5. Definition of Development Pathways

This study assessed and compared the cumulative impacts of three different renewable energy development pathways in the Sekong Basin (Table 5.1 and Table 5.2) that would lead to generation capacity capable of producing 9 terawatt-hours (TWh) to 14 TWh annually (Figure 5.1).

The *full development pathway* is the expected situation in 2030 if all projects proposed in this timeframe are implemented. This pathway includes 35 hydropower projects (34 in Lao PDR and one in Vietnam): 12 already commissioned or due to be commissioned by 2020, five committed, and 18 candidate projects.

The *conservative development pathway* has been defined with a focus on maintaining the Sekong mainstream free flowing to keep it intact and ensure fish migration, whereas the tributaries will be developed as in the full development pathway. The rationale for this conservative pathway is to maintain the Sekong mainstream uninterrupted in response to concerns with fish migration, erosion and sediment transport, resettlement and land use change, and impacts on the Mekong Delta.

The *intermediate development pathway* involves the same hydropower projects as the full development pathway with the exception of the two uppermost hydropower projects (Sekong 4B and 5) on the Sekong mainstream.

All three pathways assume some development of wind and solar by 2030, by which time it is expected that these technologies will be more competitive. The assumption is that 600 megawatts (MW) of solar power (land based and floating) and 600 MW of wind power are in operation, providing approximately 3 TWh of energy. Use of reservoirs for floating solar power plants involves no alteration in land use and minimal effect on the aquatic environment.

Table 5.1: Alternative Development Pathways Assessed

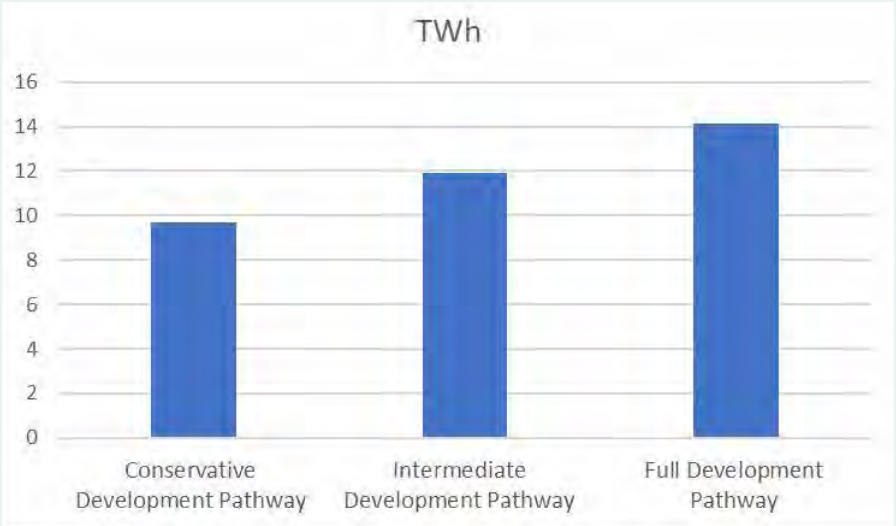
Development pathway	Time frame	Renewable energy projects
Present situation	2020	12 hydropower projects already built or under construction and due to be operational in 2020
Full development	2030	35 hydropower projects proposed to be built and commissioned in 2030 Wind and solar projects with 3 TWh of annual generation
Conservative development	2030	28 hydropower projects (as in full development pathway but omitting all seven mainstream dams) Wind and solar projects with 3 TWh of annual generation
Intermediate development	2030	30 hydropower projects (as in full development pathway but omitting five of seven mainstream dams) Wind and solar projects with 3 TWh of annual generation

