maintenance regimes and test procedures.

The requirement for a physical or CFD model study should be considered in the revised guidelines. Such a study will be required to determine the most suitable configuration to be adopted when a reduced number of gates is in operation. A physical model or CFD analysis is also required to investigate the potential for scour and demonstrate that the safety of the dam cannot be compromised by erosion progressing upstream from the spillway stilling basin area.

**Climate change resilience**

Resilience to climate change is not mentioned in the current PDG. This topic should be addressed when the document is updated. A climate change risk assessment is a standard requirement for the development of a hydropower project and is an important dam safety consideration. The World Bank has recently commissioned technical guidelines to improve climate resilience for hydropower and dams projects. The guidelines document is intended to map out a workable process for incorporating climate change and disaster risk management into the concept development, design and operation.
stages of a hydropower project. This document will be available in mid-2017 and its recommendations should be considered for incorporation in the updated PDG.

**Seismicity**
Seismic design parameters are typically derived by an assessment of regional structural geology and a study of historic seismic events in the wider area. It would be appropriate for a project specific assessment to also be undertaken for the Mekong mainstream dams. In order to achieve a consistent approach the PDG should provide guidance on the required methodology for assessing the Operating Basis and Maximum Credible Earthquake events and the required performance of the structure during such events. It would be valuable to identify and refer to accepted regional studies. In some countries in the regional guidance is published by national authorities. For example in Lao PDR the “Electric Power Technical Standard Establishment” divides the country into four zones based on historically observed earthquakes and defines the seismic intensity for each dam type. Sufficient guidance should be provided such that a consistent and acceptable design is adopted on a basin wide basis.

**Dam design**
Specific guidance is required for the design of dams. A concrete gravity section is most likely to be selected for the mainstream dams and requirements for stability will therefore need to be specified. Such requirements will cover the approach to foundation drainage efficiency and uplift pressure, performance under extreme events and the requirement to take into account potential failure planes in the foundation. Compliance with an internationally accepted code of practice should be required.

Legislative requirements are also imposed in some regional countries and compliance with such requirements must also be achieved. For example the Lao Electric Power Technical Standards impose minimum factors of safety to be achieved under defined loading conditions. These requirements are mandatory.

**Safety during river diversion**
The period of river diversion during construction is one of the highest risk periods in the projects lifetime. River diversion works will typically be designed for much lower flood return periods than the completed works and the risk of overtopping and failure is therefore very much greater. Failure of river diversion works creates a hazard for construction workers and for downstream river users. The PDG should therefore provide guidelines on the minimum standards of security required in the design of river diversion works. Guidance should also be provided on the flood alert and evacuation thresholds that should be put in place.

**Powerhouse**
Although dam safety is the primary objective of this section in the PDG, it is generally considered to be good practice to broaden the scope to cover project safety. Power station flooding is considerably more common than dam overtopping, essentially because inappropriately low factors of safety are often adopted. The revised PDG should specify the levels of security required both from tailwater flooding and pressure conduit rupture.

Requirements for fire prevention and safe egress in the event of emergency should also be specified, preferably with reference to standard international requirements such as NFPA 850 (Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter
Stations) and NFPA 851 (Recommended Practice for Fire Protection for Hydroelectric Generating Plants).

**Design review procedures**

The updated PDG should specify the required provisions for external design review and construction monitoring. There should be adequate plans and a realistic budget to retain a Dam Safety Review Panel and a Government Engineer. The input from both these resources should commence as early as possible in the development of the project, and preferably before finalisation of project design and financial close. The Terms of Reference for the Dam Safety Review Panel should be broader than dam design and construction. All safety related aspects of the project should be covered and the review requirements should extend into the operation period for a minimum of six years.

Compliance with World Bank Operational Manual 4.37 - Safety of Dams should be required. At the early stage of the project not all OM 4.37 provisions can be in place but there must be adequate budget and a demonstrable intention to develop and implement a quality assurance plan, an instrumentation plan, an operation and maintenance plan and an emergency preparedness plan. Target dates and outline contents for these documents should be required at an early stage in the project. The instrumentation plan, maintenance plan and emergency preparedness plan should be initially drafted for the impounding phase and approved before impounding commences. These documents should then be revised for the operating phase.

The PDG should make recommendations that the Concession Agreement makes adequate provision for effective review and non-objection rights by the Dam Safety Review Panel and the Government Engineer throughout the design, construction and early operating period.

**Operational safety**

The updated PDG should specify the maximum acceptable water level ramp rates and amplitudes that result from changes in turbine or spillway discharge. These criteria should be specified so that a common approach is adopted that ensures the safety of river craft and members of the public on the river banks.

The PDG should also define the requirements for protecting the power intakes and spillway from being approached by lake craft, systems for warning downstream communities before power station and spillway releases are made, and security measures for preventing the public from entering potentially dangerous areas of the project. An outline plan should also be required for catchment flood warning systems and for flood management preparedness. This plan should include recommendations for community engagement and publicity programmes.