Table 5.2: Existing and Planned Hydropower Projects in the Sekong Basin

Project name	Status	COD year	Installed capacity (MW)	Mean annual energy (GWh)	Power destination	Present situation	Conservative	Intermediate	Full
A Luoi	Operational	2012	170	650	Vietnam	X	X	X	X
Houay Ho	Operational	1999	152	450	Thailand	X	X	X	X
Xe Kaman 3	Operational	2013	250	980	Vietnam	X	X	X	X
Xe Namnoy 6	Operational	2013	5	20	Lao PDR	X	X	X	X
Xe Namnoy 1	Operational	2014	15	80	Lao PDR	X	X	X	X
Houay Lamphan Gnai	Operational	2015	88	450	Lao PDR	X	X	X	X
Xe Kaman 1	Operational	2016	290	1,040	Vietnam	X	X	X	X
Xe Kaman–Sanxay	Operational	2017	32	110	Vietnam	X	X	X	X
Nam Kong 2	Operational	2017	66	260	Lao PDR	X	X	X	X
Xe Katam 1 Xe Namnoy 2	Operational	2017	22	120	Lao PDR	X	X	X	X
Xe Pian Xe Namnoy	Construction	2020	410	1,800	Thailand	X	X	X	X
Nam Kong 3	Construction	2020	54	200	Lao PDR	X	X	X	X
Dakchaliou 1	Construction	2021	11	50	Unknown		X	X	X
Dakchaliou 2	Construction	2021	13	60	Unknown		X	X	X
Nam Kong 1	Construction	2022	150	560	Lao PDR		X	X	X
Nam Bi 1	PDA stage	2024	68	290	Vietnam		X	X	X
Nam Bi 2	PDA stage	2024	50	210	Vietnam		X	X	X
Nam Bi 3	PDA stage	2024	12	50	Vietnam		X	X	X
Nam Ang	PDA stage	2024	55	160	Lao PDR		X	X	X
Nam Emoun	Construction	2024	129	430	Lao PDR		X	X	X
Nam Pangou	PDA stage	2025	33	140	Unknown		X	X	X
Xe Pian-Houysoy	PDA stage	2025	45	200	Lao PDR		X	X	X
Lower Xe Pian	FS ongoing	2030	15	60	Lao PDR		X	X	X
Xe Katam	PDA stage	2030	81	300	Lao PDR		X	X	X
Xe Kaman 2A	FS ongoing	2030	64	250	Lao PDR		X	X	X
Xe Kaman 2B	FS ongoing	2030	100	380	Lao PDR		X	X	X
Xe Kaman 4	PDA stage	2030	70	290	Vietnam		X	X	X
Xe Namnoy 5	Unknown	2030	20	90	Lao PDR		X	X	X
Sekong 5	FS completed	2030	330	1,500	Thailand			X	X
Sekong 4B	FS approved	2026	175	750	Thailand			X	X
Sekong 4A	FS approved	2025	165	780	Thailand				X
Sekong 3A	FS completed	2027	114	430	Lao PDR				X
Sekong 3B	FS completed	2028	122	400	Lao PDR				X
Sekong Downstream A	FS completed	2030	86	380	Lao PDR				X
Sekong Downstream B	FS completed	2030	50	210	Lao PDR				X

Note: COD = Commercial Operation Date; MW = megawatt; GWh = gigawatt-hour; Lao PDR = Lao People's Democratic Republic; PDA = project development agreement; FS = feasibility study. No Xs means the power plant is not part of the respective pathway.

Figure 5.1: Overall Annual Electricity Generation under Various Development Pathways



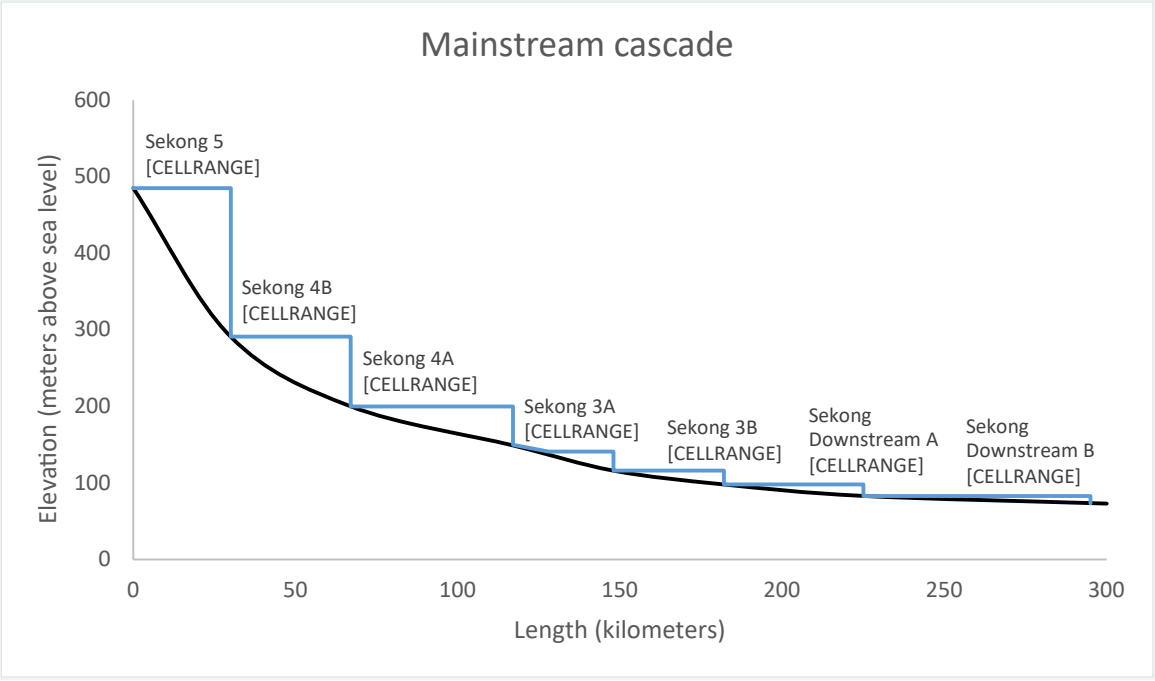
5.1 Full Development Pathway

The full development pathway (Map 5.1) comprises existing projects and all projects proposed to be constructed by 2030.