Requirements for a cascade management system covering data sharing, operation protocols and general hydro safety should be defined. It is considered good practice for a basin wide hydro safety committee to be established where the project owners can share information and experience, and develop common policies to protect public safety.
2.2.4 Inclusion of Tributary Dams in the Guidance

**Design guidance**

The 2009 PDG is specifically drafted for the mainstream dams in the Lower Mekong Basin. However, many of the more significant basin-wide environmental and livelihood impacts as well as dam safety issues relevant to the mainstream arise from the design and operation of tributary dams. It would therefore be beneficial for an updated version of the PDG to address major tributary developments (for example those of the northern Nam tributaries and the 3S system).

The recommendations in the revised PDG will be relevant to tributary dams that are low head run of river barrages with the same characteristics as the mainstream dams. However, many tributary dams are significantly different in terms of environmental impact and may have one or more of the following characteristics:

- The creation of a bypassed reach that requires an environmental compensation flow;
- A scheme comprising an inter-basin transfer that imposes significant flow regime and morphological changes in both river basins;
- A high dam that constitutes a complete barrier to fish migration and sediment transport;
- The creation of a large reservoir that creates stratification and water quality issues;
- Introduction of regulating storage that attenuates floods and reduces seasonality in the downstream discharge.

These characteristics are the basic themes addressed in the ISH0306 Guidelines and do not need to be repeated in detail in the revised PDG. There should however be a basic proposition in the revised PDG that the recommendations in the ISH0306 Guidelines should be adopted for both mainstream and tributary developments.

**Operational Guidance**

The revised PDG should also provide guidance on the operational implications of tributary projects. Large storage projects that provide seasonal regulation will have a cumulative impact on the seasonal distribution of flow in the Mekong mainstream. Reduction in seasonal flow variation in the Mekong may have important detrimental effects on the geomorphology and ecology of the river basin, particularly the Tonle Sap and delta regions. Requirements and measurable objectives for limiting loss of seasonality should be defined, for example, through joint flow releases in the 3S system to retain the important flood pulse in the downstream floodplains, delta and Tonle Sap area.

The interaction between the major tributary and mainstream projects may also be important for preserving sediment transport and fish migration routes. Objectives for conjunction operation should be defined in the revised PDG so that a basin-wide strategy can be created.
3 Review of the Hydropower Development Strategy 2001

This section is also utilizing substantial text already reported in the draft Concept Note for Update of the HDS, dated 31 January 2017 (MRC, 2017), as the consultant sees no need to redo this work. Where appropriate the assessment has been extended and further commented on.

3.1 Background

Since the signing of 1995 Agreement, which established the Mekong River Commission (MRC) in its present form, the MRC has been working tirelessly to comply with its mandate to co-operate in sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin in an integrated approach, for the economic and social well-being of the people in the riparian countries.

In 1998 the MRC Council approved the five principles that outline the role of the organisation with respect to the development of hydropower. These principles focused on: (1) information exchange; (2) international cooperation on sustainable development of hydropower projects; (3) integrated overall planning of the Mekong mainstream and tributaries (up to pre-investment stage); (4) cumulative environmental impacts and socio-economic aspects as well as public participation; and (5) encouragement of the private sector to join in developing hydropower potential with proper consideration of the environment and the social and economic well-being of the people.

These five principles were the foundation for the formulation of the MRC Hydropower Development Strategy in 2001 (HDS 2001). The results were comprehensive as they emerged in form of a variety of Studies, Guidelines and Tools which were used to provide guidance for MRC involvement in hydropower activities in the Basin including the provision of inputs for the Basin Development Plan (BDP) as well as to the Strategy concerning the use of water resources for hydropower, and the MRC Core Programmes on Water Utilisation (WUP) and the Environment (ENP), as well as the relevant Sector Programmes such as the Fisheries Programme (FIP), the Agriculture, Irrigation, and Forestry Programme (AFP), the Navigation Programme, etc. During the period of 2011-2015, the stakeholders started to appreciate the MRC efforts particularly with the implementation of the Strategic Environment Assessment for the proposed Mainstream Hydropower dams (MRC, 2010) and the application of the Preliminary Design Guidance (MRC, 2009) by three Mainstream dams project namely Xayaburi, Don Sahong and Pak Beng, as well as the extensive training for the Rapid Sustainability Assessment Tool (RSAT) for hydropower development in a Basin Wide context.

3.2 Overall Hydropower Development in the Lower Mekong Basin

Already since the previous decade, national policies has put strong emphasis on the necessity to extend electricity access to underpin poverty reduction strategies, improve regional energy security, reduce vulnerability to international energy price shocks and generate export earnings in countries such as Cambodia and Laos. These factors have led to accelerated development of hydropower and large investment in electrical infrastructure in the Lower Mekong Basin.

Concurrently, hydropower dams development is happening on Mekong mainstream and tributaries and is likely to intensify in the near future.

In 2001 there were approximately 17 hydropower projects in operation in the LMB with a capacity of less than 1,400 MW. During the period from 2002 to 2015 additionally 40 hydropower projects was built to provide a generation capacity of 6,442 MW. While some 14 dams with a total capacity around
3,000 MW are planned for commissioning during the period 2016-2020, another series of 30 dams with a total capacity around 6,653 MW are under planning status, with most of them under Feasibility phase.

The hydropower development on both the mainstream and the tributaries is anticipated to intensify in the coming decades and the ISH0306 Guidelines (MRC, 2016) gives a total overview of projects operational, under construction and planned for. This underscores the necessity of updating the HDS of 2001.

3.3 The MRC Key Result Areas and the necessity for a Hydropower Strategy

For the next five years, the MRC will focus its work in delivering outcomes under four key result areas. These represent concrete and highly focused priority areas that MRC seeks to influence to advance its mission and role as a regional river basin organization in the Mekong region.

Under each key result area, the strategic outcomes and the approach to deliver these outcomes are presented, along with associated key deliverables (outputs), resources required and monitoring indicators. The outcomes grouped under each result area are of a similar nature but contribute to a specific result within the area.

Table 3.1. Key Result Areas and their outcomes.

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<thead>
<tr>
<th>I. Enhancement of national plans, projects and resources from basin-wide perspectives</th>
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<tr>
<td>1. Increased common understanding and application of evidence-based knowledge by policy makers and project planners</td>
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<tr>
<td>2. Environmental management and sustainable water resources development optimised for basin-wide benefits by national sector planning agencies</td>
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<tr>
<td>3. Guidance for the development and management of water and related projects and resources shared and applied by national planning and implementing agencies</td>
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<th>II. Strengthening of regional cooperation</th>
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<td>4. Effective and coherent implementation of MRC Procedures by Member Countries</td>
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<td>5. Effective dialogue and cooperation between Member Countries and strategic engagement of regional partners and stakeholders on transboundary water management</td>
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<th>III. Better monitoring and communication of the Basin conditions</th>
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<td>6. Basin-wide monitoring, forecasting, impact assessment and dissemination of results strengthened for better decision-making by Member Countries</td>
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<th>IV. Leaner River Basin Organisation</th>
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<td>7. MRC transitioned to a more efficient and effective organisation in line with the decentralisation Roadmap and related reform plans</td>
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The BDS and SP underline the rising sense of urgency among stakeholders for the need to move basin development towards more “optimal” and sustainable outcomes that can address long-term needs, including environmental protection as well as ensuring water, food and energy security.

The “Key Result Area 1 (KRA1)” (Enhancement of national plans, projects and resources from basin-wide perspectives) relates to the role that MRC plays in informing the development of plans and projects by Member Countries that affect, directly or indirectly in a positive or adverse manner, the management of the basin. Under KRA1, three strategic outcomes for the period of this plan are targeted:
Outcome 1: Increased common understanding and application of evidence-based knowledge by policy makers and project planners

Outcome 2: Environment management and sustainable water resources development optimized for basin-wide benefits by national sector planning agencies

Outcome 3: Guidance for the development and management of water and related projects and resources shared and applied by national planning and implementing agencies

Albeit the fact that nowadays the sustainability of individual hydropower projects has made significant progress, yet such progress appears insufficient to solve all multifaceted issues emerged from the presence of multiple hydropower projects built across a river basin.

Outcomes from many studies and researches recommend that only basin-wide cooperation, integrated planning, development and management can help achieve sustainable hydropower development. These approaches is being increasingly accepted as fundamental to assure a long term hydropower sustainability in a basin-wide context which is also true for the Mekong Basin.

As a supplement to the above, experiences learnt from other regions reveal that activities at national and regional level to enhances cooperation and joint action such as joint planning, development (with cost and benefit sharing deals) and management, will promote a long-term balance between development effort and the basin’s environment/ecosystem protection. For instance, little cooperation together with limited joint action may lead the management of a river basin with hydropower projects to face many types of conflicts which in return will put the hydropower project at serious financial risk leading to potential threats such as: implementation delay, project abandonment, missing energy targets at national level, etc. Then for sure, the opportunities to meet energy needs while also maintaining other key values of the river basin will be all lost.

Consequently, should a new Hydropower Development Strategy (HDS) or an or updated version of the initial one be considered then the matter of basin-wide cooperation, integrated planning, development and management should be seriously taken in serious account as they are the fundamental key principles to promote further sustainable hydropower development in the LMB.

Accordingly, the principles, steps and actions will be all elaborated further in the next sections below.

3.4 The Hydropower Development Strategy and its Content

3.4.1 The 2001 Hydropower Development Strategy and its Recommendations
Prior to presenting the various components which could be proposed for the HDS2019, there are two periods to observe to start a strategic thinking for the future hydropower development in the Mekong:

1. The period leading up to the first Hydropower Development Strategy in October 2001 (HDS2001): The national and regional context are well documented in HDS2001 with description detailed in Strategic Areas and sub-components parts. The awareness of the environmental and social consequences of major infrastructure development have been renewed following the World Commission on Dams (WCD) recommendations are evident. The strategy of HDS2001 therefore emphasized the need for “true least cost development” and the strong need for Environmental and Social Impact Assessment (EIA and SIA) at a strategic and project level.
2. **The period between the HDS2001 and the Current day**: Since the emergence of the HDS2001 until 2015, there was a substantial number of the recommended outputs/activities made by the HDS2001 strategy that were implemented together with an additional amount of works completed by the MRC programmes, including the Initiative on Sustainable Hydropower (ISH). Considerable amount of gaps in information and human capacity have been addressed and filled. The plans for development of the hydropower and other sectors have been evaluated in the BDP2 “Scenarios Assessment”. However, the rapid development of the HP and other sectors continues to put pressure on the natural resources of the basin making integrated water and power planning even more vital. The concept of the “nexus between water, food and energy” has become commonly referred and therefore in the HDS2019, this concept should be reminded again as part of a fundamental concern.