This entails full development of the entire Sekong Basin, including the mainstream and most major tributaries.

The Sekong mainstream dams will impound almost all of the river, including most rapids along the mainstream totaling more than 300 kilometers, with the exception of a short distance between the tailrace of Sekong 4A power plant and the reservoir of Sekong 3A (Figure 5.2). If a closer analysis were to be conducted, it is likely that the Sekong 3A reservoir will affect this stretch of river during flood periods.

Figure 5.2: Approximate Location and Impoundment Levels of Sekong Mainstream Reservoirs



Map 5.1: Hydropower Projects in the Full Development Pathway

Source: Shuttle Radar Topography Mission (SRTM), Mekong River Commission (MRC), Greater Mekong Sub-Region (GMS)

The Nam Emoun, Upper Xe Kaman, Xe Katam, and other mountain tributaries will also become regulated, and the only free-flowing tributaries will be the Xe Xou and Xe Kamphon, which account for only 3,217 square kilometers, or less than 13 percent of the Sekong Basin.

The uppermost two dams proposed on the Sekong mainstream have a combined head of nearly 300 meters.[12] The lower five dams have only 130 meters of head between them, meaning they are classified as low-to-medium head projects.

5.2 Conservative Development Pathway

In the conservative development pathway (Map 5.2), the Sekong mainstream remains free flowing with natural seasonal flow variations, more sediment transport downstream through Cambodia and to the Mekong Delta, and no barriers to fish migration. Maintaining a free-flowing Sekong mainstream is a basin-scale mitigation strategy for preserving fish biodiversity and sediment transport. Furthermore, this would avoid the need for large scale resettlement of communities along the Sekong mainstream.

The conservative development pathway includes 800 MW of proposed projects in the Xe Katam, Nam Emoun, Bolavan, and Nam Kong sub-basins. Most of these projects will have only a small and local impact on hydrology. The Nam Emoun project has no seasonal reservoir, large dam, or resettlement. The Xe Katam and Nam Bi projects are located above the existing Xe Katam 1 reservoir, which mitigates downstream impacts. The Nam Kong 1 project will form a barrier to fish migration and sediment, but the additional impact is likely to be minor given the existence of Nam Kong 2 and Nam Kong 3 on the same tributary.

5.3 Intermediate Development Pathway

This pathway (Map 5.3) allows for substantial hydropower development in the Sekong Basin while avoiding projects with higher environmental and social costs and lower profitability.

Because the tributary basins are already substantially developed for hydropower, discussion of what might be a balanced trade-off can be focused on the Sekong mainstream. The Upper Sekong cluster provides an amount of power from two projects similar to that of five projects in the Lower Sekong cluster (Appendix A, Table A.5, Map A.1).

Even when cost calculations are provided on a comparable basis (which is not the case at present), the five dams in the Lower Sekong cluster are likely to have higher costs per megawatt of installed capacity as low-head dams are generally more expensive because of complex river diversions, large spillways, and other required design factors. Therefore, the low-to-medium head projects will always struggle to become financially justifiable given the role of envisaged power exports to Thailand and Vietnam.

From the point of view of power system planners in Thailand and Vietnam, high-head projects (similar to Nam Theun 2, Theun Hinboun, and Xe Pian–Xe Namnoy) would be preferred to provide competitive peak power to their systems. As such, the Upper Sekong projects with 300 meters of head should be considered a more suitable, cheaper cascade than the Lower Sekong cluster of five projects to meet peak megawatt export demand in agreements already made among Lao PDR, Thailand, and Vietnam.

In terms of economic, environmental, and social efficiency, the five lower dams along the mainstream Sekong appear to be the most environmentally and socially disruptive and the most costly, so the intermediate development pathway has been defined to exclude these five downstream projects, which will result in significantly less negative cumulative impact on the Sekong mainstream than the full development pathway.

[12] *Head* is the difference in water level between the hydro intake and the discharge point or a turbine runner. It is a vertical height measured in meters. More head means more potential energy per unit of water.

Map 5.2: Hydropower Projects in the Conservative Development Pathway

Source: SRTM, MRC, GMS.

Map 5.3: Hydropower Projects in the Intermediate Development Pathway

Source: SRTM, MRC, GMS.