Furthermore, the 2001 Hydropower Development Strategy (HDS) proposes an immediate objective of developing the hydropower resources of the Mekong mainstream and its tributaries according to true least cost planning, while fully considering environmental and social impacts. This objective requires a basin wide approach with strategic portfolio planning based on multi-criteria assessment. The HDS recognises that this objective creates challenges at a number of levels.

**Key Players**

Participation of the private sector is necessary to gain access to capital and expertise but the parameters within which the private sector operates must be carefully defined. If a private sector investor is charged with undertaking environmental assessment and project optimisation studies then the outcome may not be consistent with other projects and objectives on a basin wide scale. The HDS notes that different finance structures can produce different outcomes. The 150 MW Houay Ho project was financed on a balance sheet basis that allowed construction of the project to commence before studies were fully complete. The result was that the project performance transpired to be less attractive than originally predicted. By comparison the 210 MW Theun Hinboun project was undertaken on a project finance basis. This is typically perceived to be a more time consuming process but delivers more reliable results because all studies need to be complete before finance can be raised and construction commences. Theun Hinboun is generally accepted as a successful and high quality project. Similarly, developers that have an interest in project construction will probably propose a different project to a developer with a long term interest in stable revenue. Project definition cannot be left to the private sector.

Commercial lenders are key players in the hydropower sector and will influence outcomes and the sequence in which projects are developed. This sequence may well be at variance with the national generation expansion plan. A major consideration for commercial lenders will be control of risk and certainty of revenue. This consideration may favour smaller run of river projects in preference to large storage projects with complex environmental and social impacts, and long construction periods. Commercial lenders will typically take a very active interest in social and environmental compliance. Most international lenders will subscribe to the Equator Principles which is a risk management framework for determining, assessing and managing social and environmental risks. The Equator Principles set a minimum standard for due diligence and responsible decision making.
Development banks such as ADB and the World Bank perform a broader function. They provide funding for pre-investment studies, broader industry wide research programmes and support basin wide monitoring and mitigation projects. Development Banks may also participate in project finance and provide guarantees that allow commercial lenders to participate.

At the highest level, river basin authorities provide overall strategic guidance and direction. The mandate of such authorities varies throughout the world but frequently includes the management of international water resources. Such organisations are necessary because national plans are likely to be sub-optimal at a basin wide level. In the case of transboundary assets, such as Kariba Dam on the Zambezi, water resources allocation can only be managed by a basin wide authority with a mandate based on an international treaty. The MRC plays an important role in co-ordinating and monitoring in the LMB. It provides a knowledge resource and enhances planning and development through providing a forum for co-operation. The 2017 HDS Update Concept Note correctly notes that the Mekong will require a more direct and real time agency for co-ordination and management as the environment for hydropower development becomes more congested. This might cater for even more Joint Action between the member states (see also Figure 3.3).

**Least Cost Planning**

A key objective of the 2001 HDS is to promote true least cost planning. The proposition is that considerations of alternative sources of energy and overall environmental and social impact can only be fully assessed at a basin wide level. The HDS refers to studies (World Bank 1999 – Power Trade Strategy for the Greater Mekong Sub-Region) that demonstrate a basin wide assessment may result in:

- A more efficient transmission network that avoids parallel developments from private investors and national objectives;
- Reduced need for peak capacity by sharing reserve capacity and benefiting from peak load periods occurring at different times in the region;
- Postponement of investment decisions where reserve capacity exists elsewhere in the region; and
- Reduced system operating costs.

An updated study of these issues is now required but it seems likely that the findings would reinforce the case for basin wide development planning by a regional authority.

The key virtues of hydropower are sustainability and reduction of greenhouse gas emissions. The key concerns are environmental and social impact. These are diverse concepts with different metrics. The 2001 HDS and the Concept Note (MRC, 2017) propose that these issues can only be fully assessed and optimised on a basin wide basis using a multi-criteria analysis (see also above text). The MRC could provide this role and has developed tools to assist with this process including ISH02 and RSAT.

**Strategy Areas**

The 2001 HDS proposes that the longer term development objective and the immediate objectives require a strategy based on three areas as follows:
Strategic Area 1. Consideration of integrated water use, environmental and socio-economic factors;

Strategic Area 2. Efficient hydropower generation and distribution mechanisms; and

Strategic Area 3. Information system and capacity building.

For Strategic Area 2 the 2001 HDS notes that the key objectives should be:

- Study the potential for improved efficiency, reduced power demand and savings in investments in the power sector in the riparian countries through Demand Side Management and other options;
- Study practices and obstacles for private participation in hydro-power development in the riparian countries, develop and propose efficient and fair principles for private participation.

The first objective remains valid and it is most likely there are significant advantages to be achieved through improved regional efficiency, power trading, joint planning and demand side management. One of the implementation recommendations in the 2001 HDS is the development of tariff structures that facilitate optimum dispatch decisions. This is a valuable and fundamental recommendation. The current practice in the region is to enter into energy based PPA’s that contain take or pay obligations based on projected energy outputs. This structure constrains both parties and limits the dispatch instructions that can be given. On the mainstream projects this is less likely to be of significance since pure run of river operation is required. An alternative approach would be to make capacity payments to the developers and not pay for energy. This would leave energy dispatch and resource management to a central authority so that the performance of the entire system can be optimised.

The second objective may need to be revised in the updated HDS. There is no shortage of private developers investing in the hydro power sector. The more important challenge is to ensure that national and regional interests are adequately protected in commercial arrangements with private developers. The updated HDS could usefully set out some basic and common heads of agreement that may not be varied when concessions are awarded to the private sector.

3.4.2 The Strategic Plan 2016-2020 and Basin Wide Perspective

The Strategic Plan 2016-2020 has provided some suggestions to be include in the Basin-wide strategy for sustainable hydropower development:

“Energy from hydropower projects plays an important role in each of the LMB country’s energy supply mix and also contributes to the growing regional inter-dependency from cross-border energy trading. At the same time, the reservoir storage provided by these projects helps to regulate mainstream flows from the wet to the dry season, opening up opportunities for increased dry season abstractions and potentially for flood control. However, hydropower development has adverse transboundary impacts as well, e.g. on capture fish migration, rural livelihoods and sediment movement. From a basin wide perspective, national plans are sub-optimal as they do not take into account opportunities to enhance benefits beyond national borders and minimise adverse transboundary impacts. According to MRC and other assessments, the location, number and size of mainstream and tributary hydropower have
differing impacts across the basin. Taking into account regional energy needs (GMS and ASEAN integration agenda), national economic development priorities, comparative national advantages in hydropower development, the development of storage for flood and drought management, and the preservation of key environmental assets for economic, social and environmental purposes, a basin-wide strategy is needed to address the difficult trade-offs and to design more optimal and sustainable hydropower development pathways. The basin-wide strategy will support improvement of national sector planning and contributes to the overall Basin Development Strategy”.

Consequently, as already suggested in the above section, the SP 2016-2020, particularly KRA1 (see Table 3.1), will be achieved if only a Strategic Hydropower Development with a series of ‘Strategic Actions’ can be implemented. They will help to promote activities at national and regional level to enhance cooperation and joint action, to promote a long-term balance between development effort and the basin’s environment/ecosystem protection in the LMB. Further, these ‘Strategic Actions’ should make use of the lessons learned from, and the studies completed by; the MRC’s Initiative for Sustainable Hydropower (ISH) over the last 9 years. Joint and Integrated planning are to be implemented with the use of IWRM principles. The HP Strategy could be developed in a consultative and cooperative manner maximising the development opportunity at a national and regional level while dealing with the significant risks and impacts.

3.4.3 Key Concerns and Issues for the Updated HDS

It is true that after having compared to other global regions in the world in terms of actual renewable water resources per capita, the Mekong basin is not water stressed. However a number of locations are starting to face a series of critical water issues, such as:

- Water shortages in Thailand coupled with increasing irrigation water demands
- Increasing salinity intrusion in the Mekong delta in Vietnam;
- Threats and declines in basin fisheries and the degradation of natural habitats in many parts of the basin;
- Recurring un-seasonal floods and droughts;
- Reduced water quality, land-subsistence and morphological changes in the floodplains and delta areas; and
- Intensification of sectoral competition within and amongst the Mekong countries.

Consequently, the MRC’s effort to provide careful Basin wide planning with development and conservation well balanced must continue. In addition to the MRC endeavours and commitment to promote closer cooperation and good governance in water resources management at basin wide level, sustainable hydropower development should also introduce new approaches for each stages of a hydropower project cycle, such as:

- Careful measures sequenced through project site selection (including strategic portfolio planning),
- Design and operation steps to introduce equitable sharing of benefits at basin, national and local levels;
- Joint planning and monitoring;
- Innovative financing; and
- Public-private partnerships.
Furthermore, impacts from climate change, the mitigation (including GHG emission reduction), resilience and adaptation issues need to also be factored into the hydropower sustainability equation. Awareness raising, strategic communication and capacity building must all continue to come again to the forefront. All of the above should be included in the update for the Hydropower Development Strategy which must be built with the participation of the Member Countries and thereafter approved by the MRC Join Committee.

The BDS and SP 2016-2020 emphasise the need for the national plans to be “optimized” at a basin scale, to maintain the benefits with minimization of all kind of basin scale impacts. Therefore, to achieve the above Key Results Areas and their Outcomes and to respond to the basin concerns and needs as well as to overcome Basin Challenges, a series of key tasks are also suggested to include as solution for further ‘key actions’:

**Table 3.2. Proposed key actions related to concerns, needs and challenges.**

<table>
<thead>
<tr>
<th>Concerns, needs, challenges</th>
<th>Proposed key actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and livelihood security</td>
<td>To enhance through inclusion of multiple use opportunities, better project selection and implementation that minimizes disruption to local communities, national to local benefit sharing; food security (i.e through the link to the basin <em>Fisheries Management Strategy</em>), etc.</td>
</tr>
<tr>
<td>Resilience against Climate Change including drought and flood</td>
<td>To enhance through cooperation on design and operations both locally and at a basin scale; To take account of the <em>climate change, water poverty</em> challenges in the basin. (e.g. through provision of adequate information on potential effect of CC on HP and ways HP can help to mitigate CC)</td>
</tr>
<tr>
<td>Energy security</td>
<td>To enhance in through the development of Hydropower projects; least cost development as proposed in the HDS2001 and can be facilitated through regional integration of energy markets and electricity power transmission plans. Optimisation of the use of a number of hydropower dams in the power system to maximize its value would also be important (e.g. to support other renewables, integration between storage and run-of-river schemes).</td>
</tr>
<tr>
<td>Improvement in Navigation</td>
<td>To improve through the implementation and operation of new navigation locks constructed with hydropower dams on the Mekong Mainstream along with safety and environmental safeguard secured though the application of the design guidance (e.g. PDG).</td>
</tr>
<tr>
<td>Environmental degradation</td>
<td>To minimize and apply the transformative benefits of HP while reducing the risks and cost of HP (e.g. through design guidance, appropriate project location, design, implementation and operations, monitoring and adaptive management) Design guidance and basin scale HP planning</td>
</tr>
<tr>
<td>Trans-boundary cooperation</td>
<td>To facilitate integrated planning to develop a basin-wide strategy for sustainable hydropower To <em>optimise national plans and identify joint opportunities for basin wide benefits</em> and use this as a development proposal assessment framework in cooperation with GMS and ASEAN To strengthen trans-boundary cooperation and governance through • Join activities for sustainable planning and management of HP • Monitoring and coordination of hydropower operations • Governance and transboundary cooperation</td>
</tr>
</tbody>
</table>
3.5 Proposed Updates Based on ISH0306 Results

3.5.1 Procedures for Use of the Mitigation Guidelines throughout the Planning Process

As already mentioned under Chapter 3.3, the new Hydropower Development Strategy (HDS) should take into account basin-wide cooperation, integrated (spatial and strategic portfolio) planning, development and management. The aforementioned should function as key fundamental principles to promote further sustainable hydropower development in the LMB. This is also a key outcome of the ISH0306 Guidelines whereupon also the use of mitigation hierarchy and its approaches throughout the planning process, or project life cycle, is an integral part of this.

Furthermore, the Mekong Agreement also requires the countries to “make every effort to avoid, minimize and mitigate harmful effects…”, i.e. to adopt the mitigation hierarchy in the planning and implementation of hydropower and other infrastructure projects.

With relation to the mitigation hierarchy (Figure 3.1) avoidance is most regularly used at concept stage (master plans, pre-feasibility and feasibility studies) identifying alternative sites or technology to eliminate impacts. Minimisation is most often used prescribing actions during feasibility, design, construction and operation stage to minimise or eliminate impacts. Compensation is used to offset residual impacts identified at the various stages.

Figure 3.2 transfers the general principles from the mitigation hierarchy (Figure 3.1) into the HP project life cycle and can be seen as an overarching generic practical process for risk and impact mitigation in LMB.
Figure 3.2. MRC adjusted Generic Practical Process for Risk and Impact Mitigation - Project Life Cycle.

More detailed approaches to mitigation for the various HP Life-Cycle Stages can be found in the ISH0306 Guidelines (Volume 1), henceforth reference is made to this, for further details.

3.5.2 Procedures for Integrated Systems Planning of Hydropower

Spatial planning or strategic hydropower portfolio planning versus traditional project planning, e.g. integrated systems planning, was already mentioned in under Chapter 2.2.1 under the PDG review. With regard to mitigation discussed previously under 3.5.1, this is especially relevant for early avoidance at the start of the HP project life cycle (e.g. at Master Plan stage).

Hence, integrated hydropower planning at the system scale (basin, catchment) should be the New Frontier for the LMB countries (see also Nature Conservancy/IDB, 2013 for discussion on the benefits of system scale hydropower planning), and thus be an integral part of the new Hydropower Development Strategy. Loucks (2003) also neatly links this to maximization of benefits by stating – “the interdependence of system components and decisions strongly argues for managing them in an integrated holistic and sustainable manner if maximum benefits are to be obtained from them”. For this to be realised the Member Countries will need even more integration than at present within the cooperation continuum and move from cooperation towards even more joint action as portrayed to the right in Figure 3.3.

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1 This was also one of the most important «take home messages» at the Hydropower Sustainability Forum: Mekong+, arranged in Oslo, Norway between 4-6 August. See http://www.mrcmekong.org/news-and-events/events/oslo-forum-2/ and http://www.mrcmekong.org/news-and-events/news/oslofroum/
The concept of Integrated Systems Planning has also been further developed in a recent publication by The Nature Conservancy (Oppermann et al., 2017) focusing on how system scale planning and management of hydropower at a broader scale than just early avoidance can yield economic, financial and economic benefits and terming it Hydropower by Design. Hydropower by Design (HbD) can identify strategic and sustainable hydropower systems that deliver economic value to countries, financial value to developers, and greater environmental values from rivers. Key points from their studies, also through a series of case studies on HbD, are as follows:

- System-scale approaches to planning and managing hydropower (HbD) can produce significant economic benefits for countries, while reducing environmental impacts, social conflict and investment risk.
- The case studies demonstrated that Hydropower by Design can result in improved environmental performance for similar levels of energy generation, along with economic gains of 5 to more than 100 percent in other important river services.
- While the strategic planning required to achieve those balanced outcomes has often been equated with delayed implementation or associated with projects that are not financially attractive, Oppermann et al. (2017) used in-depth financial and energy system modeling to show that the risk-management and engineering optimization benefits of Hydropower by Design can result in projects that are: one, financially competitive; and, two, strategic and low impact.
- In effect, the strategic economic and environmental benefits of system planning can be “paid for” by the financial benefits of Hydropower by Design. The potential global economic benefits of widespread adoption of Hydropower by Design are large: even a 5 percent improvement in other water-management resources in river basins where hydropower plays, or will play, a major role would produce up to US$38 billion per year in benefits, a sum comparable to average annual investment in hydropower.

Figure 3.4 that is copied from Oppermann et al. (2017), gives an snapshot and an overview of the economic and environmental improvements possible through application of Hydropower by Design in case studies from 9 river basins.
3.5.3 Inclusion of Strategic Topics in HDS Update

The Strategic Plan 2016-2020 has revealed that ‘from a basin wide perspective, national plans are sub-optimal as they do not take into account opportunities to enhance benefits beyond national borders and minimise adverse transboundary impacts. According to MRC and other assessments, the location, number and size of mainstream and tributary hydropower have differing impacts across the basin’. Therefore, a revisit of the national plans particularly the National Indicative Plan of each MRC MC will be necessary.

The list of hydropower projects to be constructed should be re-assessed by using RSAT, ISH0306 Guidelines and other MRC tools. Ideally, each individual hydropower project should be re-assessed for its project sustainability within the LMB Basin-Wide context. However, in real life this suggestion may not appear to be realistic because some of the projects are in advance stage of commitment between the Government and the hydropower project developers.

Therefore, it is proposed to do a first screening and to identify:

- The ones which are already strongly committed such as projects having their Concession Agreement signed or being under construction or will be constructed very soon and
- The list of hydropower projects which still be under planning or under pre-Feasibility Study. These type of projects have greater ‘flexibility’ and still can be re-assessed with the use of RSAT, ISH0306 and other MRC tools.
While using RSAT, ISH0306 and other MRC tools to do the assessment for hydropower sustainability in the context of Basin-Wide, it is important to constantly remember to discuss concerns and questions of trans-boundary nature. The table below attempts to provide some examples:

**Table 3.3. Strategic Topics for the HDS Update and suggested use of tools, guidelines etc.**

<table>
<thead>
<tr>
<th>Strategic Topics (Based on RSAT)</th>
<th>Examples of particular Basin-Wide and Trans-boundary concerns requiring special attention</th>
<th>Suggestion for potential possibility to use ISH Tools, Guidelines, Methods, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Topic 1:</strong> Institutional Capacity</td>
<td>National sustainable development policy frameworks to consider trade-off and synergies between water and energy;</td>
<td>ISH02</td>
</tr>
<tr>
<td><strong>Topic 2:</strong> Option assessment, siting and design</td>
<td>To consider options assessment on water services/energy, demonstrated needs against siting selection, maximal energy production, minimisation of impacts; To conduct multi-criteria options assessment, To do Risk and Avoidance assessment and mitigation measures, etc.</td>
<td>ISH01 ISH02 ISH0306</td>
</tr>
<tr>
<td><strong>Topic 3:</strong> Economic contribution of hydropower</td>
<td>Verify maximal social and economic value Check efficiency and long term revenue from Power Development Plan perspectives against a realistic power production assessment Regional macroeconomic assessment, SEA and Tb Economics benefits as well as Options for “Joint Action/Projects”, etc.</td>
<td>ISH02 ISH0306 Alignment with GMS and ASEAN integration Concept of Benefit Sharing as promoted by BDP</td>
</tr>
<tr>
<td><strong>Topic 4:</strong> Equitable sharing of hydropower costs and benefits</td>
<td>Discuss possibilities for Joint Action/Project - mutual benefit Discuss GMS and ASEAN interconnection, electricity power trading, etc. Discuss possibilities for Strategy for Carbon finance, etc.</td>
<td>ISH01 ISH02 ISH0306 SIMVA, BDP</td>
</tr>
<tr>
<td><strong>Topic 5:</strong> Social issues and stakeholder consultation</td>
<td>Check Stakeholder Consultation report Check Baseline demographics, poverty, gender, ethnic matters, etc. Check Social risk assessment, food, poverty at basin scale, etc. Check biodiversity and hotspot areas;</td>
<td>ISH01 ISH02 SEA, SIMVA, BDP Compare with BDP Scenario, GMS assessments</td>
</tr>
<tr>
<td><strong>Topic 6:</strong> Environmental management and ecosystem integrity</td>
<td>Avoid Ecology sensitive areas and Hot Spots Option to maximize multi-purpose use of HP Reservoirs</td>
<td>ISH01 ISH02 ISH0306</td>
</tr>
<tr>
<td><strong>Topic 7:</strong></td>
<td>Optimize use of HP capacity and storage in system cascade;</td>
<td>ISH01</td>
</tr>
</tbody>
</table>

**For consultation only**

**Cannot be referenced.**
### Strategic Topics (Based on RSAT)

#### Examples of particular Basin-Wide and Trans-boundary concerns requiring special attention

<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
<th>Suggestion for potential possibility to use ISH Tools, Guidelines, Methods, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flows and reservoir management</td>
<td>Discuss options to assist with drought and flood management; Discuss environmental flows</td>
<td>ISH02  ISH0306</td>
</tr>
<tr>
<td><strong>Topic 8:</strong> Erosion, sediment transport and geomorphological impacts</td>
<td>Sediment locations, ranking and mitigation in strategy for basin scale</td>
<td>ISH11  ISH0306</td>
</tr>
<tr>
<td><strong>Topic 9:</strong> Management of fisheries resources</td>
<td>River fishery resources through baseline and monitoring surveys, and impact assessment both upstream and downstream fisheries, changes in flows and water quality, fish biodiversity and threatened species</td>
<td>ISH11  ISH0306</td>
</tr>
<tr>
<td><strong>Topic 10:</strong> Dam and Community Safety</td>
<td>Discuss Cascade operations, dam safety, Community safety and emergency response</td>
<td>ISH0306</td>
</tr>
</tbody>
</table>

#### 3.5.4 Engineering Response to Design and Operation

The Concept Note (MRC, 2017) sets out a clear and well-argued case for an update to the Hydropower Development Strategy. The need for true least cost development, informed by strategic assessment at a basin wide scale is emphasised.

The hydropower industry has made significant progress with improving the sustainability of individual projects. Considerable efforts are made to mitigate environmental impact on a well-designed project. An example would be an assessment of embodied carbon. It is now standard practice to assess energy consumption during construction which includes energy requirements for construction plant and materials, installed equipment and transport of personnel from and to the site. CO$_2$ emissions in the form of methane from the reservoir will be assessed during the early stages of project operation. This total carbon equivalent will be compared with CO$_2$ emissions from displaced thermal generation. Virtually any reasonable hydroelectric project will show an enormous environmental benefit when assessed on this basis.

However true least cost decision making at a strategic basin wide level will most probably yield very different recommendations for design and operation than if assessment is undertaken on a project by project basis. For example, it may be concluded that certain reaches of river should be left undeveloped to retain critical ecological processes even though highly attractive hydropower project locations may exist on that reach (for example by using Strategic Portfolio Planning). The commercial and food security value of fish migration may be comparable to the economic value of the energy, resulting in zero net economic benefit from hydro power development.
It is currently the case that private sector investment is the only realistic route available for major power scheme development in the region, but it is not realistic to rely on the private sector to undertake basin wide strategic studies. These must be undertaken by the public sector at a basin wide level, probably with support from the international community. The output of such studies would be to determine which projects should proceed and to define the design and operational constraints within which they must be developed. The industry has typically adopted an approach based on “maximum affordable energy with acceptable impact”. This approach is sub-optimal at a cascade and basin wide level, henceforth also for the society and the environment it rely on at large.

The Concept Note (MRC, 2017) further recognises that in an increasingly complex and congested operating environment the requirements for joint monitoring and co-ordination between different project owners becomes increasingly important. The updated Design Guidance will provide a degree of direction but a regional agency for co-ordination and management is required.
4 Recommendations for Immediate Steps

4.1 PDG Update

The drafting of the timeline has been undertaken by MRCS itself. Mobilization to update the PDG to DG has already started and National and Regional Consultations is planned to take place in September and October 2017, to agree on objectives and scope. The planned timeline with its various steps is given in Figure 4.1 below. Some important milestones are Joint Committee and Council endorsement by November 2017, team mobilisation by January 2018 and Finalisation of DG by July 2018.

Figure 4.1. Proposed Timeline for Updated Design Guidance by 2018.
4.2 HDS Update

The drafting of the timeline has been undertaken by MRCS itself. A ToR has already been drafted by August/September 2017 and these are to be submitted to the Member Countries for National and Regional Consultations in October and November 2017. The planned timeline with its various steps is given in Figure 4.2 below. The update of the HDS spans a longer period that the PDG/DG. Draft Final Report is planned due in March 2019 with MRC JC consideration and approval in November the same year.

Figure 4.2. Proposed Timeline for development of the sustainable Hydropower Development Strategy by 2019.
REFERENCES
Grant C, Sustainable Hydropower Designs and Operation, Hydropower Sustainability Forum: Mekong+, Oslo 4-6 September. A joint MRC, GIZ and Multiconsult event.


The Nature Conservancy, 2013, The next frontier of hydropower sustainability: planning at the system scale. By Joerg Hartmann, David Harrison, Jeff Opperman, Roger Gill.